



Digital Rail Summer School 2022

CERTIFICATION OF TESTAUTOMATION FOR RAILWAY APPLICATIONS – ABSTRACT

Presentation Funkwerk

ABOUT US

Funkwerk Systems GmbH



Funkwerk Systems GmbH

Funkwerk is a leading supplier of innovative communication, information and security systems.

Funkwerk provides tailor-made concepts for railway companies, vehicle manufacturers, industrial companies and institutions around the world manage and rationalize operations in transport, logistics, buildings and public and private institutions of any kind.

Funkwerk develops professional radio equipment for railway companies, public transport, inland waterways and airports, as well as intelligent electronic security systems to protect buildings, squares, industrial buildings, property and persons.

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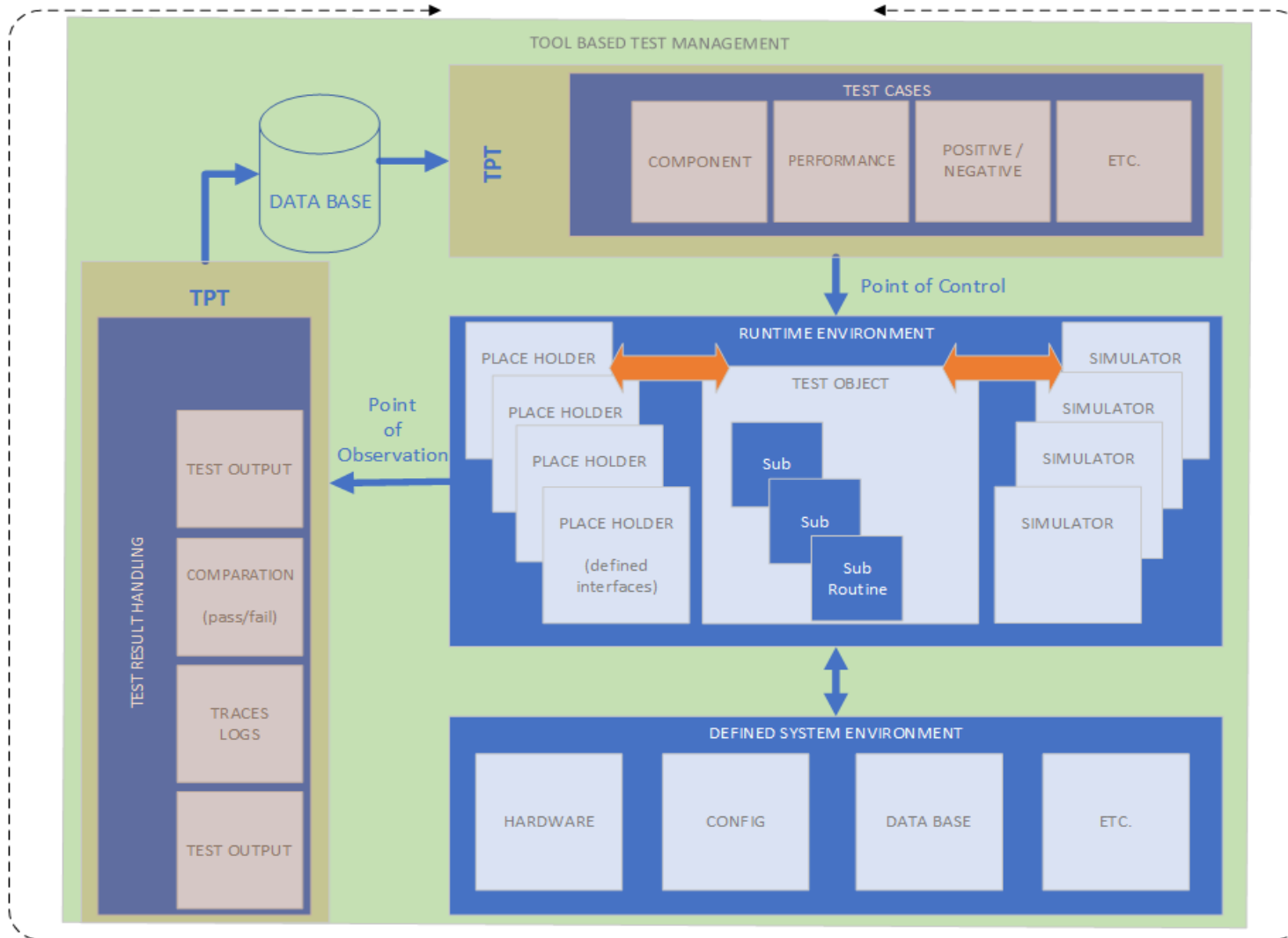
| Funkwerk AG | Im Funkwerk 5 D-99625 Kölldeda | |
|--|--|--|
| Funkwerk Systems GmbH | Im Funkwerk 5 D-99625 Kölldeda | Mobil radio systems for railways |
| Funkwerk Systems GmbH <i>Location Karlsfeld</i> | Liebigstr. 1a D-85757 Karlsfeld | Information systems for passengers |
| Funkwerk Video Systems GmbH | Thomas-Mann-Str. 50 D-90471 Nürnberg | Video monitoring and detection systems |
| Funkwerk Systems Austria GmbH | Ignaz-Köck-Str. 1 A-1210 Wien Vienna/Austria | Mobil radio systems for railways |

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AGENDA

- Test Framework
 - Simulators & nodes
 - Protocol nodes and simulator nodes
 - Independent simulators
- Time Partition Testing - TPT (Windows Application from PikeTec GmbH)
 - Test sets and configuration
 - Start scripts
 - Test report function
- Start scripts and TPT-Launcher
- Management of the test environment
- Delimitations and manual testing
- Looking forward

TEST FRAMEWORK



Basic test framework according to TMap next process (ISBN: 978-3-89864-461-7) as well as Spillner/Linz „Basiswissen Softwaretest“ (ISBN 978-3-86490-024-2)

TEST FRAMEWORK

Test object (e.g. cab radio or HMI) in a defined system environment which shall be as close as possible to the live environment

Simulators (Java applications)

- Replaces physical hardware components
- After connection they have automated and permanent communication with the test object
- Independent from TPT-tool

Place holders (nodes ; for TPT DLL files are used)

