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## Design of a Methodology to Support Software Release Decisions

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## 2 RESEARCH DESIGN

*“Science works with concept of averages which are far too general to do justice to the subjective variety of an individual life.”*  
-- Carl Gustav Jung --

### 2.1 Introduction

The design of the study is discussed in this Chapter, and in Section 2.2, different trajectories for building theories are discussed, towards deriving the overall design of the study.

This framework is used to describe the research design in more detail, and discussed in:

- ❖ Section 2.3 ~ the research philosophy
- ❖ Section 2.4 ~ the research approach
- ❖ Section 2.5 ~ the applied research strategy
- ❖ Section 2.6 ~ the corresponding time horizon
- ❖ Section 2.7 ~ the data collection methods, including tactics used to obtain a high level of reliability and validity.

Considerations on the role of the researcher are discussed in Section 2.8, and the Chapter ends with a summary and conclusions, in Section 2.9.

### 2.2 Overall Research Design

A theory explains how ‘something’ works and can predict how ‘something’ will behave under specific conditions. Theory development means formulating a consistent system of statements that unify, enlarge and deepen ideas, which had, before, been more or less intuitive and disconnected. Engelen and Zwaan (1994) describe two theory trajectories: *theory development* and *theory application*, as in Figure 2-1.

The theory development trajectory has three basic steps:

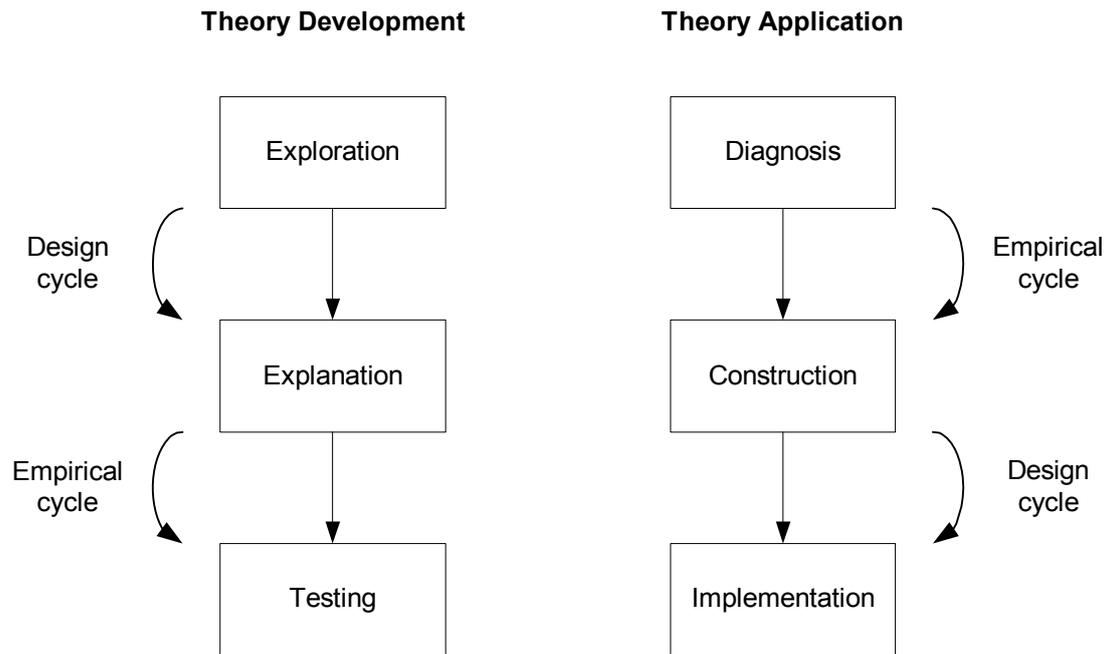
*exploration → explanation → testing*

Using existing theory and practices, a new theory is constructed that should describe reality, preferably with a high predictability. This theory is tested in reality to determine if the theory can be confirmed or rejected, thus answering the question ‘Is it correct?’

The theory application trajectory also has three steps:

*diagnosis → construction → implementation*

A problem is diagnosed, the problem is accurately defined and theories to improve the unwanted situation are determined. The theories are then applied to create a potential solution for the problem and this solution is implemented, thus answering the question ‘Does it work?’



