*L3 Mention Informatique*
*Parcours Informatique et MIAGE*

# Génie Logiciel Avancé - Advanced Software Engineering

## From Analysis to Design

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# Plan of the Chapter

- Introduction: The Role of Design
- Objectives of the Design Phase
  - capturing non-functional requirements
  - refining functional aspects
  - linking decisions, tracing requirements
- Techniques

# The Role of the Design Phase

- Transition from an analysis model to a collection of more detailed, more executable, more explicit models
- Shift of Focus
  - Analysis: Understanding the Requirements Documents (Cahier de Charge)
  - Design: Understanding the Implementation and the specific constraints resulting from technology choices (programming language, frameworks, libraries, protocols, … )
- Producing more refined UML models dor documentation

# The Objectives of Design (1)

- Taking « non-functional » requirements into account :
    - legal constraints, technical norms
    - security
    - performance
    - robustness
    - synchronization

  ☞ Adding technical classes and methods
- Instantiating architectural schemata
  (design patterns, N-tier architectures)
- Reuse of «Components Off The Shelf » (COTS)
- for classes and packages

  ☞ interface code might be necessary

  ☞ component tests to provide !

# The Objectives of Design (2)

- Implementing Class/Use-Case/Sequence/ State-Chart/Architecture Diagrams
  - Introducing algorithmic aspects
  - Refining/detailing component interactions (interfaces)
  - Choice classes and methods implementing interactions
  - Choice of implementation language/technology
  - Coping with limitations:

☞ Inheritance ? Simple or multiple ?

☞ Visibility rules ?

☞ Exceptions

☞ Libraries ? Number Representations
(integer? longint? multi-precision?)

# Refining Class Diagrams

- Adding technical classes and methods
  - arithmetic operations (int, longint, multi-precision ints ?)
  - date representations
  - classes for protocols (streams ? sockets ? VPN ?  web-protocols ?)
  - classes for standard solutions
    (package for credit-card payment, ...)
  - synchronization protocols for data
    in distributed systems

# Refining Class Diagrams

- Adding technical classes and methods
  - Reuse of «Components Off The Shelf » (COTS)
  - additional classes and operations for interface code (example: “communication layer” abstracting “POSIX”, ... “data-base layer” abstracting “mySql”, ...)
  - Provide tests for interfaces of COTS components to understand their behaviour in corner cases

# The Objectives of Desig (3)

- Systematics:
  - Documenting the design choices
  - Tracing  choices wrt. requirements / cahier de charge (doors)
  - Checking the coherence of choices,
    trying to keep the design simple
  - Writing design document, linking to analyse documents

Classes of Analysis -> Design Classes

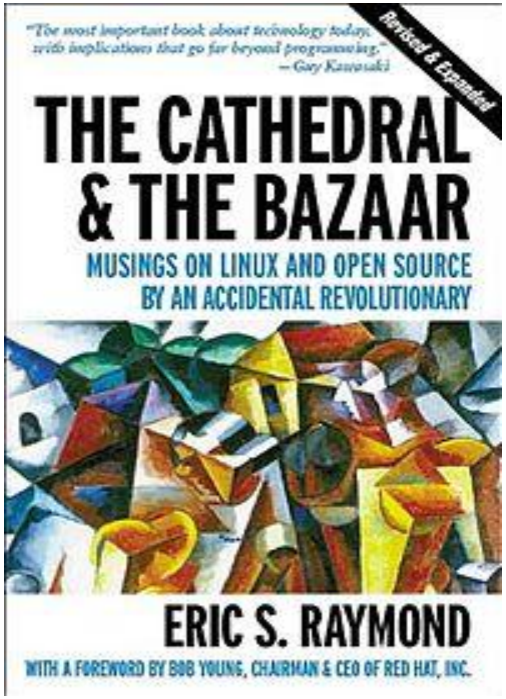
Associations of Analysis -> Attributes, methods, tables ?

Operations of Analysis -> Methods in design classes

# Context: Norms in Software Engineering

Amusing Book: Raymonds Cathedral-Bazaar

Metaphor for (Open-Source) Processes:


"The most important book about technology today, with implications that go far beyond programming." —Guy Kawasaki
Revised & Expanded
THE CATHEDRAL & THE BAZAAR
MUSINGS ON LINUX AND OPEN SOURCE BY AN ACCIDENTAL REVOLUTIONARY
ERIC S. RAYMOND
WITH A FOREWORD BY BOB YOUNG, CHAIRMAN & CEO OF RED HAT, INC.

- ... The *Cathedral* model, in which source code is available with each software release, but code developed between releases is restricted to an exclusive group of software developers. GNU Emacs and GCC are presented as examples.
- ... The *Bazaar* model, in which the code is developed over the Internet in view of the public. Raymond credits Linus Torvalds, leader of the Linux kernel project, as the inventor of this process.

# Norms for Cathedral Style

- Many attempts to control development processes and software products by standards (norms)
- Attempts to assure and certify software quality.
  - Most serious and relevant (in France):
  - DO 178B (Avionics)
  - **ISO/IEC/IEEE** 29119 (Software Test)
  - **ISO/IEC/IEEE** 15408 «Common Criteria» for computer security certification requiring formal models as well
    as proof techniques for EAL 6 and EAL 7.

