M A S T E R ' S T H E S I S

Procurement- & Contract models for Construction- & Infrastructure projects in the Semiconductor industry

under guidance of

Associate Prof. Dipl.-Ing. Dr. techn. Iva Kovacic
Institute of Interdisciplinary Construction Process Management

submitted to the Technical University of Vienna
Faculty of Civil Engineering

from

Tamás Burján

Matr.Nr.: 1326953

Vienna, 2016

Acknowledgements

I would like to express my sincere appreciation to the people who supported me throughout the whole time I was working on this thesis.
First I would like to thank my supervisor, Associate Prof. Dipl.-Ing. Dr.techn. Iva Kovacic for the guidance, advices, comments and the endless time she invested into my work.
I would also like to give my special thanks to the people by Infineon, especially to Dipl.-Ing. Dr. Andreas Wittmann for the opportunity to learn about the semiconductor industry, for the assistance and for the supportive attitude towards me and my work.
Furthermore, I would like to thank the Institute of Interdisciplinary Construction Process Management for providing me the opportunity to participate in this project.
I am also more than thankful to my family and close friends for their never ending support and their faith in me. Without them, I would not have had the motivation to take the challenge of writing this thesis.

Kurzfassung

Im Zuge der industriellen Revolution wandelte sich das Weltbild für einen Großteil der Menschheit. Das Streben nach Effizienz der damit einhergehende technische Fortschritt, das Wirtschaften im globalen Kontext schuf Kriterien für neue Unternehmungen. Ein Resultat dieser Entwicklung ist die Infineon AG, ein Unternehmen wohl bekannt in der Halbleiterindustrie. Die Produktionsstandorte verteilen sich über drei Kontinente, das Beibehalten dieser Expansionspolitik wird angestrebt. Anhaltende Investitionen, in eine notwendige Infrastruktur, an unterschiedliche Standorten, bieten Potenzial für weitere Entwicklungen.
Hauptziel der vorliegenden Diplomarbeit besteht in der Beurteilung bestehender Vertragsmodelle der Firma Infineon hinsichtlich der Effizienz. Des Weiteren werden Optimierungsmöglichkeiten, deren notwendige Voraussetzungen und eine abschließende Evaluierung, vorgestellt.
In dieser Arbeit angeführte Ergebnisse basieren auf zwei grundlegenden Informationsquellen. Zum einen, eine fundierte Literaturrecherche mit Grundlagen und Merkmalen der wichtigsten Abwicklungsmodelle. Zum anderen eine qualitative Recherche, der zur Verfügung gestellten Projekte.
Diese Projekte, drei an der Zahl, wurden freundlicherweise seitens Infineon zur Verfügung gestellt. Durch den Autor durchgeführte Interviews der Projektbeteiligten finden ebenfalls Einzug in diese Arbeit. Die abschließende Diskussion basiert auf der Auswertung der gesammelten Informationen.

Abstract

During the industrial revolutions, the world changed completely. The urge for efficiency created an environment suitable for a more global economy and enhanced scientific development. One of the results of this is Infineon, a company well known in the semiconductor industry. Their production is running in three different continents already and further expansion is almost certain. The continuous investments in establishing the necessary infrastructure, each in the most adequate country for their special functions, offers potential for improvements.
The study's main area of interest is to find out how efficient the examined contract types are, how could they be improved, under what circumstances are they the most appropriate and what their main benefits and limits are.
The final conclusions are based on two main sources. The first is the literature review, which summarizes the most common traits and facts about the main delivery methods. The second part is a quality based research, analysing three projects supported by open-ended interviews with various project participants. The final conclusions are based on the evaluation of the gathered information altogether.

Abbreviations

BIM - Building Information Modelling
BOT - Build-Operate-Transfer (project delivery method)
DAX - Deutscher Aktienindex (German stock index)
DB - Design-Build (project delivery method)
DBB - Design-Bid-Build (project delivery method)
DIN - Deutsches Institut für Normung (German Institute for Standardization)
CFO - Chief Financial Officer
CM - Construction management
CMA - Construction Management agency
CMAR - Construction Manager at Risk
CR - Clean Room
CT - Core Team
CUB - Central Utility Building
EPC - Engineering Procurement Construction
EPCM - Engineering Procurement and Construction Management
EU - European Union
FAB - Fabrication Plant
FEED - Front-End Engineering and Design
FIDIC - Federation Internationale Des Ingenieurs-Conseils (International Federation of Consulting Engineers)
GM - General Contractor
GMP - Guaranteed Maximum Price
GMPM - Guaranteed Maximum Price Model
HQ - Headquarters
IPD - Integrated Project Delivery (project delivery method)
IPDM - Integrated Project Design and Management
IT - Information Technology
ITB - Instructions to Bidders
Mio - Million
PL - Project Leader
PM - Project Management
QA/QC - Quality Assurance and Quality Control
RFE - Ready for Equipment
RFP - Request for Proposals
RFQ - Request for Quotation
TM - Traditional Model
USA - United States of America
WP - Work Package

Contents

Chapter 1

Point of Departure

1.1 Statement of the Problem

Infineon is one of the economically most important companies in Germany (it is part of the DAX index), one of the biggest semiconductor manufacturers EU-wide and it is the market leader in many of its areas of interest: Automotive, Industrial Power Control, Power Management & Multimarket and Chip Card & Security. As soon as the whole company was made in 1999, when it spun off from the Parent Company Siemens, it started growing immediately. This rapid growth is supported with constant investments all around the world, for its manufacturing, development, and controlling divisions. The new buildings had to be built in different countries (for example: Austria, Germany, Malaysia, China and so on), in a different climate for different functions. It has to be mentioned as well, that these Projects are big investments (hundreds of millions of Euros) and that some of them (for example: manufacturing plants) have to be completed as fast as possible, because the typical product looses its value fast and Infineon's customers demand strict deadlines. Therefore, it is crucial to choose the perfect type of contract for a project. Another important factor for projects in the semiconductor industry, is the required infrastructure and technology. The production is not just complicated, as the product goes through many phases until it is ready, it also needs various materials in very pure forms. Therefore their efficient supplement and storage is also crucial. Furthermore, the technology is based on numerous extremely expensive equipment. As their total cost is even higher, than the cost of the whole building, it is essential not to have any of the equipment idle for longer than necessary, as it will appear as an instant loss (non producing investment). On the other hand, the costs have to be kept under control, over securing the production makes it un-financeable. The balance of costs, time, quality (and certainty) has to stay at an acceptable level.

1.2 Objectives and Aims

The main purpose of this study, is to analyse Infineon's current delivery methods, to acquire a detailed but short overview, for further adjustments and improvements. The answer should be found through the following research, based on the collected information and a comparative case study of three projects.
The first source of information is the literature review, that summarizes the most important factors of the main delivery methods. The mentioned advantages and disadvantages are tested during the research using the case studies.
The second source of information is based on three projects. The project conditions are completely different: There are areas in the buildings for production with extreme requirements, for research and development purposes and there are office areas as well. The first case is in Asia while the other two were delivered in Europe. The project analysis is supported with open ended interviews with various project participants, asking for their personal experience and own thoughts about the projects.
The positive and negative factors mentioned by the respondents are compared to each other and to the literature review, providing the outcome of the study. The conclusions offer support for the choice of contract types and suggest possible improvements to the existing models. Therefore the main goal is not to find a new theory, but to provide useful information for typical construction projects for semiconductor industry, furthermore to offer possible improvements for them, either generally applicable changes or adjustments for special areas, utilizing the existing experience from the completed projects.

Chapter 2

Methodology

The methodology employed in this study is based on a literature review, case studies and a longitudinal case analysis. The literature review provides a summary of important factors, advantages, disadvantages, that can be used later for further comparisons.
The second part consists of case analyses (described in detail later in section 2.1), from the three cases provided by Infineon. The last part is a longitudinal case analysis, to create a more overall applicable theory. This is supported with further data collected from the open ended interviews (details in section 2.2) with various project participants. Therefore the end result should to provide conclusions built upon all the informations collected during the study.

2.1 Theory building from cases

According to Eisenhardt and Graebner (2007), this case building method is based on a qualitative research, taking advantage of rich empirical data. This approach "relies on continuous comparison of data and theory beginning with data collection", suggests Eisenhardt (1989). The iteration of data and theory should continue to a point, where further iteration provides no significant improvement to the research.
Another key factor is the number of cases used during the process. There is a difference between using only one case to make conclusions and using multiple cases as the basis. The cases are often chosen purposely, on the basis of having a higher potential for better result. Adding extra cases is efficient and reasonable as long, as there is not enough information, however there are projects (as this study), where the cases are preliminarily appointed. This study is a multiple case study, using three projects, provided by Infineon. First the projects are used as simple experiments, than at the end the three cases are analysed together. Therefore the method has to handle the conflicting conclusions, leaving a shorter and more solid final theory. Even a few additional cases can significantly improve the quality, compared to a single case theory. According to Eisenhardt (1989) an ideal number of cases is between four and ten, as four cases already provide a theory with sufficient complexity, and ten is not too many, to make the volume of data too difficult to handle.

Analysis

The basis of any research, is the collected data. As the project course is an iteration between data and literature and as the research target is not defined precisely in the beginning, it is vital to write down every information, even if it does not seem important, because it may still turn out to be significant. The second equally crucial step is the analysis. It is not just important, having significant impact on the work, but it is difficult as well. First of all, there is no detailed process-flow to follow, there are almost as many ways as authors. Only overall similarities can be found between different studies. Therefore it is hardly possible to understand what circumstances and ideas turned the vast amount of information into the end conclusions.

Nevertheless there are some key features that are often used.

Literature Review

A key point in delivering a successful theory, is supporting it with sufficient amount of literature. This, and the open ended interviews are the backbones of this study. A wide range of information has to be collected, examined and stored, as theories both conflicting with the emerging theory, both literature supporting it are necessary. Both of them have to be compared to the main subject. Conflicting theories provide a more creative work, with more interesting results and it also has a positive effect on the generalization of the theory.

Case analysis

The next important step is the case analysis. One drawback of the huge amount of information, is the difficulty to handle it. To have a better overview of the cases, and to split the staggering amount of data into smaller more manageable portions, the cases are analysed separately. This shows case specific factors, before creating the general conclusions. The cases have to be well detailed to enable easier comparison. There are numerous methods for this, such as: creating transcripts, using tabular displays or graphs of informations and many more, *"In fact, there are probably as many approaches as researchers"* - Eisenhardt (1989).

Parallel to the sub-case analysis, there is the cross-case analysis, where all the cases are examined together to find any interesting connections or similarities. As this requires all the information about all of the cases, it has to be simplified and it has to be analysed from various viewpoints. The following three methods, are suggested by Eisenhardt (1989): The first method to make the data manageable, is by separating the big group of cases, into smaller groups, depending on case dimensions, or other categories. Thereafter the categorised groups and the whole group has to be analysed.

Another way to handle the rich information source, is based on the analysis of case pairs. The similarities and differences have to be collected. Looking for similarities in differing cases, or looking for similarities in differing cases can lead to better results and it can make the research more interesting. The third possibility to handle data, is to divide it by data source.

Strengths

Combining archives, interviews, questionnaires and observations is a huge amount of information to handle, but on the other hand it can be seen as an advantage, such as the capability to use the method for various tasks, like providing description and testing- or generating theory. The use of personal experience and opinions, that is proven to be overly useful in generating a theory, was even successful in providing conclusions objectively.
An other further strength is the ability to apply creativity to the process with analysing confronting evidence, motivating the author to find unknown connections. As the theory is emerging from real life cases, it is probably empirically valid. The basis of the research, is the process itself, where the patterns have to be found. Therefore after a successful analysis, it result in a theory, that closely mirrors the reality.

Limitations

However promising this method might be, it also has difficulties and problems to avoid. Using data from a case might result in a detailed description of the project instead of generating a testable theory. Without a preliminary defined aim, it is likely to become overwhelmed by the vast amount of information. For example it may lead to an overly complicated theory. Although it is equally important to acknowledge, that this early identification of the research focus is still tentative, as the construct, it's definition, and measurement are regularly determined during the analysis, not beforehand. The tremendous amount of data has to be handled carefully. The result can lack overall perspective, therefore the author should pay attention to highlight only the most important details, to offer the reader a satisfyingly general theory. Unfortunately at the end, the final product may show no clear patterns, or it may just replicate a preliminary theory.

2.2 Open-ended interview

Open-ended interview is an information collecting technique for qualitative empirical research. The aim of this method is to gather special knowledge about the subject, in this case, about the three projects. The special knowledge is simply details the interviewees share with the questioner, such as their own thoughts, suggestions, opinions or simply the facts, that are hard to find otherwise. Therefore the people taking part in the survey, as well took part in the projects, preferably in different divisions, for different project participants (for example: contact persons from design team, project management team and so on). It is important in order to have multiple opinions and to be able to examine any factor from various viewpoints for a more general understanding.
Therefore the questioner concentrates on collecting personal thoughts, motivating the interviewees to express their own thoughts. Regarding to Glaeser and Laudel (2010), by asking open ended question, minimizing any external effect on the answers, is an efficient way to do this.

Chapter 3

State of the Art Literature Review

In this chapter, the basic aspects of the project delivery systems will be highlighted, in order to make the upcoming cases easier to understand.
According to the literature, there are numerous project delivery methods, for example: Design- Build (and Design-Build-Operate-Maintain), Design-Bid-Build, Construction Management at Risk, Integrated Project Delivery and Build-Operate-Transfer. Any of these, or their variation can be the best way to deliver a project, it only depends on the factors the owner finds important, such as cost certainty, time, responsibilities, risk management and so on.

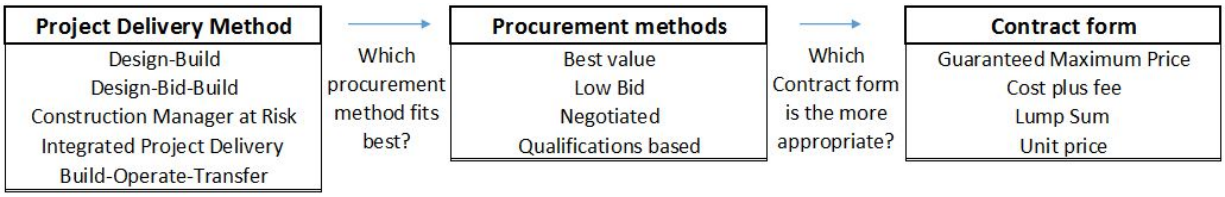


Figure 3.1: Project flow

3.1 Design-Build (DB)

Mahdi and Alreshaid (2005) states, that DB has gained popularity in recent years in both the private and public sectors . This can be explained with the change in quality investors are looking for.
In DB projects, the owner is usually responsible for about 5- 30% of the preliminary design, before the DB entity takes over the whole project development. The owner develops a detailed request for quotation (RFQ), request for proposals (RFP) to make the selection process more efficient. These describe the essential project requirements in performance terms and are used to shortlist the interested bidders. Instructions to

bidders (ITB) than gives a guideline to the DB team how to develop their proposals. Important for a smooth project flow, that the owner must recognize the effort and completeness, that is essential for the preliminary design, and that it contains all the necessary information to form the basis of the contract with the DB contractor. As the preliminary design happens at an early stage, and the owner might not have own design teams, additional consultant's experience is necessary to develop it successfully.

With the established preliminary design, a contractor has to be selected. There are two possibilities: one-step process and the two-step process. The first is a method based on best value to the owner agency, where the best value is defined with the combination of technical merit and price. The two-step process, on the other hand separates the technical proposal from the price. In this case the RFQ makes sense.

There are three possible types of DB entities: Contractor led (subcontract design or joint venture), Designer led (subcontract construction, or joint venture) or a single firm with both capabilities internally.

Regardless of type, the designer is part of the builder's team, rather than being under direct contract with the owner. This makes the construction management (CM) an important party for the owner, as it will act as the owner's representative, assisting with the development of the owner's project requirements and providing the necessary technical know-how. It is most efficient when the CM's role begins early in the project, to be able to guide and assist the owner through all phases of the project delivery. All in all, the CM is particularly critical if the owner does not have experience with the DB delivery method.

Summarizing the most important factors, the owner can count on the following factors, if he chooses this method (complemented by Touran et al. (2009), and SAIC et al. (2006)):

Advantages:

- Performs well with cost restrictions, fewer cost overruns
- Provides fix price earlier than other methods
- Continuous execution of design and construction and overlapping phases are possible which is ideal for fast tracked projects
- Risk for errors and omissions in the plans, are contractor risks.
- Having the single point of responsibility for design and construction decreases the potential for conflict as well between the engineer and constructor and between the design team and the constructor team.

Disadvantages:

- Owner's loss of control over design (and possibly lack of design and construction checkpoints) might cause shortcomings in the quality of design or construction
- Initial scope has to be well defined otherwise it can lead to increase in costs
- If total risk is on the contractor, it can drastically increase the insurance costs (owner should assume what risk to bear and what risks should be allocated to the contractor)
- Size of the bid package and the bid preparation costs may reduce the number of qualified bidders
- The contractor has a motive to decrease the initial costs of the project (might have a negative effect on life-cycle costs)
- Early pricing might leave the owner vulnerable to claims for scope that was missing in the RFP.
- When a lump sum pricing is used, contractor assumes some risk in pricing because of the lack of appropriate design at pricing stage
- Fewer but more experienced staff is needed on the owner's side
- May be inappropriate if the owner is looking for an unusual or iconic design

Extending the DB method, there is the Design-Build-Operate-Maintain method, taking the operation tasks as well, after the building is ready. It is an efficient method, when the client wants to keep all the responsibilities and guarantees in one hand.

3.2 Design-Bid-Build (DBB)

Another widely used project delivery method is the DBB system. It is the most common project delivery method and AIA and AGCA (2011) refer to it as the traditional option. For most of the 20th century, public works were almost certainly built using this method, as this was supposed to protect taxpayer investments. In the first phase the designer provides the required documents, for example constructional drawings and specification. Once it is complete, the bid package is made available to the interested contractors to prepare and submit their proposals. The selection depends on the owner, for example technical merit or costs can be the decisive factors. The chosen company, the contractor, will be than responsible for constructing the project. In the construction phase, the designer usually maintains limited oversight on the project, on behalf of the contractor.

It has to be mentioned that this might not be the cheapest method to deliver the project, but it is the lowest cost associated with the design documents prepared prior to the construction phase, according to Mahdi and Alreshaid (2005). In this case, there are

three main parties: owner, designer and builder, which results in an additional selection phase compared to DB. As the design and construction is completely separated from each other, and therefore the two entities have different contracts with the owner, the DBB method provides an additional system of checks and balances.

CMAA (2012) mentions an important variation of DBB: multiple–prime contracting. In this system, the construction works are separated into smaller parts, and they are separately contracted, therefore the owner or it's construction management has to take the responsibility to manage the overall schedule and budget. As these work packages are bid separately, and awarding construction contracts is already possible during the design phase (as the plans for the smaller parts are ready),it is possible with this method to deliver fast track projects as well.

Figure 3.2: DBB Participants during project from AmWins

Furthermore, the owner has increasing control over the project schedule, since setting the timeline stays in his or her hand. It has to be mentioned that the positive effects have got a price. This method needs increased coordination as there is no general contractor to oversee and manage the activities of various trades. The construction management has to manage this task, as the owner's representative. Additionally the procurement method causes the project price to be unknown, until the final prime contract is procured.

Summarizing this method, the following advantages and disadvantages can be found. (From the following sources: Touran et al. (2009), CMAA (2012),)

Advantages:

- Checks and balances provided by separate contracts
- Clearly defined roles, well understood, widely applicable (very common)
- Owner has significant control over the end product
- Method help the owner to divide risks between the designer and constructor

- Costs are certain, because of detailed design (however the opposite can happen as well, because of large number of claims and change orders)
- Competitive (market competition might get a low bid)

Disadvantages:

- Longer duration compared to other delivery methods
- Schedule growth tend to be bigger (compared to other methods)
- Hardly any schedule compression
- Designer has limited ability to assess scheduling and cost ramifications (more expensive project)
- More adversarial relationship rather than cooperation between project participants
- The absence of construction input might limit the effectiveness and constructibility of the design.
- Claims and disputes between project participants (owner, designer, constructor)

3.3 Project delivery with Construction Management

Preussl (2013) suggests a project delivery, based on the use of construction management (CM) can be distinguished from the other delivery methods. The project starts with the design phase, where the construction manager already joins the process in which definitive input and assistance has a positive effect on efficiency of the design process. This is extremely important for projects with limited time available. The construction management will provide the necessary feedback for the design phase and than it will either deliver the project itself (at Risk), or just provide support to the client(agency) without any contractual obligations to time or cost.

Construction Manager Agency (CMA)

In this case, the CM provides professional services as project manager. The subcontractors and designers are directly contracted to the client, not to the CM, therefore it does not deliver any construction work itself. As the CM is not responsible for time or costs, the risks and the profits belong to the client. AIA Minnesota suggests, that the CM agent can provide early cost estimation, scheduling and assistance throughout the phases to the owner. It is beneficial for large, complex projects.

The main Advantages of CMA are the following (according to AIA Minnesota):

- Next to the architect, the owner has an extra agent with construction expertise, to supervise the project (reducing the owner's management tasks)
- CMA's scheduling and capabilities may be beneficial for fast track projects
- CMA's cost estimation and construction expertise at design phase assists in monitoring construction costs

Disadvantages:

- CMA is extra cost
- Owner is at risk for final costs
- Multiple prime contracts increase the potential for disputes for the owner

Figure 3.3: CMA Participants during project from AmWins

3.3.1 Construction Manager at Risk (CMAR)

Another delivery method, similar in many ways to the DBB system, is the Construction Manager at Risk. *"CM at Risk is also called CM\|GC, as the construction entity becomes the general contractor through the at-risk agreement"* - AIA and AGCA (2011).
After the design phase, the construction manager signs the contract for providing construction services to deliver the already sufficiently detailed design (in many cases 60% of the design is ready, however occasionally 80-90% is required for a decent cost estimate for the contract). At this point, the construction manager acts as the general contractor and takes the responsibilities for construction performance and guarantees the completion of the project in time, for a negotiated price. Important for this delivery method is that the role of the construction management differs from it's role in a DBB delivery in one major aspect: *"may not be the primary provider of construction expertise and advice to the project team during the pre-construction phases once the construction management firm*

is engaged by the owner, and as such may not be called upon to perform as many tasks" - CMAA (2012). Tasks remaining with the construction management include verification of schedule, cost tracking, quality control, contract administration and coordination with all owner stakeholders.
Another important feature is that contract with the constructor is signed during the design phase, which enables the project to begin prior to completion of the design. In this case, the contractor and the owner often negotiate a guaranteed maximum price contract (3.7.1).

Figure 3.4: CMAR Participants during project from AmWins

To give a short overview of this method, the following advantages and disadvantages can be determined for this system:

Advantages:

- Ideal for fast track projects, start of construction prior to completion of design (overlapping activities)
- Constructor input on design (alternate design systems before commitment to a specific design)
- More expensive (Agency cheaper, at Risk more expensive because of different risk allocation)
- High Project transparency through "open book"
- Early cost commitment gives the owner project cost certainty

Disadvantages:

- The construction management is an extra cost (best value) and Risks assumed by the contractor increases the price as well
- Still two contracts to manage
- Adversarial relations between designer and contractor (owner between them)
- Negotiating an early price may be difficult because some subcontractors may be reluctant to give their prices without a complete design

3.4 Integrated Project Delivery (IPD)

The forth important delivery system is the IPD method. This method is the most modern system but unfortunately it is not common. According to NASFA et al. (2010), many clients in past years have not been completely satisfied with the traditional methods, because of the lack of cooperation, and that they are full of conflicts (conflicting interests for example). The main idea and the focus of this method is to concentrate on incentive collaboration, and to use the benefits of new technologies available. This sounds promising, however it has to be mentioned, that it needs change in the approach of the participants (designer, constructor companies) delivering projects and it needs time to be adopted. In this system, for each of the partners the main goal is to deliver the project as one entity, not only to perform their own parts. Understanding that their main purpose is the same, that there are no adversaries and that they have to communicate and exchange information is crucial. In an ideal IPD system, all of the participants are on the same level and they work as one team together.

IPD defines three main levels, according to the amount of collaboration they imply. Level 1, and 2 use IDP as a philosophy, as they mainly function with traditional delivery methods, however with some minor changes. The third level, with the most collaboration, is the real integrated project delivery. The owner, designer and the constructor all sign one contract. Apart from the contract, there are other key differences between level two and three. Level three projects elevate project relationships by making responsibilities, contractual obligations and risks to be managed by the core group, as it is in the best interest of the project (instead of being shifted to another party).

	Level One "Typical" Collaboration	Level Two "Enhanced" Collaboration	Level Three "Required" Collaboration
Level of Collaboration	lower ⟷ higher		
Philosophy or delivery method?	IPD as a Philosophy	IPD as a Philosophy	IPD as a Delivery Method
Also known as...	N/A	IPD-ish; IPD Lite; Non Multi-party IPD; Technology Enhanced Collaboration; Hybrid IPD; Integrated Practice	Multi-Party Contracting; "Pure" IPD; Relational Contracting; Alliancing; Lean Project Delivery System™
Delivery Approaches	CM at-Risk or Design-Build	CM at-Risk or Design-Build	Integrated Project Delivery

Figure 3.5: Integrated Project Delivery - Levels, from NASFA et al. (2010)

There are three important groups of factors that lists fundamental principles for IPD. Furthermore any other project delivery method can be improved by implementing any of them:

Contractual principles:

- Key participants bound together as equals
- Collaborative decision making and the participants agree not to sue each other
- Shared risks and rewards
- Fiscal transparency between key participants
- Early involvement of key participants
- Intensified design (to avoid changes during construction phase)
- Jointly developed project criteria

Behavioural principles:

- Mutual respect and trust
- Willingness to collaborate
- Open communication

Catalysts:

- Multi-party agreement (one contract between all the key participants)
- Building Information Modelling (enhance collaboration, sharing of information)
- Co-location of team (collaboration and innovation)

However attractive this method seems to be, there are risks to be mentioned. First, it is a relatively new system, which needs further refinements, and there are only a few projects completed which to look for guidance. Another problem is, that it requires significant and mutual trust between the parties, and it might be difficult to change the old ways of thinking in order to make the right decisions. It is almost impossible to apply this method for companies that have never worked together yet. Most IPD projects do not require guaranteed maximum price as well, however the owner might not want to give it up. Without the perfect participants it is difficult to give up the control and command provided by the traditional methods.