**Figure 2-1: Theory Development and Theory Application**  
(Engelen and Zwaan 1994, p.86)

Engelen and Zwaan (1994) distinguish two main research cycles for management studies:

1. *Empirical cycle*. With five steps:
  - 1) Research goal,
  - 2) Research design,
  - 3) Data collection,
  - 4) Data analysis, and
  - 5) Reporting.
2. *Design cycle*. Also with five steps:
  - 1) Design goal,
  - 2) Design specifications,
  - 3) Generation of different designs,
  - 4) Selection from different designs, and
  - 5) Reporting.

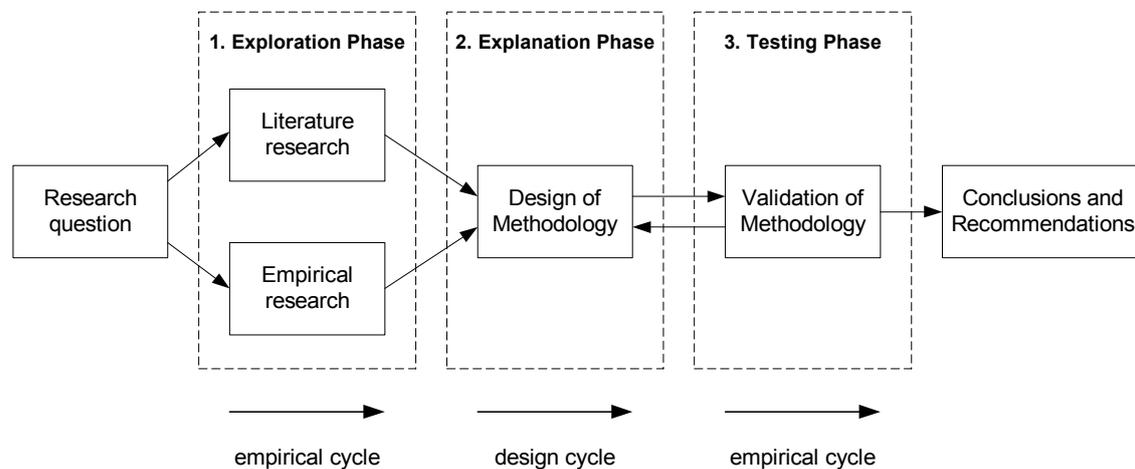
As illustrated in Figure 2-1, these research cycles are found in both trajectories. In developing theory, the emphasis is on design, and using existing theories, new relationships are explored. The resultant 'designed' theory is then tested in an empirical context. For theory application, the order of the two cycles is reversed. An undesirable situation in an empirical context is diagnosed and alternative solutions are evaluated to choose the most appropriate one.

As discussed in Section 1.6, the aim of this study is to develop theory regarding strategic software release decisions by developing a methodology. This methodology should describe the relevant practices that, when implemented successfully, help to achieve a better chance of success when making strategic software release decisions. Such a methodology should have a descriptive character and a judgmental character, thereby creating an instrument to identify possible improvement areas.

No suitable theories were found describing, or explaining, the important aspects of strategic software release decisions, and this research primarily follows the trajectory of theory

construction. During the Exploration phase, the study phenomenon is explored in-depth from both a theoretical point of view [literature review] and a practical point of view [empirical research]. The results obtained are used during the Explanation phase to design a methodology, describing all the important aspects of strategic software release decisions in a coherent and consistent way. The methodology is validated in the Testing phase to see whether it is correct. Following these steps implies that the empirical cycle is executed twice. During the Exploration phase, not only are existing theories explored, but case studies, in a practical context, are also used for a better understanding of the main problem areas faced by software manufacturers. The design cycle is applied during the Explanation phase. During the Testing phase, the empirical cycle is used to again test the designed methodology in an empirical context.

The research also incorporates elements of theory application as the research question addresses the question of how to improve strategic software release decisions. It was however decided to focus on only developing and validating new theory, taking into account the requirement for the methodology to support a software manufacturer in identifying possible areas of improvement. Validating whether the implementation of the theory helps a software manufacturer improve its capability in this area falls beyond the scope of this study. An overview of the resulting research design showing the three research steps is given in Figure 2-2.