# Domain Specific Safety Standards

- The following standards use SIL as a measure of reliability and/or risk reduction
  - ANSI/ISA S84 (Functional safety of safety instrumented systems for the process industry sector)
  - IEC EN 61508 (Functional safety of electrical/electronic/programmable electronic safety related systems)
  - IEC 61511 (Safety instrumented systems for the process industry sector)
  - IEC 61513 (Nuclear Industry)
  - IEC 62061 (Safety of machinery)
  - EN 50128 (Railway applications - Software for railway control and protection)
  - EN 50129 (Railway applications - Safety related electronic systems for signalling
  - EN 50402 (Fixed gas detection systems)

# Domain Specific Safety Standards

- Hard «digital» requirements arise:

  The international standard on functional safety for software development of road vehicles ISO26262-6 requires the

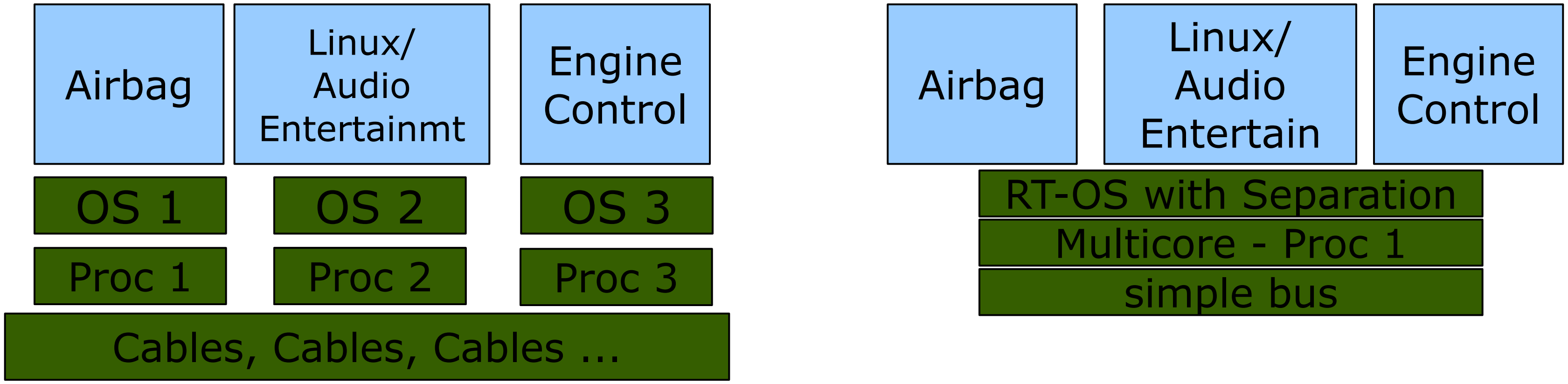
  freedom from interference by software partitioning

- Thus it is aimed at providing a trusted embedded real-time operating system, which is oriented to ECUs (Electronic Control Units) in automotive industry. (avionics similarly)

# Security vs. Architecture : Consequences

- A current industrial challenge resulting from the requirement «Freedom of interference»
  - Real-time Operating System Kernels assuring not only memory protection, but « Non-interference »

    (PikeOS, Sel4, INTEGRITY-178B, RTOS Wind River Systems… )



Airbag

Linux/ Audio Entertainmt

Engine Control

OS 1

OS 2

OS 3

Proc 1

Proc 2

Proc 3

Cables, Cables, Cables …

Airbag

Linux/ Audio Entertain

Engine Control

RT-OS with Separation

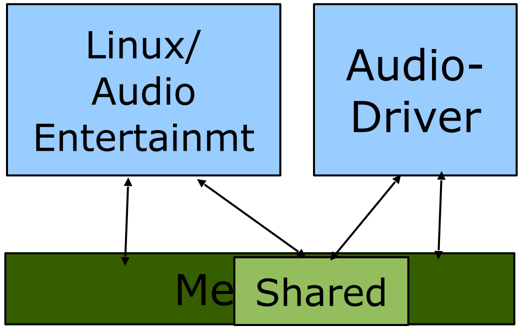
Multicore - Proc 1

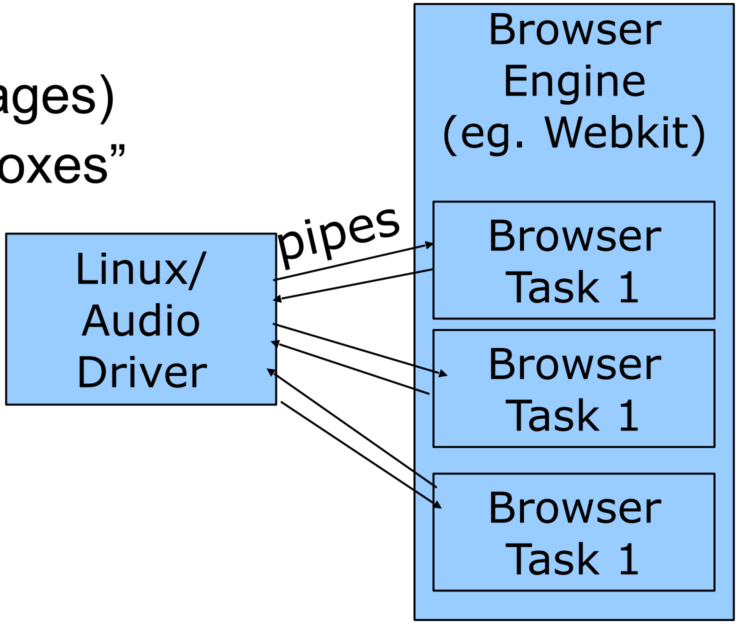
simple bus

# Robustness vs. Efficiency : Consequences

- Communication between components
  - Pipe-Communication

    (flexible, compatible with dynamic process creation)
  - Shared-Memory Communication
    (fast, but rigid wrt. component-architecture)
  - message-passing
    (very fast, but only for small messages)
  - synchronous/asynchronous "mailboxes"



