

*Requirements Engineering is more difficult now,  
because all systems that were easy to specify  
were built some time ago. Tom DeMarco 2001*

## Vorlesung „Methoden des Software Engineering“

Block A „Requirements Engineering“

# Grundlagen

Martin Wirsing

Einheit A.1, 26.10.2004

## Ziel heute

- **Grundlegende Begriffe des Requirement Engineering**
- **Historische Entwicklung des Requirement Engineering**
- **Inhalte einer Anforderungsspezifikation**

# Requirements Engineering



As proposed by the project sponsor



As specified in the project request



As designed by the senior analyst



As produced by the programmers

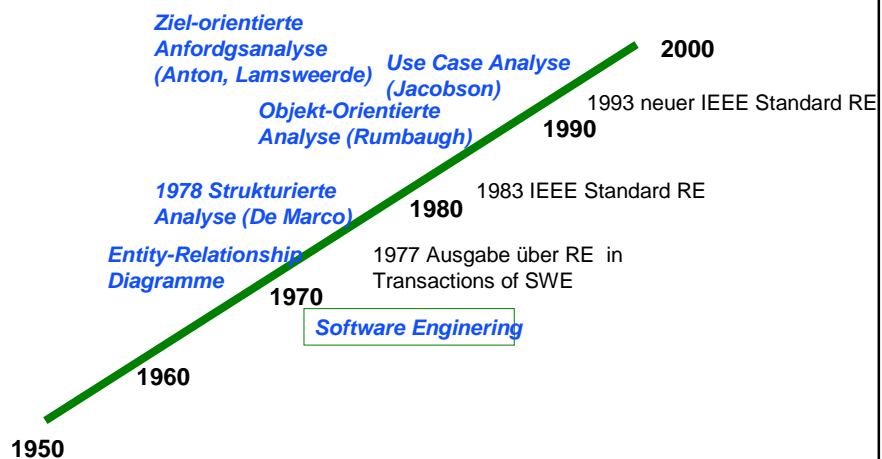


As installed at the user's site

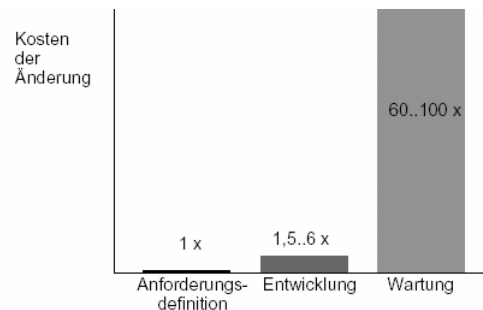


What the user wanted

# Geschichte des Requirements Engineering



## Bedeutung der Anforderungsermittlung



- **These von Boehm:** Fehler sind besonders häufig bei Anforderungs- und Entwurfsaktivitäten; und je später in der Entwicklung ein Fehler gefunden wird, um so aufwendiger ist seine Behebung.
- **These von Glass:** Anforderungsmängel sind eine Hauptquelle für das Scheitern von Projekten.

[Endres, Rombach 2003]

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## Grundlegende Definitionen