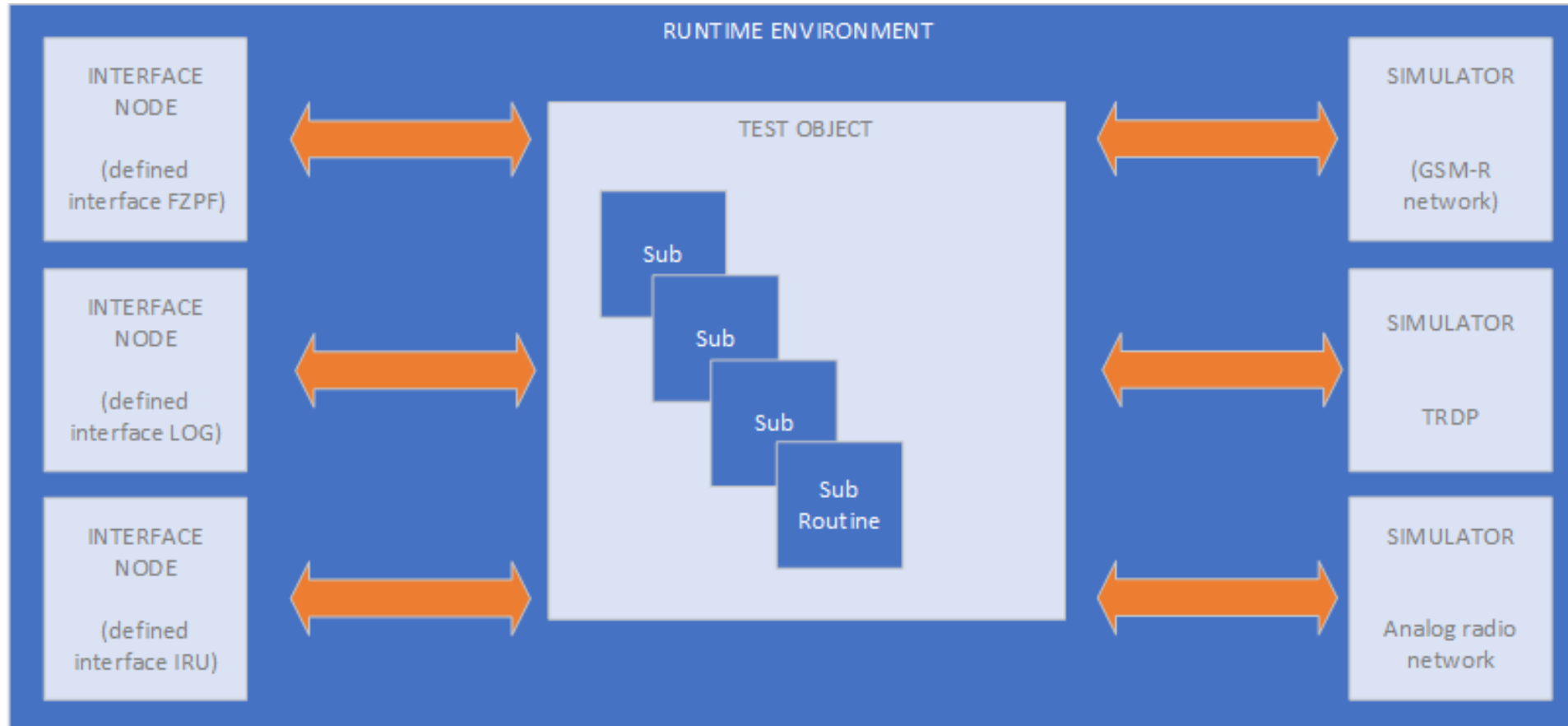
- Conducts commands from TPT to simulators or direct to the test object
- Conducts data from simulators or the test object to the TPT

Time Partition Testing - TPT (Windows Application of PikeTec GmbH)

- Graphical user interface for editing execution scripts
- Script based test execution
- Generates reports
- Communicates via nodes with the simulators or the test object

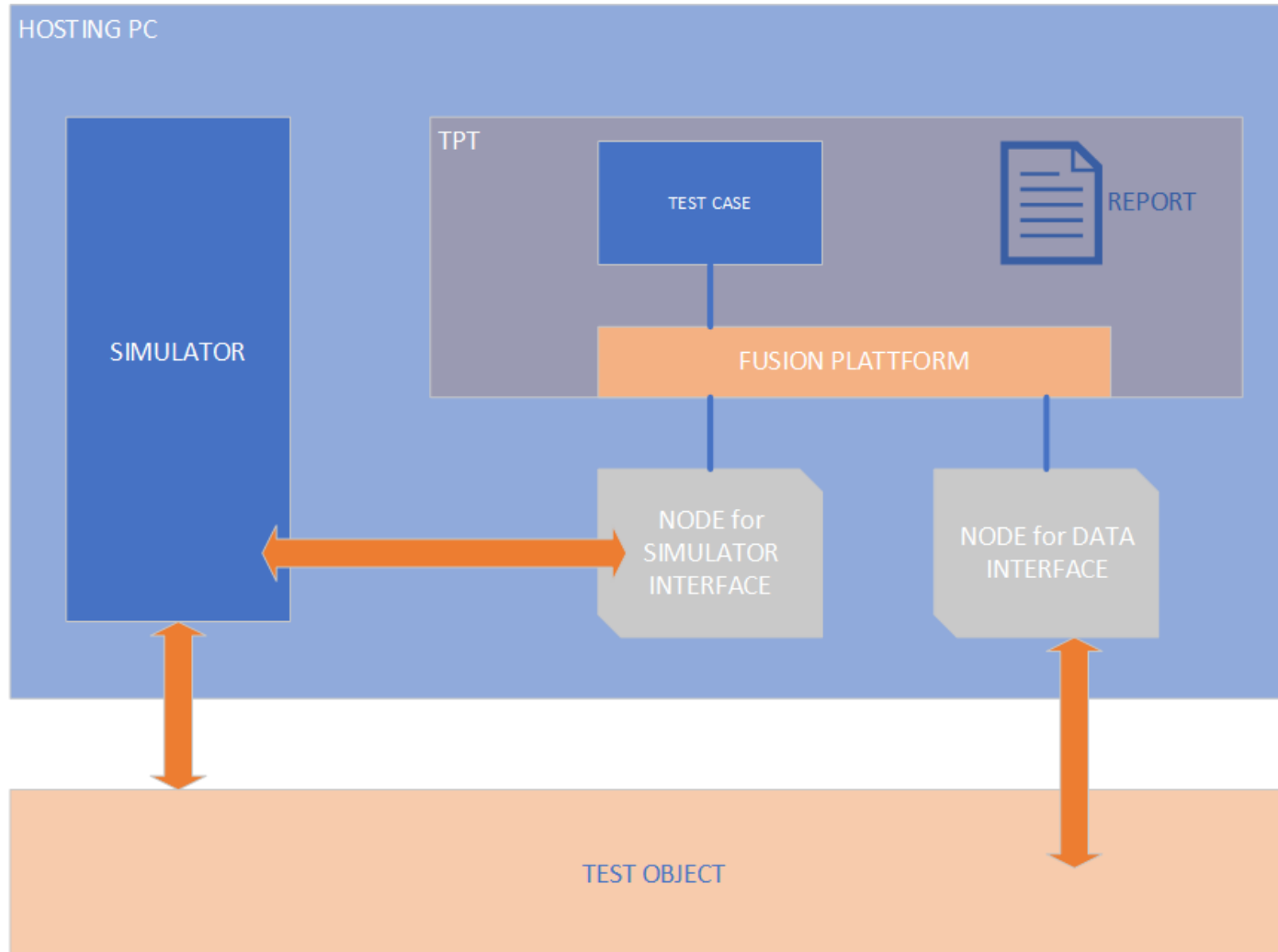
Test Management and test case baselining

