Teil V: Werkzeuge für spezifische Zwecke
70. Werkzeuge zur Anforderungsanalyse

Prof. Dr. rer. nat. Uwe Aßmann

Institut für Software- und Multimediatechnik

Lehrstuhl Softwaretechnologie

Fakultät für Informatik

TU Dresden

http://st.inf.tu-dresden.de

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1) Requirements Management
2) Requisite Pro
3) Ontology-Driven Requirements Engineering (ODRE)
4) Traceability to other Artefacts

References

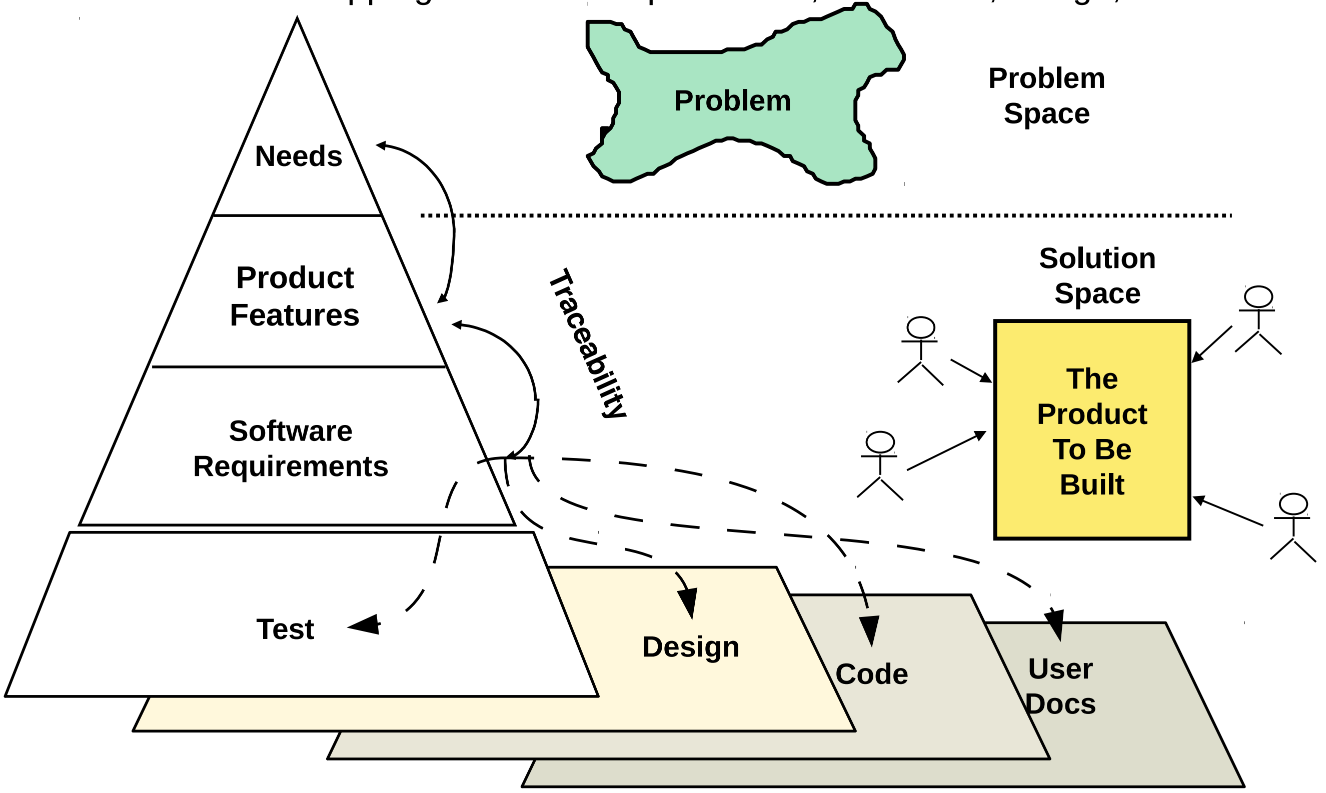
- Katja Siegemund, Edward J. Thomas, Yuting Zhao, Jeff Pan, and Uwe Assmann. Towards Ontology-driven Requirements Engineering. Semnatic Web Enabled Software Engineering (SWESE) Workshop at ISWC 2011, Koblenz
  - http://iswc2011.semanticweb.org/fileadmin/iswc/papers/workshops/swese/4.pdf
- [Mylopoulos1999] John Mylopoulos, Lawrence Chung, and Eric Yu. From Object-oriented to Goal-oriented Requirements Analysis. Communications of the ACM, 42(1):31 37, 1999.
- [Zowghi2002] Didar Zowghi and Vincenzo Gervasi. The Three Cs of Requirements: Consistency, Completeness, and Correctness. In Proceedings of 8th International Workshop on Requirements Engineering: Foundation for Software Quality, (REFSQ'02), 2002.
- [Lamsweerde2000] Axel van Lamsweerde. Requirements Engineering in the year 00: A Research Perspective. In International Conference on Software Engineering, pages 5, 19, 2000.
- Grady, Robert; Caswell, Deborah (1987). Software Metrics: Establishing a Company-wide Program. Prentice Hall. pp. 159. ISBN 0-13-821844-7.

Tool References

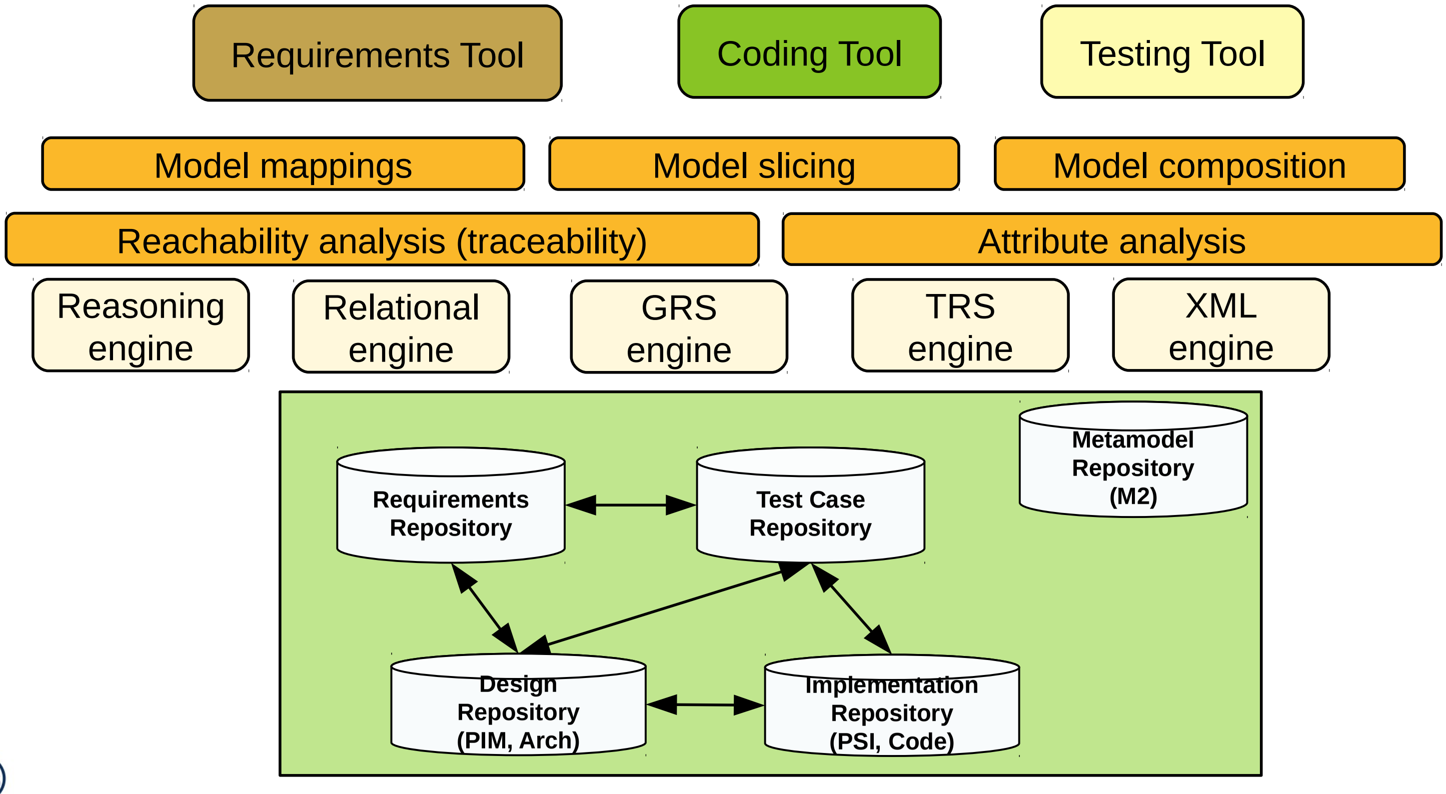
- [RPro] Requisite Pro User's Guide
  - ftp://ftp.software.ibm.com/software/rational/docs/v2003/win_solutions/rational_requisitepro/reqpro_user.pdf
- Dominic Tavassoli, IBM Software. Requirements Definition and Management - Ten steps to better requirements management. June 2009
  - ftp://ftp.software.ibm.com/software/emea/de/rational/neu/Ten_steps_to_better_requirements_management_EN_2009.pdf
- Tools: http://www.jiludwig.com/Requirements_Management_Tools.html
- Free community-licensed tool Axiom (Windows, Linux): http://www.iconcur-software.com/
  - http://d60f31wukcdjk.cloudfront.net/docs/Axiom_4_User_Manual.pdf
- Teach videos of Axiom
  - http://www.iconcur-software.com/resources.html
  - Video on linking matrix (traceability matrix) http://iconcur-software.com/tutorials/matrix.htm