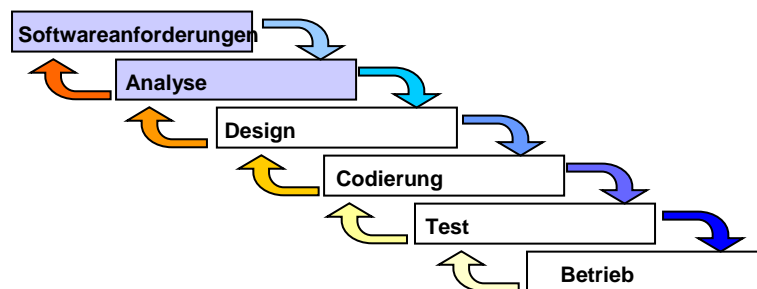
- **Anforderung**
  - Eine Bedingung oder Eigenschaft, die man braucht um ein Problem zu lösen oder ein Ziel zu erreichen:
  - "A condition or capability that must be met or possessed by a system or system component to satisfy a contract, standard, specification, or other formally imposed document. The set of all requirements forms the basis for subsequent development of the system or system component". [IEEE Std]
- **Requirement Engineering**
  - **Requirements Engineering** ist die **ingenieurmäßige Ermittlung der Anforderungen** an die Automatisierung eines Systems und ihrer Aufarbeitung zur Realisierung in Hardware und Software.
  - Requirements Engineering beschäftigt sich mit der Identifizierung der Aufgabe eines SW-Systems und seinem Nutzungskontext; es bildet die Brücke zwischen den Bedürfnissen der Nutzer und der Leistungsfähigkeit von SW-intensiven Technologien.
    - "... RE is concerned with identifying the purpose of a software system, and the contexts in which it will be used. Hence, RE acts as the bridge between the real world needs of users, customers, and other constituencies affected by a software system, and the capabilities and opportunities afforded by software-intensive technologies." [RE'01 CfP]

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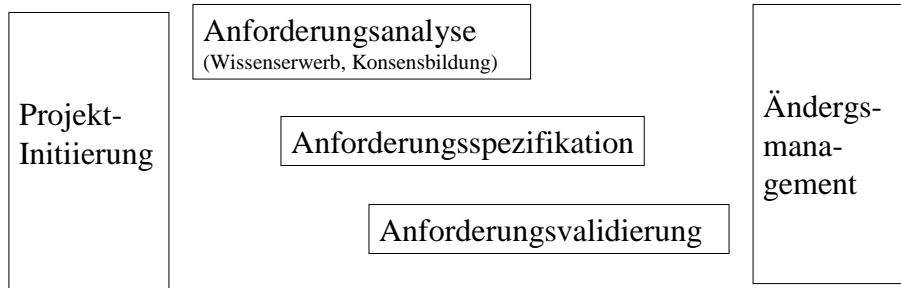
## Probleme und Erfolgsfaktoren bei der Anforderungsermittlung

- **Probleme**
  - Unterschiedliche Ziele verschiedener Nutzer
  - Interessenkonflikte von Beteiligten
  - Schwierigkeiten bei der Wahl von Prioritäten bei widersprüchlichen Anforderungen
  - Ständig veränderte Anforderungen
  - Unklare und sich ändernde organisatorische Rahmenbedingungen
- **Erfolgsfaktoren**
  - Stabilität der Anforderungen über den Projektzeitraum hinweg
  - Disziplin beim Änderungsmanagement
  - das Maß, in dem die Projektbeteiligten die Projektziele verstehen
  - das Maß, in dem die Anwender/Kunden am Projekt beteiligt werden

## Requirements Engineering im Wasserfallmodell

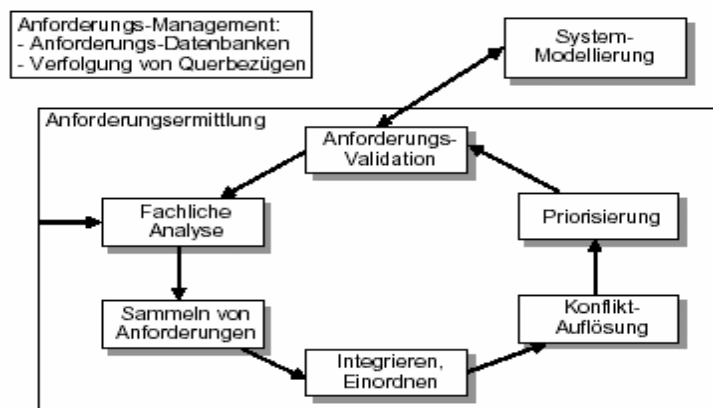


## Aufgaben des Requirements Engineering



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## Vorgehensmodell der Anforderungsermittlung