SIMULATORS & NODES



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SIMULATORS & NODES



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NODES (DATA INTERFACE)

Direct communication between TPT and the test object

Reasons for data interface node without additional simulator

- No direct user interface
- Small or medium set of functionality

Current main data interface nodes are:

- LOG-Node storing of trace output from the test object including search function;
 must be adapted for different test objects (protocols: Telnet & FTP)
- AGP-Node Abstract Gateway Protocol
- EDA-Node External Data Application
- ...

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NODES (SIMULATOR INTERFACE)

Communication between TPT and separate simulators

Current main simulator interface nodes are:

- HmiSim-Node HMI-Simulator; replaces physical human-machine-interface
- FuMoNeSi-Node FUnkwerk MOdem and Network Simulator (simulates a GSM-r network and in future 4G or 5G railway specific functionality)
- NfSim-Node Low Frequency-Simulator; required for testing voice paths through the test object
- DigitalIOSim-Node Digital input/output/power simulator; able to control external power supply
- ARA-Node Analogue radio network simulator; allows to simulate all analogue radio networks based in 70cm band on mode variants A, B, E including sub modes C, O, N,...and 2m operations
- ...

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SIMULATORS

HMI-Simulator. Simulation of physical Human-Machine-Interface (different HMI types via XUI file loadable). XUI file can be created with a GUI configurator.

Network-Simulator. Replaces physical GSM-R modem. Simulates GSM-R-modem and network based on the AT-command interface

ATR-Simulator. Replaces the physical analogue train radio modem. Simulates the ATR module and the ATR network based on serial interface commands.

DigitalIO/Power-Simulator. Control unit for all integrated contacts, relays, lines and outputs. Switch functionality includes the controlling of external power supply units.

NF-Simulator. Switching and proof of internal voice frequency paths through the audio matrix. Check of output levels.

GPS-Simulator. Replaces the physical GPS-module. Simulates the NMEA interface commands.

IPTCOM-Simulator. Simulates an external IptCom master (TMS) for IP communication with the train radio system.

CIP-Simulator. Simulates an external CIP master (TMS) for IP communication with the train radio system.

...

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HMI-SIMULATOR

Starts a server which connects to the HMI

Uses the interface protocol declarations for HMI including ist file system and software



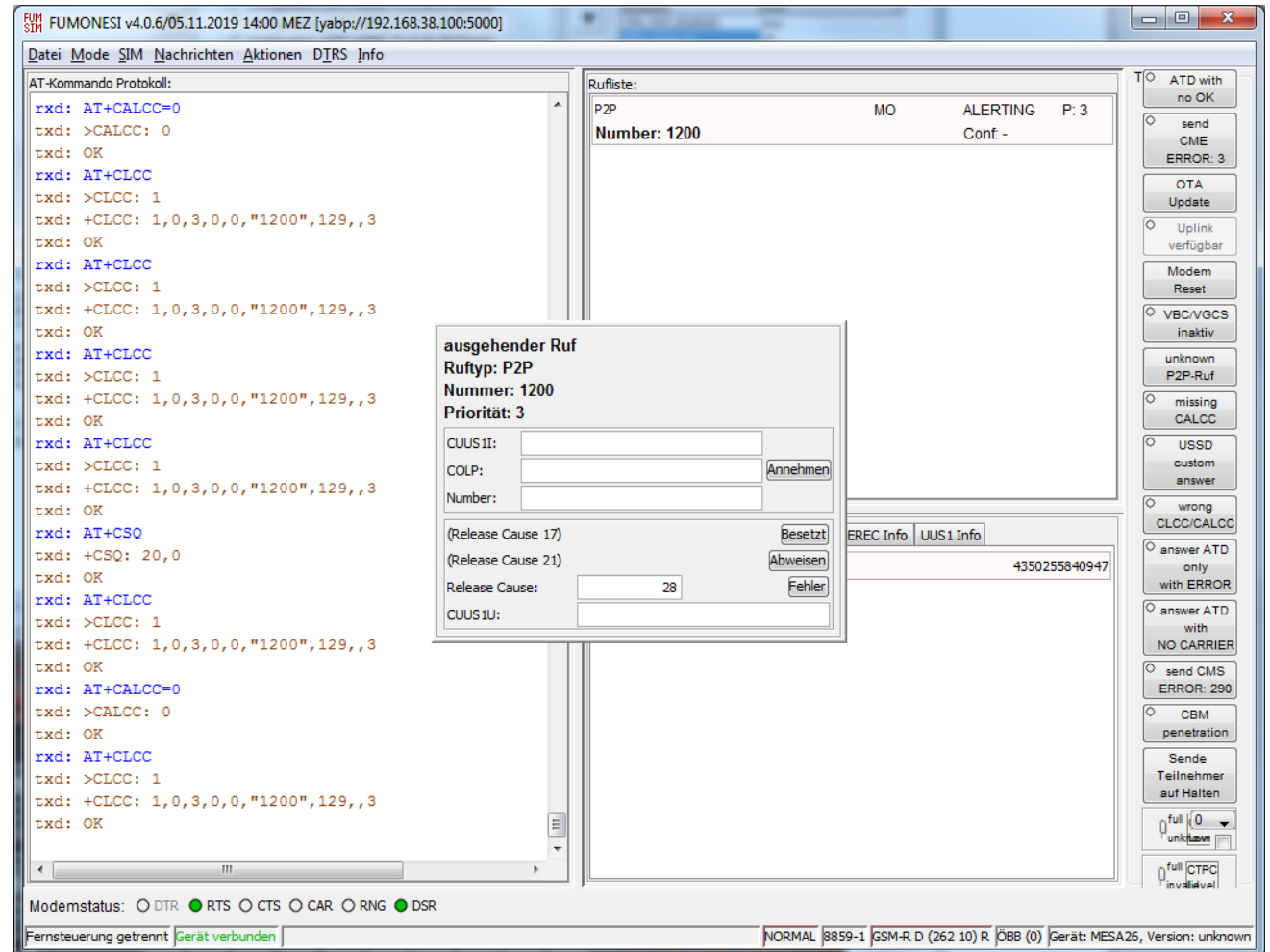
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FuMoNeSi

GSM-R modem and network simulator. User can initiate network action (e.g. incoming REC) and respond to train radio system activities (e.g. functional registration)

Initiate via TCP/IP a connection to the AT-interface configurable server or connects via additional PCB board.