**Figure 2-2: Research Design**

Having defined the research question and the overall research design for this study, the next step is to discuss the design in more detail: the research philosophy, the research approach and research strategies used. Much literature is available on research philosophies, approaches and strategies. Saunders *et al.* (2003) define the so-called research process ‘onion’, consisting of five different layers, as in Figure 2-3.

| Layer                      | Approaches  |
|----------------------------|---|
| 1: Research philosophy     | Positivism, Interpretivism (or Phenomenology), Realism                        |
| 2: Research approaches     | Deductive, Inductive  |
| 3: Research strategies     | Experiment, Survey, Case study, Grounded theory, Ethnography, Action research |
| 4: Time horizons           | Cross Sectional, Longitudinal   |
| 5: Data collection methods | Sampling, Secondary data, Observation, Interviews, Questionnaires             |

**Figure 2-3: The Research Onion**

(Saunders *et al.* 2003, p.83)

As approaches in the different layers have dependencies, they suggest a research design should be developed from the top down, starting with the outside layer [adopting a research

philosophy] and thereafter peeling away each layer until the fifth layer is reached [defining data collection methods]. This approach, also suggested by Remenyi *et al.* (2000), is used in this study.

### 2.3 *Research Philosophy*

A *positivistic philosophy* aims at the derivation of laws or law-like generalizations similar to those in the physical and natural sciences (Remenyi *et al.* 2000, p.32). Quantitative research allows researchers to familiarize themselves with the problem or concept to be studied. The emphasis is on facts and causes of behaviour (Bogdan and Biklen 1988), with the information in the form of numbers that can be quantified, and summarized using a mathematical process for analysing the numeric data and expressing the final result in statistical terminology (Charles 1995).

The *realistic philosophy* shares two features with a positivism philosophy: a belief that the natural and the social sciences should apply the same kinds of approach to the collection of data and to explanation, and a commitment to the view that there is an external reality to which scientist direct their attention (Bryman 2001).

The *interpretivistic philosophy*, on the other hand, asserts that the assumptions of both philosophies are unwarranted; especially in cases where the objectives of study are influenced by many factors, extremely difficult to isolate and control in experimental laboratory settings (see for example Hirschheim and Klein 1994). Qualitative research, broadly defined, means any kind of research that produces findings not arrived at through quantification (Strauss and Corbin 1990, p.17) and which arise from real-world settings (Patton 2001, p.39).

It is not possible to classify this study as either positivistic/realistic or interpretivistic. It could be argued that the study can be classified best as more interpretivistic, because no theories have been found to describe the study phenomenon. Therefore, studying a software release decision as a real, certain and precise phenomenon, and collecting data that are factual, truthful and unambiguous is difficult. Software engineering is still a relatively young discipline and there is a lack of general agreement on software measurement and a lack of maturity in measurement (Bourgue *et al.* 2004).<sup>16</sup> Few organizations collect quantitative data on their projects (McConnell 2002). On the other hand, the study aims to collect facts and causes of behaviour, being more characteristics of a positivistic research philosophy.

### 2.4 *Research Approach*

*Inductive reasoning* applies to situations where specific observations or measurements are made towards developing broader conclusions, generalizations and theories (Saunders *et al.* 2003, pp.87-88). Opposed to inductive reasoning is *deductive reasoning*, where one starts thinking about generalizations, and then proceeds toward the specifics of how to prove or implement the generalizations (Saunders *et al.* 2003, pp.86-87), mostly applicable in disciplines where agreed facts and established theories are available (Remenyi *et al.* 2000, p.75). From Figure 2-4, listing the main differences between deductive and inductive research approaches, an inductive research approach is considered the most appropriate for an interpretivistic research philosophy.