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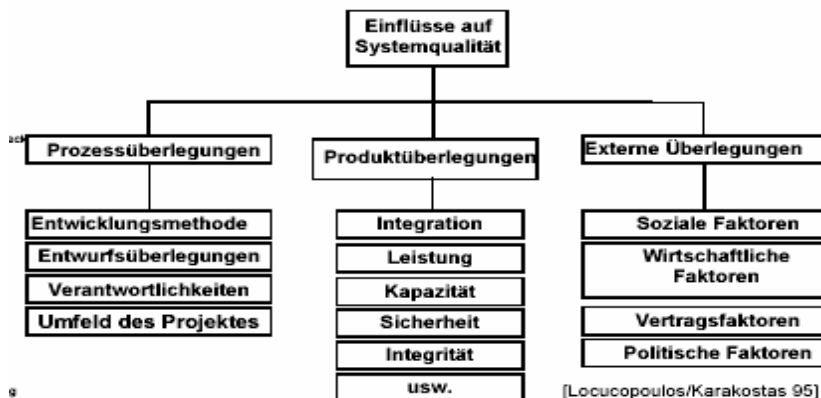
## Beispiele für Anforderungen

"Das System soll einen Mechanismus zum Dimmen der Lampen vorsehen.,, (Funktionale Anforderung)

- "Das System soll zeitprogrammierte Vorgänge mit einer Genauigkeit von 1 Minute plus/minus 5 Sekunden ausführen, wobei die Zeit durch die Systemuhr gemessen wird.,, (Nicht-funktionale Anforderung)

## Funktionale & Nichtfunktionale Anforderungen

- Eine **funktionale Anforderung** beschreibt, **was** das System tun soll.
- Eine **nichtfunktionale Anforderung** ist eine **einschränkende Bedingung**, wie die funktionalen Anforderungen zu realisieren sind.
- Klassifizierung nichtfunktionaler Anforderungen:





## Validierungsbeispiel

- **Anforderung R:**
  - Rückwärtsschub soll nur dann möglich sein, wenn das Flugzeug auf der Landebahn rollt
- **Anwendungseigenschaft D:**
  - Radsensoren stehen auf “an” genau dann, wenn sich die Räder drehen
  - Ein Rad dreht sich genau dann, wenn es sich auf der Landebahn bewegt
- **Spezifikation S:**
  - Rückwärtsschub ist möglich genau dann, wenn die Radsensoren auf “an” stehen.
- **S + D implizieren R**
- **Aber was geschieht, wenn das Anwendungsbereichsmodell falsch ist? (Z.B. bei Aquaplaning?)**

## Noch ein Beispiel

- **Anforderung R:**
  - Die Datenbank soll nur von berechtigten Personen abgefragt werden dürfen
- **Anwendungseigenschaft D:**
  - Jede berechtigte Person besitzt ein Passwort
  - Nicht-berechtigte Personen haben keinen Zugang zu Passwörtern
- **Spezifikation S:**
  - Zugriff auf die Datenbank wird nur Benutzern gewährt, die ein Passwort besitzen
- **S + D implizieren R**
- **Aber was geschieht, wenn das Anwendungsbereichsmodell falsch ist?**

## Inhalte einer Anforderungsspezifikation

- **Zielsetzung**
- **Allgemeine Beschreibung**
  - Umgebung, generelle Funktion, Restriktionen, Benutzer
- **Spezifische funktionale Anforderungen**
  - möglichst quantitativ (z.B. Tabellenform)
  - eindeutig identifizierbar (Nummern)
- **Spezifische nicht-funktionale Anforderungen**
  - z.B. Antwortzeit, Speicherbedarf, HW/SW-Plattform
- **Entwicklungs- und Produkt-Standards**
- **Qualitätszielbestimmung**
- **Zu erwartende Evolution des Systems**
- **Grobe Identifikation von Versionen**
- **Formalia: Abkürzungsverzeichnis, Glossar, Index, Referenzen**  
(sehr wirkungsvoll zur Konsistenzsicherung!)

