Best Practises in New Product Development: The Zyray Wireless Case Study.

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Submitted in partial fulfilment of the
Requirements for the degree

Magister Scientiae (Technology Management)
In the
Faculty of Engineering, Built Environment and Information Technology

UNIVERSITY OF PRETORIA
JUNE 2005

Acknowledgements

Dankie aan my ouers en Louise se volgehoue steun.

Dissertation Summary

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A case study of a start-up company was performed. The study analysed the New Product Development Process at the start-up.

The start-up under investigation was Zyray Wireless, a start-up in San Diego California. Zyray makes processors for the next generation of mobile phones.

The research done with the particular start-up company will identify ***what*** *the* ***differences*** *are between generally accepted best practise methods and the best practise methods implemented by a particular* ***start-up*** *company.*

The **study** will therefore aim to answer the following questions.

How does the product development process change over the life cycle of the company?

How do the best practise processes implemented in the industry differ from those implemented during the life cycle of the company under investigation.

Why does the company implement best practise processes at a specific time in its life cycle and not during other times?

What percentage of best practise processes are accepted and implemented by the company, why were they chosen and why were others not.

Multiple types of evidence were used including participant observations, documentation and surveys. The survey taken at Zyray was compared with the industry averages. Results were also obtained at three different points in time (Concept/Seed, Product Development and Market phases).

By comparing these results with the industry results it was possible

to gauge the differences between the industry and Zyray Wireless in general.

Zyray Wireless scored above the industry average in the following categories: continuous quality improvement, product success, project success, cycle time improvement, customer involvement questions, project selection, product strategy questions, technological leadership and product goal questions.

The best practises for metrics, human resource development, documentation and change control implemented by Zyray Wireless scored at or below the industry average.

The best practise results showed that the start-up focused more on strategy and engineering and less on process control.

The study revealed the following important points:

1. In the initial phases the start-up's customers were the venture funds.
2. The project selection process was informal but driven by economic criteria.
3. The company discovered that it had to choose a product strategy early on and then develop the product according to this strategy.
4. Marketing created the design concept but it also influenced the future of the company because it dictated the company's product strategy.
5. The company followed a technology follower strategy. The technological competency was of such a high standard that a product was developed after very few iterations.
6. The start-up showed that internal documentation was limited but that external documentation to clients and manufacturers had to be of a high standard.
7. The company showed that change control was limited to the engineering function.
8. The start-up showed that over-achieving on goals set by itself and investors was of critical importance.
9. The start-up showed that process control was kept to a minimum and that it could react very quickly to changing situations.
10. The start-up showed that the establishment of a strong team is of critical importance to the success of the company.

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1. New Product Development Processes in Start-up Companies.

The evolvement of the company's New Product Development (NPD) process will be investigated. NPD processes have changed over the last few decades as engineering projects have become more complex, requiring more involvement from all the disciplines within a company.

The unit of analysis for the case study will be the product development process followed in a start-up company.

Most NPD theory concentrates on companies in their steady-state or market phases. In current NPD theory 'best practises' for NPD are defined. However, these best practises might not all be applicable to the start-up company. How the development process changed and evolved will be investigated.

The different life cycle phases (Bell 1991:251) are defined as; *Concept, Seed, Product Development, Market Development and Steady State*.

Best practises (Dooley 2002:20) can be divided into the following categories: customer involvement, project selection, product strategy, concept design, technological leadership, documentation, change control, product goal, metrics, process control and human resource development.

The dissertation will therefore present a case study that will aim to determine the degree of adoption of product development best practise items over the life cycle of the start-up company.

This chapter will give context to the different factors that influence the process of starting a high-technology company. First, entrepreneurship will be described and defined. Next, the sources of capital for new ventures will be described. This will help to put some key issues of importance to start-up companies into context. Next a more detailed discussion of the different functions within a business will be presented. Different tiers of strategy will be defined and the range of tasks within various business functions will be highlighted.

In the second chapter the history of NPD will be highlighted. The progress of NPD, starting after the Second World War, will be detailed. Some of the areas highlighted will be the NPD process, project management, knowledge management and resource management amongst others.

The third chapter presents the best practise categories. It will give a more detailed description of the theory behind the best practise categories.

The fourth chapter describes the research design chosen and describes how the data will be captured. Part of the description of the data capturing techniques used is a full description of questions to be presented to the company under investigation.

The fifth chapter presents the data gathered and an analysis of the data. The sixth and final chapter outlines the final results and presents the conclusions.

1.1. Entrepreneurship defined.

In the years between 1970 and 1985 the United States created 40 million new jobs (Drucker 1985:1). During the same time frame big business in America declined. Many of the big employers—including the oil industry and steel manufacturers—weren't growing at all. After the Second World War, traditional employers could not create the number of jobs the 'Baby Boom' generation needed. On a worldwide scale the American expansion was unique. During the same time period Europe lost millions of jobs. The Russian economist Nokolai Kondratieff is known for developing the 'Kondratieff wave' theory. This included the 'fifty-year Kondratieff long wave'. According to this theory an economy reaches its peak every fifty years or so. During the last twenty years of the cycle the industry of an economy is very profitable but the technology becomes stagnant. After a crisis event the industry cannot continue its growth, and consequently jobs are lost. Why does it seem that Europe followed this trend while the United States did not?

During the American expansion the Fortune 500 companies were cutting jobs while mid-sized companies (revenues of $25 - $1 billion) were growing in profits and sales at three times the rate of Fortune 500 companies. They were also adding jobs at three times the national average rate. These mid-sized companies included service businesses as well as manufacturing companies and spanned the board from low-technology to high-technology. According to Peter Drucker (1985:20) in the highly respected "Innovation and Entrepreneurship" the only thing that all these enterprises have in common is the new technology of entrepreneurial management.

Drucker however singles out high technology companies as culprits who do not subscribe to the "systematic, purposeful management of entrepreneurship". He sees high technology companies as inventors rather than innovators and speculators rather than entrepreneurs. He also views management as a systematic discipline developed only after the Second World War. There is still a lot to be learned, mostly, according to Drucker, about the management of the knowledge worker. The high technology worker and business are the most difficult to manage. Innovation in high technology has a very short window in which it has an opportunity to penetrate the market. This

is mostly due to high levels of competition and fast-changing technologies.

The next question is; what defines an entrepreneur? Entrepreneurship could be defined as *the process whereby something new or different is created.* This could literally be a new customer type or a new market. Innovation is the process used to exploit the change and create a new business. To innovate implies that you do something in a unique way that gives you an edge in the business. This includes the management process. It should however be noted that the debate as to the accepted definition of an entrepreneur is continuing.

This dissertation will concern itself with the start-up company. The start-up company offers everyone involved a unique opportunity to be innovative. The ideas mentioned above will be revisited later on but first the company must actually get to a point were it can start doing business. Even at the best of times it is difficult for a company to survive and prosper. This is especially true for companies involved in New Product Development (NPD). Because of increased levels of competition, rapidly changing markets, higher rates of technology change and shorter product life cycles competition is fierce. These challenges are significantly amplified for start-up companies.

1.2. Capital for the start-up technology company.

Technical firms are seen to go through 4 phases of existence (Roberts 1991:11). First is the pre-company Research and Development (R&D) phase, second is the start-up phase where initial seed money is obtained, third is the initial growth phase, and lastly the sustained growth phase.

During the pre-company phase the founders—without any specific funding—work on their idea. Studies into the feasibility of the technology and the creation of a product are conducted. The beginnings of a business plan are developed during this phase.

The next phase is initiated when a company is formed as a formal entity. A corporate and sometimes business strategy is devised and the first members of the team are brought on board. At this point the feasibility of the product has to be demonstrated and the business plan must be formalized. By now the founders have left their previous jobs and are actively involved in the management and R&D process of the company on a full-time basis. At this point salaries must be paid to technical personnel and equipment must be purchased. Whoever is willing to provide source capital must be patient and willing to wait between five and ten years on returns.

The initial growth phase starts when the company has a product line

and some sustained sales. It now has to improve its products, and company processes within the various functions (R&D, marketing, production and personnel) and the management team. The company needs capital to sustain its growth. The type of financial backer changes in this phase. The risks are lower and their investment terms can be shorter. The company can also start looking at becoming a publicly-traded company.

In the sustained growth phase the company has multiple product lines and customers in various markets. Its rate of growth has become its biggest problem. It may not have the cash flow and resources it needs to enter all the markets and pursue all the customers it wants to. Because it has assets and a good track record it is much easier for the company to get cash advances and good terms of credit from different risk-averse organisations.

During the different life cycle phases of the company the available financial sources changes. Traditional venture capital (VC) companies are very risk averse. What other financial sources are available to start-up companies? According to Roberts (1991:9) the prime financial sources for seed money are the personal savings of the founders, family and friends, wealthy private individuals, and private family venture capital groups. The next most likely investment group is the traditional VC corporation. The sources mentioned are the types of sources that would invest in the early stages of the companies' existence.

Phase 3 and 4 investors include VC's and small business investment companies that could be government-controlled but mostly not interested in high-technology. They could invest in start-ups but their financial resources are usually limited. Other groups of investors are: corporations that invest in specific technologies, commercial banks, and public stock issues.

The problem with the first two financial sources that were mentioned—personal savings and family—are that they are usually not able to front a lot of money. It might be enough to fund the very early stages but the funding gained from these sources usually does not last very long. The rest of the sources are all sources not personally known by the founders. At this point the founders must write a business plan to show to potential investors. The business plan is written to prove (or not) that the founders have thought out a viable strategy for the setup and operation of the company. VC's only invest in about 1% of companies they receive business plans from. The obvious next question is; what do fund managers look for in a business plan that would encourage them to invest?

Different VC's have different decision criteria. Some only invest in the early stages of a start-up, while most do not. Some do not invest in technology while some others exclusively invest in technology-

based start-ups. VCs' do have one thing in common however; they all analyse the business plans presented to them for deficiencies in similar ways. The business plan must address the concerns of the potential investors correctly and adequately. The *business plan* can be sub-divided into; *marketing, management, technology and product, and planning and finance* (Baird 1995:103).

Successful business plans include a detailed section about the particular market and the potential for growth within their market. A business plan is specific about how and when the new product will be used in the market. It also includes a detailed strategy for how sales goals will be realized. To have someone on the management team with marketing and sales experience is a definite plus.

The product could fit into an existing or a new market, and the product itself could be either new or existing. Depending on which market combination companies compete in the market will be different. The company does not want to compete against entrenched products in an existing market it also does not want to create a whole new market.

A new product in a new market is also known as a *technology push* market. This is an extremely difficult market to break into because it requires the company to educate the market and create a need. In this type of market a company must protect its technology or product with patents. It might be too easy for someone else to enter the market and over take the company after it has done all the pioneering work.

A *market pull* strategy—where the market already exists but the company's product differentiates on being able to do the job better—is a more desirable strategy. The company relies on the market's desire for a specific benefit to create sales; the customers are already available (Baird 1995:35).

Investors favour companies with more than one founder. They also favour a management team where at least one person is slightly older and has a lot of managing experience. Most founders tend to be technical leaders without enough business experience. Companies that have people with marketing and production skills (if applicable) are also favoured (Roberts 1991:12).

According to Baird (1995:67) the emphasis of the business plan has to be on the management team. The resumès of the management team must be easily accessible to the investor as they need to foster confidence in the management capabilities of the team. However if the team is inexperienced the business plan should focus on you're the company's unique technology and unique opportunity in the market.

The financial plan must include financial statements; this includes

income statements, balance sheets and cash flow statements. Analysts use various methods to determine the financial viability of the start-up. The common thread with analysts however, is a desire to be able to predict whether or not the company is going to be financially viable, and to determine the current financial state of the company.

According to Baird (1995:116) analysts could use the following analytical methods; *balance sheet conditions, liquidity analysis, solvency analysis and the probability of business failure*. Even though the company probably does not have any sales, inventory or profits at this point, these financial methods have to be addressed.

Some key balance sheet terms and ratio's are accounts payable, accounts receivable, current assets, current liabilities, net sales, total assets and working capital.

Some common liquidity ratios include the current ratio, which is a company's current assets divided by its current liabilities. If this ratio is too small a company might not be able to pay its bills. Another ratio is cash and accounts receivable added together and divided by current liabilities. The turn-over ratio is the ratio of sales divided by working capital. This ratio indicates whether or not there are sufficient funds to fund sales.

There are also some available methods for predicting the likelihood of failure for the company. One such method is Altmans Z-Score method (Baird 1995:55). In the USA auditors are obliged to report the fact that a business has a high probability of failure.

The business plan should also include a time-line of the product plan. The company must show milestones for the development effort as well as the manufacturing process (if applicable). By having measurable milestones specified the investor will be able to judge the progress of the product more easily. It will also allow the investors to feel more comfortable with the capabilities of the company when these milestones are met. By planning the development process thoroughly it will be easier to predict what type of cash flow needs a company has.

Finally, the business plan should show that the technology or process is unique in some way. (Cost differentiation is not considered to be a good enough criterion as it is too easy to manipulate data.) The plan must indicate who the competitors are and how this solution is better than what they have to offer. It should also indicate to what extend the market is protected to entry and whether the company has any patents that will keep competitors from entering the market. The plan must indicate how far the product has been developed, and if the product is not yet available, how much development is still necessary.

It is evident that VCs want to see product sales before investing money into any corporation. The dilemma the corporation faces is that in many cases it cannot produce a product without some financial investment. In the first and second phases described above, companies do not have a lot of resources. Not many VCs are interested in funding the company in these stages as they have not proven themselves and are considered a high–risk investment.

The company has to produce a quality product and subsequent sustained sales to be considered viable by more potential investors. Even at this later stage companies must be able to move fast and produce products for different market segments.

1.3. Structure of the start-up company.

A start-up does not have all the bureaucratic trappings of larger companies. It does however need to have the minimum resources to perform the necessary tasks previously presented. A start-up needs to have a CEO (chief executive officer), CTO (chief technical officer) and possibly a vice President of marketing. The company does not necessarily have to have these positions but will have to perform the functions of these positions. In Figure 1 the possible positions in a start-up and the possible responsibilities of the various functions are outlined.

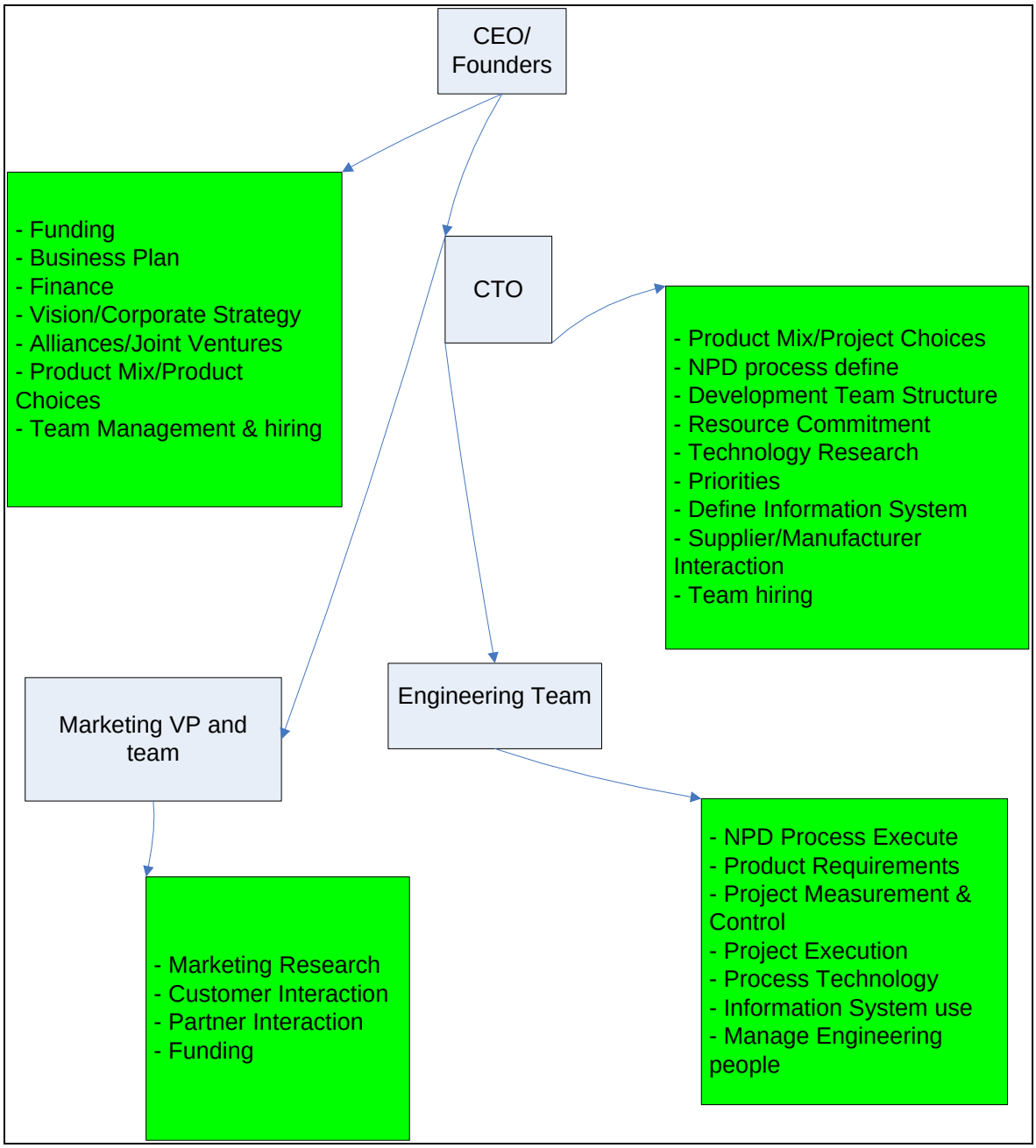

Figure 1: Company Structure

There are several dimensions necessary for success in a new company. One of these dimensions is the management team (Baird 1995:67). Venture capital investors prefer to invest in companies that have management teams with a good track-record. Often the company is founded by a technical person, this person however has to critically evaluate himself and decide whether or not he has all the qualities and experience needed to be a CEO. The founders all have to realise their limitations and get experienced outside help when necessary. Not only will this help with the operations aspect of a company but will have the added advantage of investors looking at

the company more favourably.

Selecting the correct individuals for the start-up is extremely important as one mistake could mean the failure of the company (Baird 1995:67). People have to be interviewed thoroughly and their backgrounds need to be checked. Each person has to fit in with the other team members and have the correct attitude towards the start-up company. The management team also has to be chosen in such a way as to avoid personality clashes (Baird 1995:72). The team can be viewed as a marriage of sorts where in-fighting due to a clash of personalities will destroy the company.
Generally people in start-up companies should share the following traits; the ability to thrive on risk, be incurably optimistic and have dogged persistence.

The next important dimension of the management team is the board of directors. The board is elected by the shareholders of the company; this includes the founders and the investment partners. Some of the functions of the board are; appointing senior management, declaring dividends, issuing additional shares, reviewing financial performance, reviewing marketing plans and reviewing any other major decisions affecting the company. The board has to bring experience and sound judgment to the table.

Strategy must be defined within a specific context. The company has three tiers of strategy; corporate strategy, which defines in which businesses and markets the company competes, competitive or business strategy, which defines how the company will compete (Porter 1986:36), and finally a functional strategy which defines the specific processes a functional group (marketing, human resources, product development etc.) will perform.

1.3.1. Corporate strategy

Corporate strategy defines what the growth, size and profitability goals of the company are. As stated before the company defines in which markets, businesses and geographical areas the company competes. These factors are driven by the business and technology knowledge within the company. The corporate strategy is linked to the visions and goals of the owners of the company. It is important at this point to **identify disruptive technologies** that will make the corporate strategy and products of the company irrelevant. Disruptive and sustaining technologies are treated in more detail in chapter 2.

The NPD does not take place in a void. It takes place within a specific company structure; in this case a start-up company. People and not machines perform NPD; the correct climate has to exist for the knowledge worker to perform. In ‘Managing Innovation’, Tidd

Besant and Pavitt (1997:305) suggest specific performance strategies that help to build the innovative organisation. These decisions influence how the people inside the company perceive the organisation.

The members of the organisation have to have a shared vision, be able to show leadership and be willing to innovate.

The organisation has to choose the correct structure for the company as a whole. The company has to find balance between an organic structure that easily changes and does not have a lot of control,. and a mechanistic structure where rigid rules are followed.

The organisation has to enable the right people by giving them authority to perform and achieve the goals of the organisation. People have to be genuinely rewarded when they perform well. The organisation has to be committed to education and training.

The correct team structure has to be defined so that the company can communicate effectively. This is addressed in more detail later.

The organisation has to have the right structure in place in order to be a 'learning organisation'. The company should learn from every phase of development. This includes both technical as well as process learning.

The organisation has to focus on the needs of the client and ensure that the correct structures are in place to bring the best products to fruition.

The CEO and CTO handle these decisions with input from marketing and engineering. These decisions are presented to possible investors in the business plan of the company. Investors will make decisions based on a sensible corporate strategy.

1.3.2. Competitive Strategy

On the level of competitive strategy, marketing has a major influence in decision-making on this level. It is of the utmost importance that the correct product mix is defined. The CTO plays an important role at this level to balance marketing needs with technological realities. The maturity of different technologies and standards play an important role in determining how difficult it will be to enter a market. They also determine how much longer the market will be around for.

According to Porter, **5 forces influence competitive strategy: industry competitors, potential entrants, suppliers, buyers and substitutes**. The company must differentiate itself in the eyes of the customer. It should gain a competitive advantage over the rest of the

incumbents.

Barriers to industry entry are: economics of scale, differentiation, capital requirements, access to distribution and government policy.

Supplier bargaining power increases if there are: few suppliers, there are no substitutes, the supplier has more important customers, the supplier's inputs are critical and high switching costs are involved.

Factors that influence increased rivalry among competition are: numerous rivals, equally balanced rivals, slow growth, high fixed costs, low differentiation, low switching costs, high exit barriers, diverse competitors and high monetary stakes.

Customer bargaining power is increased by customers buying in volume, standardized or undifferentiated products, low switching costs, low profit margins, purchase not being important to the buyer even though the buyer has all the relevant information.

The factors mentioned in the previous paragraphs are all influenced by the technology a company chooses to compete in. The technology S-curve plots the advance of a technology over time. According to Roussel et al (1991:19), a **technology's maturity can be divided into embryonic, growth, mature and aging phases**.

The phase a technology is in influences the time it will take to produce a product. As stated earlier this is a very important factor to potential investors. In the lifecycle of a technology, the influence of a specific parameter changes over time. In the embryonic phase of a technology the standards might not yet have been determined. There may be many competitors and manufacturing costs and price differentiation might not be so important. In the well-documented video machine wars of the late seventies and early eighties the choice of a dominant standard, either Beta or VHS, dominated the buy decision more than price did. Price and features now dominate the buy decision.

According to Wheelwright and Clark (1992:49) products can be divided into four categories; **new core products, next generation, addition to the product family and add-ons to current products**. These experts state that the aggregate project plan must ensure that the collection of projects in the company helps the company achieve its strategic goals. The start-up company has to decide what its core products will be and how these products will evolve into the future. In the start-up this decision is crucial.

When a company has defined which products that fit its business and corporate strategies it wants to develop, it has to identify the capacity and skills required to produce those products. For a start-up this step will help it identify how much money it will need to further

the venture.

Subsequently the start-up has to manage and control the NPD process. This will be the main focus of this paper. The project has to go through problem solving, functional integration, testing and prototyping phases. Midcourse corrective actions need to be taken and managed. The project and the company in general must attain the tools and define the structures necessary to help it manage and control the NPD process.

1.4. Problem Statement and Research questions

It is difficult for a new company involved in new product development to filter which business practises to use when and at what rate. A new company is bombarded with tools and techniques to improve the development process in the start-up company. It is, however, impossible to implement and follow every product development process available. Conversely, if the company starts with the idea that they will be able to break all rules and do everything ad-hoc, they run the risk of reinventing the wheel rather than learning and adapting well-worn techniques for their specific use. As stated before; **because of increased levels of competition, rapidly changing markets, higher rates of technology change and shorter product life cycles, competition is fierce. Companies, specifically start-up companies, are not allowed any room for failure.**

This dissertation will firstly identify different best practise business processes. **These best practise methods have been identified as crucial in adding to the success of new product development processes in studies over the last 50 years.**

The research done with the particular start-up company will identify ***what*** *the* ***differences*** *are between generally accepted best practise methods and the best practise methods implemented by a particular* ***start-up*** *company.*

The **study** will therefore aim to answer the following questions:

How does the product development process change over the life cycle of the company?

How do the best practise processes implemented in the industry differ from those implemented during the life cycle of the company under investigation?

Why does the company implement best practise processes at a specific time in its life cycle and not during other times?

What percentage of best practise processes are accepted and implemented by the company, why they were chosen and why were others not?

2. Literature review

2.1. Introduction

As stated previously, the focus of this paper will be on new product development. Therefore, the literature review in this chapter will first identify major contributions to the NPD process over the last five decades. Specifically, the evolution of the NPD processes from first to third generation process will be detailed. At the same time the industry standard evolution of best practise categories over the last few decades will be reviewed. Following this, changes in project management, knowledge management and resource management will be looked at in more detail.

2.2. NASA and phased project planning

According to Roussel (1991:25) the environment in the 1930s through to the 1950s was one of boundless opportunities. There was a lot of potential, technology and money. Governments in all the industrially advanced nations were liberal in their support of academic research. This however started changing with a decline governments' financial resources. This had an effect on both companies and the government. The government had less money to spend, therefore they had to be more careful in controlling how it was spent. The companies in turn had to be more careful in how they used the funds that were given to them.

Some form of a phased project planning (PPP) process was followed by the United States military before 1964. PPP was implemented to set up specific deliverables over a period of time. In the PPP process the project is checked at every milestone to ensure it conforms to requirements before more money is given to the contractor. Not everyone followed the same development process. With the establishment of NASA (2002) in the late 50's, certain problems were identified. It was necessary to establish cost and design controls over contractors. Nobody knew what was happening beyond his or her field of expertise and involvement. It was also found that there were no incentives offered to contractors for early delivery.

1964 was a watershed year in NASA's operation. A number of projects ran into schedule slippage problems. The Apollo program looked like it would not produce a moon landing before the end of the decade and the cost was projected to be in excess of 20 billion dollars (NASA 2002). The program called for a launch module, spacecraft modules and ground support equipment. A lot of problems were experienced when integrating everything in the project. A study performed by Hilburn (NASA 2002) in 1964 suggested the following solution; PPP must be implemented across all projects and NASA

management must review the project at major decision points. These decision points were at financial as well as development/integration levels. For PPP implementation to be possible the project had to be very well defined with detailed requirements set out. Project planning was therefore forced onto the contractors by the government agency managing the contract.

The contractors used the techniques of NASA and other government agencies as their own because they were judged by them. The PPP process is known as a first generation process. It is characterised by a lack of a strategic framework for the management of technology inside the company (Roussel 1991:26). General management (of the contracting company) does not have a lot to do with the technology direction of the company or with defining which projects to take. What technologies should be used and which projects to undertaken is mostly managed by the development departments. Project planning is done at line-management level. The project is handed off from one function to the next as it progresses over its life-cycle. Further problems with first generation systems are that resources are not allocated correctly partly because it is difficult to prioritise projects.

2.3. Second generation NPD process.

The previous PPP process did not address the external market and environment that private, consumer-driven organisations have to cope with. It also did not address other functions within the corporation. The external environment includes; laws, standards, technology trends and customer requirements. PPP did not address the roles of marketing, manufacturing and customer support. It only addressed the role of engineering. Marketing has to present the requirements to engineering. Manufacturing has to be involved from the beginning to ensure that it is possible to successfully manufacture and support the product.

Organisational learning, cross-functional integration and system change and development are critical success factors. Cross-functional integration is the process whereby all functions are involved in the design of the product. Inputs from all the functions are taken into consideration when designing the product.

In 2nd generation systems the cooperation between management and the development team involves jointly managing projects over time (Roussel 1991:30). This includes project-cost, impact of the project on the business, uncertainties, their management and their execution. Management tries to manage projects with quantitative information like return on investment and net present value. The portfolio concept, one of the most notable parts of 3rd generation processes, however, is still missing.

2.4. Lockheed's Skunkworks: The autonomous team.

During World War II Lockheed developed the 'Skunkworks' approach. It focused on radical or breakthrough projects. It suggests a Tiger team with complete responsibility over process, design and methods. The team is implemented by co-locating a number of people with their own budget and resources. This approach works well for radical or breakthrough projects where technical success is a high-risk factor (Wheelwright 1992:160). When looking at the problems associated with 1st generation PPP systems—most notably resource allocation, project management and prioritisation—it becomes clear why this method was such a success. PPP also uses a cross-functional team that is advantageous in that the various functions are aware of the problems within their sphere of influence early on in the process when changes can still be made without too much of an impact on milestones.

A Tiger team and a start-up company lead us to draw obvious comparisons. The Tiger team emulates the advantages of a start-up. It can change and adapt quickly and is not a slave to laborious big-company policies. The one thing that a Tiger team does not address, however, is which projects to perform. In the start-up environment this is of crucial importance to the survival of the company.

2.5. Best practise studies.

Because of increased levels of competition, rapidly changing markets, higher rates of technology change and shorter product life-cycles, any organisation involved in NPD must be able to effectively manage its product development (Griffen 1997:430). It can no longer be seen as research where something useful sometimes appears. The goal is to make money, and to achieve this goal viable products have to be produced. Depending on the business and technology environment of the company, the company has to define a NPD process that fits the specific company's needs. Drucker (1985:122) postulated that the company must 'do the right thing' to be effective.

Griffen (1997:440) found that the NPD process continues to evolve and become more sophisticated. NPD changes on various fronts and firms that fail to keep their NPD process up to date will suffer a disadvantage. Because of increased levels of competition, rapidly changing markets, higher rates of technical obsolescence and shorter product life cycles the way NPD is managed continuously changes.

New techniques and processes for NPD are continuously being developed; the various techniques are, however, accepted in business at different rates (Griffen 1997:441). While the validity of some ideas is researched thoroughly some ideas are presented as useful

without any proof. One possible way to determine whether an idea or technique is valid is to sample the techniques used in business. The methods most commonly used can then be denoted as best practise techniques. In the best practise studies a number of companies are interviewed or investigated, the data gathered is analysed and amendments to the NPD process are suggested. In some of the studies NPD success is mapped against the methods used in order to determine whether specific techniques are more useful than others.

Best practise studies are seen as useful tools in themselves. The Product Development and Management Association (PDMA) made it one of their goals to regularly investigate changes in the NPD management process by conducting best practise studies.

The organisation has to adapt and change constantly. Current best practice might not be best practice in the future. The NPD strategy must be flexible and allow the process to change. In technologically fast-changing fields it might not be possible to define all the requirements before the project starts. It is therefore necessary to learn the requirements as time passes. The NPD process has to change as the company grows over time.

One of the first best practise studies were conducted in 1968 by Booz, Allen and Hamilton. A 6-stage process is suggested (Griffen 1997:431): *exploration, screening, business analysis, development, testing and commercialisation*. The process is industry- and company-specific. The NASA and military development processes have to be adapted and not blindly followed. The organisational structures that helped the NPD process were identified as: *new product departments, product teams and new product committees*. A market has to exist for the product and the product has to fit into the total strategy of the company. The company should not jump at every possible opportunity but must measure the opportunity according specific criteria at every stage. The project is evaluated at every stage and decisions must be made to commit resources to further the project or to stop or change the project.

In 1980 Merle Crawford in 'Defining the Product Innovation' suggested that the company should have a *new product strategy* (Dooley 2002). This strategy defines *which products to design* rather than how to design them. This tie in with the NPD process where the project is evaluated at every stage. One of the criteria is therefore the fit of the project with the rest of the projects in the company and the company strategy.

In the 1982 Booz, Allen and Hamilton report this 7th Strategic Planning step was added to the front of the NPD process (Griffen Abie 1997:433). The company has to development *a portfolio of products* that complement each other and the capabilities of the company. Resources and design information must be shared or re-

used between different products.

In 1990 the PDMA conducted a broad industry cross section survey in which they found NPD performance had to be measured and multi-functional teams had to be used (Griffen 1997:433). *They also found that best practise is context-specific*. It was found that in high-tech firms manufacturing should devote at least 10% of its time to NPD. Concept testing and market testing was found to be a success criterion.

Arthur D Little (Griffen 1997:433) conducted a survey in the manufacturing industry and it was found that multi-functional teams that wield control and have significant autonomy had to be used. They also found that top management had to be involved in the NPD process and that suppliers had to be involved early in the process. A multifunctional team could be taken as far as a Skunkworks, mentioned earlier, or alternatively a start-up can be seen as a focused multifunctional team.

In a study conducted by Kucmarski (1993) it was found that tangible and visible top management support was necessary (Griffen 1997:433). The study also showed that adequate resource had to be provided, more time had to be spent on the up-front steps of the NPD process and focus had to be put on newer products.

Mercer management and consulting (1994) found that a customer-centered, disciplined NPD process had to be followed, the product portfolio had to be managed and a planning stage had to be added (Griffen 1997:433). Subsequently the Product Development Consulting group found that a distinction had to be made between product features and needs. They also found that the project scope had to include the entire augmented product.

Eisenhart and Tabrizi (1995) found that in the computer industry firms using a strategy of multiple design iterations, extensive testing, frequent project milestones, multifunctional teams and a strong leader accelerated development (Dooley 2002:6).

Pittiglio, Rabin, Todd and McGrath (1995) found that both project *performance and development effectiveness had to be measured*. They also discovered that multi-functional teams had to be used in a structured process with action-oriented phase reviews along the way (Griffen 1997:435).

Zirger and Hartley (1996) found that cross-functional teams, fast time to market as a development goal and overlapping development activities were characteristic of better companies (Dooley 2002:7).

Dooley (2002) found that best practises associated with the strategic implementation of NPD (project selection, goals, technological

leadership, product strategy and customer involvement) are more widely excepted than best practises associated with controlling the execution of NPD (process control, metrics, documentation, change control). In linking best practise with impact it was found that *product success depends strongly on having strong product concepts and then selecting the correct projects to develop*. The NPD process has to be controlled via project management, the team has to be strong and lessons learned have to be shared between projects so that cycle time can be positively influenced.

Currently, most companies use a cross-functional stage-gate process for NPD (Griffen 1997:440). Because of the rapidly-changing environment it is not possible to keep a rigid NPD strategy. The NPD strategy could be based on implementing a set of applicable best practice procedures within a stage-gate process (Griffen 1997:440).

None of the studies cited specifically differentiated between whether the company was new or well established. The only differentiating factor cited, in some cases, was the specific industry in which the study was performed.

2.6. Innovation and entrepreneurship

In 1985,Peter Drucker (1985:122) suggested that the organisation can manage innovation and that it is not black magic. The 'luck' of the company should be managed and if mid course corrections have to be made they should implemented immediately. Top management learns from all the functions (their view points on current and possible products) and measures the company's performance against competitors. New innovative projects must be managed as separate businesses from the start. Key people should be rewarded and compensated appropriately so that technical people do not leave technical work for management because they have reached a compensation platform.

2.7. Aggregate project plan

In 1992 Steven Wheelwright and Kim Clark (1992:48) published 'Revolutionizing Product Development' and suggested an aggregate plan for all products within the strategy of the firm. They identified an *aggregate project plan that identifies new, next generation additions to product family and derivative products*. The product funnel is used to filter ideas and decide which will turn into products. Wheelright and Clark identified the rate of communication between up-stream and down-stream functions and the need for cross-functional involvement and they identified prototyping as an integral part of the development process. They also identified post project learning as an important process.

The different phases of product development are different for every company but concept development, product planning, engineering prototype, commercial preparation and market introduction are presented by Wheelwright and Clark (1992:173) as possible phases. It would also make sense to add a support phase that feeds customer requirements back to the company and the designers. The various functions within the business have different tasks to perform during the life cycle of the product.

In the concept phase the engineering function proposes new technologies and builds models, marketing investigates product concepts while manufacturing investigates process concepts.

During the product-planning phase engineering interacts with the suppliers and defines the product architecture; marketing defines the target customers' parameters, develops sales margins and initiates contact with clients; and manufacturing develops cost estimates, defines the process architecture and validates suppliers.

During the development phase engineering develops a detailed design and builds full-scale prototypes. Marketing performs customer tests with the prototypes and establishes a distribution plan; and manufacturing creates a detailed design of the process, develops tooling and builds next-phase prototypes.

During the subsequent phases engineering evaluates pilot units, solves problems, and evaluates field experience with the units; marketing trains the sales force, fills the distribution channels and continuously interacts with the clients; and manufacturing builds the units, verifies the supply chain and ramps up production while ensuring quality, product yield and cost.

2.8. Third generation new product process

First generation phased review processes defined hard decision and design phases for every product (Cooper 1994:4). Every phase is gated and the next phase is not allowed to start unless everything in the previous phase has been completed. This process mainly involved the engineering function. Marketing and support is not part of the design process.

Second generation systems retained a phased approach but the boundaries between the phases got 'softer'. This implies that the next phase could start even if the current phase was not completely finished. Every business could also define its own phases. This process is known as a stage-gate process (Cooper 2001:130). The stage-gate process is cross-functional. Marketing and manufacturing are involved from the outset and play a part in every decision phase.

3rd generation management seeks to create a strategically balanced

development portfolio created in full cooperation with engineering (Roussel 1991:35). Development's isolation from the rest of the company is broken, experiences and information are shared across all functions. Because projects are now judged to fit within the strategic framework of the company resources can be effectively assigned and technological synergy can be achieved throughout the company. Strategic fit is beneficial in that project importance can be prioritised within the organisation. *The most fundamental change in the stage-gate process described below is the way in which decisions are made at every gate throughout the process.*

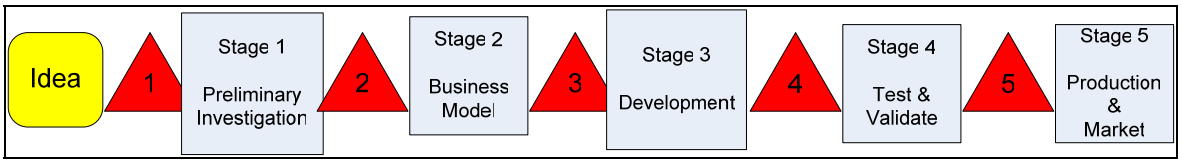

Figure 2: Stage gate process

Every stage in the process contains techniques, procedures or best practise items unique to the needs of the specific company. Every diamond in figure 2 is known as a gate. At these gates decisions are made as to whether the project should continue or not. The decision criteria at each gate are also unique to the needs of the specific company. The output of the gate is a decision regarding the continuation of the project and resources being allocated accordingly. *The decision criteria are based on the projects strategic fit within the company.* In first and second generation processes the decision criteria were limited to technical and financial decisions. *If the project does not fit with the technology and business strategy of the company it is discontinued.*

The first stage is the initial idea generation stage; many different techniques are available to create new product ideas. These include customer surveys, focus groups, user product analysis, idea vault, keeping abreast of new technologies and trends, trade shows, supplier information and marketing information.

The first screen is a gentle screen that generates a preliminary 'go' decision to proceed and obtain more information. Possible criteria for this gate are: strategic alignment, project feasibility, market size, synergy with business resources and a fit with the company's policies.

Stage 1 of the stage-gate process is the preliminary investigation stage. During this stage a more thorough investigation is done on the feasibility of the project. This includes a market assessment study, a

technical feasibility study and a financial assessment of the product. At the second gate these issues are critically evaluated and a 'go/kill' decision is made.

In the 2nd stage the business case for the product is built. A detailed specification is drawn up for the product based on user requirements, evaluation of the competition, feedback gained from a concept design, and technical and manufacturing feedback. The output of this stage gives a detailed description of the product features, namely: the market, the customers, financial return on investment, resource allocation and a detailed project plan. The 3rd gate is the point at which a decision is made about whether to proceed and develop the product. The output of this phase is an expenditure commitment made by the company. The development plan must be available and a cross functional team allocated to performing the development.

The 3rd stage is the development stage; the output of this stage is a working product prototype. The company can follow different development methods, most popular being a build, a test cycle of different prototypes so that various technical issues can be resolved. In parallel to this the marketing and manufacturing functions are ramping up to manufacture and market the product. Project management is done at a level of detail necessary for the specific project. This includes: activities, time frames, resources and intermediary project milestones.

The 4th gate is the post-development review gate. At this gate the decision of whether or not to put the product through testing and validation based on financial forecasts and product performance has to be made.

Testing and validation is performed in the 5th stage. Tests are performed in-house, field trials are performed and pilot production runs are done. At the next gate the final launch and commercialisation decision is made.

The final stage is the full production and marketing phase where the product is introduced into the market. During this stage the progress of the product is critically monitored and customer feedback suggestions are included in subsequent releases of the product. The company must also formally review what it learned during the project so that the organisation can learn from any mistakes that were made.

Next generation processes build on second-generation stage-gate processes but have particular emphasis on efficiency but are more fluid and adaptable. Stages in these processes can also overlap. The processes implement fuzzy gates rather than absolute decisions.

2.9. Fourth and fifth generation NPD

According to Miller (1999: 271) the 3rd generation process focused on incremental innovation. This was due to feedback coming from sales and marketing. Sales only serve to define needs in current markets. By doing market studies people's explicit knowledge, not their tacit knowledge, is ascertained. An example of this is the use of airbags in moter vehicles. The motorist will not tell you that he needs an airbag if he does not know that something like it exists (Miller 1999: 92).

Discontinuous innovation is, however, needed in today's competitive markets. Targeting the correct developments to implement is the most important practise. The only way to choose the correct development is to identify all possible development choices. The 'fuzzy front end' is where the 4th generation process invests heavily in knowledge aggregation and concept development. Sources of information are: continuous feedback from ongoing use, and lead customers' participation in research. At this point prototypes can be used in new real-world scenarios.

In this way both tacit and explicit needs are discovered and can be used to generate new designs. By researching needs throughout the life-cycle of the product the requirements the technology needs to satisfy are defined. The focus therefore shifts from the technology to the use of the technology. The next design will not be identified by looking at current dominant designs, but rather by looking at the needs of the customer throughout the life of the product.