Semi-Transparent-Mode possible

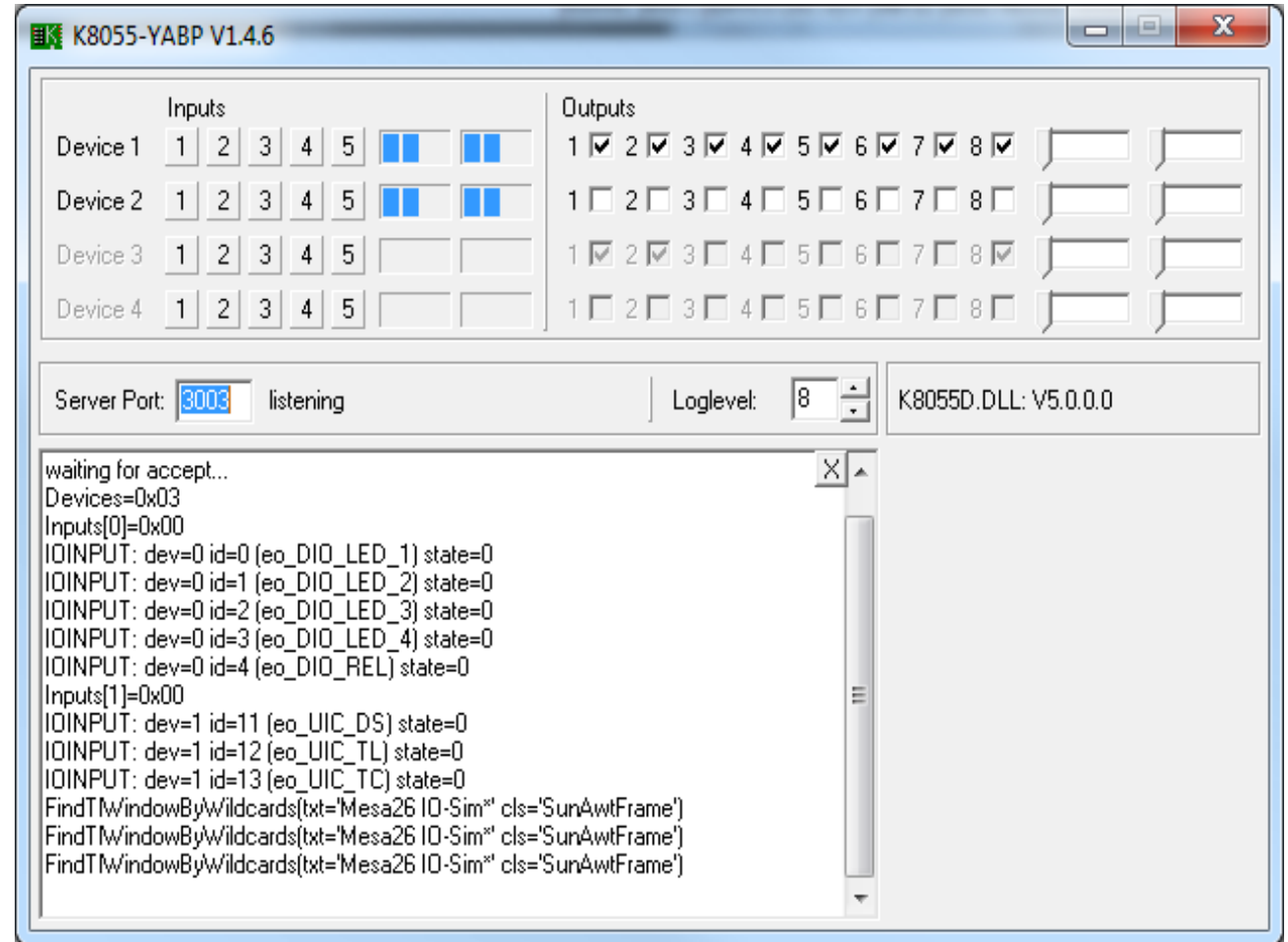


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DigitalIO/Power-SIMULATOR & K8055-YABP

K8055-YABP is a program for connection with the K8055 board for controlling the digital input and output (DIO) on the train radio system