Introduction to Requirements Management (RM)

- RM bridges the needs of the customer to testing, design, coding, and documentation
- RM relies on model mappings between requirements, test cases, design, and code



Tools in an Integrated Development Environment (IDE)

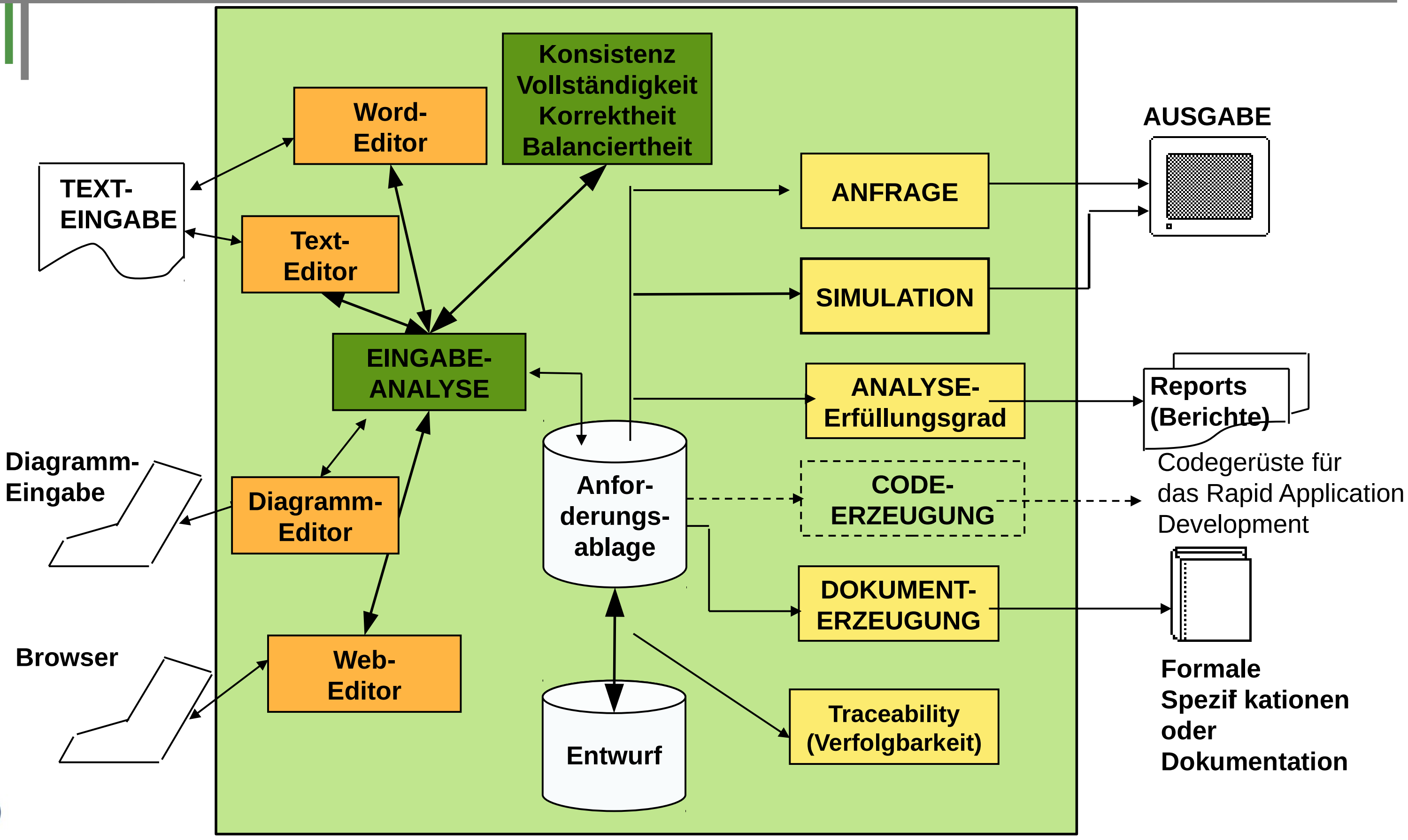


Deficiencies of Current RE Methods

- Relationships among requirements are inadequately captured
  - Causal relationship between consistency, completeness and correctness [Zowghi2002]
  - Completeness and consistency are not verified
- Requirement problems (e.g. conflicts, incompleteness) are detected too late or not all
- Relationships between requirements and dependent artifacts are insufficiently managed (test, documentation, design, code)
- Desirable:
  - Models for RE need richer and higher-level abstractions (goals, problems, needs) to validate that they are fulfilled [Mylopoulos1999]
  - **Model mappings (direct and indirect)** between the artifacts (design, code) and the goals, problems, needs of the customer
  - Requirements are consistently managed with design, code, and documentation

70.1 Tool-Based Requirements Management

Requirements Tools on the Requirement Database



Metamodeling of Requirements

- Generell empfiehlt sich die Metamodellierung von Requirements, da
  - sich viele Domänen und Anwendungsbereiche unterscheiden
  - die Granularität der Requirements unterschiedlich ist (Balancing)
  - die Requirements dann als Modellelemente exisiteren und über Model mappings in den Entwurf, die Architektur und den Code verfolgt werden können (**traceability, Verfolgbarkeit)**
  - Verfolgbarkeit wird über Modellabbildungen (model mappings) hergestellt
- Many requirement tools are metamodel-controlled
  - die die Requirements typisieren
  - und Requirements verlinken

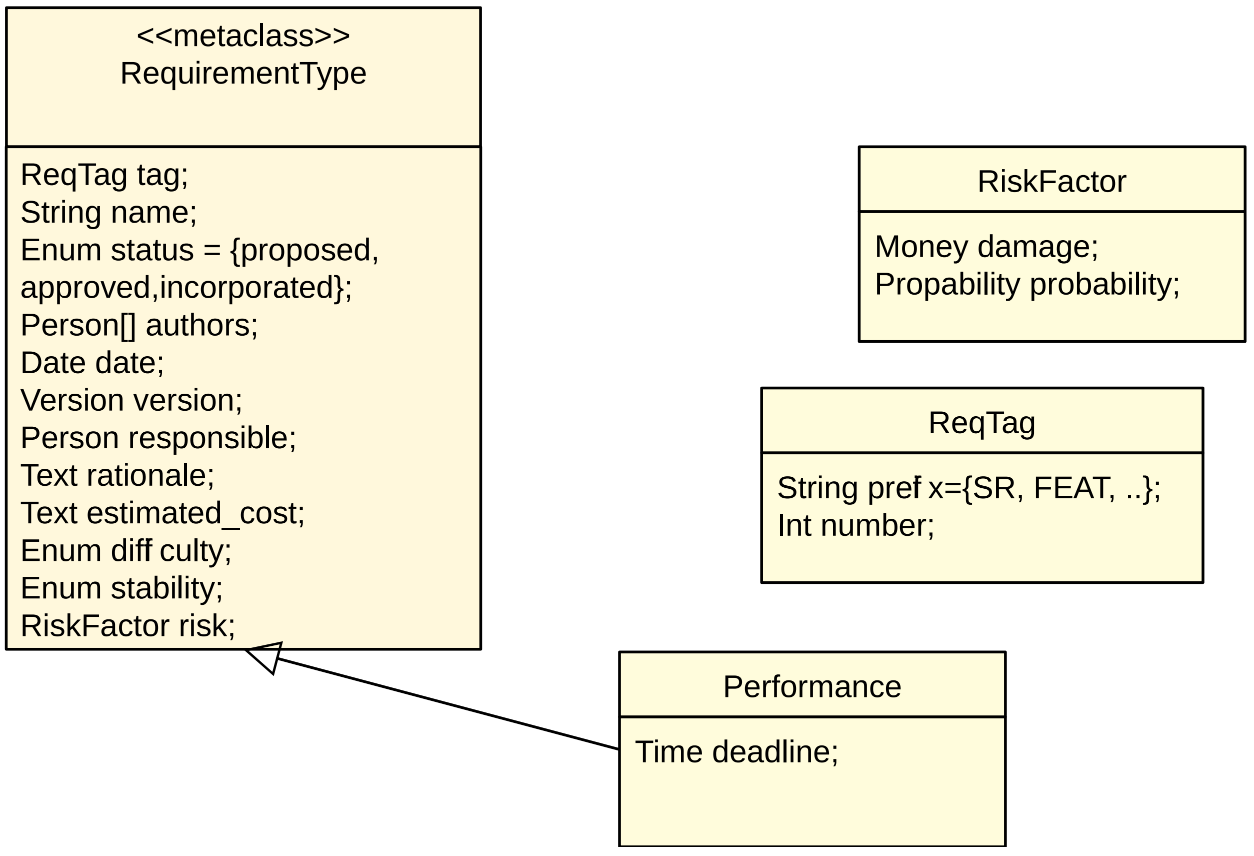
70.2 Requisite Pro

RequisitePro (IBM)