In the anticipated 5th generation (Amidon 2005) management processes will be knowledge-based and collaborative. The innovation system is designed in collaboration with suppliers, partners, distributors, customers and other stakeholders. The enterprise does not only have financial capital; it also has intellectual assets. These assets now include the exchange of information with research institutes and business units, alliances, and joint ventures.

This culminates in the emergence of virtual research enterprises (knowledge innovation systems) without functional, industry, sector or geographical borders. Knowledge has to be built and retained inside the corporation so that innovative products can be created.

2.10. Sustaining and disruptive technologies

As stated previously, in the fast-changing business world the company has to be managed so that it keeps up with technological change. Christensen (2000:26) found that disruptive technological changes caused industry leaders to be toppled from their positions of leadership. The technology s-curve is a well-known technique used to plot the technology performance increase against time and engineering effort.

Typically, the rate of technological change at the start of a new technology is slow, the technology then enters a growth phase where rapid progress is made, and finally the technology reaches maturity where a lot of time and effort has to be spent to improve the performance. At this point the technology is ready to be surpassed by a newer technology.

Disruptive technologies are not any of the new technologies shown on the graph below. Technology 2 on the graph might be a sustaining technology that logically follows from technology 1 on the graph. Rather, a *disruptive technology happens when the vertical axis, or the way performance is measured, changes* (Christensen 2000:46).

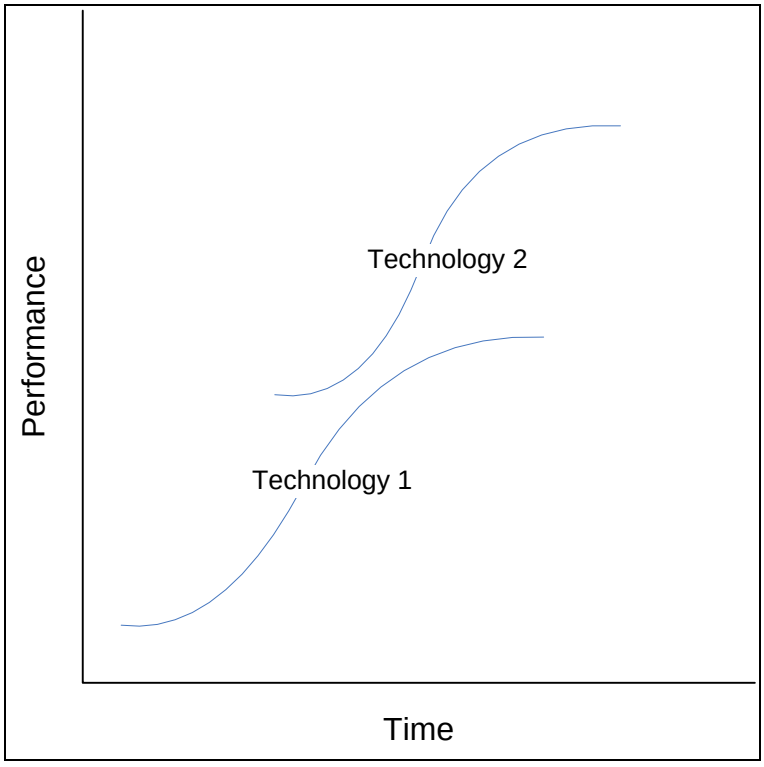

Figure 3: Technology S-curve

Christensen (2000:6) studied the history of the computer hard drive industry starting with the first drive made by IBM in the 1950's. The industry has seen an annual increase of 35% in the amount of megabits of information per square inch of disk space. The two biggest technology changes at the time involved the technology for the heads(ferrite-oxide, thin-film, magneto resistive) of the disk drives and the actual size of the drive (14-inch; 8-inch; 5.2-inch; 3.5-inch etc.). He found the first type of technology to be a sustaining technology while the second type was disruptive.

During a sustaining technology change the current leaders in the field remained the leaders in the industry. When the second type of technology change occurred, however, the leaders were toppled from

their positions. Christensen (2000:17) found that 14-inch drives were mainly used in the mainframe business, 8-inch drives in the mini computer field, 5.2-inch drives in the desktop computer world and 3.5-inch drives in laptops. None of the industry leaders in the 14-inch field were successful in the 8-inch field and similar results were seen for the rest of the technological fields. This occurred because the performance measure changed from one technology to the next. While 8 inch manufacturers were listening to their clients and creating more capacity for their mini-computers new entrants were building 5.2-inch drives for the new PC market which demanded smaller size rather than more capacity. The same thing happened to the 5.2-inch leaders when yet smaller size and less weight became the performance measure for laptop computers a decade later.

Christensen (2000:xxiii) postulated 5 reasons why companies do not manage successfully through disruptive technological changes:

The first principle is that companies depend on customers and investors for resources. Generally this means that companies are dictated to by customers and investors as to where money should be spent. Small emerging markets are not necessarily the place to spend money. Effectively companies listen to closely to their customers.

The second principle is that small markets do not solve the growth needs of big companies. Many large companies wait for markets to become big enough to warrant investment. At the same time a small company or start-up does not need the market to be big to warrant investing in getting their products on the market. At the start of the emerging market, the small company becomes a big company itself and effectively dominates the market, making it impossible for late entrants to enter the market.

Principal 3 is that markets that do not exist cannot be analysed. Sound business principals dictate that the market and its growth rate have to be analysed so that financial predictions can be made. Planning and marketing techniques are only useful in sustained technology markets.

Principal 4 is that an organisation's capabilities define its disabilities. A company's processes and values (dictating priorities) are tuned to be optimal for a specific market and industry. However, when the market changes the company processes and values could be totally wrong for the new product. For example, for the laptop industry the values of the company must change to accommodate the fact that weight and power consumption are the biggest differentiating factors in the market rather than disk capacity which is an important factor in the desktop market.

The fifth principal is that technology supply may not equal market demand. In some cases the performance of a product outstrips the

market need of performance. When this happens the clients basis of product choice changes from technology to functionality to reliability, then to convenience and lastly to price (Christensen Clayton 2000:xxviii).

Christensen (2000:33) further identified the firm's *value network* as the context in which a firm makes decisions, reacts to competition and seeks profit margins as the framework upon which decisions about new technologies are made. The corporate strategy and vision defines where resources will be allocated. With a disruptive technology it becomes difficult to allocate the correct resources to the new technology as it does not fit with the corporate strategy. This is an integral part of 3rd generation product development decision-making process. When it is necessary to move to a new technology the firm as a whole has to be moved to a new corporate strategy so that resource allocation can also change. Alternatively, it might become necessary to start a new division, separate from the main company (Christensen 2000:36).

2.11. Organisational learning

Along with process innovation, a need for a system to retain information has been identified as necessary. Carlson et al (1976:3) identified an organisation as a learning system in 1976. In practice this means that an organisation must look at past successes and failures, assess what happened, and use the information to better the company in the future. Where possible, product and design information have to be retained so that new product and product upgrade design lead times can be shortened. The retention of knowledge is easier in small companies because people are more aware of what is going on. In big companies the same product might be redesigned numerous times because information is not properly shared with other divisions.

With the advent of technological conformity over the last decade Davenport (1998:45) identified that knowledge had to be managed with the technology available to the business. Data or knowledge has to be stored and available to be used so that the same work does not have to be redone time and time again. Electronic data storing is therefore a possible tool used to retain and share information.

Business is challenged to learn from past experiences, retain the knowledge and use it to decrease development cycles in the future.

2.12. Project management.

The structure of the development team greatly influences how it is managed. In a rigid functional company structure every function—marketing, engineering and manufacturing—remains as a separate entity that is managed by functional managers. This type of team is

consistent with first generation NPD processes where every function passes its finished part of the project 'over the wall' to the next function. Little coordination and communication exists between the different functions. They are their own little empires.

Another team structure is the light-weight structure. A project manager acts as a liaison between the different functions. The problem with this structure is that the project manager has little influence over the functional managers. The project managers cannot make difficult decisions that will change the way the functional teams operate. This structure does, however, have better communication upstream and downstream between the functions during the various project phases. The project manager can get the manufacturing function to start talking with engineering earlier so that manufacturing can positively influence product design.

The next type of team structure is known as the heavy-weight structure. In this structure, the project manager is a senior manager who has influence over the functional managers. The senior manager has insight into the market and the impact it has on the various functions. If need be he/she could use his/her authority to use resources and change processes.

The fourth structure used is the autonomous team structure. In this case, resources are taken from a function and allocated to a team managed by a senior manager. This team is co-located and can make its own rules and define its own processes. The biggest strength of the team is focus. This team is often called a 'tiger team'. In this team, cross-functional integration and communication is not a problem. The team is well-suited for NPD. The disadvantage associated with the team is that it is difficult to control the team. Care must be taken to give the team clear guidelines. Many of these teams go on to become new business units and possibly new and autonomous companies. This type of team structure is therefore the most useful to use as a possible guide for a start-up firm. In a start-up firm the entire organisation is on the team. The team has been hand picked and everyone shares the vision to succeed. The members of the team are free to define processes and structures as they see fit. At this point people are able to take ownership of the company and the products.

This however, is a double-edged sword. Failure is more final than in a big well-established structure. The correct decisions have to be made as the start-up does not have a lot of leverage when something goes wrong. One catastrophic event could spell the end of the venture; there is very little time for trial and error.

The start-up also has to keep in mind what will happen to the team once the first platform product is out and the next generation product has to be developed. At this point the company undergoes a major

shift in need. The product in the field has to be supported while the new product has to be developed. The whole company is not working towards the same single-minded goal anymore. The company moves towards a functional structure. According to Wheelwright and Clark (1992:197) the technology the company deals in influences how long it will be able to have a product with only incremental changes in its current product line. In a high-technology environment the need for a tiger team that develops breakthrough platform products has to be offset with functional teams that build products from existing platforms and support current products in the field.

2.13. Knowledge management.

The transferral of knowledge between people and the retention of knowledge has been defined in various studies by Numata (1996:361), Davenport et al (1998:45) and others as a critical success factor. The postulation is that the more a person does a task the better he/she gets at doing the task. Intuitively this postulation makes perfect sense. With the 'capability maturity model' DRM associates (2002) identifies the cycles that a product/process has to go through before real understanding of it is achieved. The levels are defined as: initial , repeatable (processes established), defined (cost, schedule, requirements under control), managed (development process is predictable) and optimised. At the optimised level knowledge is shared freely and the whole organisation is focused on improvement.

Individuals in the organisation gain tacit knowledge on the project they work on. Unless the same person continuously works on the same project some knowledge will be lost if somebody else does the same type of task the next time around. The challenge to the organisation is to change the individual's tacit knowledge into organisational knowledge (Cross 2000:70). The development team as a whole has to learn from the experience of individuals. Conversely, the team must be able to guide inexperienced members with the team's knowledge. For a team to have knowledge its members have to learn to communicate the correct information to the rest of the company. The processes within the company have to facilitate the learning process.

The individual's tacit and explicit knowledge must be built up through experience and training. Regularly scheduled reviews of the performance of the development team must be held. This information is used to modify the product development process itself. Peer-reviews are held to illicit input from team members on technical issues, typically a design review. Databases should be repositories of knowledge i.e.: methodologies, tools, best practise examples and online communication.

To achieve a higher level of process maturity on a company-wide

scale, data has to be managed so that the organisation learns from past experiences. The creation of the company-wide knowledge base has to be correctly managed. Davenport et al (1998:43) identified eight success factors for a knowledge management project.

Firstly, it must be linked to economic performance or industry value. The most important factor shows up on the net profit of the company. An example of this is effective licensing of patents.

Next is technical and organisational infrastructure. If the knowledge project uses the broader company infrastructure and technology it is more likely to succeed.

A standard, flexible knowledge structure must be implemented. The knowledge repository must have the correct structure so that it is easy to extract information from the structure.

A knowledge-friendly culture must be built. The company has to reward and encourage the generation of innovative ideas. Employees must be motivated to contribute to the system via long-term incentives.

At the onset of the knowledge management project the company must clearly identify the goals of the project and identify what 'knowledge management' means to the company.

Multiple channels for knowledge transfer must be defined. Various tools (internet, database, e-mail etc) are used to contribute to the knowledge process.

Senior management must provide the funds and resources to properly support the project.

The previously-mentioned points identify the need to manage information and the need to coordinate the implementation of a company wide process. The next step is to actually look at some of the tools available to manage the different processes. According to Elliot (2002), NPD information has four dimensions: well-documented NPD process, project management, information management and collaboration. This ties up with the eight success factors used to define *which* specific areas knowledge has to be managed in. The eight factors provide a guideline as to *how* the overall gathering of knowledge must be managed.

Various tools are available to manage the NPD process. Some solutions offer an all-inclusive solution where the company implements the NPD process that vendor of the tools uses. A tool in this category is Sopheon: it implements a stage-gate process (Sopheon 2002). Other tools are more flexible and let the user configure the process. A tool in this category is Project Net (Project

Net 2002).

PACE, or product life cycle excellence is a process whereby the NPD process is evaluated continuously to ensure that the correct product is developed most effectively. IDE offers products to support the PACE process (Integrated Development Enterprises 2002).

NPD project management controls and measures the process:

- These tools are useful to control the usual project management activities (gantt charts, critical paths, resource allocation, work breakdown structures etc.). Typical products include; Microsoft Project, Project Scheduler, SureTrak etc The theory of constraints (TOC) is a relatively new theory that extends the critical path to a critical chain (Goldratt 1997:34) that includes resource constraints in the definition of NPD risks. ProChain offers a set of tools that extends Microsoft Project to add critical chain scheduling.

- The next version of these tools helps the project leader to manage the project scheduling across the Internet. The need to manage geographically dispersed development groups has always been there. The internet provides the capability to manage these groups more effectively.

Information management tools:

- Any product has a set of requirements to conform to. The requirements can be internal to the company (although the source of the requirement is still its customers) or, more often than not, from an external source (a standards body). It is important to manage the requirements and relate requirements to the design documentation.

- An electronic document management (EDM) system (also known as a Product Data Management (PDM) system) that helps with document retrieval, has an integrated database, implements a change control system and does version control is required (Sprague 1997). These configuration management (CM) issues become even more critical when the product is delivered to the client. The EDM system helps by improving the publication process (user manuals), improving business process, improving communication and leveraging organisational memory (Sprague 1997:51).

- Workflow systems offer integration between requirements, design and change requests, tasks, and configuration management. Workflow systems are installed across an enterprise and work from a central database. All processes that were previously paper driven are now computer-based with the

effect that changes are immediately visible across all affected areas. In the NPD environment this workflow process is known as PLM or product life-cycle management software.

- Products in this category are DOORS from Telelogic (Telelogic 2002) and Cradle from 3SL (3SL 2002). With the help of a database all specifications documents and requirement documents are placed in a central database from where they are accessible.

Collaboration tools help with the communication process.

- When groups are geographically dispersed they need to be able to communicate visually. The internet is the main facilitator in this virtual meeting process. It has also become more critical to communicate with suppliers, vendors and sub-contractors, not only other business units of the company, throughout the project. Tools in this category are Netmeeting from Microsoft (Microsoft 2002) and WebeX's Meeting Manager (WebeX 2002). With these tools real-time messaging and files can be shared and viewed.

2.14. Resource management

The engineering manager has to manage the engineers effectively so that productivity can increase. The success of development depends on creative, enthusiastic people. This is even more true in a start-up environment. The start-up asks employees to give a lot more of their time and energy to the company than the average nine to five big business does (Baird 1995:28). This tends to place enormous stress on the people involved and on their personal lives. Their environment at work should not add to the numerous technical challenges.

In a study by Hans Thamhain (1983:232) the following factors were identified as the most important influences on job satisfaction (in descending order of importance):

- Interesting and challenging work
- Professionally stimulating environment
- Professional growth
- Overall leadership
- Tangible rewards
- Technical expertise
- Assistance in problem solving
- Clearly defined objectives
- Management control
- Job security
- Senior management support
- Good interpersonal relations

- Proper planning
- Clear role definitions
- Open communication
- Minimum changes

It is clear from the above list that management; partiularly the CEO, has a strong influence over the needs of the engineers. The strategy of the company, the support of management for the projects and the product development process followed all play a part in creating a winning environment.

Roussel et al (1991:173) suggests that the company must plan their resource needs on a five to ten year horizon. In a start-up this would obviously be very difficult; nonetheless the engineer's needs must fall into place with those of the company. Technical prowess should not be the only trait considered when evaluating a new engineering candidate. The individual's role in the team is important in order for team balance to be achieved. The experts found that the following factors greatly influence team morale:

Firstly, productivity is linked to a sense of partnership with the enterprise.

Secondly, morale is a product of doing challenging work in a rewarding environment.

Finally, challenging work is derived from meaningful targets and rejuvenating variety.

2.15. Conclusions and further analysis.

This chapter identified a number of important concepts to be used in the research for this dissertation. Firstly, the concept of best practise categories and the evolution of these categories over the years have been described. The best practise categories identified by Dooley (2002:20) will be used extensively in the rest of the dissertation to define a framework upon which questions will be presented and analysis will be done.

Dooley (2002) has been chosen because it incorporates work done in previous studies. In paragraph 2.5, the evolution of best practise studies starting with Booz, Allen and Hamilton's initial work is shown. Most importantly, Dooley quantifies his results. These results will be compared with the results from this study. It will also be shown that by using the Dooley survey as a pattern, the data collected can be compared against the survey and thereby its internal validity will be strengthened.

These studies include the different categories defined by Dooley (2002:20) and will be described in more detail in the next chapter.

In chapter 4 the research questions are formulated. Detailed information given in chapter 3 will clarify the questions asked in chapter 4 and give the reader a good background to draw from when analysis of the results is performed.

From the review of the literature it was found that these best practise categories, and other tools and techniques, are not specifically formulated for a start-up company. As stated at the end of chapter 1, it is the goal of this dissertation to find out whether a difference exists between best practise methods for start-up companies and those of established companies.

3. Theoretical Framework

3.1. Introduction

This chapter presents the current theory which is directly applicable to the research to be done. While chapter 2 gave a wide-range review and history of current theory, this chapter will discuss every category and tool to be used when designing the research instrument. In this case the research instrument to be used is the interview questionnaire.

First, best practise categories as defined by Dooley (2002:20) will be described. Later, when formulating the research questions, the best practise categories will be used directly. It is therefore necessary to clearly describe and define what is embodied in each best practise category.

Second, a company evaluation technique defined by Bell is described in the second part of this chapter. This method will be modified so that the research questions asked will be relevant to the specific life cycle phase of the company.

3.2. Current theory

Dooley (2002:20) suggested that best practise activities could be grouped in specific categories. These categories will later be used to define evaluation questions. To fully understand the best practise questions, background information on each category defined by Dooley is given.

3.2.1. Customer involvement

The first three stages of the development process, according to Cooper (2001:130), are: the discovery phase, the scoping phase and building the business case phase. The customer must be involved in all these phases so that the company can deliver a superior product. Gating meetings are held between all the phases in order to screen ideas.

The first phase or ***discovery*** phase does not take long. The idea is to generate and investigate a multitude of ideas. Various tools and techniques are available to capture these ideas. One such tool is voice-of-the-customer research. Ideas, either from the customer itself or from technology disruptions in the customers industry, have to be captured and analysed. Another useful technique is to work with lead users who are on the cutting edge of technology and new products in the industry.

After the initial idea screening, the second phase or ***scoping*** phase is entered. While the first phase is completed in a short period of time using limited resources, the second phase is more thorough. The second phase encompasses preliminary market-, technical-, business- and financial assessments. The customer gets more involved in this phase. While a large customer base was used in phase 1, in phase 2 the customer base used for interviews and site visits is more focused. No detailed questionnaires are required yet but face-to-face discussions with key customers are very useful. It is important to speak with more than one person at the each company as different people have different perspectives on the problem. After assessing what the customer wants a technical feasibility study has to be done. Customer feedback can now be used to provide specific requirements for the product. The technical risks and feasibility of the project can now be assessed because specific requirements for the product are now available.

In stage 2 or the ***business case building*** phase, the customer's knowledge becomes critical. The output of this phase is a complete description of the product. A superior product has to be delivered; one that provides unique benefits and value to the customer (Cooper 2001:201). A ***user-needs-and-wants study*** can be performed to answer specific questions. These questions are: what does the customer consider to be real value, what is a benefit, and which features, attributes, and performance characteristics translate into benefits and value for the customer?

Various methods and tools can be used to gather this information. Focus groups and on-site interviews are two techniques for information gathering. Specific questions have to be asked so that the correct data is gathered. Robert Cooper (2001:190) suggests the following 10 questions that a customer should be asked:

- How is the customer currently solving its problems?
- What unsolved problems are the customer experiencing?
- If the customer had a choice, which product or brand would the customer buy now?
- Which criteria does the customer use when making a buy decision? How do current products rate with regard to these criteria?
- What does the customer specifically like and dislike about current products?
- Which specific features, attributes and performance criteria is the customer looking for?
- What trade-off is the customer prepared to make?
- What is the customer's use-system for the product?
- What is the customer's economics?

After the information has been gathered it has to be analysed. A tool that is helpful for analysing such information is a House of Quality (HOQ)—shown below. This matrix correlates the needs of the

customer, (as determined by marketing), with the engineering capabilities of the company. The left hand side of the house lists the needs of the customer according to their importance to the customer. The right hand side of the matrix lists competing products and the customer's perception of these products' abilities to satisfy the customer's needs.
The customer's needs are translated into measurable engineering units in the design attributes section. In the engineering measures box, the competing products are analysed according to engineering units. The middle of the HOQ is a relational matrix that judges which design attributes influence which customer needs. The roof of the matrix shows the interrelationship of the design attributes with one another.

The HOQ is one way of visualizing the relationship between customer needs and the engineering capability. The important point to recognise here is that the product has different inputs for different requirements. The requirements must be extensively analysed before the product is designed.

Due to the limited resources available to the start-up (mentioned in chapter 1) it will be difficult for the start-up to study a variety of customers. A marketing team has to be available to do the research work. It will take time to find the right people to assemble such a team.

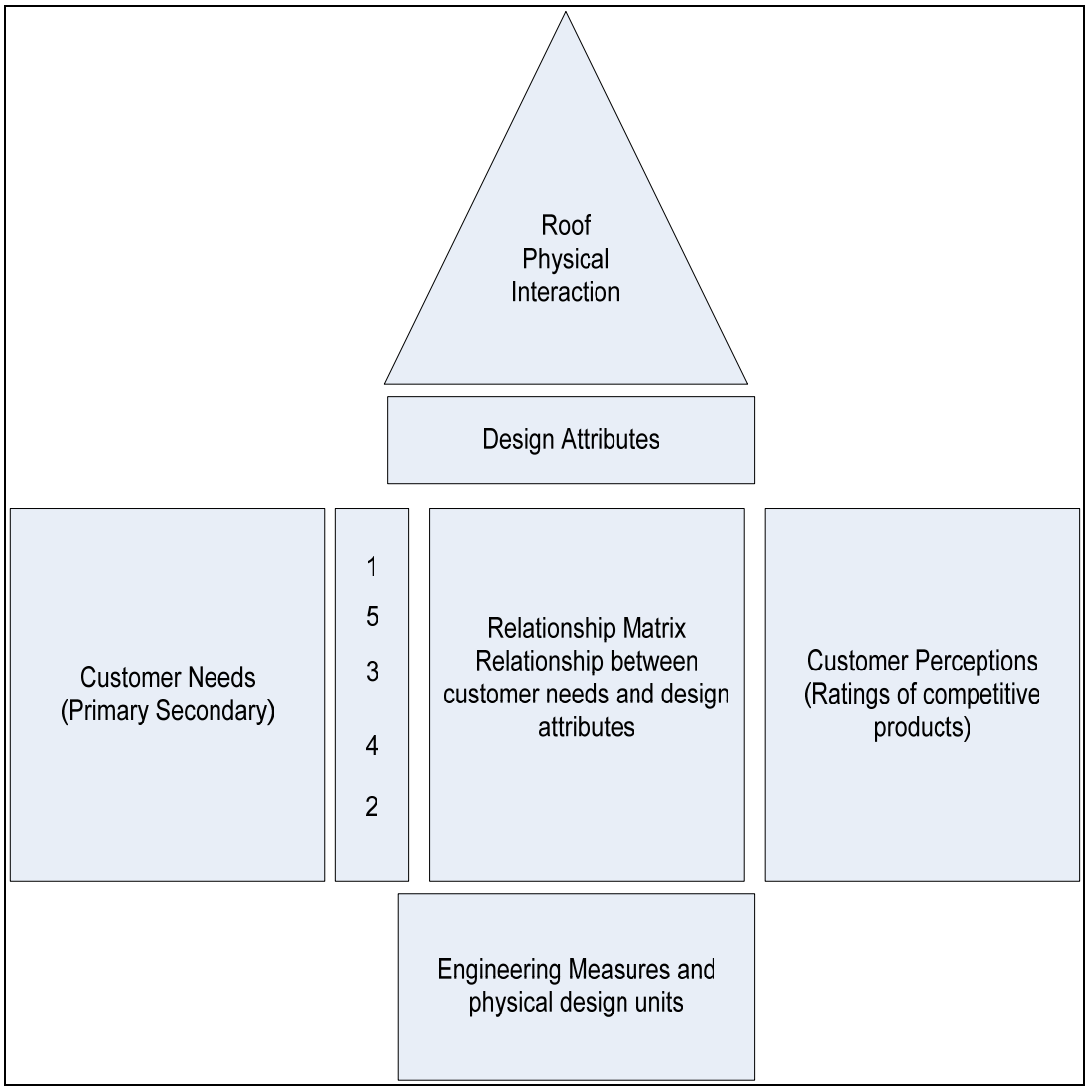

Figure 4 House of Quality

Proposition 1: Customer involvement will increase over the life-cycle of the start-up.

3.2.2. Project selection

Cross-functional analysis of new projects is complete and NPD plans are most influenced by informal planning activities.

The development funnel is a method, proposed by Wheelwright and Clark (1992:111), to select between different proposals. It eliminates proposals according to the company's product strategy until only the projects that fit the company are left.

Table 1 Development funnel stages

Phase 1	Screen 1	Phase 2	Screen 2	Phase 3
Product/process idea generation and concept development	Screened according to technology, product market strategy and other criteria	Detail proposed project bounds linked to business and functional strategies	Make a go no go decision after which the remaining projects are staffed and moved into development	Projects turn into products or development is stopped

Robert Cooper (1999:35) states that one of the biggest problems with and projects in companies is that management is unwilling to make tough choices and stop projects when necessary. Gates are held as the place where decisions are made and resources allocated. If this is not done too many projects will use too few resources. Gates therefore, have three advantages: they act as quality control points, they act as resource allocation points and gates provide focused areas for resources to work on. Robert Cooper (1999:144) suggests three different approaches to project selection.

First, benefit measurement techniques can be used. These techniques are subjective and do not act on physical data such as financial data. The projects fit with strategic variables such as corporate objectives, and competitive advantage and market attractiveness can be assessed. These techniques are most useful in the initial screening phase.

Second, financial or economical models can be used. Computational approaches such as payback-period, break-even analysis, return on investment and discounted cash flow can be used. Because data is inaccurate, techniques such as decision analysis can be used to analyse available options. Two problems with this method, however, are that data is often inaccurate and the project is viewed in isolation.

The third group of methods are portfolio selection methods. One of the advantages to a portfolio approach is that resources can more easily be allocated. Specific techniques are available to prioritise and allocate resources. Different tools are available such as: portfolio maps, bubble diagrams and the strategic buckets method. Portfolio methods should, however, be used in conjunction with the previous two methods.

During the life of a project, it has to go through various gate decisions. At every gate meeting the project has to be evaluated

according to specific criteria. Three types of quality issues exist: the quality of the project execution, the project's fit with the business and the fact that an action plan for the future has to be evaluated. The aim of the gate meetings is to reduce risk and ***make 'go/kill' or 'hold' decisions***. A two-part decision is made at a gate. First the project is evaluated to see if it is a good project to take on. Next the project is evaluated against the other projects in the company; this forces a resource allocation decision to be made based on project priority. Robert Cooper (2001:132) suggests that the following questions be answered at gate meetings;

- Is the project strategically aligned with the company's business strategy?
- Is there a market need for the project?
- Is the project technically feasible?
- Does the project have a unique advantage for the customer?
- Does it meet all safety, health, environmental and legal requirements?
- Does the project make financial sense?

While big companies might have numerous projects happening at any moment, small start-up companies would typically not have the resources to pursue many different projects at a time. The start-up is either internally funded or funded by investors. In either case, a tight reign has to be kept on resources.

Proposition 2: The start-up will be forced to make gating decisions as to which projects to perform.

3.2.3. Product strategy

Technical strategy is defined and should be known throughout the organisation.

Projects must be aligned with internal constraints and capabilities as well as external factors like regulations and competition. The company must choose projects that fit with the current product mix and that therefore leverage the internal capabilities of the company.

The company has to manage its ***project portfolio***. According to Robert Cooper (1999:189) the three main reasons for this are:
Firstly, the correct new products are fundamental to business success. ***secondly,*** new products are a manifestation of the company's business strategy. ***thirdly,*** resources must be allocated to the correct projects.
The ***three main goals*** of portfolio management are: ***value maximization, balance and strategic direction***.

Value maximization entails the allocation of resources so that specific objectives, either long term or short-term profitability,

return on investment, or other objectives are met. Different techniques can be used to measure the value of the product. When the project is evaluated at a stage-gate review the project has to be judged according to these criteria. Possible techniques are: expected commercial value, productivity index, dynamic rank-ordered list and scoring models.

Balance entails the allocation of projects in order that a number of different parameters can be met. This could be the allocation of projects according to various criteria: new core product, next generation of the core product, addition to the product family and derivatives and enhancements. The amount of risk, technologies used or specific market penetration could also be criteria. Bubble diagrams are a useful resource to use when plotting various criteria against each other. Possible bubble diagrams to use are: risk vs. reward, technical newness, and cost to implement vs. time to implement, among others.

The final criteria, strategic direction, ensures that the project portfolio reflects the business strategy of the company. The breakdown of spending over projects, products and markets must reflect the business strategy. The business strategy could define which technologies or markets to focus on or indicate that the business focuses on new leading edge products.

When the project portfolio is evaluated, projects and products must be evaluated according to the chosen criteria as they relate to the dimensions mentioned. Whether resources are allocated and whether the decision is made to continue with the project depends on the project scoring high on the criteria defined by the company as important.

The start-up company will typically not have a large portfolio of diverse products. It will usually only have the resources to work on one product. This would be the product the start-up initially got funding for. All the product strategies as well as the business plan would be focused on selling the company's product to investors.

Proposition 3: The start-up company will focus more on product strategy than the rest of the industry does.

3.2.4. Concept design

Concepts for new products can be generated by different sources. These sources include employees, customers, new technologies and suppliers, among others. These new ideas have to be analysed and screened using various criteria before they are selected for further development. If the product is selected for further exploration a concept design is created and a risk analysis performed.

The concept design phase fits in between the product development and building the business case phases. Tools like the house of quality are used to match product requirements, customer needs and technical feasibility. This needs-identification-and-translation process could be flawed however. Therefore, before going into product development, the company must test how well the customer needs were really translated. Two assumptions have to be tested: firstly, the assumption that the customer knows what his/her needs are and is able to verbalize them, and secondly, that these needs were correctly translated into final product specifications. If errors are discovered adjustments can be made and the product specification can be corrected. When the customer holds the product in his/her hands he/she might be able to more clearly visualize how he/she will use it and therefore describe the requirements better. The concept design could take on many different forms depending on the industry. It could vary from brochures, virtual prototypes, mock-ups and drawings to a clearly written description. The prototype should be presented to a wide variety of potential customers and their feedback should then be formally gauged. According to Robert Cooper (2001:35) the following should be done when presenting the concept to the customer:

- The customer's interest in the product must be measured.
- Which facets of the concept the customer likes and which not must be measured.
- How the customer rates your product against the competition must be measured.
- What the customer expects to pay needs to be ascertained.
- The customer's purchase intent at a specific price needs to be determined.
- Information useful in finalizing the positioning strategy must be gathered.

Technical advantages can also be attained when the prototype is designed to test new technologies or processes. If the technical risks of a new technology are high it would make sense to test them or at least the process of creating the product; be it testing the tools used in developing the product or determining the resources required to develop the product. To gather this type of information a more-complex prototype has to be made.

A prototype could be advantageous to a start-up company when the concept design demonstrates the capabilities of the group of founders. It might serve to convince a venture capitalist to give the start-up more money to further the endeavour.

Proposition 4: Concept designs in the start-up will be done to a limited extend, not more than the industry average.

3.2.5. Technological leadership

According to Gordon Bell (1991:114) the company has to have a technology balance sheet. This encompasses, amongst other dimensions, a technology base. The technology base includes internal and external sources of components, as well as know-how represented by critical personnel, patents, computers and software, tools, and laboratory equipment and processes. The company has to investigate every aspect of the technology it needs to use to build a product with. The company can follow different technology strategies as either the technology leader or follower. In either case, the company has to be able to produce products with superior technologies. However, the company still has to adhere to industry standards when designing the product. An example of a standard is WCDMA (wideband code division multiple access), the company can design its product with the technology of its choice but the standard itself, as set out by the standards committee, has to be adhered to. The company must be involved and up-to-date with changes in the specification as set out by the standards body. The company could also define internal standards. These could range from software and hardware coding to the way in which requirements are specified. These internal and external standards are only useful if all the relevant people involved are aware of and adhere to them.

Another dimension of the technology balance sheet is the technological future of the company. The technological future dimension measures the new venture's ability to sustain the competitive viability of the technology. The company must assess its products and architectures relative to state-of-the-art process technologies under development and the company's ability to hire competent people. The company has to be able to build competitive products in the future so that competitive advantage over the competition can be built and sustained.

Technological changes are monitored and the technological strategy of the company is aligned with these changes. A well-known technology tool is the technology s-curve. The technology s-curve plots technological advances in a field against time. In the beginning of a technology's life-cycle, advances are slow. Eventually momentum picks up and major improvements are made in a short time period. At the end of a technology's life-cycle, technological advances start to slow down. It is important to monitor this period of a technology's existence as the technology is ready to be over-taken by something new. A new technology that replaces the old one will have obvious improvements on the technology it replaces.

The rate of change is dependent on the field the company is in. In the electronics industry technology obviously changes faster than in the steel manufacturing industry. Whatever the field the company is in, it must keep abreast of advances in its field. An organisation would not want to be the only company making mechanical typewriters when the

rest of the world is using computers.

To be a technology leader requires resources. Unless the company got funding to develop a break through technology, the start-up would not typically be able to develop new technologies.

Proposition 5: The start-up company will follow technology leaders.

3.2.6. Documentation

Documentation forms part of the bigger Knowledge Management process as described earlier. The organisation must be able to learn, documentation of concept, product, process and project information helps the transferral of knowledge throughout the organisation.

Documentation is used throughout all stages in the stage-gate process. These stages are: idea generation, preliminary investigation, detailed investigation, development, testing and validation, and full product and market launch. Documentation forms an integral part in the earlier stages of development where ideas are generated and where those ideas are later changed into requirements for the product and for the functions that will design, manufacture and market the product. At the gate meetings of the stage-gate process where ideas and progress are judged according to formal criteria, the results and decisions of these meetings need to be documented so that all departments involved are fully aware of the decisions made in the organisation.

As the documentation of a product changes over the lifetime of the product, including changes made after the product is launched, formal change control has to be implemented to prevent problems when supporting or manufacturing the product. Even when a new-generation product is developed, the next-generation product must build on accurate information from documentation about the old product.

3.2.7. Change control

Formal change control must be implemented across the life-span of the product. The impact of a decision to change a product must be made visible to all the parties involved. Change control is part of the knowledge management process. The impact of the change must be evaluated. This impact could be on cost, schedule slippage, regulatory standards, procurement, manufacturing and testability, among others.

During development the engineering, manufacturing or marketing functions must be able to easily and formally enter a change request when an error is discovered. The problems or errors should be clearly

explained, this includes indicating the specific version of the product or development project. The problem should be explained in as much detail as possible. Details could include the specific conditions under which the product failed or the design flaw or non-compliance to a formal standard that could make the product fail when it is finally released. The problem must then be assigned to a specific person to take ownership of and mobilize the relevant people into solving the problem. The problem should also be given a criticality rating so that everyone is aware of the seriousness of the problem. This will help people in making decision regarding what priorities they should give to the various tasks assigned to them.

This process will only work if people are quickly and easily informed of the new problem. Typically, a database that is accessible to everyone involved over the internet is an ideal solution for facilitating communication.

When the relevant people have assessed the problem an estimate must be given as to the length of time necessary to solve the problem and the impact the problem will have. When the problem is fixed or flagged as a possible enhancement that could be added to the next generation of the product, the problem must be formally closed with a detailed description of the solution implemented. This information must once again be communicated to the relevant people.

In a new company no processes have yet been defined. While the company is still small enough not many processes are required as everyone knows everyone else and communication is fairly simple. Documentation need only be generated if it is required by sources outside the company. The company resources are spent on developing the product not on documenting anything non-critical.

Proposition 6: In a start-up company change control and documentation will be of secondary importance.

3.2.8. Goals and metrics

In the stage-gate process specific criteria are defined against which the product is measured at every stage of the development process. If the product measures up to all the criteria set the product may progress to the next stage with all the necessary resources committed to it at that point in time.

The development process metrics must be quantitative. Proper metrics must be selected to measure process, project and product performance. Metrics help the organisation to set goals and to measure whether or not the goals have been achieved.

Short-term metrics help to measure the effectiveness of the

development process. Project metrics measure the schedule- and cost performance of the project. Product metrics measure how well the product performs in the field. Product metrics also measure how well the production of the product is going.

The specific metrics chosen by the company are specific to their product portfolio, which again ties in with the company's product and business strategy.

Like any other company, the start-up survives on cash flow. In the start-up the cash is provided by the investor, or if the product is already selling, by the customer.

Proposition 7: Goals and metrics will closely follow investor or customer milestones.

3.2.9. Process control

Process control or, as Gordon Bell (1991:114) puts it, operational management, is the process whereby the organisation manages itself by meeting product specifications, budget- and schedule commitments. The management of the start-up includes use of various techniques, including design reviews, objectives, metrics, staff meetings and team building, amongst others.

The structure of an organisation influences how project management is done in the company. The most common organisational structure is a matrix structure. In this structure resources are grouped into functions. Project managers take resources from the different functions to use as resources for development projects. How much relative power the functional managers yield versus how much power the project manager has influences how the project is managed. As stated before, a start-up company usually does not have constraints such as these. The start-up generally works on one or two projects that might share resources. The project manager might be a senior manager. The real test of project management is in judging the success of the project.

The stage-gate process uses input from all the functions during the different stages of the development cycle to make 'go/kill' decisions during gate meetings between phases. Therefore, manufacturing, marketing and the company's suppliers are involved from the start.

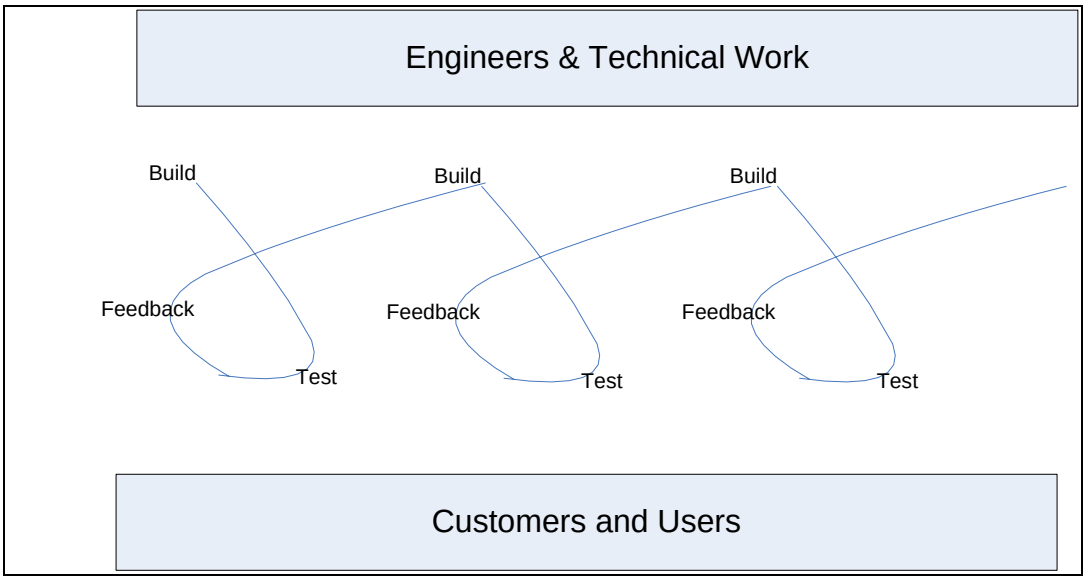

Figure 5 Design process

The detail design is specified and put under formal change control. The detail design is taken from the requirements given by the customers, engineers and any formal standards. Documentation that describes the product and design decisions is generated. The product is verified through the testing of prototypes. Design is an iterative process that progresses through various prototyping phases (Wheelwright 1992:148).

Manufacturing is not complete when engineering finishes the product. Manufacturing plays a role from the beginning of the development process. Input from manufacturing is used to generate key design requirements. Manufacturing's role changes as the product moves through its design life-cycle.

Table 2 Manufacturing's role during the development process

Development phase	**Manufacturing activities**
Concept development	Design process concepts.
Product portfolio	Develop cost estimates for the process; define the architecture of the process. Simulate the process and validate component suppliers.
Detailed design and development	Create a detailed design of the process and build a full-scale prototype. Refine the process and prototypes iteratively.
Commercial preparation	Build pilot units and start the commercial process. Train personnel and verify the supply chain.
Market introduction	Ramp up the plant for production targets and verify quality, yield and cost targets.

A key step in these processes is that they have to be communicated to the staff and everyone else involved. Everyone should take ownership of the process. This sense of ownership should stimulate progress and not become a hindrance. The start-up will have a fluid organisational structure, depending on the product needs, it will change.

Proposition 8: The start-up company's organisational structure will change as the product goals change.

3.2.10. Human resource development

The company must be staffed with the correct people. The employees then have to be motivated to perform. Their careers have to be developed and the team must be trained to work together.

