Telelogic

2004

User Group Conference

Innovation Realized

Implementing Testing with DOORS at Dräger Medical

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Implementing Testing with DOORS at Dräger Medical

The presentation gives an overview of the new DOORS based testing approach at Dräger Medical (starting from the general concept and the desired traceability, via template descriptions, up to a set of comprehensive DXL tools).

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Dräger medical Overview

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- (65% Dräger and 35% Siemens)
- 5700 employees
- Represented in more than 190 countries
- 100+ years experience in setting technology standards for the acute point of care
- The mission is to provide innovative products, services and integrated solutions that support clinical processes and enable effective and cost-efficient patient care in all CareAreasTM: from Emergency Care, the Operating Room and Anesthesia on to Critical Care, Perinatal Care and Home Care.
- Such as: Ventilation, Monitoring, Anesthesia, IT-Systems, Incubators and Oxygen/Sleep Therapy.

Zeus Overview
(Anesthesia Workplace System)

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- First networked Anesthesia Expert System
- Incorporates Patient Monitoring, full ventilator control and anesthetic drug delivery with „AutoPilot“ functions
- First touch screen controlled Anesthesia System
- First complete PC controlled system (6 different processor systems)
- 5 years of development time
- Up to 50 engineers working on the project.
- Several new patents were written

Dr. Bernd GRAHLMANN Overview

- Requirements Management and DOORS consultant / trainer:
  - *among others ~1 year for Dräger Medical*
- 3 years Global Manager for first DOORS then all of Requirements Management for General Electric Medical Systems:
  - *Responsible for all aspects of requirements management: processes and guidelines for req. mgt., validation, verification, DOORS; req. mgt and DOORS trainings (material, organization and conducting); server and client installations / upgrades, maintenance / trouble shooting; helpdesk; evangelist; internal audits; web site development; ... Worldwide and cross-modalities (~2000 engineers).*
- 6 years Project Manager / Director:
  - *Responsible for the PEP project: Software tool for modeling, simulation and verification of parallel systems; 500,000 lines of code, 30 developers.*

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Context / Scope

- As a manufacturer of medical devices for anesthesia and intensive care Dräger Medical is highly regulated w.r.t testing (among others by the FDA – the American Food and Drug Administration).
- Validation and verification is a major part of the development (just the Zeus V&V team consists of approximately 10 persons).
- Dräger Medical (anesthesia as well as intensive care department) was looking for an overall solution for validation as well as verification which:
  - satisfies regulations of all kind;
  - ensures proper validation and verification; and
  - is time and cost efficient.

Requirements for a 'Testing Solution' (#1)

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We started by gathering the (user) requirements on such a 'Testing Solution' in a DOORS module (of course ;-).

This DOORS module contained sections on:

- the hierarchy of test specifications / runs (in particular, the division into test cases and further down into test steps;
- information which shall be:
  - global for the test specification / run (such as: test equipment, test duration, overall test result, list of anomalies, etc.)
  - associated with test cases
    - from the test specification point of view (such as: test goal, quality status, auxiliary test equipment, expected run time, test preparation steps, test steps, etc.)
    - from the test run point of view (such as: overall status of test case run, anomalies, product, tester, date, etc.)

Requirements for a 'Testing Solution' (#2)

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  - associated with test steps
    - from the test specification point of view (such as: expected result, actual result dummy, etc.)
    - from the test run point of view (such as: actual result, status, anomalies, comments, etc.)
- Developing tests (such as: derive necessary tests from requirement; organize and reference tests; specification of test method; etc.)
- Running tests (such as: time planning; determine test equipment; determine version to be tested; determine set-up; document actual result, status, anomalies, tested configuration; etc.)
- Traceability for tests (such as: determine tests to be (re-)done for requirement; determine test status for requirement; determine test runs on specific configurations; review of test results; etc.)

Requirements for a 'Testing Solution' (#3)

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- Printing / report generation
- Optimization and Re-use (such as: minimize number of tests to be run; minimize testing time; minimize number of tests run on wrong versions, etc.; minimize not relevant test results; compliance with standards and guidelines; re-use in modularity/platform/increment context; etc.)

Then, we reviewed, clarified and prioritized the requirements and goals.