- Aufbau einer **metamodellgesteuerten Anforderungsdatenbank**:
  - Formulargesteuerte Erstellung eines Metamodells für die Anforderungen (**requirement types)** (Metasprache ERD)
    - Spezifikation von Anforderungsattributen, wie Status, Priorität, Schwierigkeit, Stabilität, Kosten
    - Anforderungsabhängigkeiten und -verknüpfungen
    - Möglichkeit der hierarchischen Verfeinerung, sowie unterschiedlicher Sichten auf Anforderungsverknüpfungen
  - Anfragen und Querying möglich
  - Konfigurationsmanagement/Änderungsverwaltung: Revisionsstände, Abhängigkeiten, Historie
  - Unterstützung gruppenorientierten Arbeitens
  - Integration in Vorgehensmodelle und SEU, z. B. Rational Unified Process mit Rational Rose, ClearCase sowie MS Project.
- **Verfolgbarkeit:** in einer “Traceability Matrix” können Requirements mit den Testfälle verknüpft werden
- Erstellen von **Anforderungsdokumenten mit Word-Vorlagen:**
  - Dokumente strukturiert nach (Standard-)Vorlagen (templates)
  - Unterschiedliche Typen von Anforderungen werden unterstützt (z.B. Produkt-, Software-, Test- und Anwendungsfall-Anforderungen).

http://www-142.ibm.com/software/products/de/de/reqpro/
ftp://ftp.software.ibm.com/software/rational/docs/v2003/win_solutions/rational_requisitepro/reqpro_user.pdf
http://public.dhe.ibm.com/common/ssi/ecm/en/rad10955usen/RAD10955USEN.PDF

Metaclass RequirementType (Ex.)



<<metaclass>>
RequirementType

ReqTag tag;
String name;
Enum status = {proposed, approved,incorporated};
Person[] authors;
Date date;
Version version;
Person responsible;
Text rationale;
Text estimated_cost;
Enum diff culty;
Enum stability;
RiskFactor risk;

RiskFactor

Money damage;
Propability probability;

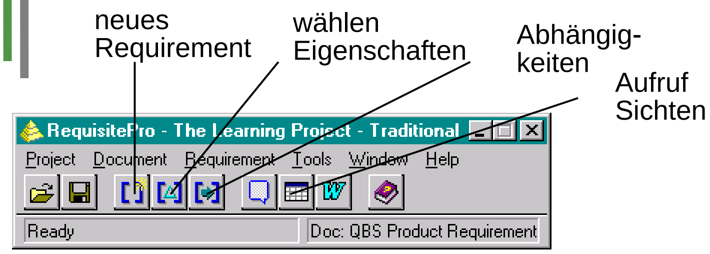
ReqTag

String pref x={SR, FEAT, ..};
Int number;

Performance

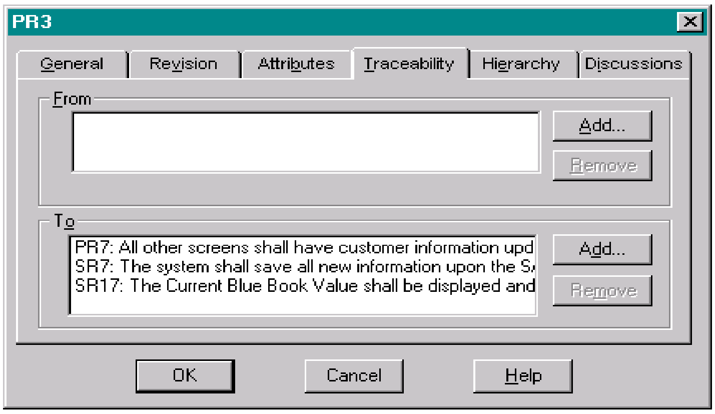
Time deadline;

RequisitePro - Hauptansichten

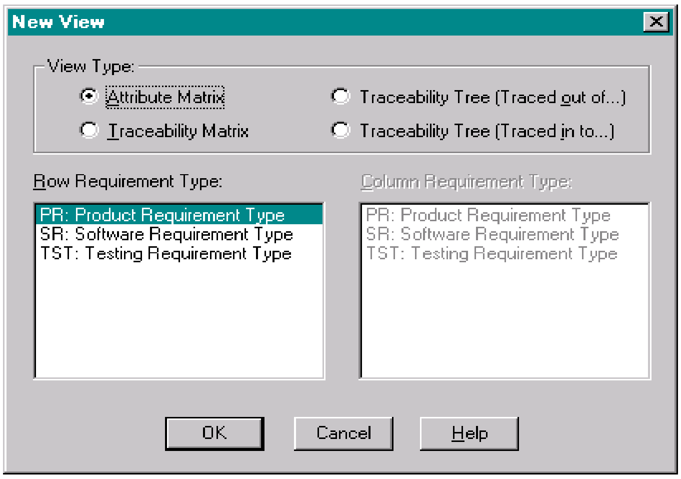

neues Requirement
wählen Eigenschaften
Abhängig-keiten
Aufruf Sichten
RequisitePro - The Learning Project - Traditional
Project Document Requirement Tools Window Help
Ready
Doc: QBS Product Requirement

Auswahl unterschiedlicher Sichten und Requirementtypen

Beschreibung des Requirements **PR3**


PR3
General Revision Attributes Traceability Hierarchy Discussions
From
Add...
Remove
To
Add...
Remove
OK
Cancel
Help

PR7: All other screens shall have customer information upd
SR7: The system shall save all new information upon the S
SR17: The Current Blue Book Value shall be displayed and



View Type:
- ● Attribute Matrix
- ○ Traceability Matrix
- ○ Traceability Tree (Traced out of...)
- ○ Traceability Tree (Traced in to...)

Row Requirement Type:
- PR: Product Requirement Type
- SR: Software Requirement Type
- TST: Testing Requirement Type

Column Requirement Type:
- PR: Product Requirement Type
- SR: Software Requirement Type
- TST: Testing Requirement Type

FURPS Classification of Requirements

FURPS delivers RequirementTypes for RequisitePro

[Wikipedia] [Grady/Caswell] in Hewlett-Packard

- **Functionality** - Feature set, Capabilities, Generality, Security
- **Usability** - Human factors, Aesthetics, Consistency, Documentation
- **Reliability** - Frequency/severity of failure, Recoverability, Predictability, Accuracy, Mean time to failure
- **Performance** - Speed, Efficiency, Resource consumption, Throughput, Response time
- **Supportability** - Testability, Extensibility, Adaptability, Maintainability, Compatibility, Configurability, Serviceability, Installability, Localizability, Portability

Attribute Matrix of Requisite Pro

- The attribute matrix is a hierarchical table (relation) of requirement objects and their attributes
  - Super and subrequirements
  - Priority and Status, and other attributes