Gordon Bell (1991:19) quotes John Shoch as saying that "lack of a team is the number one company killer". He goes further and says that although team building is important in any organisation, it is of critical importance in a start-up environment. The employees in a start-up must be able to communicate openly regarding a number of tasks including; defining the product for customers, manufacturing the product, resolving customer problems, meeting operational and financial objectives, and being committed to quality. It is especially important in a start-up that team leaders are technically competent people who are not only involved in management but also actively involved in the design process. This helps to create a better team spirit; the team leader can truly act as a mentor to the people under him or her. The organisation is lean from the start and it is easier for the team to build respect for management.

In a start-up it is important to show respect for the personal lives of the staff as the company is usually understaffed due to financial constraints. Also, if people are over-scheduled there is nothing to fall back on when a crisis arises. After years of hard work, over-scheduling and 80 hour workweeks eventually lead to burn out and disgruntled employees. It is important to reward employees in proportion to the contribution they make to the organisation. Rewards should be based on peer and management reviews of the employee's performance. Gordon Bell (1991:21) says, however, that "the measure of the team's success is how the contributions that its members make through their individual roles combine to produce an overall result that is greater than the sum of the separate contributions". Therefore, the team as a group should also be evaluated.

Investor capital should be spent with respect. (Gordon 1991:23) The money must be used with discretion but employees also need to have the appropriate tools with which to perform their tasks. Where

necessary, employees must be sent on internal and/or external skills-development training programs so that they are able to properly and effectively use their tools.

The start-up does not have the resources (time in particular) to spend on training staff. The start-up does however have an exceptional chance to help the staff grow in their fields of expertise, in many cases expanding their horizons as they company needs change. In the initial phases the start-up will probably not have a separate human resource department.

Proposition 9: The start-up company's human resource development will be as good as the industry.

3.3. The Bell-Mason diagnostic.

The one dimension missing from the previous discussion however, is that the start-up company's needs change over time. Gordon Bell (1991:251) suggests a technique for evaluating a company's growth. It is known as the Bell-Mason diagnostic and has four major elements to it:

1. The five stages of company growth.
2. The twelve dimensions that are measured to assess a start-up.
3. The rules used to evaluate the twelve dimensions
4. A relational graph plotted against the ideal model for success.

The four elements are detailed below.

Firstly, the life-cycle of the start-up company can be divided into five different stages.

The first stage, known as the concept stage, is where the idea for the company is formulated. The output of the **concept stage** is a business plan.

The second stage is the **seed stage**. In the seed stage, money is secured from investors, the team is put together, and the product and financial goals are aligned.

The third stage is the **product development stage**. This stage can be divided into **four parts: hiring, design and build, alpha testing, and beta testing**.

The fourth stage is the **market development stage** where the product is prepared for and introduced into the market. This phase can be divided into the market calibration stage, market expansion stage and steady-state operation stage.

The fifth stage is the **steady state stage**. The company has to produce new products during this stage to remain successful.

Secondly, every stage is evaluated according to the same **twelve dimensions**. The company has to be in balance across all the dimensions before moving on to the next stage. The twelve dimensions are: the **business plan, marketing, sales, the CEO, the team, the board of directors, money, finance ability, operations control, technology and engineering, product, and manufacturing.**

The technology and engineering dimension has to be judged to be superior so that technology can be changed into quality products time and time again. According to Bell, the company's technology balance sheet has to include design, quality and other processes, project planning, engineering specifications, manufacturing specifications, an extremely competent chief technical officer, and good operational culture amongst other dimensions. This dimension is the one detailed in this dissertation. During the data analysis and gathering process this dimension will be concentrated on, it will therefore also be the dimension that will be judged critically in the case of Zyray Wireless.

The product itself is judged according to its uniqueness in the market, and the benefits it offers as well as its price are measured against its competitors' products. The company must be able to deliver the product, support it and build the next generation of products.

The company's manufacturing process, whether internal or external, must be judged to be able to deliver superior quality products on schedule. Inventories of the product must be kept at optimum levels so that product is available to the company's clients.

The company has to have a realistic, working business plan. Presumably the plan would have been reviewed by investors and it would contain: a mission and vision statement, an outstanding technology platform, a product strategy, a marketing and sales strategy, a human resources and reward structure as well as detailed financial requirements. The product and financial milestones have to be spelled out and need to be achievable.

The company has to have a detailed marketing plan. The plan has to spell out the product details, who the buyers will be, how the product will fulfil requirements, where the product will be sold and when the product has to be sold.

The company has to be judged to have an exceptional sales manager and a competent sales team.

The CEO has to be judged very critically. It is, after all, the CEO

who makes all the crucial decisions. The CEO must be able to manage employees under him, have strong leadership capabilities, create the company culture and be able to attract investors and buyers to the company.

The top-level management team has to be comprised of high-quality people. They have to be able to build and attract top-level personnel. They must be able to function together as a team and also be innovative.

The board of directors must know the business the company is in. They must be able to guide the company when necessary and attract the best people to the company to help with growth, technology, sales and marketing. The board must be able to review and judge the strategic plans of the company and its products.

Cash-flow is what makes or breaks many companies. The company must have their expenditure under control and must be able to accurately predict how much money is available and how much is used so that the managers are clearly aware of when new money needs to be brought in.

The company must be able to attract enough investors for subsequent rounds of funding. Investors will only finance the company if they see growth-potential in the market the company is in.

Control has to be maintained throughout the company. Everyone in the company must know the goals of the company and their role in achieving these roles. It is important that everyone knows when milestones are to be reached and how important they are for the company's success.

Thirdly, rules have to be used to evaluate each dimension. These rules can be seen as requirements for every dimension. Specific questions are asked in order to evaluate how well the company does in each of the dimensions. The rules may carry different weights depending on the criticality of each issue at a specific point in time. Questions are formulated from a heuristic observation that defined a rule.

For example, the heuristic observation was made that software engineers make better code when their peers review their code. The rule is therefore that engineering companies should have a code walk-through as a part of the design process. The question defined is therefore, "Does the company have some process that includes code walk-through as a way to ensure quality?" The rule has a yes or no answer.

If the company cannot answer 'yes' to the question it must decide whether the question is relevant, irrelevant or whether or not they

have found a better way to achieve the goal than the rule provides. Depending on the answers the company can move forward to the next phase.

Note that the rules become more stringent as the company grows.

The ***fourth*** dimension is a relational graph. The graph is a type of polar coordinate graph. The life-cycle phase is plotted going outward from the centre of the graph. The twelve dimensions form the lines extending from the centre. Every dimension is scored according to the life-cycle phase the graph is created for. Every dimension should at least be with the minimum and maximum score for the current and the next phase. The most important dimensions change as the company moves through its life-cycle. During various life-cycle stages, the emphasis shifts to different dimensions.

4. Research design

Research design is defined as the technical plan that attempts to link the beginning and end of a study, helping the investigator get from the start to the finish (Yin 1993:45). The design must ensure that the data collected is pertinent to the research question asked. The data must then be interpreted in a logical way.

The research method followed in this dissertation was ***a case study research methodology using an interpretive philosophy.***

Research methods can be classified as belonging to either ***quantitative*** research methods or ***qualitative*** research methods (Myers 2002).

Quantitative methods are used by the natural sciences to describe natural phenomena. Quantitative methods include surveys, laboratory experiments and numerical methods. Qualitative research is used by the social sciences to describe social and cultural phenomena. Examples of qualitative research are action research, case study research and ethnography. Data sources include: observation, participant observation, interviews, documents and the researcher's impressions.

Whether a person is conducting qualitative or quantitative research, some underlying philosophical assumptions about the validity of the research methods have to be made. Michael Myers (2002) suggests the adoption of three categories of research based on the underlying research epistemology (assumptions about knowledge and how it can be obtained): ***positivist, interpretive and critical***.

Positivism tests theory in an attempt to increase the predictive understanding of phenomena. Research can be classified as positivist if there is evidence of ***formal propositions, quantifiable measurement of variables, hypothesis testing and the drawing of inferences about a phenomenon from the sample to a stated population*** (Myers 2002).

Interpretive studies try to understand phenomena through the meanings that people assign to them. Interpretive research does not define dependant and independent variables, but focuses on the full complexity of human sense-making.

The main task of ***critical*** research is to deliver social critique. Although people can act to change their circumstances they are constrained by forms of social, cultural and political domination. Critical research aims to eliminate the causes of alienation and domination.

Qualitative research has four main research methods. These are ***action research, ethnographic research, grounded theory research and case study research*** (Myers 2002). The research method influences the way in which the researcher gathers data. Each method can be addressed using any one of the three research philosophies previously mentioned.

Case study research falls under the empirical research design group (Mouton 2001:148). Case study research is qualitative in nature and is ideal for describing a particular business situation. According to Robert Yin (1993:46) the case study approach can be used to define specific questions ahead of time, to emulate logical positivism in developing rival hypotheses and to collect evidence bearing on these questions, and finally to carry out field work in a targeted fashion. *Logical positivism* is the philosophical school of thought that entails the ***process of developing hypotheses, collecting empirical data and developing conclusions based on the analysis of such data***.

According to Robert Yin (1993:44) Case study research is the best way to capture dynamically changing conditions. First, the most important questions that should be asked at the start of a case study research process will be discussed.

A case study research design should answer the following questions (Yin 1993:43):

1. How will the case be defined?
2. Are single or multiple case studies going to be performed? If multiple case studies will be performed, when and in what order will they be performed should be noted.
3. How should the study be bounded with regard to time, participants and relevant evidence?
4. What is to be proved, concluded and observed?
5. How should the researcher decide whom to interview and how long the interviews must be. What instruments should be used, if any?
6. How should other sources of evidence be treated? How should the situation be treated if the company changes drastically?
7. What must be done with the notes when everything is to be written up?

4.1. Defining the type of case (unit of analysis).

According to Robert Yin (1993:47) the unit of analysis or unit of study must be defined, as this becomes the main analytical level for the case being studied.

Robert Yin (1993:48) states, "A key challenge in constructing an acceptable case study research design is to ensure that the major questions of study are pertinent to the selected unit of analysis. ***If the questions do not coincide with the unit of analysis, the data collected may not answer them either***".

The ***unit of analysis*** for the case study will be the ***product development process followed in the start-up company.***

This will be the major unit of analysis. Robert Yin (1993:48) points out that embedded units of analysis may be used as long as the major questions remain at the same level as the major unit of analysis.

Therefore embedded units of analysis will be defined as necessary as long as the questions asked at an embedded level coincide with the major unit of analysis.

4.2. Type of case study methods

Case study research offers a lot of choices as to the type of case study methodology to follow (Garson 2003). ***The two biggest factors are, however, the number of entities studied and the bounding of the study over time.***

The first two types of case studies are more focused on the single case design philosophy. The first possibility is the snapshot case study where an entity is studied at one point in time in detail.

The next possibility is the longitudinal case study where an entity is studied over multiple points in time.

Third is the pre-post case study where one or multiple research entities are studied before and after a critical event.

Forth is the patchwork case study method. This entails the study of multiple entities using snapshot, longitudinal and or pre/post designs. It provides a more wholistic view of the research subject.

The final possibility is the comparative case study, which involves the qualitative or quantitative comparison of multiple case studies and multiple research entities.

The Zyray case study will follow a longitudinal model. The investigator used the participant observation method due to working for the company for the duration of the case study.

One of the biggest issues with case study research is how ***representative*** the case studied is. Case studies cannot be representative of the entire population, therefore over-generalizations cannot be made. In case study research generalizations are made to a

theory based on cases that represent that theory, not on generalizations about the whole population.

The case to be studied should be driven by the theory being investigated. Cases available in the literature that claim theories other than the one suggested must also be cited. It helps to investigate contrasting theories.

Because the case studied here is a single case it is not possible to generalize the results to the whole population. The results obtained here were compared to current industry results but not generalized to the rest of the industry.

4.3. Boundaries of the case study

Data can be collected in one of two fashions: it can be collected once over a short period of time or a number of times over a longer period of time. In the first case post-hoc longitudinal data is collected, in the second case true longitudinal data is collected (Yin 1993:47).

Data gathered for this dissertation was collected over a long period of time, therefore; true longitudinal data could be collected. ***The data collected spans the time from the start of the company to three years later.*** This was made possible by the fact that the investigator also works for the company.

Before data can be collected a strategy has to be formulated for analysing the data. By knowing how the data has to be analysed it will become clearer as to how the data has to be collected (Yin 2002:99).

4.4. Analysis

According to Yin (2002:99) the ultimate goal is to treat the evidence fairly, to produce compelling analytical conclusions, and to rule out alternative interpretations. The role of the general analytical strategy is to help the researcher choose between different analytical methods. According to Yin (2002:100) two general analytical strategies exist. These two strategies are: ***relying on theoretical propositions*** and ***developing a case description***.

The first strategy proposes that the researcher should follow the theoretical prepositions that led to the case study in the first place. This reflects a specific set of research questions, literature to review and new insights to be made. The research proposal should guide the researcher as to which data to collect and focus on, and which data to ignore.

The second strategy requires the researcher to develop a descriptive framework for organizing the case study. This strategy can be used as

an alternative to the first if theoretical propositions are not available (Yin 2002:101). A descriptive framework could be looked at as the chapters in a storybook that give guidance as to what logically happens next.

In the case being analysed in this dissertation, theoretical propositions were made in the previous chapter. These propositions are based on the research questions and the unit of analysis defined in chapter one. The questions have to do with how, why and in what ways a start-up is different from other companies. The chosen unit of analysis is the product development strategy followed by the start-up. This will be contrasted with the product development strategy of the industry and therefore the research questions will be answered by comparing the product development strategy in the industry with that of the start-up.

After the decision has been made as to the general strategy to follow, the researcher has to decide on the mode of analysis to be used when analysing the data. This will allow the researcher to develop internal and external validity in the case study. The ***dominant modes of analysis*** are: pattern-matching, explanation-building and time-series analysis (Yin 2002:103).

This study uses ***pattern-matching*** research. Zyray Wireless is studied over a period of three years. Specific points in the company's history are identified and data is collected at these points in time. The points in time were defined as concept/seed-, product development- and market phases.

The data collected is matched to the survey done by Dooley. The results from the study by Dooley are used as the pattern that results will be matched against. If the results obtained are the same as the Dooley results, that would indicate that a start-up is no different from any other organisation. If the results do not match the pattern shown by the Dooley survey however, we can conclude that Zyray is different from other companies. Because patterns are matched over the life-cycle of the company the results might also indicate when the start-up is similar to and when it is different from other companies.

4.5. Validity and reliability

According to Yin (2003:34) researchers have to take care to preserve external validity, internal validity, and construct validity, as well as reliability.

External validity is concerned with showing whether facts can be generalised. Because this is a single case study it is not possible to

generalise the results. It is, however, possible to compare the findings with similar aspects of the current industry. The results obtained would therefore show how the specific start-up differs from or compares with the industry. The results could, however, become able to be generalised if more studies at different start-up companies are performed.

Internal validity concerns itself with the question of whether or not the results obtained and the inferences made are valid. When the investigator infers that some event led to some other event, all rival theories that could have had the same result have to be investigated.

A method to ensure internal validity is pattern matching. As stated earlier this study will compare the results from the survey at Zyray wireless with the survey results obtained by Dooley in an industry-wide study. In this way any variances detected can be compared against valid survey results.

Any inferences or propositions are therefore compared with the industry and not with any biased views the investigator may hold.

Construct validity seeks correct operational measures for the concepts being studied. The biases of the person doing the case study must not influence the study.

To ensure that the results were valid, alternate sources of information were used to cross-check the results obtained from interviews. As an example, the product roadmap and changes to it were confirmed by looking at press releases and cross-checking them with information from the interviews. In the data analysis part of the study a proposition is only accepted as being true when multiple sources of information are found that support the preposition. To ensure that the participant observations were not biased, multiple interviews were conducted. Interviewees were asked to score the answers to all the questions, thus making it possible to do mathematical analysis on the results. This ensured that one subjective opinion did not skew the findings. Also, if a person felt they did not have enough information to give an educated response to a specific question it was noted as such.

To further ensure validity, a chain of evidence should be kept. In this study the information used is made available for a third party to analyse. Reference is made to pieces of evidence and with the available data it is possible to validate that the conclusions drawn were correct.

Reliability is the measure of possibility for a different investigator to obtain the same results (Yin 2003:37).

Yin suggests using a case study protocol as the main tool for ensuring reliability, specifically in multiple case studies. The protocol includes an overview of the project, a summary of field procedures, the case study questions and a guide for the case study report.

Because this is a single case study it is easier to ensure validity. Who the respondents were, and the way the survey was prepared, are documented. This is in contrast with a multiple case study that would be used for investigating various companies where it might not be clear who was interviewed and where documentation was obtained from.

A well-documented survey is used in this case study and for it is therefore easier to reproduce the survey results. The first step the investigator should take is to conduct the survey again, using the same respondents. One of the recommendations of this study is to conduct the same survey at different start-up companies.

All other documentary evidence is included in this document. The main path to reliability is the investigator's knowledge of the company. An external investigator investigating the company would obviously not have all the knowledge of the participant observation investigator. This highlights why it was so important to conduct a survey. The survey ensured that other people's opinions were taken into account.

4.6. Data collection

According to Yin (2002:78) three data collection principals are more important than any other: multiple sources of evidence, a case study data base, and finally, a *chain of evidence that links the questions asked with the data collected and the conclusions drawn*.

Data can be collected in various ways for case-study-based research. According to Yin (2002:79) case studies can use six sources of information: documents, archival records, interviews, direct observation, participant observation and physical artefacts. A more detailed discussion of each of these methods follows.

The first source of information is ***documentation***. This includes letters, memoranda, agendas, minutes of meetings, progress reports, formal internal documents, proposals, progress reports and articles in the mass media.

Care must be taken to ensure the validity of the data in a document. The researcher must critically interpret the content of all documentation. Documents can be used to corroborate and augment

evidence from other sources. Inferences can be made about the business by looking at the way documents are handled in the business.

The second information source is ***archival records***. This includes; service records, organisational records, survey data, personal records, and maps and charts. As is the case with documentary evidence; the validity of records must be treated critically.

The third information source is ***interviews***. Various types of interviews exist. The first type is the open-ended interview in which the researcher asks respondents questions concerning the facts of the matter as well as their opinions. The respondents can even be asked for their insights into the matter. It is best to corroborate what the respondents say with other sources of information to confirm the validity of their responses.

The second type of interview is the focused interview. These interviews are shorter and usually follow a specific set of questions from the case study. The third type is structured along the lines of a survey. Data from the survey is analysed with techniques developed specifically for this process.

The fourth source of information is ***direct observation***. By visiting the case study site, evidence as to behaviour and environmental conditions can be collected. Observations can include meetings, sidewalk activities, factory work, classrooms or similar activities. To ensure unbiased information, more than one observer might be asked to make observations, thus ensuring that the evidence collected is not biased.

The fifth source of information is ***participant observation***. When this source is used the investigator partakes in the case study environment as (for example) a staff member or a key decision maker in the organisation being studied. The major advantage of participant observers is that they gain access to events and information that nobody else would have access to. The major problems with participant observation are that the investigator might have or develop a bias when accumulating the evidence.

The sixth, and final source of information is ***physical artefacts***. This includes physical or cultural artefacts, a technological device, a tool or instrument, or a work of art.

In this particular case the following artefacts will be used:

- Documents
- Interviews
- Participant observations

Interviews will be conducted with:

- The chief executive officer (CEO)
- The vice president of business development and marketing
- The vice president of engineering
- The director of ASIC development

The mode of reasoning will be inductive or a-theoretical. The focus of the case study is the evolvement of the product development process throughout the lifetime of a company. The theory will be tested in the specific environment of the start-up company. Particular focus will be placed on which best practise methods were used by the company and which were not.

The interview questions are taken from the study by Dooley (2002:25) and an adapted version is presented in the following sections. The questions from the Dooley study were chosen so that the results from the Zyray study could be compared directly with the results from the Dooley study. The results from a start-up could then be compared against the industry results in the Dooley study.

The study was started with a specific set of best practise categories. After acquiring the necessary information and analysis, the results suggested the best practise categories and questions presented in the following paragraphs.

The first four categories (paragraphs 3.2.1 to 3.2.4) are NPD performance measurement questions. The questions for NPD performance are presented here but they might not be applicable to the company yet. The rest of the categories are presented there after (paragraph 3.2.5 to 3.2.14).

Dooley found that NPD success was influenced more significantly by best practises controlling the execution of NPD (process control, project management, metrics, documentation and change control) than by NPD best practises associated with the strategic implementation of NPD (project selection, goals, technological leadership, product strategy and customer involvement). They also found that best practises associated with strategic implementation was more widely adopted than best practises associated with controlling and executing product development.

Table 3 Questionnaire Questions

	Questionnaire questions
1	**Continuous quality improvement**
1.1	Were/are new products introduced before the competition?
1.2	Do/did we improve the quality of our new products?

1.3	Do/did we improve the success rate of our new products?
2	**Product success**
2.1	Do/did our products meet profitability targets?
2.2	Do/did our products capture significant market share?
2.3	Do/did our new products generate significant revenue growth?
2.4	Do/did our products provide unique benefits to our customers?
3	**Project success**
3.1	Were/are our projects on schedule?
3.2	Were/are our projects within budget?
3.3	Does/did a project outcome agree well with predicted expectations?
4	**Cycle time improvement**
4.1	Did our NPD cycle time improve?
5	**Customer involvement questions.**
5.1	Were/are customer needs identified through multiple sources of information?
5.2	Were/are product requirements solicited, consolidated and fed back to potential customers?
5.3	Were/are new product concepts generated jointly by employees, customers and suppliers?
5.4	During requirements definitions development, were/are potential customers involved continuously and interactively?
5.5	Were/are demographic changes in our marketplace continuously investigated and forecasted?
5.6	Was/is market receptiveness evaluated by key customer feedback prior to launch?

6	**Project selection**
6.1	Were/are projects initiated through a process involving multiple functional areas?
6.2	Were/are project priorities updated periodically through a systematic process?
6.3	Were/are new opportunities most often put through a formal process to determine priorities?
6.4	Were/are NPD plans mostly influenced by informal planning activities (SWOT, forecasting)?
7	**Product strategy questions.**
7.1	Were/are projects terminated through a formal decision making process?
7.2	Was/is project funding primarily based on potential business contribution to the company?
7.3	Were/are company constraints incorporated into established division "design rules"?
7.4	Were/are product strategies used by departments to collectively align priorities with other departments?
7.5	Were/are development projects categorized and matched with appropriate existing NPD processes?
7.6	Was/is regulatory compliance handled through design guidelines that anticipate compliance challenges?
7.7	Was/is market research used as input into design decision-making?
7.8	Were/are NPD plans most influenced by analyses of overall value to potential customers?
8	**Concept design.**
8.1	Were/are new product concepts based on anticipated industry technological capabilities?
8.2	Were/are new product concepts explored in an

	unconstrained manner?
8.3	Were/are concepts selected using multiple, explicit criteria?
8.4	Were/are concept selection based on simultaneous evaluation of multiple concepts?
8.5	Do/did concept selections occur after manufacturing issues have been addressed?
8.6	Were/are concepts designed to optimise product performance through it's the product life-cycle?
9	**Technological leadership.**
9.1	Were/are technologies proactively developed to gain competitive advantage?
9.2	Were/are technological changes in the industry actively driven by our R&D efforts?
10	**Documentation questions**
10.1	Were/are product requirements documented and subjected to formal change control?
10.2	Was/is agreement on concept selection in the form of explicit (documented) buy-in from all departments?
10.3	Were/are concepts documented and subjected to formal change control?
10.4	Was/is risk analysis performed to proactively determine project priorities?
11	**Change control**
11.1	Do/did formal change controls begin at the concept stage?
11.2	Were/are product requirements only allowed to be changed during the early stages of the design?
11.3	Were/are the number of changes in each project phase tracked?
11.4	Were/are decisions on changes about product requirements

	based on assessment of multiple predefined criteria?
12	**Product goal questions.**
12.1	Were/are project goals supported by documented resource commitments?
12.2	Does/did a project objective include economic, market and product outcomes?
12.3	Were/are project goals primarily based on economic criteria?
13	**Metrics questions.**
13.1	Were/are process metrics aligned with management goals for NPD success?
13.2	Were/are development process metrics quantitive?
13.3	Have we been collecting process data for a while?
14	**Process control**
14.1	Were/are suppliers selected based on a formal supplier certification program?
14.2	Did/does transition to production occur through early product and process integration?
14.3	Did/does documentation describe the product and its production processes?
14.4	Was/is project slippage tracked on a continuous basis?
14.5	Were/are metrics used to improve the NPD process?
14.6	Does/did project planning emphasize the prevention of problems in projects?
14.7	Were/are new products developed using processes that are explicitly documented?
14.8	Does/did process learning occur through the exchange of process data and analysis of other projects?
14.9	Is the development process controlled through process data

	and intermediate steps from multiple projects?
15	**Human resource development**
15.1	Were/are teamwork training required of team members?
15.2	Do/did career development programs include external assignments?
15.3	Do/did development process goals emphasize building up new development competencies?

4.7. Data analysis.

The best practise categories and questions described earlier have to be evaluated throughout the life-span of the company. During the various stages of the company's development the requirements for a specific dimension changes. Zyray Wireless will be used as a test-bed to determine when a best practise item becomes applicable for the company.

Zyray Wireless is a typical high-technology start-up company. Zyray satisfies the high-technology label as the company aims to produce a product in the third generation cell phone market. The product itself is a silicon chip or ASIC and as such requires complex knowledge and technologies for production. The company employs a large number of engineers with doctorates in the field of WCDMA (wide band code division multiple access). Cell phone technology as such has been around for a relatively short period of time. The start-up label is easy to satisfy as the company was founded by two engineers using investor money. The investors in the company's first round of funding are typically investors specializing in seed-stage investment funding.

It would be useful to study other companies in similar positions to determine whether the same conclusions are reached through the study of other start-up companies. **Every year numerous high-technology companies obtain investment capital; therefore, there is a need to analyse a high-technology start-up company.**

The study will use the premise of the Bell-Mason diagnostic to

measure best practise categories across the different stages of the company's life cycle. The study will therefore focus on some of the dimensions of the Bell-Mason diagnostic. These dimensions are: team, operations control, technology and engineering, and finally product and manufacturing. The Bell-Mason dimensions are replaced with the best practise categories as described earlier.

The same survey as defined by Dooley (2002) will be conducted at the start-up company. The difference is that results will be captured at different times in the company's development as defined by Bell-Mason.

The table below shows the frame work in which the data will be analysed.

Table 4 Best Practise mapped through the company life cycle

Best practise category	Concept	Seed	Product development	Market	Steady state
Human resource development					
Concept design					
Change control					
Documentation					
Metrics					
Process control					
Customer involvement					
Product strategy					
Technological leadership					
Goals					
Project selection					

The study by Dooley (2002:27) rated adoption rates of best practise activities on a scale of zero to five. A zero-rated adoption score indicates that the best practise was not adopted by a company, while an adoption score of five indicates that the best practise was fully adopted in the organisation.

When adoption rates were calculated for each best practise category the following results were obtained:

Table 5 Best Practise Adoption Rates

Best practise category	Average	Low	High
Human resource development	1.72	0.00	4.33
Concept design	1.96	0.00	4.16
Change control	1.98	0.00	5.00
Documentation	2.18	0.00	5.00
Metrics	2.40	0.00	5.00
Process control	2.67	0.00	4.30
Customer involvement	2.67	0.86	4.57
Product strategy	2.70	0.00	5.00
Technological leadership	2.79	0.00	5.00
Goals	3.05	0.00	5.00
Project selection	3.16	0.00	5.00
Average score	**2.48**	**0.078**	**4.76**

The survey will therefore show how the acceptance of specific best practise items changed over time during the various stages of the company life cycle.

A single case study will be performed. The company under investigation will be Zyray Wireless, a start-up in the mobile phone wireless industry. The following chapter gives more background information about the industry in which Zyray competes.

4.8. Zyray Wireless business environment

As noted before the company under investigation is Zyray Wireless, a start-up company in San Diego California. Pieter van Rooyen and Michiel Lötter started the company in South Africa in August 2000. The company originally operated under the name Ronin Wireless. When the company moved to the USA in middle 2001 the name was changed to Zyray Wireless. Both founders have doctorates in engineering, in particular wideband code division multi access (WCDMA). WCDMA is a technology used in cellular communications (Zyray Wireless 2003).

To better understand where WCDMA fits into this case study, the history of cellular technology has to be traced. Cellular technology appeared in the early 1980's. Analogue technology was used for the biggest part of the 1980's. Analogue technology was denoted as 1st generation cellular technology. Analogue gave the user wireless telephony without data services.

The move to a digital technology started at the end of the 1980's. Many competing standards appeared (UMTS Forum 2003). The most successful technologies were code division multiple access (CDMA), in the USA, propagated by Qualcomm, and GSM (global system for mobiles) in Europe lead by companies like Nokia, Ericsson and Siemens. 2nd Generation digital telephony offered voice as well as data services and better security attributes. These services included caller identification and short messages service (SMS), however data rates for these services are low. GSM technology gained the widest global appeal with about 700 million subscribers. GSM is seen as a very dependable technology with a large support base. In the last decade the form and use of the cellular phone has also changed. It has become smaller, has longer standby times and is seen as a social necessity rather then just a business tool. The handset itself is available in various forms, from voice-only versions to personal digital assistants (PDA's) that also offer voice services. The evolution of the latter has created the need to merge voice and data services into one handheld device where the user is constantly connected to various data services.

Upgrading current systems, however, is not a trivial task. Network operators have to spend money on new bandwidth and on new base station technologies. Data-centric services are evolving in a two-phased approach. The first phase has been named 2.5 G or second and a half generation. GSM evolved into GPRS (general packet radio services) to give the user higher data rates on mobile devices. GPRS still operates on the same carrier frequencies, as GSM and the network operator's therefore do not have to pay for the extra bandwidth. Voice calls use a circuit switched network. In these networks a channel is opened and the same rate of data is always sent. Data networks use packet switched technology where the data rates are determined by the need at that moment. GPRS offers data rates of up to 64 kilobits per second (kbps) and GPRS devices can be used to surf mobile web sites to get the latest news and information. Because of the higher data rates it has become possible to send pictures via mobile device. Newer devices incorporate cameras and colour screens for better graphics viewing.

UMTS (universal mobile telecommunications system) with their 3rd GPP (generation partnership project) governs the setting of standards for WCDMA. WCDMA is one of a few possible 3rd generation standards. One of the competing standards is CDMA2000, which is the evolution of Qualcomm's CDMA technology into a 3rd generation service. Because 3rd generation standards require new bandwidth that has to be bought from the government by carriers, the implementation of the new standards has been dogged by problems and delays. NTT DoCoMo in Japan, introduced the first 3rd generation pilot sites in Tokyo in 2001. The rest of the world has been sluggish to follow. Especially in the wake of the Internet and stock market bust in early 2001, pilot sites have been slow to emerge in Europe and the rest of

the world. Delays include technical difficulties experienced by both handset and base stations manufacturers.

Because of the previously mentioned network constraints, today's networks are upgraded gradually. Multi-mode (GSM and GPRS) and multi-frequency phones are the norm. Different chipsets offer multimode functionality in one silicon chip. The technology used in a cell phone can be divided into various tiers. The first tier is the RF (radio frequency) level. At this level the base-band signal is modulated and demodulated. The second tier is the base-band decoding and encoding, or modem level. At this level data to and from the device are encoded and decoded into the correct format.
The OSI (open systems interconnection) model denotes this level as layer 1 or the physical layer.

The protocol stack layers follow layer 1. These include layer 2, or the access stratum (AS) up to the non-access stratum (NAS). The protocol stack implements the higher level signalling with the base stations and the network. On top of this tier is the user interface. In WCDMA the user interface becomes more important than before because of its ability to download data and the view high-resolution video clips on colour displays. The phone manufactures put all of the parts together and manufacture the phones. Depending on the phone manufacturer, part or all of the tiers of technology mentioned above can be bought externally.

Zyray Wireless's market is typically any of the manufacturers that need a WCDMA modem or the intellectual property (IP) of the WCDMA modem. A potential client could be a protocol stack company that has to prove its technology to the phone manufacturer who does not produce its own WCDMA modems.

Zyray's first experimental modem chip was manufactured in December 2002. The first chip offers only WCDMA technology but later releases will offer integration with other protocols, for example: GSM and GPRS. The IC is known as SPINNER. SPINNER can be used in conjunction with current GSM/GPRS modems. SPINNER contains the WCDMA core, an ARM7 processor, memory and a mixed signal part. The mixed signal part includes A/D's (analogue to digital) used to digitise the incoming base band analogue signal. It also includes DAC's (digital to analogue converters) used for control and generation of base band analogue to the RF that is external to the IC.

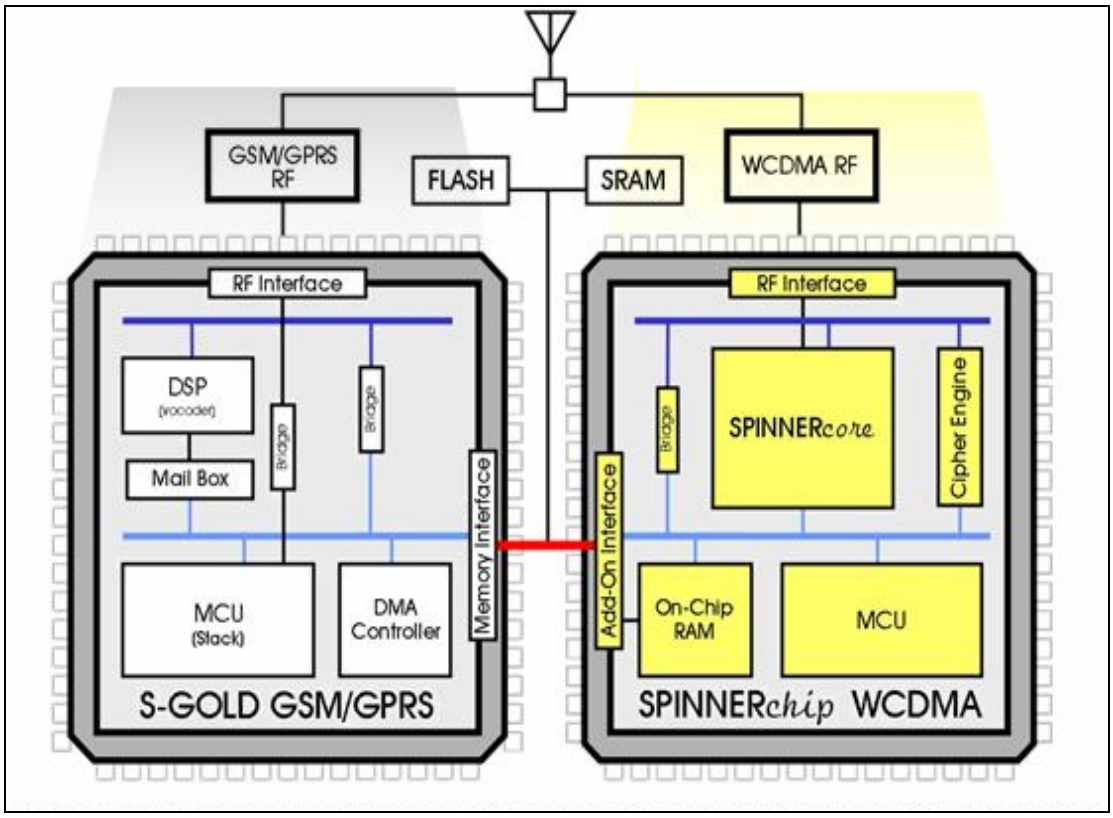

Figure 6: SPINNER Chip

The company manufactured an IC for two reasons. Firstly, because the company is a start-up they have to prove their competence before any other company will use Zyray's IP in their own IC's. Secondly, at the start of the WCDMA life-cycle, the cost of an integrated GSM/GPRS/WCDMA chip is still far higher than a dual-chip solution.

The company's core technology competency is WCDMA system engineering. Zyray's group of engineers develops high-level computer models of the signalling environment for both the base station and the handset. The models are used to design, develop and test the core WCDMA modem design. The system engineering has to comply with 3GPP standards as well as innovative performance features that provide the company with an advantage over the competition.

After the system engineering group has proven that their design works, a group of hardware design engineer's code these designs in VHDL (very high description language). The code is then compiled to run on physical hardware. Currently FPGA's (field programmable gate array) are used as a hardware test-bed. The hardware offers an interface to a CPU (central processing unit) that is connected to the WCDMA processing hardware. The processor executes software and the software on the processor completes the physical layer

requirements according to 3GPP specification.

The software group writes software that controls the hardware according to higher layer protocol stack software. This software is written in assembler and C and compiled to run on the host processor. The software also decodes information received from the modem to determine what the base station that is sending the data requires. The interface with the protocol stack is an important part of the modem as the same hardware interface has to communicate with various protocol stack hardware and software configurations. The software also has to control various peripherals, including RF chipsets, A/D converters and DAC's.

The final step in producing a chip is the integration of the SPINNER core hardware, processor, memory and peripheral into an ASIC (application specific integrated circuit) design. This design must then be tested with PC-based software simulators and base station test hardware before the design is given to a manufacturer who will produce the IC. This part of the development process is extremely critical as the IC fabrication process is very expensive. It is also very difficult to correct any mistakes after this point. The relationship with the manufacturer is crucial due to the high level of coordination and technical difficulty. Due to this level of integration the relationship is seen as a long-term one where the manufacturer will typically produce a few test IC's, and, as the company gets orders, produce production chips.

The hardware design group designs test-beds for the FPGA's, RF and the ASIC to be tested on. They produce hardware reference designs for other companies to use when placing the chip inside their own environments. Evaluation platforms are also produced so that the SPINNER chip can easily be tested and evaluated by 3rd parties.

The interface between the physical layer and the higher layers is an extremely important element of the design. A dedicated group integrates the SPINNER chip with various GSM base band processors and protocol stacks. Firstly, for partners the aforementioned interface is what makes the chip function in the actual cell phone. Secondly, when integrating with various processors testing proves that the chip is able to function with the various processors of potential partners and clients. Often this capability is used as leverage by marketing and business development when competing against other companies for business.

The marketing and business development group identifies and initiates contact with potential customers and partners, controls advertising and press releases, and handles all the organisation surrounding trade shows. An important output of the group is research information about current technology and market trends. Part of the marketing function is also client support, which boils

down to making sure that the problems and questions of clients and/or partners are brought to the attention of the engineers. Field application engineers handle this function. Obviously this function only became necessary when the engineers working in development could not handle the workload of new development while also supporting partners in San Diego and travelling to partner locations. The field applications engineer must also coordinate the testing of the modem against actual networks. Before a network operator allows a phone onto its network, interoperability testing has to be successfully performed.

The information technology function of the company is contracted out. The goal of this team is to provide the company with an integrated information technology strategy. This strategy forms an integral part of the documentation and change control functions.

4.9. Conclusions

In summary, the research to be done centres around the adoption of industry-accepted best practise categories. Best practise categories have evolved over the past few decades into the generally-accepted categories detailed in the previous chapter. The problem defined earlier is that the start-up company is not mentioned in particular as having any needs that are different from those of well-established companies.

The aim of this dissertation is therefore to determine whether a difference exists between industry best practise methods and the needs of a start-up company.

The unit of analysis of this dissertation is the evolvement of the product development process in California start-up company Zyray Wireless. The research will be conducted as a case study research methodology. This entails collecting empirical data, making propositions and then developing conclusions based on the analysis of the data. To this end various methods will be used to collect data including: participant observation, documentation and interviews.

5. Data gathered

Three data collection principles are more important than any others: multiple sources of evidence, a case study database, and finally a chain of evidence that links the questions asked, the data collected and the conclusions drawn. To this end data is collected from different sources as detailed in the following paragraph.

The aim of the study is to analyse which best practise categories are accepted by the company throughout its lifetime. The data gathered will be investigated to see whether various sources of information show that the same set of best practise items were implemented over time.

5.1. Data gathering process

As stated previously, data was gathered from various sources. This included participant observations, various documents and interviews. Firstly, a chronological history of the company will be given. This information was mostly obtained through the experience of the writer while working for the company being studied and the press releases in Appendix 5. Secondly, information on the changes in the company structure will be given. This information was partly gathered through participant observations and company structure information from company presentations. Thirdly, the results from the interviews conducted with various staff members will be presented. At this point the focus will mainly be on the comments made and not on the scores given. Fourthly, the evolution of the NPD process will be discussed. The data for this discussion was gathered through participant observations and presentations on the company development and documentation processes. Lastly, data on the human resource aspects are given.

5.2. Data or information gathered

5.2.1. Detailed history of the company

Below, a time-line of the history of Zyray Wireless is given. The history of Zyray wireless can be divided into various phases. According to Mason the various company development phases are: concept, seed, product development, market and steady state. The company was started in the middle of 2000 in South Africa. The founders received their initial capital from an investor to build a WCDMA phone. They used initial capital to secure offices in Midrand, South Africa and began recruiting engineers. By September

2000, 20 engineers were working for the company. The company was divided into two main groups. The first group was involved with the layer 1 software and hardware while the second group was tasked with developing the layer 2 and 3 software (refer to paragraph 4.7 for detailed information). Michiel Lotter was head of engineering while co-founder Pieter van Rooyen handled the business side of the company.

The first few months were mostly spent learning the necessary specifications and deciding which tools and methods were going to be used. The company essentially used a flat management structure with no real middle management. Some people were tasked with performing some project management duties but they didn't carry any authority to manage as such. Most meetings involved everyone in the company and in these meetings people used their knowledge from previous experiences to enlighten everyone else. In some cases this was useful but it also often ended up being very tedious. The biggest asset, however, was that everyone started to get to know everyone else. Some people had worked together previously, but people generally were not aware of the expertise and personalities of most of the other employees.

Towards the end of the year it became obvious to the founders that their current investors were not going to be able to support them. For this reason they started looking at various options. Ted Alexander from San Diego-based Mission Ventures made a due diligence visit to the company in January 2001. He subsequently decided to make a substantial investment in the company.