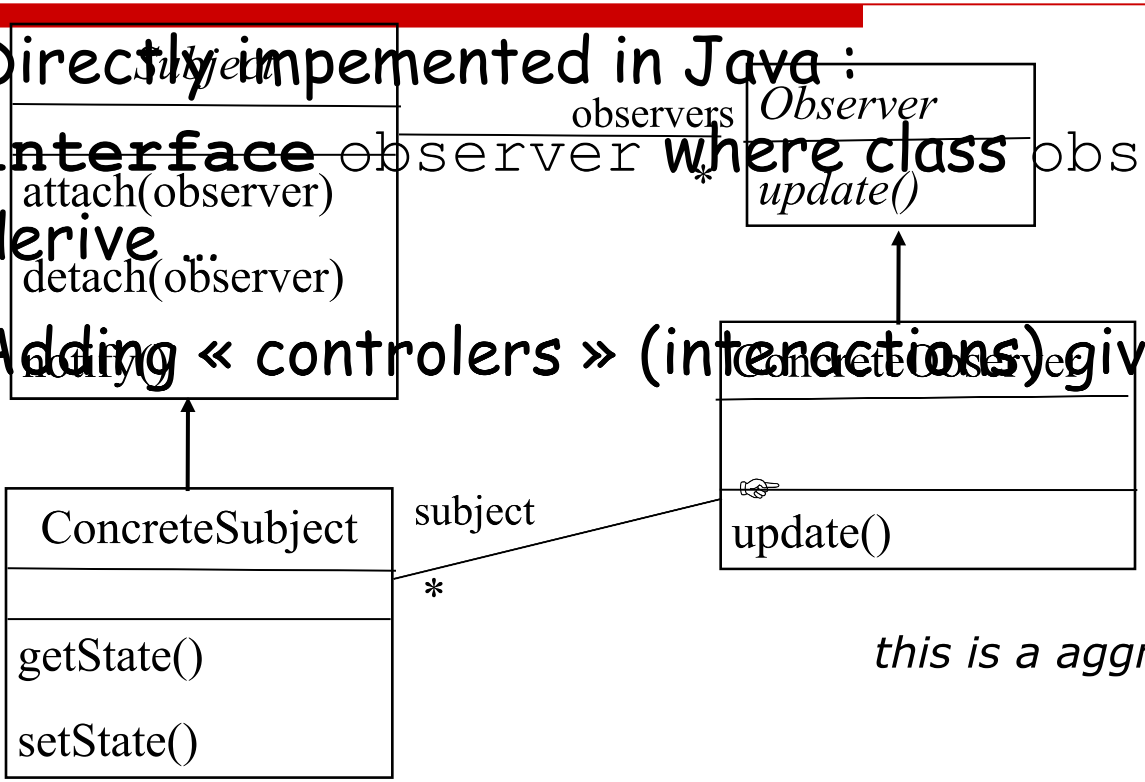


# Example Design Patterns : « Observer »

- **Objective**: Maintain coherence of different « **views** » of a piece of data;
- **Motivation**: decoupling management of an objet and its use in different components
  - an observer can observe several objects ; this list can dynamically change
  - an observed object can be target of several observers; this list can dynamically change
- **Collaborations**:
  - an observer registers for the observed object
  - the observed object notifies his registerd observers
  - the observer can store specificinformation in the observed object

# Example Design Patterns : « Observer »

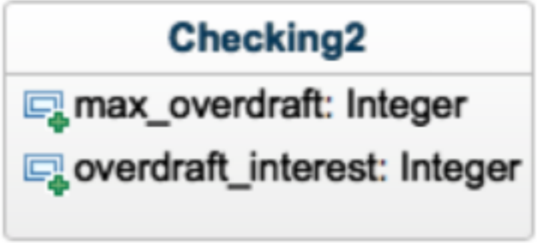
- Directly impemented in Java : **interface** observer where class observable is to derive …
- Adding « controlers » (interactions) gives MVC.