## Beispiel: IEEE/ANSI Standard-Gliederung

[IEEE-STD-830-1993]

1. Introduction
    - 1.1 Purpose
    - 1.2 Scope
    - 1.3 Definitions, Acronyms, and Abbreviations
    - 1.4 References
    - 1.5 Overview
  2. Overall Description
    - 2.1 Product Perspective
    - 2.2 Product Functions
    - 2.3 User Characteristics
    - 2.4 General Constraints
    - 2.5 Assumptions and Dependencies
  3. Specific Requirements
- Alle Anforderungen stehen hier (der Hauptteil des Dokuments)
- Beschreibt Produkt und Anwendungsbereich
- Beschreibt Inhalt und Struktur der restlichen SRS
- Beschreibt kurz alle externen Schnittstellen: System, Nutzer, Hardware, Software, ...
- Übersicht über die wichtigen Funktionen
- Alles, was die Möglichkeiten des Entwicklers einschränkt: Regelungen, Zuverlässigkeit, HW-Beschränkungen, Verteilung,...

## Beispiel: IEEE/ANSI Standard-Gliederung Kap. 3

### [IEEE-STD-830-1993]

3.1 External Interface Requirements	3.3 Performance Requirements
3.1.1 User Interfaces	(wichtig: Messbare, nachprüfbare Beschreibung)
3.1.2 Hardware Interfaces	3.4 Design Constraints
3.1.3 Software Interfaces	3.4.1 Standards compliance
3.1.4 Communication Interfaces	3.4.2 Hardware limitations etc.
3.2 Functional Requirements	3.5 Software System Attributes
3.2.1 Mode 1	3.5.1 Reliability
3.2.1.1 Functional Requirement 1.1	3.5.2 Availability
...	3.5.3 Security
3.2.2 Mode 2	3.5.4 Maintainability
3.2.2.1 Functional Requirement 2.1	3.5.5 Portability
...	
3.3 Performance Requirements	
3.4 Design Constraints	
3.5 Attributes	
3.6 Other Requirements	

## Beispiel für Anforderungsspezifikation

- Das folgende Beispiel beschreibt die Anforderungen an ein Marktplatzsystem.
- Die Spezifikation umfasst funktionale und nicht-funktionale Anforderungen und folgt im Großen und Ganzen dem ISO-Standard.
- Die Spezifikation ist vor allem in englischer Sprache verfasst; in neuen Ansätzen versucht man dagegen Anforderungsspezifikationen besser zu formalisieren, um automatische Analysewerkzeuge einsetzen zu können.

## Beispiel: Anforderungsspezifikation für ein Marktplatzsystem [Firesmith 2003]

### Executive Overview

- The Global Personal Marketplace (GPM) system will be a global Web-based marketplace bringing together private individuals and small companies to buy and sell all manner of items. It will take advantage of the Internet and World Wide Web to radically improve the way they buy and sell items.
- **The buyer objectives** for the GPM are to:
  - Provide them with a huge selection of items (and sellers).
  - Enable them to easily search for, find, and buy the items they want.
  - Minimize risks associated with buying over the Internet. ...
- **The seller objectives** for the GPM are to:
  - Make selling more convenient by allowing them to sell items:
    - Anytime (i.e., 24 hours a day and 7 days a week).
    - Anywhere the sellers have access to the Internet
- **The GPMC objectives** for the GPM are to:
  - Minimize the costs of providing a marketplace (e.g., capital costs, labor costs) compared to a physical marketplace (e.g., a shopping mall) by maximizing automation and thus minimizing labor and facilities costs.
  - Maximize income by maximizing the number of sellers (i.e., merchants) paying marketplace fees.