Therefore IPD is not ideal for all projects and for all participants. It is hard to measure the possible extra risks and the benefits of this project, to be able to decide if it is the perfect choice or not. Applying many of its features to other methods however is also possible (models can be improved until a point, where the client finds it most satisfying)

3.5 Build-Operate-Transfer (BOT)

BOT is a very unique delivery method. This delivery method was first coined by ex-prime minister of Turkey, Turgut Ozal in 1984, however as a delivery method it was already used about a hundred years earlier for the Suez Canal. It is a form of project financing, wherein the private entity receives a concession from the private or public sector to finance, design, construct and operate a facility. There are some other forms worth mentioning: Build-operate-own, Build-operate-own-maintain, Build-operate-own-transfer, but this literature review summarizes only BOT and it's most important factors.

This system is mostly used for infrastructure projects. The main idea is that the private sector finances the project and their investment is refunded (for example in a form of a user fee) with some profit during the concession period. Because of this, the most important feature of this method is, that the owner's (normally government) budget does not have to manage the burden of financing the project, instead the users pay for the infrastructure. (For example: fees for the tunnel along A10 Highway in Austria)

In a BOT project, there are a number of major participants (mentioned by BOT, Llanto (2008)) with different functions and different amounts of risks taken. Usually the major parties are the following:

I. Principal

It is mostly a government department or statutory authority, with the responsibility to grant the sponsor the concession (the right to make a BOT project), to make the use of the building site possible (to lease it or to sell it) and often to acquire the service provided by the facility.

II. Concessionaire

It is the party, usually a consortium of interested groups which, in response to the invitation by the government prepares their proposal for the project (construct, operate, finance).
The concessionaire can be a company, partnership, unit trust, limited partnership, unincorporated joint venture or any combination of them.
The property rights of the facility belongs to the concessionaire during a specified concession period wherein the investors\owners try to recover their investments and earn some extra profit.

III. Investor

The participants providing the necessary financing are the investors. It includes the shareholders (infuse money in exchange for equity) and lenders (provide credit financing,

often commercial banks, insurance companies). There are two categories of equity providers: with direct interest in the operation (such as contractors, operators), or those that are solely involved as equity investors (such as public shareholders).

IV. Construction contractor

The construction company can be one of the sponsors. The contractor bears the risk of completing the project on time within budget to the appropriate specifications. It is important for the project, that the construction company has the sufficient strength and size, with adequate capital to guarantee the completion of the facility.

V. Operator

As the construction is finished, the operator starts to manage the operation of the facility. This method is very different from the other systems mention in this study, as BOT projects are usually long term projects (minimum 10-15 year) as the concession needs time to finance itself.

3.6 Engineering Procurement and Construction Management (EPCM) & Engineering Procurement and Construction (EPC)

This two methods are suggested to be special variations of the DB method, however there are certain qualities that help to distinguish them from any other methods. Usually these projects can be divided into two main parts.
They start by setting the design parameters to define the work scope and by breaking the work down into WPs for budgeting and planning purposes, in order to enable efficient tendering (most important source for this section is Loots and Henchie (2007)). This is often referred to as Front-End Engineering and Design (FEED). This conceptual design often contains basic engineering and design, project schedule, cost estimates and sometimes procurement of certain equipment. The FEED can be produced by specialist engineering firms (see in 4.1) or by the EPC contractor (if they have the necessary in house capability, for example in 4.3).

For the second part: Project implementation, there are four ways if the project is not cancelled.
1. If the FEED contractor is capable and willing to develop the concept into a detailed design and to build the project, the owner may seek to continue the FEED contract on the existing or similar terms and conditions and deliver the project a reed tender rates.

2. At the end of the preliminary design phase, the owner may wish the FEED contractor to deliver the project in the form of a lump sum EPC project. At the end of the conceptual design phase, the FEED contractor may be in pole position, as there might be no other EPC contractor avaliable, capable, or willing to develop the design and build the facility. Therefore, to avoid extra costs, the option of converting the FEED contract into a lump sum turnkey contract should be built into the FEED contract.
3. The owner might appoint the FEED contractor to assist the owner to manage and procure a third party EPC contractor to develop the detailed design from the FEED and to build the project.
4. The forth choice is an EPCM project. The owner appoints the FEED contractor, to deliver the detailed design and than to manage the procurement and construction of the work, on the owner's behalf.

3.6.1 Engineering Procurement Construction (EPC)

EPC project is also called turnkey project, as the client just has to turn the key, and the facility is running. This method is basically a special form of the DB method (in section 3.1). The specific features which helps to distinguish it from the other methods, making this system perfect for certain projects, are according to Haskell the following: single point of responsibility, design and construction in one hand and that the contractor takes the risks for costs, schedule and performance.

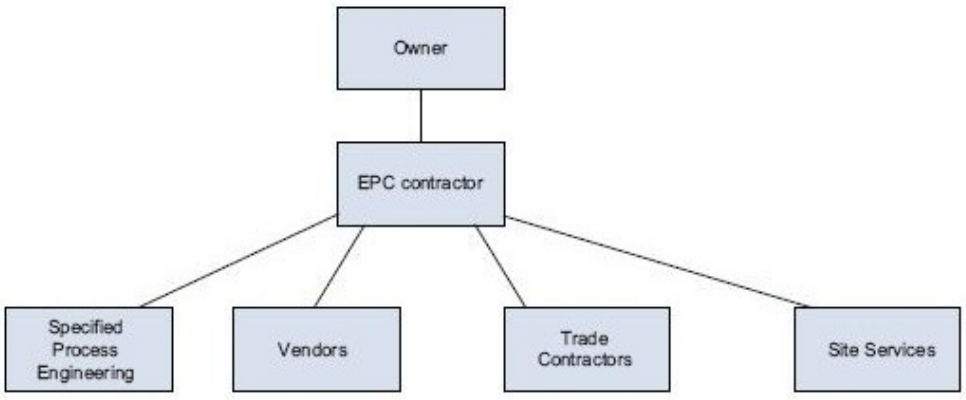


Figure 3.6: Typical EPC Arrangement from Loots and Henchie (2007)

This method has several key features (from DLAPiper (2012)). First of all, there is a single point of responsibility for the project. The general contractor is responsible for the project from detailed design to finish. The second key property is a fixed contract price. This is usually a GMP (more detailed in section 3.7.1) or a lump sum contract, in both cases there is a maximal budget for the project. It can also be an incentive to the contractor, as

the cost savings can be shared. The third key feature is the fixed completion date, because EPC projects are often fast track projects. This date is given in the contract and it is known from the very beginning (the general contractor signs the contract for delivering the project in time). This is a strict condition, if the delivery is late, the contractor has to face the consequences (penalty). As the contract, the price and the time is based on the conceptual design, it has to be prepared well.

3.6.2 Engineering Procurement Construction Management (EPCM)

This contract form also has similarities with some of the previous methods. It has the single point of responsibility of the DB system, but in the construction phase, the general contractor takes no responsibilities for time or costs, furthermore it only provides management services.

The similarities and differences with EPC are the following: They are the same in the first few steps, they are both responsible for the detailed design (”E” Engineering), according to a preliminary design. The contractor is also providing Procurement (”P”) services to the client. It *"will advise on the timing of the letting of the relevant packages and will advise the employer on the terms available and will typically negotiate the contract packages on the employer's behalf"* - NortonRoseFulbright).

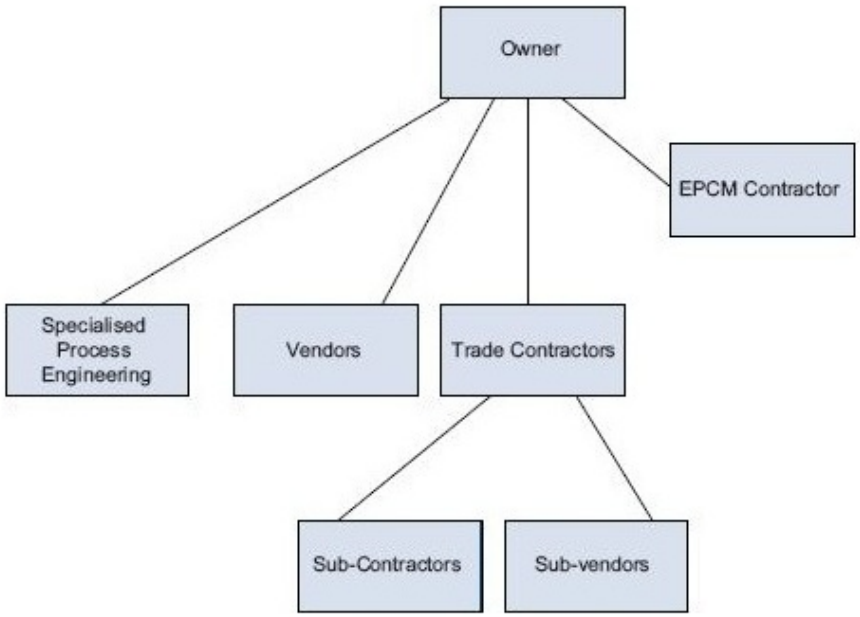


Figure 3.7: Typical EPCM Arrangement - Loots and Henchie (2007))

In the construction phase the contractor takes the responsibility for overall management ("CM" Construction management). NortonRoseFulbright suggests, that the main difference between EPC and EPCM is found in the construction phase and in risk allocation. The EPCM contractor acts as the owner's agent and creates direct contractual relationships between the owner, the suppliers and the trade contractors. Important that each trade contract is a contract directly between the owner and the trade contractors. This can result in lower costs, but require bigger and more experienced staff from the owner.
The EPCM contractor is not a party to any dispute which arises between the trade contractors and the owner (however it can assist the owner), it does not take responsibilities (not with costs or time).

3.6.3 EPC\EPCM

EPC and EPCM are very similar to each other. The first difference is that EPC has a standard form of contract, meanwhile EPCM does not and furthermore it is not so well known in the building industry. The second more technical difference is that EPCM is a professional services contract, with an almost opposite risk allocation as EPC has. An important feature is that the project is constructed by other parties, not by the EPCM contractor.
As every construction project is a prototype, the methods have to be adjusted to accordingly, therefore there are cases where the delivery method is not EPC, nor EPCM, but something between them. An interesting example would be a project, which is on behalf of risk allocation, is an EPC project, but the construction is delivered by the construction management directly contracting all the subcontractors itself, therefore taking the responsibilities of an EPC contractor as a construction management.

EPC	EPCM
Existing standard form of contract	no standard
Single point of responsibility	Responsibility depends on risk allocation
Certainty in respect of time and cost	no guarantee from GC
Expensive (Contractor assumes too much risk)	lower costs (but client bears more risk)
If the owner orderes variations, they are expensive and can delay completion (crutial to have a complete scope)	Changes are negotiable and tend to be reasonable

Figure 3.8: EPC\EPCM differences

3.7 Special contract forms

3.7.1 Guaranteed Maximum Price (GMP)

On one hand GMP is simply a contract form, on the other hand it is sometimes considered a partly separate delivery method, as it has many unique features.
First of all, there is no universally accepted definition of GMP, there are various expressions used in the contract, such as: "price cap", "no upward price adjustment", price cannot be exceeded", "fixed price guaranteed", therefore it is more accurate to view the GMP as:
"The intention of the Guaranteed Maximum Price Contract is to provide a lump sum contract under which there will be no adjustment of the tender price unless the scope required by the client changes." - Gander and Hemsley (1997))
(Therefore it is important to understand the true meaning of Guaranteed: It is a maximal price with some reserves, which is not to be exceeded. The amount of reserves is often high, as the contractor has to guard itself from over-expenditures, as it is his very own risk (it has to be negotiated, therefore a good team on the client's side can achieve significantly lower cost cap). Above all, if the scope changes the guaranteed price might get higher. To sum it up: the real cost is often lower than the contract price, but can even go higher if there is a change in the scope (often happens, as it is extremely hard to define everything required in the conceptual design). In the authors opinion "Guaranteed" is a word that does not precisely describe this system. It is a word with a strong meaning suggesting a more fix price. Estimated- or Target-cost would fit better.)

The key of GMP is to set an agreed ceiling price for the project in the main contract to guarantee the completion of the project within the contract period with an early start before the design is fully developed. This conceptual design is than the basis for the contract, the price and the time, therefore it has to define the requirements precisely, possibly making any scope changes unnecessary. A not clearly defined scope not only upsets the GMP, but causes disputes between the parties involved. The guaranteed price set in the beginning usually changes during the project (as the scope changes), making the "guaranteed" part often changeable.
Risk management is also a key point, because it is usual to transfer the risks from the client to the contractor (however it increases the price (Risk premium)). These risks can include: unforeseen ground conditions, unexpected encounter with service mains, changes in legislations, bad weather, insolvency of suppliers and subcontractors, disasters (for example: Earthquake). As these are unforeseeable, and not easy to influence for the contractor, they might cause disputes when the client wants to transfer them fully. Risk sharing and transferring has to be well considered, as risks can be quantified and they easily increase the costs unnecessarily, if not handled well.
Other important features are the incentives. The contractor is rewarded for any savings made against the GMP, and penalized when the sum exceeds it (as it is supposedly caused by mismanagement). In the negotiation phase, the client and contractor agrees in a share

ratio for both of them. Normally the client receives a bigger part in both of them. Sharing the savings motivates the contractor to work cost efficiently, to innovate and to use value engineering techniques.

Applying IPD, even if it is only the first level, can adjust many disadvantages found in a normal GMP delivery. IPD as a philosophy has a significant positive effect on teamwork. For start, the "open book" provides the fiscal transparency, one of the key features of this method. For adaptation of further qualities it is crucial for the project participants to change the traditional delivery method's way of thinking. The most important is, that the relation between them is no more adverse, rather than they work for the same goal, almost as one entity. If we assume it is true, and that it is an open book agreement, further adjustments can and should increase the efficiency (applying the principals of the IPD system). There is in this case a team made of the client, contractor and consultants solving problems together. The risks should be handled collectively, or at least the client should share some of the risks, keeping the risk premium possibly low and helping them to work as a team. Furthermore, a risk allowance sum might enable a more compact risk management strategy.

Collaboration Level 1/2 - Typical/Enhanced	
Common Contract Types	Case 1
Open-book, cost-plus with a Guaranteed Maximum Price (GMP); fixed fee	Guaranteed Maximum Price, Open book cost plus
Design: Qualifications Based Selection (QBS)	Conceptual Design: Qualification Based (the chosen companies work often together with Infineon).
Construction: QBS or Best Value	Design& Construction: Best Value from the qualified bidders.

Figure 3.9: Integrated Project Delivery, Level 1/2

To summarize it: rather than transferring the risks to the contractor, as it is in the basic GMP, the risks should be handled as problems to solve as a team and shared gain\shared pain system should support the project as motivation for more efficient (team-) work.

Open book contract

Open book GMP, or cost-plus GMP is typically the used contract type for Infineon's construction projects. The open book contract management focuses on value for money, not just lowest cost. At the beginning of a project, the contract sets the payments (how and after what the contractor is paid), than a fully transparent cost control allows the owner to have truly collaborative relationship with the GC. The most important features of the open-book contact is it's transparency and the flexibility. After the GC contract is signed and the parties have reached an agreement, the open-book provides flexibility to satisfy the semiconductor industry's frequent changes and the fact that the contract is signed with only a conceptual design at hand. It usually works most efficiently for cost plus contracts.

3.8 Summary of delivery methods

The following table gives a comparative overview about the discussed delivery methods of the study. It helps to find where the advantages and disadvantages can be found for each of the delivery methods discussed in the study. It has to be mentioned that there is more than one solution for almost every projects, and the choice of the method depends on the owner, and his or her personal experience. Furthermore the contracts are the results of the negotiations. They are never the same and the different interests influence the contracts, according to each of the participant's argumentation skills.

Summary of delivery methods		Design-Build	Design-Bid-Build	Construction Manager at Risk	Integrated Project Delivery	Build-Operate-Transfer	EPC	EPCM
Costs	Total	-	+	-	*	Concessions	+/-	-
	Certainty	+	+	0			+	-
Time		+	-	+		0	+	+
Quality		-	+	0		0	0	0
Risks	Investor	-	0	0	Shared Risks	0	+	-
	Contractors	+	+	0		+	-	+
Conflicts		+	-	+/-	++	+	0	-

++	Big Advantage
+	Advantage
-	Disadvantage
+/-	Advantage and Disadvantage as well
0	Nothing mentioned

* It depends on the chosen contract type, for example GMP. It is hard to determine the advantages and disadvantages, as it depends on the contractor and the quality of the collaboration. There should be effort to perform well, but there is risk that tha lack of control cause some problems

Figure 3.10: Tabular summary for delivery methods

Chapter 4

Case Studies

The comparative case study is based on three cases(projects), provided by Infineon. They were chosen prior to the study, as they are the most recently delivered projects. The cases are listed on the next page in figure 4.1.
As it was mentioned in the second chapter, each of the cases contains two kinds of information. First there is the data provided by Infineon's project representative, either as written documents or information verbally explained. This includes planning material, costs and other relevant information that are summarized in this chapter. For example the project story was always built up from the conversations rather than from written documents. The second source of data is formed from the open-ended interviews, from at least two participants for each project.

The study uses confidential information, such as costs and time and due to their importance, they can not be shown directly, therefore they will be presented in comparison to each other, appointing a baseline for each case.

The companies are not named as well. Every one of them is named Company X-n. "X" is a letter (A, B or C) and they identify a company within a project, while "n" stands for the number (1, 2 or 3) of the Case, where the current company is involved.

For the same purpose, the interviewees are named Person Cn-N, where "Cn" stands for C1, C2 or C3, representing the three cases, while "N" identifies the person within the Case.

Project name		Case 1	Case 2	Case 3
Project type		New Facility	New Facility	New hybrid building
Project type (extended)		Production, Laboratory, (Office cancelled)	Production, Laboratory, Office	Production, Laboratory, (Office cancelled)
Place		Asia	Europe	Europe
GFA (Gross Floor Area) (%)		100	25,2% of case 1	13,8 % of case 1
Contract	Design	Open book cost plus + GMP	Lump Sum	Open book cost plus
	Construction		Cost plus	
Investment (Mio€)		100% (33% of maximal cleanroom)	19% of case 1	17% of case 1
Conceptual Design		Conceptual Design made by the **Client's team** (Company B-1 and Company C-1, they are part of the PM team as well)	Conceptual design made by the **client** and **Company B-2**	Conceptual design made by the **general contractor** (Company A-3)
Design		Design made by the **general contractor** (Company A-1), support and guidance from the **Client's team** (Company B-1 and C-1)	Design made by the **overall designer** (Company A-2)	Design made by the **general contractor** (Company A-3)
Construction		**General contractor** (Company A-1), as Construction Manager at Risk, support and guidance from the **Cilent's team** (Company B-1 and C-1)	The **overall designer** of the design phase (Company A-2), as Construction Manager agency with Infineon	Construction delivered by the **general contractor** (Company A-3), as construction Manager at Risk, Associate contol made by an **external company** (Company B-3)

Figure 4.1: Cases (Case 1 is set as baseline. The other cases are represented in relation to Case 1)

4.1 Case 1

In Asia Infineon has numerous partner countries, where different production facilities manufacture the necessary items for the customers. This region is very popular between big companies for their investments, as the area offers lower costs and even with the high environmental standards, the governments have a proactive attitude towards investments providing a chance for faster development.

4.1.1 Project information

Project	Case 1
Place	Asia
Conceptual Design	Conceptual Design made by the **Client's team** (Company B-1 and Company C-1, they are part of the PM team as well)
Design	Part of the **general contractor** contract. (Company A-1)
Construction	**General contractor**, work packages had to be done by subcontractors (one sub does one package) (Company A-1)
GFA (Gross Floor Area)	100%

Figure 4.2: Case 1

The aim of the project was originally to build a new production facility and an office building, next to a fully operational facility. The size and the structure of the new factory (FAB 2) has similarities with the existing (FAB 1), with a different layout, as it supposed to be built upon the current technology. The project consists of three main buildings:

- FAB Building (Main production building, with CR, 4 storey)
- Central Utility Building (CUB) (Support Building for the FAB building, 2 storey)
- Office & administration Building (5 storey)

and further auxiliary items, such as:

- Fire and Process Water Tank
- Link/Utility Bridges
- Gas Yard (as many kinds of gases are needed to be stored for the production, in large quantities)
- Refuse Centre
- Motor Cycle and Bike shelter
- Bulk Chemical Building (Optional)

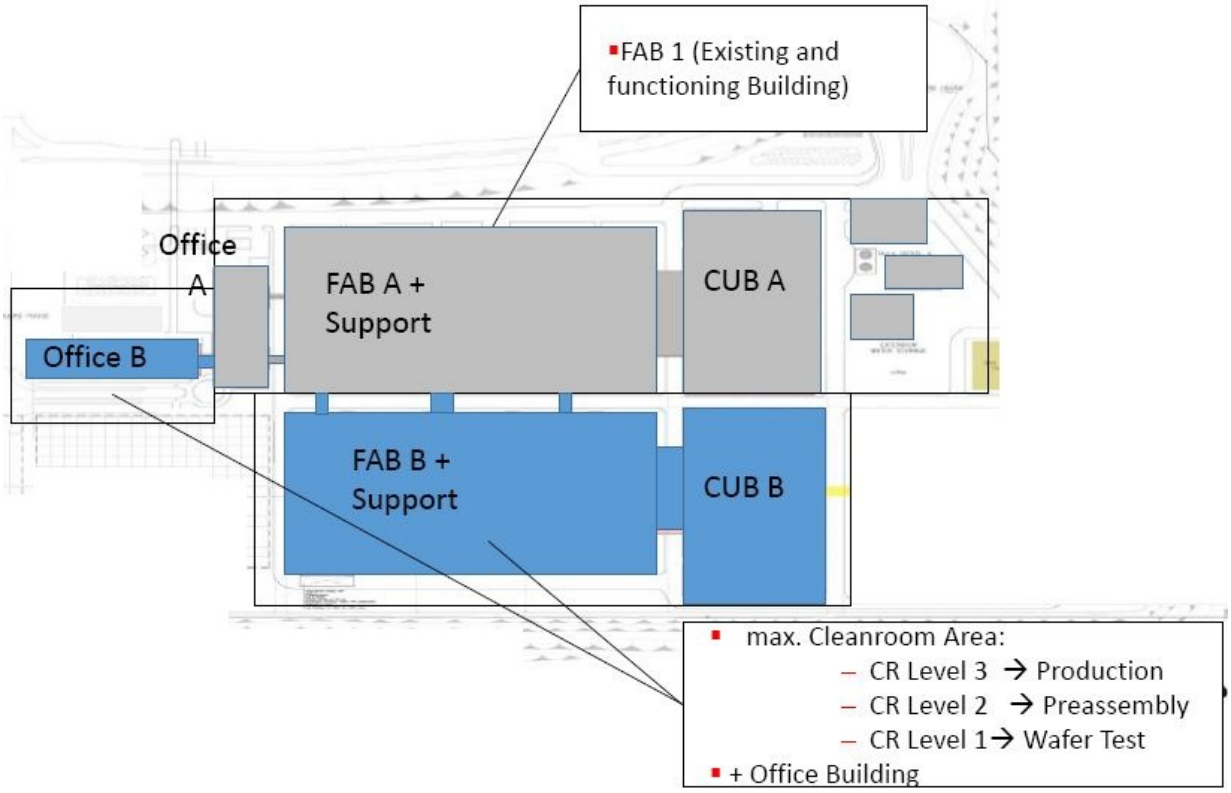


Figure 4.3: Case 1 - Overview

Semiconductor production is a very special and overly complicated part of the industry with immense financial support required. The high investment costs do not come only from the size of the building, or the maintenance costs but the extremely expensive equipment, which is usually worth more than the whole building itself. This means two things. First, the project delivery is supposed to set a point of time (RFE), already at the beginning of the project, for installing the equipment, in order to minimize the time of machinery staying idle. After this the production has to run continuously, nothing can interrupt or stop any of the equipments. This is a potential risk, as the new facility is not just right next to a running factory, but it will as well be connected to it, making the production more integrated.

The chosen delivery method for this project was Infineon's special system, developed by Siemens Industrial Building Consultants during the time Infineon was part of Siemens. This method is a special EPC method, where the general contractor delivers as a construction management at risk (more detailed in section 3.3.1). To decide whether it is an EPC or EPCM is not easy. The GC takes the role of construction manager ar risk, for the construction phase. On one hand, in the construction phase the GC is construction manager at risk and On the other hand, the risk allocation and the fact that the subcontractors sign their contracts with the GC instead of the client shows the most important factors of the EPC model.

Delivery Method: Integrated Project Design and Management (IPD&M) (Weltzer and Graebner (2001))

This is a special delivery model developed by Siemens for it's fast-track projects. The demand for a more efficient delivery method was formed, as the new semiconductor fabs are extremely complicated and they have to be built even faster. Traditional methods often fail, when the project contains high risks with regard to quality and cost.

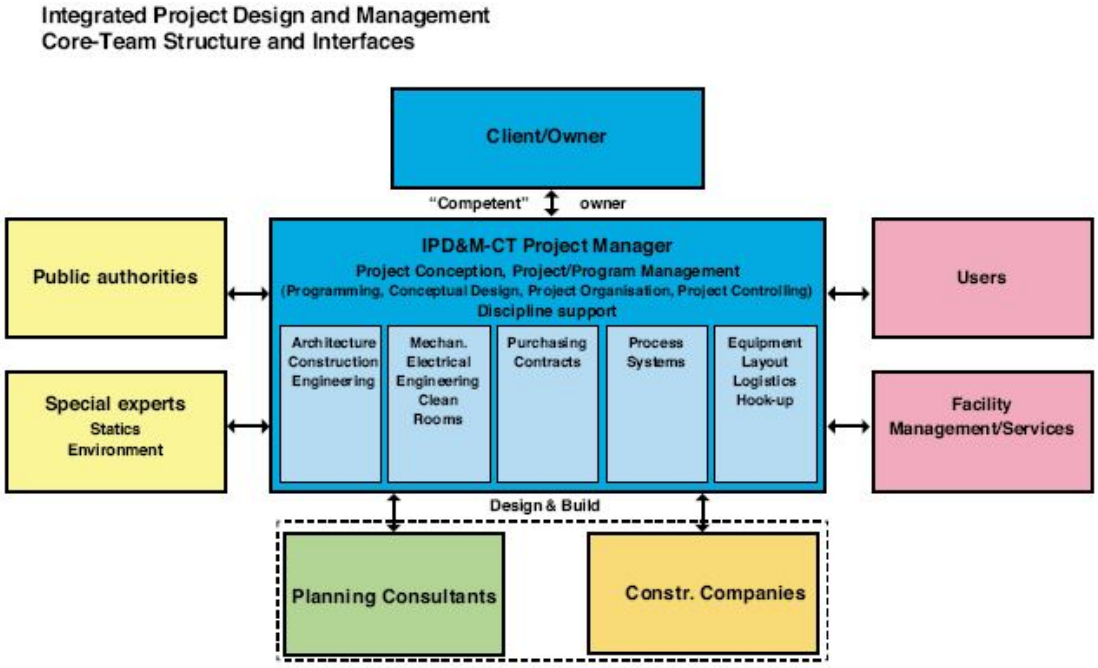


Figure 4.4: IPDM - Core Team (Weltzer and Graebner (2001))

First of all, a dedicated, highly experienced Core Team (CT) (it's structure shown in Figure 4.4 above) has to be formed. This team works on the project from the very start to the end. They are responsible for the conceptual design and afterwards, they guide the general contractor during the design and construction phase, as the client's representatives.