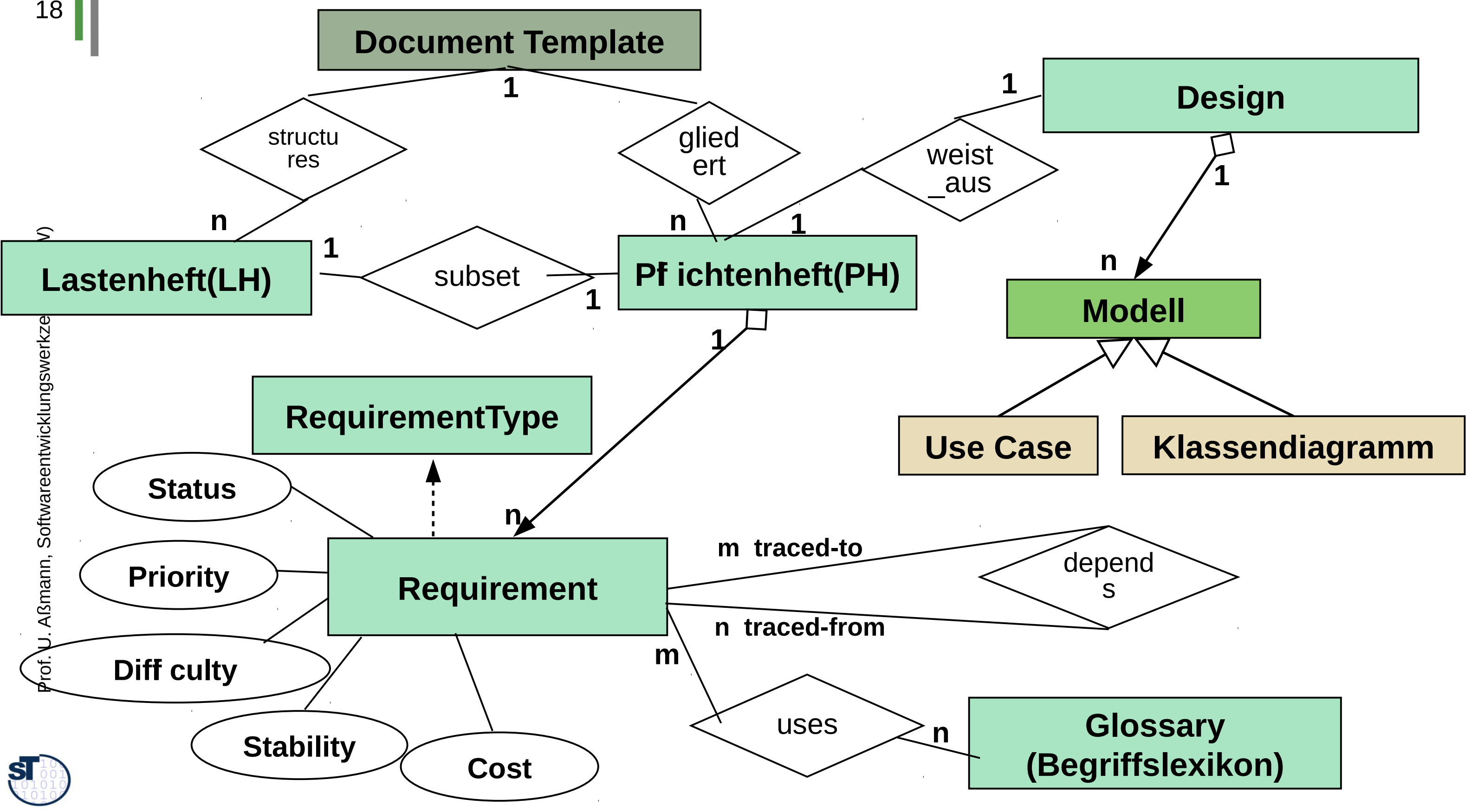
Formalizing Requirement Texts

- If requirements are entered in Word text, they can be **formalized by text mining** with
  - Verb-noun-analysis
  - Keyword identification: MUST, MAY, SHALL, SHOULD, WILL, CUSTOMER
  - Markup information, such as section headers, emphasizing, etc.
  - Concept recognition by looking up nouns in domain models (glossaries, taxonomies, ontologies)
- Requirements can also be recognized from Word tables [RPro]

Traceability with Model Mappings

- The Traceability Matrix connects and relates requirements by **direct traces** and **indirect traces** over **trace_to** and **trace_from** relationships
  - The trace relationship is a model mapping within the requirements model
  - External projects can be imported, and traces to their public requirements can be defined
- Direct traces are entered
  - into a form
  - into the corresponding bitfield of the traceability matrix
- If somebody changes the requirements later, the trace links become **suspect** and should be checked

Begriffe des Requirements Managements in RequisitePro



Tools

CaliberRM	Borland	http://www.borland.com/us/products/caliber/index.aspx
DOORS	IBM	http://www-01.ibm.com/software/awdtools/doors/ http://www.docstoc.com/docs/90794258/Getting-the-most-out-of-DOORS-for-requirements---NJIT-Computer
Siehe auch Test Tools		

70.3 Ontology-Driven Requirements Engineering (ODRE)

Uwe Aßmann[1], Katja Siegemund[1], Edward J. Thomas[2],
Jeff Pan[2], Yuting Zhao[2]

1 Technische Universität Dresden, Germany

2 University of Aberdeen, UK

SWESE Oct 24, 2011

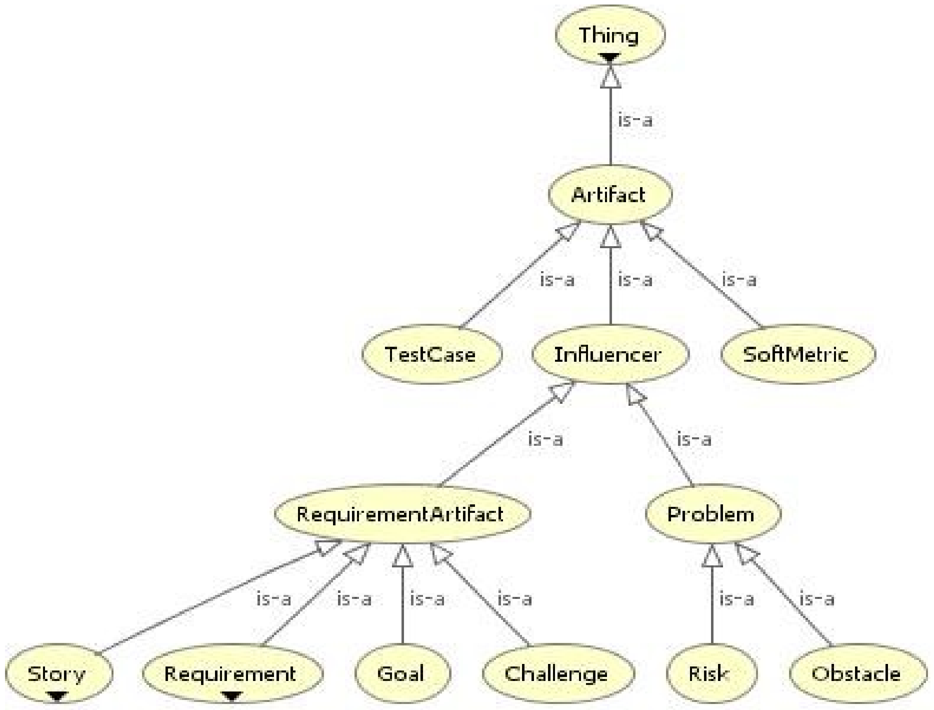
Why Ontology-Driven Requirements Engineering (ODRE)?

- Use graph-logic isomorphism to store requirements and their requirement types in logic, more precisely, in an OWL ontology
  - Provide a metamodel (T-Box of requirements ontology) with a huge set of relevant metadata and requirement relationships
- Use reasoning services to
  - provide meaningful checks for completeness and consistency, e.g., as queries to the A-Box with SparQL
  - Make specific suggestions to repair inconsistencies and incompleteness
- Ontology consists of T- and A-Box
  - TBox (Terminological Box) provides metadata
  - ABox (Axiom Box, Fact Base) provides requirements, goals, relationships,...

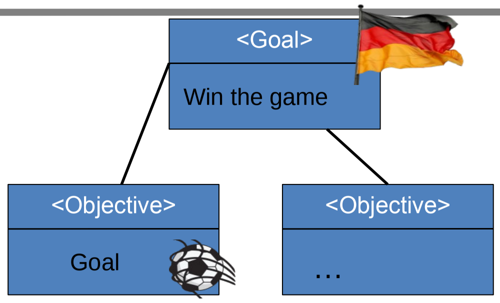
ODRE Needs Goal-Oriented RE (GORE)

- Lamsweerde defines **goals** as "declarative statements of intent to be achieved by the system under consideration" [Lamsweerde2000]
- Benefits of explicit specification of goals in GORE:
  - Goals drive the identification of requirements
  - Goals provide a criterion for sufficient completeness of a requirement specification
    - Specification of pertinent requirements
    - Relationships between goals and requirements can help to choose the best one
  - Concrete requirements may change over time whereas goals pertain stable

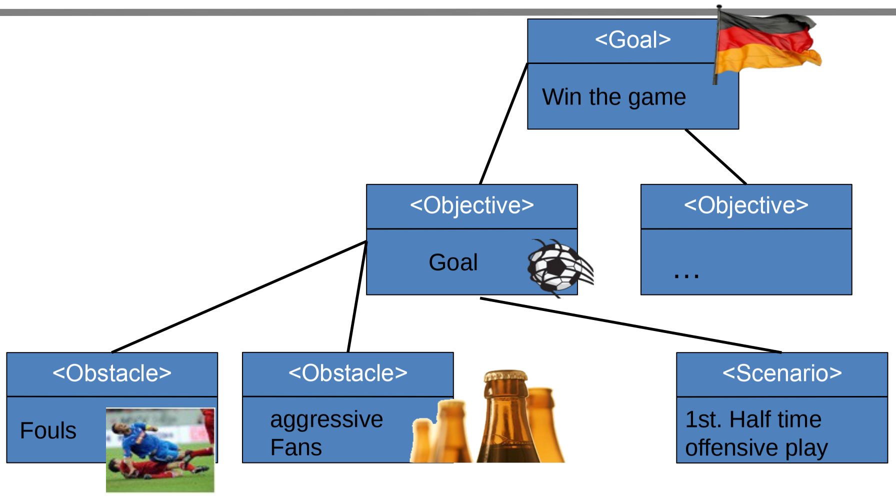
Goal-Oriented Requirements Engineering (GORE) – TBox of GORE Ontology