Developing a 'Testing Solution' (#1)

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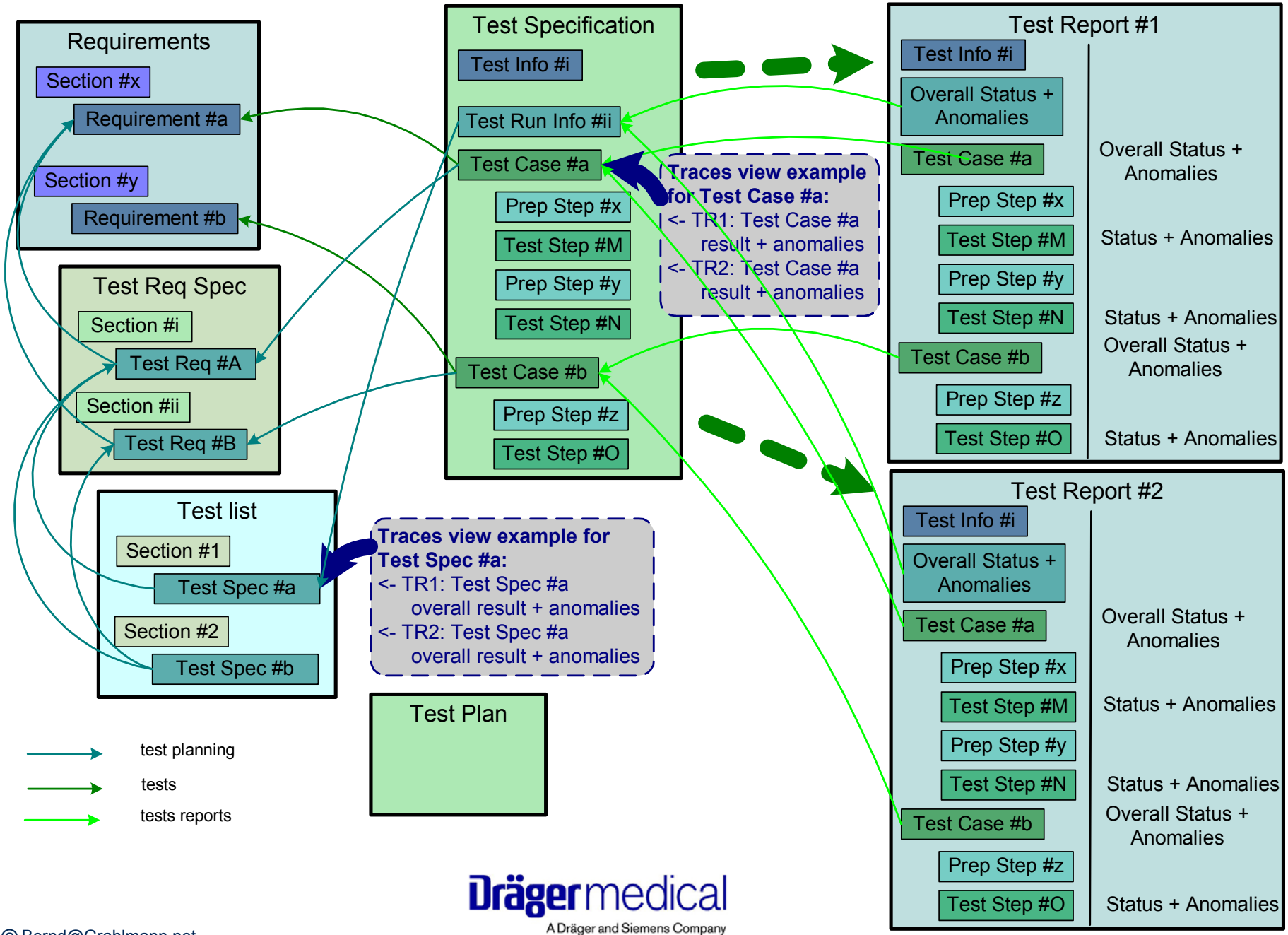
Based on the requirements / goals we then developed / proposed a 'Testing Solution':

- Using brainstorming and performing working sessions
- Using prototypes / dummies to test alternatives
- Associating solutions to the corresponding requirements (as an attribute in the DOORS module)
- Testing approaches on real test specifications



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DXL Traceability Attributes

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We developed a sophisticated DXL traceability attribute:

- analyzing two different attributes:
  - the module type - such as ***TS*** (Test Specification), ***TR*** (Test Report), ***TSR*** (Technical System Requirements), ***RMHA*** (Risk Management Hazard Analysis), etc.
  - the object type – such as ***Test Case***, ***Test Step***, ***Anomalies***, etc.
- displaying different information (in addition to the ***Module Type***, the ***Object Type***, the ***ID*** and the ***Object Heading***/***Text***) depending on their values, e.g.:
  - ***Overall Status*** and ***Anomalies*** for a ***Test Case*** Object found in a ***TR*** (Test Report).