*this is a aggregation in practice*

# Refining Class Diagrams

- Fixing (Arithmetic) implementation types



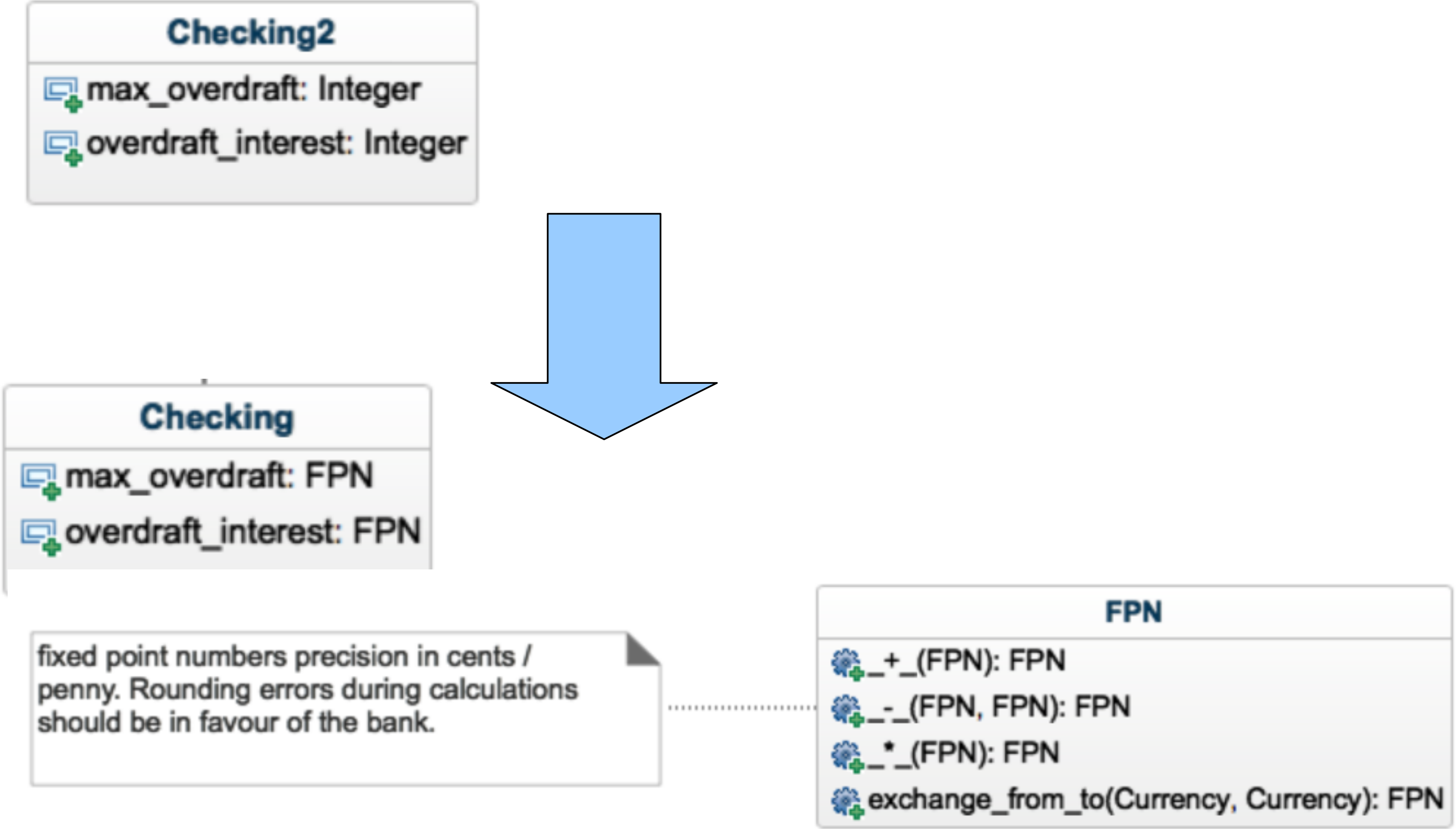
**Checking2**

max_overdraft: Integer

overdraft_interest: Integer

# Refining Class Diagrams

- Fixing (Arithmetic) implementation types



**Checking2**

max_overdraft: Integer

overdraft_interest: Integer

**Checking**

max_overdraft: FPN

overdraft_interest: FPN

fixed point numbers precision in cents / penny. Rounding errors during calculations should be in favour of the bank.