Simulator connects via TCP/IP to K8055-YABP

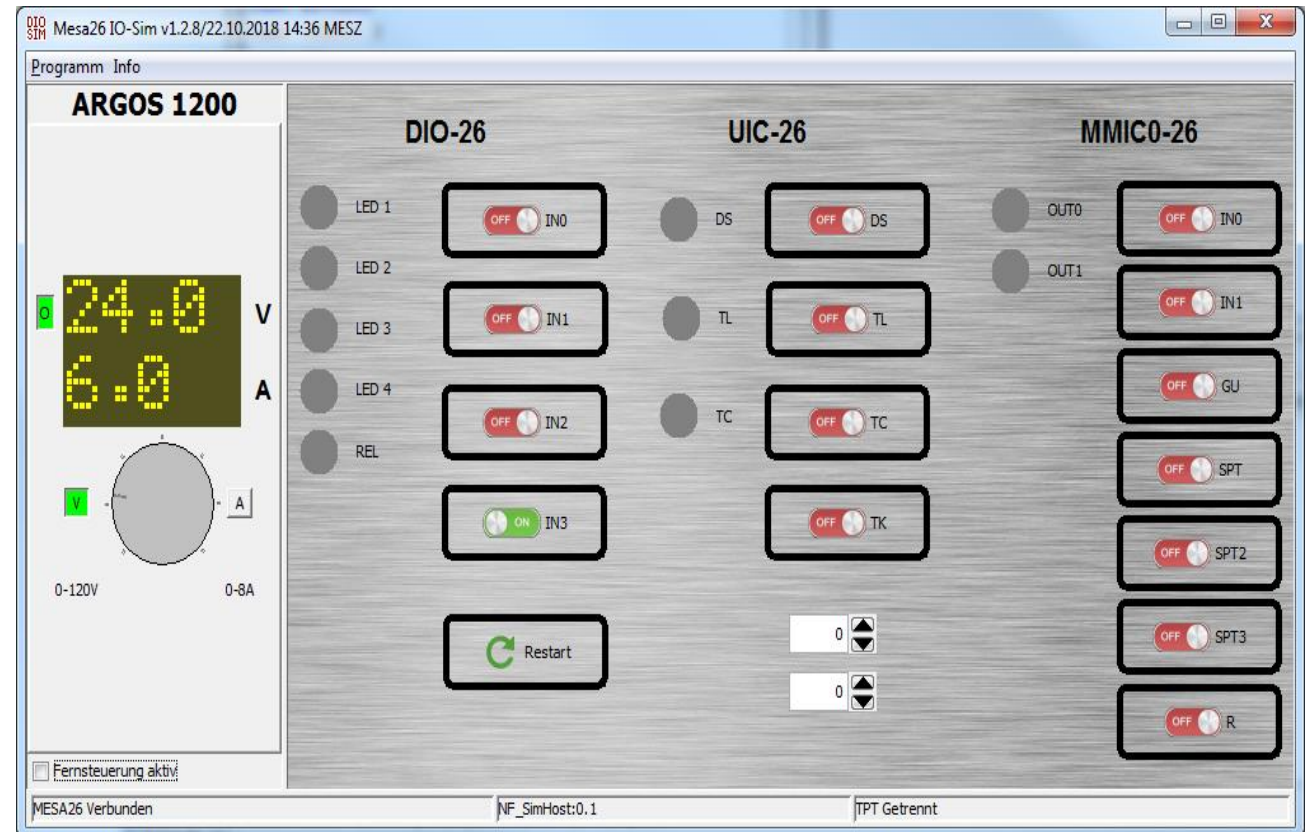


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DigitalIO/Power-SIMULATOR & K8055-YABP

Additionally the DigitalIO/Power-simulator can connect itself with external ARGOS or R&S power supplies and can control the external power.

IO contacts can be organized and structured as switches via XUI configuration.

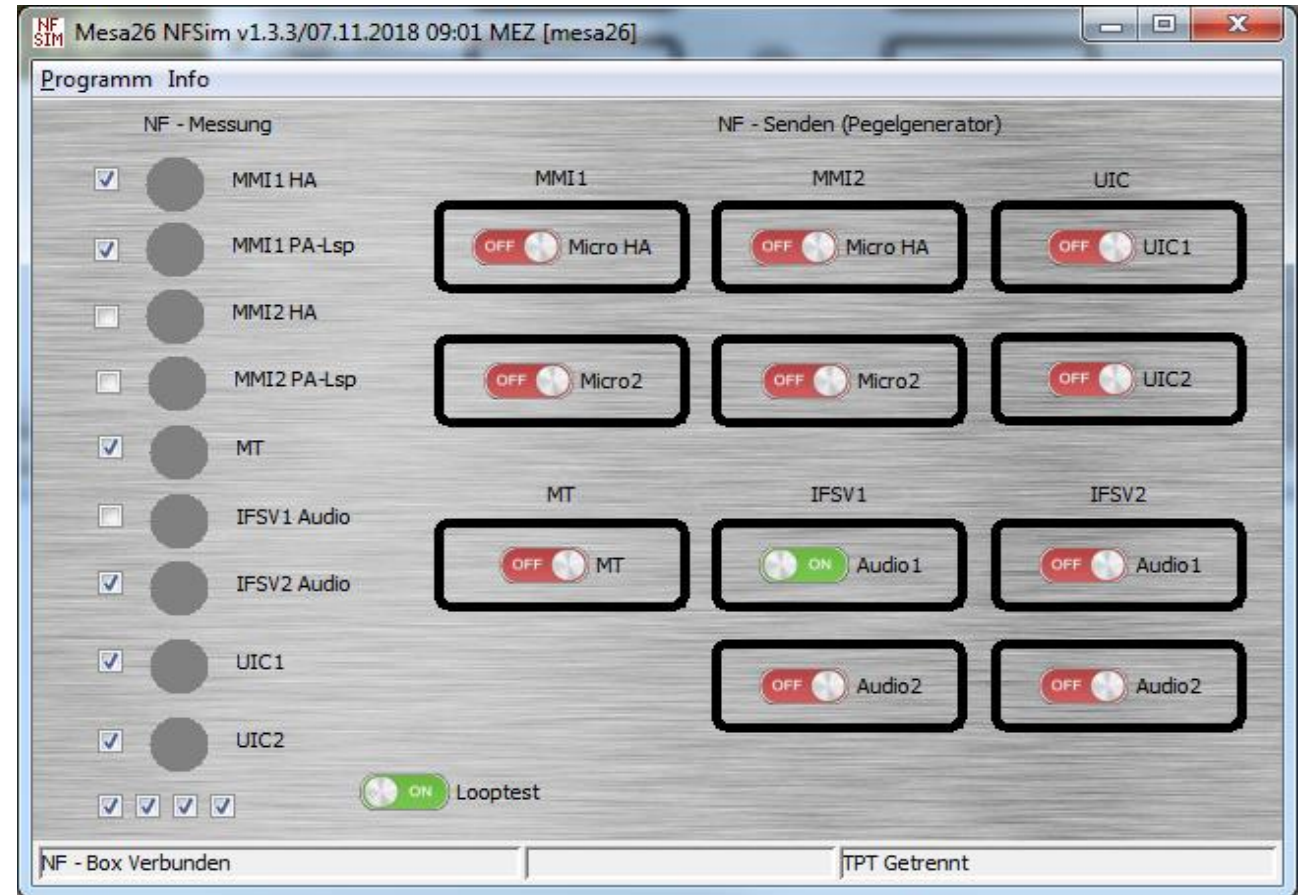


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NF-SIMULATOR

The Keithley 2016-P Audio Analyzing DMM send a voice frequency signal to an audio input.

The audio analyzing box checks all outputs one after one if a voice signal is detectable.