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<sup>16</sup> According to Sellami and Abran (2003) the majority of software measures proposed in the literature are not based on verifiable approaches, and therefore cannot be qualified as measurement methods.

| Deduction  | Induction   |
|--|---|
| <ul style="list-style-type: none"> <li>▪ Scientific principles</li> <li>▪ Moving from theory to data</li> <li>▪ Need to explain causal relationships between variables</li> <li>▪ Collection of quantitative data</li> <li>▪ Application of controls to ensure validity of data</li> <li>▪ Operationalisation of concepts to ensure clarity of definition</li> <li>▪ Highly structured approach</li> <li>▪ Researcher independence of what is being researched</li> <li>▪ Necessity to select samples of sufficient size in order to generalize conclusions</li> </ul> | <ul style="list-style-type: none"> <li>▪ Gaining an understanding of the meanings humans attach to events</li> <li>▪ Close understanding of the research context</li> <li>▪ Collection of qualitative data</li> <li>▪ More flexible structure to permit changes of research emphasis as the research progresses</li> <li>▪ Realization that the researcher is part of the research process</li> <li>▪ Less concern with the need to generalize</li> </ul> |

**Figure 2-4: Deductive and Inductive Research**

(Saunders *et al.* 2003, p.89)

Although involving some elements of a deductive approach, this research can best be classified as inductive. Inductive reasoning is applicable to business and management studies where established and accepted theories are unlikely to be available (Remenyi *et al.* 2000, p.75), as is the case in this study.

## 2.5 Research Strategy

An important step in the research design is the choice of research strategy for collecting data. Data are collected both during the Exploration and the Testing phases.

### 2.5.1 Exploration Phase

As discussed in Chapter 1, limited theories regarding strategic software release decisions are found. The first step in the research is therefore to explore how software release decisions are made in a practical context; to supplement insight gained from the literature review. Most literature suggests *case studies* can be used as the appropriate research strategy for discovery or exploration (Benbasat *et al.* 1987; Hutjes and Buuren 1992; Lammers *et al.* 1997). Benbasat *et al.* (1987) give three main reasons for using case studies as the appropriate research strategy for exploration:

1. The researcher can study the study phenomenon in a natural setting, learn the state of the art and generate theories from practice.
2. The researcher can answer the questions that lead to an understanding of the nature and complexity of the processes taking place.
3. It is an appropriate way to research a previously little studied area.

These reasons are all applicable to the nature of the Exploration phase in this study. A theory (methodology) is constructed later during the Explanation phase, using the results of the literature review and supplemented by case studies. The literature review can be used to identify specific questions for the case studies, to create a better understanding of the nature and complexity of the release decision-making process. Only limited study results are available on strategic software release decisions.

Others confirm the choice for case studies as the research strategy during the Exploration phase. Yin defines a case study as an empirical enquiry that '*investigates a contemporary phenomenon within its real life context, when the boundaries between phenomenon and context are not clearly evident*' (Yin 1994, p.13). This applies to the objective of the Exploration phase and is confirmed by Walsham (1993), who states that the appropriate research strategy for studying objectives in a practical context is case studies, and Bell (1993) describes case studies as an umbrella of research strategies having, in common, the decision to focus on an enquiry around a specific instance or event. Finally, as Schramm (1971) notes: '*the essence of a case study, i.e. the central tendency among all types of case studies, is that it tries to illuminate a decision, or a set of decisions: why they were taken, how they were implemented, and with what result*'. This applies to the objective of the Exploration phase. Criteria used to select case study environments are described in Chapter 4.

### 2.5.2 Testing Phase

The objective of the Testing phase is to validate whether the methodology can be used to understand the different aspects relevant to strategic software release decisions, and whether it offers the possibility of assessing an organization's capability in this area, and an instrument to identify possible areas of improvement. Research strategies considered here are: action research, experiments, large-scale surveys and case studies.

*Action Research:* The theory trajectory chosen for this study is theory development, not theory application for which action research would be an appropriate research strategy. The fundamental contention of an action researcher is that complex social processes can best be studied by introducing changes into these processes and observing the effects of these changes (Marsick and Watkins 1997). For theory development however, the focus is on explaining the study phenomenon and not diagnosing a problem and applying a theory to improve the situation. Assuming that also the trajectory of theory application was chosen [implementing the designed methodology], applying action research during the Testing phase could have been considered. However, possible criticism is that action research could have created a risk for the reliability and validity of the study results. When researchers intervene, they become part of the study, i.e. one of the study subjects. Action research may therefore incorporate interpretive statements that include the observer's values and *a priori* knowledge, which, invariably, intrudes on the observation, and the researcher perceives the 'meaning' of the observation. According to Eden and Huxham (1996), as the researcher attempts to understand what is observed, this personal understanding will invade the recording of the observation and deductions that may follow. As the research design is restricted to theory development, action research is not considered as a possible research strategy.