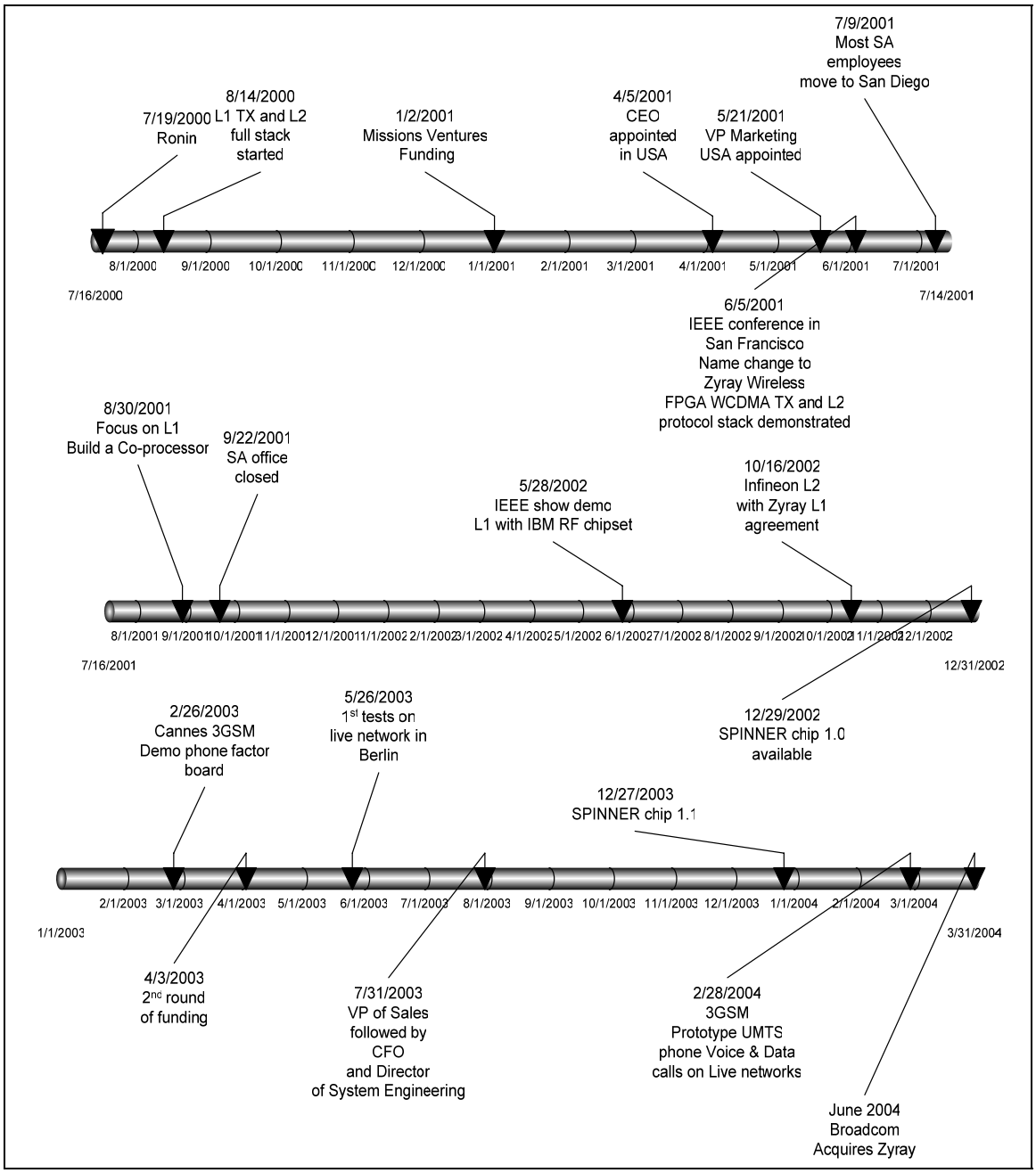

Figure 7: Zyray timeline

The old investors were reimbursed, and this left the company free to continue without their involvement. The new investment, however, carried some prerequisites. Firstly, the company had to relocate to San Diego, California. Secondly, the company had to demonstrate working software and hardware at an IEEE show to be held at the end of May 2001 in San Francisco in the USA. This would also be the company's debut in the United States.

The first part of 2001 was therefore spent preparing for the conference and getting the office in San Diego set-up. The company also made the name-change from Ronin to Zyray as the Ronin name was already registered in the United States. At this time Werner

Sievers was appointed as the company CEO . Mr Sievers is South African expatriot who has started and led numerous companies over the years, including Dimension Data. He moved to America in the early nineties. A vice president of marketing was also appointed. Mike Civiello lived in Arizona but agreed to commute to San Diego. Mike spent nearly 20 years working for Motorola in America as well as Japan. While the Zyray team in America was still finding its feet, more people were appointed in South Africa. The understanding was that only people from the original group and not these people would have to move to America. Most people in the original group had no problem whatsoever with moving to America. The additional people were employed primarily to work on higher layer software including the graphical interface.

By the end of May two demos were available. The layer 1 demo demonstrated the WCDMA transmitter hardware running in an FPGA test bed. The Layer 2 demo demonstrated mock-up phones running part of the protocol stack, making a data call and running Java applications. The major advantage of the company's participation in the show was getting the Zyray name out as well as proving to the investors that the company could deliver on its promises.

The next few months were spent thrashing out a new strategy for the company and moving the balance of the people over to the United States. At the end of August management made some very difficult decisions. Firstly, the office in South Africa had to be closed and everyone who was still working there had to be retrenched. The South African office had become too much of a burden on resources. This change also fit with the second change in the company. Henceforth the company would concentrate on layer 1 and not implement anything above layer 1 at a commercial level. System engineering and layer 2 people in the company would spend all their time developing solutions to facilitate the successful delivery of a commercial layer 1. Initially it was thought that the IP (intellectual property) could be sold to a chip vendor. Marketing, however, found that no one would trust the start-up if they could not prove that their solution worked inside a chip. Subsequent to receiving this information more American-based people with chip development skills were employed. This part of the team was headed by Frederic Hayem, originally from France. He had several years of experience working at Philips and had been involved in the process of designing a full solution that could be handed to a foundry that would then 'spin' or manufacture the chip.

The final strategy decision was made to develop a co-processor chip that would sit next to a current GSM chip and make the GSM chip upgradeable to WCDMA. The chip would therefore be marketed as a WCDMA modem. With this strategy in mind, potential investors and clients were approached.

Part of the strategy was not to develop the RF front-end of the system but to be compatible with any commercially available RF solutions. At the same time IBM in San Diego were developing a WCDMA RF solution. IBM agreed to team up with Zyray for the IEEE microwave convention to be held in Seattle in May of 2002. Zyray would demonstrate their FPGA solution working with the IBM RF solution at IBM's booth at the conference. This was seen as the next big deadline for the team as it included a basic working WCDMA receiver.

The show was successfully completed and following it Zyray made contact with Infineon, a major German chip manufacturing company. Later that year an agreement was signed with a subsidiary of Infineon called Comneon. They design the higher layer software for cell phones. This was a perfect fit for Zyray's co-processor strategy as Infineon and Comneon had all the parts of a 3rd generation cell phone except the WCDMA modem part. The co-operation agreement stipulated that Zyray's SPINNER chip; at that point not yet ready for production; had to be available for integration with Infineon hardware and software by the start of 2003. A form factor phone had to be demonstrated at the annual 3GSM conference in Cannes at the end of February. The company had 30 employees at this point.

The first SPINNER chip, version 1.0, became available at the end of 2002. Integration with new hardware and with software started early 2003 and a phone form factor board was demonstrated at both the Infineon and Zyray booths at the 2003 3GSM congress. The success of the congress stimulated interest in the company both from other venture capital firms and from potential clients. At this point the market started accepting WCDMA as the de-facto standard as networks in Europe and Asia started operating and experiencing a need for handsets. Zyray secured their second round of funding, headed by Mission Ventures, after the congress. This money would enable them to employ more people, buy more test equipment and fund the manufacturing of the next version of the SPINNER chip.

The focus of Zyray shifted again at this point in time. The team had moved from trying to survive and prove that they could functionally adhere to standards and get a chip out, to working on real networks. Because of mounting pressure it was decided to employ a new head of system engineering in the form of Mark Kent. Michiel's work-load had become too much. Michiel would now manage the development while Mark would manage all system engineering efforts. Mark's previous experience helped Zyray to advance their design for the next version of the SPINNER chip, which had to be a fully functional and commercially viable solution.

In May of 2003 the company started with field trials in Germany. The main reason for this, apart from the fact that the client was in Germany, was that no networks were available in the United States.

This started to put a lot of strain on the engineers who were developing software for the chip as they had to develop new software and conduct field trials. The solution was to employ a FAE (field application engineer). The FAE would filter any customer queries from the development engineer and only let questions that he could not answer through. Because the development engineers were not involved at the IOTs the tools used to capture telemetry information from the software on the chip also had to improve. The telemetry tools subsequently became a selling point for the chip as the high-speed serial link could be used to capture large amounts of data for analysis. Clients looking at the company as a potential partner had to be sure that the company could also deliver proper support for its product. A bug-tracking database was started so that client errors could be logged and analysed by the engineers in San Diego.

One of the contacts made at the 3GSM conference, Broadcom, decided to kick off a development project with Zyray to interface the Broadcom GSM solution with Zyray's solution for a laptop PCMCIA card. The layer 2 team, who up to this point were responsible for creating an interface abstraction layer between the layer 1 software and the client stack, took a leading role in the development process with Broadcom.

With markets opening up Zyray had to strengthen and expand its management team. A vice president of sales was appointed followed by a CFO (chief financial officer). Up until this point the sales position was also the responsibility of the vice president of marketing while the CFO position was contracted out as a part-time job.

The second half of 2003 was therefore spent preparing for the release of the next version of the SPINNER chip and doing further field trials with the current SPINNER chip. The company now had 39 employees. At the end of 2003, SPINNER chip 1.1 was successfully manufactured and tested. The chip was then incorporated in an Infineon prototype phone. This completed phone, including GSM, keyboard, display, user interface software and bluetooth, was then demonstrated at the 2004 3GSM conference in France. The phone garnered immense interest at the conference. The phone was used on live networks in Germany and Italy, and at the conference itself. The subsequent talk was of imminent orders and not just development interest. Zyray now entered the next phase of its evolution. The company now had to finish field trials and produce the first version of a commercial product.

In April 2004 Broadcom made a decision to investigate the possibility of acquiring Zyray. Zyray subsequently delayed obtaining investment money and went through a due diligence process with Broadcom. In June 2004 Broadcom (see appendix 4 for the press release) announced that it would acquire Zyray for $96 million. This

was a huge feather in the cap of everyone involved in the company. Broadcom would use Zyray's technology and resources to enter the 3G market. This strategic acquisition would allow Broadcom to enter the WCDMA market in 2005 and to continue using their current GSM/GPRS solutions. The real start date for WCDMA is 2005 and if a company entered the market too late it might never be able to get in. Broadcom came to the conclusion that Zyray had the right mix of competent people and core technologies to warrant such a big investment.

From the very beginning Zyray had one of 3 routes to go. The first was to remain private and on their own with strategic partners. The second was to go public, however since the internet bubble this has proven to be very difficult. The third was to be acquired by a larger company that preferably was already publicly traded. The people in the company saw the acquisition as an acknowledgement of their work ethic, competence and abilities.

5.2.2. Tracking organisational changes

When the company originally started in South Africa a flat organisational structure was used. People were organised into different groups based on the work they were doing, however nobody was given power to determine tasks or assign work except Michiel. Louis, Luis and Simon were tasked with tracking project progress. Most meetings were overcrowded with lots of people involved. As most of the people hired by the company had done significant development work, experience and skills learned were applied to the problem at hand. At this point the organisation was set up to develop a phone. The major components were the hardware that would do all the bit level processing. A system team developed models in Matlab and the hardware team implemented the models in FPGA. The firmware team developed the control software that would set up the hardware in the FPGA.

The software team would have to develop the full WCDMA stack, layers 2 and 3. This team was compromised of a number of people who had previously developed stack software for land line telephones and exchanges. The tools used by this group were SDL language compilers. SDL is a high level language used to write protocol software.

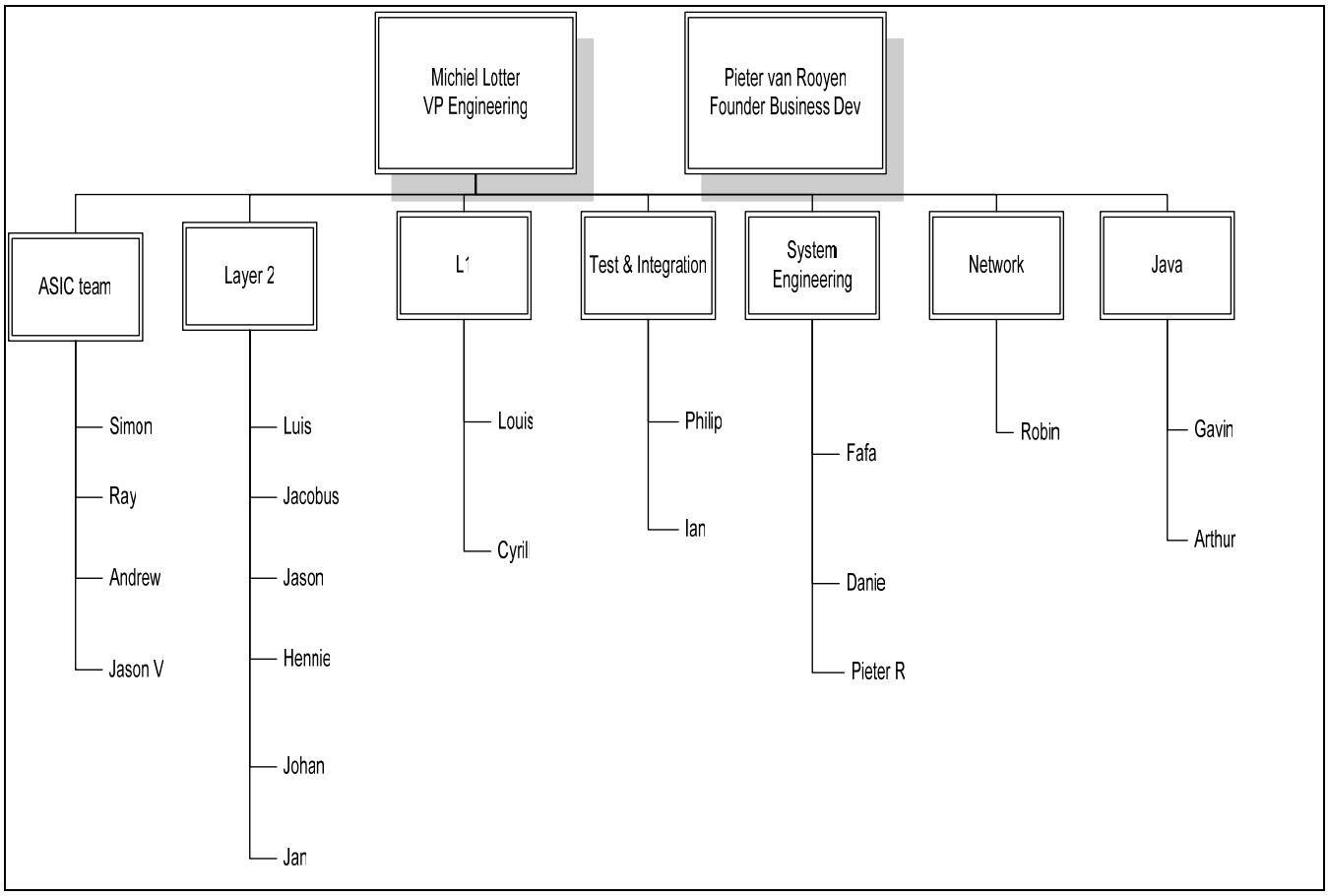

Figure 8: Initial company structure in 2000

The user interface would be developed on a JAVA virtual machine that had to be adapted to work on the hardware to be used.

A decision was made to use ARM software and processors as ARM processors were used in most cell phones at the time.

Ian was tasked with developing test software so that the various parts of the protocol stack could be tested against available test cases. TTCN tools were used to develop these tests.

All these tools created a strain on the company's cash flow as they were all expensive.

The network and PC support was handled by one person within the company. Secretarial services were provided by the group who leased office space to Ronin. The network used was run on a Windows NT server with Windows file sharing. This enabled everyone to share information and have personal space on the server as the server was backed up periodically. The Microsoft Office suite of products was used for project planning, documentation and presentations. The shareware software version control system CVS was used as the

company's version control system. It ran on a Linux server but everyone's desktop PC had a Windows interface to it.

As previously noted, when the company moved to the United States the management team was expanded. This management team included a CEO and a vice president of marketing. An office manager was also hired to handle all tasks from human resources to buying office supplies. The network maintenance from this point onwards was handled by external companies. The company hired to maintain the network changed over time but no permanent personnel were appointed to perform this function. The company also bought company-wide medical insurance. In South Africa this was the individual's responsibility. In the United States, however, the South Africans had not yet developed credit-worthiness and therefore had to be backed by the company.

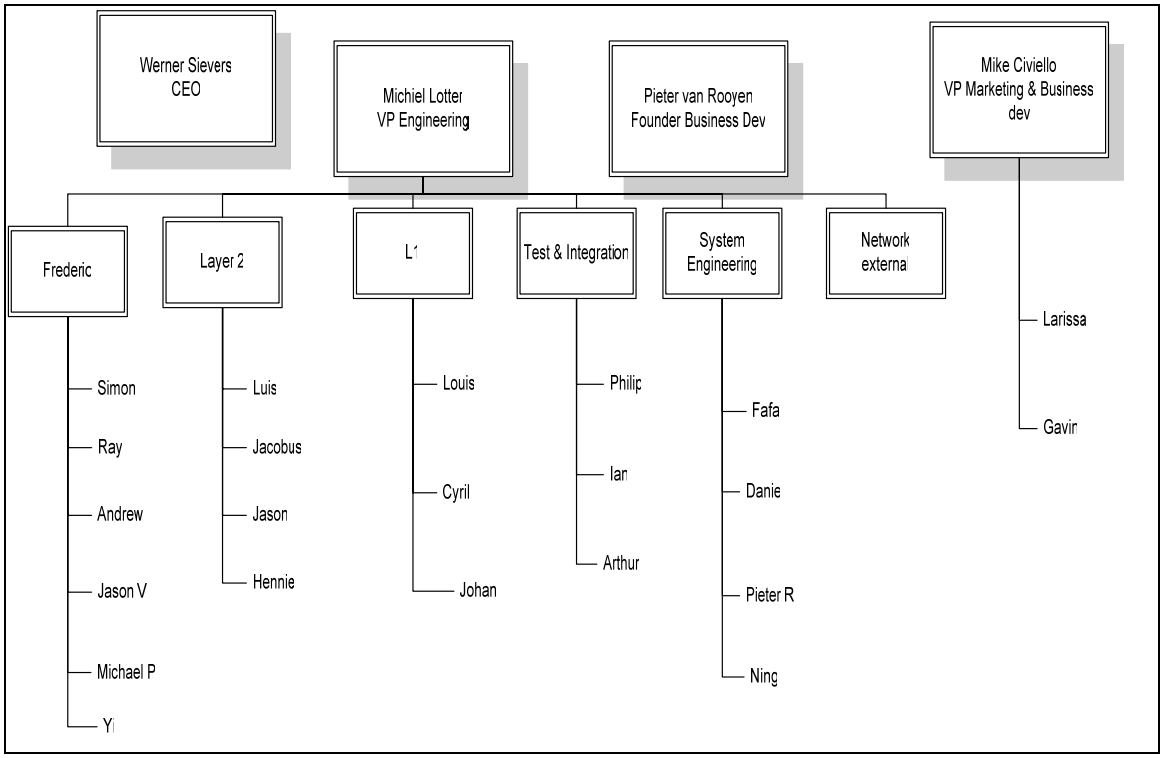

Figure 9: Initial USA company structure

A new product road map was created for the company after bringing the new CEO and VP of marketing on board. The company now had at least three people who were primarily focused on market analysis and client and investor relations. They were: Mike–the VP of marketing, Werner–the CEO and Larissa–who moved from the investment firm that backed Ronin to Zyray.

The most important decision to come out of the market analysis was that the company would not develop any part of the WCDMA product commercially except layer 1 or the physical layer. People involved

with functions other than layer 1 development were moved to different areas. Some went to layer 1 development, some to marketing, and others were tasked with building software for a test layer 2 and base station so that the layer 1 could be properly tested.

Initially it was thought that Zyray would be able to sell intellectual property (IP) to someone who made a WCDMA modem chip. It however became evident from market analysis that Zyray would have to create a chip to gain trust from the market. To meet this challenge a director of ASIC development was employed. The hardware development team was expanded to include people well versed in the process of designing commercial chips. In California, unlike South Africa, a huge pool of talent existed in this field. The advantage offered by being in the United States became very evident at this point. Firstly, a physical address in California created credibility that an address in South Africa would never be able to command. Secondly, the necessary people and chip fabrication knowledge were readily available while they would have been much more difficult to come by in South Africa.

The company had now, after being in existence for a year, gained the focus necessary to have a chance to be successful. The decisions made at this point were of extreme importance as the direction of the company for the next few years was set. Up until now the testing of the layer 1 had been done with internal test beds. The company had to buy external test equipment against which to test the modem. This required substantial capital outlays. The most critical effect it had, however, was that the engineers had to be sure that they were meeting the requirements as set out by the 3GPP group. The company invested in a system that would allow them to trace the system engineering requirements back to the requirements in the 3GPP specifications. The product used for this was called DOORS. This program required that all 3GPP specifications be placed in DOORS and every requirement in the specification had to be given a requirement number. The system engineering and design document also had to be placed in DOORS. This allowed traceability all the way from 3GPP specifications right up to the design of the modem.

In theory this seemed like a good idea. In practise however, it proved to be a flawed system. The biggest contributing factor was the fact that the engineers did not want to accept writing documents in a format other than Microsoft Word. No amount of pleading or convincing could get them to accept this. They did not agree with the notion that it was a good idea. The second problem was that the specifications were updated often. A person had to be employed full-time to change the 3GPP Word documents into DOORS documents. All of these barriers lead to the abandonment of this process after trying to make it work for longer than a year.

The company also had to start formalising the design process. System

engineering, test and design documents had to be written and reviewed at logical points in the design cycle. For a typical piece of hardware the following procedure would be followed: the system engineer would design the solution, simulate it and present the findings to the hardware designer, the software designer and the VP of Engineering for review; upon acceptance of the design, the development would split into parallel processes. On the one hand the systems team would further test the design and generate test vectors while the design team would have a kick-off meeting where all the requirements would be analysed; the integration lead would then generate a project schedule.

The next step was for the hardware designers to write the hardware code. Upon completion of the code the design would be reviewed and then placed in an FPGA where the software engineer with the test case designer would start testing and verifying the hardware design. The actual hardware result would then be compared with the results obtained in simulation with test vectors. At the end of the testing process when all tests passed, a final review would be held. This process was followed in order to design and implement all the major hardware blocks. The software used at this point can be viewed as drivers as it was not implemented as a total solution yet.

At the point where the blocks were integrated to form all the parts of the WCDMA modem some new requirements came up. Commercial hardware development platforms did not satisfy all the requirements. Additional people were therefore employed to design custom hardware development platforms. It also became evident that the chip had to be integrated with different RF chip sets. Zyray had to prove that the modem worked with different RF chip set solutions. These two hardware design engineers became an integral part of integrating the Zyray solution with the hardware platforms and RF chip sets of potential partners and customers. Zyray now produced various hardware platforms so that partners and customers could integrate their development platforms with Zyray's.

One of the biggest changes at this time was that the L1 firmware team took on the responsibility of being in charge of the total integration process and not just for writing the firmware. As the firmware was the last task to be performed, the firmware engineer was charged with leading the integration process. The firmware engineer had to make sure that all hardware, platforms, test equipment and test vectors were available for integration testing. The company structure at this point in time is shown in figure 10. This proved to be a highly effective strategy as only one point of responsibility existed.

With all the blocks integrated and tested the chip design was ready for manufacturing. In parallel with the testing of the hardware functionality the ASIC people were working with a chip foundry to

design the chip for manufacturing. After all test vectors passed the design was frozen and given to the chip foundry for production. The first samples were delivered at the end of 2002.

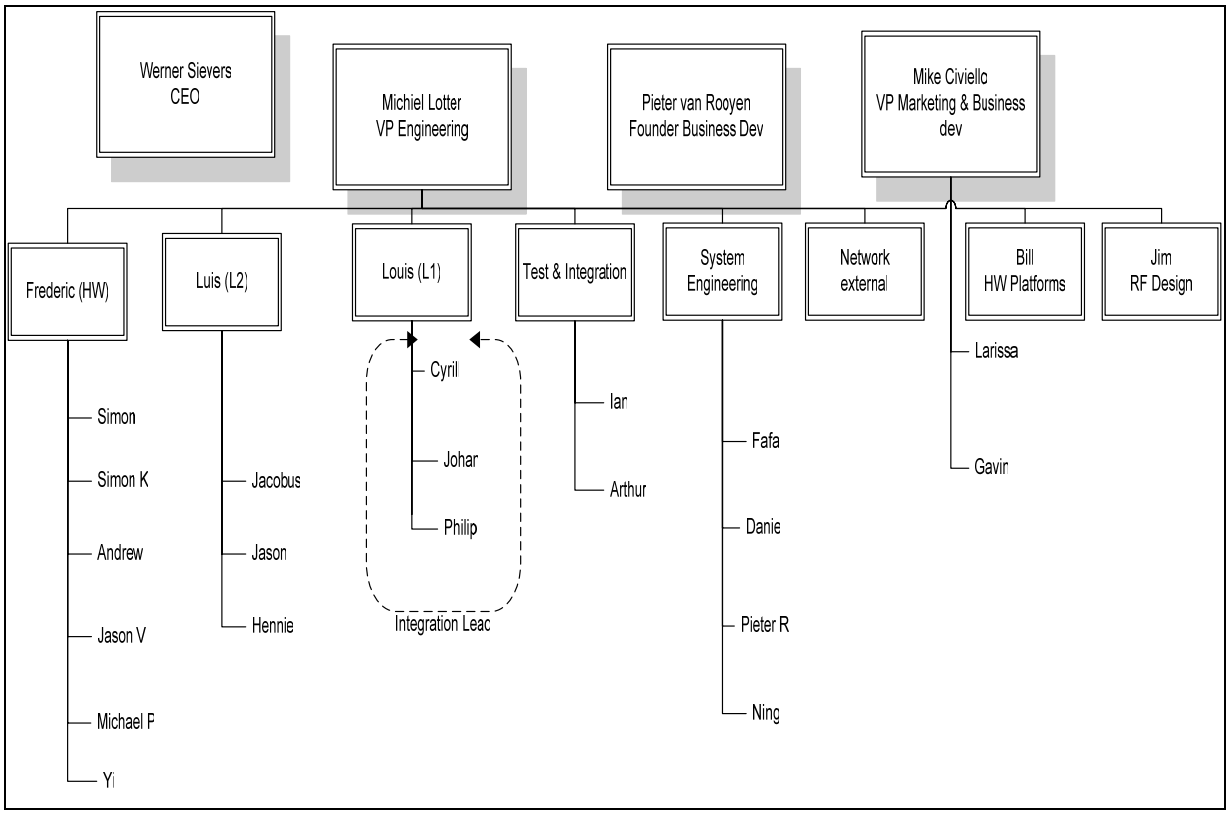

Figure 10: Chip design company structure

The next phase of the development process was now entered. The chip had to be integrated on phone form factor hardware. The hardware was then tested against base station test equipment. Close integration with Zyray's partnership company, Comneon, an affiliate of Infineon, now started. The firmware team's workload seemed to double at this point as they had to upgrade functionality on the current SPINNER chip while at the same time working on the next release of the chip. Customer support involved travelling to meet with the customer in Europe. Obviously with pressure from the customer being more critical than internal deadlines some schedules started to slip. The customer started working with network inter-operability testing (IOT) on various cell phone networks in Europe and Asia. It became evident that a solution had to be found for the new development needs.

It was finally decided to employ a field applications engineer (FAE). This person would be responsible for first level customer support; he/she would filter all support requests so that the firmware engineers would not be inundated with support requests. The FAE would also be the representative at IOTs. Firmware engineers would

only attend an IOT if problems existed that the FAE could not solve.

At the release of the next version of the SPINNER chip this process was in full operation. At this point Zyray only had one customer and partner. At the beginning of 2004 however, the market changed quite drastically in favour of adopting WCDMA as a number of networks went into operation across Europe. The demand for Zyray's technology increased dramatically. New customers and partners were signed up. As new partners appeared firmware engineers were assigned to the partner and new FAEs were appointed.

The firmware engineers' responsibilities shifted slightly away from system engineering and more to integrating with partners. The customer structure can be seen below.

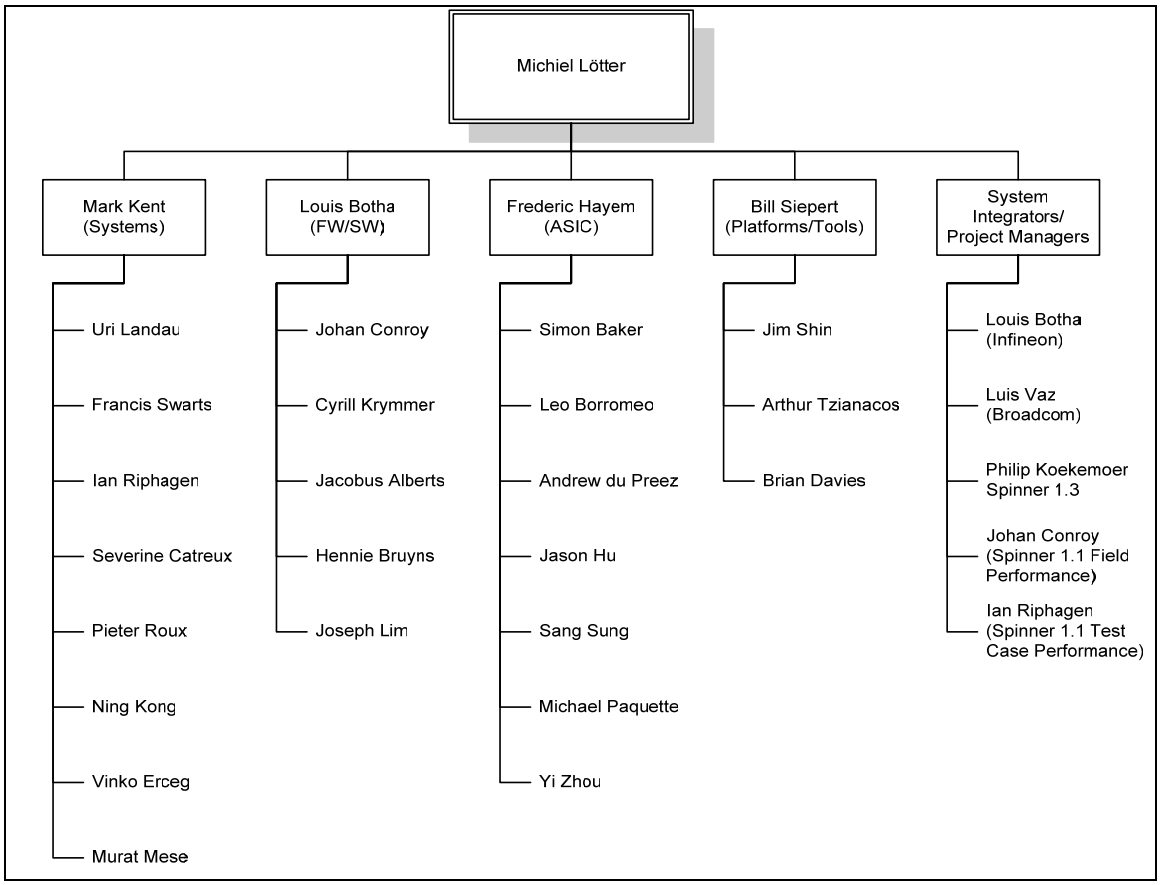

Figure 11: Company structure with partners included

5.2.3. Research questions feedback discussion

The survey questions that were discussed previously were given to various people in Zyray. People were chosen in such a way as to reflect a wide range of disciplines. Starting at the top, Werner

Sievers the CEO of Zyray was interviewed. Werner joined the company early in 2002 just as the company got started in the USA. Werner's knowledge of the early days of the company was gained mostly through hearsay but he was intimately involved in formulating the company roadmap and therefore had knowledge of early mistakes.

Next in line, as vice president of engineering, was Michiel Lötter. Michiel is also one of the founders of the company. His knowledge therefore spans the entire life-time of the company. It also spans all the functions within the company. Michiel's role changed over time from his initially being responsible for system engineering, engineering development and supporting marketing To his becoming the head of engineering of Zyray. The system engineering responsibility was taken over by Mark Kent.

Following Michiel was the vice president of marketing Mike Civiello. Mike joined Zyray in May 2002 from Motorola. As was the case with Werner, Mike helped shape the product strategy of Zyray. Mike's knowledge therefore also incorporated the state of affairs experienced while Zyray was still in South Africa.

Frederic Hayem was employed as the director of ASIC development. After initial investigations into the market by Werner and Mike the decision was made to produce an ASIC. The ASIC acronym stands for application specific integrated circuit. Frederic's task would therefore be to lead the team that would design an ASIC so that a foundry like Philips semiconductors could use the input to produce a physical device. Frederic started work with Zyray in the third quarter of 2002 after leaving Philips semiconductors.

Luis Vaz started with Zyray in South Africa. Initially Luis was hired to manage the stack development team. When the decision was made to use a third party stack Luis' role changed from managing to leading the team in designing the interface software between the Zyray physical layer software and the protocol stack. Luis' team was also responsible for the porting of software to various hardware platforms and for supporting the internal Zyray stack used for basic conformance testing.

Bill Siepert came to Zyray with an impeccable reputation for designing hardware platforms. Bill's responsibilities initially included the production of hardware test platforms used to test the chip design before it was given to Philips to produce, and ASIC development. Later, Bill's responsibilities also included managing the people responsible for the creation of support and test equipment, and software for the SPINNER chip.
Gavin Stone was initially employed with Zyray in South Africa to do development on the phone application level. When Zyray changed its product roadmap to exclude all commercial development outside the physical layer Gavin's job description changed to marketing manager.

Gavin is responsible for market research, marketing and company branding.

In this chapter the explanations for answers given by the interviewees to the various questions in the survey are presented. In some cases the scores given to a specific question are significantly different. This could be due to a different interpretation of the question as the function the particular interviewee is a part of may have implemented the specific best practise while the best practise may never have implemented in a different function.

5.2.3.1. Continuous quality improvement

Were/are new products introduced before the competition's?

Mike, Werner and Gavin all replied that Zyray is middle of the road with regard to this question as Zyray introduced its products before some of its competitors while the big competitors like Nokia, Qualcomm and Sony-Ericsson amongst others introduced their WCDMA chip set products ahead of Zyray.

Do/did we improve the quality of our new products?

The consensus was that new products were improved, particularly in the transition from SPINNER chip 1.0 to SPINNER chip 1.1 as the product improved technically as well as feature-wise.

Do/did we improve the success rate of our new products?

Werner answered yes to this question, largely because Zyray defined the products accurately in terms of market needs. For a small company, Zyray did valuable work in terms of quantifying feature sets with operators and handset manufacturers.

5.2.3.2. Product success

Do/did our products meet profitability targets?

The consensus was that Zyray is meeting its profitability targets. Mike commented that according to pricing, market value and Zyray's cost levels, the company is doing well.

Do/did our products capture significant market share?

In the 3rd quarter of 2004 the company was in the early stages of market acceptance. Werner commented that the real market would start in the 2nd quarter of 2005 where Zyray/Broadcom is projected to capture between 5 and 12 percent of the market.

Do/did our new products generate significant revenue growth?

The consensus on projected market share is that the company will generate $35 million in 2005 from virtually nothing in 2004.

Do/did our products provide unique benefits to our customers?

The answer to this question was yes as the co-processor strategy enables the customers to reuse their old GSM/GPRS/EDGE protocol stack software and current IC's. Michiel noted that we didn't create a unique product for customers but rather a strategic fit for partners. For customers our solution was not any better than the competition's.

5.2.3.3. Project success

Were/are our projects on schedule?

From the very start of the company the engineers managed to meet or exceed all external project milestones. All demonstrations, trade shows and chip manufacturing milestones have been met. If these deadlines were not met, investment in, and/or the eventual acquisition of the company would never have happened. Meeting of project schedules earned the confidence of partners, customers and investors. Internally it sometimes took extremely long hours to meet milestones but according to the outside world everything was delivered on time.

Were/are our projects within budget?

The above question elicited a wide range of answers. According to Luis the budget was missed because the company ended up needing much more—and more expensive—test equipment than was initially projected. According to Frederic, Gavin and Bill the company was on budget most of the time. Gavin and Frederic believed this to be true mostly because every spin of the chip was successful and the team did not need to spend additional money to correct ASIC errors. Werner commented that the company managed to stay on budget most of the time except when the team moved from South Africa to the USA.

Does/did a project outcome agree well with predicted expectations?

According to Luis, who is involved in engineering, the engineering expectations were lowered in order to meet milestones. All other interviewees however agreed that the company met most of the predicted project expectations. Frederic, for example, commented that the chip worked from the start and could be used in a phone, which is the ultimate sign of success. The working chip built enormous confidence in the company, especially after SPINNER 1.0.

5.2.3.4. Cycle time improvement

Did our NPD cycle time improve?

Frederic commented that the cycle time for the first and second spins showed no real improvement. Bill, however, said that by using previous knowledge the project cycle times significantly improved.

5.2.3.5. Customer involvement questions

Were/are customer needs identified through multiple sources of information?

Mike and Gavin commented that the identification of customer needs significantly increased from the seed/concept stage to the development and market phases. Currently network operators, handset manufacturers, partners and semi conductor partners are all polled for market information.

Were/are product requirements solicited, consolidated and fed back to potential customers?

The consensus was that requirements are solicited and fed back to potential customers.

Were/are new product concepts generated jointly by employees, customers and suppliers?

The consensus was that new product concepts are jointly generated by employees and customers and much less by suppliers. According to Mike, this joint generation increased in usage from the seed/concept stage to the current phase. Big design decisions including the RF interface to the chip were solicited from customers.

During requirements definitions, were/are potential customers involved continuously and interactively?

Once again, according to Mike, the involvement of customers during requirements definition increased from the early company phases to the latter phases.

Were/are demographic changes in Zyray's marketplace continuously investigated and forecasted?

The consensus about this question was that it is not applicable to Zyray as we do not work with the end handset users.

Was/is market receptivity evaluated by key customer feedback prior to launch?

Same answer as previous question.

5.2.3.6. Project selection

Were/are projects initiated through a process involving multiple functional areas?

The consensus was that multiple functions worked together from the early phases onward on all projects. In the latest company development process the first step is an initial meeting between all the functions to determine requirements and time frames.

Were/are project priorities updated periodically through a systematic process?

According to Luis priorities in engineering were updated but not according to a formal process. At the marketing level, Mike, Werner and Gavin agreed that the company roadmap was updated periodically to reflect priorities.

Were/are new opportunities most often put through a formal process to determine priorities?

Mike listed multiple opportunities to follow various routes while informal decision-making processes included management meetings every week to discuss new priorities, customers, etc.

Were/are NPD plans mostly influenced by informal planning activities (SWOT, forecasting)?

NPD plans are mostly influenced by informal customer feedback.

5.2.3.7. Product strategy questions.

Were/are projects terminated through a formal decision-making process?

Top–level projects were mostly terminated through an informal process (no known company process). The process was usually affected by the availability of funding. Multiple people at the management and board levelwere involved in these decisions.

Was/is project funding primarily based on potential business contributions to the company?

Zyray is a venture-funded company and therefore all project funding is exclusively driven by potential business contributions.

Were/are company constraints incorporated into established division

"design rules"?

Once again, because Zyray is a venture-funded company, constraints on all levels are known and drive how design is approached. Engineering has to work within specific budget and resource boundaries. According to Luis design rules were also very much driven by the needs of partner firms. This meant that the processes of the partners were incorporated into Zyray's process so that it would be easier to integrate work more.

Were/are product strategies used by departments to collectively align priorities with other departments?

Priorities are shared between functions as no real departments exist in the company. Because of Zyray's small size, it is easier to communicate priorities between functions.

Were/are development projects categorized and matched with appropriate, existing NPD processes?

Because of the small size of the company the previous question is not applicable to Zyray.

Was/is regulatory compliance handled through design guidelines that anticipate compliance challenges?

At the management level it was felt that compliance was handled well within the company. In the case of Zyray this means the 3GPP specifications and changes to the specifications were handled well. When Zyray entered cell phone network testing, any gaps in compliance became evident. At the engineering level however, it was felt that compliance could have been handled better with a more formal process. On the chip level, Frederic felt that Zyray complied well with the design guidelines set fourth by the ASIC manufacturers.

Was/is market research used as input for design decision-making?

Bill felt that this issue did not apply to his department as most of the requirements, at least initially, were internal. The rest of the team however, felt that market research was used successfully as the co-processor design and chip functional requirements were attained through market research. Mike noted that at the seed/concept stage this was not done well but that marketing input was used much more often in the latter stages.

Were/are NPD plans most influenced by analyses of overall value to potential customers?

The consensus (excluding Bill whose NPD plans were influenced by internal requirements) was that NPD plans were influenced by their

value to potential customers. The company is venture funded and has to show how it is going to make money to continue to receive funding from new venture firms.

5.2.3.8. Concept design.

Were/are new product concepts based on anticipated industry technological capabilities?

According to both Luis and Frederic very much so, Zyray's product roadmap follows the roadmap of future 3GPP specifications.

Were/are new product concepts explored in an unconstrained manner?

Frederic felt this issue was not applicable to Zyray as the company only has one product. Luis however, felt that his group had the option of looking at different solutions to problems.

Were/are concepts selected using multiple, explicit criteria?

In the ASIC design team, the technology and architecture of the chip were investigated.

Was/is concept selection based on simultaneous evaluation of multiple concepts?

This issue is not applicable to the company. Different concepts are looked at but which one to use is decided before the design begins. No funds are available for any development beyond what is necessary.

Does/did concept selection occur after manufacturing issues have been addressed?

Concept selection occurred before manufacturing began. Lessons learned from SPINNER 1.0 were incorporated and/or corrected in SPINNER 1.1 after manufacturer feedback. The design rules for manufacturing are dictated by the chip manufacturer. Zyray has to follow these rules when designing the chip.

Were/are concepts designed to optimise product performance through its life cycle?