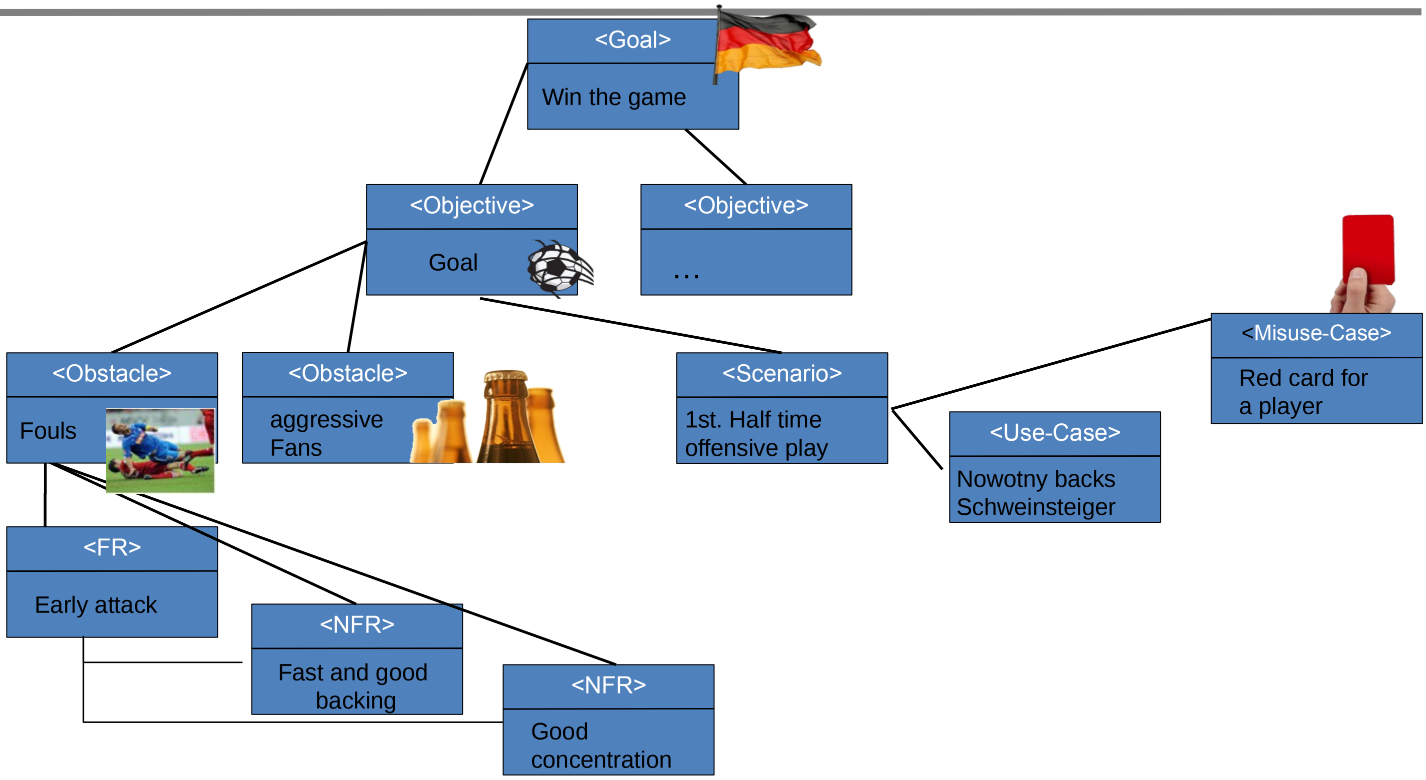
Goal-Oriented RE (Motivation Example)



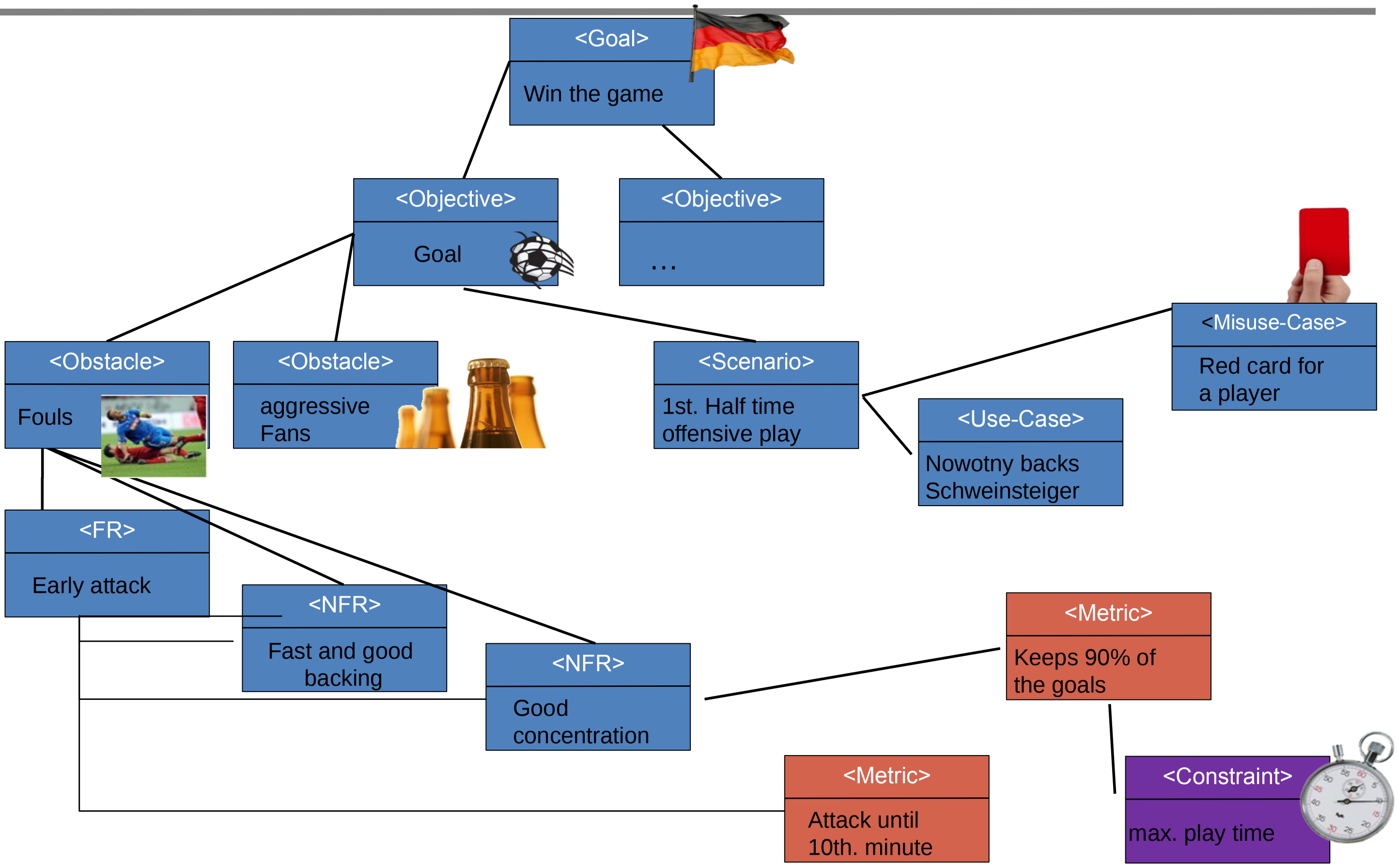
Goal-Oriented RE (Motivation Example)