## Beispiel: Anforderungsspezifikation für ein Marktplatzsystem [Firesmith 2003]

<b>1 Introduction</b> 1.1 Specification Definition 1.2 Specification Objectives 1.3 Intended Audiences 1.4 References 1.5 Specification Overview <b>2 Marketplace System Overview</b> 2.1 Definition 2.2 Business Goal 2.3 Business Objectives 2.3.1 Buyer Business Benefits 2.3.2 Sellers Business Benefits 2.3.3 Marketplace Owner Business Benefit 2.4 Context of the Marketplace 2.4.1 External Hardware 2.4.2 External Roles 2.4.3 External Software 2.4.4 External Systems 2.5 Global Personal Marketplace Capabilities 2.5.1 Summary of System Capabilities	<b>3 Functional Requirements</b> 3.1 Summary Use Case Diagrams 3.2 External Roles <i>(Accountant, Buyer, Security Officer, Seller, User, User Support Agent)</i> <b>4 Data Requirements</b> <b>5 System Quality Requirements</b> 5.1 Accessibility 5.2 Auditability 5.3 Branding 5.4 Configurability 5.4.1 Variant Capabilities 5.4.2 Internationalization 5.4.3 Personalization 5.5 Correctness 5.6 Efficiency
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## Beispiel: Anforderungsspezifikation für ein Marktplatzsystem [Firesmith 2003]

...	<b>6 System Constraints</b>
5.8 Installation	6.1 Business Rules
5.9 Interoperability	6.2 Data and Content Constraints
5.10 Maintainability	6.2.1 Databases
5.11 Operational Availability	6.3 Hardware Constraints
5.12 Performance	6.4 Software Constraints
5.12.1 Capacity	6.4.1 High-Level Languages
5.12.2 Latency	6.5 Industry Standards
5.12.3 Response Time	6.6 Legal and Regulatory Constraints
5.12.4 Throughput	
5.13 Portability	<b>Appendices</b>
5.14 Reliability	A. Envisioned Future Enhancements
5.15 Reusability	B. Open Issues
5.16 Robustness	C. Major TBDs
5.17 Safety	D. Assumptions
5.18 Scalability	
5.19 Security Requirements	
5.20 Testability	
5.21 Usability	

## Beispiel: Anforderungsspezifikation für ein Marktplatzsystem [Firesmith 2003]

### 1 Introduction

The section introduces the system requirements specification (SRS) for the Global Personal Marketplace (GPM) system to its readers.

#### 1.1 Specification Definition

This specification documents the system-level requirements for the GPM system.

#### 1.2 Specification Objectives

The objectives of this specification of the GPM are to:

- Provide a system overview of the GPM including definition, goals, objectives, context, and major capabilities.
- To formally specify its associated:
  - Functional requirements, data requirements, quality requirements, constraints

#### 1.3. Intended Audiences

The intended audiences of stakeholders for this specification of the GPM include:

**Global Personal Marketing Corporation (GPMC) Employees:**

**Firesmith Consulting Employees** (especially members of the GPM Project Team):

**Users**, that take part in a sale held in the GPM

#### 1.4 References

This specification references or complies with the following documents:

**GPM Project Documents**

**OPEN Process Framework (OPF) Conventions**

## Beispiel: Anforderungsspezifikation für ein Marktplatzsystem [Firesmith 2003]

### 1.5 Specification Overview

This specification is organized into the following sections:

**Introduction**, which introduces the specification for the GPM to its readers.

**System Overview**, which provides a brief, high level description of the GPM including its definition, business goals, business objectives, context, and capabilities.

**Functional Requirements**, which specifies the functional system requirements in terms of a use case model consisting of each external's use cases and use case paths.

**Data Requirements**, which specifies the system data requirements in terms of required data components.

**Quality Requirements**, which specifies the required system quality factors.

**Constraints**, which documents required architecture, design, and implementation constraints on the GPM.

**Appendices**, which defines ancillary information including future envisioned enhancements, open issues, TBDs, and assumptions.

## Beispiel: Anforderungsspezifikation für ein Marktplatzsystem [Firesmith 2003]

### 2 Global Personal Marketplace System Overview

This section provides a high level description of the Global Personal Marketplace (GPM) system including its definition, primary business goal, business objectives, context, and capabilities.

#### 2.1 Definition

The Global Personal Marketplace (GPM) system will be a global Web-based marketplace bringing together private individuals and small companies to buy and sell all manner of items.

#### 2.2 Business Goal

The business goal of the Global Personal Marketplace (GPM) system is to take advantage of the Internet and World Wide Web to radically improve the way private individuals and small companies buy and sell items.