<- TS (***Test_Case***) **Zeus.TS.Demo-180**:
Power-Down from System-Standby
<- TR (***Test_Case***) **Zeus.TR.Demo-12092004-180**:
Power-Down from System-Standby **|*Passed*|**
<- TR (***Test_Case***) **Zeus.TR.Demo-11092004-180**:
Power-Down from System-Standby **|*Failed*|** CQ-ID42

DXL Traceability
Attribute Code Extract

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```
... } else if (omodtype=="TR") {
        string ooverallresult = probeRichAttr_(linkedObject,"aPJ Overall Test Run Status", false)
        string oresult = probeRichAttr_(linkedObject,"aPJ Test Run Status", false)
        string oanomalies = probeRichAttr_(linkedObject,"aPJ Anomalies", false)
        oanomalies = clean_pard(oanomalies,"")
        string oanomaliesclassification = probeRichAttr_(linkedObject,"aPJ Anomalies Classification", false)
        string oanomaliesevaluation = probeRichAttr_(linkedObject,"aPJ Anomalies Evaluation", false)
        if (otype == "Test_Case") {
                displayRich sIndent   omodtype " ({\\b \\i " otype "}) " //
                        "{\\b " identifier(linkedObject) "}: "
                displayRich s_plus_Indent "{\\b " oheading "}" "{\\i " otext "}" //
                        "{\\b \\i |" ooverallresult "|}" "{\\i " oanomalies "}"
        } else if (otype == "Test_Step") {   // if Test_Case
                displayRich sIndent   omodtype " ({\\b \\i " otype "}) " //
                        "{\\b " identifier(linkedObject) "}: "
                displayRich s_plus_Indent "{\\b |" oanomaliesclassification "| }" //
                        "{\\i " oanomaliesevaluation "}"
        } else ...
```

Advantages of DXL Traceability Attributes

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- Main part is in a separate include file which is used by different traceability attributes (impact or trace, each time as 1, 2 or all step)
- Dräger deploys thin clients where the include file is taken from a share. Thus, an update of the include file updates all modules.
- The DXL works for modules of all kind.
- The result is nicely formatted and only contains relevant information.
- DXL attributes are much quicker than layout DXL (only re-calculated upon request – via *Tools -> Refresh DXL Attributes*).
- DXL attributes do not have scrolling problems + you can grab (copy) the text.
- DXL attributes can easily be backup'ed (via *Tools->Functions->Copy Attributes*). Thus, all traceability is recorded (and remains in baseline).
- Light-years ahead of traceability visualization in Rational's ReqPro ;-)

TS/TR Template (Test Spec Views)

The TS & TR Template has some views showing the Test Specification:

#Test Spec	= ID + main + aPJ Object Type + aPJ Expected Result
#Test Spec with 1 step trace	= ID + main + aPJ Object Type + aPJ Expected Result + aPJ DXL 1 trace
#Test Spec wth Actual Result	= ID + main + aPJ Object Type + aPJ Expected Result + aPJ Actual Result
#Test Spec with traces&impact	= ID + aPJ DXL all impact + main + aPJ Object Type + aPJ Expected Result + aPJ DXL 1 trace
#Test Spec with version	= ID + main + aPJ Object Type + aPJ Expected Result aPJ start version + aPJ last version

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Test Specification View

ID	Zeus.TS.Demo	Type	Expected Result
Zeus.TS.Demo-180	**5.1.1.1 Power-Down from System-Standby**	Test_Case	
Zeus.TS.Demo-182	**Preconditions** Zeus is in System-Standby mode.	Test_Prep	
Zeus.TS.Demo-183	Press the 'Power Down' button.	Test_Step	Zeus displays a confirmation box, whether you want to 'Power Down'.

TS/TR Template (Test Run Views)

The TS & TR Template has some views showing the Test Run/Report:

#Test Run all with impact = ID + main + aPJ Object Type + aPJ Expected Result + aPJ Actual Result + aPJ Test Run Status + aPJ Anomalies + aPJ Anomalies Details + aPJ DXL all impact + aPJ Anomalies Class + aPJ Anomalies Evaluation + aPJ Overall Test Run Status