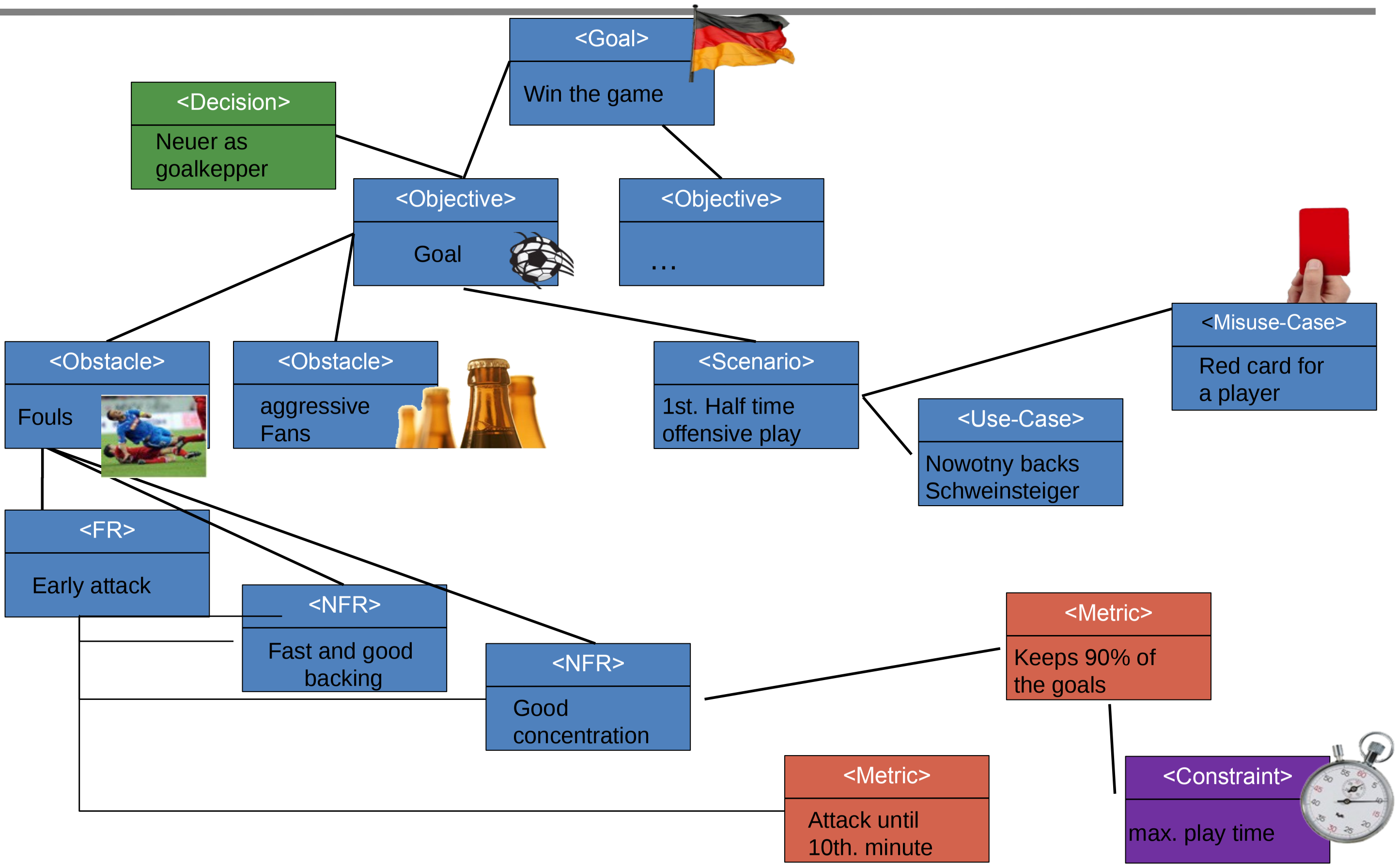
Goal-Oriented RE (Motivation Example)



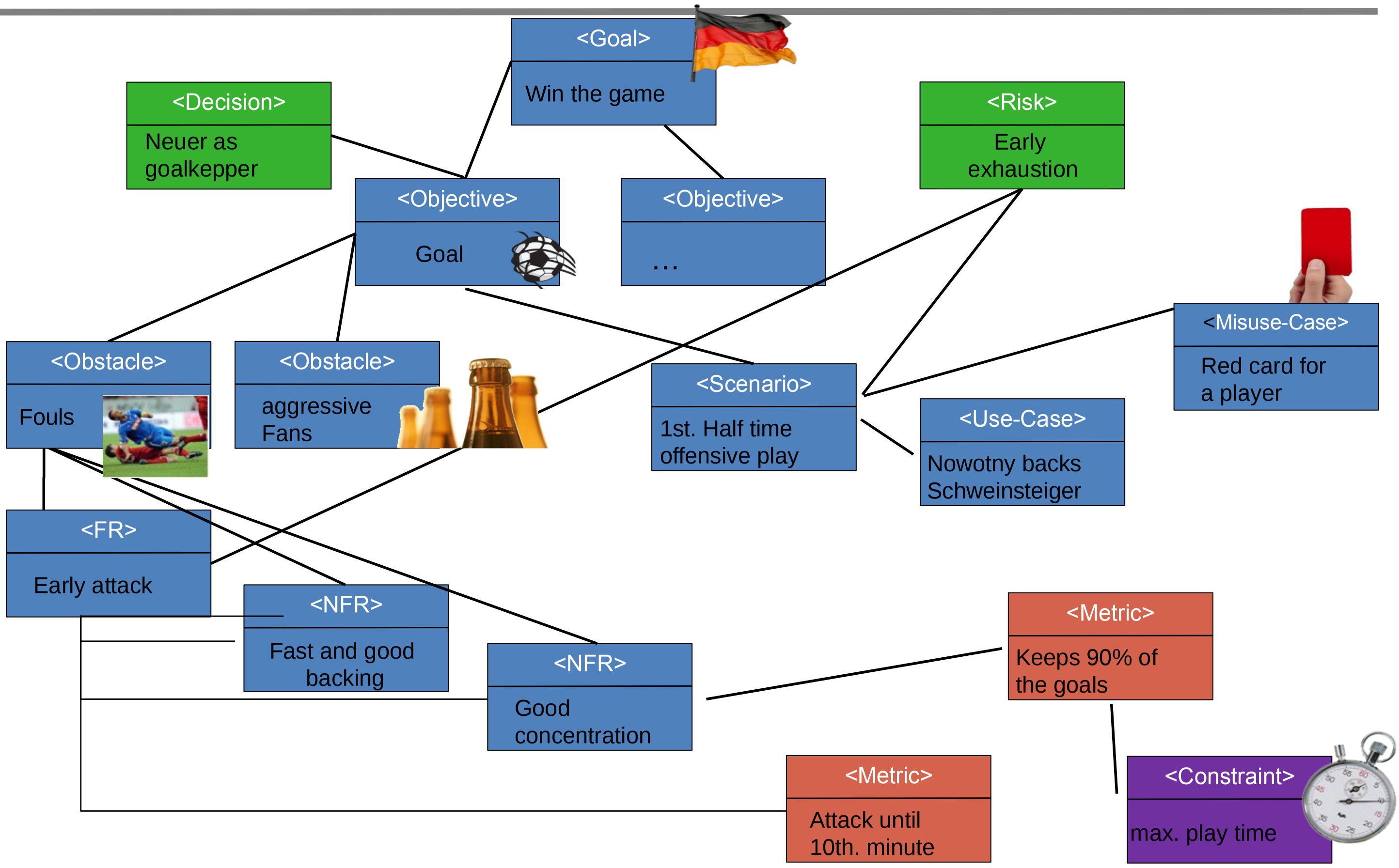
Goal-Oriented RE (Motivation Example)



Goal-Oriented RE (Motivation Example)



Goal-Oriented RE (Motivation Example)