#### 2.3 Business Objectives

The business objectives of the GPM are to provide the following business benefits to its buyers, sellers, and owners.

1. 2.3.1 Buyer Business Benefits ...

## Beispiel: Anforderungsspezifikation für ein Marktplatzsystem [Firesmith 2003]

### 2.4 Context of the Marketplace

This subsection documents the context of the GPM in terms of the significant externals with which it interacts.

#### 2.4.1 External Hardware

The GPM interacts, either directly or indirectly, with the following significant external hardware:

- Client Hardware: Employee Workstations, User Client,
- Networks: Internet, Local Area Network, Leased Phone Line.

#### 2.4.2 External Roles

The GPM interacts, either directly or indirectly, with the following significant client roles: Employees, Accountants, Security Officers, ...

#### 2.4.3 External Software

The GPM interacts, either directly or indirectly, with the following significant client software: Browser

#### 2.4.4 External Systems

The GPM interacts, either directly or indirectly, with the following significant external systems: Authorization Processor Gateway

### 2.5 Global Personal Marketplace Capabilities

This subsection provides a high-level overview of major capabilities of the GPM. Note that this subsection provides useful information for understanding the following requirements, but does not contain specific testable requirements.

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## Beispiel: Anforderungsspezifikation für ein Marktplatzsystem [Firesmith 2003]

### 3 Functional Requirements

The section of the SRS specifies the functional requirements of the GPM in terms of use cases and their associated use case paths. The use case model is primarily organized in terms of the externals that benefit from the use cases.

#### 3.1 Summary Use Case Diagrams

The following use case diagrams summarize the functional requirements for the GPM:

- Employee Summary Use Case Diagram
- User Summary Use Case Diagram

### 4 Data Requirements

This section specifies the data requirements on the GPM system. ...

#### 4.2.3 Service Fees

Users can be charged the following service fees:

- The account balance past due service fee, ...

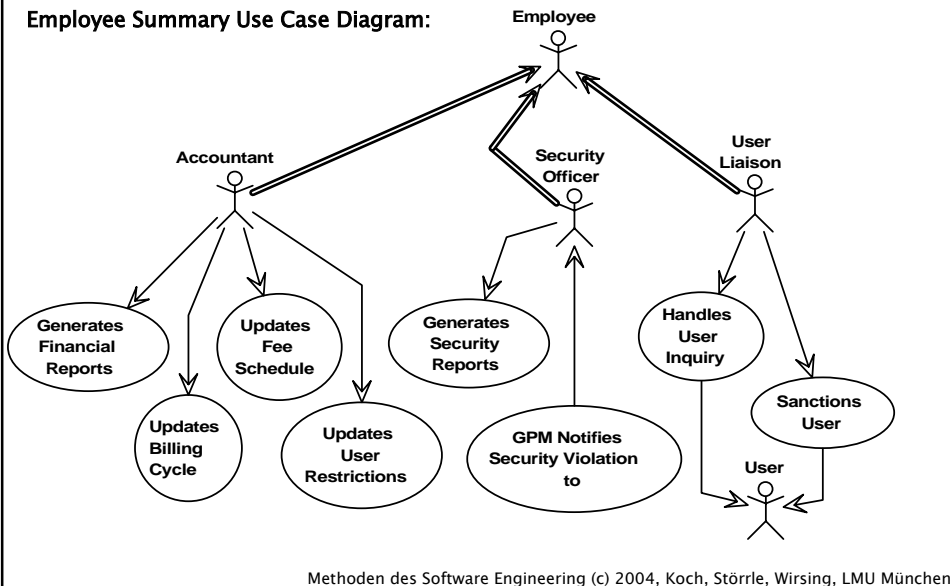
Listing Fees:

The listing fee for each of the following ranges of minimum bid (Yankee auction) or initial price per item (direct sale):

\$0.01 – \$9.99, \$10.00 – \$24.99, ...