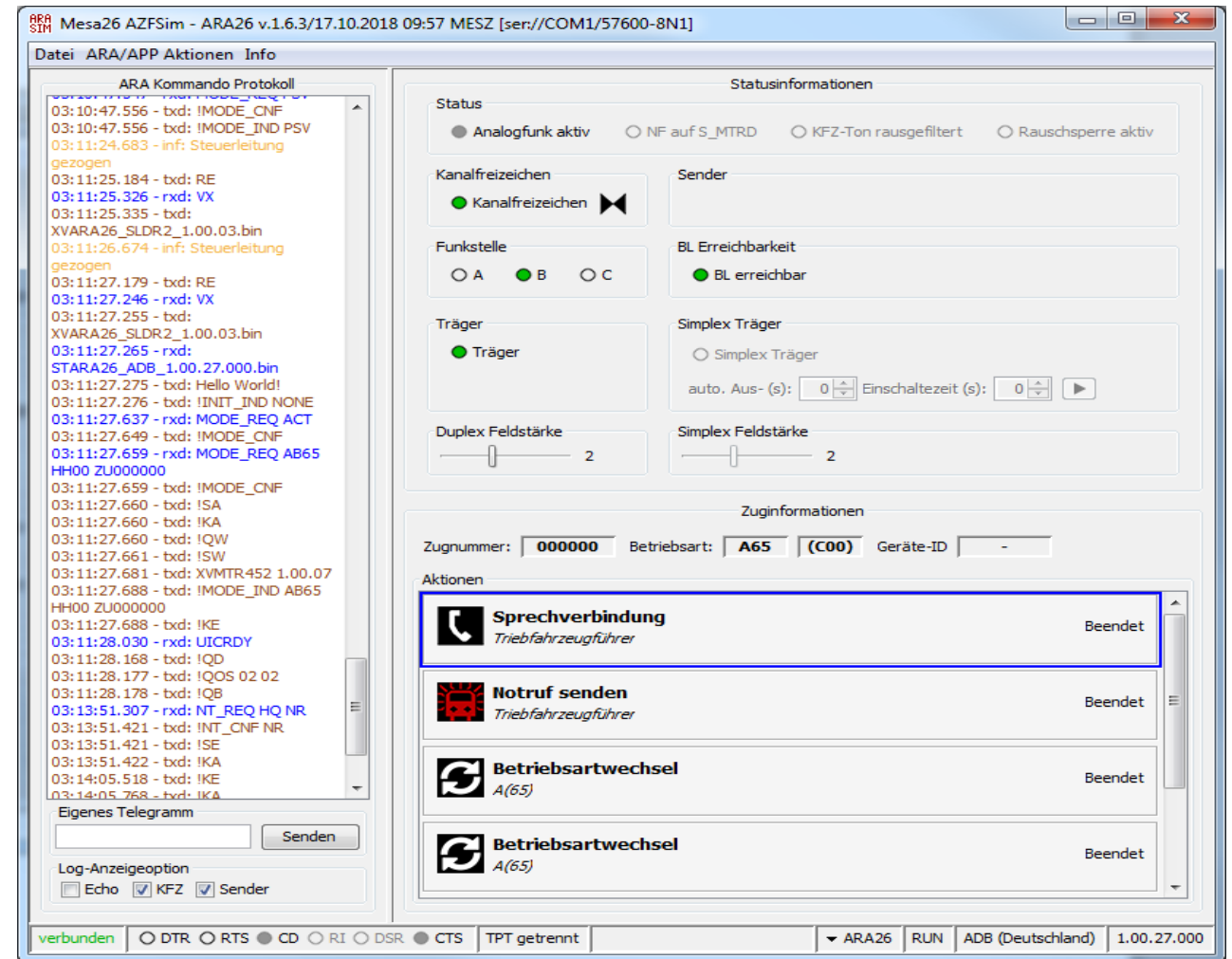


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ATR-SIMULATOR

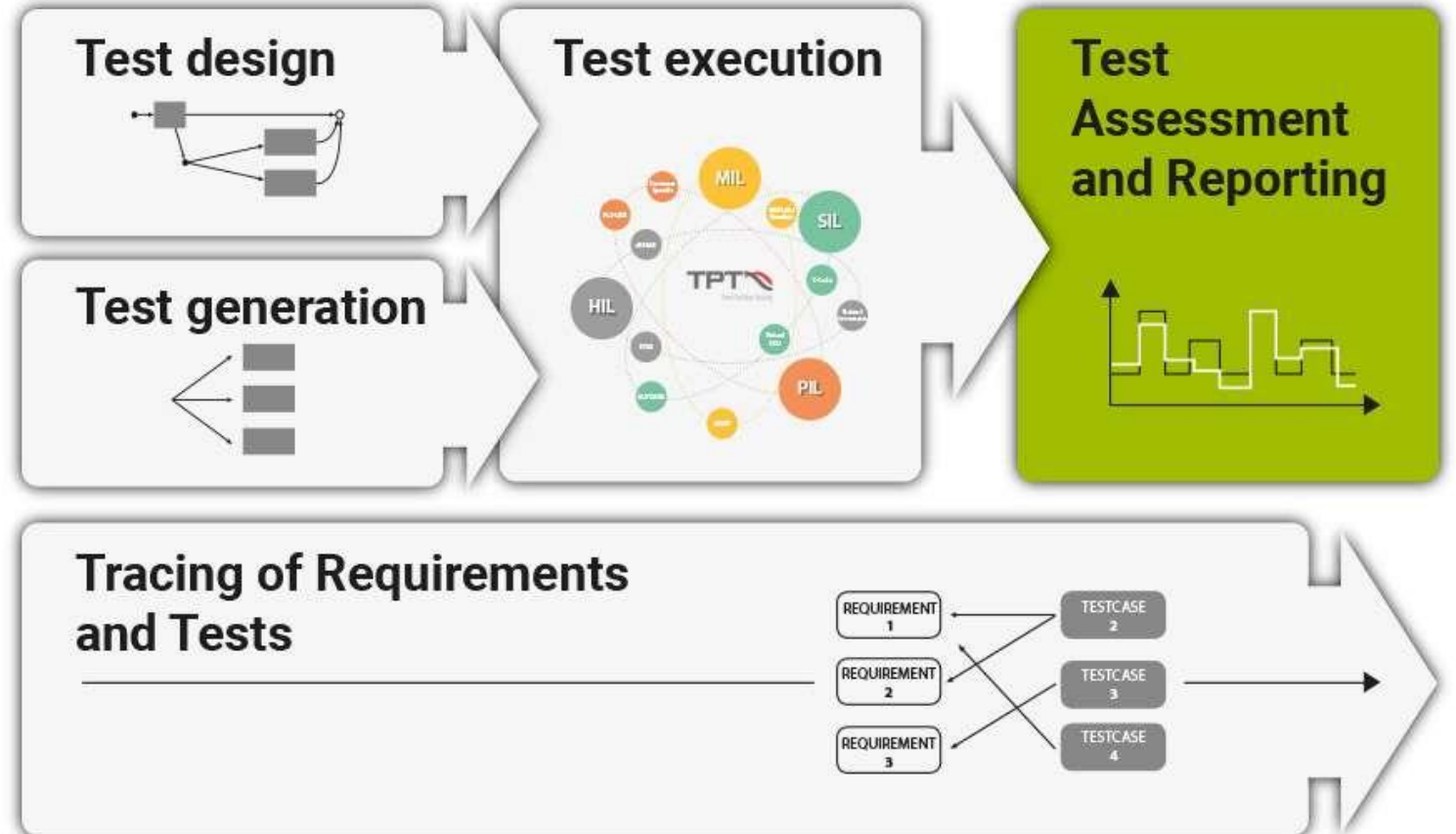
Uses serial interface to the configured IFS of the train radio system.