<Goal>
Win the game

<Decision>
Neuer as goalkepper

<Risk>
Early exhaustion

<Objective>
Goal

<Objective>
…

<Misuse-Case>
Red card for a player

<Obstacle>
Fouls

<Obstacle>
aggressive Fans

<Scenario>
1st. Half time offensive play

<Use-Case>
Nowotny backs Schweinsteiger

<FR>
Early attack

<NFR>
Fast and good backing

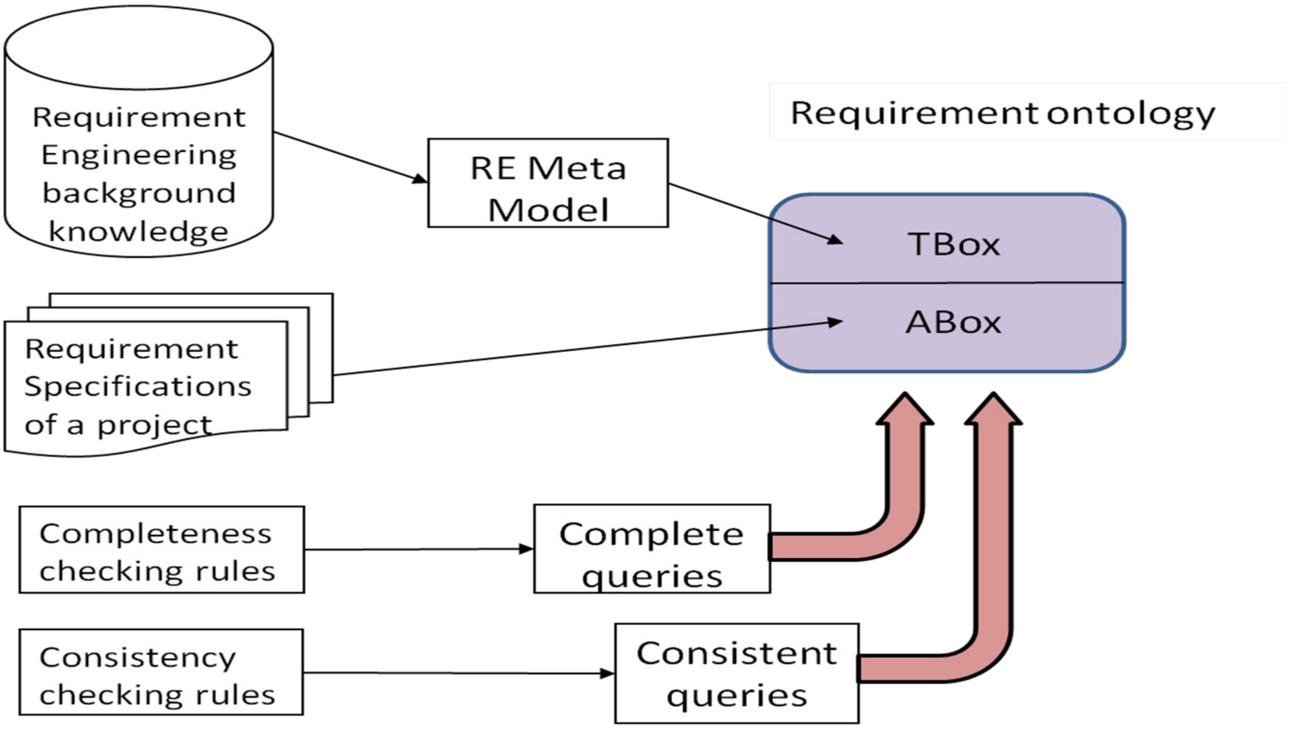
<NFR>
Good concentration

<Metric>
Keeps 90% of the goals

<Metric>
Attack until 10th. minute

<Constraint>
max. play time

Architecture for ODRE Tool



Requirement Engineering background knowledge

RE Meta Model

Requirement ontology

TBox

ABox

Requirement Specifications of a project

Completeness checking rules

Complete queries

Consistency checking rules

Consistent queries

Reasoning for RE – Completeness Check

- Example of Completeness Rule:

> “Every Functional Requirement (FR) must define whether it is mandatory or optional. ”

- The GORE ontology of Lambsweerde needs 46 completeness rules
  - Implemented as SPARQL queries on the A-Box
  - The requirements model is deemed incomplete if a specific rule fails
  - Reasoning Strategy: Closed World Reasoning (for negation as failure)
    - supported by SPARQL 1.1 and TrOWL reasoner

Reasoning for RE – Completeness Check (Example)

> “Every Functional Requirement (FR) must define whether it is mandatory or optional. ”

- SPARQL rule:

```
IF FR is NOT mandatory AND NOT optional THEN
     Print error: "You did not specify whether
       the following FRs are mandatory or optional:
       [FR_n].“
      "Please specify whether these FRs are mandatory
       or optional."
```

Reasoning for RE – Completeness Check (Example)

- Extract of individuals and relationships of the A-Box from the SPARQL analysis :

isRelatedTo(Goal2;UseCase7)
NonFunctionalRequirement (NonFunctionalRequirement1)
IsOptional(NonFunctionalRequirement1; true)
FunctionalRequirement(FunctionalRequirement1)

```
Error.
You did not specify whether the following FR are mandatory or
optional:
FunctionalRequirement1. Please specify this attribute for the FR:
FunctionalRequirement1. Every FR must specify AT LEAST ONE
requirement relationship.
```

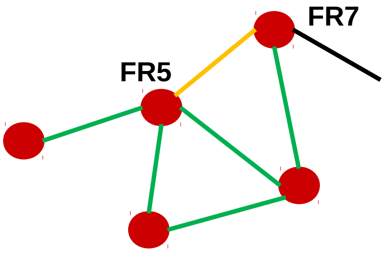
Reasoning for RE – Consistency Check

- GORE needs 6 consistency rules among requirement artefacts (valid relations between requirement artefacts)
  - Based on a chosen subset of requirement artefacts
  - Consistency rules are encoded as DL axioms in the A-Box
- Instance specific error messages resulting from validation displayed by Guidance Engine

Reasoning for RE – Consistency Check (Example)

- Extract of individuals and relationships of the A-Box from the SPARQL analysis :

isExclusionOf (FunctionalRequirement5; FunctionalRequirement7)
ChosenRequirement(FunctionalRequirement5)
ChosenRequirement(FunctionalRequirement7)



```
Error.
The following requirements exclude others:
FunctionalRequirement5.
Please choose one of the following options:

Suggestion.
Exclude the following requirements from the chosen requirement
set: FunctionalRequirement5. OR
Find alternatives for: FunctionalRequirement5 or
Revise the requirement relationships of(FunctionalRequirement5,
FunctionalRequirement7).
```

Reasoning for RE – Verification Methods (Example)

- **Consistency check of requirement selection (6 rules)**

Excluding requirements must not be included in one set.

```
IF excluding requirements are included in one set
THEN print error: "The following requirements exclude
    Others: [R_n]."
"Please choose one of the following options:
Exclude the following requirements: [R_n],
Find alternatives for [R_n] or
Revise the requirement relationships of [[R x, R y],... ]."
```

Status of ODRE

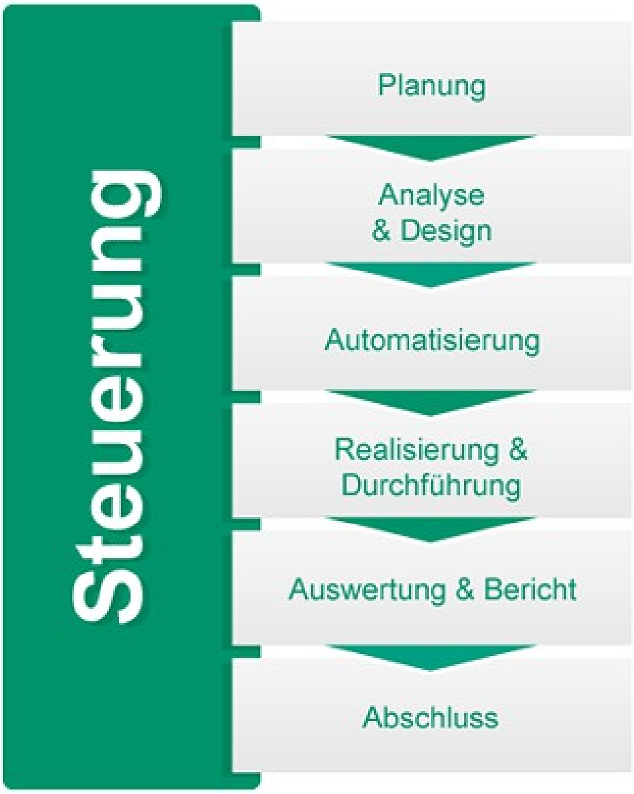
- All Requirement artefacts and meaningful relationships can be captured within an Ontology Metamodel
- ODRE Approach detects **inconsistent** and **incomplete** requirements
- Standard tooling (reasoners) are useful
  - Specification of requirements uses OWA
  - Verification needs CWA
- First evaluation proves applicability for medium requirement specifications
  - Problem: available requirement specifications do not provide sufficient information (much less than could be captured by ODRE)
  - Primary evaluation within MOST Project
    - Capture all requirement artefacts
    - Detect all inconsistencies and incomplete metadata
  - Main evaluation planned for PhD Thesis of Katja Siegemund (2012)

70.4 Traceability to other Artefacts

Direct Traceability

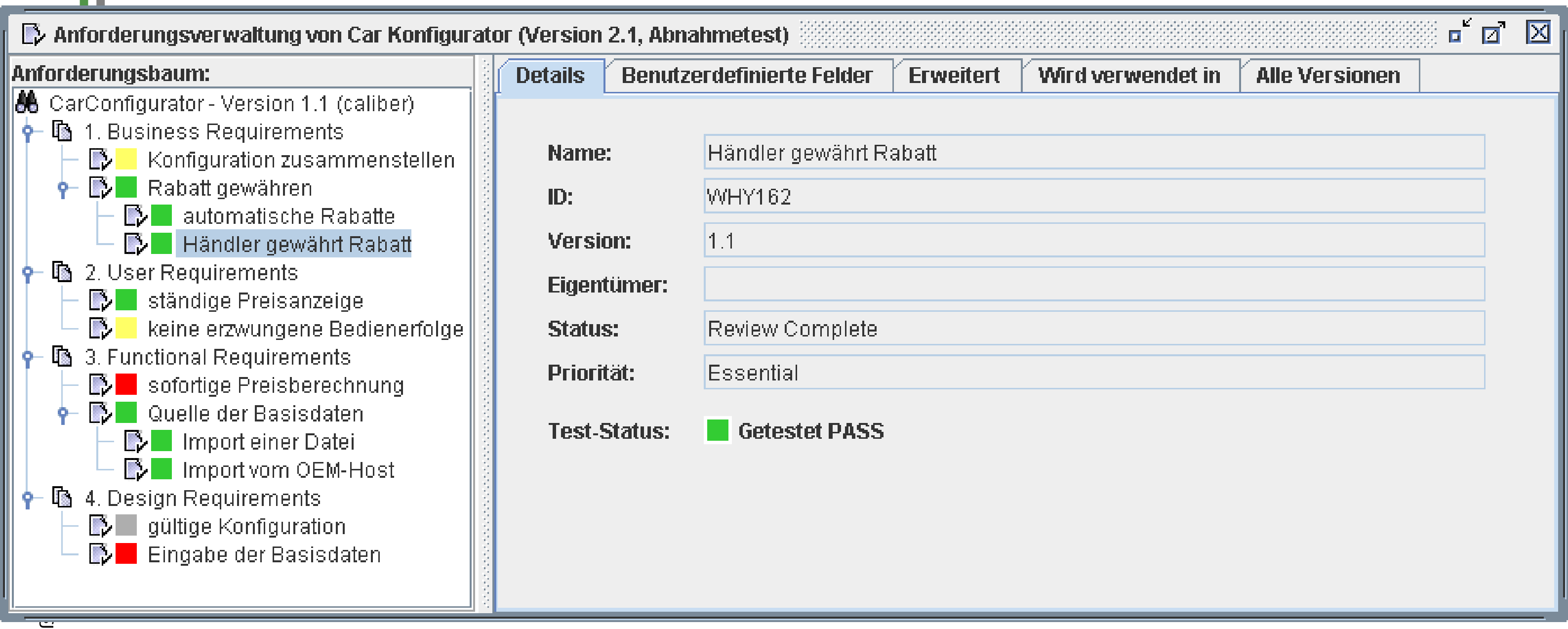
- With a **direct model mapping**, a requirements model can be linked
  - to a test case specification
  - to a documentation
  - to an architectural specification
  - via the architectural specification, to the classes and procedures in the code