**FPN**

_+_(FPN): FPN

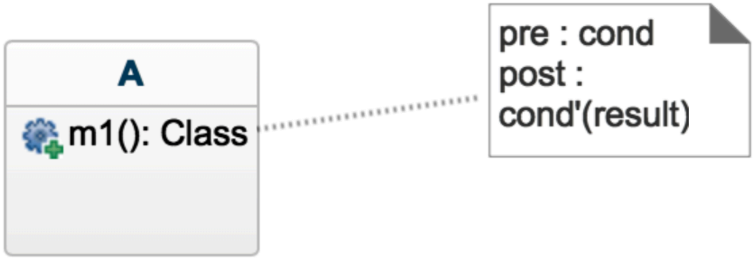
_-_(FPN, FPN): FPN

_*_(FPN): FPN

exchange_from_to(Currency, Currency): FPN

# Refining Class Diagrams

- Totalizing operation contracts with exceptions



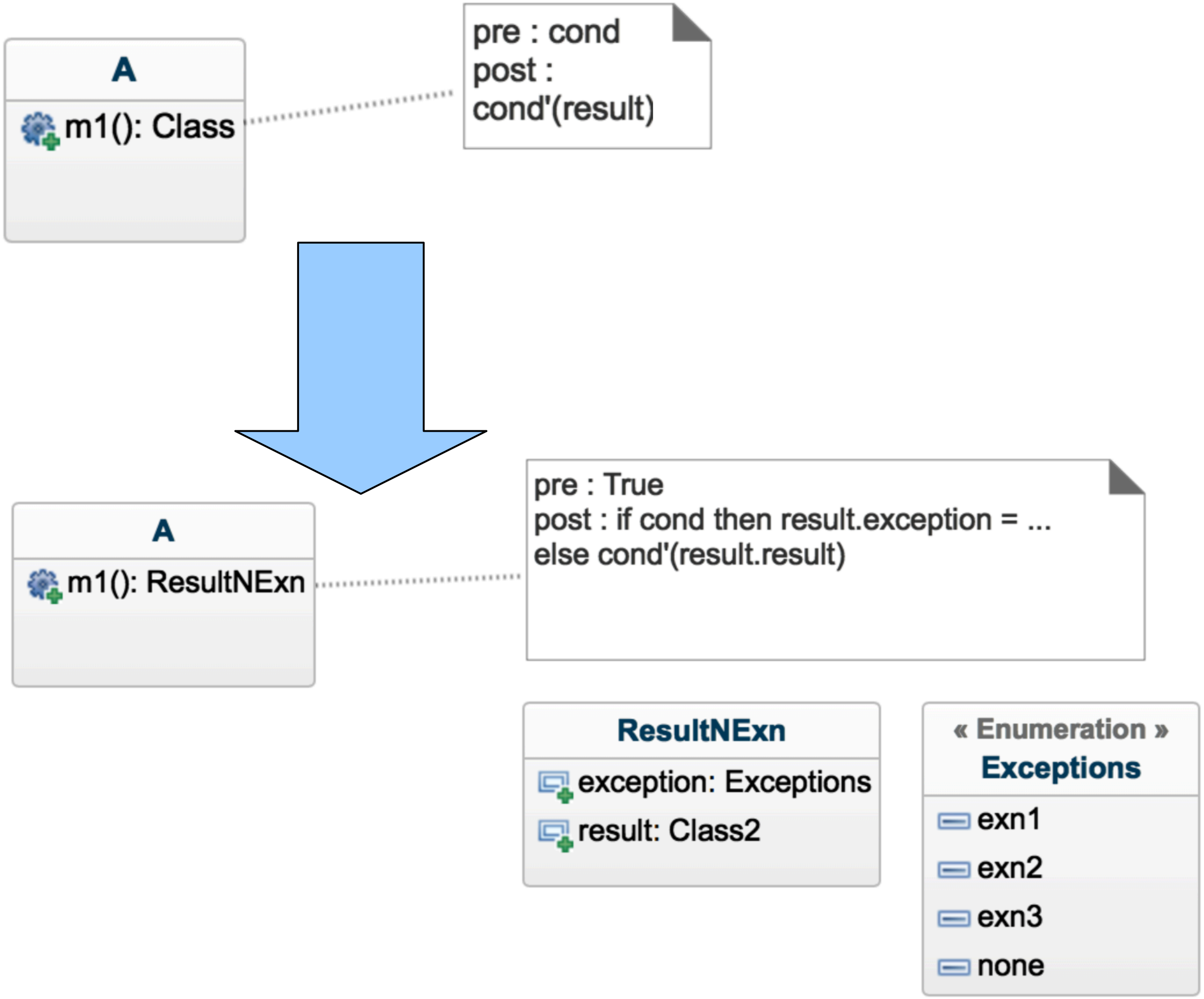
A

m1(): Class

pre : cond
post :
cond'(result)

# Refining Class Diagrams

- Totalizing operation contracts with exceptions



A

m1(): Class

pre : cond
post :
cond'(result)

A

m1(): ResultNExn

pre : True
post : if cond then result.exception = ...
else cond'(result.result)

ResultNExn

exception: Exceptions

result: Class2

« Enumeration »
Exceptions

exn1

exn2

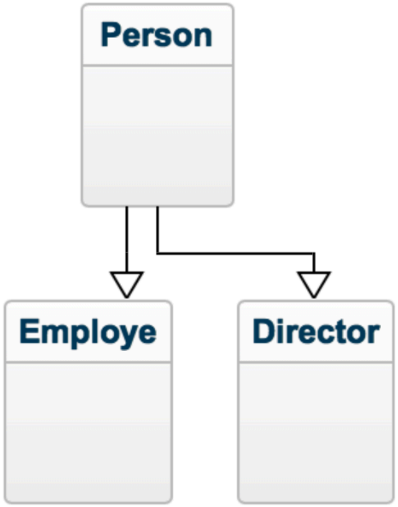
exn3

none

# Refining Class Diagrams

- Expressing Inheritance
  - ... because the target language doesn't support it
  - ... because the instance shouldn't loose its identity

  when  changes



# Refining Class Diagrams

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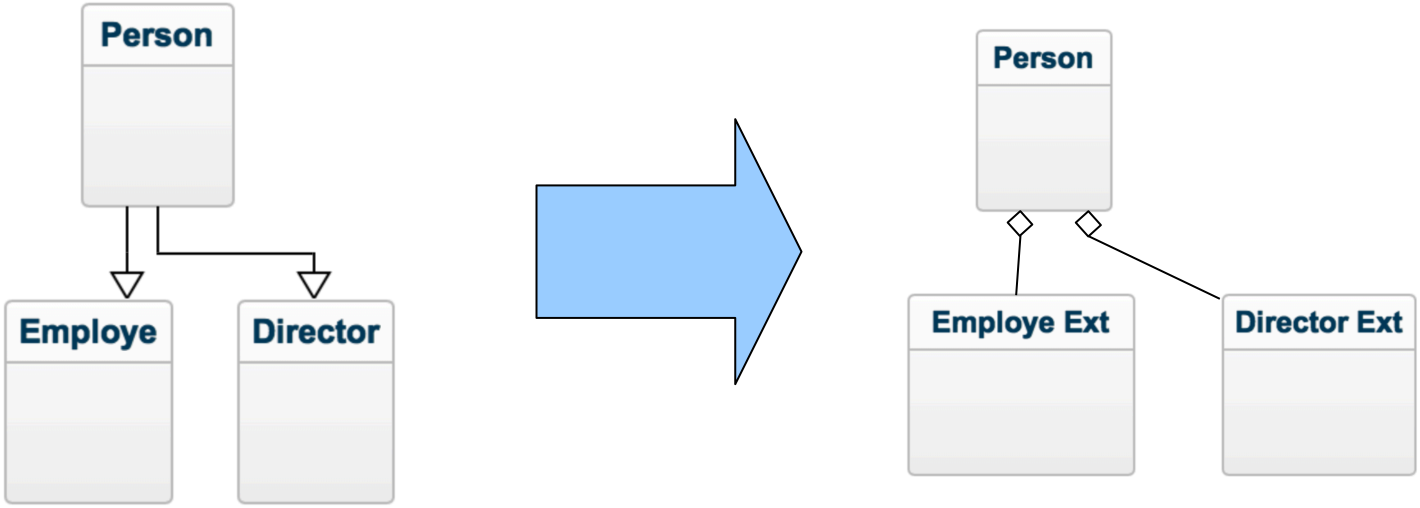