*Experiments:* Yin (1994, pp.4-9) recommends experiments and case studies as the appropriate research strategy when the form of the research question is 'how' or 'why', and when the study focuses on a contemporary event, as shown in Figure 2-5. Experiments were rejected for several reasons. The objective of the Testing phase is to validate the methodology constructed. Simulating all aspects of a release decision starting at the project proposal phase [when the project boundaries and thus the initial release criteria are defined] until the implementation of the release decision is assumed to be difficult. It is assumed that not all relevant issues can easily, or convincingly, be studied in laboratory settings (Remenyi *et al.* 2000, p.56). In a laboratory setting, it is, for example, difficult to simulate the stress that arises in practical action, which can hamper decision-making (Levi and Tetlock 1980). Other examples of factors influencing decision-making that cannot be easily simulated are discussed in Section 8.2 [cognitive limitations]. It was assumed that organizations and individuals would not usually collaborate in such experiments (Remenyi *et al.* 2000, p.56), making it difficult to find a representative group to conduct experiments.

| Research strategy | Form of research question               | Control over behavioural events? | Focuses on contemporary events? |
|-------------------|---|----------------------------------|---------------------------------|
| Experiment        | how, why                                | yes                              | yes                             |
| Survey            | who, what, where,<br>how many, how much | no                               | yes                             |
| Archival Analysis | who, what, where,<br>how many, how much | no                               | yes / no                        |
| History           | how, why                                | no                               | no                              |
| <b>Case Study</b> | <b>how, why</b>                         | <b>no</b>                        | <b>yes</b>                      |

**Figure 2-5: Different Research Strategies**

(Yin 1994, p.6)

*Large-scale surveys:* Surveys are a common approach to research in business and management, offering an opportunity to collect large quantities of data or evidence (Saunders *et al.* 2003, pp.56-57). Surveys allow evidence to be gathered concerning ‘who’ or ‘what’ or ‘where’ or ‘how many’ or ‘how much’, but are of less value when the researcher is asking about ‘how’ or ‘why’, i.e. questions with an open-ended character. Surveys are less suitable when questions are more profound and complicated (Leeuw 2003). As the designed methodology addresses for instance the initial positions of different stakeholders prior to the decision-making process and the processes/strategies they apply to realise an outcome of the decision as close as possible to their own position (see Chapter 8), surveys as a research strategy are considered less appropriate. It is assumed to be difficult to collect such confidential information using questionnaires only.<sup>17</sup>

*Case studies:* Adopting case studies as a research strategy [qualitative research] means researchers cannot fully escape their personal influences due to the inherent involvement of the researcher in the research domain (Peshkin 1988; Maxwell 1992; Robson 2002). This is a potential source for criticism regarding the reliability and validity of the collected data. However, both Yin (1995) and Zwaan (1999) argue that case studies can be used for validation to check if certain theories are correct; the exact objective of the Testing phase. It was decided to use case studies as the research strategy during the Testing phase as well. Tactics to reduce or eliminate the criticism regarding the reliability and validity of the collected data are discussed in Section 2.7. Criteria used to select case study environments are described in Chapter 11.

## 2.6 Time Horizon

Software release decisions are taken in a limited time frame, and case studies in the Exploration and Testing phases are not aimed at studying change and development. The objective in the Exploration phase is to explore how software release decisions are made in a practical context, whereas the objective in the Testing phase is to validate the designed methodology. A cross-sectional time horizon is therefore considered most appropriate.<sup>18</sup>

## 2.7 Data Collection: Reliability and Validity

Case studies are criticized for failing to meet the criteria for scientific, quantitative, research, namely: *study reliability*, *construct validity*, *internal validity* and *external validity* (Yin 1994, pp.34-38; Remenyi 2000, pp.179-181).

<sup>17</sup> In Section 2.7, questionnaires are described as a data collection method, but used in combination with other data collection methods.

<sup>18</sup> The case studies conducted were retrospective studies, as opposed to longitudinal studies.

Stenbacka (2001) argues that study reliability has no relevance in qualitative research as it concerns measurements.