The first, from the three phases (shown in Figure 4.5), is the Project Programming. The special requirements demand a long and intensive workshop with the owner, user and representatives of all relevant technical disciplines (example shown in Figure 4.6) in order to set up a qualified program. The IPDM project manager leads the workshop with the CT's assistance. The key tasks contain: the understanding of purpose and goals, definition of project target, determination of relevant requirements, master plan, concepts, definition of the flexibility range, determination of all restricting elements, integration of the top management of all disciplines (Jointly invented), continuous visualization of the

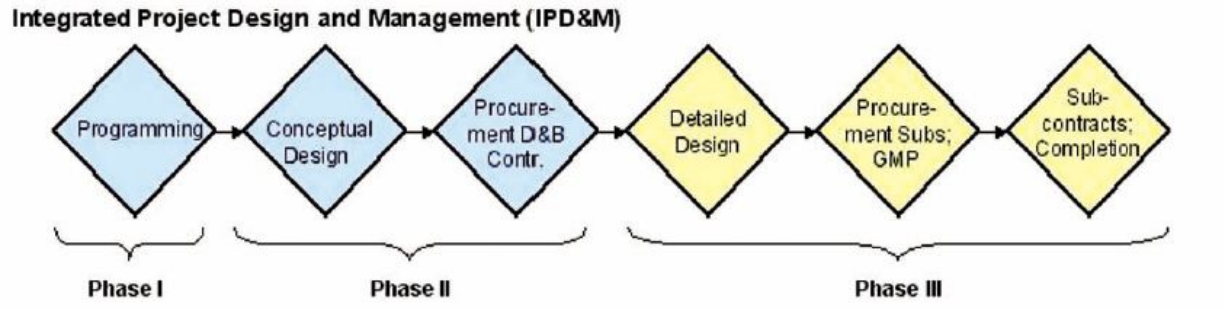


Figure 4.5: IPDM - Phases (Weltzer and Graebner (2001))

work results, Milestone time schedule and most important: a cost budget.

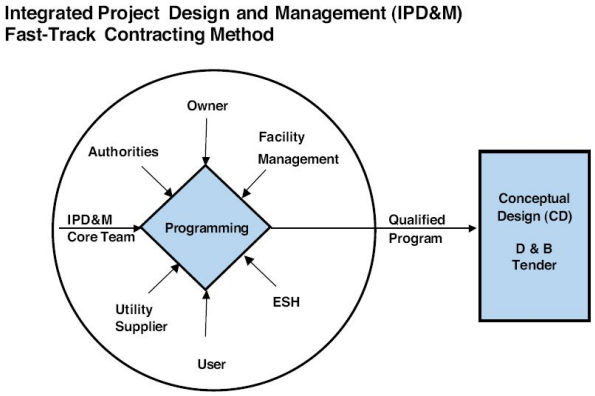


Figure 4.6: IPDM - Project Programming (Weltzer and Graebner (2001))

The second phase is the Conceptual design phase. After a successful project programming, the CT starts developing the conceptual design. It contains all the necessary information for building and infrastructure to select the contractor on competitive bids. Afterwards the budget is split up into single cost packages. The concept for each package consists of a detailed functional description, specifications and process diagrams for technical systems. Therefore the conceptual design represents a comprehensive description of the whole project and enables the general contractor to place a precise and solid RFP. The target cost structure is used during the competition phase for negotiation purposes and it is an excellent basis for fixing a GMP (using the advantages mentioned in 3.7.1). The second phase has the following key tasks: Supporting client in Defining further concepts, Development of an integrated design, Verification that the acceptance for approval is guaranteed (with authorities), Evaluation of the insurance requirements, Definition of standards, Definition of the cost budget(nomination of non included items), Preparation of a Milestone time schedule and Management of the general contractor with GMP tender.

The last phase is project controlling and coordination. After choosing the general

contractor, the CT slips into the role of project controller. The contractor than has to complete the detailed design according to the conceptual design and has to prepare the necessary documents for selecting the subcontractors. The CT, as it is the client's representative, approves the bidder's list and participates in all vendor meetings, which are led by the general contractor. The final vendor selection is a collective decision of the client, the CT and the general contractor. Another important cost criteria is a well-balanced ratio between invest and operational costs. The subcontractors are enabled to challenge the concepts and there is room to reduce the costs and to increase the project quality. For semiconductor projects it is a fact, that the contractors have to deal with frequent changes caused by revised tool layout or new manufacturing process which needs to be applied to the detailed design. The CT controls and steers the necessary modifications in a proactive manner and ensures that the technical solutions are optimized and integrated with the lowest possible negative influence on cost and schedule. A GMP with an open-book approach makes it possible to realize changes with high transparency and without time-consuming negotiations. The quality, time and costs are monitored during the project to identify any deviations early enough to compensate them efficiently. The key tasks for this phase are the following:Verification of the planning steps (to meet the targets and requirements of the conceptual design), value engineering during all project phases, evaluation of possible synergy effects, continuous control of progress and schedule (proactive measures if differences occur), quality checks, continuous comprehensive reporting to top management with project result forecast (function, quality, costs,time schedule), continuous cost tracking, active change management (minimization of impacts on function,quality, costs, time schedule).

From project start until the end, there were three main participants delivering the project. It is important to see their distribution to the project, compared to each other (shown in figure 4.7).

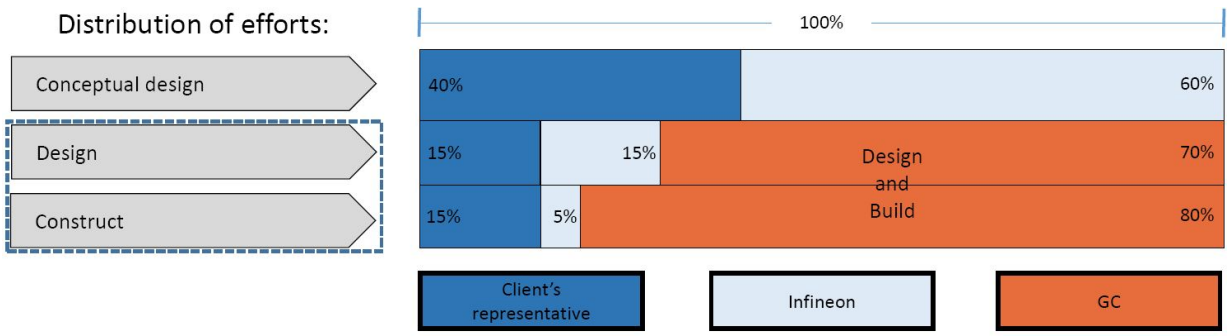


Figure 4.7: Case 1: Distribution of efforts

Risk Management
Defined in the project procedure guide, "the overriding strategy is to consider the effect of a potential risk and take all necessary actions to minimize it." According to this strategy, the contractor maintained a schedule of the ten most serious risks, potentially threatening each of the work packages. These risks were sorted on the basis of their probability to happen and the impact they might cause. From these factors, the risks received the following ranks: Critical, Major, Significant, Minor, And Routine. Having the potential risks categorized, the next step is to minimize or to eliminate the chance of their occurrence, to think about a way to deal with them if occurred and to depute a person responsible for dealing with the problem.

Work Packages (WP)
For a project like this, the whole construction work is built up from Work Packages (WP). After the tendering process done, the chosen contractor starts the designing process according to the guidelines stated in the conceptual design. Afterwards, the contractor divides the construction work into separate WPs, as it is prescribed in the contract. The packages go through a procurement process, where the contractor finds the necessary subcontractors for each of the packages. The client can of course nominate or disqualify any companies it finds unacceptable. Each of WPs are awarded to a single Subcontractor, and the subcontractor is not allowed to delivery any other WPs, unless the Employer's representative agrees in writing that it can do so. Another restriction is that the general contractor or any company with mutual ownership, or any company influenceable by the main contractor is not allowed to perform any work, unless the client's representative accepts it as well.

4.1.2 Project Story

In 2010 the management decided to extend it's production capacity in that area, using the already built buildings and infrastructure. After some cost-calculations, Infineon set a maximal budget for the project and started the conceptual design Phase, with two Companies (Company B-1 and Company C-1)

Both of the companies were chosen, from the few designers with the desired experience and necessary capabilities on the basis of having a long and successful history and partnership together with Infineon.
After a four month long conceptual design phase, the tender went out to nine companies. From the contacted companies, six of them were interested and five of them were qualified enough. After this, one had withdrawn on behalf of another, who than withdrew as well because of an awarded large scale project, a huge petro-chemical investment in the region. A third possible bidder had as well withdrawn its tender, due to non-acceptance of Guaranteed Maximal Price. For the negotiations, two companies had submitted

their bids. Both of the parties had shown great effort, and had assembled decent teams but at the end, Company A-1 was chosen as the general contractor to deliver the whole project from design to construction. The contract was signed separately for the following: Design and Engineering incl. test piling, Phase 1 (first 50% of CR), Phase 2 (second 50% of CR, in the future), and Office Building (later it was completely cancelled).

The design phase started and ended according to the estimated time plan, while the piling was already running parallel to the design. During the piling, Infineon's management called for reconsideration of the project, as the global economy was changing, not in a way that it was predicted to change during the start of the project: demand for the products were dropping. The calculations and estimations set four possible variations (shown in figure 4.8): The most direct way was to cancel the project (V1) as soon as possible, and loose the already invested money. The other variants suggested to stop the development temporarily, and to continue it afterwards. The second possibility (V2) was to finish piling and the pile heads and the third (V3) proposed to finish the whole foundations as well. The forth solution, *"Scenario Weathertight"*, as Infineon had faith in itself and faith in the project and expansion, was to build the building with cost cuts, *"not spending today the money of tomorrow"* (Interview Person A-1). This meant the building and only the basic infrastructures, with no CR. On the 13th of December 2011 Phase 0.5, scenario Weathertight had been launched.

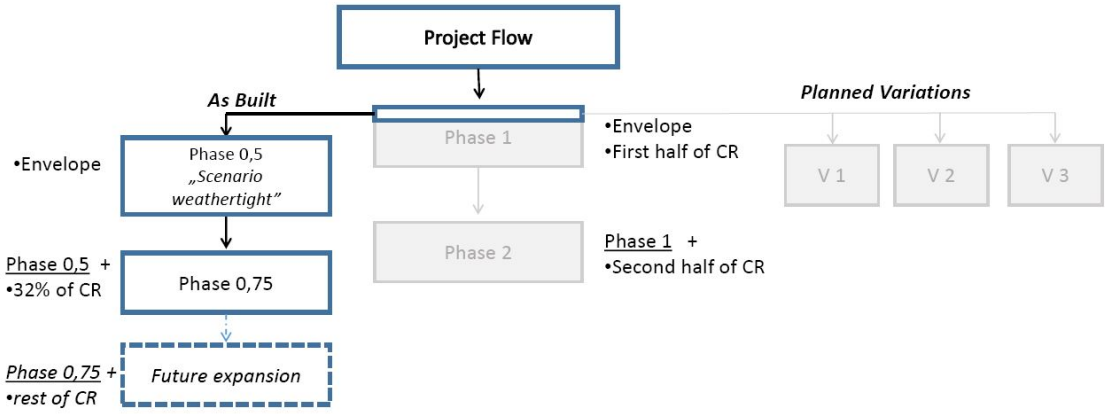


Figure 4.8: Case 1: Project Story 1/2

For this point, from the time, quality and cost triangle the time factor was no longer important, as the building was running in idle mode after it was ready. The building was accepted on the 31st of May in 2013, thereafter it was operated by Company A-1. For the Building operation, there was no other contender, Company A-1 was directly entrusted with it, as for Infineon it was important not to bring any other parties to the project in order to keep the responsibilities and the guaranties in one hand.

In 2015 the operation Phase ended, as Phase 0.75 was launched. It is (as it is currently running) the project to apply the necessary infrastructure fit out measures and improvements to the building for the first 33 % of the maximal CR.

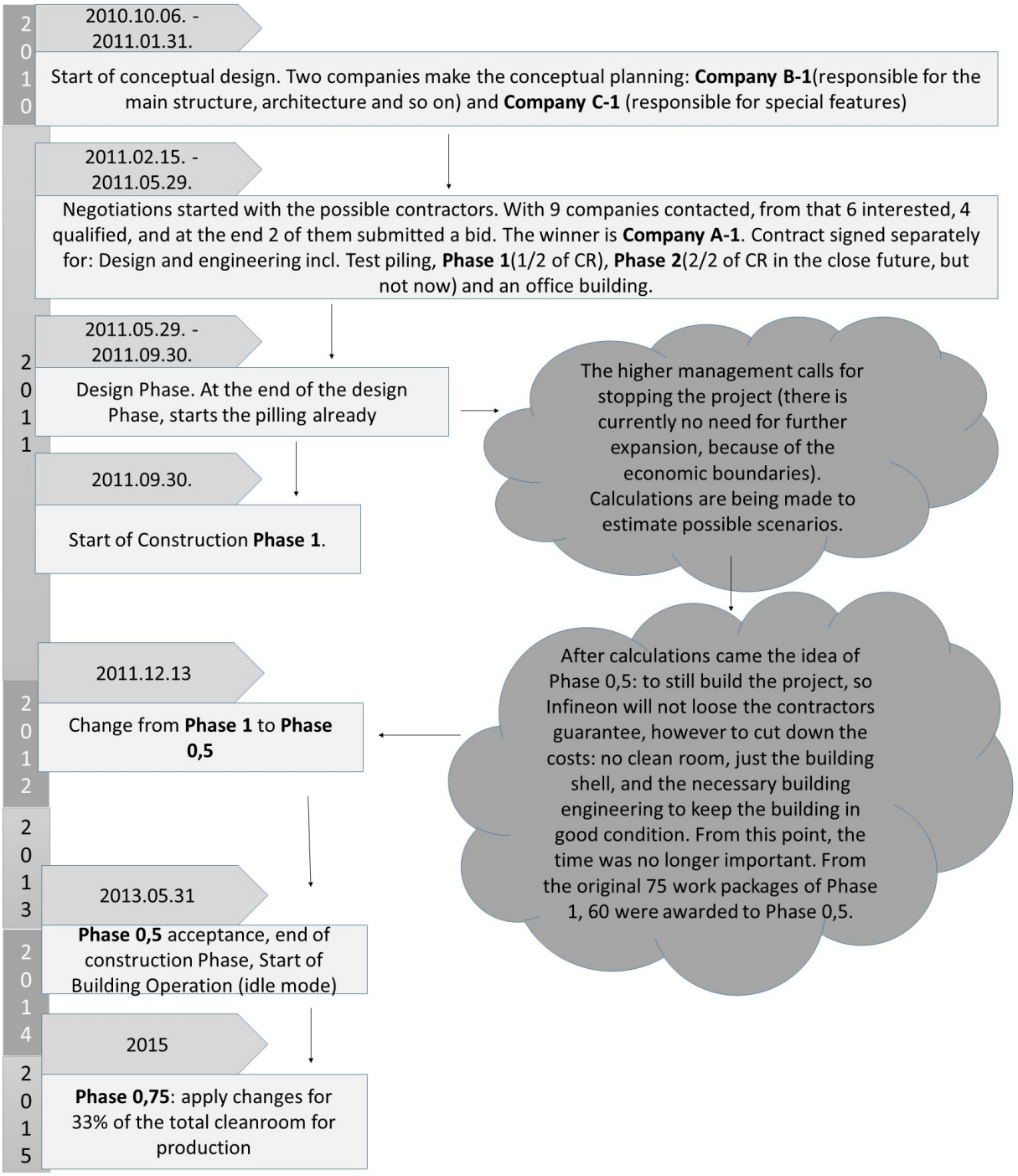


Figure 4.9: Case 1: Project Story 2/2

4.1.3 Participants

The Project is developed through the Basic model (in section 5.1), an EPC Delivery system, with a Guaranteed Maximum Price (Open book, cost plus) contract. The most relevant part, the conceptual design, was made by two companies: Company B-1, Company C-1. As the whole contract and the scope is based on their work and any mistake or inadequacy can lead to disputes and extra costs, they were chosen extremely carefully. Fortunately, Infineon has many projects behind itself and has enough experience and good professional business partners. These partners, not only have the necessary knowledge, capacity and experience, some of them also share the same roots, being part of the Siemens group in the past. With many projects delivered together, there is also mutual trust between them making Infineon directly select them as conceptual designers and consultants for the whole project.

Company B-1 was responsible for the conceptual design, and to support Infineon's project management team on the day to day site based activities in the following areas: Mechanical, CR, Electrical, CSA (Civil, Structure, Architecture) and Commercial systems.

Company C-1 was responsible for the conceptual design and to support Infineon's project management team on the day to day site based activities in the following areas: UPW (Ultrapure Water), WWT (Waste Water) and Gas & Chemical systems.

The project started with the conceptual design phase. This was developed by Company B-1 and Company C-1 with support from Infineon. In this stage they are the contractors and after a successful tender, they changed sides and control and supervised the project together with Infineon's project management (shown in figure 4.10).

After the conceptual design, the main contractor had to be chosen. As at the end, only two contractors submitted their bids, there were no big competition. Company A-1 won the tender as they were cheaper and they had better agreement with the contract as well. Furthermore they more or less brought the old team from the former project, who were familiar with the circumstances and the building. After winning the tender, Company A-1 was contracted to finish the design (according to the conceptual plan) and to manage the construction phase.

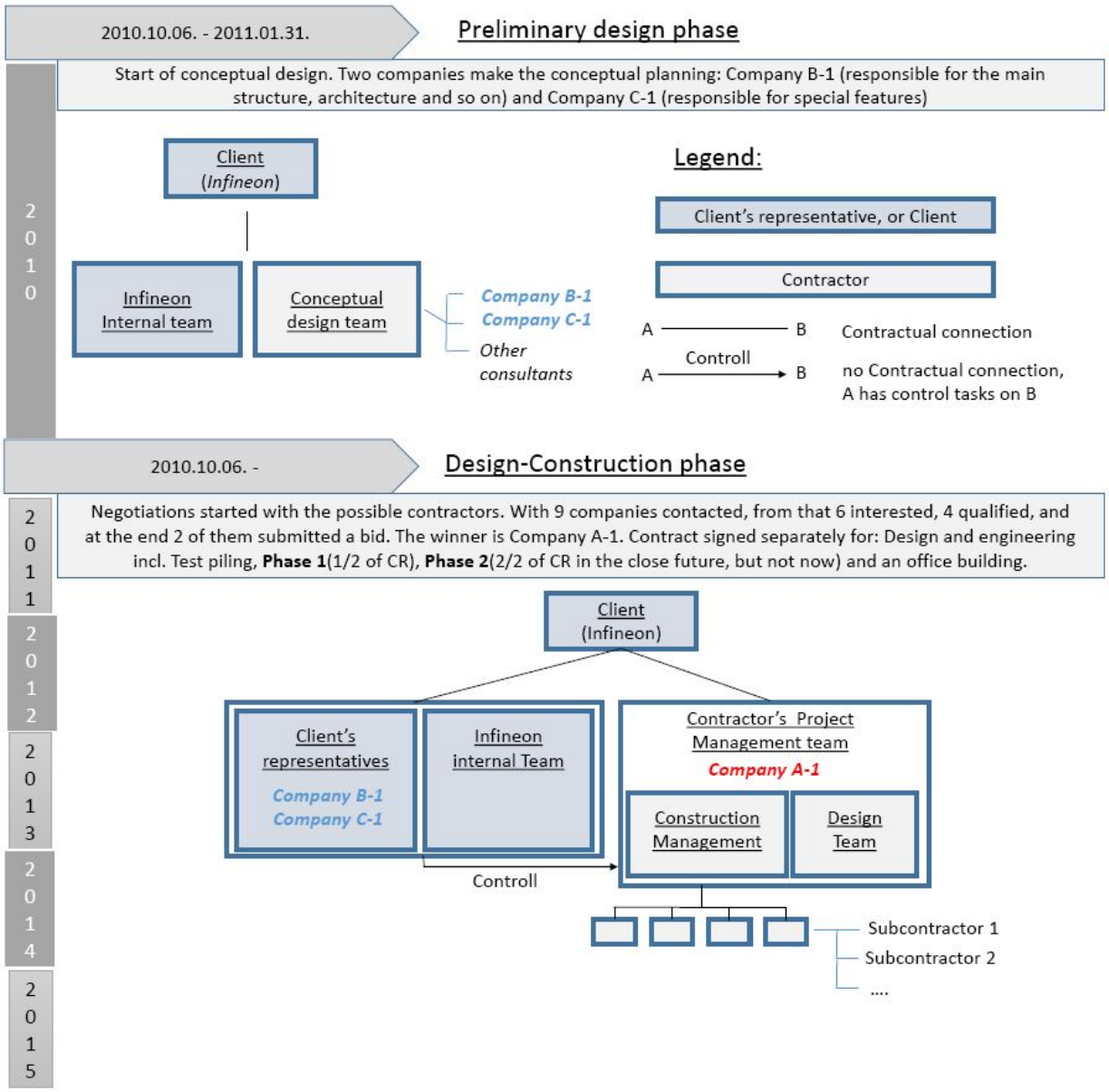


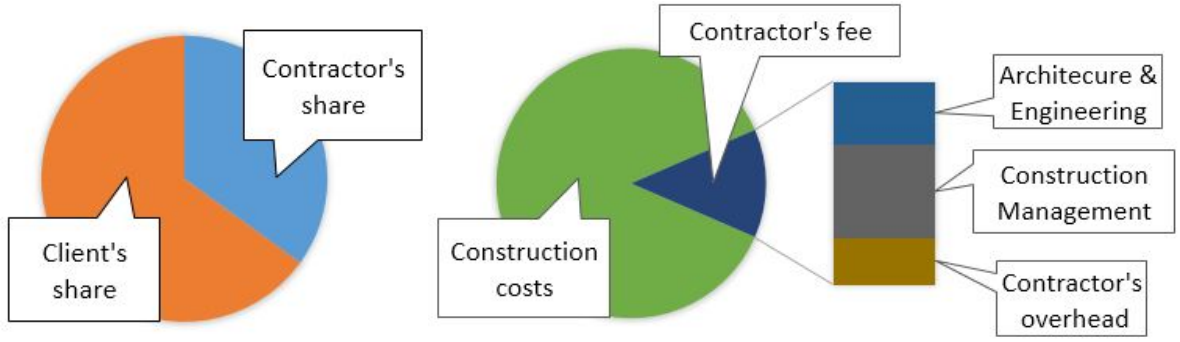
Figure 4.10: Case 1: Project participants

4.1.4 Costs

Cost distribution

After the negotiation had ended, the client reached an agreement with the contractor about the general contractor's fees (shown in figure 4.11b), in transferring approximately 1/7 of the total costs. It was put together from three smaller parts. The smallest part was awarded as contractor's overhead, the biggest was awarded as fee for the construction management and the last part was the cost of the architectural & engineering services. This amount was naturally calculated within the maximum price, the remaining money is

the total construction costs, transferred to the subcontractors.
The contractor could achieve additional income if it succeeded in lowering the cost of the construction. The savings (if the GMP was higher than the costs) were shared between the client and the contractor, approximately 1/3 was the contractor's part and the remaining 2/3 was kept by the client (shown in figure 4.11b).



(a) Share ratio (b) Contrator's fee

Figure 4.11: Cost distribution

Phases
As it was explained in section 4.1.2, the project did not go according to the preliminary expectations. For the whole project, there were four phases defined, however in the future there will be at least one more phase, to utilize the maximum production capacity of the facility.
The costs of the phases are shown in the following table (Figure 4.12). It summarizes the most important information of the phases, as additional information for figure 4.8:

Cost variations along the project
During the tendering, Company A-1 signed the contract to deliver Phase 1 within a certain budget and already a few months later the whole budget had to be reassessed, as Phase 1 was cancelled, and phase 0,5 was launched.
It is hard to make any conclusion from only the costs as these numbers do not show precisely what was or what might have been a good idea. There are many other factors, such as inflation, uncertainty: when the project might start again and so on, which can change everything completely.

This first budget was the starting GMP price for phase 1 and it was based on the prices of 2010. This will mean 100 % for the cases, to allow any comparison with the other costs. First of all, stopping the project for an indefinite time, meant instantly additional cost, that is about 16,9 % of phase 1 (and further costs for operation until the next phase). This extra cost contains the necessary resources to restart the construction, to rebuild some parts and to renovate it for the next phase. Another alternative was to stop the project immediately, which would be responsible for further expenses (13,7-17,2

Phases		Date of creating phase	Start of Phase	Envelope	End of Phase	Amount of ceanroom built (%)	Estimated costs (%)	End costs
Planned Variations	Phase 1	2010	2011	yes	cancelled	First 50%	100,0	-
	Phase 2	2010	-	-	-	Second 50%	-	-
As Built	Phase 0,5	2011	2011	yes	2013	0%	58,7	58,1
	Phase 0,75	2015	2015	-	-still running-	First 32%	48,3	-
	Estimation*	2011	-	-	-	First 50%	59,7	-
					Phase 0,5 + 0,75	32%	106,3	

Phase variations
Actual Phases

*It was just an estimation of delivering 50% of the cleanroom after Phase 0,5 (like phase 2, but not the second half of the cleanroom as extension, but the first half to an empty building)

Figure 4.12: Case 1: Project phases

% of phase 1). However low this amount might seem, it would suggest insecurity in the company's development. Furthermore a simple loss of money might be more painful than a more expensive project. An obvious alternative was simply to finish phase 1, but it was probably not worth it, as a full FAB building with the CR, would have had way more capital and material costs just for maintenance, moreover an extra 41.4% (difference between phase 0,5 and phase 1) which would have been spent as investment during a time, when the global economy was fragile and unstable. Even phase 0,5 was a big risk as the investment was idle and unproductive for an undefined length of time.