# Refining Class Diagrams

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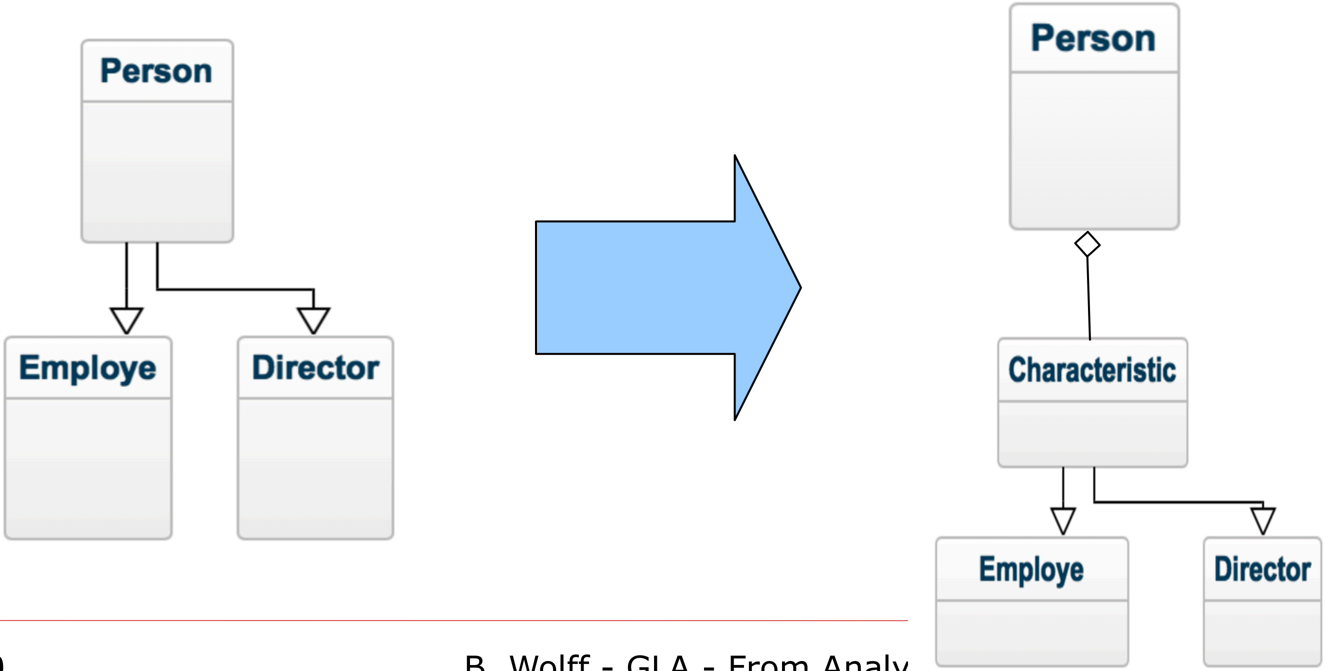
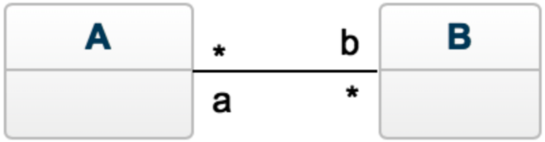


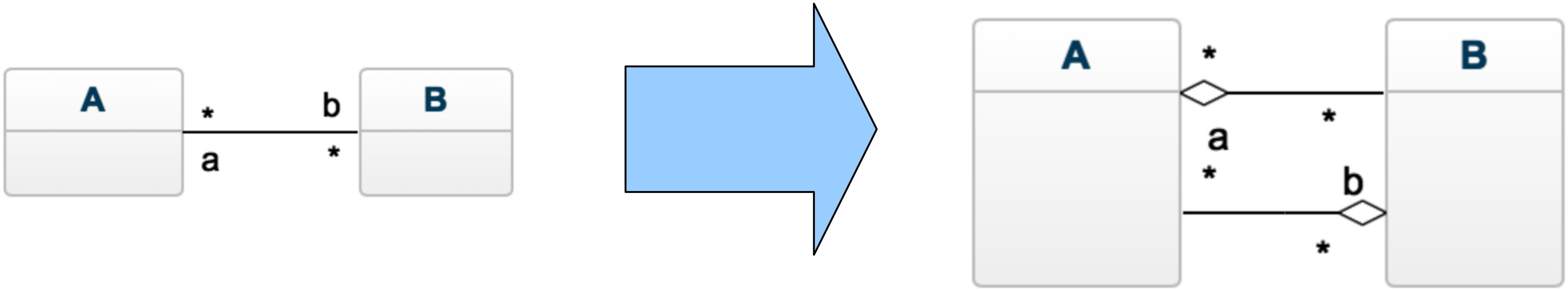
# Refining Class Diagrams

- Implementing Associations
  - ... depends on cardinality (1 ? * ? 1..5 ?)
  - ... depends on type (set ? multiset ? list ? )