Guba and Lincoln (1989) claim that the above criteria are not meaningful and should be replaced by confirmability, credibility, transferability and dependability. There is considerable debate among methodologists about the value and legitimacy of this alternative set of criteria for judging qualitative research (Golafshani 2003).

Many quantitative researchers see the alternative criteria as just a re-labelling of successful quantitative criteria to accrue greater legitimacy for qualitative research. They suggest that the correct reading of quantitative criteria shows they are not limited to quantitative research and can be applied to qualitative data.

Qualitative researchers may have a valid point about the irrelevance of traditional quantitative criteria. How can the external validity of a qualitative study that does not use formalized sampling methods be judged? How can the reliability of qualitative data be judged when there is no mechanism for estimating the true score?

In this study, Seale's view (1999, p.226) is adopted, focusing on the trustworthiness of a study: '*the trustworthiness of a research report lies at the heart of issues conventionally discussed as validity and reliability*'. To claim the trustworthiness of this study, the approach suggested by Yin (1994, pp.32-38) is followed in using the conventional criteria definitions and defining research tactics to eliminate, or at least reduce, possible criticism:<sup>19</sup>

- ❖ *Study reliability*. For each case study, a case study database with various artefacts was created. For each series of case studies [Exploration and Testing phases] a case study protocol including questionnaires was first developed, enabling an independent person to establish a peer review or an audit on the research process followed (Yin 1994, p.94). Both in the Exploration and the Testing phases, this case study protocol, including questionnaires, was subject to review prior to the conduct of the first case study. The results of each case study were then archived, consisting of the returned questionnaires, interview recordings, accessed documentation and the approved case study report.
- ❖ *Construct validity*. In each case study, multiple sources of evidence were looked for, also called *triangulation*, to obtain a synergistic view of evidence (Yin 1994, p.90; Stake 1995, pp.110-115). Data collection methods used are questionnaires and interviews as primary sources, and documentation as a secondary source. A chain of evidence was established so that the route of data could be tracked to its sources (Yin 1994, p.98). Finally, the draft version of each case study report was reviewed by at least two key informants. At the end of the Exploration phase, a report covering the analysis of all case studies was written. This report was reviewed by all participating organizations as well as two independent reviewers.
- ❖ *Internal validity*, defined as being of concern in causal and explanatory studies of the relationship between different events, can be demonstrated by sound argument even if all the evidence is not present (Remenyi *et al.* 2000). During the Explanation phase, pattern-matching is used as the analytic strategy for analysis (Yin 1994, pp.106-110). During the Testing phase *explanation-building* is used as the analytic strategy for analysis (Yin 1994, pp.110-113). As the case studies in both phases are post-mortem research, special attention is given to threats like *perceptual inaccuracies* [perceptions of past events may not be accurate], *Halo effects* [the informant is preconditioned to answer], *memory recall biases* [including forgetting and distortion (Schmidt and Calantone 1997)], and *reflexivity* [informants give answers the researcher would like to hear].

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<sup>19</sup> Note that both Yin (1994, pp.94-99) and Remenyi *et al.* (2000, pp.177-179) stress the importance of using multiple sources of evidence, creating a case study database and maintaining a chain of evidence as principles of good practice.

- ❖ *External validity*, defined as concern with knowing whether the findings can be generalized to a wider context beyond the immediate research environment (Remenyi *et al.* 2000). For external validity, it may be difficult to predict from the results in one context what the results will be beyond that context. To deal with this problem, multiple case studies were conducted to create a context for falsification (Yin 1994; Zwaan 1999). This was considered especially important in the Testing phase of this study, concerned with the validation of the designed methodology. The objective should be to either predict similar results [*literal replication*] or to predict contradicting results under explicitly stated conditions [*theoretical replication*] (Yin 1994, p.46). Another choice made is that software manufacturer organizations could only be involved in either a case study in the Exploration phase or a case study in the Testing phase.