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## Beispiel: Anforderungsspezifikation für ein Marktplatzsystem [Firesmith 2003]



## Beispiel: Anforderungsspezifikation für ein Marktplatzsystem [Firesmith 2003]

### 5 System Quality Requirements

This section specifies the required system quality factors that are not related to the specific functional requirements documented in the use case model.

#### 5.1 Accessibility

This subsection specifies the following requirements associated with the degree to which the system must be accessible to people with disabilities:

- ACC-1) Any graphical user interfaces of the GPM shall be usable by persons with color blindness.

#### 5.2 Auditability

This subsection specifies the following requirements associated with the degree to which the system must support independent auditing of its transactions and finances:

- AUD-1) The GPM shall maintain a record for 1 year of each invoice. ...

#### 5.4 Configurability

This subsection specifies the following requirements associated with the degree to which the system must exist in multiple simultaneous configurations or variants:

##### 1.1.1 Variant Capabilities

- There are no requirements for multiple variants of the GPM. ...

##### 1.1.3 Personalization

- The degree of personalization is an open issue that has not been resolved.

## Beispiel: Anforderungsspezifikation für ein Marktplatzsystem [Firesmith 2003]

### 5.5 Correctness

This subsection specifies the following requirements concerning the degree to which the system can contain defects and still be acceptable to the customer. ...

#### 5.5.2 Accuracy

This subsection specifies the following requirements concerning the degree of correctness of the system's outputs:

- COR-4) Values of money shall be correct to the nearest penny.

#### 5.5.3 Precision

This subsection specifies the following requirements concerning the resolution of the system's numerical outputs:

- COR-6) Values of money shall be precise to the nearest penny.
- COR-7) Values of time shall be precise to the nearest second.

#### 5.5.4 Timeliness

This subsection specifies the following requirements concerning the degree to which the system must ensure that its persistent information is current (i.e., up-to-date):

- COR-8) When one user updates some data, the system shall ensure that other users shall automatically see the update within 2 seconds.

## Beispiel: Anforderungsspezifikation für ein Marktplatzsystem [Firesmith 2003]

### 5.6 Efficiency

This subsection specifies the following requirements associated with the degree to which the system effectively uses its resources:

- EFF-1) The GPM shall not require users to permanently download software to their computers.

### 5.7 Extensibility

This subsection specifies the following requirements associated with the degree to which the system can be modified to meet changing requirements or goals.

- EXT-1) The GPM shall be easily extendable to enable sellers to sell services as well as goods.

### 5.8 Installation

This subsection specifies the following usability requirements associated with the ease with which the system can be installed.

- INS-1) The typical user shall not average more than 5 minutes to install or upgrade any required GPM software on his/her personal computer.

### 5.9 Interoperability

This subsection specifies the following requirements associated with the ease with which the system can be integrated with other system (e.g., browsers, legacy applications, and required databases).

- The GPM shall interoperate with the following browsers:
- IOP-1) Internet Explorer 4.0 IOP-2) Netscape Navigator 4.0

## Beispiel: Anforderungsspezifikation für ein Marktplatzsystem [Firesmith 2003]

### 5.10 Maintainability

This subsection specifies the following requirements associated with the ease with which the system can be maintained:

- M-1) The GPM shall permit the swapping and upgrade of hardware without down time.

### 5.11 Operational Availability

This subsection specifies the following requirements associated with the percent of time that the system must function correctly.

- OA-1) By release 0, the GPM shall provide actors with a minimum operational availability of 99%.

### 5.12 Performance

This subsection specifies the following requirements associated with the speed with which the system shall function.

#### 5.12.1 Capacity

This subsection specifies the following requirements concerning the minimum number of objects that the system can support:

- PER-1) The system shall support a minimum of 10,000 simultaneous open sales.

### 5.13 Portability

The GPM shall enable users to use the following environments (e.g., platform and operating system) to interact with the GPM:

- POR-1) PC with minimum of Pentium I chip, 16 meg of RAM, and a 28.8 K modem

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## Beispiel: Anforderungsspezifikation für ein Marktplatzsystem [Firesmith 2003]

### 5.14 Reliability

This subsection specifies the following requirements associated with the reliability (e.g., mean time between failures, number of failures per unit time) of the system.