The current phase running (2015), has a budget of an additional 48,3 % to the investment of phase 0,5 and the operation, resulting in a budget 7% higher than phase 1 for only 32 % of the total CR as there is currently no need for more.

4.1.5 Open ended interviews

Interviewees

To acquire as much of the overall information possible, the interviewees were chosen from both the investor's team, both from the teams of other participants (listed in figure 4.13). A summary for each interview will be presented in this section, instead of a complete transcription.

	Position	Company	Gender	Age	Experience (years)	Date of interview
Person C1-1	Project Manager (client)	Infineon	Male	46	over 10	24.07.2015
Person C1-2	Client's representative+ conceptual designer (Architecture, structure, ect.)	Company B-1	Male	58	over 10	19.10.2015
Person C1-3	Client's representative+ conceptual designer (Process systems)	Company C-1	Male	57	over 10	26.10.2015
Person C1-4	Project lead (contractor)	Company A-1	Male	-	over 10	22.10.2015

Figure 4.13: Case 1: Interviewees

Interview with Person C1-1

Construction and Design

What were the most important criteria in choosing the project participants?
The consultants were chosen on behalf of ther mutual past, experience and the numerous projects delivered together. For general contractor: Reference, size of the company, financial stability and representation in the area was important. For the Subcontractors Infineon has a process, first there is a pre-qualification(certain criteria have to be fulfilled), than Company A-1 suggests potential subcontractors, than Infineon has to approve them. Infineon has veto- and suggestion right

How good/bad was the communication and teamwork between project participants? (Construction and design)
They completed workshops together. It started with a programming workshop, compilation of needs and there were design workshops.
There was good ongoing communication, It sometimes went easier, sometimes harder (depending on the partners).

Conflicts?
There are conflicts naturally in every project. The contractor and the client's representatives have different points of view and they have to be solved.
They always have found a good solution at the PM level. It was clear that they had to find a solution and it was mutually important for both of them (Company A-1 and Infineon), otherwise the project stops.

Did the client's representatives have enough weight to solve the problems?
If it was necessary Infineon was there to escalate the process. It happened but not often.

From your own point of view: Positiv\Negative aspects?
The mutual pursuit of the project aims. Company A-1 understood the client's needs and acted in a customer-orientated way (for example, they were very straightforward about stopping the project). They could have made it more difficult. They were very cooperative about accepting Infineon's requirements.
Also positive was the way they found solutions together, furthermore a very good cooperation and a very high level of teamwork was typical.

Negativ?
Until now, there was no pressure on the team(in Phase 0,5). Now(Phase 0,75) however it is hard to manage the balance between the project aims and the operator expectations.

How much flexibility did the contract type allow?
This contract type is fundamentally very flexible. Through a change-management process, they have an efficient way to modify the contract. Changing a quality or quantity is relatively uncomplicated.

Did the project participants influence each other?
Naturally yes. The stronger a person is, the closer he can get to his goals. Infineon as well tries to influence the contractor. Everything depends on the person's argumentation and chain of reasoning. If someone is good at it, he/she will achieve his/her goals.
For Infineon it is important that their arguments are supported by the consultant's technical knowledge, as they are extremely experienced (decades of experience in the semiconductor industry).
Therefore Infineon is satisfied with it's consultants. They have strengths and weaknesses as well, but the strengths outweigh the weak points and the two companies complete each other.

Contract type

What was important for you in the project? (for example: low complexity)
All in all it was important for Infineon to keep the responsibilities in one hand, from design through construction to warranty management and authority management.

Were you satisfied with the chosen contract type?
General contractor with GMP is not suitable for every project, but for this case, it was the proper choice.

Please rank the following after their importance: Time-, Cost-, Quality certainty, length of time, Costs.
Quality is defined and it is a boundary condition. It has to be delivered with the defined quality. The other four, beginning with the most important: Time certainty, Cost certainty, Cost, Length of time.

General questions

Please identify the most important problems.
It is most important to define the demands properly, as they are the base of the design. A difficulty for this is the nature of the semiconductor industry: the demand might change quickly.
It is as well important for the team operating the facility to be involved during the designing process. Furthermore it is necessary to find the balance between "nice to have and golden door handles": to manage the standards.
For Infineon it is crucial to have a decent general contractor team. For example it is

difficult to manage the design teams, as there are only few designers with the necessary knowledge and experience and they are scattered all around the world. It is a critical point to have this know-how for the project.

Was it a problem that the design team did not have enough experience?
There were designers with the necessary knowledge, but they were working on other projects at the same time and they sit in Singapore. There were local design teams as well, who are stationed in Kulim (often younger people who start their carrier here).
To sum it up, it is vital for the teams to have the necessary know-how (for example: construction management team)
For this project Infineon had a really good team (Contractor), with some minor weaknesses. They have to work on the weaknesses and Infineon and the consultants compensates them if it is necessary.

Please identify the most important benefits.
It is important of have the know-how inside Infineon and to agree to the niveau of the expected standard.

Please suggest any ideas for improving the process.
It is difficult to organise the teamwork. It needs time and procedures.
Further problem is the huge amount of paperwork(*"on site paperless work flow would be nice"*), it could be improved with more IT support. It is difficult to bring the various IT systems of the companies together into one system.
Generally information exchange could be improved. Approving all of the documents, results in an enormous extra documentation work. However Company A-1 has a documentation management connected to Infineon, there are still a lot of information that has to be approved in writing. An electronic work flow would probably make it faster.

Please describe your own experience about cost-, quality- and time control in the project (Positiv\Negativ)
There is a meeting structure. Weekly-, monthly meetings. All time relevant aspects are to be mentioned weekly to keep them in mind and to manage them.
There were cost reports monthly to update the balance. The monitoring was efficient, there were no surprises.

Were there any problems because of a cultural differences?
Culturally it is totally different. It is vital to have culturally compatible partners who know how the system works. It has to be kept in mind that cultural difference is Infineon's task to deal with. As a European company, to have a factory built alone in Asia would definitely cost more, if the management does not keep the cultural difference in mind.

Were there any problems with the different standards?
It is a problem to deal with. It is always a detail problem, for example with connections for the ventilation (DIN vs British Standard). That is always a potential problem for international projects.

The most relevant positive and negative factors mentioned by the interviewed person are summarized below, in figure 4.14 :

Project-specific evaluation: Case 1		
Person C1-1		
Positive +	Neutral/Difficulties /	Negative -
Really good communication with general contractor (naturally there were conflicts)	Important to define the requirements clearly!	Only two bidders qualified for final tender (from the 9 conacted companies)
Good attitude in finding a solution for problems. (handled as a team)	Important to "*find the balance between nice to have and golden door handles*"	Too much paperwork (more IT support would be nice)
Mutual pursuit of the goals, as a team	Important: staff suited for the project (not many and all around the world)	Paperless workflow would be nice
Employer's team is all around complete thanks to the consultants	Important: for the team to have the necessary know-how	Information exchange is complicated (approvals and different systems)
Appropriate choice of contract for this exact project	Different standards (DIN vs British standard)	Hard to manage the balance between project aims and operator expectations
Contract type is flexible		
Responsibilities in one hand		

Figure 4.14: Case 1: Guided Interview with Person C1-1 (Project Manager)

Interview with Person C1-2

Construction and Design

What were the most important criteria in choosing the project participants?
There were two parts. The first step was, that the client itself chose their partners to develop the project: the consultants (one to do the design and another one to do the process part). This is a very important part, because you have to choose people that have a certain amount of experience in the semiconductor industry. There are a lot of good consultants, but if this consultant does not have the necessary input how it works in the semiconductor industry, you can make a lot of mistakes. It is important for Infineon or Intel to have a pool of consultants specialized in this field and based on this pool they choose their consultants.

How good/bad was the communication and teamwork between project participants? Such as with Person C1-3?
Working with Person C1-3 was a very important part as Person C1-2 and C1-3 had to start developing the project design. They have also completed many projects together and Person C1-2 described that working together was easy and that they had good cooperation, furthermore they completed each other. In the conceptual phase there are further in-house participants(Infineon), responsible for Logistics, Process, Production and the main users, who will run the facility. It is a hard job to optimise the design according to their requests and than to balance them with the budget. It is very time-consuming to collect all the requests making it hard to complete the conceptual design before starting the tender phase.
Generally working together with Company A-1 was good, technically they are good, but getting the budget was very hard.

Were you satisfied with the conceptual design?
To have a reliable design, you need four months. There are a lot of parties involved therefore the problem is that it takes time to collect all the information. The expected changes during the design development can lead to lot of change orders.
Better communication with Infineon might be useful and further *"taking time in the design phase can save you a lot of money"*.

Did the participants influence each other? Anything positive or negative?
Influencing each other is basically good as it brings the experience together, it is *"beneficial"*. The disadvantageous side is the input from the team operating the building. They want to take zero risks, which is impossible. They want the maximum or want to over engineer things that is not necessary.

Contract type

Why did Infineon choose this contract type (GMP)?)

There was a problem with the old contract form: the changes increased the budget. The former Siemens CFO said: *"I would like to have something where the budget is second and set"*.

For big projects, over 50 Mio Euro, the GMP is the right choice. In normal construction projects, 5-10 % deviation from the start price is normal, therefore it can mean extra cost of millions of Euro.

This contract type has many advantages. First of all it is flexible. The amounts can be changed through a change request easily, even the project can be stopped with no penalties, unlike stopping with a lump sum contract. The most important feature is that the contract is open book. This is responsible for the flexibility and it influences the price positively as well. The transparency makes it hard to contain hidden costs and it works perfectly as long as the subcontractors are external. In case the general contractor deliver any WPs itself, it causes disputes, as the contractor will try to keep the price high.

Have the contract type fulfilled your expectations?

Yes. The budget met the expectations. Time and quality were as well in order, as it could be influenced by choosing the right subcontractor, as it was chosen together (Infineon, consultants, Company A-1).

Were you satisfied with the contract type?

Yes, it is a good instrument, but it is not so common in the EU, many contractors do not accept it yet. It is good for big, complicated projects.

Please evaluate the following words. The most important gets 1, the least important gets 5.

1. Time certainty
2. Quality certainty
3. Costs
4. Cost certainty
5. Length of time

Please explain what the following words mean for you and evaluate them. The most important gets 1, the least important gets 4.

1. Teamwork

It is important to be able to understand each other, and to be able to work together. There are sometimes excellent people who are unable to work as a team. Next to this, there is another quality that is vital. The parties have to trust each other, so trustworthiness is almost as important as teamwork.

2. Reliability. The partners have to be reliable.

3. Motivation
Most of the people are motivated, it is just the nature of the project.
4. Creativity
It is important as well, but it can take you out from the project if you are too creative. Positive creativity would be more accurate. Unnecessary creativity can lead to a lot of change orders. It is good, but alone it not enough.

General

Please identify the most important problems.
One problem comes from production. The project starts with a certain requirement, than it changes. It is rather unfortunate, as it can influence the time and the costs badly. Fix requirements would be better.
The other problem is the end user. In the beginning they are not involved enough, than later they start requiring a lot of things.

Please identify the most important potentials and please suggest any improvement possibilities.
More time for designing and defining the project would be useful and to get all of the parties involved from the beginning. Furthermore it might be better to not just set the time, sometimes being more flexible toward the general contractor might be better.
It is also important to define more accurately what design development and what change order is, according to the contract.

Please share your experience about Cost-, Quality- and Time control.
Cost control was positive. Procurement and negotiation with subcontractors was good as well, the project is below budget.
Quality control was good as well, but it has to be improved, there are currently more people on the site. Time was also well controlled.
An additional important factor is Environment & Health & Safety. *"Environmental safety is becoming very important in this region"*, any accident can close the whole site. More than 2-3 Mio work hours with no accidents have been achieved so far. Some subcontractors are doing better, some are doing worse and Company A-1 is doing really well(another client was Intel and for them safety has a really high priority). Europe has a long way ahead of herself to achieve the same standard.

The most relevant positive and negative factors mentioned by the interviewed person are summarized below, in figure 4.15 :

Project-specific evaluation: Case 1		
Person C1-2		
Positive +	Neutral/Difficulties /	Negative -
Really good teamwork between consultants	You need to have consultants with the neccesary experience	Communication with the people operating the facility was complicated (more organised)
Teamwork with the general contractor was good	Teamwork and mutual trust are important	
Open book GMP perfect for big projects	Being a bit more flexible towards the contractor (when setting the time) might help	Cotract type is not common in the EU
Open book GMP is flexible: amounts can be changed easily		Lot of changes (bad for time and costs)
Open book: better cost transparency	Define more accurately what design development, what change order is	If general contractor delivers a WP, there are disputes.
Delivery method works perfectly with external subcontractors	Environment & Health & Safety is more important in this region as it is in the EU	Gathering the necessary informations for the concept is time consuming (either more time for concept (4 months) or more efficient communication inside Infineon)
Client has infuence on choosing the subcontractors		

Figure 4.15: Case 1: Guided Interview with Person C1-2 (Client's representative and conceptual designer)

Interview with Person C1-3

Construction and Design

What were the most important criteria in choosing the project participants?
Experience and the long-standing work relationship were important by choosing the general contractor. Furthermore Company A-1 was awarded the first module as well.

How good/bad was the communication and teamwork between project participants?
Working together depends on the people. Company A-1 is a big company with a lot of international projects. Sometimes the people with the most experience are not available. You can not just say that Company A-1 is perfect, everything depends on the people who will be on the site at the end. The teams for FAB 1 in 2005 and for FAB 2 in 2011 were experienced, but the team now on site is less experienced.

Were you satisfied with the conceptual design?
There was enough time for the conceptual design, it was adequate but there is always room for further improvements.

Conflicts?
Rather disagreements. People have different viewpoints on technical matters, therefore a technical discussion would fit better. Often it is about the material quality for the project. As it has direct impact on the costs, it is important to find reasonable balance between technical necessity and financial affordability.

Contract type

Why has Infineon chosen this contract type (GMP)?)
Infineon started using this contract type 10- 15 years ago. The most important feature was the cost certainty.
On one hand the contract is flexible, because it allows change orders. On the other hand, any change can result in extra costs. The general contractor has a time limit and a time plan and a change order can influence the time plan, therefore it is hard to keep the price.

Please evaluate the following words. The most important gets 1, the least important gets 5.
1. Quality certainty
2. Cost certainty
3. Time certainty
4. Costs
5. Time

Please explain what the following words mean for you and evaluate them. The most important gets 1, the least important gets 4.
Motivation is important, but not the most relevant. For people who are paid for their work, motivation is not a question.
The importance of the other three words depend on the project phase. In the conceptual design phase before tender:
1. Creativity, to make a smart design
2. Teamwork. It is still important, but in the preliminary phase the teams are working parallel to each other, everyone does his or her part.
3. Reliability
The other version is in the phases, where the general contractor has already signed the contract:
1. Teamwork
2. Reliability
3. Creativity

General

Please identify the most important problems.
There is a time-consuming documentation, that has to be optimised. It contains a lot of paperwork and it can get out of hand.
Furthermore it is difficult when there are many modification from the client. First if there are a lot of changes, it can be disturbing (or confusing) and the fact, that the team (Company A-1) is not that experienced, can make it more complicated.
Further difficulty is, that some of the people are in Europe and they can not be in Asia for too long.

Please identify the most important potentials and please suggest any improvement possibilities.
It is very helpful if the core team (Company B-1 and C-1) has a lot of experience and they have delivered numerous projects together.
For improvements, it would be sometimes more efficient to assign some of the WPs directly, without the general contractor, as there some areas where they are not necessarily competent (like process system) and it just goes through them.

Please share your experience about Cost-, Quality- and Time control.
The negotiations with the subcontractors were very successful for Company A-1/Infineon, so the profit for the subcontractors was reduced and most likely lower than expected by them. Usually the subcontractors try to increase their margin during execution and scope changes caused by Infineon are opportunities to gain some extra money. Yes, there is an open book policy with Company A-1 but scope changes and the associated variation orders are not that transparent anymore. Furthermore a tight project schedule does not allow extensive negotiations after awarding.
The performance specifications define the work. The problem is that written text is never perfect, there is always a chance for different interpretation. The client and the consultants defined one thing and the contractor or it's subcontractor interpret it differently. Naturally it can increase the price despite the fact that it should be according to international standards in the first place.

The most relevant positive and negative factors mentioned by the interviewed person are summarized below, in figure 4.16 :

Project-specific evaluation: Case 1		
Person C1-3		
Positive +	Neutral/Difficulties /	Negative -
Contract allows change, but it tend to cost more	The ability to work together depends on the people, not on the company.	Sometimes the experienced people are not avaliable
Very helpful that the core team (Company B-1 and C-1) have a lot of experience together (good teamwork)	There is room for impoving the conceptual design	Time consuming documentation (lot of paper work)
The controll functions were efficient	It is important to find the reasonable balance between technical necessity and financial affordability	Difficult when there are many modifications from the client
Procurement and negotiation with subcontractors was good	Difficult that a some of participants are in Europe, not in Malaysia	Different interpretation of specifications has caused arguments
	Assigning some of the process relevant WPs directly would be better	Usually the subcontractors try to increase their margin during execution and scope change

Figure 4.16: Case 1: Guided Interview with Person C1-3 (Client's representative and conceptual designer)

Interview with Person C1-4

Construction and Design

What were the most important criteria in choosing the project participants?
This project is actually a fit-out of the existing FAB 2 building which was constructed by Company A-1 as General Contractor in year 2012-2013. Due to these specific circumstances and considering a long term relationship with Company A-1, Infineon choose Company A-1 as their preferred partner.

Clients Team:
Clients local representatives consists mainly of members from two consultants: CSA/Mechanical/Electrical/LV is covered by Company B-1, whereas Process systems are supervised by Company C-1. Both companies have German roots and long-term experience in the semiconductor field and grown relationship with Infineon and were already involved in the former Asian Infineon Fab 1 project as well as other Infineon projects.

Company A-1 Subcontractors:
Company A-1 built up long term relationship with its Asian subcontractors over the last two decades. All of them are highly qualified to work on complex high-tech projects following advanced international standards regarding EHS and QA/QC. The procurement of the works was split in more than fifty work packages starting with creating bidder list which were approved by the client. The potential subcontractors first had to accept the contract type, project execution schedule and commercial conditions. Various rounds of technical and commercial clarification meetings were conducted for each work package to ensure a technical compliance with the tender specifications followed by final commercial negotiations ending up in a final best price. The procurement approval was than done in most cases based on the cheapest price.

How good/bad was the communication and teamwork between project participants?
Communication was continuously being improved during the project. Protocols and guidelines where established to align the various parties such as Infineon Management, clients Team and Company A-1 team. In addition to phone and e-mail correspondence, various weekly meetings/WebEx meetings where scheduled with attendance of all related project participants, followed by meeting minutes to enable effective actions. Teamwork was not always as good as it could be, especially some client's team members played their role very formally. On a fast track project like this with an accelerated Ready for Equipment (RFE) date, all participants should be very flexible and also willing to overcome time constraints. Responses on technical submittals should be faster. Client's review and approval of shop drawings should not be misused to change the existing engineering.

Were you satisfied with the conceptual design?
This project actually did not start with a conceptual design but with a "design refreshment" of an existing Final Design which was done by Company A-1 at an earlier stage. The reason why doing so is linked to the history of the project which was designed in the year 2011/2012. Construction started in 2012. Infineon decided to stop fitting out works by May 2013. The refreshed Final design was adjusted to latest lessons learned and recent clients process requirements.

Did the participants influence each other? Anything positive or negative?
Naturally yes. Being convincing is vital. Person C1-2 is for example very convincing and he is good in arguments. Everyone who is in a leading position, has to be communicative and has to be good at selling his ideas.

Contract type

Why has Infineon chosen this contract type (GMP)?)
This is Infineon's standard contractual model for these types of projects and it was never in discussion to change it. Company A-1 has long term experience with Infineon and also this type of contract. The contractual model is EPCM Open book (General Contractor)-Engineering, Procurement, Construction Management with guaranteed maximum price on open book basis. Most important for Infineon is besides achieving schedule milestones the certainty of the budget from the very beginning as a basis of their investment decision. This budget certainty can only be achieved by a proposal from a reliable General Contractor who is experienced in the semiconductor business and willing to take the related contractual risks. The open book GMP approach gives a full budget and scope transparency. The GMP on top guarantees a maximum price for the contractual scope but also offers Company A-1 shared savings if the total final cost are lower than the GMP.

Did you find this contract type flexible?
One of the big advantages of the EPCM Open book model is its flexibility. This is important because scope is changing frequently during project execution. The open book makes scope additions or deductions very transparent. Additional scope will increase the GMP as well. It is even possible to extend the contractual scope significantly by including fitting out works for additional areas within the Fab simply by using COs (Change orders).

Were you satisfied with the contract type? Did it fulfil your expectations?
Yes, we know how to work with that contract type and it is fulfilling our expectations. For Company A-1 it is not the first time, using a GMP contract with Infineon. This model is widely used in the semiconductor industry. All the participants know their rights and responsibilities.

Please evaluate the following words. The most important gets 1, the least important gets 5.
From management perspective, items 1 to 3 have the same importance.
1a. Time certainty
1b. Quality certainty
1c. Cost certainty
2. Length of time (RFE is set by client in advance) 3. Cost (Cost set by contract)

Please explain what the following words mean for you and evaluate them. The most important gets 1, the least important gets 4. Teamwork, Reliability, Motivation, Creativity.
"As a manager I have to tell you, that all of them are equally important..." 1. Teamwork is most important, as what we produce is always the product of teamwork.
2. Reliability is also very important. You have to rely on people, team members, subcontractors. Less reliability always leads to corrective actions to overcome any negative impact to the project which costs unnecessary extra effort.
3. Motivation is always relevant, but you have to keep in mind, that no one is 100 % motivated every day. Nevertheless the job has to be done with or without motivation.
4. Creativity is not so important in the execution stage of the project. Design is done anyway and the task is to follow the existing procedures to ensure that we can deliver the project in time quality and cost following our EHS policy

General

Please identify the most important problems.

- Subcontractors deviating from Company A-1as specifications
- Subcontractors delaying the project schedule
- Too many technical submittals for clients review and approval causing delays for project execution schedule
- Clients consultants team playing its role partially as an end in itself.
- Control and coordinate the influence of the Infineon local Fab 1 team to the project.
- No permanent Infineon project manager established on site causing a lot of additional electronic correspondence and is delaying decisions. Infineon's project management rotates usually weekly.

Please identify the most important potentials and please suggest any improvement possibilities.

- Consider a different project management set up with Infineon's representatives being permanently on site. One technical and one commercial project manager would be perfect.
- Clients team members should be chosen according their willingness to integrate themselves as team players.

The most relevant positive and negative factors mentioned by the interviewed person are summarized below, in figure 4.17 :

Project-specific evaluation: Case 1		
Person C1-4		
Positive +	Neutral/Difficulties /	Negative -
Open-book helps to provide a clear documentation and budget transparency	Company A-1 would prefer creating the conceptual design itself	No constant attendance of the client, Infineon's remote management is not ideal
Good and ongoing communication	Different unterstanding of the concept can cause arguments	Teamwork was not always as good as it could have been
Shared savings	one technical one commercial project manager, directly on the site for the whole project would be better	Specifications should be better detailed
Company A-1 have a lot of experience with GMP and working with Infineon		Information transfer has room for improvements (lot of extra work)
Big advantage of this method is it's flexibility		Ongoing changes are inconvenient
The EPCM delivery method with GMP Open book is perfect and it should be applied in other projects in the future		Too many technical submittals for clients review and approval causing delays for project execution schedule
		Client's team shoud integrate themselves more as team players

Figure 4.17: Case 1: Guided Interview with person C1-4 (Contractor's Project Manager)

4.1.6 Case 1 results

Project-specific evaluation: Case 1			
Person C1-1, C1-2, C1-3, C1-4			
Positive		Negative	
+		-	
Contract allows amout change and offers a possibility for scope change (flexible)	1 2 3 4	Information exchange is complicated (approvals and different systems). More It support, less paperwork, less documentation wold be better	1 3 4
Very helpful that the core team (Company B-1 and C-1) have a lot of experience together (good teamwork)	1 2 3	Difficult that a lot of participants are in Europe, not in Malaysia	3 4
GMP open book was effective for this kind of project (transparency)	1 2 4	Difficulities managing the operator team's needs against the project aims	1 2
Good teamwork and communication	1 2 4		
The controll functions were efficient	1 3	Only two bidders for tender	1
Responsibilities in one hand	1	Contract type is not common in the EU	2
Open book: better cost transparency	2	If general contractor delivers a WP, there are disputes.	2
Delivery method works perfectly with external subcontractors	2		
Client has infuence on choosing the subcontractors	2	Sometimes the experienced people are not avaliable (assigned some other project)	3
General contractor is experienced in GMP	4		
Budget certainty, shared savings (incentive)	4	Too many technical submittals for clients review and approval causing delays for project execution schedule	4

Neutral/Important comments	
Lot of changes (bad for time and costs, but it is the nature of the semi conductor industry)	1 2 3 4
Important to define the requirements clearly!	1 3 4
Important: staff suited for the project (not many and all around the world)	1 2
Important to "find the balance between nice to have and golden door handles"	1 3
Being a bit more flexible towards the contractor (when setting the time) might help	2
Define more accurately what design develpment, what change order is	2
Environment & Health & Safety is more important in this region as it is in the EU	2
The ability to work together depends on the people, not on the company.	3
Assigning some of the process relevant WPs directly would be better	3
M+W would prefer creating the conceptual design itself	4
One technical one commercial project manager, directly on the site for the whole project would be better	4

Figure 4.18: Case 1: Summary of the open ended interviews

4.2 Case 2

This Project was developed in Europe, the continent where Infineon and Siemens were both established. Europe is the core of research and development, whereas it also gives place to production. The main goal of Case 2 is to increase one of the bigger site's production capacity and to extend the current office and laboratory capacities.