In Figure 2-6, the applied tactics are summarized.

| Study Criteria     | Tactics   |
|--------------------|---|
| Study reliability  | Case study database with artefacts<br>Case study protocol and questionnaires (subject to review)                                      |
| Construct validity | Multiple sources of evidence (triangulation)<br>Case study report (subject to review)<br>Report Exploration phase (subject to review) |
| Internal validity  | Attention to perceptual inaccuracies, Halo effects, memory recall biases, reflexivity   |
| External validity  | Multiple case studies   |

**Figure 2-6: Tactics applied to Study Criteria**

A question is whether the use of *intercoder agreement* or *inter-rater agreement* [degree to which two or more researchers using the same materials and observing the same people produce essentially the same results] is necessary to guard against the introduction of subjective bias in the coding and analysis of qualitative data (Palys 1997). This subjective bias could have adverse consequences and lead to inappropriate theoretical conclusions and/or ineffective or harmful recommendations and interventions. Carey *et al.* (1996) suggest this approach should apply to all qualitative research; the implication being that a high intercoder agreement (high interpretive accuracy) will necessarily result in an authentic interpretation of the data and thus produce more credible findings. It was decided that for this study interpretive authenticity is best achieved when the interpretations made are reviewed by the study participants and additionally some independent reviewers. It is the study participants who know best the meanings they intended to convey through their responses. Put differently, the applied tactics for construct validity (use of multiple sources of evidence and reviews) were considered appropriate instruments to assure the quality of the interpretations made.

## 2.8 Role of the Researcher

The researcher prepared and co-ordinated the case studies and performed the later analysis. During case studies, it is considered important to establish a relationship between the researcher and the informant(s) where trust is established early during contact (Saunders *et al.* 2003, p.257). The researcher should also be aware that informants may want to give answers the researcher would like to hear (Yin 1994, p.80) or that informants may have reasons to hide certain information. To establish mutual trust and be aware of the possible effects of reflexivity requires experience in searching for reliable sources of evidence, and here the researcher has a

strong background in performing audits and assessments. Finding adequate substitutes, able to operate at the same experience level, was considered too difficult, and therefore it was concluded that the benefits of letting the researcher collect the data outweighed any negative aspects.

The case studies conducted during the Exploration phase can be described as exploratory, whereas the case studies conducted during the Testing phase can be described as explanatory studies (Saunders *et al.* 2003, pp.96-98).

This implies the following roles for the researcher.

- ❖ During the Exploration phase, the role of the researcher is best characterized as observer and interpreter, trying to recognize and substantiate new meanings, hoping to connect to known theories (Stake 1995, p.97).
- ❖ During the Testing phase, the role of the researcher is best characterized as observer and evaluator, trying to identify strengths and weaknesses of the methodology being validated (Stake 1995, p.96).
- ❖ For both phases, it is considered important that the researcher does not become involved as a consultant, or express his ideas on how software release decision-making can be improved. This leads to another research strategy, namely action research (Remenyi 2000, p.49; Saunders *et al.* 2003, pp.93-94). In this study, the researcher limits his activities to observing the study phenomenon, and conducting retrospective cross-sectional case studies without intervention. To stress this choice and avoid possible problems, the researcher did not conduct case studies in software manufacturer organizations where he was, or had recently been, active as a consultant.

## 2.9 Summary and Conclusions

In this Chapter the overall research design, and the underlying research philosophy, the research approach and the research strategy are discussed, as summarized in Figure 2-7. The absence of a solid theory was the reason for following the theory development trajectory. The study has characteristics of both a positivistic and an interpretivistic research philosophy, and can probably best be classified following an inductive research approach. The appropriate research strategy for studying software release decisions in a practical context is found to be case studies, both for the Exploration and the Testing phases with a cross-sectional time horizon and different data collection methods [questionnaires and interviews as primary sources, and documentation as a secondary source]. Possible criticism regarding the study reliability and validity are reduced, or even eliminated, by defining appropriate tactics, and some considerations on the activities and role of the researcher in the case studies are discussed.

| Layer                     | Exploration Phase                               | Explanation Phase | Testing Phase                                   |
|---------------------------|---|-------------------|---|
| 1: Research philosophy    | Positivistic / Interpretivistic                 |                   |   |
| 2: Research approach      | Inductive                                       |                   |   |
| 3: Research strategy      | Case studies                                    | -                 | Case studies                                    |
| 4: Time horizon           | Cross sectional                                 | -                 | Cross sectional                                 |
| 5: Data collection method | Interviews,<br>Questionnaires,<br>Documentation | -                 | Interviews,<br>Questionnaires,<br>Documentation |

**Figure 2-7: Research Philosophy, Approach and Strategy**