- REL-1) The mean time between failures (MTBF) shall exceed 3 months.

### 5.15 Reusability

This subsection specifies the following requirements associated with the degree to which the system can be used for purposes other than originally intended (e.g., as part of other applications).

- REU-1) The GPM shall incorporate a database continuous availability layer.

### 5.16 Robustness

This subsection specifies the following requirements associated with the degree to which the system continues to properly function under abnormal circumstances.

- ROB-1) The GPM should gracefully handle invalid input (i.e., detect invalid input, request valid input, and not crash) from all externals:
  - The human actors.
  - The Authorization Processor Gateway.

### 5.17 Safety

This subsection specifies the following requirements associated with the degree to which the system does not directly or indirectly (e.g., via inactivity) cause accidental harm to life or property (e.g., loss of money or data).

- SAF-1) The GPM shall not accidentally lose user account information.

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## Beispiel: Anforderungsspezifikation für ein Marktplatzsystem [Firesmith 2003]

### 5.19 Security Requirements

This subsection documents the security requirements that specify the extent to which the GPM shall protect itself and its sensitive data and communications from accidental, malicious, or unauthorized access, use, modification, destruction, or disclosure.

#### 5.19.1 Authentication Requirements

- Accountant – A minimum of 99.999% of the time, the GPM shall verify the identity of the accountant before permitting him or her to perform the following accountant use cases:
  - Accountant Generates Financial Reports

#### 5.19.2 Authorization Requirements

- Accountant – A minimum of 99.999% of the time, the GPM shall restrict the performance of all accountant use cases to persons who a security officer has currently designated as accountants.

#### 5.19.3 Immunity Requirements

This subsection documents the immunity requirements that specify the extent to which the GPM shall protect itself from infection by unauthorized harmful programs (e.g., computer viruses, worms, and Trojan horses):

- **Scanning** – The GPM shall scan all entered or downloaded data and software against the published definitions of known computer viruses, worms, Trojan horses, and other similar harmful programs.
- **Disinfection** – If possible, the GPM shall disinfect any data or software found to contain such a harmful program. ...

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## Beispiel: Anforderungsspezifikation für ein Marktplatzsystem [Firesmith 2003]

### 6 System Constraints

The section documents the major architecture, design, and implementation constraints on the system.

#### 6.2 Data and Content Constraints

The subsection documents all required data constraints.

##### 6.2.1 Databases

The subsection documents all required design constraints regarding the use of databases.

- None

##### 6.3 Hardware Constraints

The subsection documents all required constraints associated with minimum or actual hardware.

- None

##### 6.4 Software Constraints

The subsection documents all required software constraints.

###### 6.4.1 High-Level Languages

The subsection documents all required design constraints associated with the use of high-level programming languages.

- SYSDC-HLL-1) Application server software shall be written in Java.

##### 6.5 Industry Standards

The subsection documents all required design constraints associated with industry standards.

- DC-STD-1) The system shall conform to ISO 10646 (Unicode UTF-8) and ISO 10646-1 (Unicode UTF-16) standards for character set encoding.

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## Zusammenfassung

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- Requirements Engineering ist die ingenieurmäßige Ermittlung der Anforderungen an die Automatisierung eines Systems und ihrer Aufarbeitung zur Realisierung in Hardware und Software.
- Bei der Ermittlung von Anforderungen müssen unterschiedliche Nutzer, Anwendungskontext und Änderung von Anforderungen berücksichtigt werden.
- Man unterscheidet funktionale und nichtfunktionale Anforderungen
- Aktivitäten des RE sind Projektinitiierung, Anforderungserfassung, -spezifikation, -validierung und Änderungsmanagement
- Eine Anforderungsspezifikation enthält eine allgemeine Beschreibung des geplanten Produkts, die funktionalen und nichtfunktionalen Anforderungen sowie Standards und Qualitätsziele.