4.2.1 Project information

Project	Case 2
Place	Europe
Conceptual Design	Infineon and Company B-2
Design	**Overall designer** (Company A-2)
Construction	**The overall designer** of the design phase (Company A-2 as CM agency)
GFA (Gross Floor Area)	25,2% of case 1

Figure 4.19: Case 2

The purpose of the project was to deliver the two buildings, according to the conceptual design. The extensions will be connected to the neighbouring facilities and to each other through bridges, to allow barrier free material flow.

Building A is responsible for the production. It is built up from three main functional areas: Production-, Transfer- and Infrastructure areas. The Production area contains the CR, which can be located in the two-storey hall. Most of the transfer- and Infrastructure areas are in the second half of the building, which have two more storeys.

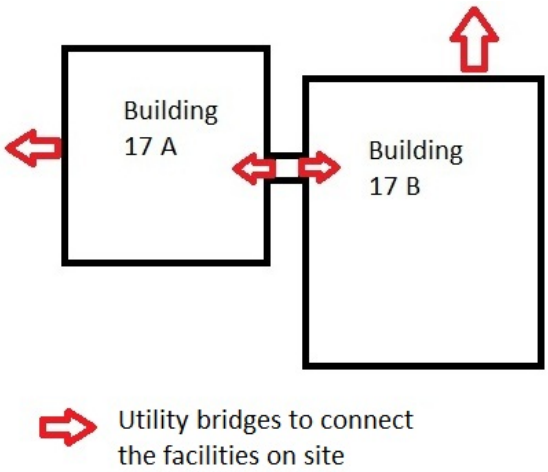


Figure 4.20: Case 2 - Overview

Building B, the second half of the extension, is responsible for the necessary office and laboratory areas. It is a five storey building, which is connected to the neighbouring facilities as well as to building A.

Delivery Method

The delivery method chosen for this project was the typical method Infineon uses on this site (TM, more detailed in section 5.2). The main difficulty for this project was the short length of time available. The concept was created by Infineon with the help of an external partner, and it was used for both tender and board's approval.

An important difference is that unlike Vase 1 or 3, there is well experienced and sufficient staff available to aid the project execution. The most important role of the contractor is the overall-designer. The responsibilities for delivering the complete design lies in one hand with all it's obligations, from design to accountability for costs and time. The necessary information for the design is provided by various Infineon co-workers, who are all specialists in their fields of science. The construction phase has similarities with the other projects, but it has major differences as well: for example the subcontractors sign their contracts with Infineon, instead of the main contractor (The main contractor is providing CM agency services, more detailed in section 3.3).

The used contract is a lump sum contract for the overall design phase. Open book is unnecessary, as the whole cost control and subcontractor contracts are managed by Infineon and there is no GMP, as it does not work with this risk allocation. Therefore the risk of keeping the budget belongs to Infineon, however the lump sum allows some soft guarantees: The contractor's fee is a certain percent of the overall costs, irrespectively of how often Infineon orders them to redesign the plans in the name of efficiency. Using the flexibility (even more flexible than Case 1 or 3) of the method, probably the most value possible, can be achieved from a fix budget by undertaking extra management- and control tasks (and responsibility for the project). Infineon has a different contract for the construction phase, where the overall designer provides CM services. The contract for this phase is an open book cost plus contract.

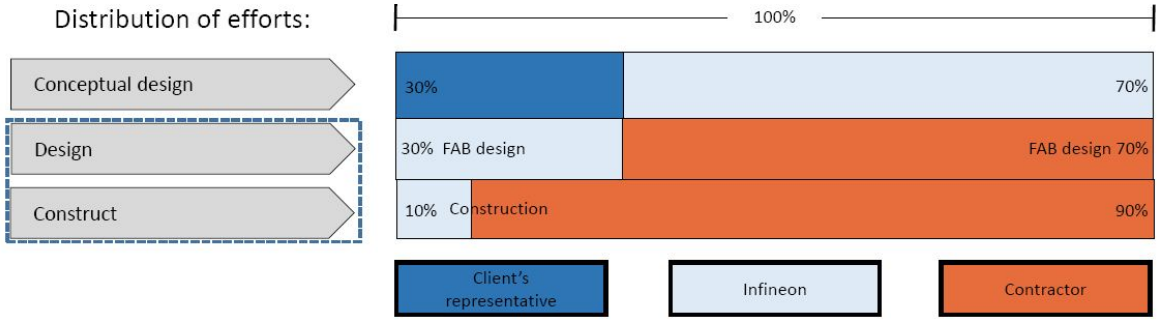


Figure 4.21: Case 2: Tasks/Phases

On the other hand, there are some difficulties with this system as well. The most important requirement is to have the decisions made by a management with the necessary region-wise experience and knowledge, for example about costs. This is extremely difficult

as the HQ has to have 100% trust in them, for what a continuous and close collaboration is a boundary condition (for over-see projects, it is hard).

Risk Management

Risk allocation is very different in this case. As there is sufficient staff on this site who are experienced enough, Infineon can bare more risks with the attached extra management tasks.
In the design phase, Company A-2 was fully responsible for the overall design from negotiations with the authorities through the detailed design to the tender documentations.
In the construction phase, there was huge differences between this and the other cases. The contract was a lump sum contract, without open-book or GMP. Infineon managed the contracts with the subcontractors itself, taking the responsibility for itself. Most importantly the cost control and keeping the budget were as well internal Infineon tasks.
Summarizing it, Infineon took most of the risks for the construction phase, by taking extra management and control tasks. This resulted in an even more flexible project with a high chance for "become more for the same money".

Work Packages

The project is similar to the others in preparing the WPs and having subcontractors deliver them. One subcontractor can deliver more than one package, furthermore it can also deliver just part of any packages if it is beneficial for the project (just like the other projects).

4.2.2 Project Story

This project is a complex extension, such as the other two cases. The project includes areas for research & development, office and production, additional parking places and a site purchase agreement.
This delivery started directly with the conceptual design phase, that was developed by a well experienced external company (Company B-2) and Infineon together in two months. Based on the concept and the cost estimation, the executive board approved the project and the tender documentation was sent out to find the overall designer.
From the five qualified bidders (big enough, have experience in the semiconductor industry and with Infineon) Company B-2 was chosen and two months after the board's approval the actual design work started. To accelerate the project, Infineon used old designs as basis and furthermore it already had a well thought out system for the office. Therefore the contractor produced only about 20% of it, while it was responsible for about 70 % of the FAB design.
As it is mentioned in 4.2.3, the overall designer had three significant subcontractors. The company responsible for process engineering was suggested by Infineon, while the other two (for fire safety and building physics) were chosen by the contractor. The design was guided by Infineon's project leader in order to apply the necessary cost optimisations, even if it meant redesigning the building (therefore the design phase was longer).

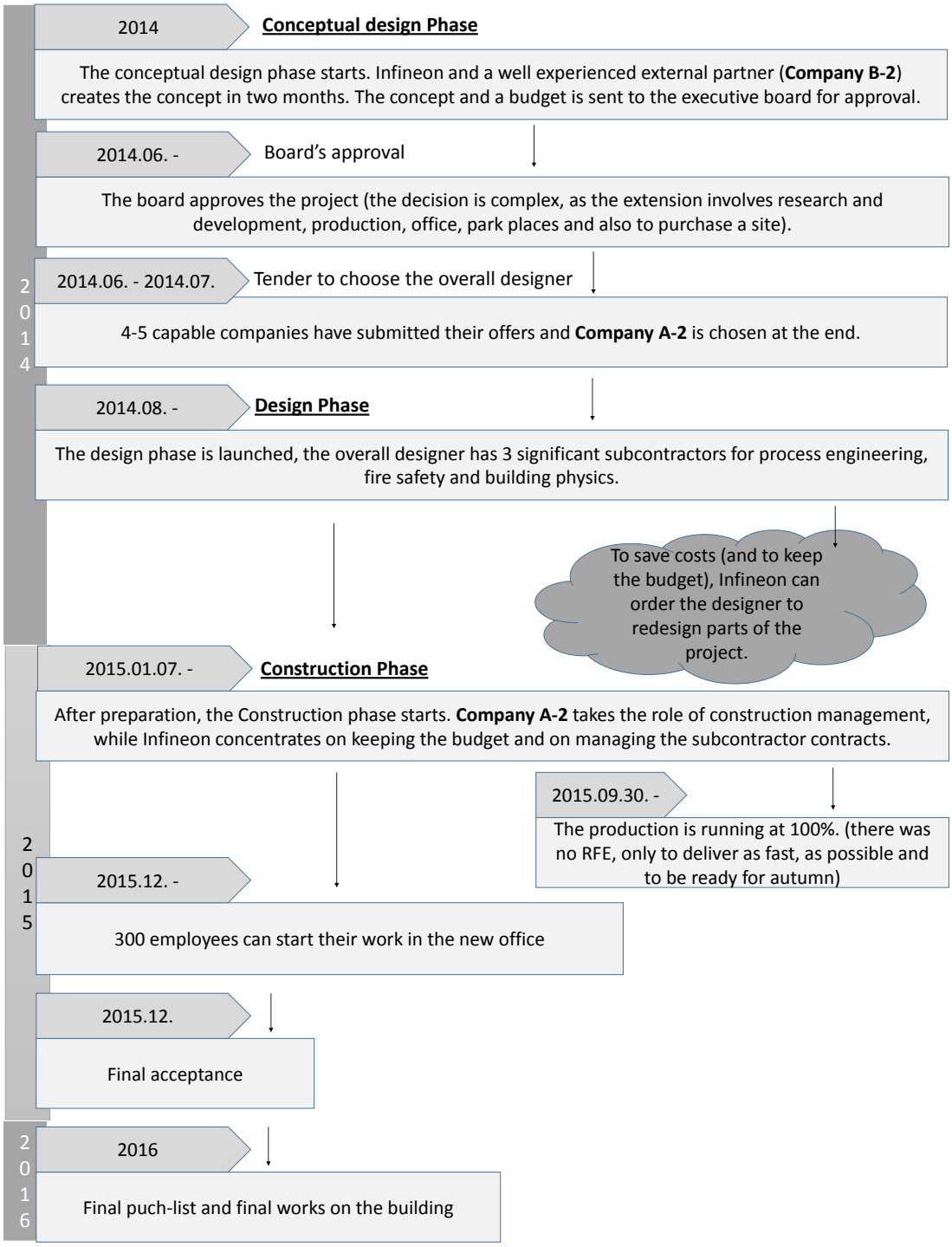


Figure 4.22: Case 2: Project Story

The construction phase started in January of 2015. The contractor was providing construction management services (project control, site management and so on), while Infineon had to concentrate on keeping the budget and as also mentioned in 4.2.3, managing the contracts. The two buildings were built parallel to each other, both as fast as possible with no significant problems. The time frame for the project was adequate, the production was launched in September and from December the office was also in use, the buildings were accepted. The last finishing works were completed later on, parallel to the punch list.

4.2.3 Participants

The Project started with a basic conceptual design, which was developed by Infineon's in-house specialists and with help from an external partner (Company B-2). As there was extremely short time available, the design team had to use existing plans as basis. This design also contained the necessary information for the budget indication for the executive board's approval and for the tender, choosing the overall designer.

The most important role of the chosen company (Company A-2) in this project was the role of the overall designer, as it was vital that the responsibility for all of the tasks from design activities to tender specifications are kept in one hand. In this phase there were three significant subcontractors. Sub A-2 was suggested by Infineon for the process systems, Sub B-2 and Sub C-2 were chosen by the contractor, to provide the design for fire safety and building physics. The design was based on the conceptual design and further specifications were provided by Infineon's co-workers (each of them competent in their own areas of interest).
The contractor delivered the plans, technical descriptions, lists of materials and parts, that had to be approved by Infineon, thereafter they together chose the appropriate companies for quotations. Company A-2 sent the tender documents, collected the bids and after that, the first prices could be compared. The last step was taken by Infineon: to contract the chosen companies.

Company A-2 was chosen as overall designer, to keep all of the design tasks in one hand from negotiations with the local authorities to the final tender documentations for the WPs. Furthermore this company was also assigned to assist the project as construction management (CM Agency, more detailed in 3.3).

Company B-2 was a partner who worked together with Infineon on the conceptual design.

Sub A-2 was a subcontractor in the design phase, responsible for process engineering. It was suggested by Infineon and it was contracted by the overall designer. According to the Project Manager of Company A-2, its experience in the semiconductor industry and with Infineon was very helpful.

Sub B-2 and **Sub C-2** were other subcontractors in the design phase contracted by the overall designer.

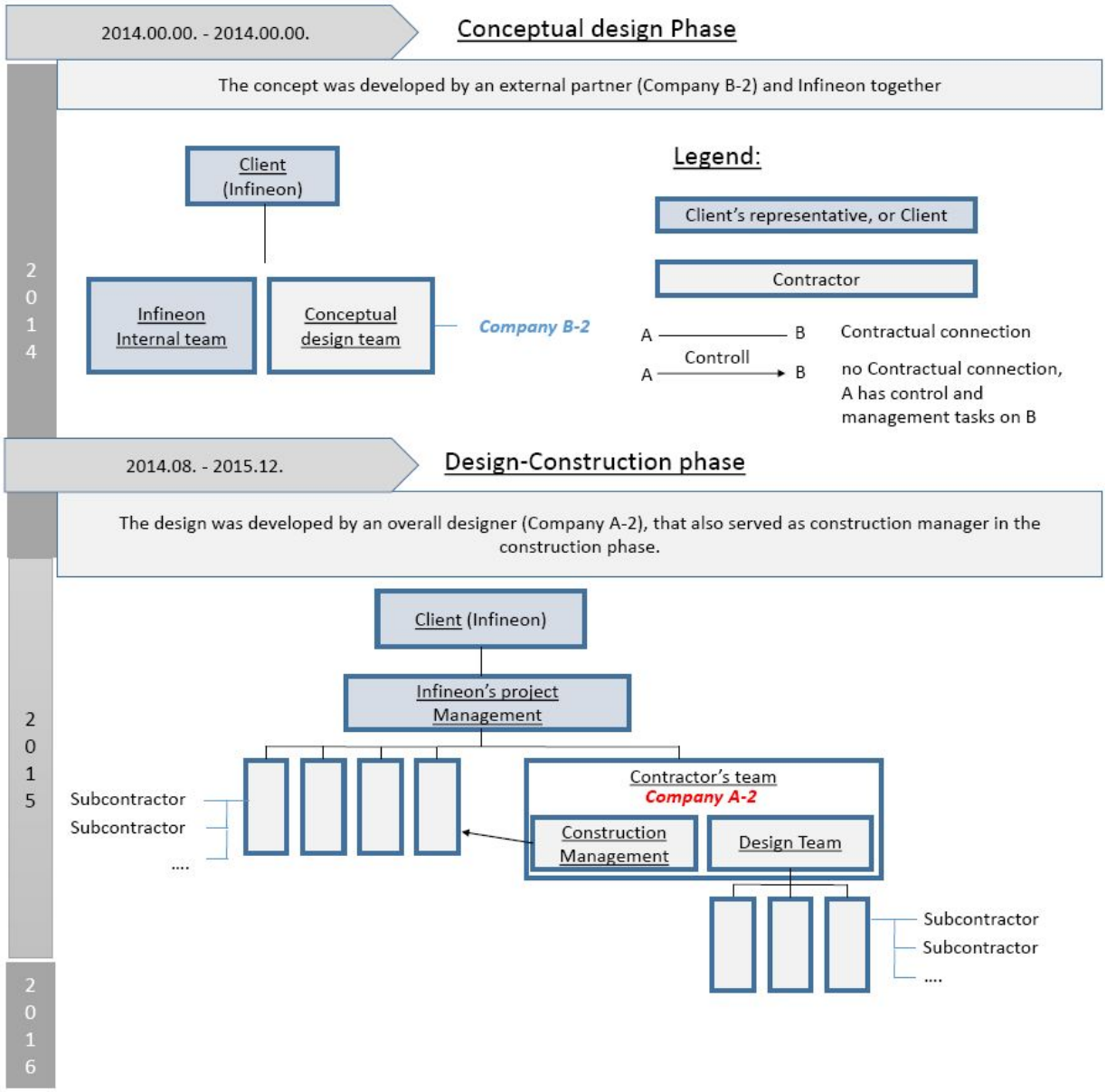


Figure 4.23: Case 2: Project participants

In the construction phase the overall designer took the role of construction management, supporting Infineon until the final acceptance. The tasks included site management, project controlling and supervision of the construction.
Infineon was responsible for the overall project success (and to keep the tight budget), therefore it had to work hard on budget control and on potentials for savings.

4.2.4 Costs

The cost control was Infineon's task during the project and the commercial team was very efficient. The imperfect conceptual design made the designer estimate a lower budget and the cost of the improved design exceeded the budget by 40 %. The project was redesigned efficiently, in order to cut the costs impressively, but the original budget still had to be increased. As the project is still running, it is still uncertain, if the budget is sufficient.

The contract with the overall designer was a lump sum contract. It was set in the beginning to be between 8-10 % of the start budget. It was a fix cost, giving a soft guarantee to both of the partners: on one hand the project can not be stopped, on the other hand it is a fix cost irrespectively of the actual efforts invested into the project by the overall designer.

4.2.5 Open ended interviews

Interviewees

The open ended interviews were made with four participants, shown in figure 4.24. A translated summary for each of the interviews will be presented in this section.

	Position	Company	Gender	Age	Experience (years)	Date of interview
Person C2-1	Project leader	Infineon	male	over 40	over 10	18.02.2016
Person C2-2	Commercial PL	Infineon	male	over 40	over 10	18.02.2016
Person C2-3	Project office	Infineon	male	40	over 5	05.02.2016
Person C2-4	Project manager of overall designer	Company A-2	male	40	over 10	18.02.2016

Figure 4.24: Case 2: Interviewees

Interview with Person C2-1 (additional comments from Person C2-2)

Construction and Design

What were the most important criteria in choosing the project participants?
The most important qualities were: reliability, competence and the overall designer had to have region-wise knowledge.
Person C2-2: Sufficient capacity was also important. If a project had to be accelerated, the contractor had to have more people in reserve.

How good/bad was the communication and teamwork between project participants? (Construction and design as well)
It was fine. There was intensive and un-bureaucratic cooperation with company B-2 during the conceptual design phase.
It was also decent with company A-2. However, communication with the designer could be more open in the future. Their capacity in the project management and construction phase could have been reinforced.
Person C2-2: Company B-2 had previously prepared protocols and their standard price overview was also very professional.

Were you satisfied with the quality of the conceptual design?
Yes, Infineon had also worked hard on it, the requirements were understood well.

Conflicts?
There are always conflicts. Some of them can be avoided, if the tasks are well defined. A potential conflict can be the not precisely defined allocation of tasks.

Contract type

Why has Infineon chosen this contract type and delivery method for this project?
Person C2-2: Infineon has a lot of know-how and capacity on the site, which is crucial for this project.
*Person C2-1:*It is true, however the Infineon's side had to be reinforced for the project. For this size, the method was good. For bigger size, it can also be good, however the capacities have to be under control and they have to be calculated in advance and also the responsible people (decision making) have to be appointed.
The model is really flexible. The experience on the client's side allows faster decision making by the changes.

What is important for this contract type and delivery method? (requirements)
As it was mentioned earlier, if there is a small budget, to reach the project goals, the commercial team has to be well integrated into the project. It was necessary here and it was fulfilled.

How much flexibility did the contract type allow?
The most possible. There is no dependence on a GC, the team can always go back to the market. (Responsibility to keep the budget belongs to Infineon)

How precise is the price?
Person C2-2: The price is precisely calculable, just as the changes, it is however not fixed. A change order causes modifications in the budget.

What was important for you in the project?
To achieve the most from the fixed budget on engineering and infrastructure.

Were you satisfied with the chosen contract type?
Yes. Furthermore it can be considered, if there is a huge time pressure on the project, to keep the supervision of the construction and site management to Infineon. It might allow better control over the overall designer, however it would also require significantly more effort from the team.

Please rank the following after their importance: Time-, Cost-, Quality certainty, length of time, Costs.
All of them are important. In this case, the length of time had lower priority, while the most important were the quality (for the production) and second the budget.

Please explain what the following words mean for you and evaluate them. The most important gets 1, the least important gets 4. Teamwork, Reliability, Motivation, Creativity.
The most important was the reliability (1). It is important for both the contractors and for both Infineon internal team. Motivation (2) is also a key factor. It is an important project for the site as it is a big image project. Teamwork is also one of the most important factors, not just internal (commercial and technical) but external as well. The last word: creativity is something, that has to be there for two things. First it is crucial for finding solutions and second, as it is a prototype building and for problem solving.

General questions

Please identify the most relevant problems/potentials.
To have the design team on site, integrated to the Infineon team. If it is not, it is a problem, if it is there and it is integrated, it is very positive. It might show great potential to have the design team on site, already from the beginning. For this project size, it is possible to sustain a project office on site and it can be very helpful.

Priority-changes during the project?
Both of the building were required to be delivered parallel to each other, which turned out to be rather difficult. Therefore the production received the higher priority, while the office and other tasks were set on lower priority.

The most relevant positive and negative factors mentioned by the interviewed person are summarized below, in figure 4.37 :

Project-specific evaluation: Case 2		
Person C2-1		
Positive +	Neutral/Remarks /	Negative -
Good communication and teamwork	Important for participants: reliability, competence and region-wise knowledge	CM's PM team should have been reinforced
Good conceptual design	More open communication with overall designer would be better	
For this size the method was good	For bigger size it is also good, however it has to be adjusted and well prepared	
Very flexible method and no dependence on a GC	Idea: Keep the supervision of the construction and site management for Infineon	
Commercial team integrated to the technical team	Idea: to have the design team (a project office) on site, integrated into Infineon's team from the beginning	
comments from Person C2-2		
Positive +	Neutral/Remarks /	Negative -
Company A-2 was professional (good protocols and standards)	The overall designer must have sufficient capacity (accelerating the project)	
	Infineon has lot of know how and capacity on site	
	The price is always calculable and the changes as well, however it is not fix. (unpredicatble changes)	

Figure 4.25: Case 2: Open ended Interview with Person C2-1 (Project leader) and Person C2-2 (Commercial Project leader)

Interview with Person C2-3

Construction and Design

What were the most important criteria in choosing the project participants?
It was teamwork, professional knowledge and experience. Internal was the teamwork more important, for external partners the other two.

How good/bad was the communication and teamwork between project participants? (Construction and design as well)
The communication with the subcontractors was going through the overall designer and it was all right.

Were you satisfied with the quality of the conceptual design?
The conceptual design was fine. The design however could have been better. More experience in the semiconductor industry would have been favourable.

Conflicts?
There were conflicts with the budget.

Contract type

Why has Infineon chosen this contract type and delivery method for this project?
On this site, Infineon uses this model every time.

How much flexibility did the contract type allow?
It allows enough flexibility.

Were you satisfied with the chosen contract type?
It is acceptable, but the method applied for case 1 with GMP might be better. It has some drawbacks as well, for example: many decisions have to be made beforehand, but on the other hand it provides the "maximum price" and the responsibilities are better defined (more risks taken by te GC).

Please rank the following after their importance: Time-, Cost-, Quality certainty, length of time, Costs.
Quality certainty (1), Total costs (2), Cost certainty (3), Length of time (4), Time certainty (5).

Please explain what the following words mean for you and evaluate them. The most important gets 1, the least important gets 4. Teamwork, Reliability, Motivation, Creativity.
Teamwork(1) is the most important for good results with reliability (2). After them comes creativity (3) for better problem solving. The last is the motivation (4), as good teamwork can motivate the team.

General questions

Please identify the most relevant problems/potentials.
The designer team did not have enough experience in the semiconductor industry. Furthermore there were difficulties with the budget. The designer did not know that there was a fix maximal budget, that can not be exceeded. Many things had to be redesigned and creative "value engineering" was also important to reach the budget, which resulted in a longer design phase.
A big potential was the preparedness and creativity of the internal team and the good work of the commercial team. Another positive factor was the fast construction phase.

The most relevant positive and negative factors mentioned by the interviewed person are summarized below, in figure 4.26 :

Project-specific evaluation: Case 2		
Person C2-3		
Positive +	Neutral/Remarks /	Negative -
Communication and teamwork wasgood	Important for internal participants: Teamwork (1), professional knowledge and experience	Design team not experienced enough in the semi conductor industry
Fine conceptual design	Important for external participants: Professional knowledge (1) and exxperience (1) and teamwork	Case 1 with GMP has better risk allocation
Enough flexibility		
Prepared and creative internal team		
Efficient commercial team		

Figure 4.26: Case 2: Open ended Interview with Person C2-3 (Project office)

Interview with Person C2-4

Construction and Design

What were the most important criteria in choosing the project participants?
The quality of the team was extremely important as you have to rely on your team during the project. It was important for the project members to be able to keep the deadlines, to work in a team and so on.

How good/bad was the communication and teamwork between project participants? (Construction and design as well)
In the design phase it was a two way story. On one hand, Infineon was motivated to help the contractor and to provide the necessary input. On the other hand, the tasks were not clearly defined. There were some tasks, that were considered by both of the participants to be the other one's task (it was not defined clearly in the contract). It should have been previously decided by Infineon. The work with the subcontractors was good, for example without Sub A-2, the project would have been completely different (Sub A-2 has a lot of experience with Infineon).
The extreme tight deadlines made the construction phase very difficult. The subcontractors were nervous and some of them tried to use the pressure to gain more profits. It was true for about one or two companies, while the others caused no additional problems.
All in all, communication and teamwork were fine.

Were you satisfied with the quality of the conceptual design?
It could have been better. Some elements were missing from it, therefore they were not part of the first design. Furthermore the conceptual design would not have worked.

Conflicts?
It was a project with a lot of conflicts. The deadline and the short budget caused the most serious problems. The first design was estimated to be 40% over the original price (mentioned in the tender documents), which resulted in intense cost savings and re-designs.

Contract type

Why has Infineon chosen this contract type and delivery method for this project?
Infineon wanted to try out the company. (It is a big company with almost all of the necessary design departments in- house)

What is important for this contract type and delivery method? (requirements)
As it was mentioned before, the company has almost all of the necessary design departments in- house, which can influence the effectiveness and speed of the design as the whole design team was sitting in the same office. If the project required more capacity, external partners were involved as well (for example: for supervision of the construction).

How much flexibility did the contract type allow?
Infineon was aware of the time pressure, therefore there were no big changes after the design phase.

How precise is the price?
What Infineon wanted in the beginning, was not possible from the start budget. The first design had already shown 40% extra costs. The workshops and the re-design resulted in a lower cost, but it was as well over the start price (more than 15% extra). It was also difficult to optimise the project, without knowing what the real budget is.

Were you satisfied with the chosen contract type?
Yes, it is typical for Company A-2 (Overall design and construction management).

Please rank the following after their importance: Time-, Cost-, Quality certainty, length of time, Costs.
All of them are key factors for a project. Quality(1) is slightly more important, while the time certainty (2) is also important, as the project has to be delivered as fast as possible. The cost certainty (3) is as well a key factor as the budget was very tight.

Please explain what the following words mean for you and evaluate them. The most important gets 1, the least important gets 4. Teamwork, Reliability, Motivation, Creativity.
Teamwork(1) is the most important, as the project is developed by a team and not by a single person. Reliability (2) is integrated to teamwork, as the project leader has to rely on the team as he/she can not do it alone. Motivation (3) is something that has to be there. And last, creativity(4) is a factor that can be useful in the beginning, but after that the project does not necessarily need it.

General questions

Please identify the most relevant problems.
Motivating the companies was a great challenge, as there was high pressure on the teams (subcontractors and Company A-2 as well) caused by the deadlines. Another important problem was the already mentioned lack of clearly defined task allocation.

Please identify the most relevant potentials.
There was good teamwork and the construction went extremely fast and it was finished in time. Furthermore, the team responsible for operation was very cooperative (questions and support).

Any ideas for improvement?

- Clearly defined task allocation
- More time for design and construction
- To know the budget, that has to be reached

The most relevant positive and negative factors mentioned by the interviewed person are summarized below, in figure 4.27 :

Project-specific evaluation: Case 2		
Person C2-4		
Positive +	Neutral/Remarks /	Negative -
Client was motivated to support the overall designer	Important for participants: Reliability and to keep the deadlines	Tasks not clearly defined
Communication and teamwork was fine	Experienced subcontractor was big help (if the overall designer does not have enough experience in the semi conductor industry)	Extreme tight deadlines made the project difficult (some subs tried to use it and the pressure made all of the subs nervous)
Company A-2's big advantage is the in-house capacity (departments)	Motivating the subcontractors was not easy	Design according to the concept was way over the budget
Infineon's operation team was supportive		Not efficient budget
		Real budget unknown for main contractor

Figure 4.27: Case 2: Open ended Interview with Person C2-4 (Overall designer's Project Manager)

4.2.6 Case 2 results

Project-specific evaluation: Case 2			
Person C2-1, C2-2, C2-3, C2-4			
Positive		Negative	
+		-	
Good communication and teamwork	1 2 3	CM's PM team should have been reinforced	1
Good conceptual design	1 3	Design team not experienced enough in the semi conductor industry	3
Very flexible method and no dependence on a GC	1 3	Tasks not clearly defined	4
Commercial team integrated to the technical team	1 3	Extreme tight deadlines made the project difficult (some subs tried to use it and the pressure made all of the subs nervous)	4
Company A-2 was professional (good protocols and standards)	2	Design according to the concept was way over the budget	4
Prepared and creative internal team	3	Not efficient budget	4
Client was motivated to support the overall designer	4	Real budget unknown for main contractor	4
Company A-2's big advantage is the in-house capacity (departments)	4	Motivating the subcontractors was not easy	4
Infineon's operation team was supportive	4		

Neutral/Important comments	
Important for participants: reliability, competence and region-wise knowledge	1
More open communication with overall designer would be better	1
For bigger size it is also good, however it has to be adjusted and well prepared	1
Infineon has lot of know how and capacity on site (important for this model)	2
The price is always calculable and the changes as well, however it is not fix. (unpredicatble changes)	2
Important for internal participants: Teamwork (1), professional knowledge and experience	3
Important for external participants: Professional knowledge (1) and experience (1) and teamwork	3
Case 1 with GMP has better risk allocation	3
Experienced subcontractor was big help (if the overall designer does not have enough experience in the	4

Figure 4.28: Case 2: Summary of the open ended interviews

4.3 Case 3

The third and last case of the study is a project in Europe, such as Case 2. This is as well an extension for Infineon, as the company has already got a running facility on the site. This is not a regional headquarters, the nearest city is one hour away and the project had an extremely tight time schedule, therefore the contract had to apply some unique features.

4.3.1 Project information

Project	Case 3
Place	Europe
Conceptual Design	**General contractor** (Company A-3) + **Infineon**
Design	**General contractor** (Company A-3)
Construction	**General contractor** (Company A-3) + associate control: **Company B-3**
GFA (Gross Floor Area)	13,8%

Figure 4.29: Case 3

The goal of this project was to extend the local facility. The management decided to build a completely new building instead of modification of an existing building what was proposed by central Real Estate Department. This new facility is a hybrid building, as it contains Office-, CR- and Laboratory areas as well. Using the same building for multiple purposes is reasonable for this area, as all of the three functions had to be enlarged, but the scale of the extension was not comparable to the other two cases.

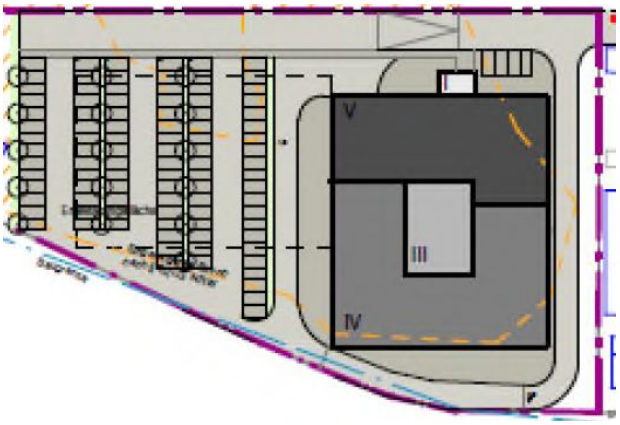


Figure 4.30: Case 3 Overview

The new facility is a square shaped building with 5 levels. The first floor contain the material storage and the necessary engineering for the CR. Over this, the most important part, the CR can be found. Over the CR, the remaining floors contains the office area. The not-used part of the site was designed to serve as parking place for the employees.

Delivery Method

The chosen delivery method in this case has similarities with both of the other cases as it was based on Case 1's model, but it still is different in many other aspects, such as the GC taking part in the preliminary design. The chosen delivery method was based on the Basic Model (more detailed in section 5.1). The most important similarity is that Infineon has no permanent on site staff for a construction project, the regional HQ has to provide support for the project (decisions have to be made together with certain executive members). The significant difference between the projects can be found in their sizes. This extension is also considerably smaller than Case 1 and there are no big companies close to the site. Furthermore it has to be delivered within extremely short time.

The project was delivered through an EPC (more detailed in section 3.6) system, where the GC creates the feasibility study with Infineon's guidance and on Infineon's request it delivers the project from detailed design to construction. The main idea behind this was to accelerate the project by not wasting time with a tender and contracting. Furthermore it is useful that the GC already knows the project from creating the feasibility study and the concept itself.
After the board's approval, the design phase was lunched. The GC was responsible for the detailed design. In the construction Phase the GC was providing the services of a construction manager at risk (more detailed in section 3.3.1), the same way as the GC of Case 1. Another relevant difference is the lack of GMP. If it is possible Infineon usually attempts to have a cost cap, to secure the budget for the projects, but in this case the conceptual design was not detailed enough (not enough time to provide a detailed concept) to allow a GMP, therefore it was Infineon's and not the GC's risk and task to keep the budget. A GMP is an efficient tool, but the smaller size does not make it unconditional (for bigger projects, like Case 1 it is extremely important to have it).
For the better understanding of the participant's involvement in the project, figure 4.31 gives a good overview.

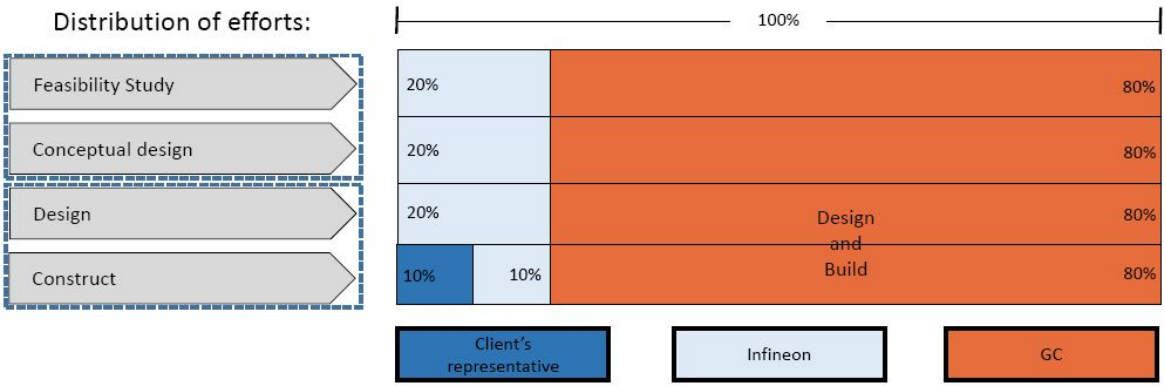


Figure 4.31: Case 3: Tasks/Phases

Work Packages

During the design phase the GC created the detailed design. To allow faster construction and to make the tendering and the cost control more efficient, the project is usually built up from WPs. The WPs in this case were fix packages, as they were for Case 1. Each of the packages had their own budget and were to be delivered by separate subcontractors. The GC was also delivering some of the packages, which resulted in some extra work for the owner to control the project efficiently. Finding the necessary subcontractors and selecting them through tendering was a major problem in this case, as the local companies were often un-qualified or too small and the bigger companies had no local settlements in the area.

4.3.2 Project Story

The idea of extending the existing capacities of this site was formed in 2011. This was in accordance with the development of the global economy of the past few years. The project started almost as a typical semiconductor project, with an extremely tight time schedule. Being an Infineon project, the typical method started with a feasibility study. The important feature of the site is that it is a small facility (the expansion is also considerably smaller than Case 1) furthermore, there are no big cities or big companies close by. The local companies were unfortunately not qualified to deliver the whole project as it was too complex and big for them and for bigger, international companies it was too small and too far away (furthermore there are not many companies capable of building such facilities). This is a problem for complex fast-track projects, as it is vital for the GC to have experience in delivering a project, therefore Infineon decided to choose a company (Company A-3) directly. Company A-3 knows the site well, has experience in working with Infineon and furthermore it hired two former employees of a big company (experienced in the semiconductor industry) who has the necessary experience and contacts for a successful project.

The feasibility study was completed by Company A-3 with Infineon's guidance and after the board's approval, Company A-3 was contracted to deliver the whole project as general contractor. The project had to deal with enormous pressure as there was extremely short time available. This caused Infineon to depart from its usual project delivery system as in this case the preliminary design was as well developed by the GC. The lack of time forced the client to sign an open-book cost plus contract with no guarantees of a GMP contract (there was no conceptual design detailed enough, to form a GMP).

In the design phase the requirements were specified by Infineon's specialists and the detailed design was developed by the GC concurrently with the construction. Already in the conceptual design phase, there was an underestimated problem. The site had to be purchased from another company, and the complexity of the agreement was beyond expectations, which resulted in a delay of 4 months. The former owner forced Infineon to solve many problems and disagreements that had nothing to do with this facility in exchange for the purchase agreement.

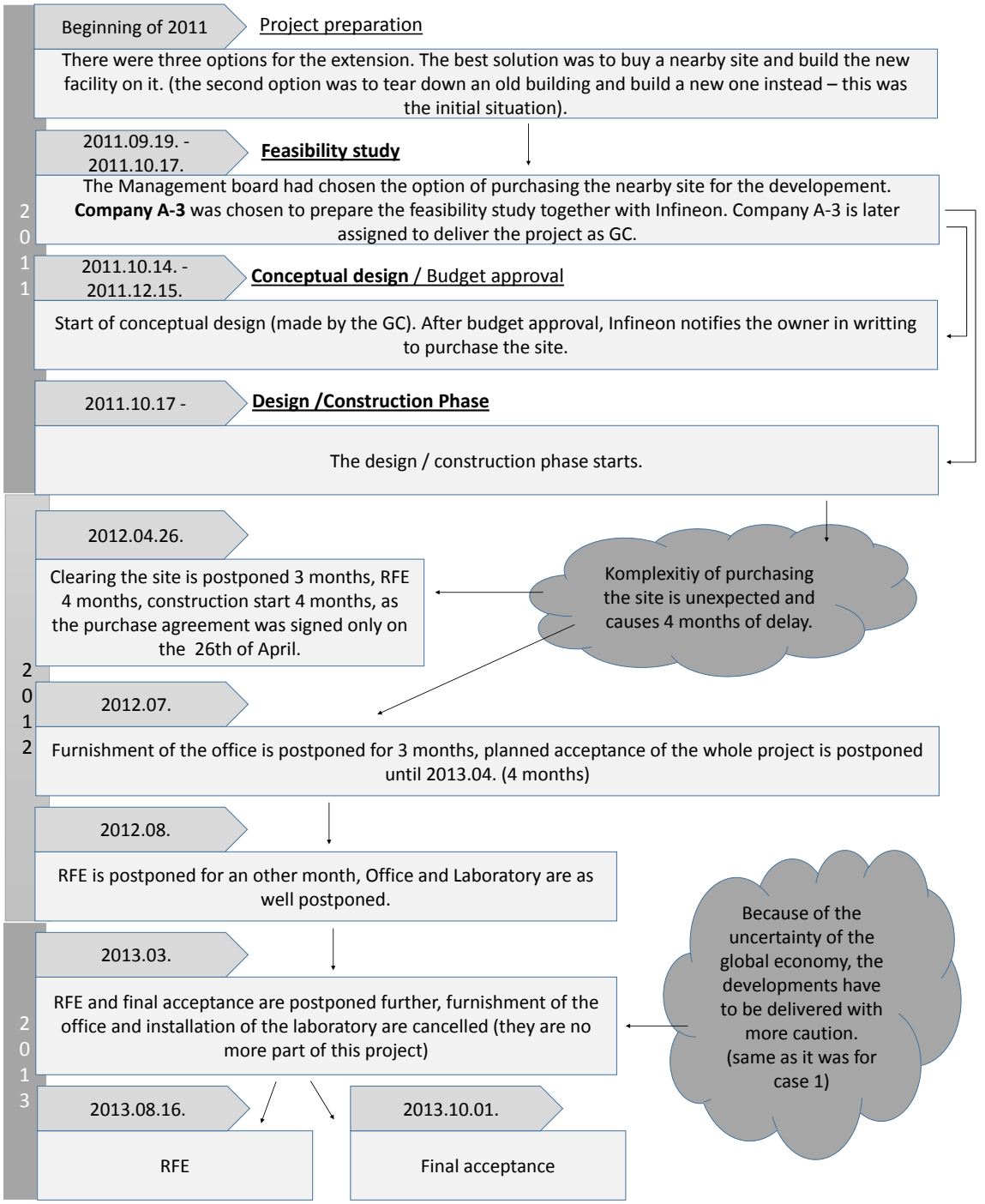


Figure 4.32: Case 3: Project Story

The already tight time schedule therefore had to be revised and the RFE was postponed for 4 months as well. Later on, as the project was running, the same problem occurred as in Case 1: slower development of the global economy. This meant that the RFE had to be no more as fast as possible. The main priority for the second part was the cost of the project rather than the time. The project took an other turn at the end. The deadline for final acceptance was postponed again in order to have a more balanced fiscal year (Infineon's expenses had to be better distributed), even though it meant extra costs.

4.3.3 Participants

The project was delivered with the same concept as Case 1, however there were compromises to be made. It would have been ideal to have a team delivering the feasibility study and the conceptual design and to have this very same team as the client's representative for the design-construction phase. This additional control team is most efficient if it participates in the project from the very beginning. In Case 3 the feasibility study and the conceptual design was delivered by the later GC because, among other factors there were enormous time pressure and an almost impossible deadline for the project.

Company A-3 was truly the general contractor. Tasks: feasibility study and conceptual design with Infineon together, Design, Construction as CM at risk.

Company B-3 was helping Infineon with controlling the GC's work in the construction phase.

The client's representative (Company A-3) took its role after the management board's approval for the construction phase. As this extension was considerably smaller and less complicated as Case 1, a smaller control team was enough.
First the GC was assigned to produce the feasibility study and conceptual design, which together formed the preliminary design phase. In the second phase the GC (Company A-3) was appointed to deliver the whole design-construction phase. The GC was chosen on behalf of having experience in working with Infineon and furthermore the GC contracted two former associates of a huge company with experience in the semiconductor industry, who could provide the necessary know-how and contacts for a successful project.

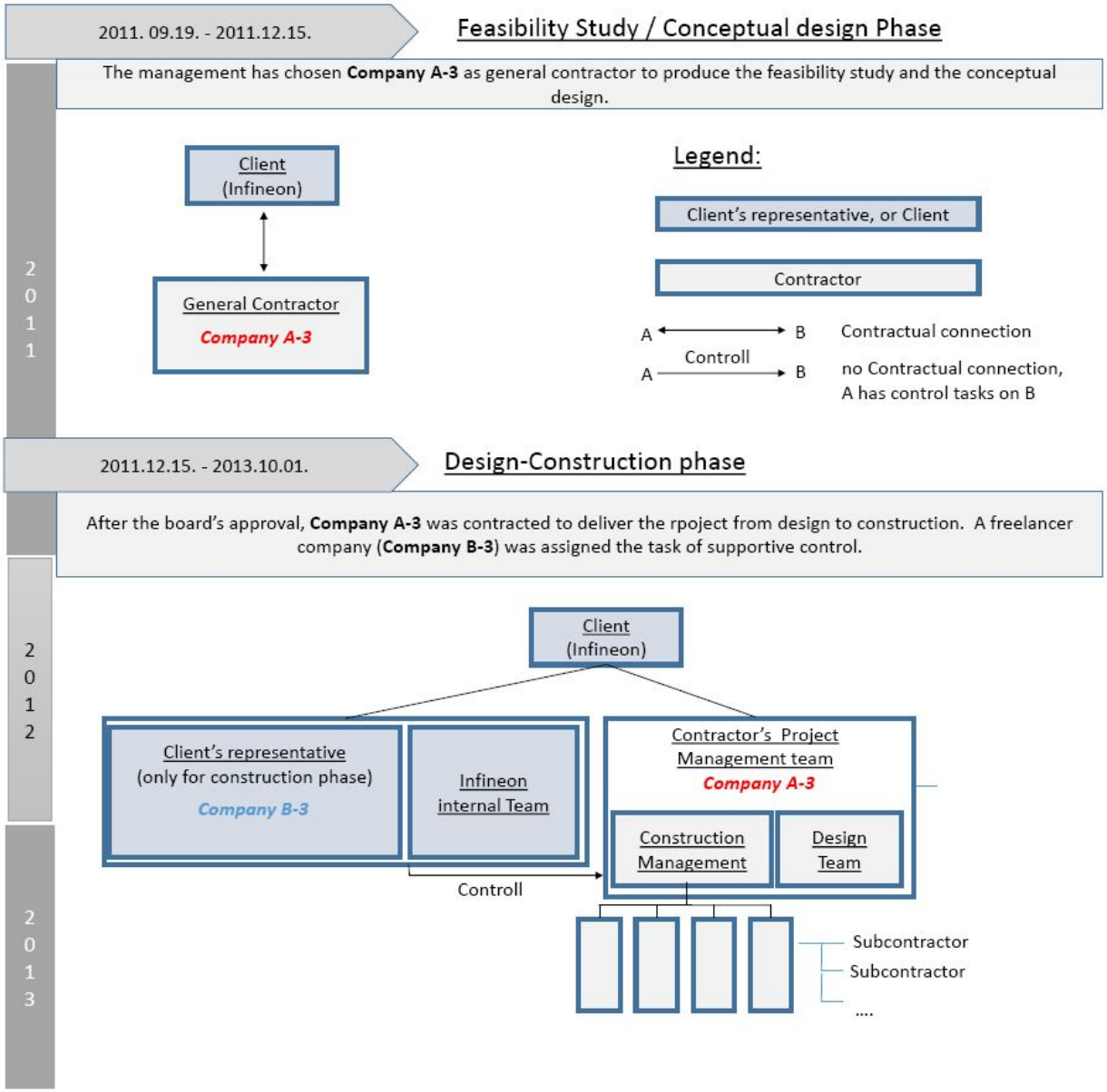


Figure 4.33: Case 3: Project participants

4.3.4 Costs

Budget

As it was mentioned in chapter 4.3.1, the budget certainty was Infineon's responsibility in this case. This project had to deal with many difficulties, as there was no time to prepare the concept and because there were internal problems. On the beginning, there was very short time to prepare an adequate design for a preliminary cost calculation to be submitted to the board for approval. Furthermore the production team added numerous changes to the production capacity, shortly after the approval that meant a significant growth in the costs, which needed further approvals. Further changes and delivery speed adjustments

altered the budget (budget development in figure 4.34) throughout the project even more. The speed of the project did not allow a detailed concept to be produced, therefore there was no GMP arranged. This in theory harms the cost certainty, but in this case the continuous changes would have changed the GMP price anyway, probably costing even more, as the risks would have been taken by the GC and not the client.

Budget development				
02.2011	57,8	Plan A	Old idea	Rough estimate (just parts)
08.2011	90,3	Plan A	Old idea	Concept study
09.2011	96,6	Plan B	New Site	Concept study (same content as the one before)
09.2011	**100,0**	**Plan B**	**New Site**	**+Concept study (same content as the one before) Compensatory mesures**
08.2012	108,0	Plan B	New Site	+Change in quality, Budgetcuts
07.2013	111,8	Plan B	New Site	+Longer construction

100% is the approved budget when the project started

Figure 4.34: Case 3: Budget development

Contract

The contract for the project was the typical cost plus contract, that was used for Case 1 as well. The participants agreed to the percentages in the beginning and than the project started. In this case, there were no separate Architecture & Engineering and Construction Management, but they were handled together. The contractor's fee was a certain percentage (shown in figure 4.35) of the overall costs and as the volume of this project is less than 1/5 of Case 1's, it should be and is higher on a percentage basis (1,5-2 % more).

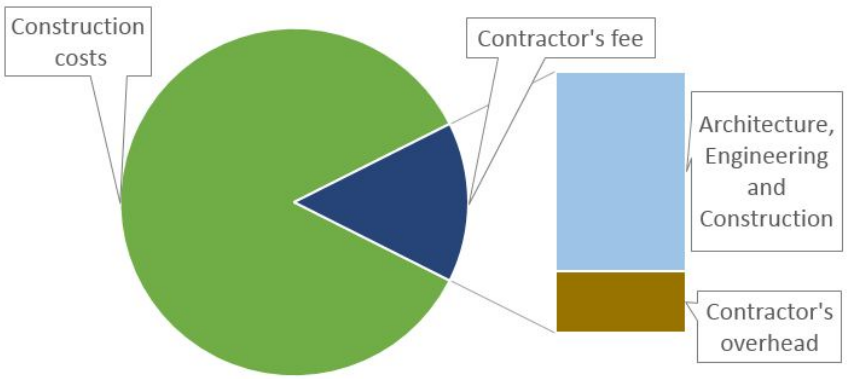


Figure 4.35: Case 3: Contractor's fee

4.3.5 Open ended interviews

Interviewees

The open ended interviews were made with four participants, shown in figure 4.36. A translated summary for each of the interviews will be presented in this section.

	Position	Company	Gender	Age	Experience (years)	Date of interview
Person C3-1	Commercial PL	Infineon	female	50	over 10	28.01.2016
Person C3-2	PL for construction	Infineon	male	41	over 10	01.02.2016 and 04.02.2016
Person C3-3	Commercial PL	Infineon	male	49	over 10	05.02.2016
Person C3-4	Client's representative	Company B-3	male	49	over 10	18.02.2016

Figure 4.36: Case 3: Interviewees

Interview with Person C3-1

Construction and Design

What were the most important criteria in choosing the project participants?
Important to have the technical know-how, management qualities and the appropriate soft-skills, such as good communication and conflict management.

How good/bad was the communication and teamwork between project participants? (Construction and design as well)
It was good. Naturally it is different for every project, it always depends on the people. For the contractor, this field might have been somewhat new, for example Company A-1 would have been more familiar with a project like this (and more expensive as well).

Were you satisfied with the quality of the conceptual design?
The initial situation was far from perfect. There were not enough specifications from the production team and the demand was not defined precisely, which led to some expensive changes. From this point of view, Case 1 was more efficient. It was difficult, as there was enormous time pressure on the project, therefore there was no other choice, but to ask Company A-3 directly to deliver the project. Normally the choice would have been made on the basis of the feasibility study and the submitted bids. Unfortunately there was no time for tender.

Conflicts?
There were conflicts naturally. The available time until the deadline was extremely short. Furthermore the undefined user requirements caused big changes in the budget, which had to be approved.

Contract type

Why has Infineon chosen this contract type and delivery method for this project?
A traditional DBB project with multiple contracts is simply too much work for these projects, therefore it is more typical to have a general contractor.

What is important for this contract type and delivery method? (requirements)
It is important to have enough time to produce a conceptual design and the documentation for the tender, to receive competitive bids. The conceptual design does not have the quality of a preliminary design, but it is more detailed in technical topics. For a typical GMP open book contract, it is important to trust the GC (Infineon and Company A-3 has a long history of working together). This project had an open book cost plus contract, as there was no conceptual design detailed enough to form a GMP contract. The lack of time made Infineon just build the project because there was not enough time for design.

How much flexibility did the contract type allow?
Infineon attempts to use a contract that is flexible from the start.

What was important for you in the project?
To reach the project goals in time, in budget. There are naturally always problems as well, but they have to be solved. Most of the problems however are eliminated by the correct choice of contractor. Infineon chooses a partner that can work well in a team, have the "chemistry" towards Infineon's team and furthermore the GC has to be competent and good at solving problems.

Were you satisfied with the chosen contract type?
Yes!

Please rank the following after their importance: Time-, Cost-, Quality certainty, length of time, Costs.
It always depends on the project. For Case 3, the most important was the length of time. 2.: time certainty, 3.: Budget certainty, 4.: Quality certainty, 5.: Budget

Please explain what the following words mean for you and evaluate them. The most important gets 1, the least important gets 4. Teamwork, Reliability, Motivation, Creativity.
It is extremely important to have good teamwork. For Case 3, there was efficient teamwork. Motivation is also important, however it is hard to keep everyone motivated for longer projects. Reliability is also a key success factor and creativity can also be important, if it supports the problem solving competence.

General questions

Please identify the most relevant problems.
It is unfortunate if the user can not provide the necessary requirements in time.

Please identify the most important benefits.
Cost plus contract provides a good opportunity for cost savings.

Please suggest any ideas for improving the process.
The delivery model and contract type used for Case 1 is very efficient. That model could be applied for future projects. The client's representatives were very efficient for Case 1, it provided good counterbalance to the GC.

The most relevant positive and negative factors mentioned by the interviewed person are summarized below, in figure 4.37 :

Project-specific evaluation: Case 3		
Person C3-1		
Positive +	Neutral/Remarks /	Negative -
Communication and teamwork was good	Important to have the necessary know-how, management qualities, soft skills and communcation	Initial situation was far from perfect
Good chemistry	Important to have enough time for conceptual design and tender docmentation	Many expensive modification and they needed approval
Open book cost plus is flexible	Communication is important	Enormous time pressure
	Trust between the GC and Owner is important	Not enough specifications from production team. (caused problems and expensive changes)
Cost plus provides a good opportunity for cost savings	Time pressure made Infineon choose this delivery method.	
	Case 1 has a very efficient client's team. (the model used for case 1 should be used in the future)	
	Many problems can be eliminated by choosing the correct GC	

Figure 4.37: Case 3: Open ended Interview with Person C3-1 (Commercial Project leader)

Interview with Person C3-2

Construction and Design

What were the most important criteria in choosing the project participants?
The most important factors were the following: professional competence, work experience and the ability to work as a team.

How good/bad was the communication and teamwork between project participants? (Construction and design as well)
It was good with the GC and with the subcontractors as well. There was running communication and ongoing teamwork.
The cooperation between the local- and central teams was good as well, however there is room for improvements.

Were you satisfied with the quality of the conceptual design?
Principally it was fine. The time available was very short, it was the best that could be made in such a short period of time.

Conflicts?
There were some conflicts, for example purchasing the site was very complicated. There were old problems, that had to be solved. They had nothing to do with this project, but the time pressure of the project made Infineon accept these extra tasks.
There was also the question of stopping or still delivering the building, but the project was already too far ahead to stop it. Furthermore an important member of the team also left. It was an unusual project, but part of the team and the GC tried to identify the actual project goals and the expectations to still deliver the facility.

Contract type

Why has Infineon chosen this contract type and delivery method for this project?
Accelerating the project was the most important criteria and it caused deviation from a typical process. The GC was chosen on behalf of having experience with Infineon and the site, furthermore there was mutual trust between the companies. It was important to have a preferably flexible contract as the project aims were not clearly specified. The lack of conceptual design did not make a GMP possible, therefore a simple open book, cost plus contract was signed.
The best choice was to describe the necessary performance on the basis of the feasibility study and to have the facility be built. It has to be mentioned, that there are only few companies capable of delivering semiconductor projects (it is a special real estate).

What is important for this contract type and delivery method? (requirements)
Clear description of the project aims, sufficient budget. The costs can be adjusted with different quality requirements, vice versa.

How much flexibility did the contract type allow?
Open book offers enough flexibility and transparency, even so it does not offer the flexibility of a DBB project with multiple contractors.

Did the contract type and delivery method satisfied your expectations?
It was expected from the management to support the project with clear and punctual decisions. Furthermore the demand for a fast project development normally assumes all of the intern participants to go along the same lines, which was not the case.

Were you satisfied with the chosen contract type?
Ideal would have been the delivery method applied for Case 1: two companies producing the conceptual design that serves as basis for the GC tender. This specialist team is also better at balancing the GC in the construction phase.
Everyone wants to have the best for their site preferably without the interference from the central. Furthermore if the project aim is clearly described by the client's team in the conceptual design phase, the tender is more efficient in choosing the most appropriate partner. Finding suitable subcontractors was also difficult and a specialist client's team could provide useful support in this matter as well.

Please rank the following after their importance: Time-, Cost-, Quality certainty, length of time, Costs.
For Case 3, the length of time was the most important criteria. 2. Cost certainty, Quality depends on the region, in Asia quality control is more important than it is in Europe. It is hard to evaluate time certainty, as inexperienced people think that it can run faster (length of time matters).

Please explain what the following words mean for you and evaluate them. The most important gets 1, the least important gets 4. Teamwork, Reliability, Motivation, Creativity.
Teamwork (1) is crucial. It is favourable if there is a whole team with the overall project leader and the client In the beginning, every participant was highly motivated (2). For the GC it was a pioneer project, they wanted to do a good job, the local team wanted to have a new production facility and the central team wanted to have a good project as well. It was a nice project: some laboratory, some office and some production.
Reliability (1) is also a key feature. The GC was generally good, however there was no real pressure on them, as the deadlines were postponed really early.
Creativity (4) was important in finding solutions (for example for the extremely compli-

cated purchase agreement). Creativity with pioneering spirit is most useful (applying new technical solutions).

General questions

Please identify the most relevant problems.

Incomplete documentation sent to management board for approval. The scope was not clearly described.

The demand reduced during the project, but it was already too far developed to stop it.

Please identify the most important benefits.

Despite the circumstances, a small central team still delivered a successful project (and managed to find a capable company for the realisation).

Please suggest any ideas for improving the process.

Clearer parameters for the board's approval and a better feasibility study would have helped the project. The chosen delivery method was the only choice for such extreme time pressure, however it is better to have an independent (from the GC) designer team to produce the conceptual design in collaboration with the production team and the local team. After that, choosing the GC is usually more efficient.

Please share you experience about time-, quality- and cost control for this project.

The premature approval resulted in a minimal cost overrun (partly because of additional performance). It was translated by the management more negatively, than it should have been.

Even though the deadlines were absolute unrealistic, the team still found an appropriate model for fast project development. Unfortunately getting from project idea to project start consumed too much time (it could have been used more efficiently).

Please share you experience about negative or positive factors in this project.

An important experience was to see the contrast between local and central, it can be useful in the future.

The most relevant positive and negative factors mentioned by the interviewed person are summarized below, in figure 4.38 :

Project-specific evaluation: Case 3		
Person C3-2		
Positive +	Neutral/Remarks /	Negative -
Good teamwork with the GC and Subcontractors	Important: the clear definition of project aims	Not enough support from upper management
Mutual trust	Important to have a sufficient budget (costs can be adjusted with Quality)	No clear goals and aims.
Flexible contract and Good transparency		
The team has still found an appropriate modell for such unrealistic deadlines	Important for members: competence, experience, teamwork	Not perfect intern teamwork (Local - Intern)
		Incomplete documentation for board's approval
The GC turned out to be a good partner	Few companies are capable of delivering semi-conductor projects	Lack of detailed concept did not allow a GMP (no cost cap)
	Conceptual design was adequate, despite the lack of time	Valuable time lost beween project idea and project start
	Specialist client's team (like for case 1) is very useful + serves as a good counterbalance in the constructtion phase	Purchasing the site was complicated (old conflicts and the time pressure caused extra costs)

Figure 4.38: Case 3: Open ended Interview with Person C3-2 (Project leader for construction)

Interview with Person C3-3

Construction and Design

What were the most important criteria in choosing the project participants?
Naturally important for the project members to be competent Furthermore it was important for them to have experience in the semiconductor industry. It is also crucial that the participants trust each other, as the project had to run fast with a high quality.

How good/bad was the communication and teamwork between project participants? (Construction and design as well)
There was a confident relationship between the members. There were design workshops to put forth the basics for the project and there was also regular information exchange. All in all, there was good communication and teamwork.

Were you satisfied with the quality of the conceptual design?
Even though the time for the conceptual design was limited, it was still a decent design. The GC designed according to the requirements Infineon provided. It was however an inconvenience, that the local team included many expensive changes after the preliminary design phase. Case 1 had many change orders as well, but they were generated by the requirement alteration, they were not known in the conceptual design phase. The changes of Case 1 were typical for the semiconductor industry.

Conflicts?
There were unfortunately in-house (Infineon) conflicts. The project started with an incredibly ambitious schedule with various arrangements for further acceleration, which later had to be well restrained to run significantly slower, than it had to run faster again. If you accelerate a project, it has certain costs (for example: night shift) and slowing it down does not necessarily mean lower costs as well. Longer construction time means that the crew and the equipment have to stay longer on the site. In this case, there were no conflicts with the GC, it accelerated the construction if it was necessary and it delayed the progress, if it was desired. There was however a disagreement between the local and the central management. The central management ordered the project to slow down, however the local management was supposed to be charged with the extra expenses of slowing it down. At the very end, slowing it down did not cause significant increase in the cost but the experience of the disputes remained.

Contract type

Why has Infineon chosen this contract type and delivery method for this project?
Many projects were developed with Open book cost plus approach with a GMP and it had shown good results, the teams were usually satisfied with it. In Case 3 there was no GMP, but the project development was still the same. Only the cap (keeping the budget was therefore Infineon's task) was missing and the overall costs unfortunately exceeded the budget. All in all Infineon has positive experience with this contract, especially with the transparency. This type only works in an environment with mutual trust. Further decisive factors are the people, who have to work together. Naturally the first priority for everyone is the interest of their own company, but it is crucial that the "chemistry" is correct: the participants have to work together for the same goal.

What is important for this contract type and delivery method? (requirements)
As it was mentioned above: trust, working together for the same goal, the people. Naturally not everything is black and white, it is not a model of harmony. There are plenty of arguments about the changes: what is the difference between design development or change order.

How much flexibility did the contract type allow?
Open book contract has an important advantage: it does not allow background games (high transparency). The bidder list can be influenced by Infineon (removing companies, or awarding preferred bidders).
The tender and the whole project can be influenced by Infineon if it is desired, therefore it is flexible enough for these Projects.

Did the contract type and delivery method satisfy your expectations?
To deliver the project in time (or even faster, if it has to), with high quality within the budget. There are often changes in a typical semiconductor project, you have to be prepared for that. There were almost no projects which was not asked if it can run faster or slower.

Were you satisfied with the chosen contract type?
Yes, the project was transparent, the delivery was uncomplicated and the team always found a solution for the problems.

Please rank the following after their importance: Time-, Cost-, Quality certainty, length of time, Costs.
Case 3 had big time uncertainty, caused by Infineon. First to accelerate the project, than to slow it down: it was a strong deviation from the original plans. If the original time plan would have stayed, there would have been better time certainty. It was an internal problem, the GC provided the necessary time certainty.
Cost certainty was the same. There was an original budget that was sufficient, but the additional requirements, accelerating the project, than slowing it down however meant extra costs that led to cost uncertainty (also internal problem).
The quality certainty was the opposite. Slower project development can increase the quality, therefore the quality certainty was better.

Please explain what the following words mean for you and evaluate them. The most important gets 1, the least important gets 4. Teamwork, Reliability, Motivation, Creativity.
Teamwork (1) is very important, with the GC and internal as well. It is desirable, that the participants trust each other and work together hand in hand. The support from the central was not enough in this case (Case 1 had good support from upper management), the team was sometimes left alone. The external teamwork with the GCs was for both cases very effective, both of them were good partners.
Motivation (basic requirement) is something that has to be there.
Reliability (2) is also important, especially when the project has to run fast, for example: to transfer the right information. Another positive factor of the open book is that it helps to discover potential mistakes.
Creativity is an interesting factor. The design is defined precisely. Creativity often means changes, which has cost consequences, therefore it can be disadvantages. ("I would rather have people be less creative and just do what is planned. We are not making art, it has to be fully functional.").

General questions
Please identify the most relevant problems.
Most of the problems were internal. If the GC is good, it does what it is told to do, there are relatively few problems. There are always conflicts, but this is the nature of the projects. The serious problems are the internal problems: additional requirements, accelerating than slowing it down.

Please identify the most important benefits.
There are lessons to be learned from every project. An important potential would have been to know the requirements and variables. Furthermore the lack of support from the upper management was also a problem. Considering it is an ongoing but slow process.

Please suggest any ideas for improving the process.
You have a project plan: time and quality and you just deliver the project with no changes. Unfortunately however the semiconductor industry does not work like that. A relevant problem is that there is always a time plan with an estimated phase for the board's approval and with a fix RfE. If however the board needs 2 months more for the approval, the RfE still stays the same. It is a serious problem for fast track projects, which are already accelerated in the preliminary design phase. Faster decision making could turn out to be useful in the future.

Please share you experience about time-, quality- and cost control for this project.
Additionally: it is positive that the open book allows good transparency and possibility for cost savings.

The most relevant positive and negative factors mentioned by the interviewed person are summarized below, in figure 4.39 :

Project-specific evaluation: Case 3		
Person C3-3		
Positive +	Neutral/Remarks /	Negative -
Good communication and teamwork	Important for participants: competent, experienced, mutual trust	Not well detailed requirements from local team
Open book cost plus with GMP is good contract form (chance for cost savings)	Important for model: good people, good chemistry, teamwork	Many changes soon after board's approval (requirement should be better considered)
High transparency, enough flexibility	Participants have to work together	In-house conflicts (Local - Central)
The GC was a good partner	Faster decisionmaking coud be useful (upper management)	Not enough support from central
Open book (transparenc helps to discover problems)	No GMP -> keeping the budget is Infineon's task	It is not a model of harmony

Figure 4.39: Case 3: Open ended Interview with Person C3-3 (Commercial Project leader)

Interview with Person C3-4

Construction and Design

What were the most important criteria in choosing the project participants?
The most important criteria was the professional qualifications and that the tasks were precisely defined.

How good/bad was the communication and teamwork between project participants? (Construction and design as well)
The team was sitting in the same room, furthermore there was a meeting every morning. Communication and teamwork was very good with Infineon, the GC and with the subcontractors as well.

Were you satisfied with the quality of the conceptual design?
Yes, it was well structured.

Conflicts?
There were no big conflicts. A big exception was the trouble caused by the site, which had to be purchased. The owner made the negotiations very difficult.

Contract type

Why has Infineon chosen this contract type and delivery method for this project?
It was a cost- and time driven project. The most important criteria was to keep the expenses inside the budget and to finish the project in time.

What is important for this contract type and delivery method? (requirements)
To have professionals in the team, who are familiar with the semiconductor industry. The only extraordinary factor in the project was the biotope on site and the extra task to deal with nature preservation.

How much flexibility did the contract type allow?
The office was removed from the project in order to keep the budget and for better utilization.
As long as there are no changes, this method has high cost certainty. If the scope is changed, the price can change with the deadlines. Furthermore if the GC is delayed, there are penalties to be paid, but the modifications will soften the penalties and the deadlines as well.

Were you satisfied with the chosen contract type?
The budget and the deadlines were well arranged, the system was good.

Please rank the following after their importance: Time-, Cost-, Quality certainty, length of time, Costs.
As the client's representative, the certainty of the quality has to be the most important. The second and third are Time- and Cost certainties, depending on the actual project.

Please explain what the following words mean for you and evaluate them. The most important gets 1, the least important gets 4. Teamwork, Reliability, Motivation, Creativity.
Motivation is the most important, as unmotivated staff can not do anything and unmotivated partner can not be helped with even the most efficient contracts and models. Motivated people doing what they are told to do, can achieve many things ("with that, you can win a war").
Second is reliability, to have the necessary know-how and third is teamwork.
And last, creativity is important for problem solving.

General questions
Please identify the most relevant problems.
The counterpart of the original owner of the site. He made the arrangement extremely difficult, but working perfectly as a team, sharing the tasks and supporting each other helped Infineon to overcome this problem.
An other time consuming and expensive difficulty was the biotope. It had to be dealt with, but it meant significant extra effort.
It was inconvenient, that the local staff saw competition in the central team instead of working together. It often happens, that local teams do not necessarily like people from the central, who are sent to them, as they are used to their locally developed structure and want no interference. It was however necessary, as it was not a small development, but a big extension in which the local team had no experience. There are rules to be kept, which the local team is unfamiliar with.

Please identify the most important benefits.
The tasks were divided efficiently (and clearly), there was unity in the team which meant good teamwork. The team was open and fair and was always available, if a question occurred.

Please share you experience about time-, quality- and cost control for this project.
Person C3-4 was responsible for quality and time (on site), while the cost control was internal Infineon task. 80 % of the work was to control the GC, it was normal.

The most relevant positive and negative factors mentioned by the interviewed person are summarized below, in figure 4.40 :

Project-specific evaluation: Case 3		
Person C3-4		
Positive +	Neutral/Remarks /	Negative -
Very good communication and teamwork.	Important for participants: professioal qualifications	Difficult to reach purchase agreement
	Important: precisely defined tasks, professional experience	Changes can soften penalties and deadlines
Open and fair team allowed good problemsolving	Important: experience in the semi condutor industry	Biotop was time consuming and expensive
	Time and budget was the leading factors	Local - Central relations could be improved (local should accepct help and not see competition in the central team over certain project size)
	If there is no change, the model has high cost sertainty	

Figure 4.40: Case 3: Open ended Interview with Person C3-4 (Client's representative)

4.3.6 Case 3 results

Project-specific evaluation: Case 3			
Person C3-1, C3-2, C3-3, C3-4			
Positive		Negative	
+		-	
Communication and teamwork was good	1 2 3 4	Not enough specifications from production team, not detailed enough. (Many changes soon after board's approval, caused problems and expensive changes)	1 2 3
Open book cost plus is flexible enough	1 2 3	In-house conflicts (Local - Central)	2 3 4
Good transparency	2 3	Not enough support from HQ	2 3
The GC was a good partner	2 3	Purchasing the site was complicated (old conflicts and the time pressure caused extra costs)	2 3
Cost plus provides a good opportunity for cost savings	1	Initial situation was far from perfect	1
		Enormous time pressure	1
Mutual trust	2	Biotop was time consuming and expensive	4
The team has still found an appropriate modell for such unrealistic deadlines	2	Valuable time lost beween project idea and project start	2
Open book cost with GMP is good	3	No clear goals and aims.	2
Open book (transparency helps to discover problems)	3	Overall project leader was not experienced enough	2
Open and fair team allowed good problemsolving	4	It is not a model of harmony	3
		Changes can soften penalties and deadlines	4

Neutral/Important comments	
Participants: know-how and experience	1 2 3 4
Participants: mutual trust	1 3
Participants: Teamwork	2 3
Important: the clear definition of project aims	2 4
Specialist client's team (like for case 1) is very useful + serves as a good counterbalance in the constructtion phase	1 2
Time pressure made Infineon choose this delivery method.	1
Case 1 has a very efficient client's team. (the model used for case 1 should be used in the future)	1
Many problems can be elinimated by choosing the correct GC	1
Important to have enough time for conceptual design and tender docmentation	1
Conceptual design was adequate, despite the lack of time	2
Few companies are capable of delivering semi-conductor projects	2
Lack of detailed concept did not allow a GMP (no cost cap)	2
Faster decisionmaking coud be useful (upper management)	3
No GMP -> keeping the budget is Infineon's task	3
Important: experience in the semi condutor industry	4
If there is no change, the model has high cost certainty	4

Figure 4.41: Case 3: Summary of the open ended interviews

Chapter 5

Conclusions

The collected information, interviews and documents support the assumption that Infineon has two main project delivery models for its fast track projects. The study will call them GMP Model (GMPM) and Traditional Model (TM) and the this chapter will summarise and compare their most important features. The two models have many common features (both are fast track projects, same phases, similar organigrams and the use of CM), but they have completely different risk allocation. Each of the systems can be applied for delivering a new facility, but the more the project is out of the model's "comfort zone", the more adjustments have to be made.

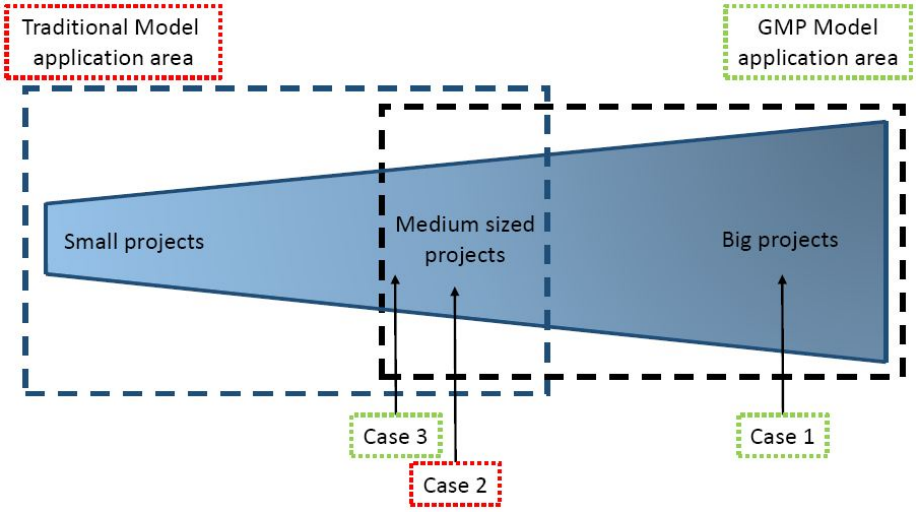


Figure 5.1: Effective application area

As the figure suggests, the size of the projects can also influence the effectiveness of the models. Both of the models are applicable for any project, but their effectiveness may decreases, if they are out of their comfort zone, resulting in extra costs.
Bigger sites and regional HQs tend to use the Traditional Model for medium sized projects as well while the smaller sites lack of experience in delivering bigger projects make them use the GMP Model even for smaller (still over 10 Mio euros) projects with support from the central.

5.1 GMP Model (GMPM)

This is the model applied for Case 1 and Case 3. The pure model was used for Case 1 and a modified method was applied for Case 3. The idea of the model is to deliver a big and complex project with cost guarantees, controlled by a team from the HQ that has the necessary authority and experience.
It is most effective for big and complex projects all around the world. The main difficulty is to find an appropriate GC and experienced and trusted representative, who can provide technical and region-wise knowledge.

5.1.1 Typical contract type

The used contract form is an open book cost plus contract with GMP. The beginning is crucial as the conceptual design is the base of the project. Any lack of information or any mistake can cause extra costs or delays, therefore it has to be prepared well.

This type provides enough **flexibility** for the project. The amounts of the quality can be adjusted easily, while bigger scope changes are possible as well by change orders. The disadvantage of the scope change is that it has negative effects on the budget and it has influence on time as well (it can soften up the deadlines). Preventing unnecessary delays and extra costs, the client and the client's representatives have to be good at arguments (and have to have the necessary technical knowledge to support the arguments). Conflicts are caused be the GC trying to raise the budget (for extra profit and as the subcontractors are also trying to increase the costs).

A **cost plus contract** is built up from two main parts. First is the direct costs: It is the flexible part, it is the cost of the WPs delivered by various subcontractors (this cost can be influenced during the project).
The second part is the fix costs: it is negotiated with the GC in the beginning as it defines the GC's fees (Design costs, Construction management and contractor's overhead). It is a certain percent of the construction costs.

The **GMP** and the shared gains have multiple purposes. First and most importantly they motivate the contractor to work efficiently and to provide value for money as they can gain from the savings, furthermore the cost control is no more Infineon's task (this risk naturally has a certain cost).

The **open book** is also non negligible, it provides excellent transparency, good flexibility and allows Infineon to discover the hidden cost (they can be limited during the negotiations). It also allows the GC, the client and its representatives to work in closer cooperation (it is however not a *"model of harmony"*, there are a lot of arguments caused by costs and change orders).

The weak point of the GMP is difficult to handle. It is a fast track project and there is not enough time for the concept. Furthermore, the scope is modified or often changed, which has an impact on the GMP (can go higher) and it might loosen up the guarantee for time as well. One of the most important role of the client's team (Infineon's internal team and the client's representatives), is to deal with these problems during the whole project and not to let the GC raise the budget too much (the cost of the change should stay at the current market price).

5.1.2 Risk allocation

The model transfers most of the risks on to the contractor. The responsibility to complete the project in time is completely the contractor's risk. The open book GMP not only forces the GC to work efficiently but it makes the GC responsible for costs as well, while confining the effect of the modification and change orders. If the GMP is exceeded, it is the GC's cost.

5.1.3 Typical organigram

The project can not be described with only one organigram, it is different in the conceptual design phase and in the Design-Build phase.

Conceptual design phase

The conceptual design phase is an essential phase for both of the models, but this model depends on a precise design even more, as the scope defines the project, contract, budget and the GMP (therefore a good concept can save a lot of unnecessarily spent money and unnecessary delays).
The concept is usually developed by Infineon and the client's representatives together. In the Design- Build phase this team will control the GC on Infineon's behalf. Therefore, it is crucial that the team is experienced and can work together perfectly.

As these projects always have great time pressure, there is never enough time for a perfect concept. Three or four months could be enough, but it usually has to be done in two months, which means that it has to be extremely efficient. The main difficulty of this phase is to collect all of the needs from the numerous parties involved as fast as possible. The internal team has to work together and they have to understand each other, while the external team (Client's team) has to work in harmony (it can be built up from multiple companies) and have to provide the experience and know-how for the project execution.
The client's representatives of the design-construction phase is technically a contractor in this phase, but it will be on the client's side later on.

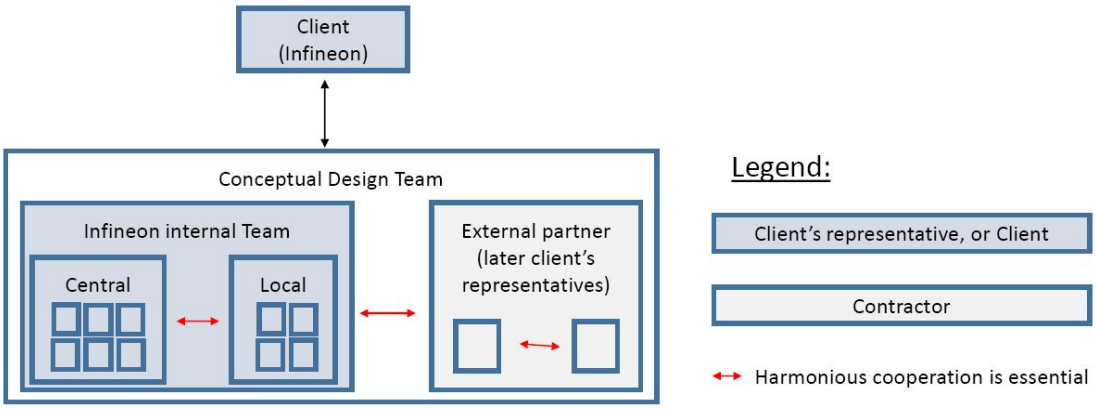


Figure 5.2: Conceptual design phase

Design - Build phase

The project is controlled by the team on the client's side. The project lead is usually provided by the central with support from the local team (for example the team responsible for operation). The most important partner for the client are the client's representatives. It is the external, well experienced, professional team, that provides the necessary know-how and capacity for Infineon to control the project often far away from the central. The design is developed by the GC with support and guidance from the client's team.

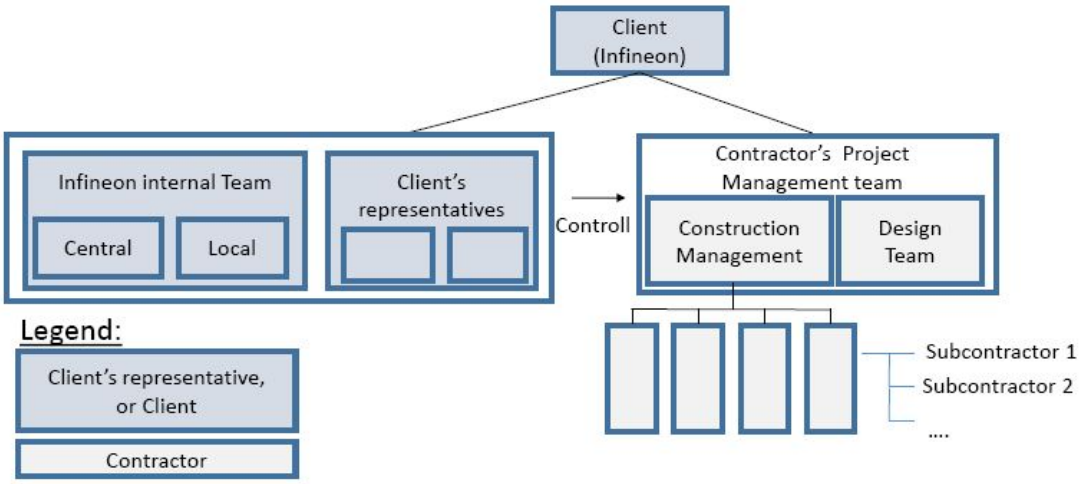


Figure 5.3: Design - Build phase

In the construction phase the GC provides CM services (CM at risk), as the WPs are to be delivered by independent subcontractors. The bidders for the WPs are collected by the GC (Infineon can suggest any subcontractor) and the most appropriate companies are chosen together (GC, Infineon and client's representatives) however, the final decision

is Infineon's. After this, controlling and managing them is the GC's task. The WPs are to be developed by subcontractors, who have no connection to the GC. If the GC wants to keep a WP for itself, Infineon has to approve it first, as this means that it has to be controlled by the client and it results in more management tasks (and can result in extra costs) for the client.

For the whole project the GC takes the responsibility for delivering the building in time within budget. This risk has a certain price, but in return, Infineon is granted a guaranteed maximum price and a fix deadline for the project. It is very positive as most of the risks are managed by the GC, therefore a smaller team is necessary on the client's side (however the effectiveness depends on how precise and well developed the conceptual design is and on how good the client's team is during negotiations throughout the project).

Application area

The model can be applied anywhere, but finding the appropriate GC and client's representatives (if there is no staff experienced enough on site) is a key factor for success. As all the responsibilities are in the GC's hand, the project has some extra costs, but in exchange, Infineon can have a project delivered with a significantly smaller internal team. The model in this form is set for big and complex projects, but it can be modified (for example for higher time pressure) to meet the requirements of any other project, therefore it can be applied for smaller projects as well.

5.1.4 Ideas for improvement

Necessary improvements

- Conceptual design phase: more efficient information flow for the concept. Collecting the requirements should be smoother and faster (standardisation or help from management)
- Local operation team should be involved from the beginning (their representation has to be under control: negotiation between the project and production people)
- A well prepared conceptual design should have high priority (enough time, or a more efficient information flow to collect all the necessary input from the different departments as many things depend on the concept)

Further ideas

- Local operation team should be involved from the beginning (through a representative who can negotiate between project and operation. Main requirement is the

perfect negotiation and argumentation skill and to understand both project and both operation culture)

- If there is experienced staff on site (which is the requirement for the other method), this team can take the role of the client's representatives, however this team has to understand the differences (completely different risk allocation and the need for teamwork with the GC)

5.1.5 Most important negative and positive factors

The following table (5.1) collects the most important factors of the model according to the literature and the open ended interviews.

EPC (mixture of DB and CM at risk) completed with informations from the interviews	
+	-
Peforms well with cost restrictions (cost cap possible earlier)	Loss of control over design
Ideal for fast track projects (overlapping phases)	Insufficient scope can increase the costs
Responsibilities in one hand (less conflicts for the client)	Total risk on contractor increases the price
Early cost commitment gives the owner project cost certainty	Size may reduce the number of qualified bidders
Constructor's input on design	Early pricing is risky with lump sum
Needs and supports good teamwork, communicaton and mutual trust	Fewer but more experienced staff needed on site
Open book GMP is perfect for big complicated projects	Difficult, when there are many modifications from the client
Open book GMP provides good flexibility and transparency	INFINEON own problem: information exchange is complicated
Works well with external subcontractors	Contract type is not common in the EU
GMP's shared savings is incentive	

Crucial factors:
It is important to create a clear and detailed scope
Concept not detailed enough and change orders can increase the price
Important for the client to have a staff suited for the project
Important to balance the needs with the budget

Mentioned in the literature
Additional information from the Interviews

Figure 5.4: GMP model: Positive/Negative

5.2 Traditional Model (TM)

This is the model applied for Case 2. It is the traditional way of project delivery, with its benefits and drawbacks. The project is controlled by the client through the whole project, all the other participants are on the same level (subcontractors). The main advantage is the even higher flexibility, independence from big companies and the highest chance for reasonable costs.
The biggest disadvantage is that the client takes the responsibility for project success, by taking the risk for cost and time. To control the project, Infineon needs an internal team big enough and experienced enough (familiar with a project with this size, have region wise knowledge and know how Infineon works), therefore the size of the site determines the maximal size of the new project this model is appropriate for. Therefore, it is most appropriate for small or medium sized projects.

5.2.1 Typical contract type

This model has to manage many contracts, as Infineon is responsible for every contract from designer team to the subcontractors in the construction phase. The most important contract is the contract signed with the overall designer. This participant is not only responsible for the whole design, but it normally provides CM agency services(supervision of the construction, site management, cost/time tracking) to the client. It has similarities with GC of the other model, but the main difference is the taken risks and amount of control over the project.
Fpr the design phase, it is a lump sum contract that provides some soft guarantee to the client, as it does not go higher irrespectively of how long or difficult the design phase is.
Open book is not necessary as it is a lump sum contract for the overall designer and the costs in the construction phase is managed by the client itself (with help from the CM). A GMP is also not negotiated, as it does not work with this risk allocation.
The construction phase uses an open book cost plus contract. This works good with the CM agency.

5.2.2 Risk allocation

Infineon takes the risk for time and costs in this model making changes less complicated, but radical changes (stopping the project) is not as easy as it is with the other model after signing the lump sum contract with the overall designer.

5.2.3 Typical organigram

The project can not be described with only one organigram, it is different in the conceptual design phase and in the Design-Build phase.

Conceptual design phase

The conceptual design is the base of the design and it is used for the overall designer tender as well. It is developed in the same way as it is for the GMPM: Internal Infineon team working together with a highly experienced team in close cooperation(see figure 5.2). The other purpose of the concept is to set the budget for the project, therefore it is vital to define precisely the requirements. Not precise enough concept result in an insufficient budget, which leads to unnecessary delays and costs.

Design - Build phase

The design is developed by an overall designer. As the design is crucial and there is always time pressure on the project, it is ideal to keep the responsibilities for design in one hand: a company who has enough capacity, experience in developing similar sized projects and experience in the semiconductor industry. Furthermore it was a positive factor for the overall designer for Case 2, to have almost every necessary departments in-house (better teamwork).

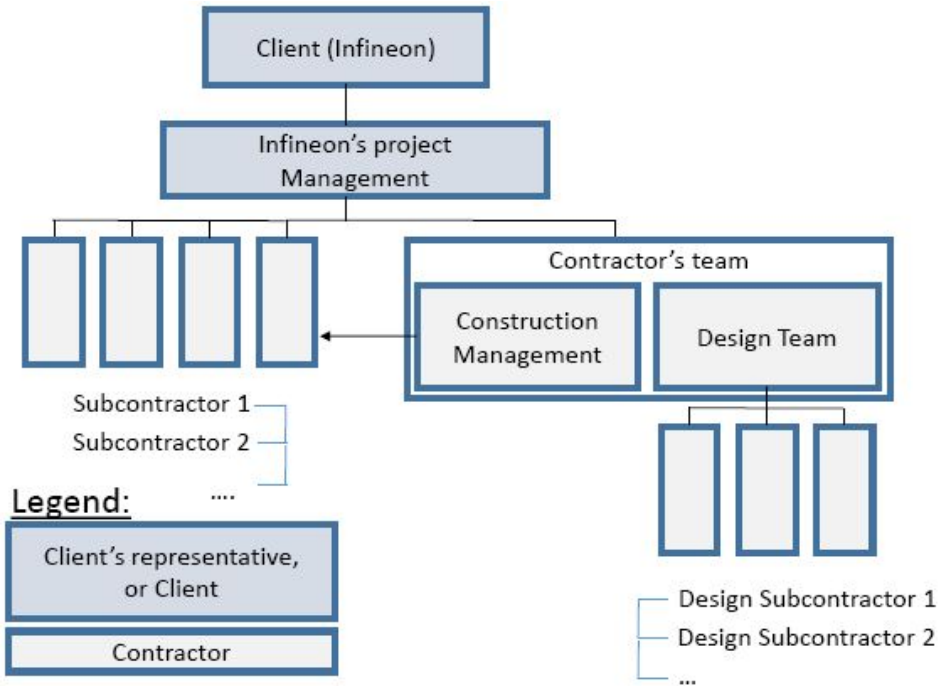


Figure 5.5: Design - Build phase

The construction phase was, as shown in figure 5.5, controlled by the client completely. The overall designer provided the necessary construction management services, while Infineon was controlling the costs and managing the contracts.

Application area

As the project responsibilities are taken by Infineon, it depends on the available staff on site. The main and most important requirements are:

- Experienced internal team (region-wise-, semiconductor-, commercial- and technical experience for the certain project size)
- Sufficient capacity
- Constant presence on site

If they are fulfilled and Infineon is willing to take the risks (lower costs, higher risk and more management tasks), this method is ideal for small and medium sized projects. The bigger investments have bigger risks and they need a bigger team as well. It is possible if it is prepared well, but this model is better for smaller projects. (the lump sum contract is not perfect if the project has to be changed drastically)

5.2.4 Ideas for improvement

- Person C2-1 (Infineon's PL fro Case 2): Worth considering to take the project supervision and site management (however the CM works best, if it is connected to the design team)
- To have a project office (designer team) on site from the beginning
- A more collaborative atmosphere (the CM should be handled as a team member)
- Worth considering to have a cost plus contract with the overall designer (and to agree to a GMP for only their part, for incentive measures, to set a maximal price for their work and to allow more radical changes during the project).
  A semiconductor project has to deal with numerous modifications and adjustments, therefore the client should be able to apply any changes unconditionally (to stop the project if the estimated price is unsustainable). It is important if this model is applied for big projects.

5.2.5 Most important negative and positive factors

The following table (5.2) collects the most important factors of the model according to the literature and the open ended interviews.

EPCM (mixture of DB and CM agency) completed with informations from the interviews	
+	-
Ideal for fast track projects (overlapping phases)	Insufficient scope can increase the costs
Fewer but more experienced staff needed on site	Early pricing is risky with lump sum
Constructor's input on design	Owner is at tisk for final costs and time
Very flexible	Multiple contracts for construction phase increases the potential for disputes for the owner
No dependance on a big company (GC)	It was hard for the CM agency to motivate the subcontractors
Experienced subcontractor can help the inexperienced overall designer	Multiple disputes for the Client to handle

Crucial factors:
More teamwork would be better (integrate the overall designer into Infineon's team)
Bad conceptual design and changes have a negative effect on the cost certainty
Tasks were not defined clearly

Mentioned in the literature
Additional information from the Interviews

Figure 5.6: Traditional model: Positive/Negative

5.3 Final conclusions

The Case studies, the analysis and the literature suggests, that the typical semiconductor projects share five main characteristics. First of all, they are fast track projects as the production has to start as fast as possible. The time pressure and the possibility of changing the requirements, demands the second feature: flexibility. The third key factor is that the production has many special areas such as clean room or ultra pure water systems and this combined with the high quality, may result in high expenses. The last typical feature is the budget certainty. The cost estimation and the available resources set a budget for the project and it has to be completed within this frame. An over expensive project might not worth to be built or there is simply not enough funds for it.

The two models (TM and GMPM) are based on the same roots, therefore they are very similar: They are both fast track projects and they both choose a contractor in the beginning, who have multiple tasks from design to Construction Management.

It is important for Infineon to be able to choose the appropriate model for the project before preliminary design, therefore a short but detailed summary of the main factors, advantages and disadvantages can serve as a useful tool for the decision making process.

Risk allocation

A decisive factor can be the risk allocation. If Infineon is willing to take the risks, the TM can be a good choice. It gives more control to the client and offers a lower price as well, but having to manage multiple contracts can result in complications at the end: it is harder to redeem warranty claims from multiple partners.
Therefore the big advantage of the GMP Model is the single point of responsibility and that the risks are on the contractor in exchange for the risk premium. Having everything in one hand provides the benefit of having only one partner contractually obliged to provide a complete facility without any errors irrespectively of who or what is responsible for a problem.
However a thoughtful risk management can be beneficial for both of the projects.

Infineon team on site

Naturally both of the models require a team, that perfectly understands the model with its weak points.
A main criteria is the available staff for the project. GMPM needs a highly experienced team (it can be a remote management team) and a good external team who provides part of the necessary know-how and the region wise knowledge. This means no restrictions for the project, on the other hand it is harder to find an experienced and big enough company who can serve as the GC. Furthermore, applying a big company who can handle the

project and the risks automatically transfers some control over the project from Infineon to the GC.
An ideal project delivered with the TM needs a bigger, similarly experienced team from the client because of the additional control over the project (cost-, time control and managing the subcontractor contracts). It is however still possible to extend the team with external staff, but it is crucial for the internal team to have the necessary region-wise knowledge (the internal team has to provide the region wise knowledge, unlike in the GMPM, where the external client's team is responsible for this quality).

Size

The two models are prepared for different kind of projects. GMPM is prepared for big and complicated projects, that has to be delivered fast with guarantees to cost and time. It is crucial that the GC (the GC's team delivering the project, not just the company) has experience in semiconductor projects with similar size and complexity. The model can be modified for medium sized projects as well, to eliminate some of the drawbacks, but the smaller a project is, the more the model is out of its comfort zone (it result in higher costs).
The TM is more suitable for medium sized or small projects. This model allows Infineon to have more control over the project and this grants further flexibility for modifications to the conceptual design. A bigger project needs a bigger staff and the internal team does not necessarily have enough experience with huge and complicated projects.

Costs

TM offers a better price than GMPM. The lack of risk premium and the control over the project allows Infineon to deliver a project for a better price.

Quality of conceptual design, changes during the project

TM uses the preliminary design to choose the overall designer. As Infineon controls the project and costs, it is easier to handle changes.
GMPM relies on the preliminary design more, as it is the base for the GMP. The difference between change order and design development is a critical source of conflicts, as the design development does not influence the GMP and change orders can have a mostly negative impact on the budget. Therefore it is not a *"model of harmony"* and the client's team has to be good at arguments to optimise the costs.
If anything is left out or missing from the conceptual design or there is a change order, the effect on the GMP has to be negotiated with the GC and project changes can soften up the guarantee on cost and time.

Contract

GMPM uses one main contract: the GC contract, which is an open book cost plus contract with GMP. GMP with shared gain shared pain is responsible for motivating the GC to work efficiently and to save costs, while open book provides good transparency allowing Infineon to eliminate any hidden costs.
TM uses a lump sum contract for the design, and an open book cost plus contract for the CM.

What GMP guarantees

GMP is often misunderstood. For a number of companies it has a strong meaning. It gives a cost certainty to the client, but there are three typical cases, that influences the costs and the GMP defends the client only in the third option:

- Change order

The client can order any changes if it wishes to, both of the models have standard procedures for it. The client or its representatives have to negotiate the adjustments to the budget (GMP).

- Not perfect scope (Client's mistake)

It has an effect on the costs (bad for cost certainty), but there is no financial compensation for any of the parties, it simply works as a change order (same amount of changes for both models), irrespectively of which model is used.

- Scope is not understood perfectly, or the contractor estimates a lower price (contractor's fault)

Traditional Model:

In this case, it is the client's risk. The extra costs of the construction increases the budget (or the project has to be reduced), and if the change results in a lower cost, Infineon keeps the difference.

GMP Model:

If the GC calculated a lower cost, and agrees to a GMP, any extra cost over the GMP is the contractor's expense. If the scope is unchanged and the project is simply more expensive, the client does not pay more. If the change is beneficial, the savings are shared between the GC and the client (usually the client receives a bigger part). This is

positive, as it is an incentive for the GC to work efficiently and not to increase the costs and it also gives the client extreme cost certainty. On the other hand the GC does not accept a budget without reserves, the risk result in an additional cost to the budget and experienced companies pay attention to have a sufficient budget.

The following figure (Fig. 5.7) summarises the decisive factors in choosing a model for a project. It only highlights the most important general features. Each project has unique qualities, that also influences the choice of the model.

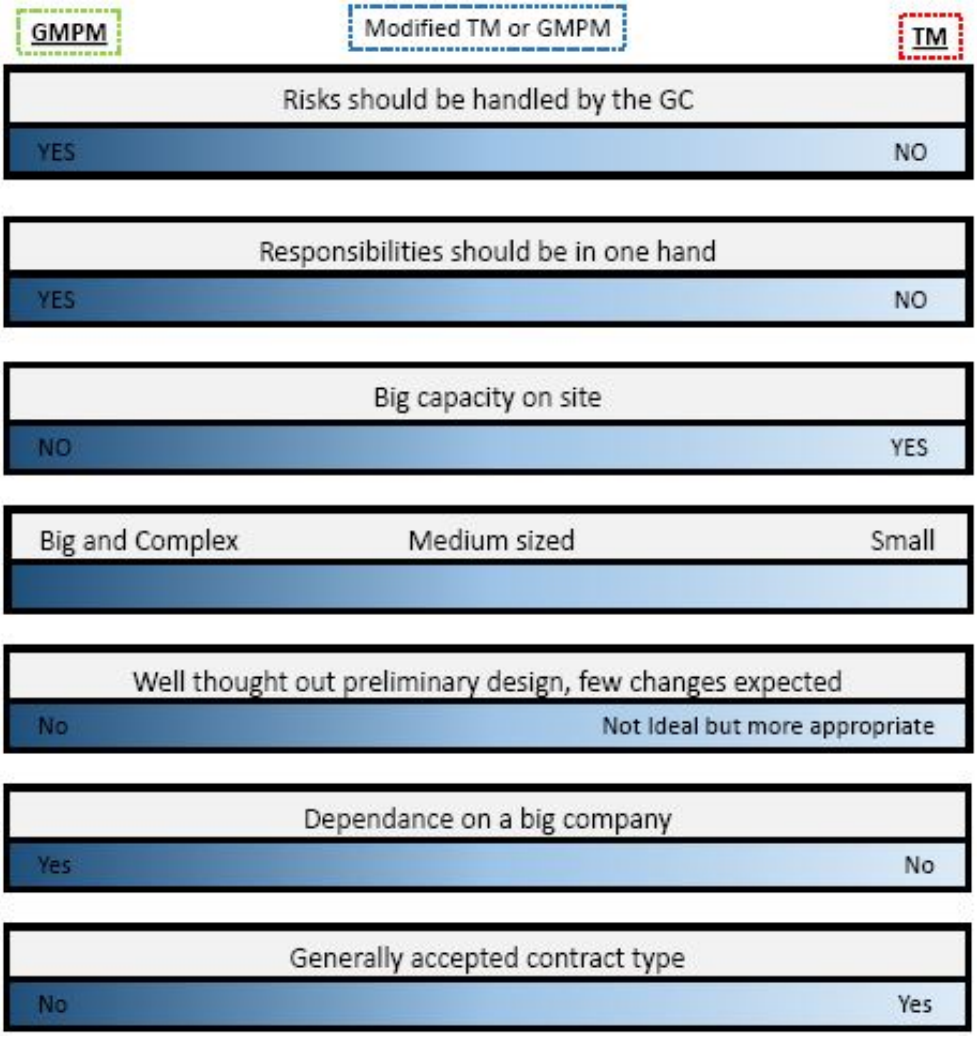


Figure 5.7: Most important features

Afterword

Both of the models were developed for Infineon's needs, they are equally good models, but they represent two completely different approaches. There is no superior model, just more appropriate for certain circumstances and needs.
The author suggests, that generally the willingness to take the risks and the quality of the internal teams are the most important differences, that is why they are the decisive factors with further project specific features, such as: budget, available time, region (companies in the region and culture).
It is not easy to find a good contractor for semiconductor projects. Experience is extremely important, the projects are stressful (because of the short time available), there are not many projects and the client wants to have a reasonable price.
The acceptance of GMP can also be difficult both in Europe, as it is not an often used tool and both in Asia, as some companies does not accept the GMP, therefore there are only few appropriate companies worldwide.
Finding one or more potential companies with enough capacity and willingness to enter this field is important for the upcoming projects. Infineon is looking for partners who can develop the projects in close cooperation (applying IPD's philosophy) and partners in development: to apply new technologies such as BIM.
In the future, as the models are efficient, they might be modified, but the frame will stay unchanged. It is however important to improve the weak points (such as information flow within a project) and to have a clear process for choosing the appropriate model.

Bibliography

Build operate own transfer (boot) projects. URL http://www.mcmullan.net/eclj/BOT.html. (last opened in July 2015).

The American Institute of Architects AIA and The Associated General Contractors of America AGCA. Primer on project delivery. 2011. URL https://www.agc.org/sites/default/files/Files/Programs%20%26%20Industry%20Relations/AIA-AGC_Primer_on_Project_Delivery_2nd_Edition-FINAL.pdf. (last opened in July 2015).

American Institute of Architects AIA Minnesota. Understanding project delivery for the design and conconstruct of public buildings. URL https://www.aia-mn.org/wp-content/uploads/project_delivery.pdf. (last opened in July 2015).

group AmWins. Client advisory, general contractor or conconstruct management. URL http://www.amwins.com/SiteCollectionDocuments/Client%20Advisories/Client_Advisory_EIFS_6.14.pdf. (last opened in July 2015).

The Construction Management Association of America CMAA. An owner's guide to project delivery methods, 2012. URL https://cmaanet.org/files/Owners%20Guide%20to%20Project%20Delivery%20Methods%20Final.pdf. (last opened in July 2015).

DLAPiper. Epc contracts in the power sector, 2012. URL https://www.dlapiper.com/~/media/Files/Insights/Publications/2012/02/EPC%20contracts%20in%20the%20power%20sector/Files/epccontractsinthepowersector/FileAttachment/epccontractsinthepowersector.pdf. (last opened in July 2015).

M.K. Eisenhardt. Building theories from case study research. *Academy of Management Review*, 14(4):532–550, 1989.

M.K. Eisenhardt and M.E. Graebner. Theory building from cases: Opportunities and challanges. *Academy of Management Journal*, 50:25–32, 2007.

A. Gander and A. Hemsley. Guaranteed maximum price contracts. pages 38–39, 1997.

J. Glaeser and G. Laudel. *Experteninterviews und qualitative Inhaltsanalyes*. 4th edition, 2010.

Haskell. Engineer procure construct (epc) delivers a complete project solution. URL http://www.haskell.com/getattachment/72f8cc50-61bf-4da0-a4a1-db0b5e643e06/EPC-Delivers-a-Complete-Project-Solution. (last opened in July 2015).

Gilberto M. Llanto. Build operate transfer for infrastructure development: Lessons from the philippine experience. 2008. URL http://www.eria.org/publications/research_project_reports/images/pdf/PDF%20No.2/No.2-part3-11.BUILD-OPERATE.pdf. (last opened in July 2015).

Phil Loots and Nick Henchie. Worlds apart: Epc and epcm contracts: Risk issues and allocation. 2007. URL http://fidic.org/sites/default/files/epcm_loots_2007.pdf. (last opened in July 2015).

M.I. Mahdi and K. Alreshaid. Decision support system for selecting the proper project delivery method using analytical hierarchy process (ahp). *International Journal of Project Management*, 23, 2005. URL http://www.sciencedirect.com/science/article/pii/S0263786305000608. (last opened in July 2015).

National Association of State Facilities Administrators NASFA, COAA Construction Owners Association of America, APPA Association of Higher Education Facilities Officers, AGC Associated General Contractors of America, and AIA American Institute of Architects. Integrated project delivery for public and private owners. 2010. URL http://www.aia.org/aiaucmp/groups/aia/documents/pdf/aiab085586.pdf. (last opened in July 2015).

NortonRoseFulbright. A guide to epcm contracts. URL http://nortonrosefulbright.com/files/a-guide-to-epcm-contracts-104176.pdf. (last opened in July 2015).

Norbert Preussl. *Projektmanagement von Immobilienprojekten*. 2. edition, 2013.

Science Applications International Corporation SAIC, AECOM Consult, and the University of Colorado at Boulder. Design build effectiveness study as required by tea 21 section 1307(f). fhwa, u.s. dot, washington, dc. 2006. URL https://www.fhwa.dot.gov/reports/designbuild/designbuild.pdf. (last opened in July 2015).

Ali Touran, Douglas D. Gransberg, Keith R. Molenaar, Kamran Ghavamifar, D. J. Mason, and Lee A. Fithian. *A Guidebook for the Evaluation of Project Delivery Methods*. Transportation Research Board, 2009. URL http://www.tcrponline.org/PDFDocuments/TCRP_RPT_131.pdf. (last opened in July 2015).

M. Weltzer and M. Graebner, M.ber. Integrated project design and management (ipdm) - a way to build fast track/low risk semiconductor fabs. 2001. URL http://www.idplan.eu/en/docs.html. (last opened in July 2015).

Appendix A

Distribution of efforts, Organigrams

A.1 Distribution of efforts