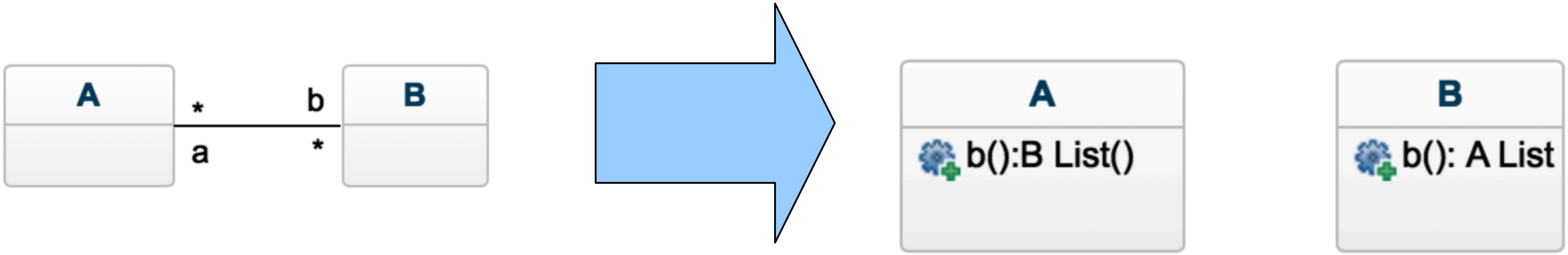
# Refining Class Diagrams

- Implementing Associations
  - ... depends on cardinality (1 ? * ? 1..5 ?)
  - ... depends on type (set ? multiset ? list ? )
  - ... as mutually linked lists (or arrays) of references



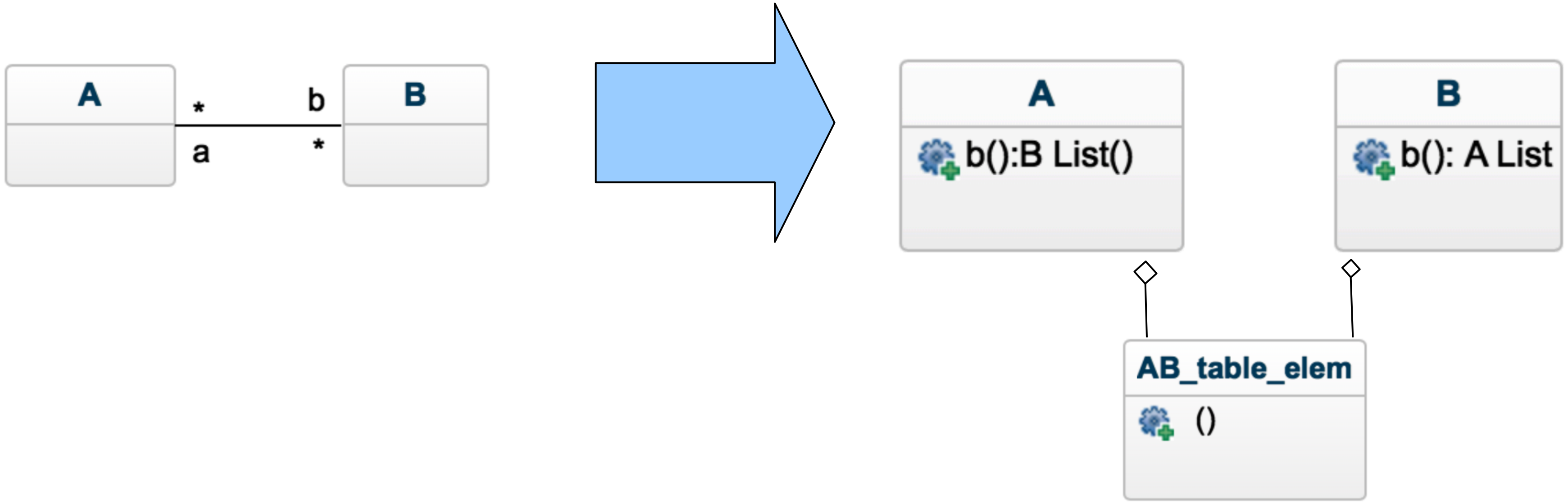
# Refining Class Diagrams

- Implementing Associations
  - ... depends on cardinality (1 ? * ? 1..5 ?)
  - ... depends on type (set ? multiset ? list ? )
  - ... as recomputing methods ...



# Refining Class Diagrams

- Implementing Associations
  - ... depends on cardinality (1 ? * ? 1..5 ?)
  - ... depends on type (set ? multiset ? list ? )
  - ... as recomputing methods using an index table