Example: imbus TestBench



http://www.imbus.de/produkte/imbus-testbench/hauptfunktionen/

Requirements get “red-yellow-green” Test Status Attribute

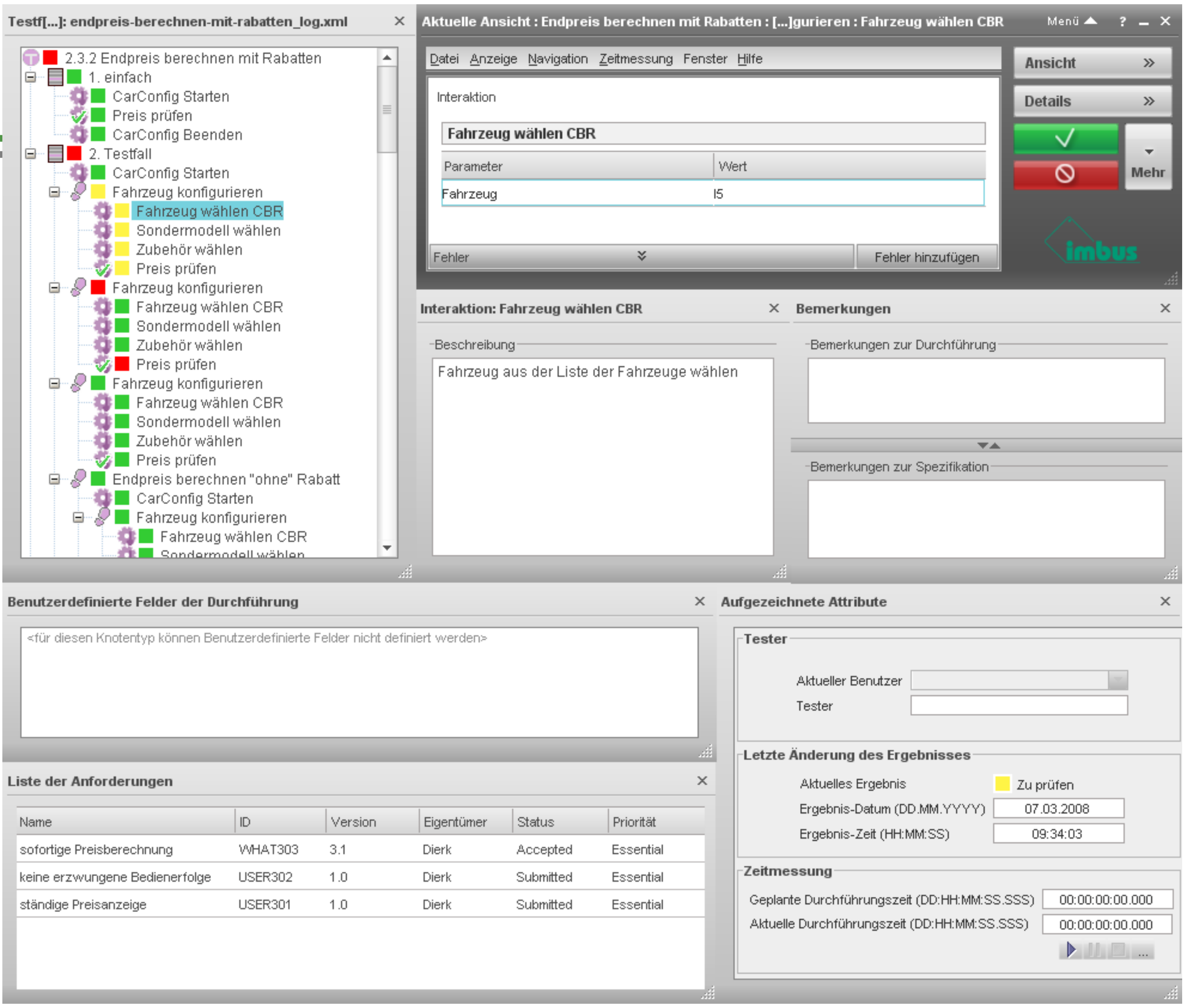


Anforderungsverwaltung von Car Konfigurator (Version 2.1, Abnahmetest)

Anforderungsbaum:

- CarConfigurator - Version 1.1 (caliber)
  - 1. Business Requirements
    - 🟨 Konfiguration zusammenstellen
    - 🟩 Rabatt gewähren
      - 🟩 automatische Rabatte
      - 🟩 Händler gewährt Rabatt
  - 2. User Requirements
    - 🟩 ständige Preisanzeige
    - 🟨 keine erzwungene Bedienerfolge
  - 3. Functional Requirements
    - 🟥 sofortige Preisberechnung
    - 🟩 Quelle der Basisdaten
      - 🟩 Import einer Datei
      - 🟩 Import vom OEM-Host
  - 4. Design Requirements
    - ⬜ gültige Konfiguration
    - 🟥 Eingabe der Basisdaten

Name:	Händler gewährt Rabatt
ID:	WHY162
Version:	1.1
Eigentümer:	
Status:	Review Complete
Priorität:	Essential
Test-Status:	🟩 Getestet PASS



Testf[...]: endpreis-berechnen-mit-rabatten_log.xml

- 🟥 2.3.2 Endpreis berechnen mit Rabatten
  - 🟩 1. einfach
    - 🟩 CarConfig Starten
    - 🟩 Preis prüfen
    - 🟩 CarConfig Beenden
  - 🟥 2. Testfall
    - 🟩 CarConfig Starten
    - 🟨 Fahrzeug konfigurieren
      - 🟨 Fahrzeug wählen CBR
      - 🟨 Sondermodell wählen
      - 🟨 Zubehör wählen
      - 🟨 Preis prüfen
    - 🟥 Fahrzeug konfigurieren
      - 🟩 Fahrzeug wählen CBR
      - 🟩 Sondermodell wählen
      - 🟩 Zubehör wählen
      - 🟥 Preis prüfen
    - 🟩 Fahrzeug konfigurieren
      - 🟩 Fahrzeug wählen CBR
      - 🟩 Sondermodell wählen
      - 🟩 Zubehör wählen
      - 🟩 Preis prüfen
    - 🟩 Endpreis berechnen "ohne" Rabatt
      - 🟩 CarConfig Starten
      - 🟩 Fahrzeug konfigurieren
        - 🟩 Fahrzeug wählen CBR
        - Sondermodell wählen

Aktuelle Ansicht : Endpreis berechnen mit Rabatten : [...]gurieren : Fahrzeug wählen CBR

Interaktion

Fahrzeug wählen CBR

Parameter	Wert
Fahrzeug	I5

Interaktion: Fahrzeug wählen CBR

Beschreibung

Fahrzeug aus der Liste der Fahrzeuge wählen

Bemerkungen

Bemerkungen zur Durchführung

Bemerkungen zur Spezifikation

Benutzerdefinierte Felder der Durchführung

<für diesen Knotentyp können Benutzerdefinierte Felder nicht definiert werden>

Liste der Anforderungen

Name	ID	Version	Eigentümer	Status	Priorität
sofortige Preisberechnung	WHAT303	3.1	Dierk	Accepted	Essential
keine erzwungene Bedienerfolge	USER302	1.0	Dierk	Submitted	Essential
ständige Preisanzeige	USER301	1.0	Dierk	Submitted	Essential

Aufgezeichnete Attribute

Tester

Aktueller Benutzer	
Tester	

Letzte Änderung des Ergebnisses

Aktuelles Ergebnis	🟨 Zu prüfen
Ergebnis-Datum (DD.MM.YYYY)	07.03.2008
Ergebnis-Zeit (HH:MM:SS)	09:34:03

Zeitmessung

Geplante Durchführungszeit (DD:HH:MM:SS.SSS)	00:00:00:00.000
Aktuelle Durchführungszeit (DD:HH:MM:SS.SSS)	00:00:00:00.000

The End