Implements the interface protocol of the ATR module and ATR network.



TPT

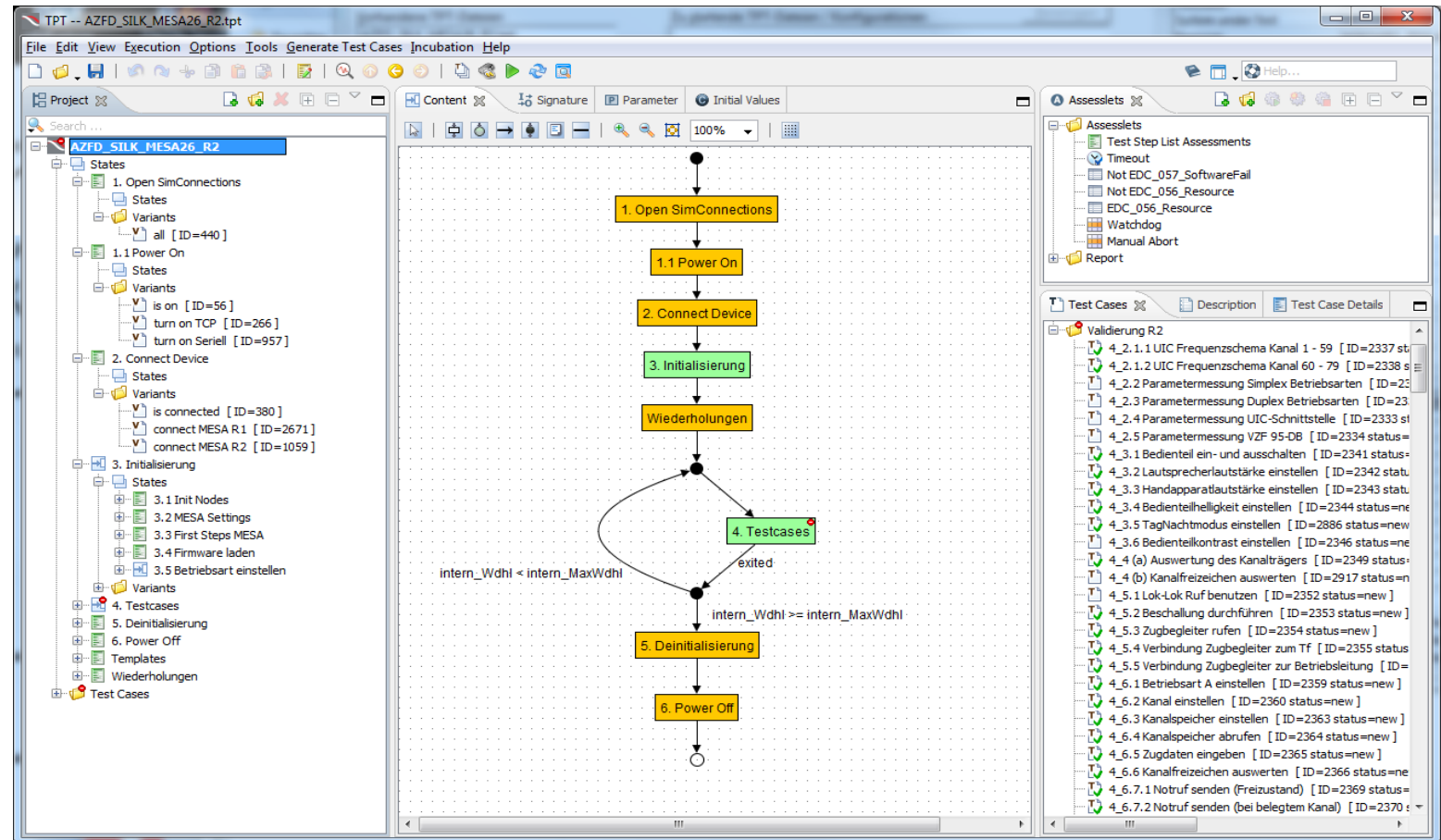
- Time Partition Testing (TPT) is a software product of Piketec
- Model based testing tool for test of embedded systems
- Graphical interface for generating test cases
- Automated test execution
- Automated test evaluation and assessment
- Automated test reporting
- Needs a license via license server or via dongle



TPT TEST CASE MODELING

State graph builds the basement for test case paths

State graph can be divided into parts, sub part graphs, states, variants, references and step lists



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TP
Event

The image displays a TestRail test suite configuration for 'Java Simulatoren'. The test suite is organized into several sections: 'Fumonesi', 'DIO', 'ARA Simulator', 'HMI 1', 'HMI 2', 'NF', and a sequence of wait and if-else steps.

Test Suite Configuration:

- 33 Java Simulatoren**
- 34 Fumonesi**
 - 35 Channel EDAcontrolParams.DTRon := true k | Once
 - 36 Channel fumonesi_sConnectionHost := "localhost" k | Once
 - 37 Channel fumonesi_iConnectionPort := 3333 k | Once
- 38 DIO**
 - 39 Channel dio_sConnectionHost := "localhost" k | Once
 - 40 Channel dio_iConnectionPort := 3004 k | Once
- 41 ARA Simulator**
 - 42 Channel ara1_sConnectionHost := "localhost" k | Once
 - 43 Channel ara1_iConnectionPort := 5057 k | Once
- 44 HMI 1**
 - 45 Channel hmi1_sConnectionHost := "localhost" k | Once
 - 46 Channel hmi1_iConnectionPort := 4444 k | Once
- 47 HMI 2**
 - 48 Channel hmi2_sConnectionHost := "localhost" k | Once
 - 49 Channel hmi2_iConnectionPort := 4445 k | Once
- 50 NF**
 - 51 Channel nf1_sConnectionHost := "localhost" k | Once
 - 52 Channel nf1_iConnectionPort := 3010 k | Once
- 53 Auf Verbindung der Nodes warten**
- 54 Wait ...** dio_iConnectionState == CONNECTED with assessment
- 55 Wait ...** hmi1_iConnectionState == CONNECTED with assessment
- 56 Wait ...** hmi2_iConnectionState == CONNECTED with assessment
- 57 Wait ...** ara1_iConnectionState == CONNECTED with assessment
- 58 Wait ...** fumonesi_iConnectionState == CONNECTED with assessment
- 59 If ...** NF1_TEST_ENABLED == true k | Once
- 60 Wait ...** nf1_iConnectionState == CONNECTED with assessment
- 61 Else**
- 62 Wait** 0
- 63 End (If)**

Test Case Details:

The right-hand side of the image shows a detailed view of a test case. The 'Asseslets' pane on the right lists various test steps, including 'Timeout', 'Not EDC_057_SoftwareFail', 'Not EDC_056_Resource', 'EDC_056_Resource', 'Watchdog', 'Manual Abort', and 'Report'. The 'Test Case Details' pane shows a table with columns for 'Attribute' and 'Value', with rows for 'Test Specification', 'Preconditions', and 'Pass Conditions'. The 'Test Case Details' pane also shows a list of test steps with their respective attributes and values.