# Tracing Requirements

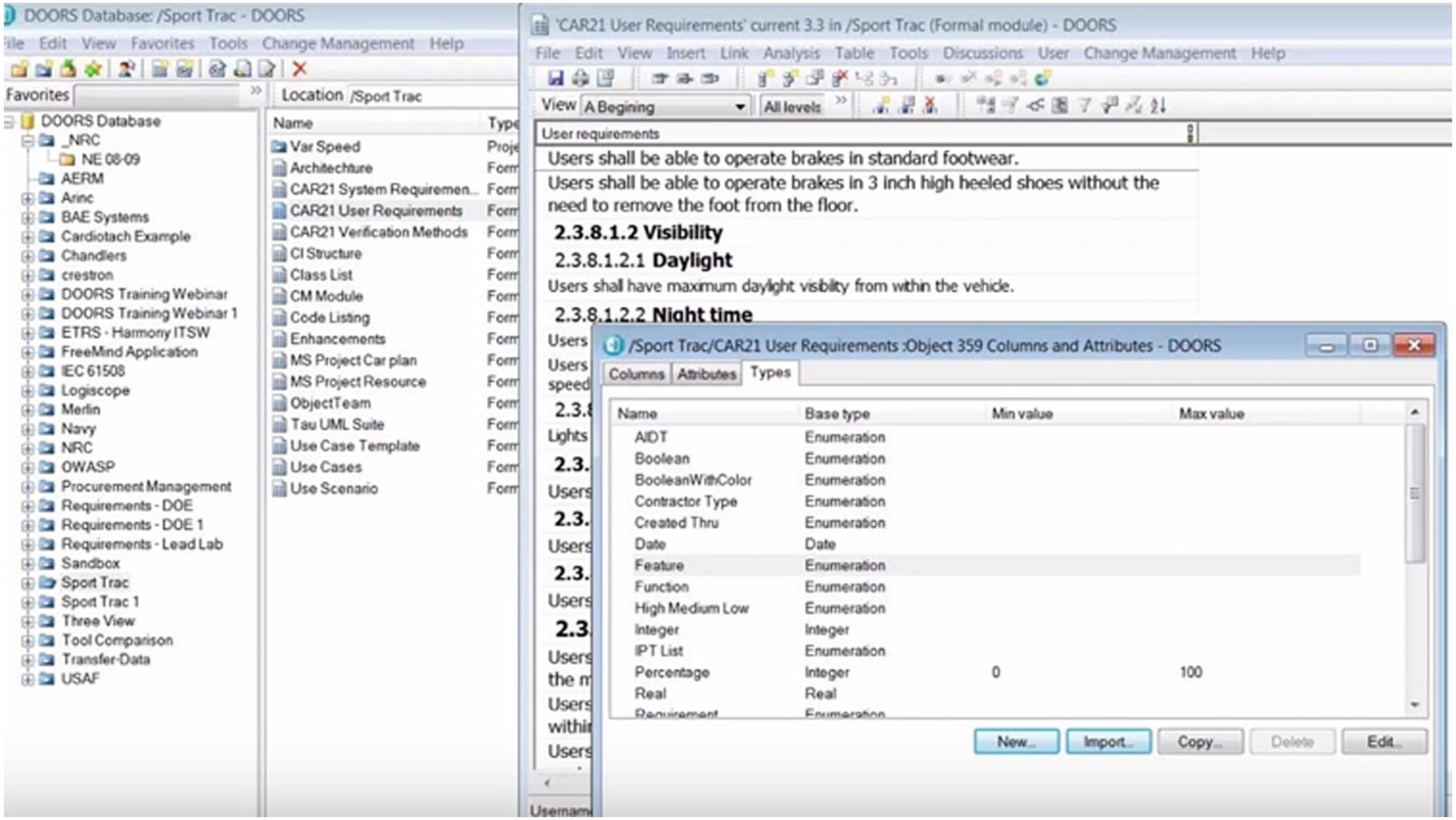
- Tracing requirements from CDC over Analysis and Design  Milestones is mandatory in many certification processes
- Technical Solution:
  - **Rational Dynamic Object Oriented Requirements System (DOORS) client–server application, with a Windows-only client and servers for Linux, Windows, and Solaris.**
  - **There is also a web client, DOORS Web Access.**
  - **For example, it is common practice to capture verification relationships to demonstrate that a requirement is verified**

  **by a certain test artefact.**
  - **DOORS comes with an own modeling language allowing to**

  **generate UML diagrams**
  - **https://www.ibm.com/de-de/marketplace/requirements-management/details**

# Tracing Requirements

- DOORS screenshot


File Edit View Favorites Tools Change Management Help
Favorites
Location /Sport Trac
Name
Type
File Edit View Insert Link Analysis Table Tools Discussions User Change Management Help
View A Begining
All levels
Columns
Attributes
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New...
Import...
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DOORS Database: /Sport Trac - DOORS

- DOORS Database
  - _NRC
    - NE 08-09
  - AERM
  - Arinc
  - BAE Systems
  - Cardiotach Example
  - Chandlers
  - crestron
  - DOORS Training Webinar
  - DOORS Training Webinar 1
  - ETRS - Harmony ITSW
  - FreeMind Application
  - IEC 61508
  - Logiscope
  - Merlin
  - Navy
  - NRC
  - OWASP
  - Procurement Management
  - Requirements - DOE
  - Requirements - DOE 1
  - Requirements - Lead Lab
  - Sandbox
  - Sport Trac
  - Sport Trac 1
  - Three View
  - Tool Comparison
  - Transfer-Data
  - USAF

| Name | Type |
|---|---|
| Var Speed | Proje |
| Architechture | Form |
| CAR21 System Requiremen... | Form |
| CAR21 User Requirements | Form |
| CAR21 Verification Methods | Form |
| CI Structure | Form |
| Class List | Form |
| CM Module | Form |
| Code Listing | Form |
| Enhancements | Form |
| MS Project Car plan | Form |
| MS Project Resource | Form |
| ObjectTeam | Form |
| Tau UML Suite | Form |
| Use Case Template | Form |
| Use Cases | Form |
| Use Scenario | Form |

'CAR21 User Requirements' current 3.3 in /Sport Trac (Formal module) - DOORS

User requirements

Users shall be able to operate brakes in standard footwear.

Users shall be able to operate brakes in 3 inch high heeled shoes without the need to remove the foot from the floor.

**2.3.8.1.2 Visibility**

**2.3.8.1.2.1 Daylight**

Users shall have maximum daylight visibilty from within the vehicle.

**2.3.8.1.2.2 Night time**

/Sport Trac/CAR21 User Requirements :Object 359 Columns and Attributes - DOORS

| Name | Base type | Min value | Max value |
|---|---|---|---|
| AIDT | Enumeration | | |
| Boolean | Enumeration | | |
| BooleanWithColor | Enumeration | | |
| Contractor Type | Enumeration | | |
| Created Thru | Enumeration | | |
| Date | Date | | |
| Feature | Enumeration | | |
| Function | Enumeration | | |
| High Medium Low | Enumeration | | |
| Integer | Integer | | |
| IPT List | Enumeration | | |
| Percentage | Integer | 0 | 100 |
| Real | Real | | |
| Requirement | Enumeration | | |

# Conclusion

- Refinement of the Analysis docs
- Objectives of the Design Phase
  - capturing non-functional requirements
  - refining functional aspects
  - linking decisions, tracing requirements
- Techniques numerous, and depend on chosen target languages / technologies