#Test Run for Tester = ID + main + aPJ Object Type + aPJ Expected Result + aPJ Actual Result + aPJ Test Run Status + aPJ Anomalies + aPJ Anomalies Details

#Test Run with Date&IDs = ID + main + aPJ Object Type + aPJ Expected Result + aPJ Actual Result + aPJ Anomalies + aPJ Test Run Status + aPJ Overall Test Run Status + aPJ Product Version ID + aPJ Tester + aPJ Test Date

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Test Run for Tester View

ID	Zeus.TR.Demo-11092004	Type	Expected Result	Actual Res.	TR Status	Anomalies	A-Details
Zeus.TR.Demo-11092004-185	**5.1.1 Power-Down**	Heading					
Zeus.TR.Demo-11092004-180	**5.1.1.1 Power-Down from System-Standby**	Test_Case				CQ-ID42	
Zeus.TR.Demo-11092004-182	**Preconditions** Zeus is in System-Standby mode.	Test_Prep					
Zeus.TR.Demo-11092004-183	Press the 'Power Down' button.	Test_Step	Zeus displays a confirmation box, whether you want to 'Power Down'.	Powers down without confirmation box.	Not OK	CQ-ID42	No confirmation box

Test Report all with Impact View

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ID	Zeus.TR.Demo-11092004	Type	Expected Result	Actual Res.	TR Status	Anomalies	A-Details	DXL all impact (use 'Refresh DXL Attributes')	A-Class	A-Evaluation	Overall TR Status
Zeus.TR.Demo-11092004-180	**5.1.1.1 Power-Down from System-Standby**	Test_Case				CQ-ID42		<- TS (*Test_Case*) **Zeus.TS.Demo-180**: Power-Down from System-Standby <- GRS (*Req*) **Zeus.GRS.Demo-51**: The power shall be turned off automatically once the operating system finished the 'Suspend to disc'. <- GRS (*Req*) **Zeus.GRS.Demo-52**: The turn off shall be controlled via a confirmation dialog. <- GRS (*Req*) **Zeus.GRS.Demo-37**: It shall be possible to turn off Zeus completely being in mode 'System-Standby' using the 'Power Down' key.			Failed
Zeus.TR.Demo-11092004-182	**Preconditions** Zeus is in System-Standby mode.	Test_Prep									
Zeus.TR.Demo-11092004-183	Press the 'Power Down' button.	Test_Step	Zeus displays a confirmation box, whether you want to 'Power Down'.	Powers down without confirmation box.	Not OK	CQ-ID42	No confirmation box	<- TR (*Anomalies*) **Zeus.TR.Demo-11092004-35**: #Anomalies# see linked objects	C	Confirmation box must appear!	

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TS/TR Template (Filter Views)

The TS & TR Template has some views with special filter:

#asp+TC wo. version or no OT =
ID + main + aPJ Object Type + aPJ Expected Result + aPJ start version + aPJ last version
* filtered on
((aPJ start version is empty) OR (aPJ last version is empty)) AND ((aPJ Object Type == Test_Case) OR (aPJ Object Type is empty))

#asp+Test_Case =
ID + main + aPJ Object Type + aPJ Expected Result + aPJ start version + aPJ last version
* filtered on
aPJ Object Type == Test_Case

TS/TR Template (Help Views)

The TS & TR Template has some views offering help:

#hlp Edit View (Help) = ID + main + aPJ Object Type + aPJ TPLHelp

#hlp all attributes = ID + main + aPJ Object Type + all attributes

#hlp-Edit View (Help) = ID + main + aPJ Object Type + aPJ TPLHelp * explicitly clears filter

All Traces View Seen from Requirements Specification (#1)

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- The DXL traceability attributes offer full traceability from requirements all the way to the test results.
- At your wishing the most important attributes are shown.

ID	Zeus.GRS.Demo	Type	All traces (use 'Refresh DXL Attributes')
Zeus.GRS.Demo-52	The turn off shall be controlled via a confirmation dialog.	Req	<- TS (*Test_Case*) **Zeus.TS.Demo-187**: Cancel Power-Down from System-Standby <- TR (*Test_Case*) **Zeus.TR.Demo-12092004-187**: Cancel Power-Down from System-Standby | ***Passed*** | <- TR (*Test_Case*) **Zeus.TR.Demo-11092004-187**: Cancel Power-Down from System-Standby | ***Not tested*** | <- TS (*Test_Case*) **Zeus.TS.Demo-180**: Power-Down from System-Standby <- TR (*Test_Case*) **Zeus.TR.Demo-12092004-180**: Power-Down from System-Standby | ***Passed*** | <- TR (*Test_Case*) **Zeus.TR.Demo-11092004-180**: Power-Down from System-Standby | ***Failed*** | CQ-ID42

All Traces View Seen from Requirements Specification (#2)

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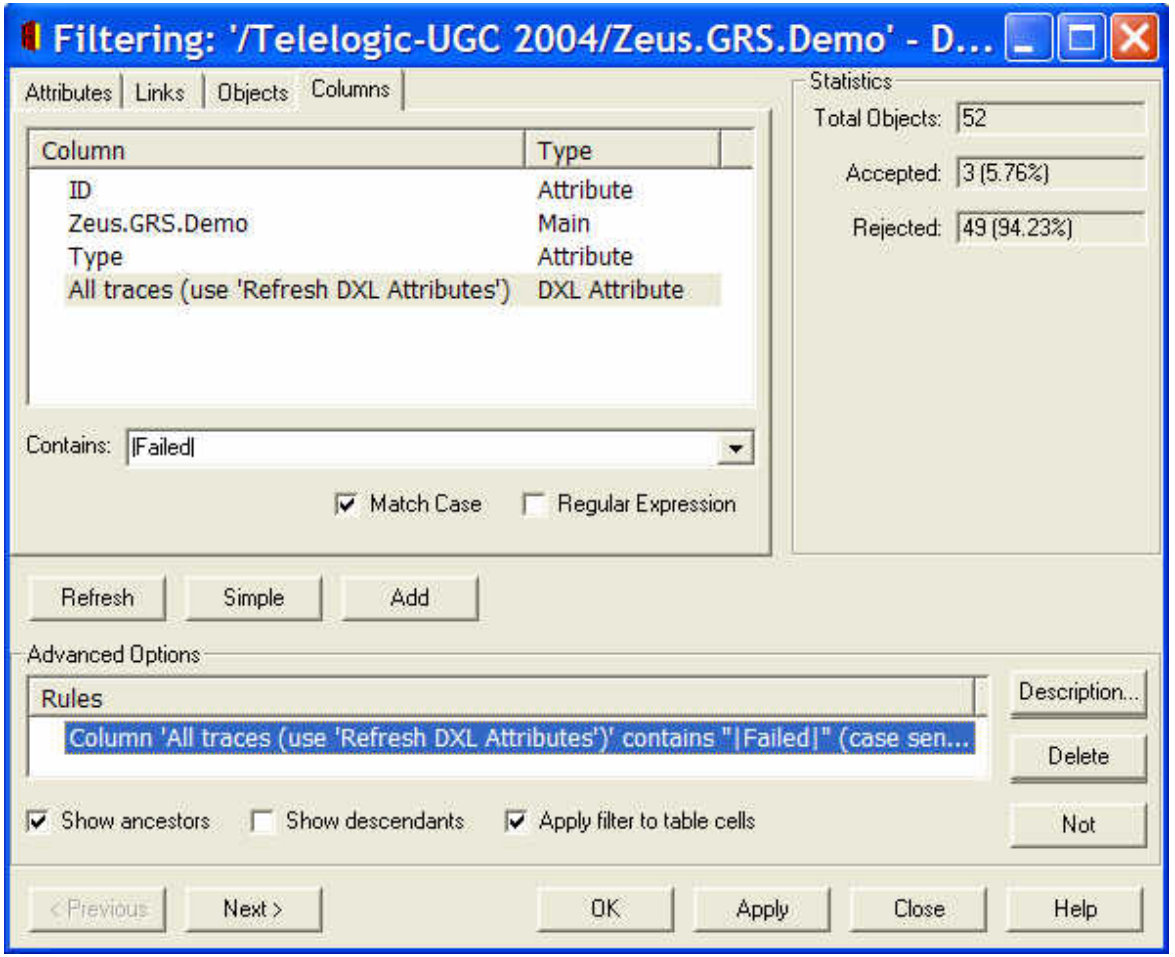
- The DXL Attribute column allows for standard DOORS filtering on column contents ☺



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DXL to Apply Template

We developed DXL to apply those TS/TR templates to existing or newly created modules:

- adding ***outline*** (asks if not empty)
- adding ***attributes*** and ***attribute types*** (without overwriting existing)
- adding ***views*** (overwriting existing)
- updating ***front-matter***

=> You update the template and you can ‘easily’ populate this update to all existing DOORS module ☺

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Special Case 'Alarms'

For the anesthesia product Zeus there is the special case of alarms:

- Zeus has important requirements on alarms (having to be raised in case of problems):
  - class of alarm, suspend properties, volume properties, silencing properties, impact on lights and various displays, activation properties, etc.
- Most of those properties / requirements were in a huge Excel file, others in different Word files with requirements specifications.
- Test specifications to test those properties / requirements were written by manually looking up the values in Excel and Word and translating them (using a common schema) into a test step with an expected result.

=> Very time consuming, error prone and difficult to maintain up-to-date ☹

New Alarm Tests Approach

Alarmlist Module

DXL Attribute in Test

ID	Zeus.AL.Alarmlist	Type	Susp.Group	Class
Zeus.AL_526	FUN_LEVEL_LOW	Alarm	Apnoe HLM	Alarm

ID	Zeus.TS.Alarms-Diva	Type	Alarmtesttypes	Alarmtestspec
Zeus.TS.A-Diva_70	FUN_LEVEL_LOW	Test_Step	All	**Alarmdialoge:** A) Im Alarminfo werden alle aktuell anstehenden Alarme gelistet. Zeit, Priorität, Alarm, Grenzen. Erklärung und Hilfetext werden in der Liste aufgeführt. B) Im Alarmlog werden alle Alarme, die seit dem Start des Cases aufgetreten sind, angezeigt.Unterscheidung Patienten- bzw. technischer Alarm. C) Dieser Alarm gehört zur ***Alarm*** Klasse, er beendet die (einfache) Stummschaltung sofort. **Alarm-Zeitverhalten:** 1. Alarmklasse: Alarm, Caution oder Advisory ***Class:* Alarm** 2. Alarm wird durch eine Vorauswahl unterdrückt ***Suspend Group:* |Apnoe|HLM|** 3. Mind. Lautstärke des Alarmtons ***minimum Volume:* —** 4. Alarm bricht All Silence nach definierter Zeit ab ***limit silence to:* —** 5. Bei Alarmierung blinkt der Messwert im Value Tool ***flashing parameter:* none** 6. Tech. Hinweise werden als Kopfzeile im Value Tool dargestellt ***value tool display:* |CO2|O2|ST|** 7. Tech. Alarm wird auf Hinweisniveau runtergestuft ***degradable:* ✓** 8. Alarm ist in General Standby aktiviert ***standby visible:* —** 9. Alarmquittierung durch die Silence Taste ***Silence deactivated:* ✗** 10. Alarm erscheint mit zusatz. Alarminfo-Dialog ***Open Alarminfo Dialog:* ✗** **Alarm aktiv in Mode:** i) Alarm ist in Aktuator Standby (A.S.) aktiv? ***active in A.S.:* —** ii) Alarm ist in Therapy Off (T.O.) aktiv? ***active in T.O.:* —** **MEDIBUS:** a) ***MEDIBUS code HEX:* 41** b) ***MEDIBUS codepage:* 2** c) ***MEDIBUS prio:* 2**

- All ‘standard’ alarm properties have been migrated into one DOORS Alarmlist Module.
- Test Specification modules:
  - contain ***Test_Step*** objects which are linked to the Alarm objects from the Alarmlist Module
  - an attribute ***Alarmtesttypes*** to choose which tests are to be done (typically = All)
  - a DXL attribute ***Alarmtestspec*** looking up the attribute values and generating the test specification.

=> quick, fully automatic, no errors,

easy update ☺

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Alarm Test DXL Extract

```
if ((All == true) || (Std == true) || (SuspGroup == true)) {
        string oalarm_SuspGroup = probeRichAttr_(linkedObject,"aPJ Suspend Group", false)
        displayRich "2. Alarm wird durch eine Vorauswahl unterdrückt"
        aux = ""
        while (!null oalarm_SuspGroup && line oalarm_SuspGroup) {
                aux = aux oalarm_SuspGroup[match 0] "|"
                oalarm_SuspGroup = oalarm_SuspGroup[end 0 + 2:]   // move past newline
        }
        if (aux != "") aux = "|" aux
        else aux = Show_EMPTY
        displayRich "     " "{\\b \\i Suspend Group: }" "{\\b " aux "}"
}
```

TS/TR Template (Special Alarms Views)

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The TS & TR Template has some views showing the Alarmtests (the main ones are):

#Test Alarms =

ID + main + aPJ Object Type + aPJ Alarmtesttypes + aPJ Alarmtestspec

#Test Alarms Run for Tester =

ID + main + aPJ Object Type + aPJ Alarmtesttypes + aPJ Actual Result +

aPJ Test Run Status + aPJ Anomalies + aPJ Anomalies Details

Special Case: Tests with Calculations of Results

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- For some tests we replaced slow and error prone manual calculations by quick, safe, automatic DXL calculations (using attribute values of the ***Test Step*** object or linked objects), such as:

```
// DXL attribute for L-Flow

/* --------- Bernd@Grahlmann.net 11/05/2004----------
   This function sets the attribute it is driving.
   aPJ Calc L-Flow = VA * Delta_P / P0 / t              */

real VA                 = obj."aPJ Mess VA"
real Delta_P            = obj."aPJ Mess Delta P"
real P0                 = obj."aPJ Mess P0"
int t                   = obj."aPJ Mess t"

// Only if there are measured values
if ((VA != 0.0) && (Delta_P != 0.0) && (P0 != 0.0) && (t != 0)) {
   // Check that there is no division by zero is already checked above
   obj.attrDXLName =  ((VA * Delta_P) / P0) / realOf(t)
}
```

Project Overview DXL Toolset

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- We developed an additional DXL ***Project Overview*** Toolset to:
  - have a ***Design History File Index*** like module listing all project documents;
  - managing document locations, reference tags, versions, status, responsibles, etc.
  - allow for comfortable, centralized ***printing*** of pre-prepared DOORS reports (combining a view with a page setup)

Zeus:Project_Overview.Demo	State	Version	Report	Report Description
2.3.2.1 TS - Systemtest Specifications (for GRS)				
/Telelogic-UGC 2004/Zeus.TS.Demo		current	Zeus.TS.Demo-TR-A3ls	Zeus.TS.Demo: • View: #Test Run for Tester • Page Setup: aPJ std_a3_landscape_full
	RELEASED	1.0 (Telelogic UGC 2004)	Zeus.TS.Demo-TR-A3ls	Zeus.TS.Demo: • View: #Test Run for Tester • Page Setup: aPJ std_a3_landscape_full

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Conclusions

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Based on DOORS 7 and DXL we have implemented a powerful 'Testing Solution' at Dräger Medical:

- Satisfying the requirements of Dräger Medical, in particular:
  - traceability from requirements to test results
  - time and cost efficient
  - satisfying regulatory 'constraints'
- Migrating all system level requirements and test specifications of the 300+ men year Zeus project to DOORS (including restructuring, etc.)
- Re-building the Testing of alarm properties such that it has become automatic, quick and error-safe ☺
- Embedding it into an overall Dräger Medical DOORS environment (providing specialized template application, printing, etc.)

=> Full success thanks to a rigorous project and the unique power of DOORS 7 & DXL ☺

Questions

- Special Thanks to the Engineering + V&V Teams at Dräger Medical !!!

- Discussion is open for questions / comments / etc.

Contact Information

- Feel free to contact me after the conference if you:
  - Have questions / comments / etc. with respect to the presentation, the project, etc.
  - Want to implement this or a similar solution in your company
  - Are interested in ***Requirements Management*** and (in particular) ***DOORS*** related ***Consultancy*** or ***Training***.

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