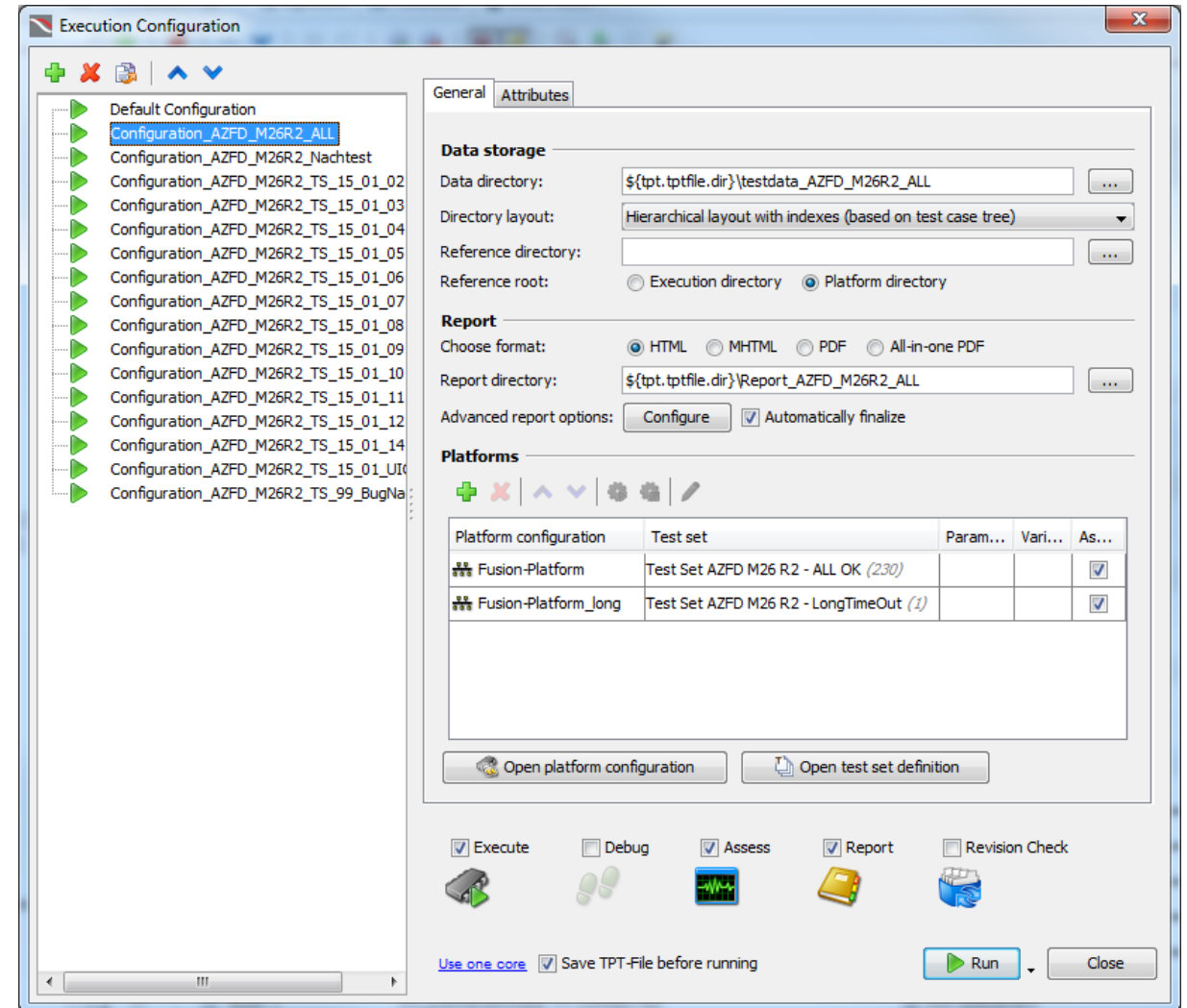
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TPT TEST SETS & CONFIGURATION

Report Directory – for storage of the generated reports

Fusion-Platform

Test set or test configuration (set of single test cases which have to be executed in a row)



report.html

← → ↻ ⓘ Datei | C:/Testautomation/R2/Report_AZFD_M26R2_ALL/Fusion_Plattform/001_Validierung_R2/000_4_2_1_1_UIC_Frequenzschema_K...

1 Test Information

1.1 Meta Information

| | |
|--------------------|--|
| Test Case Name | 4_2_1.1 UIC Frequenzschema Kanal 1 - 59 |
| Test Result | ✓ Passed |
| Test Case ID | 2337 |
| TPT-File | AZFD_SILK_MESA26_R2.tpt |
| Directory | ..\testdata_AZFD_M26R2_ALL\Fusion_Plattform\001_Validierung_R2\000_4_2_1_1_UIC_Frequenzschema_K |
| Execution Config | Configuration_AZFD_M26R2_ALL |
| Platform Config | Fusion-Plattform |
| Execution started | 15:28:00 17.01.2020 |
| Assessment started | 15:39:00 17.01.2020 |
| Duration | 810.364s (execution: 658.732s, assessment: 151.632s) |
| Custom Node | C:\TPT_Fusion\DigitalIOSim_Node.dll Package: digiosim_node // Version: 01.00.07.000 // Checksum: 20181022, C:\TPT_Fusion\HmiSim_Node.dll Package: hmisim_node // Version: 01.00.25.032 // Checksum: 20190513, C:\TPT_Fusion\HmiSim_Node_2.dll Package: hmisim_node // Version: 01.00.25.032 // Checksum: 20190513, C:\TPT_Fusion\fumonesi_Node.dll Package: fumonesi_node // Version: 01.00.12.006 // Checksum: 20180613, ..\..\TPT_Fusion\TptTestProtocolAdapterNode.dll Package: NONE // Version: 01.00.03.000 // