Baden-Baden | November 19, 2024

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Agenda

01 Motivation Motivation for Systems Engineering Combined with Digital Data Processing

02

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System Network Overview of IT Landscape and Interfaces in the Specialist Area

Method Enable Machine Processing of Data

)4 Visualize Digital Transparency Application of ReLex and SCALE.sdm in Action

05 Summary and Outlook Achieving Digital Transparency

Motivation for Systems Engineering in Combination with Digital Data Processing

Stakeholder Requirements:

- Legal
- Consumer Protection



Motivation for Systems Engineering in Combination with Digital Data Processing



Motivation for Systems Engineering in Combination with Digital Data Processing



Regulatory-compliant data retention and proof of compliance required for several decades.

System Network: Enabling Machine Processing of Data



System network of various tools that communicate with each other to provide transparency from testable requirements to final approval.

Method: Continuous Requirements (Traceability in the System Network)



> Method:

- Capture of requirements along with the verification specification, so that they can be digitally processed (broken down into individual characteristics).
- During verification, test results can be automatically assigned to the requirements and evaluated.

| Requirement: Seatbelt buckle release force after test < 60N. | | | | | | | | | | |
|---|--------------------------------|--------------------------------|--|--|--|--|--|--|--|--|
| Features | | | | | | | | | | |
| Туре | Name | Value | | | | | | | | |
| Stakeholder | Regulation Protocol Version | ECE-R_94_02(Final-2016- 06) | | | | | | | | |
| Test Criteria | Barrier | ODB | | | | | | | | |
| Test Criteria | Impact Angle | 0° | | | | | | | | |
| Test Criteria | Vehicle Speed | 56 km/h -0/+1 km/h | | | | | | | | |
| Component | Component | Seatbelt Buckle | | | | | | | | |
| | | | | | | | | | | |
| Target Value | Seatbelt buckle release force | <60 N | | | | | | | | |





Method: Continuous Requirements (Traceability in the System Network)



> Method:

- Capture of requirements along with the verification specification, so that they can be digitally processed (broken down into individual characteristics).
- During verification, test results can be automatically assigned to the requirements and evaluated.



> What do we gain from this:

- Real machine-driven digital data processing \rightarrow Thousands of requirements can be checked and verified in seconds without errors.
- Digital/continuous verification status overview from requirements through test data to approval.

Method: Prerequisite for Collaboration of Distributed IT Systems

> Standardization and harmonization of information addresses and content.



> Based on the master data glossary, the necessary expert tools are connected. This enables communication between the tools without the need for mapping.

Master Data Glossary: From Information Management to Knowledge



- > Possible Questions:
 - > Which measurement curves are required to verify a regulation?
 - > Are all requirements of a regulation verified?

> ...

| | | | ReLex Suche Redaktionsbe | ereich - | Autorenbe | reich - Hilfe - | | | | | gurt | | 0/0 | $\land \lor \forall \times$ | | |
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| | | | | | | Assoziationen < | ¢ | | | | | | | | | |
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| [| Details | atus | Name | | Veraltet | Richtlinie | Richtlinien- | Bewertungs-Pro | otokoll-Vers | sion | Тур | Versuchsart | | Geschwindigkeit | l inkslenker/P | Sitzpos |
| | | 2) 9, 🛛 | | ∇ | V | (18) ADI 🛛 🖓 | | | | V | | | ∇ | ∇ | ZIIIKSIEIIKEIIK | |
| | Q | 100 | Frontal_ECE-R_094_56km/n_ODB_0*_40%_links_LL_Fanrzeug | ' | Nein | EUE-R | ECE-R_94_0 | 2(Final-2010-00),# | (uui-rzysi_a | oruktur-r | 006 | Frontal, Front | | 15.0=10.1 | | 120220 |
| | Q | S | Frontal_ECE-R_094_56km/h_ODB_0°_40%_rechts_RL_1H3 | ' | Nein | ECE-R | ECE-R_94_0 | 2(Final-2016-06) | | | ODB | Frontal, Front | | 15.0-16.1 | RL | 1. SR lir |
| | Q | Ø | Frontal_ECE-R_094_56km/h_ODB_0°_40%_rechts_RL_3H3 | 1 | Nein | ECE-R | ECE-R_94_0 | 2(Final-2016-06) | | | ODB | Frontal, Front | | 15.0-16.1 | RL | 1. SR re |
| | Q | 3 | Frontal_ECE-R_094_56km/h_ODB_0°_40%_rechts_RL_Fahrzeug | 1 | Nein | ECE-R | ECE-R_94_0 | 2(Final-2016-06),A | udi-FzgSi_S | Struktur-F | ODB | Frontal, Front | | 15.0-16.1 | RL | |
| | Q | \bigcirc | Frontal_ECE-R_094_JAP_56km/h_ODB_0°_40%_rechts_RL_1H3 | ' | Nein | ECE-R | ECE-R_94_0 | 2(Final-2016-06) | | | ODB | Frontal, Front | | 15.0-16.1 | RL | 1. SR li |
| | Q | \bigcirc | Frontal_ECE-R_094_JAP_56km/h_ODB_0°_40%_rechts_RL_3H3 | ' | Nein | ECE-R | ECE-R_94_0 | 2(Final-2016-06) | | | ODB | Frontal, Front | | 15.0-16.1 | RL | 1. SR re |
| | Q | 8 | Frontal_ECE-R_094_JAP_56km/h_ODB_0°_40%_rechts_RL_Fahrzeug | ľ | Nein | ECE-R | ECE-R_94_0 | 2(Final-2016-06),A | udi-FzgSi_S | Struktur-F | ODB | Frontal, Front | | 15.0-16.1 | RL | |
| | Q | 0 | Frontal_ECE-R_137_50km/h_starr_0*_100%_LL_1H3 | 1 | Nein | ECE-R | ECE-R_137_ | 01(Final-2016-06) | | | 100%,100% Wand | Frontal, Front | | 13.3-14.4 | LL | 1. SR lir |
| | Q | 0 | Frontal_ECE-R_137_50km/h_starr_0*_100%_LL_1T3 | 1 | Nein | ECE-R | ECE-R_137_ | 2024-01(BestGues | s-2031-09) | | 100%,100% Wand | Frontal, Front | | 13.3-14.4 | LL | |
| | Q | 0 | Frontal_ECE-R_137_50km/h_starr_0*_100%_LL_3HF | 1 | Nein | ECE-R | ECE-R_137_ | 01(Final-2016-06) | | | 100%,100% Wand | Frontal, Front | | 13.3-14.4 | LL | |
| | Q | 0 | Frontal_ECE-R_137_50km/h_starr_0°_100%_LL_Fahrzeug | r | Nein | ECE-R | ECE-R_137_ | 01(Final-2016-06), | Audi-FzgSi_ | Struktur | 100%,100% Wand | Frontal, Front | | 13.3-14.4 | LL | |
| | Q | 0 | Frontal_ECE-R_137_50km/h_starr_0°_100%_RL_1HF | 1 | Nein | ECE-R | ECE-R_137_ | 01(Final-2016-06) | | | 100%,100% Wand | Frontal, Front | | 13.3-14.4 | RL | |
| | Q | 0 | Frontal_ECE-R_137_50km/n_starr_0°_100%_RL_3H3 | , | Nein | ECE-R | ECE-R_137_ | 01(Final-2016-06) | | | 100%,100% Wand | Frontal, Front | | 13.3-14.4 | RL | 1. SR re |
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| | Ø | 0 | Frontal ECE-R 137 JAP 50km/h starr 0° 100% RL 1HF | , | Nein | ECE-R | ECE-R_137_ | 01(Final-2016-06) | | | 100%,100% Wand | Frontal, Front | | 13.3-14.4 | RL | |
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| | 9 | 0 | Frontal ECE.R 137 IAP 50km/h starr 0° 100% RI 373 | 3, | Nein | ECE-R | ECE-R 137 | 2024-01(BestGues | s-2031-09) | | 100% 100% Wand | Frontal Front | | 13 3-14 4 | RL | |
| | a | | - TOTWELE CETT 191 _001 _001 [3181] 0 _100 % [RE 515 | | | | | | | 01-11 | | Frend 15 | | 100.111 | | |

Product Setup: SCALE.sdm



| | SCALE | .sdm | | | Confidential information | | | | ۴ | žΞ | ? | ≡ |
|--|---------|--|-------|--------------------------------------|------------------------------|--------------------------------|-----------|--------|---------|------------|---------|------------|
| | A | Requirements | | | | | | | | | + Add | « |
| Re + | IE | Milestones | | | | | | | | | | ~ |
| | | 🛅 🎟 Region 🗸 🛇 | • | Richtlinien-Test-Protokoll-Versioner | n 🙁 🕨 📰 Test case 🛞 | | Quickf | ilter | C | . T | → ← | |
| | | Group ^ | | | Description | Threshold | | Status | | | | |
| | | | | Name | Description | Threshold | | Value | Assessm | R | eferenc | Con |
| | • | | | γ | γ | | | | 7 | 7 | | V |
| Normalized Data from Master Data System | | > USA | (385) | | | | | | | | | î |
| | | > Korea | (38) | | | | | | | | | |
| | | > Japan | (114) | | | | | | | | | |
| | | | (128) | | | | | | | | | |
| | | > None | (76) | | | | | | | | | |
| | | ECE-R 94 2016(Final-2016-06) | (76) | | | | | | | | | |
| | | > Frontal_ECE-R_094_56km/h_0 | (18) | | | | | | | | | |
| Venicle Project Configurat | tion | Frontal_ECE-R_094_56km/h_0D | (18) | | | | | | | | | |
| in SCALE.sdm | | | | 1.0.00.R.O.VEHICLE_Y_DEVIATIO | Annex 3 "1.3.1. Alignment | -∞ ≤ x < -20.00 -20.00 ≤ x ≤ 2 | 20.00 + 1 | | | | | k |
| | | | | Dummy POS1 geborgen ohne Sit | 5.2.5. After the impact, it | x = YES x = NO | | | | | | k |
| | | | | Dummy POS1 geborgen ohne W | 5.2.5. After the impact, it | x = YES x = NO | | | | | | k |
| Product fosturos | | | | Dummy POS3 geborgen ohne Sit | 5.2.5. After the impact, it | x = YES x = NO | | | | | | k |
| FIGUUCCIEACULES | | | | Dummy POS3 geborgen ohne W | 5.2.5. After the impact, it | x = YES x = NO | | | | | | k |
| \sim | | | | Eine oder mehrere Tür(en) verrie | 5.2.4. After the impact, th | x = NO x = YES x = UNRA | TEABLE | | | | | k |
| | | | | Eine oder merhere Tür(en) währe | 5.2.3. During the test no d | x = NO x = NEIN | + 3 | 3 | | | | k |
| | | | | Elektrolyt in Innenraum | 5.2.8.2. Electrolyte spillag | x = NEIN x = JA | | | | | | k |
| | | | | Geschwindigkeit ECE-R_094 (Beh | Annex 3 "4. Test speed" Ve | -∞ ≤ x < 56.00 56.00 ≤ x ≤ 57 | 7.00 + 1 | | | | | k |
| | | | | Gurtschlossöffnungskraft | 5.2.5.2. To release the du | <u>-∞≤x≤ 60.0</u> 60.00≤x<∞ | + 1 | | | | | k |
| | | 4 | | Gurtschlossöffnungskraft | 5.2.5.2. To release the du | <u>-∞≤x≤60.0</u> 60.00≤x<∞ | + 1 | | | | | * - |

Configuration of project requirements based on project-independent master data in combination with the product equipment

Test and Simulation in One Cockpit: SCALE.sdm





Test and Simulation in One Cockpit: SCALE.sdm



Comparison of Test and Simulation



Report Project Status: SCALE.sdm



Project Monitoring

Verification of requirements using test or simulation data

| | Dummy POS1 geborgen ohne W | YES | Kommentar: | | |
|---|----------------------------------|------------|------------|--|--|
| | Dummy POS3 geborgen ohne Sit | YES | Kommentar: | | |
| | Dummy POS3 geborgen ohne W | YES | Kommentar: | | |
| | Eine oder mehrere Tür(en) verrie | YES | Kommentar: | | |
| | Eine oder merhere Tür(en) währe | NO | Kommentar: | | |
| • | Elektrolyt in Innenraum | NEIN | Kommentar: | | |
| | Geschwindigkeit ECE-R_094 (Beh | 56.66 km/h | Kommentar: | | |
| | Gurtschlossöffnungskraft | 61 N | Kommentar: | | |
| | Gurtschlossöffnungskraft | 14.6 N | Kommentar: | | |
| | Lenkradverschiebung nach Versu | -9.5 mm | Kommentar: | | |
| | Lenkradverschiebung nach Versu | 1.3 mm | Kommentar: | | |

Project Monitoring and Reporting: SCALE.sdm



| equirements | | | | | | + Add 《 | Region | | | | | |
|--------------------------------|---|---|---|---|--------------|-----------------------|--------------|--------------------|--|--|--|--|
| | | | | | | | | | | | | |
| Milestones | | | | ~ | 🗸 R | egulation | | | | | | |
| 🟗 📖 Region 🛛 🗸 😣 | Richtlinien-Test-Protokoll-Version | en 🛞 🕨 💷 Test case 🔇 | | Quidefilter | C | ▼ _× →ll← □ | | | | | | |
| Group 🗘 | Name | Description | Threshold | Status | A | Deference | \mathbf{v} | Test Case | | | | |
| | | 7 7 | | Value V | ASSESSITT | | | Poquiromont | | | | |
| > USA | (385) | | | | green | | | Requirement | | | | |
| > Korea | (38) | | | | green | S.U. | | | | | | |
| >]apan | (114) | | | | green | | | | | | | |
| > Indien | (80) | | | | green | \$ | | | | | | |
| ✓ ECE RL | (128) | | | | red | fier | | | | | | |
| > None | (76) | | | | red | | | | | | | |
| ✓ ECE-R_94_2016(Final-2016-06) | (76) | | | 1, | red | | | | | | | |
| > Frontal_ECE-R_094_56km/h_0 | (18) | | | | green | | | | | | | |
| ✓ Frontal_ECE-R_094_56km/h_0D. | . (18) | | | | red | | | | | | | |
| | 1.0.00.R.O.VEHICLE_Y_DEVIATIO | . Annex 3 "1.3.1. Alignment | -∞ ≤ x < -20.00 -20.00 ≤ x ≤ 20 | .00 + 1 16 mm | green | · | | l evel-by-level | | | | |
| | Dummy POS1 geborgen ohne Sit. | 5.2.5. After the impact, it | x = YES x = NO | YES | green | Test 42 | | | | | | |
| (| Dummy POS1 geborgen ohne W | . 5.2.5. After the impact, it | x = YES x = NO | YES | green | Test 42 | | evaluation and u | | | | |
| 1 | Dummy POS3 geborgen ohne Sit. | 5.2.5. After the impact, it | x = YES x = NO | YES | green | Test 42 | | aggregation | | | | |
| | Dummy POS3 geborgen ohne W. | . 5.2.5. After the impact, it | x = YES x = NO | YES | green | Test 42 | | (hierarchical data | | | | |
| | Eine oder mehrere lür(en) verrie. | | x = NO x = YES x = UNRATE | ABLE YES | green | Test 42 | | | | | | |
| | Eine oder merhere Tür(en) währe. | 5.2.3. During the test no d | | + 3 NO | green | Test 42 | | | | | | |
| | Elektrolut in Janansaurr | J.Z.O.Z. Electrolyte spillag | $\mathbf{x} = \mathbf{N} \mathbf{E} \mathbf{I} \mathbf{N}$ $\mathbf{x} = \mathbf{J} \mathbf{A}$ | INETIN | green | Test 42 | | | | | | |
| | Elektrolyt in Innenraum | Append 3 "/ Test speed" Ve | 55 00 cm (57 0 | 10 1 56 66 km/h | araan | | | | | | | |
| | Elektrolyt in Innenraum Geschwindigkeit ECE-R_094 (Beh | Annex 3 "4. Test speed" Ve | -∞ ≤ x < 56.00 56.00 ≤ x ≤ 57.0 | 0 + 1 56.66 km/h | green | Test 42 | _ | | | | | |
| | Elektrolyt in Innenraum Geschwindigkeit ECE-R_094 (Beh Gurtschlossöffnungskraft | Annex 3 "4. Test speed" Ve 5.2.5.2. To release the du 5.2.5.2. To release the du. | $-\infty \le x < 56.00$ $56.00 \le x \le 57.0$ $-\infty \le x \le 60.0$ $60.00 \le x < \infty$ | 00 + 1 56.66 km/h + 1 61 N + 1 14.6 N | green red | Test 42 | | | | | | |

Project Monitoring and Reporting: SCALE.sdm



| ALE | E.sdm | | | ▲ Confidential infor | mation | | | | ÷ := | ? |
|-----|---------------------------|-------|--|----------------------------|----------------|-----------------------------|-----------------|---------|----------|-------|
| R | Requirements | | | | | | | | | + Add |
| | Milestones | | | | | | | | | |
| | 🔠 🗰 Test-Komponente 🗸 🕲 | | ii Richtlinien-Test-Protokoll-Versione | n 🙁 🕨 🏢 Test case (| 3 | | Quiekfilter | | C 🔨 | → ← |
| | Group 🗘 | | Name | Description | Threshold | | Status Value | Assessm | Referenc | Comme |
| | | | ∇ | ∇ | | | 7 | 5 | 7 | 7 |
| | > Tür | (30) | | | | | | | | |
| | > Team Prüffeld | (21) | | | | | | green | | |
| | > Lenksäule | (20) | | | | | | green | | |
| | > Kraftstoffsystem | (140) | | | | | | green | | |
| | > Innenraum | (40) | | | | | | green | | |
| | > HV-System | (20) | | | | | | | | |
| | > H3 5% Frau | (148) | | | | | | green | | |
| | > H3 50% | (434) | | | | | | green | | |
| » | ✓ Gurtschloss | (20) | | | | | | red | | |
| | > None | (20) | | | | | | red | | |
| | > ECE-R_137_01(2016) | (10) | | | | | | green | | |
| | ✓ ECE-R_94_2016(Final-201 | (10) | | | | | | red | | |
| | > Frontal_ECE-R_094_56 | (2) | | | | | | green | | |
| | ✓ Frontal_ECE-R_094_56k | . (2) | | | | | | red | | |
| | | | Gurtschlossöffnungskraft | 5.2.5.2. To release the du | -∞ ≤ x ≤ ·60.0 | 60.00 ≤ x < ∞ + 1 | 61 N | red | Test 42 | Komme |
| | | | Gurtschlossöffnungskraft | 5.2.5.2. To release the du | -∞ ≤ x ≤ 60.0 | 60.00 ≤ x < ∞ + 1 | 14.6 N | green | Test 42 | Komme |
| | > FrontaL_ECE-R_094_56 | (2) | | | 0 | | | green | | |
| | > Frontal_ECE-R_094_56 | (2) | | | | | | green | | |
| | FrontaL_ECE-R_094_JAP | . (2) | | | | | | _ | | |
| | > None | (873) | | | | | | red | | |

| Different views of the data | I |
|-----------------------------|---|
| (e.g., component owners) | |

✓ Component

✓ Regulation

Test Case

Requirement

Project Monitoring and Reporting: SCALE.sdm





Project Monitoring and Reporting: SCALE.sdm





Summary

Successfully implemented digital transparency

- > Across the entire V-model
- > Beyond Tool boundaries

Real machine-driving digital data processing

Thousands of requierements checked and verified in seconds, without errors

> By referencing data entities, "Information" becomes "Knowledge"

Outlook



Use "Knowledge" for further use cases:

> Enable cost savings through optimization of the testing plan

>Automated resource planning (people, equipment, components, etc.) based on product definition