The consensus was that this matter does not carry high value in the company. The chip is manufactured by a 3rd party and the life-cycle durability of the product is therefore a function of their internal ASIC process. This would be focused on more closely if Zyray's products were used directly by the end customer.

5.2.3.9. Technological leadership.

Were/are technologies proactively developed to gain competitive advantage?

The consensus regarding the above question was yes because Zyray had to differentiate itself from the competition. A few examples of the use of technologies to gain an advantage are: smart antenna, MIMO and receive diversity. Zyray also has a formal technology advisory board. Michiel noted that the company needed a technology roadmap as well as a product roadmap.

Were/are technological changes in the industry actively driven by our R&D efforts?

Because of the size of the company it is difficult for it to drive the industry because research costs money. It was however felt that since Zyray owns a number of patents in core technologies it has some influence in the industry but mostly (especially on the ASIC and development boards) it just follows the industry and uses whatever is available.

5.2.3.10. Documentation questions

Were/are product requirements documented and subjected to formal change control?

The levels of change control increased over the years. In the beginning not much was done in terms of product requirement documentation and change control. Then DOORS was used, followed by Share Point and Test Track Pro. People were slowly starting to buy into the process. According to Luis Excel spreadsheets were eventually found to be a good mechanism for implementing product requirement documentation and change control. He also noted that technical requirements were overwhelming and that the company needed to find a way to condense them into something more manageable.

Was/is agreement about concept selection in the form of explicit (documented) buy-in reached in all departments?

At the start the agreement was verbal, but now it is becoming more formal. According to Bill the design review part of the development process helps to bring the departments together to formally make a decision.

Were/are concepts documented and subjected to formal change

control?

System engineering concepts were documented but no formal change control was implemented in the initial phases.

Was/is risk analysis performed to proactively determine project priorities?

Most people felt that the company is to small to warrant risk analysis on projects.

5.2.3.11. Change control

Did/does formal change control begin at the concept stage?

Software and hardware designs are placed in a change control system but changes are not formally made. Some requests and bugs are now placed in Test Track Pro and can therefore be tracked.

Were/are product requirements only allowed to be changed during the early stages of the design?

Product requirements are allowed to be changed until the chip is actually manufactured. New requirements are continually incorporated into the design. In the latter stages the development process starts to focus on trying to minimize requirement changes. Initially, however, it was a free-for-all.

Were/are the number of changes in each project phase tracked?

Initially changes were not formally tracked, however now Test Track Pro is used to track changes.

Were/are decisions on changes to product requirements based on assessments of multiple predefined criteria?

No predefined criteria (eg. people,cost etc.) are used in Zyray, the only criteria were customer needs

5.2.3.12. Product goal questions.

Were/are project goals supported by documented resource commitments?

Human resources are shown on the project schedule. As the project timeline draws closer to a milestone, other resources are also incorporated into the plan

Do/did project objectives include economic, market and product outcomes?

Project objectives did not initially include the above-mentioned outcomes but over time they changed to include all of the criteria mentioned. Zyray has to work closely with its partners in order to show new products. Project goals were: the cost of the bill of materials of the base band section of the telephone,, to show chip samples at 3GSM in 2003 and to show a working phone at 3GSM in 2004.

Are/were project goals primarily based on economic criteria?

Because the company is venture-funded, economic criteria are of the utmost importance.

5.2.3.13. Metrics questions.

Were/are process metrics aligned with management goals for NPD success?

Management and marketing felt that schedule and milestone metrics were basically the only metrics the company was concerned with and that these were well aligned with company goals. Engineering however, did not feel that any metrics were kept.

Were/are development process metrics quantitive?

Once again, management and marketing felt that milestones, budget and headcount were not specified for the NPD process. At the engineering level, metrics were not felt to have had any influence.

Has the company been collecting process data for a while?

Werner and Mike felt that the team has been collecting data for 2 years while the people in engineering once again felt that the company has not been doing anything in this regard.

5.2.3.14. Process control

Were/are suppliers selected based on a formal supplier certification program?

Suppliers are selected through an informal process that is known to the person in the company that most frequently communicates with

the supplier.

Did/does transition to production occur through early product and process integration?

Frederic noted that small production ramp ups are done with the ASIC.

Did/does documentation describe the product and its production processes?

Luis said that certain documentation will be generated more often when production is entered. Frederic, however, noted that the ASIC was documented very well. Bill noted that the development boards were well documented but would not go into production as such.

Was/is project slippage tracked on a continuous basis?

The project schedule is tracked at a project meeting once every 2 weeks.

Were/are metrics used to improve the NPD process?

The company has gone through a number of post-mortem phases after important milestones were reached. This process, however, is not carried out throughout the company.

Does/did project planning emphasize the prevention of problems in projects?

In the beginning the prevention of problems was not emphasized but later—in the USA—problem prevention improved as Zyray aquired partners and integration leads. Most often internal plans had a buffer at the end of the project so that the external milestone was buffered.

Were/are new products developed using processes that are explicitly documented?

Luis commented that the NPD process is documented but not necessarily followed. He also mentioned that it was vague and that everyone interprets it differently. Specific documents and design reviews were required at various points in the development process.

Does/did process learning occur through the exchange of process data and analysis of other projects?

The question above is not applicable because there were no other projects to learn from except the first cycle of the SPINNER project.

Is the development process controlled through process data and intermediate steps from multiple projects?

The question is not applicable.

5.2.3.15. Human resource development

Was/are teamwork training required of team members?

Teamwork training was inherent in the type of start-up situation. Due to the size of the company the team had to work together. Everyone therefore had to learn to work together in a team even if it was informal.

Do/did career development programs include external assignments?

The question is not applicable as the company is too small.

Do/did development process goals emphasize building up new development competencies?

Because of the size of the company, an informal, self-taught process was followed as time and budget were limited. Some formal, external training sessions were attended and some people received training on their own time. Once again, because of time and budget constraint training was not prevalent.

5.2.4. Company product development process.

No formal process was followed in the seed/concept phase of the company, however everyone was involved in formulating solutions. Once Zyray was located in the USA more formal documentation was kept and document design reviews were conducted. The process itself, however, was very fluid.

Once in the USA after the first spin of the chip, the more formal process shown in the figure below was followed. System engineering kicked of the design process by doing an implementation study. Requirements were solicited and a design document written. The design was then coded and simulated. Following successful simulation the hardware and software engineers were made part of the process.

Further requirements were solicited and test vectors produced. The software engineer would then present an integration plan. Hardware and software engineers would start working on their designs at this

point.

Before the hardware is tested a full test plan including all necessary tests on the hardware using the test vectors must be given to the hardware engineers by the system engineers. Extra vectors are added if product functionality had to be tested.

After the hardware engineer is finished and after significant platform software and hardware testing the hardware engineer will produce a hardware design document. The design document formulises software and hardware interfaces and the working of the hardware block. At a post-integration review the test performance is evaluated and all issues and bugs are listed.

Various blocks are tested, and then finally integrated and tested again. The final design will be used as the modem design to be implemented in ASIC.

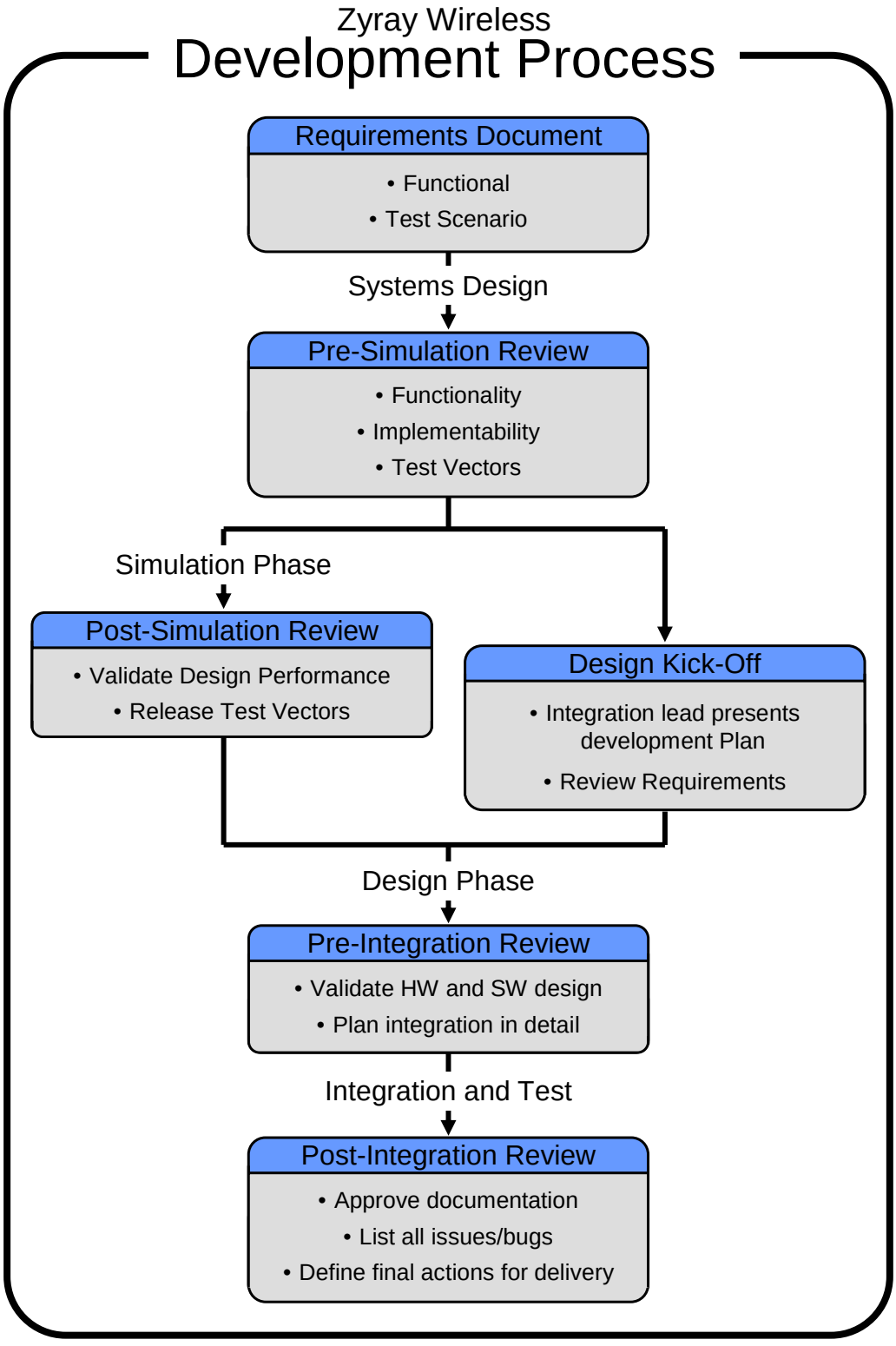

Figure 12: Development process

The figure below illustrates the documentation needed in the company. Note that in this figure DOORS is still the tool used to record requirements. The requirement-recording tool was changed to Sharepoint once the system became operational.

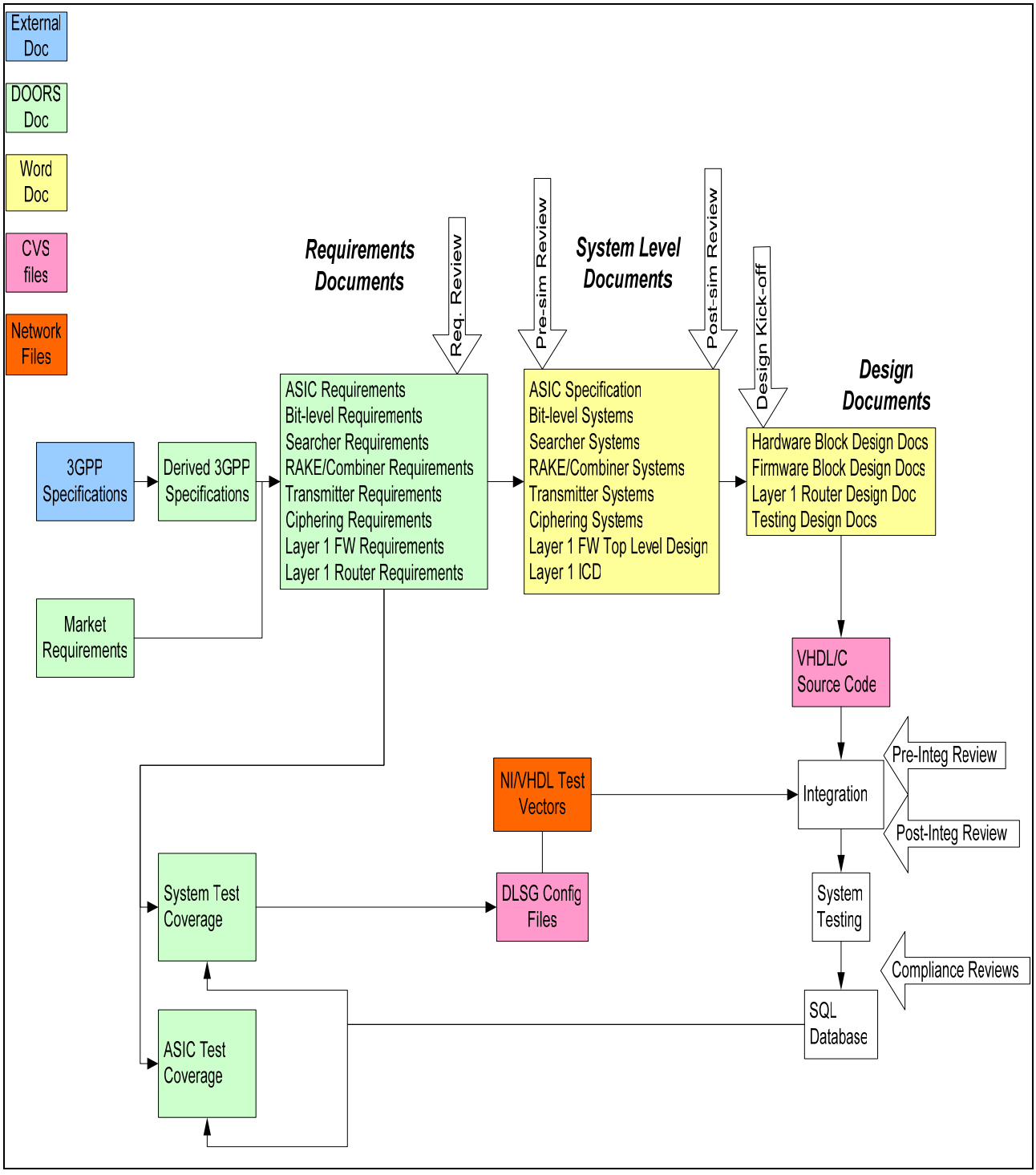

Figure 13: Documentation required

Starting from the top left corner the inputs into the requirements are the 3GPP specifications and market requirements. The next level of documentation generated is system level documents specifying the ASIC itself and the main blocks within the modem. Software requirements including the physical layer (Layer 1 FW) and the integration level (Layer 1 Router) are also generated. All of these

documents are reviewed before they are used as input into the system documents. The system documents therefore detail the design to be implemented. Before simulation and after simulation the system level documents are reviewed. The hardware blocks are then designed. At the end of this cycle the hardware design documents are reviewed.

Next, the integration and block testing phase is entered. Every time testing on a block is finished a review is held to determine compliance of the block.

This process was used to produce SPINNER 1.1 in the development phase of Zyray's life-cycle. Parts of the process were used to develop SPINNER 1.0. Following post-mortem reviews held after the completion of SPINNER 1.0 the process shown in the two figures above was developed.

Following the completion of SPINNER 1.1 and some informal post-mortem deliberations, the development process was changed to the one shown in the figure below. The most significant issue encountered in the development of SPINNER 1.1 was that new requirements were identified too late in the design phase. The product development process had to be updated to include more interaction between functions early in the design cycle.

Initially, a short list of requirements would be generated by all the functions involved. Following the generation of the requirements list it became easier to more effectively estimate resource and time requirements for all the blocks to be designed.

Once the various teams were informed, a more complete design document would be generated. This would include a detailed description of the split between hardware and software. The integration lead would now present a document describing the strategy to be followed in order to design and test the block. Following the acceptance of this document, system engineering, hardware development and software development would begin. This development would be done, using the design of their appropriate systems, over a staggered time frame.

System and hardware design documents are produced and reviewed before full integration testing starts.

After integration and testing is completed the integration lead presents the results obtained and notes all open issues and bugs.

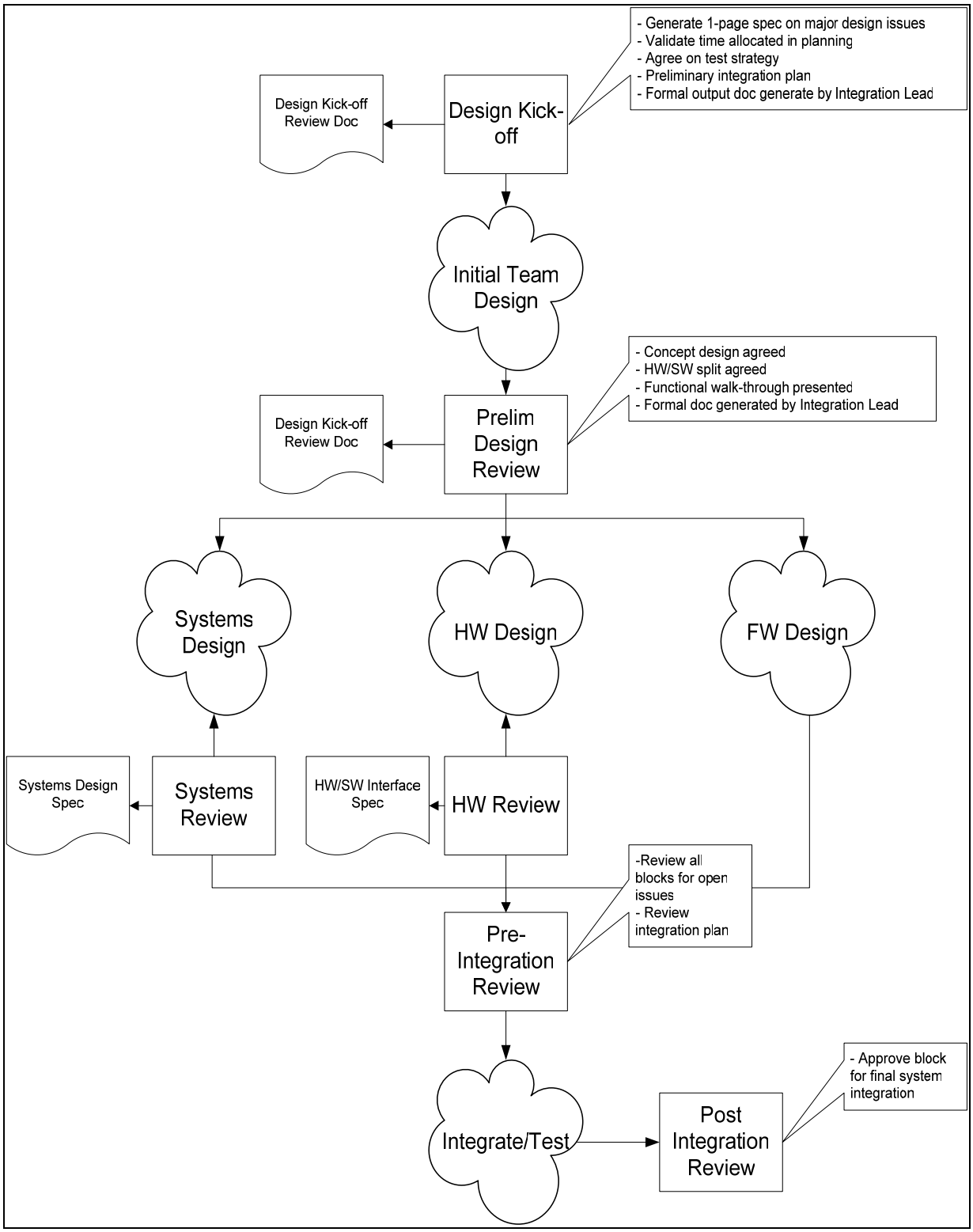

Figure 14: Product development process 2004

5.2.5. Human resource development

Human resource development as such takes a back seat to everything

else in a small, start-up, venture-funded company. No formal training programs or career paths were visible in the organisation, particularly in the beginning when the company had a very flat organisational structure. As time progressed people were placed into management roles between the vice president and engineer levels.

With one exception, no one employed in the company was employed straight out of university. Everyone on the team had very specific experience, and this enabled engineers to start producing results immediately. The engineers, in most cases, put their own career-path development on hold to produce whatever was necessary to meet schedules and thus continue receiving venture capital. This was especially true for all the South African engineers working in the USA on work visas. If the company had failed they would have to go back to South Africa. In most cases they felt very strongly that they wanted to remain and build a new life in the USA.

All employees were granted stock in the company that was vested over a four-year period. The stock options as well as the salaries earned compared favourably with that of the market.

Salary reviews were held every year and salaries were adjusted according to performance, contribution and market information for every employee.

In Appendix 3 the team leader evaluation form is shown. This evaluation was done after SPINNER 1.0 was completed. Managers used these evaluations as input for performance reviews. The reviews were also seen as a good way of building an uplifting work critique.

The figure below shows the fields of responsibility for the various functions. ‘Platform’ in this figure implies a phone platform and system engineering is therefore not shown on the diagram. With the acquisition of partners like Comneon and the subsequent establishment of an FAE responsibility, the responsibilities of the various groups had to be clearly defined.

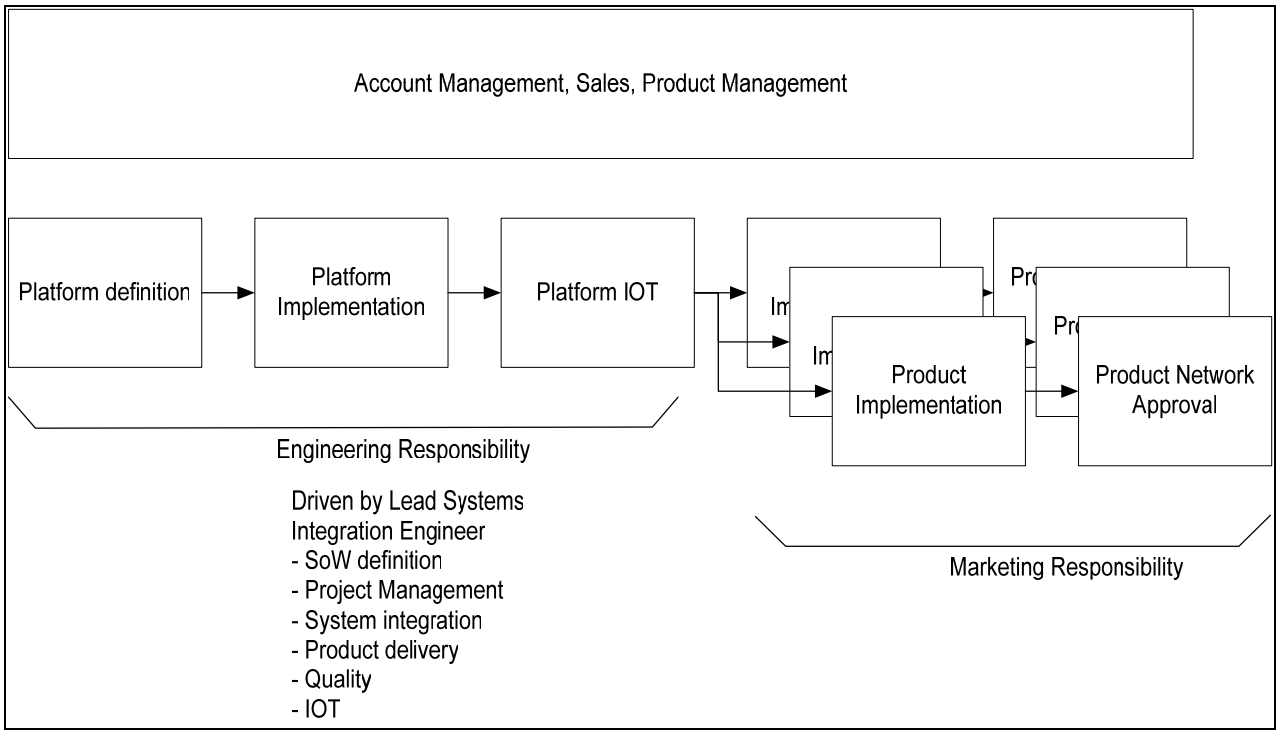

Figure 15: Responsibility fields

5.3. Data analysis

In this section the best practise scores for the various categories and life-cycle phases will be shown. As stated previously, these scores will be compared with industry-wide scores from the study by Dooley.

5.3.1. Best practise scores

The average values for the best practise items per life-cycle phase are tabulated below. The information was obtained through interviews with key employees as previously noted. Note that the concept and seed phases are shown as one phase. The steady state phase is not in the analysis as the company never entered this phase. The original scores from the study by Dooley are listed in the last column. The medians of all the scores as well as the variance and standard deviations are also shown.

Table 6 Zyray Best Practise categories results

	Concept/seed	Product development	Market	Dooley study values
Continuous quality improvement	1.50	3.42	3.33	3.5
Product success	0.00	3.59	3.78	3.6
Project success	3.50	3.83	3.74	2.94
Cycle time improvement	0.00	3.40	3.80	3.63
Customer involvement questions	2.07	2.92	2.99	2.67
Project selection	2.80	3.40	3.45	3.16
Product strategy questions	2.33	3.03	3.04	2.7
Concept design	1.50	1.71	1.92	1.96
Technological leadership	2.33	2.83	2.88	2.79
Documentation questions	1.45	1.80	1.85	2.18
Change control	1.06	1.38	1.38	1.98
Product goal questions	3.52	3.86	3.86	3.05
Metrics questions	1.43	1.71	1.76	2.4
Process control	1.22	1.89	1.92	2.67
Human resource development	0.61	1.61	1.67	1.72
Average	**1.69**	**2.69**	**2.76**	**2.73**
Stand dev	1.087	0.904	0.910	0.603
Variance	1.042	0.951	0.954	0.777
Execution of NPD	1.29	1.69	1.73	2.31

Strategic implementation	2.61	3.21	3.24	2.87

The following normalised graphs were drawn using the information in the previous table:

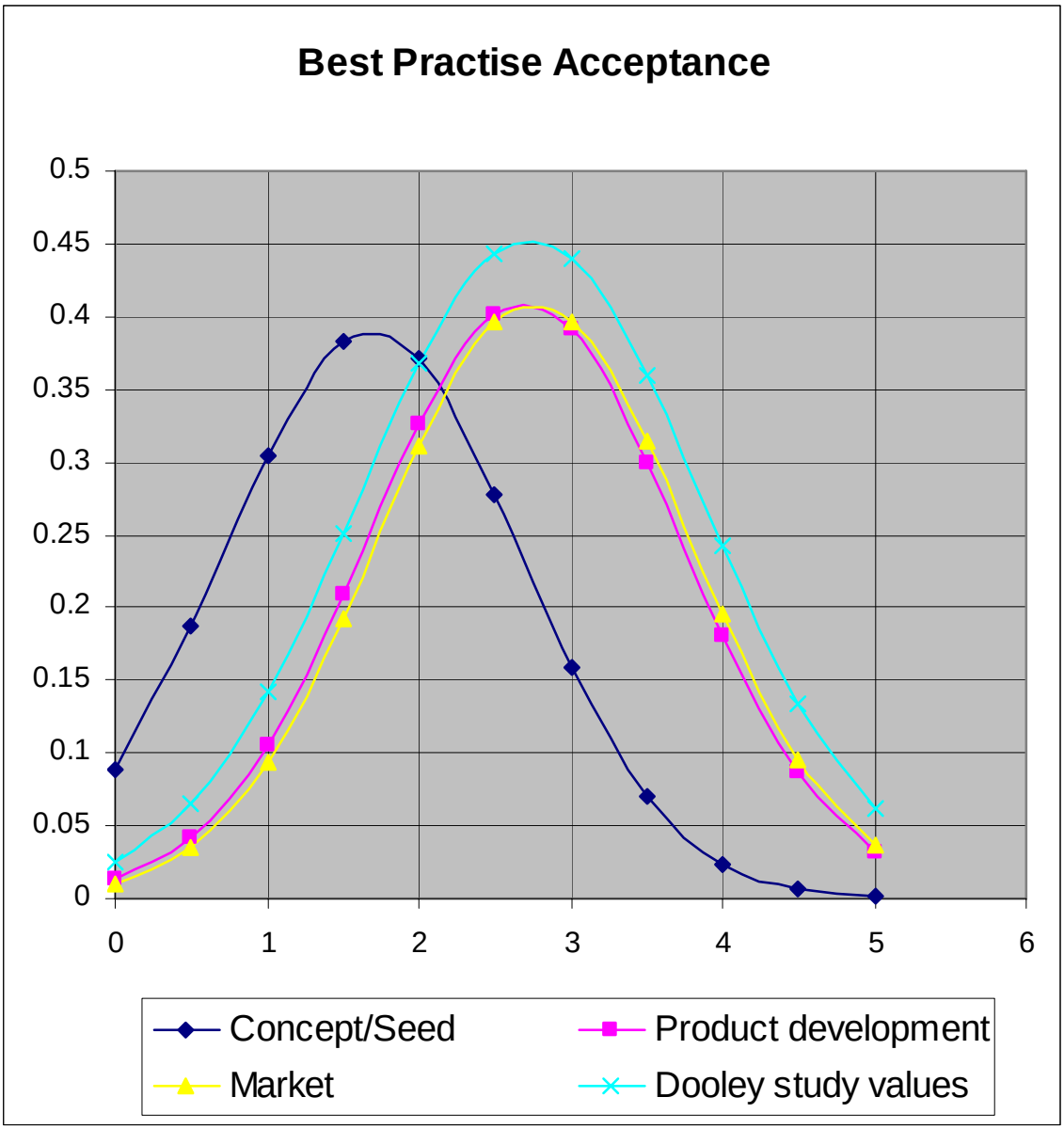

Figure 16: Normalised acceptance of best practise categories

Dooley found that NPD success was influenced more significantly by best practises controlling the strategic implementation of NPD (project selection, goals, technological leadership, product strategy and customer involvement) than by NPD best practises associated

with the execution of NPD (process control, metrics, documentation and change control). They also found that best practises associated with strategic implementation were more widely adopted than best practises associated with controlling and executing product development.

The following paragraphs will analyse the different life-cycle phases of Zyray Wireless using the findings recorded by Dooley.

5.3.1.1. Seed/concept stage analysis

In the early stages of the company's development a less formal process was followed. Consequently the average use of best practise categories was lower than the average found by the Dooley study.

Looking at Zyray, the best practise categories that were used more than average in the beginning were: continuous quality improvement, project success, cycle time improvement, project selection, product strategy questions, technological leadership, product goal questions and human resource development.

These categories were part of the best practises controlling the strategic implementation of the NPD process. At this point no formal product development process, documentation systems or change control systems were in place.

In terms of product success and customer involvement, Zyray's scores were below average in both cases. This makes sense because the company did not have products or customers at this time. The company also did not yet have a marketing department that could focus on potential customer needs.

5.3.1.2. Product development stage analysis

In the product development phase, more formal processes were being developed and followed. Also, the company had a marketing department and a CEO who were focused on determining what product roadmap to follow. **The average acceptance of best practise categories increased from 1.71 to 2.76,** which is higher than what was found in the Dooley study. The standard deviation is, however, significantly larger than the standard deviation found by the Dooley study. This difference is most probably due to the fact that the information was gained from few sources compared with the 39 companies used in the Dooley study.

The product success category showed a significant increase in acceptance from 0 to 3.59 during this phase. In this phase, the company became very focused on developing a product that would be

marketable. Both potential customers as well as investors had to be shown that the company was developing a feasible product.

The company scored above average in the following categories: continuous quality improvement, product success, project success, cycle time improvement, customer involvement questions, project selection, product strategy questions, technological leadership and product goal questions.

The average score for the execution of NPD categories (1.69) is significantly lower than both the score for execution found by Dooley (2.31) and the averages found for strategic implementation categories from both studies (3.21 and 2.87). It is therefore clear that the start-up company focused closely on developing the correct product. Focus and resources were not spent on controlling and documenting the process but rather on developing a quality product.

5.3.1.3. Marketing phase analysis

The marketing phase shows a slight improvement over the product development phase. This might be due to the fact that Zyray only entered the market phase at the time of the case study and did not yet have a fully commercial product. At the time of the case study the company was preparing to enter the market in the last quarter of 2004.

The product success category achieved a very high score (3.78) compared with the median (2.82) and the Dooley study (3.6). The start-up company had to focus on producing the correct product for the correct market at the correct moment in time. Whether or not the company continues to receive funding from the venture capital firm depends on the successful achievement of all milestones so that the confidence of the investors as well as potential clients can be earned.

The only category to show a real increase during this phase was the documentation category, increasing from a median of 1.80 to 1.85. The new median however, is still significantly below the median found in the Dooley study (2.18). In the market phase, documentation to external partners would, however, become more critical. The company was now entering a more mature phase where the gung-ho start-up attitude had to make way for a more organised structure and more formal documentation processes.

5.3.2. Analysis of historical and other company data collected

In the previous section the results from the questions posed to the various employees were presented. The data was then analysed and

conclusions were drawn.

The following section aims to accomplish two goals. Firstly, data from other sources, either documents or participant observations, will where possible be analysed according to the best practise categories. Secondly, the results recorded by this analysis will then be compared against the results obtained from the questionnaire.

5.3.2.1. Concept/seed phase

During this phase, all of the processes in the company were new. Everything was done on an as-needed basis. On the product development process front, no formal process existed. Both the development and market phases had explicit development processes that were communicated to the employees.

Project management was performed on the various items to be delivered and their progress was tracked.

No marketing department existed at this point. The company's two founders were in charge of the business development and marketing. A product roadmap was developed but it was constantly changed and it did not keep track of actual resource requirements.

No human resource department existed. All human resource matters were handled by the founders. All office management tasks were contracted out. As can be seen from the first company structure (figure XX) the company used a flat organisational structure. Most of the people employed with the company were already experts at what they were doing.

Software that was developed was put under a change control system (CVS database) but no further formal change controls existed as yet.

5.3.2.2. Product development phase

The first formal development process was defined during the product development phase and is shown in figure 6. The process control category duly increased from an average of 1.89 to an average of 1.92. Project learning occurred at this point and this helped to define a development process within a changed company structure as shown in figures 3 and 4.

The marketing department was started up under the leadership of Mike Civiello. The company also came under the leadership of an experienced CEO in the person of Werner Sievers. These two events had a major influence on the company's product roadmap. Product and company goals were set which defined what the product should and when it had to be available. The product success category duly increased from a low of 0 to a high of 3.78.

In figure 7 the documentation requirements for the development process are shown. The documentation requirements were developed in conjunction with the development process. The documentation at this point had to be done using DOORS (Appendix 1). Although this proved not to be the best solution, the company got back on track to produce specific pieces of information. The documentation best practise category showed an improvement from an average of 1.45 to an average of 1.85.

The customer involvement average increased in this phase (2.07 to 2.99). From the Zyray time-line information this could be attributed to the agreement signed on a co-development process with Infineon. Feedback from Zyray's first partner gave the company lots of design requirement information that it would not have had if Zyray were still on its own. Even with marketing doing more research on requirements, information gained on a co-operational level is more valuable than information that is shared with anyone in the industry.

5.3.2.3. Market phase

The development process followed was further refined when Zyray entered the market phase. Figure 8 shows the development process followed in 2004. This new development process shows a bigger emphasis on the design kick-off meeting where all the various functions define preliminary test strategies, an integration plan, as well as a basic design specification. The functions then collaborate to generate a conceptual design. From this point forward the system-engineering group produces the design and simulates it. The hardware and the software groups kick off their coding and testing as design specifications become available. Reviews of documents are conducted as in the previous development process. The new approach tried to limit the amount of requirement changes needed late in the design process. The concept design category duly increased from an initial 1.5 to 1.71 and finally to 1.92. As formal documents were generated earlier, the documentation category only showed an increase from 1.8 to 1.85.

The second significant change can be seen in the shift in the organisation of engineers in Zyray. These changes are shown in figure 5. Because Zyray now had to support various customers, specific people were assigned to be the single interfacing-point between the customers and the engineering team. Field applications engineers, who were part of the marketing team, would be the first line of filtering for customer questions. Any problems that could not be handled by the FAE's would then be handed off to the system integrators. These engineers would then take responsibility for finding a solution to the problem. This can be seen in the interesting change in scores for project success, which *decreased* from the development phase to the market phase from 3.83 to 3.74. At the

same time however, the average for the product success category increased from 3.59 to 3.78. This can be attributed to the fact that the focus of some engineers shifted from developing something new to refining the current software and hardware. Getting the actual product out the door now became the main focus of the company. A successful product generates trust and, most importantly, revenue.

5.4. Proposition testing

Proposition 1: Customer involvement will increase over the life cycle of the start-up.

Customer involvement increases over the life cycle of the company, therefore the proposition is correct. From the history of the company it is evident that the marketing department, led by Mike Civiello, was only launched when the company moved to the United States. Prior to this all marketing efforts were informal and handled by the founders. From the questionnaire questions regarding customer involvement it is evident that information about customer needs was first solicited from various sources when the marketing department started, and that over time, the customer involvement increased. From the questionnaire it was found that employees and customers generated concepts jointly. Also, big design decisions were made only after soliciting information from customers. The averages in the customer involvement best practise category were found to have increased during life cycle phases from an initial 2.07, to 2.92 in the development phase and finally 2.99 in the market phase.

Proposition 2: The start-up will be forced to make gating decisions regarding which projects to perform.

Zyray has, for most of its existence, only had one product. How the product actually looks and the boundaries of the product have, however, changed over time. Initially the company was going to make the physical layer hardware and all the software layers above it as well. The company was going to produce a WCDMA phone. However, when the company employed a CEO and started the marketing department it was quickly found that producing all of these elements would be too much work for such a small group of people. The company roadmap was redefined to only include the physical layer hardware in the shape of a microchip, the physical layer software and a layer of integration software. This helped the company focus its resources, which in turn helped the company achieve all the milestones set. This gave the company an advantage when negotiating with venture capitalists in subsequent funding rounds.

When asked if project goals were primarily based on economic criteria all participants answered that in the development and market phases that economic goals were the only goals.

When comparing the start-up against the industry in the project selection category, the start-up started off with a lower score than the industry average (2.8). This, however, changed to become higher than the industry average; (3.4 and 3.45 against the industry 3.16). The successful start-up was forced to continuously make critical project gating decisions.

When comparing the start-up with the industry it is evident that the average company is less focused on project selection and product strategy than the start-up.

Following from the evidence presented, the proposition that the start-up will be forced to make gating decisions regarding which projects to perform are found to be true.

Proposition 3: The start-up company will focus more on product strategy than the rest of the industry.

The product strategy category in the start-up started at a lower level than the industry at 2.33 versus the industry average (2.7) and then increased to 3.03 and 3.04. From the answers to the product strategy questions presented earlier it is evident that the investors played a significant role in defining the product strategy. The only way the start-up was able to receive funding was by presenting its business case to potential investors. This clearly forced a frequent analysis of the product strategy.

The start-up does not have many opportunities to recover from mistakes made; it is therefore of the utmost importance for the start-up not to encounter product strategy mistakes.

The proposition above is therefore found to be true.

Proposition 4: Concept designs in the start-up will be done to a limited extent; not more than the industry average.

When asked, whether concept selection is based on simultaneous evaluation of multiple concepts in the start-up, most participants felt that the question was not applicable as various concepts were looked at but not developed further as insufficient funds and human resources were available to fully build and test all of the various concepts.

Marketing stated that they solicited inputs from various sources. The product roadmap, however, never displayed multiple projects. When asked if projects were categorized and matched with appropriate processes, all participants noted that the question was not applicable.

Projects that were not directly related to product success were never started up in the company. Mike Civiello in marketing noted that

various project routes were listed at a management level but that decisions were also made at management level as to whether to go forward with the projects or not.

In the industry, only concept design with a score of 1.96 is accepted. The start-up always scored lower than the industry average (1.5, 1.71 and 1.92). This evidence therefore supports the proposition that the start-up will not spend more time than the average company in the industry on concept designs.

Following from the evidence presented the proposition presented above is found to be true.

Proposition 5: The start-up company will follow technology leaders.

From the technology leadership questions presented earlier, it was found that the company tried to differentiate itself from the competition. Some new technologies were developed and patented where possible. The company also had a technology advisory board. Most notably, however, it was noted that because of the size of the company it was difficult to drive the industry due to the high costs of research. When it came to ASIC design and WCDMA design Zyray followed the industry standards.

As was the case with the concept design best practise category, resources played a significant role in preventing the company from exploring any alternatives. Any work authorized was measured against economic criteria. The product Zyray developed was a result of its first attempt at developing this type of product while most of the company's competitors had years of experience in this type of product development.

Looking at the technology leadership category averages it can be seen that they did not change much over the life cycle of the company. In the market phase the technology leadership category Zyray scored a high of 2.88. The industry average was 2.79 which put Zyray right on the industry average (within one standard deviation). This score shows, therefore, that the company did not stand out in developing new technologies.

This proposition presented above is therefore also found to be true.

Proposition 6: In a start-up company, change control and documentation will be of secondary importance.

From the answers to the documentation questions given to the participants it became clear that documentation was not prevalent in the initial stages of a project. Figure 13 shows the documentation process at Zyray. It is clear from this figure that concepts were not documented. The final solution was documented where necessary.

Documentation became necessary when designs crossed functional boundaries. System engineering would document the system design. The ASIC designer would document his/her design as it had to be reviewed by the system engineers as well as the firmware engineers. During the latter phases of development, the documentation provided would then be driven by what the customers needed to know.

According to the answers given to the change control questions it is clear that changes in documentation were not considered to be very important. When Zyray started using Sharepoint, documents were, for the first time, put in a database where changes could be tracked. In contrast, hardware code and firmware were put in a change control database from the inception of the company. In the market stage, the company started using a bug tracking system—Test Track Pro. At this point changes were driven via a formal process.

When comparing the documentation best practise and change control categories with the averages found for the industry it is clear that Zyray was well below the average.

Documentation started with an average of 1.45, grew to 1.80 and ended up at 1.85. The industry average is 2.18. In the concept/seed stage the start-up average was one standard deviation lower. This average improved but even in the latter stages Zyray still was well below the industry average in terms of documentation.

The same pattern that was seen with Zyray's documentation was seen in change control. Zyray started at 1.06 and ended at 1.38. Both these averages are well below the industry average of 1.98.

From the analysis of the evidence it is clear that the change control and documentation best practise categories were of secondary importance to the company, and therefore the proposition is proved to be true.

Proposition 7: Goals and metrics will closely follow investor or customer milestones.

From the goals best practise category the answers given by the participants indicated that because the company was venture-funded, economic criteria in setting company goals were of the utmost importance. The goals the company had to work towards were hard external milestones, which demanded that the company product be shown at the 3GSM international conference in Cannes France in 2003 and 2004. The answers to the product strategy best category questions presented earlier also indicate that project funding was primarily based on potential business. Because the investors were such an important part of the decision-making process in Zyray, the team had to clearly show how each project would contribute to the

product being developed.

Zyray effectively only had one project that would produce one product. The line between project and product for Zyray was very narrow.

The participants of the questionnaire indicated that not a lot of metrics were looked at within Zyray. Management and marketing felt that product delivery milestones were really the only metrics that everyone in the company was judged against. Management and marketing had to keep metrics on the budget but engineering only had one metric: a successfully working product. No metrics were kept in the engineering of intermediary steps towards the goal of producing a product.

From the data collected it is clear that the product goal best practise category featured very prominently in the start-up. It started at 3.52 and improved to 3.86. In each case the value is significantly higher than the industry standard of 3.05.

The metrics category was expectedly low (between 1.43 and 1.76) and well below the industry average of 2.4.

From the data collected it is clear that product goals were aligned with investor milestones while metrics reflected only a measurement of success according to these milestones. The proposition presented above is therefore true.

Proposition 8: The start-up company's organisational structure will change as the product goals change.

The initial company structure in figure 8 shows that the company was structured along the lines of a company developing a complete product: an ASIC team, a systems team, a layer 1 team, a higher layers team, a Java team, and test and integration team.

In figure 9 the company structure in the USA is shown. It shows that the Java team has disappeared and a marketing team has been added. At this point the company started to focus on developing a chip that would only perform the layer 1 functions and not the higher layer functions as in the seed and concept stage.

In figure 10 the team has changed and added RF (radio frequency) and hardware platforms units. At this point information from the market indicated that the company would have to show the chip integrated with a radio section on form factor hardware.

Figure 11 shows the company structure after the company's first clients were landed. Specific people were assigned to support specific customers. This new structure was used to enable the

company to develop a fully working product. At this point the goal changed from making a chip to delivering a fully integrated and field-tested solution to a customer.

From the changing company structure over the lifetime of the company it is evident that the structure of the company changed as the product needs changed. This could be attributed to the fact that as the product development needs changed, people's roles in the organisation changed to support these new needs. Somebody initially writing firmware would, in later phases, be doing field trials and supporting a customer's field tests. The company did not have a set operational structure. The company also had only one product to support and could therefore adapt easily to satisfy new requirements.

The proposition that the organisation's structure changes as the product changes is therefore found to be true.

Proposition 9: The start-up company's human resource development will be as good as the industry.

All training and mentoring was informal. Because the company was small, nobody had the luxury of taking part in external assignments. Formal training was very limited due to constraints on money and time. Training was attended but it was done on an ad hoc basis. The big-company luxury of being able to attend regular training programs did not exist, however peer reviews were held to determine performance. These reviews were used as inputs for salary and share increases.

While the human resource best practise category started with a low of 0.61, it increased to 1.67 in the market phase. This score is on par with the industry average of 1.72. Personnel felt that career development and recognition were easily attained. Everyone had to be willing and able to perform at his/her peak and feel like they made a measurable difference.

Even though the company did not have a lot of training opportunities, interviewees still felt that the company did well in terms of human resource development.

This proposition is therefore found to be true.

6. Results and Conclusions

The research questions were defined as follows:

How does the product development process change over the life cycle of the company?

How do the best practise processes implemented in the industry differ from those implemented during the life cycle of the company under investigation?

Why does the company implement best practise processes at a specific time in its life cycle and not during other times?

What specific best practise processes are accepted and implemented by the company, why they were chosen and why were others not.

The Dooley survey was taken at three points in the life cycle of the company. It showed how the product development process changed and how it differed from that of the industry. The results are tabulated in table 6. The information in the table answers the first two questions.

The next two questions are answered by the analysis of the propositions made in the previous chapter and by analysis of each best practise category, to follow.

6.1. Research results

In chapter 3 the theoretical framework of the field of study was presented within the context of the best practise categories. To maintain continuity the results found will be treated within the same context.

6.1.1. Customer involvement

From Chapter 3.2.1 it is evident that customer needs have to be analysed. Customer needs are studied through 3 phases: discovery, scoping and business case building. The house of quality is a tool used to match customer needs with engineering capability.
Zyray did not initially have a marketing department or a person with marketing experience that could build a marketing team. Only when the company moved to the United States and employed a seasoned CEO did the company employ someone with marketing experience.

Proposition 1 stated that customer involvement would increase over the life cycle of the start-up company. This proposition was found to be true. Initially customer needs were identified by the founders and later by the marketing team. It can be see from the results produced

through the research questions that customer involvement scores increased over time.

One reason why customer needs were better identified over time was that as more people became available it became possible to visit more potential customer and industry leaders. While the founders could spare only part of their time resolving customer needs, the marketing department could actively chase down customer needs as part of their responsibilities.

Not employing someone with marketing skills could have been a critical oversight on the part of the founders. It is also possible that in the seed/concept stage, the start-up was catering to a different customer. The customers in the initial stages of the start-up were the venture capitalists. *The start-up had to get money from investors and therefore the product was defined from the needs of the investors rather than from actual customers.*

The problem with this approach of catering only to the needs of the venture capitalists was that the start-up was not focused on a reasonable goal. Initially, Zyray was going to build an entire phone. The problem was that this was what investors wanted to hear, and as a result that was what they were 'sold'. In later stages, however, the focus shifted to the real customers who would buy a product rather than the promise of a product. Fortunately for Zyray they managed to sell to the investors as well as real customers.

6.1.2. Project selection

Project gates were introduced in chapter 3.2.2 as a method by which projects were selected. At every stage of the product life cycle gate meetings were held to determine whether the project should continue or not. Various criteria can be used to judge whether the project should proceed or not. These techniques could be company strategy fit, financial methods or product portfolio techniques.

The proposition (proposition 2) made was that the start-up company would be forced to make gating decisions. This proposition was found to be true. Zyray started with a much broader scope to its product. Over time, and particularly after employing a CEO and vice president of marketing, the scope of the project became more focused. The major driving force to this change of scope was found to be economic criteria. Resources drove economic criteria available in the current budget.

The start-up company did not have a formal stage gate process in place, however various events in the company's life cycle forced the project gating events to be on an ad hoc basis. Some running projects were stopped after 'gating' events. One such event (as stated earlier) was at the expansion of the management team. This coincided with

the time when the company already had investment capital and had to analyse whether the initial project goals were achievable.

No significant changes were made to the product roadmap following this gating event. No formal processes were ever implemented to have specific gating meetings for various projects. The management team and the board, however, continuously looked at what the company was doing and how various projects fit in with attaining the milestones.

It was therefore found that because the company only had one product, the project selection process was never formalised. The informal project selection process, however, had economic criteria as its biggest driving factor.

6.1.3. Product strategy

From chapter 3.2.3 it is clear that the company had to manage its product portfolio using three different metrics. The first metric was value maximization, which entails the financial measurements. The second was balance; this implies that the company product portfolio has to be correct. The third was strategic direction, which encompasses the fit of products with the strategy of the company.

The scores for the product strategy best practise category improved over the life cycle of the company. The score increased from an initial 2.33 to a 3.03 and finally to a 3.04. The industry average was 2.7, indicating that the company's strategy was above average for most its life cycle.

From the answers given to the questions about product strategy it is clear that this category was one of the most important categories for the company. Management closely followed the progress of projects and made sure that all funding constraints were adhered to. People agreed that project funding was based exclusively on potential contribution to business. *All projects within the company were done to further the progress of the one product being developed.* The product portfolio consisted of a single product.

Market research was performed and used as input for the product requirements. The product requirements were again aligned with the company strategy. The original company strategy was to build the specific product. At this point the company strategy was to enable WCDMA in next generation cell phones. The product to be developed was a WCDMA chip, the product and project strategies were one and the same .

The start-up company closely followed the three different metrics given by Robert Cooper (1999:189). *Zyray showed that choosing the correct product and company strategy and then aligning all resources*

with the product development of this product are necessary to achieve success.

6.1.4. Concept design

In chapter 3.2.4 it was learned that concepts could be generated from many different sources (customers, employees, technology). The concept design could also manifest in many different forms: brochures, virtual prototypes, mock-ups, drawings or a clearly written description.

The concept design should, however, answer some fundamental questions including: what the customer is interested in, which facets the customer likes and dislikes, how the company is rated against the competition, what price the customer expects to pay and what positioning strategy information is needed.

The proposition was made that concept design would mostly be performed by marketing as there would not be enough resources available to make more complex prototypes. Marketing solicited information from various sources. These sources included network operators, phone manufacturers and suppliers. The information gained from these sources was used to create the company strategy and product roadmap. The proposition that marketing dominated the concept design was found to be true.

This marketing-dominated concept design created a successful strategy. The company strategy was taken to investors and potential clients that needed the technology Zyray provided. When Zyray brought out its first chip they also signed a co-operation agreement with their first client. The product fit the needs of the clients the company was targeting perfectly. The company could only have formulated a successful strategy by gathering the correct information. Having marketing take the concept product strategy to the correct clients proved to be essential to the success of the company. As a result of Zyray delivering the correct product to the market, Broadcom finally acquired Zyray.

The concept strategy was formulated in the second half of 2001 and implemented as company strategy soon after this. The company could focus its resources from this point forward on delivering a product. The SPINNER chip 1.0 was delivered at the end of 2002. SPINNER 1.1 chip followed at the end of 2003 and the company was acquired in 2004.

Zyray's success was therefore plotted in 2001 by the successfull prediction of what the market would want 3 years later. The concept design formulated early on would define the strategy of the company for years to come.

6.1.5. Technological leadership

The proposition made was that the start-up company would be a technology follower and not a leader. This proposition was found to be true as the company did not have enough resources to drive the industry. From the data gathered and the averages found Zyray was right on the average for the industry.

From chapter 3.2.5 a technology balance sheet was said to be an important part of the company's strategy. The company had to develop superior products using technology, adhering to industry standards and hiring competent people so that competitive advantage could be built and sustained.

The start-up company had to be evaluated against other start-up companies. Towards the last year and a half of the company's existence the company started to employ people with relevant knowledge from other failed start-up companies in the same field.

Zyray managed to run a tight schedule on the engineering front and never missed a milestone. Both chips produced by the company also worked. If any of the chips had failed the company would have been in serious trouble and very close to permanently closing its doors. Making a chip is very expensive and balance has to be kept between making a chip and developing more mature technology to put in the chip. The risk increases if the differences between chips are bigger. SPINNER 1.1 ended up being network tested inside a commercial phone.

Zyray therefore developed one test chip and the second chip had to be good enough to put in a commercial product. Zyray set the bar for all other start-ups in the same field. When taking the complexity of WCDMA into account this is a phenomenal achievement. When the company started no 3G networks existed, in 2003 and 2004 test 3G networks started up in Europe with some commercial networks following. Just comparing the 384 kbps download speeds over a wireless connection with a dial up modem at 56 kbps should already give an indication of the level of complexity of the technology.

6.1.6. Documentation

In chapter 3.2.6 it was noted that documentation forms part of the bigger knowledge management process in the company. The organisation has to learn and knowledge has to be transferred throughout the organisation.

Documentation starts at the first phases of the life cycle of the product and continues though out the life of the product.

Proposition 6 stated that documentation and change control will be of secondary importance. From the evidence gathered it became clear that documentation was not kept in the early stages of the project. It was found that only the necessary documentation was kept. The averages for documentation questions were well below the industry average. The documentation scores started at 1.45, increased to 1.80 and finished at 1.85. The industry average was 2.18. The proposition was found to be true.

The reason for the neglecting of documentation could be attributed to resources. Technical milestones drove the budget of the start-up. Anything that did not show an immediate advantage in the start-up was of secondary importance. The start-up did not have a department or a person exclusively assigned to handling documentation issues.

Various databases were used by the start-up to make documentation easier. The first product used was DOORS. This database system is detailed in the tools appendix chapter 1.3. The company's engineers, however, never accepted this tool as it forced the user to use a new system instead of Microsoft Office products. The tool that followed DOORS, called Sharepoint, was from Microsoft. Sharepoint is detailed in the tools appendix chapter 1.1. The Sharepoint program proved to be successful as it enabled the users to use the programs they knew in order to generate and manage documentation.

The types of documentation that the company could not live without were: WCDMA system design specifications, ASIC design specifications (used as input by the chip manufacturer) and documentation detailing the interface of the product to clients.

6.1.7. Change control

Change control, as documentation, is part of the knowledge management of the company. It was noted in chapter 3.2.7 that change control has to be implemented over the whole life cycle of the company. Change control should enable engineering, manufacturing and marketing to enter a change request and the effects of the change request should clearly be identified. Resources should be mobilized to take care of the change request.

Proposition 6 stated that documentation *and* change control would be of secondary importance. The average for change control was found to be well below the industry average of 1.98. It started at 1.06 and then moved to and stayed at 1.38. As stated earlier this proposition was found to be true.

The biggest influence on change control in the company was the use of a change request or bug tracking system. The company chose to use a product called Test Track Pro. The tool is detailed in the tools appendix chapter 1.2.

Change requests can be entered into the database and a responsible person can then be assigned to resolve the change request. When it came to actual intellectual property, everything was divided into two categories. The first category was all source code—be it firmware, hardware or mathematical models. This was kept in a freeware repository called CVS. Everything else was kept in the previously mentioned Sharepoint database.

The balance of the documentation kept was technical documentation. Although marketing and management kept information the change control system only applied to engineering.

Change control and documentation became more necessary the more clients the company aquired. Many documentation efforts were driven by the requirements of the client. The bug tracking system became necessary the moment the engineering department started developing the product and supporting the product at the client level. Previously one person could keep track of all the changes and all the responsible people, this however became impossible when the company had to start supporting clients.

There is no doubt that a successful company has to have a system in place to track changes and to keep information. *The most important step of such a system in the specific start-up was to get all the engineers to agree to use the chosen tools.* The engineers in the company did not agree to use DOORS because it was cumbersome, however the moment the company started using tools that truly helped the process and did not get in the way of people doing the real engineering work, the tool was accepted and used.

Change control was exclusively implemented for the engineering function starting in the product-developing phase. No change control was kept for concepts or marketing.

6.1.8. Product goals and metrics

In chapter 3.2.8 the statement is made that proper metrics must be selected to measure process, project and product performance. The metrics will enable the organisation to set goals and to measure whether the goals have been achieved. Project metrics measures the schedule and cost performance of the project. Product metrics, measure how well the product performs in the field.

Proposition 7 stated that goals and metrics would closely follow investor milestones. External and internal development goals were aligned with investor milestones. If the company achieved a milestone, the investors would continue investing. The proposition was found to be true.

From the averages found it is evident that metrics and goals were approached quite differently in the start-up than in the industry. Metrics scored very low in the start-up, starting at 1.43, going to 1.71 and ending at 1.76. The industry standard for metrics is set at 2.4. Product goals, however, scored highly, starting at 3.52 and ending at 3.86. The industry average is 3.05.

The stage gate process outlined in chapter 2.8 outlined gate meetings for the various projects in the company. At these gate meetings the project metrics were evaluated and 'go/no-go' decisions were made. The metrics could be financial, strategy or engineering metrics. The stage gate process was implemented internally. Zyray did not implement a formal stage-gate process. The various functions communicated in such a way that co-operation existed between them and information and requirements were fed back into the design process. Gate meetings as such did not exist in the company.

The company had a single product and the development of that product had to continue. Financial metrics were taken by management as a tight budget had to be kept. *In engineering no formal metrics were kept apart from making sure that the product worked.*

Externally however, investors in collaboration with management and the board defined very hard goals to be achieved. These goals put 'go/no-go' decisions on next round financing decisions. If the goals were not met the financing would be stopped. The metrics used at these milestones were technical. The chips the company produced had to work or alternatively a demonstration at a trade show had to be successful.

Zyray delivered at every milestone set for them and in some cases over-delivered. A case-in-point was that the company received the first chip on 31 December 2002; one and a half months later at the biggest GSM tradeshow in the world the working chip was demonstrated inside a form factor cellular phone. The goal set for this milestone was to have the chip on a big development platform. This was literally an order of a magnitude that was easier to achieve than what was delivered.

Over-achieving on goals set was crucial to gaining the trust of investors and clients and to finally being bought for nearly a hundred million dollars.

6.1.9. Process control

From chapter 3.2.9 it is evident that process control is the way in which the organisation organises itself to manage, control and execute the engineering of its product. Process control starts at the start of the project and continues throughout its life cycle. This

includes the documenting of all requirements and concepts. Process control is affected by the structure of the company; the company could be composed of various functions with team leaders who manage project tasks, a high-level manager could manage the project with lots of executive power or project managers with no real power over the functions could manage the projects.

Proposition 8 stated that company's organisational structure will change as the product goals change. The way the company changed over time is shown in figures 8, 9, 10 and 11. The company structure changed when the product strategy changed. It also changed when the company signed up clients and the product became more mature. Therefore the proposition was found to be true.

Process control in the company did not score very highly in the data collected. It started with an average of 1.22, improved to 1.82 and ended at 1.92. All these scores are still well below the industry average of 2.67. The discrepancy is party because the process control questions cater more to well-established companies. The documentation of processes, the formal selection of suppliers and communication with manufacturers did not exist in the start-up company.

The start-up has to define the way everything is done. The engineering manager has get people with different skills and experiences to agree on how to do things in the new company. Engineers from different backgrounds are used to doing things differently and some time has to pass during which agreement on how the company processes will work is reached. Because of limited resources all processes are designed as they become necessary, therefore, more processes are formalised over time. Input from various sources has to be taken into consideration, but in the end the engineering manager has to make the final decision and everyone has to respect and follow the processes established.

At its largest, Zyray employed forty people. This was still relatively small for a technology company and communication was still relatively easy. The company also only had one product, it therefore did not have to formalise many processes. In many cases a single person was responsible for talking with suppliers and manufacturers. *In such a case only the person's own processes have to be followed, the company does not need a formal process to govern when one person is in control.*

The biggest advantage the start-up has over well-established companies is that it can move more quickly than anyone else. Companies with 'tiger teams' still have to work within the overall company bureaucracy. *The start-up can quickly adapt itself to new situations and requirements.* People are also open to thinking and acting more freely and therefore are able to design quick solutions to

problems rather than waiting to be formally tasked to do so. This is also the case for the use of tools. Barring financial constraints, new tools can quickly be bought and used. There is no need to standardise over the whole company as the engineers are typically co-located.

6.1.10. Human resource development

In chapter 3.2.10 it was stated that it is of critical importance to a start-up to have a very strong team. The team must be able to freely communicate and must be led by a leader who commands technical as well as personal respect. The team must be compensated fairly and their personal lives must be respected. The skills of the people have to be improved through mentoring and training and they must have the appropriate tools to work with.

Proposition 9 stated that the start-up company's human resource development will be as good as the industry's. The proposition was found to be true.

The averages for human resource development started at a low of 0.61, increased to 1.61 and finished at 1.67. The industry average (1.72) is slightly higher than the company's final score. The start-up emphasised the human resource part of its development. All employees were given ownership in the company. Skills were built because employees had to work outside of set fields, take ownership of the company goals and walk the extra mile. Because of the size of the company everyone was privy to management, marketing, sales and engineering information. Each person gained a lot more experience than they would have had they worked for a big corporation.

The start-up company has to have the correct product strategy and excellent employees. Everyone has to show leadership and be willing to work independently. The data showed that the rules and regulations in the company were very limited. The individual had to take ownership, had to work well within the team and could not expect to be lead or 'spoon fed' at any point. New solutions had to be sought both technically and in management. There was no time to watch over anyone's shoulder and make sure they got the job done, each person had to have the strength to learn and finish any task.

The success of the start-up company is tightly coupled with the skills of the individual people in the company and how well these individuals form a strong team.

6.2. Implications for and/or contribution to practise

Current theory and best practise categories focus mainly on well-established companies. Although literature is available on the specific needs of the new or start-up company, most product

development techniques focus on established companies.

The study showed the following 10 important points:

1. In the initial phases the start-up's customers were the venture funds.
2. The project selection process was informal but driven by economic criteria.
3. The company showed that it had to choose a product strategy early on and then had to develop the product according to this strategy.
4. The marketing team developed the concept design but they influenced the future of the company because they dictated the product strategy.
5. The company followed a technology follower strategy. The technological competency of the team was of such a high standard that they developed a product after very few iterations.
6. The start-up showed that internal documentation was limited but that external documentation with clients and manufacturers had to be of a high standard.
7. The company showed that change control was limited to the engineering function.
8. The start-up showed that over-achieving on goals set by itself and investors was of critical importance.
9. The start-up showed that process control was kept to a minimum and that it could react very quickly to changing situations.
10. The start-up showed that the establishment of a strong team is of critical importance to the success of the company.

The purpose of this study was to show the difference between the best practise categories taken over a large industry sample and those of the start-up company. The differences were shown by comparing an industry wide survey with the same survey taken within the company. Doing this comparison also improved the validity of the study; showing how the company compared with the industry qualifies the propositions made earlier in this dissertation.

This chapter will therefore compare current theory to what was learned from the Zyray Wireless case study. The first metric would be to analyse whether the findings from the case study concur with current theory. Any deviations will be pointed out as well as anything found in the specific case study that is not mentioned in the current theory.

Firstly, Dooley found that NPD success was influenced more significantly by best practises controlling the strategic implementation of NPD (project selection, goals, technological

leadership, product strategy customer involvement) than by NPD best practises associated with the execution of NPD (process control, metrics, documentation, change control).

The start-up company followed the theory that strategic implementation categories influence the development process more than the execution categories. The strategic categories started at an average of 2.61, increased to 3.21 and ended at 3.24. The industry average is set at 2.87. The strategic categories are well above the industry average. ***These averages show that the focus of the start-up was on product strategy and on the engineering of the product even more than the industry average***.

The best practises associated with the execution of product development were, however, much lower than the industry average. They started at 1.29, increased to 1.69 and ended at 1.73. The industry average was substantially higher at 2.31. ***This shows that the start-up rejected the process control categories more than the industry average.***

To further establish the validity of the study, the findings from the study will be compared against two industry resources on start-up companies.

Gordon Bell (1991:268) suggested criteria to judge the start-up against. The criteria were extracted from current theory. In the following table the various points mentioned by Bell will be shown and the lessons learned in the case study will be evaluated against them.

Table 7 Bell start-up findings

	Gordon Bell	**This Case Study**
1	On the technology front the company has to have a technology balance sheet with design processes, a resource schedule, engineering specifications, manufacturing specifications, team culture, technical resources and good technical leadership.	The start-up had an extremely competent team, never missed a milestone and performed beyond expectation to produce a product quickly.
2	The product has to have unique benefits, the correct market price and be able to build on future products.	The product strategy and product roadmap were designed early on. The migration path of the product was also set forth.
3	The company has to have a well-	The company met all

	organised process through which it is capable of producing products according to the price, quality and schedule required by customers.	milestones and never overspent the budget.
4	The company has to have a five-year plan that is realistic and workable with a detailed description of the next 2 years.	The company had a 2-year horizon on its current product and a vision for all new products.
5	The company has to have a complete strategic and tactical market plan together with the leader and organisation to implement it.	The company employed a vice president of marketing and a CEO, both of whom had the necessary experience. After they became part of the management team a successful product and corporate strategy was defined.
6	The company has to have a dedicated sales team who understands the product, price and customers of the company in order to be able to meet sales targets.	When the company entered the market a sales person was employed. Prior to this, marketing handled sales.
7	The CEO has to show he/she has the capabilities to manage, lead, build teams, be knowledgeable about the constraints of the start-up business and be able to attract capital from investors and the board.	The CEO had previously started other successful start-up companies, negotiated another round of funding and eventually negotiated to have the company bought.
8	The team has to be composed of high-quality individuals with expertise and experience in relevant areas. All the members must be oriented to find solutions and fulfil various roles.	The people employed took ownership of the company and worked as a team.
9	The members of the board have to act as reviewers, act as counsellors and make sure that the company's strategic vision is correct.	The board employed a competent management team and made sure the company produced an achievable company strategy.
10	The company has to make sure that it has enough cash for the current stage of development and enough to carry it forward until it secures more	Management kept a tight reign on the budget and engineering worked well within the budget.

	funding.	
11	Investors have to be willing to contribute to the next round of funding based on the corporate, product and market outlook of the firm.	The company strategy showed when the product Zyray produced would become profitable and when phone manufacturers would find it necessary to acquire it.
12	Control has to be kept and milestones and schedules met.	As stated previously, all milestones were met, and on occasion even more than expected was delivered.

Michael Baird (1995:63) suggested the following ten criteria for the start-up company. They followed from Steven Brandt's 'Entrepreneuring: The ten commandments for building a growth company'.

Table 8 Baird start-up findings

	Michael Baird	**This Case Study**
1	Launch the start-up with a complete, experienced, compatible management team.	The company was launched without a CEO and marketing manager. They only started nine months after the start of the company.
2	Use a market and customer driven strategy to define your product.	Market needs were solicited from customers and the product strategy was designed accordingly.
3	A superb business plan calls for a superb, focused execution.	The team met all milestones and were always in budget.
4	Write a solid business plan that the team believes in.	The product and company strategy were spot-on in predicting what the marketed needed and when it needed it.
5	Create a complete, experienced and compatible team.	An extremely competent team was put together who worked well as a team.

6	Motivate with a fair remuneration plan, including equity participation.	All employees were given options in the company.
7	Pursue rapid profitability leading to high growth	The company was still not making money but it would sell chips for cell phones and get money for every chip sold. The market in 3G is set to really take of in 2005.
8	Project, monitor and conserve cash and credit capability.	The company stayed within budget and only produced one test chip before a product chip was produced.
9	Develop a market driven strategy. Do not concentrate on your technology to the exclusion of other success factors.	The product requirements were driven by the needs of the market as identified by marketing.
10	Develop and maintain an operational business plan after funding is obtained.	The plan was updated whenever needs changed.

From the two tables presented it is evident that the Zyray Wireless study supported all the start-up success metrics put forth by Gordon Bell and Michael Baird. ***The one exception was that the company did not immediately employ a knowledgeable CEO and marketing manager***.

Of the criteria determined necessary by the study of the start-up only two were not explicitly mentioned by the other two studies as being necessary for start-ups.

Firstly, ***in the initial phases the customers the start-up catered to were venture capitalists***.

Secondly, the study of the start-up explicitly found ***that internal documentation was limited but that external documentation with clients and manufacturers had to be of a high standard.***

The study also found that one of the biggest advantages of the start-up over an established firm was that the start-up's process control was kept to a minimum and that it could therefore react very quickly to changing situations.

The study reaffirmed what the other studies showed to be necessary for a start-up to be successful and it also showed that the start-up, when managed well, could achieve a higher level of engineering capability.

The unique contribution made by the study was that it showed how the engineering process in particular differed from the standards set by established firms. The studies on start-ups cited in this chapter only treated the engineering process as part of the bigger picture. The engineering function and its processes are, however, important and it is difficult to know how to filter all the information on product development into what the start-up really needs to know and do.

The biggest lesson learned from the study is that the start-up entrepreneur should focus more on strategy and engineering rather than on process control. A start-up company is still small enough not to need so many processes and controls. Having freedom to perform in engineering and working on the correct product and business strategy is much more important. This line can be drawn throughout the organisation where decisions on personnel and equipment have to be made. This metric would direct the entrepreneur to spend money on resources and projects that strengthen the more important aspects of the business.

Entrepreneurs could therefore use the 10 points presented as a guide in the future. These points will give them insight as to what to focus on in order to enable them to achieve success.

The best practise results showed that the start-up focused on strategy and engineering and not so much on process control.

6.3. Self assessment

Johann Mouton (2001:149) said that the strengths of the case study are high construct validity, in-depth insights and the establishment of a rapport with research subjects.

This case study showed that these points are all true. The writer started working at the company a month after the company was formed. Therefore, the writer went through all the phases of the start-up up until the point where it was bought in June 2004. This enabled the writer to have a unique insight into the development of all the processes in the company.

Information gathering was never limited to the formal interviews conducted. The information was gathered on a formal and an ad hoc basis. Information on the history of the company was gathered from a first person perspective. Many of the processes were created with the writer as a part of the process; this afforded the writer a unique

insight. It also afforded the writer the ability to gain insight into the difficult times the company faced and made sure that he did not only get the 'sanitized' version of the company history.

Johann Mouton (2001:150) also mentioned the following points as possible limitations or sources of error: lack of generalisability of results, non-standardisation of measurement, the fact that data analysis can be time consuming and also the potential bias of the researcher.

All of the issues mentioned above are applicable to this case study. Since only one company was studied it is very difficult to generalise the results to the rest of the industry. The best practise scores are a good example of this. The study found that the scores between the specific start-up company and the industry standards showed a difference. Because only one start-up was studied it is not possible to generalise the results to all start-ups.

The next potential problem Mouton mentioned was the non-standardisation of measurement. This is not a problem for the best practise categories as the points awarded are very specific, However the analysis of the results according to the Bell-Mason diagnostic, or any other metrics, are very subjective.

The next potential problems mentioned were the fact that data collection could be time consuming and the researcher could be biased. Gathering the data was definitely time consuming. The company was started in August 2001 and was bought in June 2004. The research was started in 2003 and ended nearly 18 months later, however it would not have made as much sense if the study were not bounded in this way. The fact that the company was bought for a substantial amount of money and the company was in the process of delivering a product, helped it to be classified as a successful start-up. Knowing that the company was successful made it easier to make recommendations and to concur with industry measures for success.

The fact that the researcher could be biased, however, is also true. Because the researcher was part of the company some data could be skewed to show the researcher's subjective views. However, the advantage of having insight into the company and not just getting the sanitized version of the events from questionnaires and interviews outweighs the potential negatives of being so closely involved with the subject being studied. The insight afforded the reader into the workings of the start-up should contribute a unique set of results to this field of research.

The validity of the data has to be addressed next. Due to the various sources of information used in this study, construct validity is maintained. Multiple people were interviewed, and documentation and participant observations helped to ensure that a single piece of

evidence did not skew the findings.

To maintain internal validity, a pattern-matching method was followed. The Dooley industry survey was repeated for the start-up company. Any proposition made could therefore be tested against the equivalent in the industry. It is therefore possible to say that this particular start-up accepted a specific best practise more or less than the industry did.

The purpose of the study:

*The research done with the particular start-up company will identify **what** the **differences** are between generally-accepted best practise methods and the best practise methods implemented by a particular **start-up** company.*

The research achieved this goal by first showing the industry average as found in the Dooley study. Then, by doing the survey and cross referencing it with other sources of information it was possible to confidently show the differences between the industry and the specific start-up.

6.4. Recommendations

The biggest drawback of the study is that it is not possible to generalise the results to the industry. One way to remedy this situation is to perform a study of a number of start-up companies. This, however, poses a problem, as the study should distinguish between start-ups who have achieved a measure of success and those where it is not yet possible to measure any success. Measures of success might be: income to the start-up, successful product launch or being bought by a bigger company that wants to augment its technology capability. If the researcher were to identify start-ups who satisfy these prerequisites the same best practise questions should be put to them.

The results should then be compared against the results obtained by this study. It would then be possible to generalise the results of the study to the industry.

Research about start-up companies is important as these companies create jobs and, if successful, wealth and potential contributions to science. The last few decades have shown that the likes of Intel, Microsoft and others can truly change the way the world works. It is, however, extremely risky and difficult to create success where so many others fail. The more information and tools available to the entrepreneur the better off the entrepreneur will be.

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Tools Appendix

This chapter will provide a description of the tools used by Zyray Wireless.

1.1. Sharepoint

Sharepoint is a web based collaboration tool provided by Microsoft. The goal of this system is to provide a single entry point for the knowledge available in the company. Through the portal the user must be able access internal documents and specifications, external specifications, industry news, project plans and whatever data is pertinent to the furthering of the company goals. The interface provides links to different database's including file servers, internet sites and database's.

The following technologies are used:
Windows 2000 Server it provides file and print services, internet information services, routing and remote access amongst other features.

Office XP is used this includes all the Microsoft office programs that dominate the market today. Word, Excel, Project etc.

Windows Explorer is used to provide easy navigation, viewing and search navigation.

Document management services that provides document check-in and check-out services so that a document is reserved for work by one user. Version tracking provides easy roll back to prior versions. Collaboration across the web is enabled via he discussion and mark-up features of Office. Security features ensures (attempts to ensure) that documents are only viewable by users with the correct access rights.

The Portal provides extensive search and web crawling capabilities. Relevant documents are parsed and searched to provide relevant metadata and content.

The Portal Framework is customisable so that data is presented in a way that suits the particular organisation.

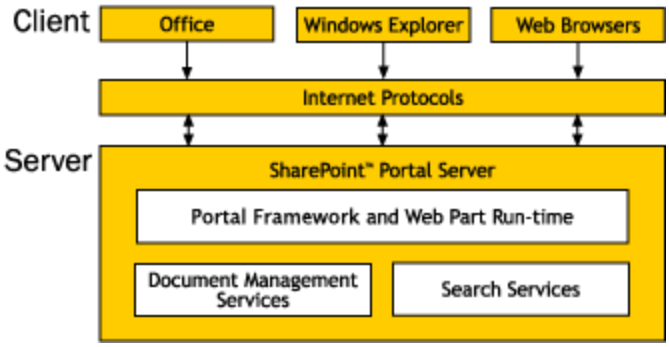

Figure 17 Sharepoint Portal Server components

The software works by creating a portal web site. This site is centralized navigate able access point for data. The data can be browsed, searched, documents can be checked in and out, document revision histories can be viewed and documents can be approved for publication.

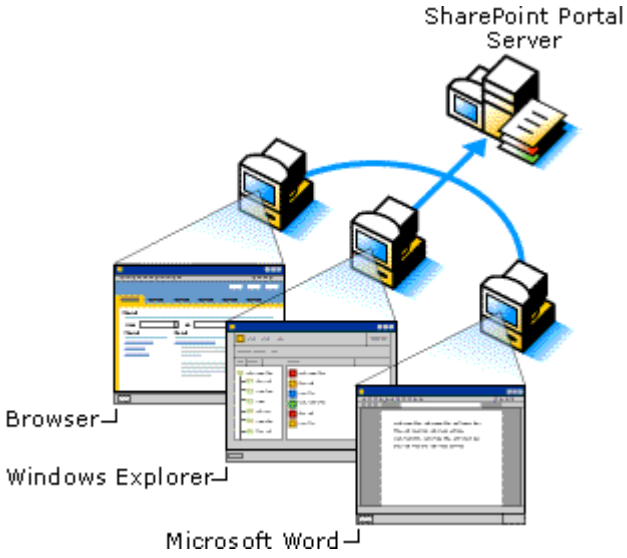

Figure 18 Internal document viewing

The portal also provides access to information off the site anywhere on the internet. Content can be searched to provide URL, parsing and filtering of relevant data from documents and organisation of the data.

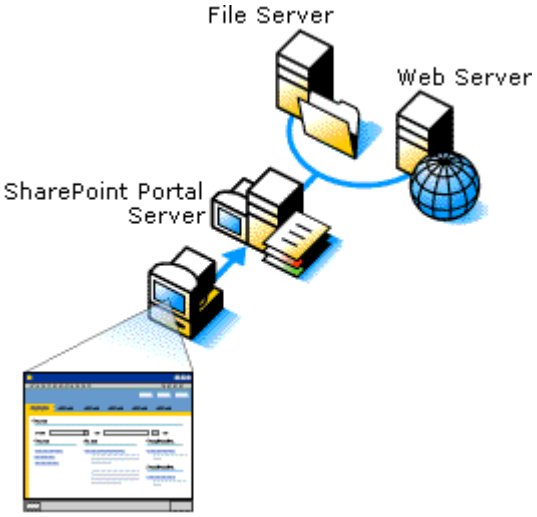

Figure 19 Web search facilities

1.2. Bug Tracking

Following the appointment of FAE's a bug tracking system was also implemented in the company. This became necessary because problem reports started coming in from different sources. A formal process had to be followed otherwise some issues might be neglected. The software used is a program called Test Track Pro.

Test Track Pro (TTP) is a bug tracking and reporting tool from Seapine software. The software can be used to report a bug and assign the bug to a specific person to fix or coordinate the process of fixing. The status of the bug is tracked and changed over time as the bug is fixed. The software also has a web-based interface that lets clients report bugs as well. The word 'bug' is used here to describe a defect in the product or alternatively a new feature that must be put into the product.

Along with every entry into the TTP database the user can add customisable information and fields. TTP lets' the user attach files and data so that the problem is clearly identified and described. Some of the fields include the product the bug was found on, the severity of the problem, the test configuration to reproduce the problem and the person who identified the problem.

As soon as a new bug is entered into the database or the status of the bug changes an email notification is sent to people or groups who were identified as necessary to know about the problem. When a defect is assigned to a specific team member he will automatically be notified. In this way all the different team members from engineers, support, marketing, management and if necessary clients are kept up

to date as to the status of the problem.

TTP also offers advanced filtering capabilities to enable the user to filter the bugs in the database according the specific criteria. The criteria includes, assigned to which user, according to status, according to the product the defect was identified on and various other criteria.

The software offers different tiers of security to control the access to the database by different groups or people.

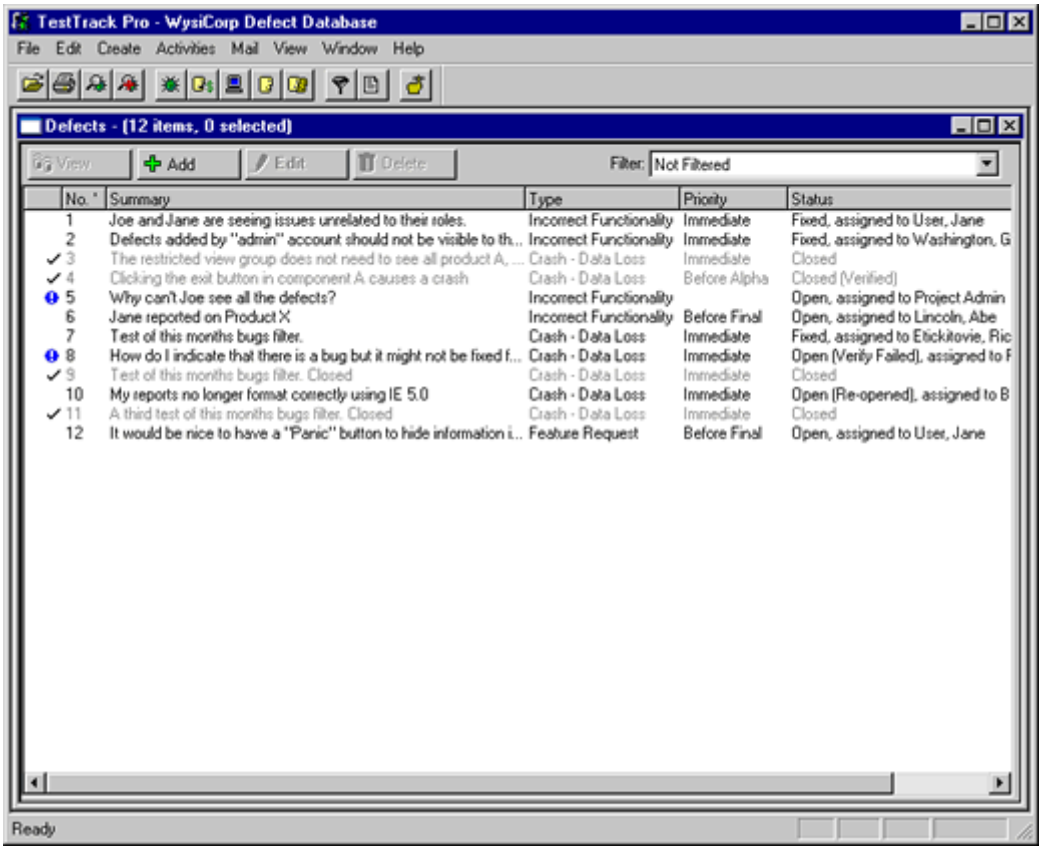

Figure 20 List of Bugs in Test Track Pro

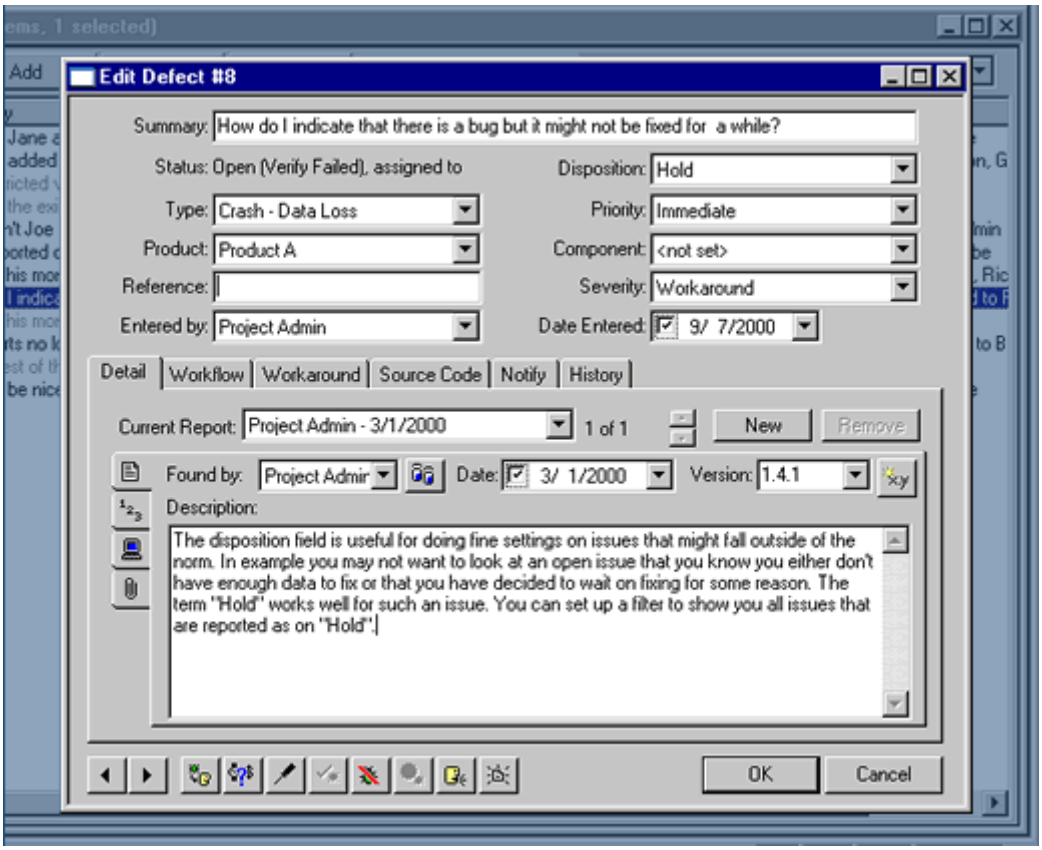

Figure 21 Editing a defect

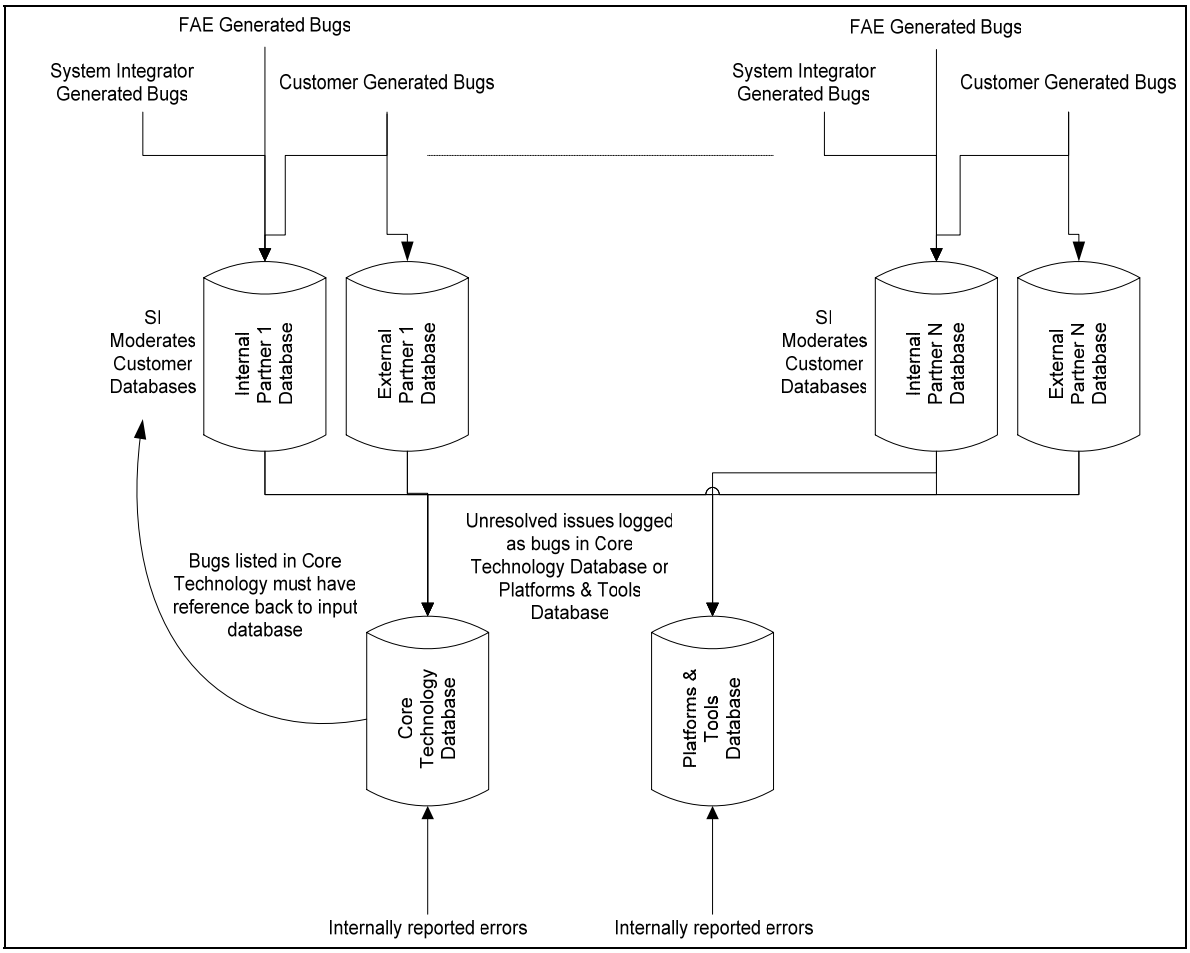

Figure 22 Bug tracking database

As can be seen from the picture above the database is split into two levels. On the higher tier the customer or partner companies enter bugs. These bugs are evaluated by the FAE and if they cannot solve them the bugs are forwarded to either the core technology team or the platform and tools team. Bugs can be assigned to a person with a specific priority. The bug can then be passed to different people, depending on who needs to resolve it. Finally the bug is cleared when it is resolved and tested.

Note that no formal bug tracking was done until mid 2003.

1.3. DOORS

DOORS is a requirements management product provided by Telelogic. It captures and links information to ensure a projects compliance with a set of standards. DOORS assigns a unique identifier to each requirement, these identifiers can be linked to other higher layer

requirements right up to the set of standards. The company can therefore track it's progress towards complying to a set of standards. It is also a way for the company to show outside parties that all requirements are met.

Documentation can be viewed over the internet and security attributes can be set on a per user basis. DOORS also implements a change proposal system that lets the user make changes or submit changes for review. When updates are made, automatic email notifications can be send to the relevant parties.

DOORS provides different tools to view and edit the information stored in it's data base. DOORS offers a local intranet viewer, am internet web-based viewer and offline editing using Microsoft Word.

Project Post Mortem Questions

1. General Questions

1. Are you proud of our finished deliverables (project work products)? If yes, what's so good about them? If no, what's wrong with them?
2. What was the single most frustrating part of our project?
3. How would you do things differently next time to avoid this frustration?
4. What was the most gratifying or professionally satisfying part of the project?
5. Which of our methods or processes worked particularly well?
6. Which of our methods or processes were difficult or frustrating to use?
7. If you could wave a magic wand and change anything about the project, what would you change?
8. Did our stakeholders, senior managers, marketing etc. participate effectively? If not, how could we improve their participation?
9. What specific part of your project showed the most innovation?
10. Was the communication within the project effective enough so that you knew all the issues affecting your design and your work all the time?

Rate the overall project (circle your choice)
1 – The worse project, you have ever worked on
3 – There were some good points in the project, but mostly bad
5 – We did no better or worse than any of your previous projects
7 – For the most part of the project, we executed well
10 – All aspects of the project were executed extraordinarily well

2. Requirements definition

11. Did you have a clear understanding at the start of the project of the exact requirements of your specific tasks?
12. Did you have a clear understanding at the start of the project of where your specific development task integrated with the larger system?
13. What was your opinion of the quality of the original design that you had to implement as outlined in your source document (3GPP spec and/or Systems docs)? Was it significantly changed after you started working on the project?
14. Did all the important project players have creative input into the design process? If not, who were we missing and how can we assure their involvement next time?
15. How could we have improved our work process for creating deliverables specifications?
16. Was the description of the design detailed and clear enough to enable a smooth development phase?

Rate the requirements you had to work from (circle appropriate source
3GPP
Systems Doc
Other _____)
(Circle your choice)
1 – The worse requirements ever
3 – After many hours, it started to make some sense
5 – Requirements were acceptable
7 – The requirements were fine
10 – You could implement the system without asking anyone a question they couldn't answer

3. Project Planning

17. How accurate were our original estimates of the size and effort of our project? What did we over or under estimate? (Consider deliverables, work effort, materials required, etc.)
18. How could we have improved our estimate of size and effort so that it was more accurate?
19. Did we have the right people assigned to all project roles? (Consider subject matter expertise, technical contributions, management, review and approval, and other key roles) If no, how can we make sure that we get the right people next time?
20. Describe any early warning signs of problems that occurred later in the project? How should we have reacted to these signs? How can we be sure to notice these early warning signs next time?
21. List any person you believe were not involved early enough in our project. How can we avoid these oversights in the future?
22. Were all team/stakeholder roles and responsibilities clearly delineated and communicated? If not, how could we have improved these?
22. Were the deliverables specifications, milestones, and specific schedule elements/dates clearly communicated? If not, how could we improve this?
23. Were all dependencies for the design phase of your project taken into account in the original plan?
24. Were all dependencies for the integration phase of your project plan taken into account?

Rate the project planning ***(circle your choice)***
1 – The plan wasn't worth the paper it was written on
3 – I once looked at the plan, but only briefly
5 –The plan was useful only as a guideline
7 – The plan had its flaws, but overall it was useful to help me to know how to schedule my effort
10 – Wow, everything worked just like the plan said it would

4. Development Phase

25. Were you proud of your deliverables? If not, how could you have improved these?
26. How could we have improved our development process for creating deliverables?
27. What part of the development phase frustrated you most?

Rate the development phase ***(circle your choice)***
1 – The most frustrating development of your life
3 – It was a struggle, but I managed to get through it
5 –Similar to previous development experiences
7 – Very stimulating
10 – The best work of my life

5. Integration and Test

28. Was the integration strategy for your work clearly defined and well thought out?
29. Did you have adequate hardware and software resources available to complete your part of the project?

30. Did the test facilities, equipment, materials, and support people help to make the test an accurate representation of how the deliverables will be used in the "real world?" If not, how could we have improved on these items?
31. Did we get timely, high-quality feedback about how we might improve our deliverables? If not, how could we get better feedback in the future?
32. Was our integration and implementation strategy accurate and effective? How could we improve this strategy?

Rate the integration effort *(circle your choice)*
1 – Nothing seemed to work together the first time
3 – Sometimes we lucked out and things worked
5 – In general, we had to spend some time to get things to work together
7 – We found bugs, but nothing unexpected
10 – Everything integrated 100% the first time

6. Management and control

33. Did you always have a clear idea of the status of your part of the project?
34. Did you fully understand how your part of the project influences other designers?
35. Did you receive adequate feedback on the project status?
36. Was the number of meetings held during the project to little, enough or to many?
37. Did you feel that you have enough input into decisions that influence your work?
38. Did you feel that management understood what you were doing?
39. Did you feel that enough emphasis was placed on the quality of the design?
40. Were the reporting lines clearly defined? Did you always know who to report to etc?
41. What is your opinion about the communication level between designers?
42. Where issues that arose addressed quickly and efficiently?

Rate the management and control *(circle your choice)*
1 – What management?
3 – Only good for signing Pos and buying pizza
5 – It felt as if I worked for a big corporate
7 – Management actually contributed to some parts of the project
10 –If it weren't for management, nothing would have worked

7. Development Process

43. Do you feel that we have a solid development process?
44. What part of the development process would you like to change most?
45. Did you have a clear understanding of what was expected from you in terms of documentation?
46. Did you have a clear understanding of what was expected at reviews?

Rate the development process *(circle your choice)*
1 – Aaarrghh!
3 – It adds very little value to the company
5 – The process was acceptable
7 – The process had some problems, but it does provide all the information required
10 – Great, it helps me to focus on the development

Team Leader Evaluation

Team Leader Evaluated: _____

Please rate this person (not their team) based on your personal interaction (not rumor or hearsay).
Scale:
1 - Always
5 - Never
? - Don't know

Leadership and Management	**Rating**
1. Establishes a clear vision of the future as well as the tasks at hand.	
2. Makes sure team goals & priorities are understood	
3. Allocates resources appropriately	
4. Empowers team members appropriately	
5. Seeks new and better ways of doing things	
6. Encourages responsible risk taking	
7. Recognizes problems and takes appropriate action	
8. Actively works to remove barriers to getting work done	
9. Effectively coordinates workload with other teams	
10. Shares credit with the team/department	
Job Knowledge and Performance	
11. Has appropriate knowledge to perform leadership role	
12. Acknowledges own mistakes and takes corrective action	
Interpersonal Skills	
13. Is accessible	
14. Is sensitive to others' feelings and points of view	
15. Actively participates as a team member	
16. Seeks and considers my opinion on decisions affecting me	
17. Seeks to understand before rendering judgment	
18. Respects my abilities	
19. Deals with pressure and conflict positively	
20. Has a positive outlook on my team and the company	
Communication	
21. Communicates clearly	
22. Encourages diversity of opinions	
23. Shares information openly with the team	
24. Is approachable on difficult subjects	
Values	
25. Is someone I trust	
26. Treats me with respect	

Mentoring and Performance Evaluation	
27. Sets reasonable expectations on scope of work and goals	
28. Provides information I need to perform my duties	
29. Provides valuable counseling and insight into my work.	
30. Discusses my career and training opportunities	
31. Is a positive role model	
32. Recognizes and rewards accomplishments	
Overall Assessment	
33. Is someone I would choose to work for on a team again	

Any additional comments:

Broadcom Acquisition statement

Acquisition Expands Broadcom's Growing Mobile Phone Portfolio to Include 3G WCDMA Products

IRVINE, Calif. and SAN DIEGO, Jun 16, 2004 /PRNewswire-FirstCall via COMTEX/ -- Broadcom Corporation (Nasdaq: BRCM), a leading provider of highly integrated semiconductor solutions enabling broadband communications, today announced that it has signed a definitive agreement to acquire Zyray Wireless Inc., a leading provider of baseband co-processors addressing WCDMA (Wideband Code Division Multiple Access) mobile devices. Zyray's SPINNERchip™ co-processor enables third generation (3G) mobile communications technology to be easily added to current generation phone handsets and data terminals, complementing Broadcom's existing EDGE/GPRS/GSM mobile products with a cost effective WCDMA solution.

Zyray's SPINNERchip technology, which is currently being integrated into several handset designs, enables data device manufacturers to bring true 3G phones to market rapidly. Pairing the SPINNERchip technology with Broadcom's single-chip EDGE/GPRS/GSM and GPRS/GSM baseband processors enables two-chip WCDMA multi-mode phones in the near term and provides the potential for future solutions with enhanced integration.

WCDMA technology provides high-speed mobile connectivity with data rates of up to 384Kbps (kilobits per second), enabling new applications such as video telephony and messaging, graphics-rich sports and news clips, interactive gaming, location-based services and improved web browsing. As cellular phones emerge as the dominant platform for media convergence, these new applications will help cellular carriers maintain and increase average revenue per user (ARPU). According to a recent Deutsche Bank Securities, Inc. market report, the worldwide WCDMA market is expected to approach 200 million units by 2008, representing over one-fourth of total handset sales.

In addition to WCDMA technology, Zyray is currently developing HSDPA (High Speed Downlink Packet Access) functionality for integration into its next generation family of devices. HSDPA is the next step in the cellular evolutionary path after WCDMA and is expected to provide data rates of up to 10 Mbps in the downlink. Zyray is also developing MIMO (Multi-In, Multi-Out) transceiver technology that can significantly improve the performance of WCDMA and HSDPA. MIMO refers to radio links with multiple antennas at the transmitter and receiver to improve the performance of wireless connectivity. These techniques have broad applicability in several wireless and mobile technologies.

"We see significant activity in the WCDMA handset space, and having Zyray's products and technologies in-house gives us the flexibility of offering our customers the ability to manufacture both low-cost EDGE phones as well as higher functionality WCDMA handsets," said Robert Rango, Group Vice President of Broadcom's Mobile & Wireless Group. "Zyray also enhances Broadcom's technology portfolio with valuable intellectual property in the HSDPA and MIMO areas."

Broadcom offers a broad portfolio of mobile communications baseband processors, reference designs and cellular software protocol stacks, including the Broadcom® BCM2132 EDGE mobile multimedia processor, BCM2121 GPRS processor, and ML2011

GSM processor. The addition of Zyray's products and technologies will enable Broadcom to offer complete WCDMA and HSDPA baseband solutions and provide Broadcom with the opportunity to add MIMO transceiver technology to a broad spectrum of mobile and wireless technologies. Broadcom's proven expertise in mixed-signal and CMOS RF also enables the delivery of complete wireless, local and personal area network (WAN/LAN/PAN) solutions for mobile data communications with compelling size, cost and performance benefits.

"With its EDGE products certified on the AT&T Wireless and Cingular networks, Broadcom is an ideal partner for our SPINNERchip technology, enabling us to provide mobile phone OEMs with immediate access to a next- generation technology coupled with a broad range of products already in use," said Werner Sievers, President and CEO of Zyray. "We expect to see our combined products play a major role in driving the adoption of smaller, lower power 3G mobile phones, significantly increasing the availability of WCDMA handsets and enabling exciting new mobile applications."

The Zyray co-processor connects to existing EDGE/GPRS/GSM baseband processors via a standard memory interface, significantly simplifying multi- mode phone development while allowing manufacturers to capitalize upon their previous technology development investment. The Zyray architecture implements WCDMA functionality as a configurable set of hardware accelerators, rather than as software running on a general purpose digital signal processor (DSP), thereby enabling improved performance and lower power while retaining the ability to software-optimize the product. Future versions of the design are intended to handle up to 10Mbps in support of HSDPA.

"With EDGE proliferating in North America and WCDMA gaining traction in Europe and Asia, we expect these technologies to dominate the cellular landscape going forward," said Neil Strother, Sr. Analyst from In-Stat/MDR. "Handset manufacturers are looking to silicon vendors for support of the full spectrum of WCDMA/EDGE/GPRS/GSM cellular standards to accommodate carriers who are aggressively moving to deploy next generation technologies."

In connection with the acquisition, Broadcom will issue or reserve for issuance approximately 2.23 million shares of its Class A common stock (with a total value of approximately $96 million based upon the NASDAQ National Market closing price on June 15 of $42.84 per share) in exchange for all outstanding shares of Zyray capital stock and upon exercise of outstanding employee stock options and other rights of Zyray. In addition, Broadcom previously invested $3 million cash in convertible notes of Zyray that will be canceled without repayment in connection with the acquisition. A portion of the total consideration paid will be subject to escrow pursuant to the terms of the acquisition agreement. The merger transaction is expected to close during Broadcom's third fiscal quarter, which ends September 30. The boards of directors of both companies have approved the merger, which awaits approval by Zyray's shareholders and the satisfaction of regulatory requirements and other customary closing conditions. At closing, Broadcom expects to record a one- time charge for purchased in-process research and development expenses related to the acquisition. The amount of that charge has not yet been determined.

About Zyray Wireless

Zyray Wireless develops the SPINNER™ family of WCDMA semiconductor products for 3G mobile devices. SPINNERchip is an add-on WCDMA baseband processor that enables handset manufacturers to develop single-mode WCDMA, dual-mode GPRS/GSM & WCDMA and tri-mode EDGE/GPRS/GSM & WCDMA devices in a cost effective, low risk and time efficient manner. The SPINNER solution incorporates Space-Time Processing (STP) technology that provides improved data-rate throughout the cell coverage area and increased network capacity.

About Broadcom

Broadcom Corporation is a leading provider of highly integrated semiconductor solutions that enable broadband communications and networking of voice, video and data services. We design, develop and supply complete system- on-a-chip (SoC) solutions incorporating digital, analog, radio frequency (RF), microprocessor and digital signal processing (DSP) technologies, as well as related hardware and software system-level applications. Our diverse product portfolio addresses every major broadband communications market and includes solutions for digital cable and satellite set-top boxes; high definition television (HDTV); cable and digital subscriber line (DSL) modems and residential gateways; high-speed transmission and switching for local, metropolitan, wide area and storage networking; home and wireless networking; cellular and terrestrial wireless communications; Voice over Internet Protocol (VoIP) gateway and telephony systems; broadband network and security processors; and SystemI/O™ server solutions. These technologies and products support our core mission: Connecting everything®.

Broadcom is headquartered in Irvine, Calif., and may be contacted at 1-949-450-8700 or at www.broadcom.com.

Press Releases

1.4. Press Releases 2004

Feb 23, 2004
Zyray's SPINNER®chip Selected by Infineon Technologies for World's First ARM®9 based Multimedia Platform supporting GPRS, EDGE and UMTS

Cannes, France, February 23, 2004: US based Zyray Wireless announced today that their SPINNERchip WCDMA co-processor has been selected by Infineon Technologies for its multi-mode (GSM/EGPRS & W-CDMA) reference handset. The reference handset has been developed by Infineon with the support of Zyray and will be showcased at the 3GSM World Congress in Cannes.

Zyray's recently released SPINNERchip1.1 serves as the WCDMA co-processor for Infineon's S-GOLD® GSM/EGPRS application enhanced modem IC. To complete the WCDMA solution, Infineon's market leading SMARTi-U UMTS single chip RF transceiver is combined with SPINNERchip.

SPINNERchip 1.1 is the latest evolution of the SPINNER family of products from Zyray, and is slated for mass production later this year. Extensive testing and verification has already been completed resulting in a robust and proven product. Interoperability Testing (IOT) has been completed with 5 major infrastructure vendors and in key European and Asian markets.

"As a leading platform provider for mobile communications, Infineon Technologies combines forces with reliable partners to offer competitive multimedia solutions to our customers," said Dominik Bilo, CMO of the Secure Mobile Solutions Group, Infineon Technologies. "Continuous innovation, short design cycles and the product quality are the characteristics that make Zyray such a preferred partner for Infineon Technologies"

Werner Sievers, CEO of Zyray Wireless, said: "Together Infineon and Zyray are able to offer OEM's and ODM's a compelling solution, which incorporates multi mode (GSM/EGPRS & WCDMA) functionality with a range of features and applications in a small form factor. With our proven speed of integration we can offer a very quick turnaround on handset projects which is important in the extremely competitive 3G market."

Visit Zyray Wireless at Hall 2 Stand F22
Visit Infineon Technologies at Hall 1 Stand A19

Feb 23, 2004
Zyray Wireless To Demonstrate Patented Smart Antenna Technology
Solution Provides 3.5 - 4.0db Improvement Over Single Antenna Solutions

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Cannes, France, February 23, 2004: With the launch of SPINNERchip 1.1 today at the 3GSM World Congress in Cannes, Zyray Wireless is showcasing proprietary technology

that enables the worlds first commercially available dual-mode (GSM/GPRS & WCDMA) multi-antenna diversity chipset for handsets. Zyray's SPINNERchip SD, which incorporates patented smart antenna technology, is the first in a series of Space-Time Processing (STP) products for mobile handsets, which the company plans to release. The product line will evolve to include enhanced MIMO and HSDPA enabled chipsets.

Increasing demand for high performance broadband wireless communication calls for use of multiple antennas at both the base station and in the subscriber unit. SPINNERchip ‘s Single Channel (SC) MIMO implementation, which utilizes two receive antennas and, combined with Zyray’s Smart Diversity, Optimum Combining and Adaptive Interference Cancellation techniques, provides an average improvement of 3.5 - 4.0dB in Signal to Interference Noise Ratio (SINR) over single antenna solutions. Benefits to network operators and cellular users include improved network capacity, significantly improved data-rates throughout the cell, improved cell coverage area, and reduced dropped calls.

Pieter Van Rooyen, Founder and Chief Technology Officer of Zyray Wireless said: “Multiple antenna technology is the only wireless technology currently available to resolve the bottlenecks of traffic capacity in the new high-speed broadband wireless internet access networks such as GPRS/EDGE, UMTS (WCDMA) and 802.11xx. It is important to note that this technology is now available for use on mobile handset platforms.”

SPINNERchip is integrated as an add-on WCDMA baseband processor coupled with existing chipsets to provide dual-mode (GSM/GPRS & WCDMA) and multi mode (GSM/GPRS/EDGE & WCDMA) solutions.

See Zyray at Hall 2 stand F22 at the congress.

Feb 17, 2004
Zyray Wireless Puts UMTS on the Fast Track With SPINNERchip 1.1

SAN DIEGO, Feb. 17 The timeline for commercial realization of UMTS-capable wireless devices has been significantly shortened with the launch of Zyray Wireless' SPINNERchip 1.1 add-on WCDMA baseband processor.

SPINNERchip enables device manufacturers to develop single-mode WCDMA, dual-mode GSM/GPRS & WCDMA and multi-mode GSM/GPRS, EDGE & WCDMA devices in a low risk, cost effective and time efficient manner. A time line of 6 months from project start to Interoperability Testing (IOT) and less than one year to mass production is achievable.

"The speed of integration afforded by the add-on architecture is evident in the fact that the new SPINNERchip 1.1 has already been integrated into
multiple form factor size platforms a mere 7 to 8 weeks after we received it back from the fab. We will be demonstrating two of these in Cannes; a world's first high performance multimedia phone platform supporting UMTS, EDGE and GPRS and a world's first EDGE+UMTS PC card," said Werner Sievers, President and CEO of Zyray Wireless.

SPINNERchip 1.1 is housed in a compact 10x10mm BGA including integrated analog

technology and is flexible enough to mate with various RF transceivers, baseband processors and dual-mode protocol stacks. This universal flexibility has resulted in SPINNERchip being adopted by multiple Tier 1 semiconductor partners and it is already being designed into multiple end customer products. SPINNERchip can also be provided in die form to be included in customizable MCM (Multi Chip Module) solutions. Given the availability of many existing mature, high volume 2G / 2.5G solutions, SPINNERchip's ability to integrate with these maximizes the benefit from their high volume/lower cost.

SPINNERchip 1.1 is fully 3GPP Release 99 December 2003 compliant and is firmware upgradeable to support Downlink Shared Channel (DSCH) and all other 3GPP Release 4 features. A configurable hardware / flexible software design approach was chosen for SPINNERchip to ensure a robust design platform for future developments as well as to facilitate low power consumption.

SPINNERchip supports 384kb/s in both the uplink and downlink and is upgradeable to a 2Mb/s class modem. SPINNERchip includes proprietary Adaptive Interference Cancellation (AIC) and Optimum Combining algorithms and support for multiple antennas in either handset or PCMCIA platforms.

A full suite of support peripherals and services are provided with SPINNERchip. "The support provided by the Zyray engineering team is key to the short integration times we have been able to achieve. We provide a complete solution with SPINNERchip, which includes evaluation boards, software development and testing tools and excellent real-time tracing and data logging capabilities. Beyond that we work very closely with our partners to ensure a quick turnaround on customer projects, " said Michiel Lotter, VP of Engineering.

Upcoming versions of SPINNERchip will support future evolutions of 3G technology including HSDPA (high-speed downlink packet access). HSDPA, an enhancement to W-CDMA technology, provides ultra high-speed downlink capability.

SPINNERchip with its unique architecture recently received the 'Most Innovative Product' Award from UCSD Connect. Part of the University of California, San Diego, CONNECT is a globally recognized organisation supporting the growth of the most promising technology businesses.

Zyray will demonstrate SPINNERchip 1.1, Stand F22, Hall 2 at the 3GSM World Congress, Cannes, France, 23rd to 26th February 2004.

Feb 04, 2004
Zyray Wireless Appoints Semiconductor Veteran as Chief Financial Officer

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San Diego, CA February 4, 2004 - Zyray Wireless, a San Diego based company developing the SPINNER<SUPTM< sup> family of wireless semiconductor products, announced today that David Lyle, has joined the company as Chief Financial Officer. Lyle has 18 years of finance experience, which includes extensive experience in operational finance within the semiconductor industry as well as venture funding and mergers and

acquisitions.

Lyle comes to Zyray from Mobilian Corporation, a wireless data communications semiconductor company. As CFO of Mobilian, Lyle was instrumental in raising over $80 million for Mobilian as well as growing the company and leading it through acquisition by Intel Corporation in October 2003.

Prior to Mobilian, Lyle served in various roles at Intel Corporation, including an operational finance role in the microprocessor and networking groups. With Intel Capital, Lyle focused on mergers and acquisitions for the wireless communications and computing group. During his tenure at Intel, he played a key role in various acquisitions including the $1.6 billion acquisition of DSP Communications and the $450 million acquisition of Basis Communications.

Lyle spent the first half of his career in commercial banking focused on corporate lending and highly leveraged transactions. Lyle received his undergraduate degree in business from the University of Southern California and an M.B.A. from Arizona State University. In addition, Lyle holds a Master of International Management (MIM) degree from American Graduate School of International Management (Thunderbird) where he graduated with distinction.

Werner Sievers, Vice President and Chief Executive Officer of Zyray Wireless commented, "David is a dedicated and talented professional who will be a valuable asset to our management team. David’s skills and experience are a perfect fit with Zyray’s needs as we make the transition from start-up and prepare for profitable growth."

1.5. Press Releases 2003

Dec 10, 2003
Zyray Wireless wins annual UCSD Connect Most Innovative Product Award

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San Diego, CA, December 10, 2003 – Zyray Wireless, a San Diego based early stage company developing the SPINNER™ family of wireless semiconductor products, has won the Most Innovative Product (MIP) Award presented today by UCSD CONNECT. Part of the University of California, San Diego, CONNECT is a globally recognized, public benefits organisation supporting the growth of the most promising technology and life sciences businesses.

Winners were selected based on their ability to demonstrate the product innovation, technological advancement, and potential for commercial success. The judges selected Zyray's SPINNERchip as the most representative of all these in the Telecommunications category. SPINNERchip is an Add-on WCDMA Baseband Processor that enables handset manufacturers to develop single-mode WCDMA, dual-mode GSM/GPRS & WCDMA and tri-mode GSM/GPRS, EDGE & WCDMA devices in a cost effective, low risk and time efficient manner. By utilizing SPINNERchip, device manufacturers can achieve a time line of 6 months from project start to Interoperability Testing (IOT) and less than one year to mass production. In addition to considerable time and cost savings, the SPINNER solution incorporates patented Space-Time Processing (STP) technology that provides improved data-rate throughout the cellular coverage area and increased network capacity.

Since 1988, the CONNECT MIP Awards program has served as a benchmark for predicting the region's most successful emerging technologies. From early stage biotechnology companies to the first products generated by the region's telecommunications boom, the awards program has been an indicator of the industries and technologies that have fueled the San Diego economy.

The winners of the MIP Awards were selected from over 100 entrees by a distinguished panel of judges from business, law, accounting, technology, academia, finance, public relations, consulting and venture capital.

"We are pleased to receive this recognition from UCSD Connect," commented Werner Sievers, President and CEO of Zyray Wireless. "We are encouraged and highly motivated by this achievement and the enthusiasm with which our partners and customers have incorporated our innovative SPINNERchip Add-on WCDMA Baseband Processor into their mobile handset designs".

Oct 28, 2003
Zyray Wireless Extends Relationship with Infineon to Take On 3G Market.

San Diego, CA October 28, 2003 - Zyray Wireless, a San Diego based early stage company developing the SPINNER™ family of wireless semiconductor products, announced today that they have extended their relationship with Infineon Technologies, building upon their prior collaboration to provide a dual mode (GSM/EGPRS + WCDMA) handset solution. The two companies demonstrated the FP-1U dual mode handset reference

design at the 3GSM World Congress in Cannes, February 2003.

The latest agreement, which builds upon their successful development partnership, now extends to include joint sales and marketing of complete handset solutions based on FP-1U, with a view towards securing multiple customer commitments. In addition, both companies are also working closely to complete additional Interoperability Testing (IOT) that will ensure the delivery of a robust and proven WCDMA solution. As the companies prepare to unveil their combined product offering, which will be commercially available in 2004, their increased collaboration provides the foundation for a strong customer proposition.

"We welcome the enhancement of our relationship with Infineon and look forward to building upon our success at 3GSM by securing key customer commitments," said Thom Degnan, Senior VP of Sales at Zyray Wireless. Having the commitment of Infineon as one of our key partners further validates our SPINNER™ co-processor solution, which efficiently and cost effectively enables single mode WCDMA, dual mode and multi mode (GSM/GPRS/EGPRS + WCDMA) products."

"Infineon Technologies is well positioned to accelerate market adoption of 3G by offering a cost-optimized solution at the right time," said Dominik Bilo, Chief Marketing Officer of the Infineon Technologies Secure Mobile Solutions Business Group. "This solution builds upon Infineon's proven 2G and 2.5G platforms and enables OEM's and ODM's to launch UMTS products quickly as an evolution of 2G products rather than developing a UMTS product from scratch. We look forward to taking the next steps together with Zyray as we work directly with handset customers."

Oct 28, 2003
Founder and CTO of Zyray Wireless to Speak on Space-Time Processing and MIMO Systems at the 2003 Wireless Internet Conference.

San Diego, CA October 28, 2003 - Dr. Pieter van Rooyen, the Founder and CTO of Zyray Wireless, a San Diego based early stage company developing the SPINNER™ family of wireless semiconductor products, has been invited to speak at the 2003 Wireless Internet Conference taking place at the University of California, Los Angeles, on October 29-30, 2003. The event brings together leading wireless experts both from industry and academia to provide a comprehensive overview of the Wireless Internet space.

The conference focuses on convergence of wide area and local area wireless networks and covers the latest business models and technological innovations in cellular and Wi-Fi systems. Dr. van Rooyen's presentation is part of the "Software Radio, MIMO and Smart Antennas, Phased-Array Antenna, Nomadic Access and Technologies" Session taking place on October 29th, from 1:45 PM to 3:15 PM. Dr. van Rooyen will speak on the use of Space-Time Processing (STP) and Multiple-Input Multiple-Output (MIMO) Systems in next generation mobile devices. "As Wireless Internet users continue to grow, network operators will face new challenges in addressing the broadband needs of their subscribers within the constraints of allocated spectrum capacity," says Dr. van Rooyen. "STP and MIMO techniques are capable of resolving the bottlenecks of traffic capacity while improving overall system performance in wireless systems."

Commercial realization of STP does, however, present a number of challenges, especially for mobile devices. STP algorithms are computationally intensive while current devices have limited battery and processing capabilities. Zyray Wireless is addressing this challenge by developing a STP and Multiple Antenna solution for mobile devices that is cost effective, power efficient and physically compact.

To learn more about Zyray Wireless please visit www.zyraywireless.com. To schedule a meeting with Dr. van Rooyen during the conference please email Larissa Kogan at lkogan@zyraywireless.com. For more information on the 2003 Wireless Internet Conference, please visit http://wireless.ucla.edu/2003w/index.asp.

Oct 09, 2003
Zyray Wireless, a leader in WCDMA and Space-Time Processing wireless technologies, invited to speak at ETRE 2003 Conference.

San Diego, CA October 9, 2003 - Werner Sievers, President and CEO of Zyray Wireless, a San Diego based early stage company developing the SPINNER^{TM} family of wireless semiconductor products, has been invited to speak at the European Technology Roundtable Exhibition (ETRE). ETRE will be held in Berlin, Germany, on October 15-18th, 2003 and brings together companies from 30 nations to discuss current technological trends and the growth of the IT and Telecommunications Industry. Mr. Sievers, who joins the CEOs of over 500 of the world's leading technology companies, will speak at 1:35 PM on October 16th.

ETRE features three days of intensive content, networking and exchange with the most comprehensive group of speakers, financiers and entrepreneurs from all over the world. It is a forum for companies ranging from existing technology leaders in hardware and software to future success stories in wireless, Internet and semiconductors. Now in its 14th year, the event is attended by the world's leading players such as Microsoft, IBM, Intel, British Telecom, Orange, SK Telecom, T-Mobile and others while also providing a platform for presentations on cutting-edge technologies by the firms that will make tomorrow's headlines.

"We are pleased to share our outlook for the future of Wireless Communications with ETRE's distinguished audience," says Werner Sievers. "With 3G technology poised to take off, the Wireless Industry is entering an explosive phase for companies like ourselves delivering the technology that will facilitate the combining of high-speed mobile access with Web-based services. To play a key part in bringing to market innovative products that allow people to communicate, access information, do business, and be entertained everywhere, is very exciting."

Zyray Wireless is enabling the rapid deployment of 3G technology by providing a low cost and low risk upgrade path for existing GSM/GPRS mobile devices to dual-mode GSM/GPRS & WCDMA terminals. Using SPINNERchip, an innovative add-on WCDMA baseband processor designed to interface with existing GSM/GPRS designs, handset manufacturers can, in a very short time frame, deliver dual-mode (GSM/GPRS & WCDMA) handsets in a low risk and cost effective manner.

Sep 17, 2003
Zyray Wireless, a leader in WCDMA and Space-Time Processing wireless technologies, invited to speak on the Hot Startups Panel at the 2003 International Wireless Symposium.

San Diego, CA September 17, 2003 - Zyray Wireless, a San Diego based early stage company developing the SPINNER™ family of wireless semiconductor products, has been invited to speak on the "Hot Startups" executive roundtable panel at the 2003 International Wireless Symposium being held at the San Diego Convention Center on September 22-23, 2003. The International Wireless Symposium focuses on existing and emerging wireless communications and networking technologies delivering mobile access to the Internet and seeks to feature the companies leveraging the individual strengths of the various technologies to create better products and services.

Dr. Pieter van Rooyen, Founder and CTO of Zyray Wireless, will share his perspective on the key challenges facing the wireless marketplace today and Zyray's unique approach to solving them. "Deployment of next generation WCDMA systems has presented the wireless industry with a set of technical hurdles. Among the key issues are the high cost of next generation handsets coupled with their general lack of availability," says Dr. Pieter van Rooyen. "At Zyray Wireless we have designed a WCDMA add-on baseband processor that enables a low cost and quick-to-market delivery of backward compatible 3G mobile devices."

SPINNERchip is a WCDMA baseband add-on chip that interfaces with existing GSM/GPRS solutions to enable low-risk, low-cost evolution of existing GSM/GPRS products to dual-mode WCDMA & GSM/GPRS solutions. The solution uses a standard memory interface to connect to the existing GSM/GPRS baseband chips, requiring minimal re-design to add WCDMA capability. Utilizing SPINNERchip enables handset manufacturers to reduce development cycle time, maximize hardware and software reuse, and minimize dual-mode GSM/GPRS & WCDMA development costs. The solution incorporates many patented technologies such as Adaptive Interference Cancellation and Optimum Combining that provide enhanced performance and enable smaller size, lower cost and shorter integration time. Advanced SPINNER products incorporate a patented implementation of Space-Time Processing Technology enabling significant improvements in maximum data rates, cell coverage and overall network capacity.

The "Hot Startups" Executive Roundtable Panel will take place on September 22nd, 1:10pm - 2:25pm. The panel will feature Zyray Wireless and five other wireless startups and will be moderated by Leo Spiegel, a General Partner at Mission Ventures. For more information on the conference, please visit www.iws2003.com.

Sep 15, 2003
Zyray Wireless, a leader in WCDMA and Space-Time Processing wireless technologies, invited to speak at Enterprise China 2003 Conference.

San Diego, CA September 15, 2003 - Zyray Wireless, a San Diego based early stage company developing the SPINNER™ family of wireless semiconductor products, has been invited to present at the Enterprise China 2003 Conference in Beijing, China, on

September 24-25th, 2003. Werner Sievers, President and CEO of Zyray Wireless, will present on "Enabling Low Cost Dual-Mode and Single-Mode WCDMA Handsets". The presentation is part of the Smart Devices Track and will commence at 10:30 AM on September 25th.

The Enterprise China conference attempts to showcase technology applications with a focus on issues of value coming first and a clear communication of the justifications within each technology concept. Zyray Wireless' SPINNERchip solution provides significant cost savings by taking maximum advantage of the rapidly declining cost of high volume GSM/GPRS chipsets. "The rollout of WCDMA networks has suffered from a lack of low cost, backward compatible, dual-mode handsets", says Werner Sievers. "Handset makers are looking for WCDMA solutions that are easily integrated with existing designs to help them achieve time and cost savings. Our solution integrates with existing 2G/2.5G technologies, such as GSM/GPRS, PHS, PDC or cdma2000 solutions to provide a low-cost and low-risk evolution of existing single mode wireless devices, to multi-mode WCDMA-enabled solutions."

Panel discussions at Enterprise China 2003 will cover a wide variety of topics, such as the deployment of next generation mobile devices and service applications. The conference is attended by top management of carriers, device makers, application developers, third party service and content providers, key enterprise customers, system integrators and regulators. Enterprise China brings together executives from China Mobile, China Telecom, Kejian Corporation, China Putian Corporation, Eastern Communications Group and other prominent government and industry organisations. For more information on the event, please visit www.enterprisechina.com.

Aug 25, 2003
Former Qualcomm Executive joins Zyray Wireless as Senior Vice President of Sales.

San Diego, CA August 25, 2003 Zyray Wireless, a San Diego based early stage company developing the SPINNER^{TM} family of wireless semiconductor products, announced today that former Qualcomm Executive, Thom F. Degnan has joined the company as Senior Vice President of Sales. He is an experienced international communications executive who has spent a significant part of his business career in Europe, Asia and Latin America. Degnan has been involved in global sales management, contract negotiation, business development, joint venture development and equity fund raising for over twenty years and has developed over $1B in revenue streams for communications companies worldwide.

Prior to this appointment, Degnan held a number of executive management positions in Sales, Marketing, and Business Development at Qualcomm. As Corporate Vice President of Business Development, he was responsible for the strategy and implementation of new wireless ventures in the international marketplace and also led the development of business relationships with key international carriers and equity funding organisations. Working with Pegaso PCS in Mexico, Degnan negotiated and closed a strategic infrastructure equipment and handset contract order that was the largest in company history. As Vice President of International Sales at Qualcomm, Degnan closed numerous contracts, led the marketing and sales effort to PCS and WLL carriers worldwide, and spearheaded the global sales and marketing effort for the advanced QuSAT wireless communications system in six target markets, including United States, South America, Europe, Southeast

Asia, China, and India.

After leaving Qualcomm, Degnan was President and COO of Verticalband Ltd., a UK and San Diego based developer of Intellectual Property for wireless communications, digital television, and WAN infrastructure markets, where he directed the early stage activities of the company, developing its global strategy and operations as well as spearheading the Series-B fund raising effort.

Degnan's extensive management experience includes executive positions at Scientific-Atlanta and Cidera. While with Scientific-Atlanta and based in Paris, he led the restructuring of the European operations at Scientific-Atlanta, organized and closed a strategic sales and distribution agreement with British Telecom, increasing the annual sales for the business unit over 300%. As a Senior Vice President of Business Development for Cidera, a global broadband service provider for streaming media for the Internet, he negotiated and closed multi-million dollar global streaming deals with Real Networks, Microsoft and Apple, and closed contract distribution contracts with Akamai, Digital Island, Intel Media Services and other service providers.

Mr. Degnan received a B.S. in Marketing from Connecticut State University and holds an MBA in International Business, and Finance from the University of New Haven, in Connecticut. He served as a member of the San Diego Host Committee for Super Bowl XXXVII, and is a regular speaker at telecommunications trade shows and industry symposiums.

"Thom will be a valuable addition to the Zyray team. His extensive international sales and business development experience will empower us to aggressively pursue new design wins in multiple markets all over the world", said Werner Sievers, CEO of Zyray Wireless. "He will play an instrumental role in leading Zyray to secure key strategic agreements with handset and semiconductor manufacturers worldwide."

Jul 14, 2003
Zyray Wireless Announces Successful Interoperability Testing of its WCDMA Baseband Processor.

San Diego, CA July 14, 2003 Zyray Wireless, a San Diego based start-up company developing the SPINNER^{TM} family of wireless semiconductor products, announced today a successful completion of interoperability tests with a major European UMTS infrastructure equipment provider.

The interoperability tests were performed using a form factor handset reference design, powered by SPINNERchip 1.0, Zyray's WCDMA baseband processor. Also part of the reference design was Infineon Technologies' S-GOLD EGPRS baseband processor and WCDMA/EGPRS RF transceiver solution including SMARTi-U and SMARTi-DC+. Comneon, a wholly owned subsidiary of Infineon, provided the multi mode protocol stack software.

The SPINNERchip test results assure that Zyray Wireless' WCDMA solution is operational on commercial UMTS infrastructure equipment. Numerous features of the combined SPINNERchip and protocol stack solution were verified, including proprietary modem

algorithms within the packet data services environment.

"We are working closely with key industry players to ensure interoperability," said Erik Jakobsen, Director 3G Software at Comneon. "Our WCDMA multimode software is a key element in the 3G mobile solutions of our customers, and we are pleased to work with Zyray Wireless to ensure a robust system when operating in a multi-vendor network environment. This will prove most important in enabling our customers to smoothly ramp up their 3G products in 2004."

"The successful completion of interoperability testing with a major infrastructure vendor is another key step in delivering our WCDMA SPINNERchip solution to the market", said Michiel Lotter, Vice President of Engineering at Zyray Wireless. "Through continued testing with the major UMTS infrastructure providers, Zyray Wireless looks forward to providing a robust and proven WCDMA solution to its handset and data card customers."

Jun 16, 2003
Wireless Technology Leader Dr. Mark Kent Joins Zyray Wireless as Director of Systems Engineering.

San Diego, CA June 16, 2003 Zyray Wireless, a San Diego based start-up company developing the SPINNER^{TM} family of wireless semiconductor products, announced today that Dr. Mark Kent has joined Zyray Wireless as Director of Systems Engineering. Dr. Kent is an established technical leader who has successfully completed multiple ASIC designs for IS-95, CDMA2000, WCDMA, AMPS, TDMA and CDPD wireless communication standards.

Prior to joining Zyray, Mark was the WCDMA baseband ASIC System Architect at Skyworks, formerly Conexant. As Systems Engineering Manager, Mark defined the complete modem architecture and implemented a revolutionary systems design methodology that significantly reduced time-to-market and improved reliability and verification.

Before Skyworks, Mark was Engineering Manager at LG Electronics, responsible for their IS-95A/AMPS chipset development. In addition, Dr. Kent actively participated and represented LG Electronics in the CDMA2000 standards development group. Mark has also held various positions at PCSI, including leading the design of a multi-mode AMPS, TDMA & CDPD chipset.

Dr. Kent received a bachelor's degree in Electrical Engineering from the University of California, San Diego (UCSD). He also holds a master’s degree and Ph.D. in Electrical Engineering from UCSD. Dr. Kent is the author of numerous patents in the area of Digital Communications Systems.

"Mark’s broad expertise in wireless technology is a valuable addition to Zyray’s development team," said Michiel Lotter, Vice President of Engineering at Zyray Wireless. "He will play a key role in our engineering organisation as Zyray continues to deliver against an aggressive product roadmap.”

May 27, 2003
Wireless Industry Executive John Major Joins The Board of Zyray Wireless.

San Diego, CA May 27, 2003 - Zyray Wireless, a San Diego based start-up company developing the SPINNER™ family of wireless semiconductor products, has announced today that John Major has joined Zyray Wireless' Board of Directors. Mr. Major is the Founder and President of MTSG, an investment and strategic consulting partnership.

Formerly, he served as Chairman and CEO of Novatel Wireless, which provides wireless data access solutions for PDAs and laptops. Mr. Major joined Novatel Wireless in August 2000 and led the company's successful IPO in the fall of that year.

Before Novatel Wireless, Mr. Major was Chairman and CEO of Wireless Knowledge, a San Diego-based joint venture between Microsoft, Inc. and QUALCOMM, Inc. Prior to joining Wireless Knowledge, Mr. Major served as corporate executive vice president of QUALCOMM, Inc. and president of its Wireless Infrastructure Division. Mr. Major also held several executive leadership positions at Motorola, Inc. As a senior vice president and CTO, he directed a broad range of research initiatives and led Motorola's efforts to develop world-class excellence in software.

Mr. Major participates in several industry, research and educational organisations, currently serving on the Board of Governors' Executive Committees of the Telecommunications Industry Association (TIA) and the Electronic Industries Association (EIA). He is also an advisor to Wireless Facilities Inc. and a past advisor to Loral Space Systems. He is on the President's Board on Science and Innovation for the University of California and a past member of Visitor's Board of the Software Engineering Institute of Carnegie Mellon University, the Computer Science and Telecommunications Board of the National Academy of Science, and the Trustee's Council of the University of Rochester.

Mr. Major received a bachelor's degree in Mechanical and Aerospace Engineering from the University of Rochester and a master's degree in Mechanical Engineering from the University of Illinois. He also holds an M.B.A. from Northwestern University and a J.D. from Loyola University. Major received an honorary doctorate from Westminster College in 1995. He has 9 US Patents.

"John's strong background in wireless technology, including his senior management leadership at leading wireless technology companies, will be a valuable asset to Zyray Wireless," said Werner Sievers, President and CEO of Zyray Wireless. "We look forward to his active involvement and contributions to Zyray's future growth."

Mar 12, 2003
Zyray Wireless Co-Founder to speak at the IEEE Wireless Communications and Networking Conference 2003.

San Diego, CA March 12, 2003 - Dr. Michiel Lotter, Co-Founder and Vice President of Engineering at Zyray Wireless, a San Diego based start-up developing the SPINNER™

family of WCDMA and Space-Time Processing IP and semiconductor products for next generation mobile devices, will speak on Optimum Combining for WCDMA devices at the upcoming WCNC 2003 Conference. The event is co-located with CTIA Wireless 2003 and is being held at the Ernest N. Morial Convention Center in New Orleans, Louisiana on March 16-21, 2003.

Dr. Lotter will speak on a new Optimum Combining Method designed to combat multi-path fading and mitigate interference in WCDMA mobile devices. "The next generation of handsets presents a design challenge to deliver optimum signal quality within the constraints of limited power consumption. Optimum Combining addresses this challenge", says Michiel Lotter.

SPINNERchip 1.0, Zyray's WCDMA add-on baseband processor, incorporates a combination of Adaptive Interference Cancellation and Optimum Combining to achieve a 1-3dB gain in SINR (Signal to Interference & Noise Ratio). These features can also be software configured to conserve power depending on the environmental conditions.

Dr. Lotter's presentation is part of the 3G CDMA Technology Session, taking place on Wednesday March 19, from 9:30AM to 12:30PM in Room 205.

Feb 13, 2003
ZYRAY WIRELESS PUTS A NEW SPIN ON DUAL MODE 3G HANDSETS.

San Diego, CA February 13, 2003: The rapid development of dual mode GSM/GPRS and WCDMA handsets is a significant step closer following the introduction of Zyray Wireless' SPINNERchip 1.0 WCDMA baseband processor solution. Sampling began ahead of schedule and a complete dual mode WCDMA & GSM/GPRS solution will be demonstrated at the 3GSM World Congress in Cannes.

Proven to connect to a majority of market-leading GSM/GPRS baseband solutions, Zyray's SPINNERchip 1.0 single chip WCDMA FDD baseband processor began sampling last month. The solution uses a standard memory interface to connect to existing GSM/GPRS baseband processors.

"As an add-on to an existing GSM/GPRS terminal design, SPINNERchip 1.0 provides handset manufacturers with the lowest-risk, lowest-cost path to dual-mode GSM/GPRS and WCDMA handsets," said Werner Sievers, President and CEO of Zyray Wireless. "This solution is key to reducing a customer's development cycle time, maximizing hardware and software reuse and reducing development costs. Significant BOM (Bill of Materials) savings can also be achieved."

SPINNERchip 1.0 can provide handset manufacturers with a time advantage of up to 12 months and can reduce the cost of a handset development project by as much as $3 million. By utilizing this dual chip strategy, per handset savings are estimated at between $10 - $20.

SPINNERchip 1.0 is a 3GPP Release 99 March 2002 compliant FDD baseband processor, supporting 384kbps operation in uplink and downlink and integrating all functionality required for WCDMA operation into a single chip. The chip includes support for WCDMA ciphering, a programmable analog I/Q RF interface, and an optional USIM interface.

SPINNERchip 1.0 includes on-chip programmable power management and proprietary interference cancellation algorithms that provide enhanced Bit Error Rate performance at minimum power consumption. Currently available in a 16x16mm 280-pin LFBGA test package, the chip will be supplied in a 180-pin, 10x10mm LFBGA production package. SPINNERchip 1.0 is supplied with a comprehensive customer development package that includes the SPINNER evaluation board.

Zyray will demonstrate SPINNERchip 1.0, Stand F33, Hall 2 at the 3GSM World Congress

Jan 27, 2003
Zyray Wireless, a leader in WCDMA and Space-Time Processing wireless technologies, announces worldwide distribution agreements with Firefly Technology, MITS Corporation and Uniquest Corporation.

San Diego, CA January 27, 2003 - Zyray Wireless, a leader in WCDMA and Space-Time Processing wireless technologies, today announced it has signed distribution agreements with three of the leading semiconductor distributors in Europe and Asia - Firefly Technology of UK, MITS Corporation of Taiwan and Uniquest Corporation of Korea.

Under the terms of the agreements Firefly, MITS and Uniquest will work closely with Zyray Wireless to introduce and distribute Zyray's SPINNER family of WCDMA and Space-Time Processing IP and semiconductors. SPINNERchip is a WCDMA chip designed to add-on to existing GSM/GPRS solutions to enable a low-cost, low-risk dual-mode solution.

"We are excited to work with such top performing and experienced distributors", stated Werner Sievers, President and CEO of Zyray Wireless. "Our distributor network is a vital component of our strategy, designed to ensure that Zyray Wireless is well positioned to take advantage of opportunities around the world as they arise."

Firefly Technology is a UK-based technical sales and marketing representative for leading-edge semiconductor, system-on-chip, software and intellectual property suppliers. Tony James, Managing Director of Firefly Technology commented, "Zyray Wireless offers us a golden opportunity to complement and expand our existing business within the European market place. Judging by the response so far, SPINNER is certainly grabbing the attention of many of our customers. Feedback suggests it is the most cost-effective and easy-to-integrate solution for wideband CDMA on the market. Thus, coupling our experience in the semiconductor industry, with Zyray's compelling product line, I certainly feel that when 3G hits the stores, Zyray Wireless will have had a pivotal role in making the 3G concept a reality." Firefly Technology focuses on high technology product areas such as Wireless Communications, Consumer Multimedia, and Military & Aerospace. Their line card includes Analog Devices, International Rectifier, NanoAmp Solutions, SpaceBridge Semiconductor and Pixelworks. To learn more about Firefly Technology, please visit the company website at www.fireflytech.com.

MITS Component & System Corp. is a top distributor in Taiwan focused on Wireless Communications, Telecom and Optical components. "Zyray Wireless is offering our

market exactly what it is looking for-- low-cost and low-risk semiconductor technology for wireless manufacturers that will enable the rapid rate of adoption of WCDMA", said Allan Lee, a Marketing Manager at MITS Component & System Corp. "The combination of Zyray's state-of-the-art technology with MITS' experienced sales team will address the fast growing demands for the development of wireless products in Taiwan." Their products include wireless multimedia, RF and baseband semiconductors. MITS Corporation line card includes Emblaze Semiconductor, Brightcom, Finisar, Micronetics Wireless, Silver Telecom and PowerCube. For more information about MITS Corporation, please visit the company website at www.mitscomponent.com.

Established in 1993, Uniquest Corporation is a leading distributor and sales representative in Korea for semiconductors and electronics components. "Zyray's SPINNER family of WCDMA will provide our customers with tools and expertise they need to develop 3G cellular devices", said Charles Lim, CEO of Uniquest. "Uniquest will continue to work closely with Zyray Wireless who has created a compelling ASIC solution enabling our customers to quickly bring new wireless devices to market." Uniquest's technology areas include Wireless Communications, Access Networking, Telecom, Computers and Internet Appliances. Their current line card includes IDT, Atmel, Intel, Silicon Labs and Altera. For more information about Uniquest Corporation, please visit the company website at www.uniquest.co.kr

1.6. Press Releases 2002

Dec 02, 2002
Dr. Pieter van Rooyen, Founder and CTO of Zyray Wireless, to speak on MIMO systems, Smart Antenna and Space-Time Processing technologies at the 802.11 Planet Fall Conference and Expo.

San Diego, CA December 2, 2002 - Dr. Pieter van Rooyen, Founder and Chief Technology Officer of Zyray Wireless, a San Diego based start-up developing the SPINNERTM family of WCDMA and Space-Time Processing IP and semiconductor products for next generation mobile devices, will speak on Multiple-Input Multiple-Output antenna systems (MIMO) and Space-Time Processing (STP) technologies at the upcoming 802.11 Planet Fall Conference and Expo. The event is being held at the Westin Hotel in Santa Clara, CA on December 3-5, 2002.

Dr. van Rooyen will be a featured speaker on two panel discussions. The first panel, "Optimizing WLAN Coverage with High-Performance Antennas", which explores advanced antenna solutions for WLAN networks, will take place at 1:30pm on December 5th. The second panel, "Beyond the Laptop", focusing on the challenges associated with incorporating WLAN technology into handheld devices, will take place at 4pm on December 5th.

"Currently the power budget for single-mode 802.11 implementations is more than double that which handheld mobile devices can handle and still maintain a satisfactory battery life and adequate communication range," says Dr. Pieter van Rooyen. Navin Sabharwal, Director of Residential & Networking Technologies at Allied Business Intelligence, agrees, "Only by dramatically lowering the power consumption of 802.11 solutions will it become feasible to add WLAN functionality to mobile devices such as PDAs and cell phones."

"Space-Time Processing utilizes multiple antennas and advanced signal processing to cancel interference, extend range and reduce the required transmission power of a WLAN device," says Dr. Pieter van Rooyen. Zyray Wireless is designing a cost-effective and power efficient Space-Time Processing solution that will enable WLAN devices to have greater range and reduced power consumption.

Nov 11, 2002
Zyray Wireless, a leader in WCDMA and Space-Time Processing wireless technologies, speaks at the Red Herring Magazine Personal Technology Panel event.

San Diego, CA November 11, 2002 - Werner Sievers, President and CEO of Zyray Wireless, a San Diego based start-up developing the SPINNER family of WCDMA and Space-Time Processing IP and semiconductor products for next generation mobile devices, was recently featured as a panelist at a recent Red Herring Briefing Event on Personal Technology. The event took place on October 23 at the Hotel Monaco, San Francisco, CA. A video stream of the panel discussion is available on Red Herring's website at http://www.redherring.com/conferences/index.htm

Panelists included Werner Sievers, CEO of Zyray Wireless, Stewart Alsop, General Partner at New Enterprise Associates, Michael Mace, Chief Competitive Officer at PalmSource, and Larry Marcus, General Partner at WaldenVC. The panel discussion focused on the issues that will drive the design of the next generation personal technology devices. The panel took an in-depth look at the so-called "converged devices" that incorporate multiple functions, like communications, video, personal information management and entertainment.

"I think we all agreed that several key issues have to be addressed before such devices can gain widespread acceptance in the consumer market," commented Jason Pontin, editor-at-large of Red Herring Magazine and moderator of the panel. "Amongst the issues are cost, battery life, display quality, and overall processor performance."

Zyray Wireless is also featured in the Briefing on Personal Technology in the upcoming November issue of Red Herring magazine. The feature analyzes the current and future trends in personal communication devices, focusing on the convergence of multiple single function devices into one combination device. "Such a device will support multiple methods of wireless connectivity - both Cellular and WLAN, " says Mr. Sievers. "Zyray Wireless is developing products to enable this integration. Our SPINNER family of products enables a low-cost and low-power implementation of multiple Cellular and WLAN standards onto a single device."

SPINNERchip is a WCDMA chip designed to add-on to existing GSM/GPRS solutions to enable a low-cost, low-risk dual-mode solution. SPINNERstp is a Space-Time Processing solution designed to cancel interference, reduce power consumption and increase cell range of WLAN and cellular devices. To learn more about Zyray Wireless please visit www.zyraywireless.com.

Nov 04, 2002
Dr. Pieter van Rooyen, the Founder and CTO of Zyray Wireless, to speak on MIMO systems, Smart Antenna and Space-Time Processing technologies.

San Diego, CA November 4, 2002 - Dr. Pieter van Rooyen, the Founder and Chief Technology Officer of Zyray Wireless, a San Diego based start-up developing the SPINNER family of WCDMA and Space-Time Processing IP and semiconductor products for next generation mobile devices, will speak on Multiple-Input Multiple-Output antenna systems (MIMO) and Space-Time Processing (STP) technologies at two upcoming conferences. Dr. van Rooyen will be a featured speaker at the National Wireless Engineering Conference, November 6th, 2002 in San Diego, CA and the Wireless Internet Conference, November 7th, 2002 on the UCLA campus, Los Angeles, CA.

Dr. van Rooyen is the Founder and Chief Technology Officer of Zyray Wireless. Pieter leads Zyray's new technology development in the areas of MIMO systems, Smart Antenna and Space-Time Processing. Pieter has published over 60 technical papers, holds 19 technical patents in the area of digital communications and is co-author of two books related to WCDMA and MIMO mobile systems.

"MIMO and Space-Time Processing have emerged as the most promising research and development area in wireless communications, capable of resolving the bottlenecks of traffic capacity in future high-speed broadband wireless access networks," says Pieter van Rooyen. "The technology has the ability to turn multi-path propagation, usually a pitfall of wireless transmission, into an advantage for increasing the user's data rate, network capacity and cell range."

Until recently, almost all STP technology development has been related to base stations and fixed wireless terminals and not to mobile handheld devices. This has been due to the computationally intensive STP algorithms and the limited battery and processing capabilities of handheld mobile devices. "The most significant challenge in adopting MIMO and STP for mobile handheld devices is developing a low power, low cost solution. At Zyray, we are taking an innovative approach to implementing this technology in a power efficient and cost effective manner," says Dr. Pieter van Rooyen.

For more information on Dr. van Rooyen's speaking engagements please visit the following websites:

National Wireless Engineering Conference Nov 6, 2002
www.iec.org/events/2002/natlwireless_nov/
Wireless Internet Conference Nov 7, 2002 www.wireless.ucla.edu

To schedule a meeting with Dr. van Rooyen during one of the conferences please email Larissa Kogan at lkogan@zyraywireless.com. To learn more about Zyray Wireless please visit www.zyraywireless.com.

Sep 30, 2002
Zyray Wireless, a leader in WCDMA and Space-Time Processing wireless technologies, to speak at the 2002 International Wireless Symposium.

San Diego, CA September 30, 2002 - Zyray Wireless, a San Diego based start-up developing the SPINNER family of WCDMA and Space-Time Processing IP and semiconductor products for next generation mobile devices, will present on the convergence of multiple Cellular and WLAN standards onto a single mobile device at the 2002 International Wireless Symposium. The International Wireless Symposium is being held at Paradise Point Resort, San Diego, CA on October 2-4, 2002.

Werner Sievers, President and CEO of Zyray Wireless will speak on the challenges posed by the integration of multiple Cellular and WLAN standards onto a single device and Zyray's solutions to address those challenges. "The next generation wireless devices represent the emergence of a new paradigm in wireless communications, converging consumer electronics, computing, and communications onto a single mobile consumer device", says Werner Sievers. "The device has to be able to connect to multiple wireless access networks, Cellular and WLAN, posing a design challenge - How do you bring multiple wireless standards (GSM/GPRS, WCDMA, and 802.11) onto a single platform under the constraints of cost, power consumption, risk and time-to-market?"

The SPINNER family of IP and semiconductor products is designed to enable the convergence of multiple wireless standards onto a single mobile device. SPINNERchip is a

WCDMA baseband add-on chip that interfaces with existing GSM/GPRS solutions. SPINNERchip enables low-risk, low-cost evolution of existing GSM/GPRS products to dual-mode WCDMA & GSM/GPRS solutions. SPINNERstp is a Space-Time Processing solution designed to cancel interference, reduce power consumption and increase cell range of WLAN and cellular devices.

Zyray Wireless' presentation is part of the Wireless Semiconductor Convergence Panel, taking place on October 3, 10am - 11:30am. The panel will focus on semiconductor solutions enabling the integration of personal, local and wide area wireless networks. For more information on the conference, please visit www.iws2002.com.

To learn more about Zyray Wireless please visit www.zyraywireless.com. To schedule a meeting with Zyray's team during the conference please email Larissa Kogan at lkogan@zyraywireless.com.

About Zyray Wireless
Zyray Wireless is developing the SPINNER family of WCDMA and Space-Time Processing IP and semiconductor products. SPINNERchip enables low-risk, low-cost evolution of existing GSM/GPRS products to dual-mode WCDMA & GSM/GPRS solutions. SPINNERstp utilizes Space-Time Processing technology to reduce power consumption and improve performance of WLAN and cellular devices.

Zyray Wireless has been ranked tenth on the list of "Top 50 Companies to Watch in 2002" in the July issue of "Electronics Industry's Movers and Shakers of 2002" published by Reed Business Information.

Sep 23, 2002
Zyray Wireless, a leader in WCDMA and Space-Time Processing wireless technologies, to showcase its SPINNERchip 1.0 WCDMA baseband development platform at the 2002 Communication Design Conference.

San Diego, CA September 23, 2002 - Zyray Wireless, a San Diego based start-up developing the SPINNER family of WCDMA and Space-Time Processing IP and semiconductor products for next generation mobile devices, will display its SPINNERchip 1.0 WCDMA baseband development platform in the Xilinx booth, #818, at the 2002 Communication Design Conference. Xilinx is the worldwide leader in programmable logic solutions. The Communication Design Conference is being held at San Jose Convention Center, San Jose, CA on September 24-26, 2002.

The SPINNERchip 1.0 WCDMA development platform provides complete WCDMA modem functionality, including patented Adaptive Interference Cancellation (AIC), packet switched data, and dual mode GSM/GPRS & WCDMA operation. The platform includes Xilinx® Virtex-II field programmable gate arrays (FPGAs). "We are very pleased to have Zyray Wireless utilize our cutting edge Virtex-II solution in the development of their SPINNERchip 1.0 WCDMA baseband ASIC", said Erich Goetting, Vice President of the Advanced Product Division at Xilinx.

SPINNERchip 1.0 is a WCDMA baseband add-on chip, designed to interface with existing

GSM/GPRS solutions. "The design of SPINNERchip enables a flexible and cost-effective method of integrating multiple wireless standards onto a single platform", said Michiel Lotter, Vice President of Engineering at Zyray.

Zyray Wireless' SPINNERchip 1.0 WCDMA development platform can be viewed in the Xilinx booth, #818 at the 2002 Communication Design Conference, on September 24-26, 2002. Please contact a Xilinx representative at the booth registration counter to obtain product sheets of SPINNERchip 1.0. For more information on Xilinx visit www.xilinx.com.

Sep 16, 2002
Zyray Wireless, a leader in WCDMA and Space-Time Processing wireless technologies, to speak at the 2002 Communication Design Conference.

San Diego, CA September 16, 2002 - Zyray Wireless, a San Diego based start-up developing the SPINNER family of WCDMA and Space-Time Processing IP and semiconductor products for next generation mobile devices, will present on its Space-Time Processing technology at the 2002 Communication Design Conference. The Communication Design Conference is being held at San Jose Convention Center, San Jose, CA on September 23-26, 2002.

Gavin Stone, Business Development Manager at Zyray Wireless will overview a Multiple Antenna and Space-Time Processing approach that combats the major pain points faced by both Cellular and WLAN communications today - high power consumption, limited cell range, and signal interference. Zyray's Space-Time Processing technology provides dramatic improvements in the quality of wireless transmission (up to 10dB improvement in signal-to-noise ratio). These gains are translated directly into power savings, range extension and interference cancellation.

“Our Space-Time Processing platform is the natural extension of the SPINNER product family”, says Gavin Stone. “SPINNER products are designed to enable the convergence of multiple wireless standards, such as GSM/GPRS, WCDMA and 802.11, onto a single mobile device. Using the SPINNER solutions, handset and PDA makers can design high performance and low power multi-mode devices at a low cost of development”.

Zyray Wireless’ presentation is part of the PAN/WAN/LAN Integration Track, taking place on September 24, 1pm - 2:30pm. The Seminar will focus on the integration of cellular, WLAN and Bluetooth technologies onto a single device and will examine the challenges associated with multiple standard integration.

Aug 12, 2002
Zyray Wireless, a leader in Space-Time Processing and WCDMA wireless technologies, named one of the

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San Diego, CA August 12, 2002 Zyray Wireless, a San Diego based start-up company developing the SPINNER family of wireless semiconductor products based on Space-Time

Processing technology, has been ranked tenth on the list of "Top 50 Companies to Watch in 2002", compiled by writers and researchers from Reed Business Information (formerly Cahners Business Information).

The publication, which evaluated a broad range of companies in the electronics industry, has chosen the top fifty companies that are developing innovative and vital technologies and products. "These companies are pushing harder than ever so they will be well poised for 2003, a year projected to show 20 to 26 percent growth for the semiconductor industry", says Susan Mulcahy, VP Research and Special Editions at Reed Electronics Group.

"We are pleased to be named by Reed Business Information as one of the 'Top 50 Companies to Watch' in the electronics industry", commented Werner Sievers, CEO of Zyray Wireless. "We attribute this recognition to the innovative products and technologies that we are bringing to the wireless marketplace". Zyray Wireless is developing Space-Time Processing and WCDMA IP and semiconductor solutions to enable low power, low cost and high performance implementations of wireless standards such as WCDMA, 802.11 and GSM/GPRS.

The list, which includes such recognized industry names as Advanced Micro Devices, Intersil, Microsoft, and IBM, was published in the July issue of "Electronics Industry's Movers and Shakers of 2002", a special magazine supplement produced annually by Reed Business Information.

Jul 17, 2002
Zyray Wireless, a leader in Space-Time Processing and WCDMA wireless technologies, announces the formation of its Scientific Advisory Board.

San Diego, CA July 17, 2002 Zyray Wireless, a San Diego based start-up company developing the SPINNER family of wireless semiconductor products based on Space-Time Processing technology, has announced the establishment of its Scientific Advisory Board (SAB). The board consists of recognized university and industry experts who bring extensive wireless communications experience to Zyray Wireless. The initial members of the Advisory Board include Dr. Sujit Dey (Chair), Professor in the Electrical and Computer Engineering Department at the University of California, San Diego; Mr. Richard Kerr, former Vice President of ASIC Engineering and Business Development at Qualcomm; Dr. Slim Souissi, Vice President of Emerging Technologies at Novatel Wireless; and Dr. Jack Winters, former Division Manager, Wireless Systems Research at AT&T Labs-Research. Zyray's Chief Technical Officer, Dr. Pieter van Rooyen and Vice President of Engineering, Dr. Michiel Lotter, also join the board.

Welcoming the formation of the SAB, Zyray Wireless President and CEO, Werner Sievers stated, "We are delighted to partner with such a renowned group of individuals. Their contribution to help guide the company in its development of unique, next generation wireless communications technologies, will be instrumental to Zyray's success."

Sujit Dey is a Professor at UCSD, leading research efforts at the UCSD Center for Wireless Communications and the California Institute of Telecommunications and

Information Technology (Cal-(IT)2) in developing adaptive protocols, algorithms, and platform architectures for next generation wireless devices and data services. He has been a technical consultant to ST Microelectronics and NEC USA on networking and wireless systems designs. Prior to joining UCSD, Dr. Dey was a Senior Researcher at NEC, where he led research projects in system-on-chip design and test. Dr. Dey has co-authored more than 100 publications and holds 9 patents.

Richard Kerr is a former Vice President of Business Development at Qualcomm, where he led international business development in the OEM and Embedded Wireless Data Modules market. Prior to that, Mr. Kerr served as a Vice President of Strategic Technology at Qualcomm assisting with the rollout of CDMA in Japan, and most importantly led Qualcomm's ASIC development effort as the Vice President of Engineering and General Manager of the ASIC Division. He holds 5 patents in wireless communications.

Slim Souissi is Vice President of Emerging Technologies at Novatel Wireless, where he is responsible for emerging products architecture and commercialization. Dr. Souissi has previously led the development of the Software Defined Radio platform at Novatel and its implementation for CDPD, GPRS and UMTS technologies. Prior to Novatel, Dr. Souissi worked at Motorola where he was responsible for FLEX/ReFLEX paging technology development and location technology platforms. He holds in excess of 23 patents in the wireless arena.

Jack Winters is a former Division Manager of Wireless Systems Research at AT&T Labs-Research where he led research on signal processing, modulation, and coding techniques for communication systems, specifically in the use of adaptive antennas in cellular and wireless local area network systems. Dr. Winters is an IEEE Fellow and Distinguished Lecturer for the Communications Society and for the Vehicular Technology Society. He has published over 40 journal and 70 conference papers, and holds 20 patents.

Pieter van Rooyen is Founder and Chief Technical Officer of Zyray Wireless. Prior to founding Zyray Wireless, Dr. van Rooyen founded and served as Director of the Alcatel Research Unit for Wireless Access, and was invited to the Sony Advanced Telecommunications Labs in Tokyo, Japan to lead research projects on Software Defined Radio and Space-Time Processing. He has also served as a Full Professor in the Department of Electrical and Electronic Engineering at the University of Pretoria. Dr. van Rooyen has published numerous technical papers, holds several patents and is co-author of several books on next generation mobile systems.

Michiel Lotter is a Co-Founder and Vice President of Engineering at Zyray Wireless. Prior to founding Zyray Wireless, Dr. Lotter led development teams at Alcatel focusing in spread spectrum, CDMA, Software Radio and WCDMA-based Broadband Satellite Communications. Dr Lotter is a co-author of several books on next generation wireless communications techniques and is a co-inventor of 4 patents in digital communications.

Jun 09, 2002
Zyray Wireless to demonstrate its WCDMA baseband IC at the IEEE International Microwave Symposium 2002.

San Diego, CA June 3, 2002 - Zyray Wireless, a San Diego based start-up company developing the SPINNER WCDMA baseband companion chip, will demonstrate a complete WCDMA baseband and RF transceiver for mobile devices at the IEEE-IMS 2002 Symposium.

Zyray Wireless will debut its SPINNERchip 1.0 device and WCDMA baseband development platform in conjunction with the newly announced WCDMA RF solution from IBM Microelectronics. The platform supports full rate 384kb/s transmit and receive, and provides for all common and dedicated channels. Customers will be able to evaluate a number of SPINNERchip features, including patented Adaptive Interference Cancellation (AIC), dual mode GSM/GPRS and WCDMA operation, packet switched data, and more.

Zyray's innovative baseband digital interface enables the SPINNERchip to attach to a multitude of industry leading GSM/GPRS digital baseband solutions. Likewise, integrating the analog (A/D and D/A) functionality enables SPINNERchip 1.0 to connect with multiple industry standard WCDMA RF solutions.

"We integrated the IBM RF solution based on its availability, performance and ease of integration with our SPINNERchip1.0 and WCDMA baseband development platform. We believe that IBM's advanced Silicon Germanium RF devices combined with Zyray's high performance WCDMA baseband solution constitutes a winning combination for a complete WCDMA solution", says Michael Civiello, VP of Marketing and Business Development.

The International Microwave Symposium 2002 is being held in Seattle, Washington, on June 4-6, 2002. For details on the symposium please check the website www.ims2002.org

Mar 13, 2002
Zyray Wireless to showcase its SPINNER family of GSM/GPRS & WCDMA IP and ASIC products for next generation mobile devices at CTIA Wireless 2002.

San Diego, CA, March 13, 2001 - Zyray Wireless, a San Diego based start-up developing the SPINNER family of GSM/GPRS & WCDMA baseband IP and ASIC products for next generation mobile devices will highlight its SPINNERchip 1.0 at the CTIA Wireless 2002 Conference.

SPINNERchip 1.0 is designed as a WCDMA companion chip that interfaces seamlessly with most existing GSM/GPRS solutions. By utilizing the SPINNER chip device manufacturers can extend the functionality of existing 2G/2.5G devices to 3G at minimum risk and cost.

"One of the strongest benefits of our solution is that it does not require GSM/GPRS redesign and extensive testing. We believe this presents a significant advantage in the eyes of device manufacturers, " says Werner Sievers, the CEO of Zyray Wireless. By reusing customer's existing GSM/GPRS baseband solution, SPINNERchip 1.0 reduces development cycle time and minimizes dual-mode GSM/GPRS & WCDMA development costs.

The CTIA Wireless 2002 Conference is being held at the Orange County Convention

Center, Orlando, Florida, USA on March 18-20, 2002.

About Zyray Wireless
Zyray Wireless is developing the SPINNER family of GSM/GPRS & WCDMA IP and ASIC products. Integrating SPINNER products into baseband semiconductors and mobile devices enables manufacturers to efficiently migrate to dual-mode WCDMA solutions.

Feb 18, 2002
Condat licenses its UMTS protocol stack to Zyray Wireless.

Berlin Feb 18th 2002 - The Berlin-based technology company Condat AG has sold a development license for its UMTS protocol stack software to Zyray Wireless, a San Diego based start-up developing the SPINNER family of GSM/GPRS & WCDMA baseband IP and ASIC products for next generation mobile devices. The agreement contains an option to upgrade to the dual-mode UMTS and GSM/GPRS license. "In addition to manufacturers of baseband products for digital and analogue data transmission, producers of mobile handsets must also shoulder a significant portion of the development cost involved with such technologies. The Condat UMTS protocol stack reduces costs and time-to-market of the hardware," states Pedro Schäffer, CEO, Condat AG: "By way of its Generic Target Interface (GTI), the Condat UMTS protocol stack is platform independent and can be ported on several different hardware platforms and real-time operating systems. It brings us several important competitive advantages." Condat offers protocol stacks, which are compatible with 2G and 2.5G as well as 3G dual mode technologies.

"Zyray Wireless is pleased to be working with Condat, whose expertise and reputation in the development of protocol stacks makes them a key partner for our company", said Werner Sievers, President and CEO of Zyray Wireless. "We are planning to integrate Condat software into our GSM/GPRS and WCDMA dual-mode baseband chipset." Zyray Wireless will provide a complete reference design for WCDMA and GSM/GPRS dual-mode mobile devices, enabling manufacturers of mobile devices and semiconductors for wireless terminals to efficiently migrate to dual-mode WCDMA solutions. As communication technologies continue to develop, the demand for software/hardware communication solutions supporting multiple air interface standards will increase dramatically.

About Zyray Wireless
Zyray Wireless is developing the SPINNER family of GSM/GPRS & WCDMA IP and ASIC products. Integrating SPINNER products into baseband semiconductors and mobile devices enables manufacturers to efficiently migrate to dual-mode WCDMA solutions.

For more information on Zyray Wireless and its products, visit www.zyraywireless.com or contact Zyray Wireless headquarters at 11455 El Camino Real, Suite 350, San Diego, CA, 92130; telephone: 858-455-0021 ext. 1109; fax: 858-704-1001.

About Condat AG
As one of the first companies to concentrate on the m-business market, Condat AG combines its mobile communications, Internet and IT technological know-how with

knowledge about users' business processes. With this service, Condat is facilitating new applications for mobile business communication. The technology company offers innovative software for mobile communications (GSM, GPRS, UMTS etc) and modern system architecture for integrating mobile components in businesses' existing information and communications systems.

Condat AG was founded in 1979 and has its headquarters in Berlin, with branches in Aachen, Hamburg and Munich, as well as wholly owned subsidiaries in Aalborg, Edinburgh and Taipei. Condat has taken a majority stake in Purple Lab S.A., Chambéry (France).

Feb 06, 2002
Zyray Wireless, a leader in WCDMA wireless technologies, to speak at the 2002 3GSM World Congress in Cannes, France.

San Diego, CA, February 06, 2002 - Zyray Wireless, a San Diego based start-up developing the SPINNER family of GSM/GPRS & WCDMA baseband IP and ASIC products for next generation mobile devices, will present on its Adaptive System Design approach at the 2002 3GSM Technical Symposium.

Werner Sievers, CEO of Zyray Wireless will highlight Zyray's low risk, cost effective approach to enhancing existing single-mode wireless solutions (e.g. GSM/GPRS or CDMA) with WCDMA capabilities through an innovative interface and architecture. "The next generation of mobile terminals will be required to function across a multitude of wireless standards and be able to handle applications rich in data and high in bandwidth. These requirements place a heavy computational and power consumption burden on the system architecture. Zyray addresses these problems by implementing a low-power, hardware centric design. The overall system flexibility, that is so essential to the continuously evolving WCDMA product market, is preserved through an adaptive software-based control system."

The 3GSM World Congress is being held at Palais des Festivals, Cannes, France on February 19-22, 2002. Zyray Wireless' presentation is part of the Mobile Terminals Seminar, taking place on February 19, 2002. The Seminar will focus on the evolution of the mobile terminal market and will examine the challenges of meeting the requirements of the next generation wireless devices.

Feb 04, 2002
Zyray Wireless, a Leader in WCDMA Wireless Technologies, to Use Telelogic DOORS® and Telelogic Tau® to Reduce Time-to-Market For Wireless Products.

-Company Chooses DOORS for Efficiency, Traceability and Speed and Telelogic Tau for Simulation, Modeling and Testing-

Irvine, California, February 04, 2002 - Telelogic (Stockholm Exchange: TLOG), the leading global provider of solutions for advanced software and systems development, and Zyray Wireless, a San Diego-based company developing the SPINNER family of GSM/GPRS & WCDMA IP and ASIC products, today announced that Zyray Wireless is utilizing Telelogic DOORS and Telelogic Tau in the development of its leading edge dual-

mode wireless products.

"DOORS has been instrumental in our development process," said Michiel Lotter, Vice President of Engineering at Zyray. "As a start-up company, we have to be very efficient with our resources. DOORS has aided our development effort significantly, enabling a rapid, well-managed and thoroughly documented design process."

DOORS was named the market leader for requirements management software in the latest Standish Group industry report. The software tool enables users to gather, trace and manage all established requirements for a development project. This ensures that the resulting application is completed on time, within budget, and with all the features and functionality originally specified.

Being able to trace and link requirements and specifications is essential to Zyray's success. Zyray Wireless uses DOORS to ensure their products conform to the latest version of the WCDMA specification. As specification updates are provided by the 3GPP, changes are easily tracked and implemented.

Telelogic Tau TTCN Suite provides a robust test environment for Zyray, linking test case scenarios with system design. "Our products include both software and hardware components. Being able to simulate ASIC performance and functionality with TTCN Suite saves us the cost and time of developing expensive, working prototypes," commented Lotter.

Scott Raskin, President of Telelogic Americas, said Zyray's use of Telelogic products provides an excellent example of how integration of development tools can provide tangible benefits. "By tying everything together, Zyray Wireless is able to keep a constant focus on the overall end solution. End-to-end traceability, with a constant eye on the final product, is the promise of lifecycle automation."

More than 75 percent of Zyray's employees use Telelogic tools including the marketing team who uses DOORS, and its Web-based companion, DOORSnet, to demonstrate and sell their products.

1.7. Press Releases 2001

Dec 04, 2001
Zyray Wireless, a leader in WCDMA wireless technologies, announces the expansion and relocation of its San Diego headquarters.

San Diego, CA December 4, 2001 - Zyray Wireless, a San Diego based start-up developing the SPINNER family of GSM/GPRS & WCDMA baseband IP and ASIC products for next generation mobile devices, has completed the expansion and relocation of its headquarters. The expansion was completed to provide additional office space to support increased headcount, expanded lab and testing facilities, advanced product development, and customer interaction.

Located in the Carmel Valley area of San Diego, the new address is 11455 El Camino Real, Suite 350, San Diego CA 92130. Carmel Valley is located 20 miles north of downtown, and is part of San Diego's expanding wireless technology corridor.

"We are truly reaping the benefits of being surrounded by such a large pool of talented engineers", commented Michael Civiello, the VP of Marketing and Business Development at Zyray Wireless. "The move will help to best serve our needs as Zyray continues to grow."

Sep 10, 2001
Zyray Wireless to highlight its reconfigurable W-CDMA and GSM/GPRS technology at the CTIA Wireless I.T. and Internet 2001 Conference.

San Diego, CA - Zyray Wireless, a San Diego based start-up developing a Wireless Processor Core for next generation mobile devices, will highlight its W-CDMA and GSM/GPRS reconfigurable technology at the CTIA Wireless I.T. & Internet 2001 Conference. The Zyray Wireless Core enables mobile semiconductor manufacturers to deliver solutions with enhanced Quality of Service (QoS) and greater power efficiency.

"We are developing an innovative physical layer solution that is reconfigurable between W-CDMA and GSM/GPRS communication standards. The design integrates both modes into a single efficient architecture," says Werner Sievers, the CEO of Zyray Wireless. "The solution will reside at the core of 2.5G and 3G mobile devices, enabling the transmission of voice, data, and high bandwidth multimedia applications," Sievers said.

The Zyray Wireless exhibit can be found in the San Diego Pavilion, booth 2512, at the CTIA I.T. & Internet 2001 Conference, September 11-13th, 2001.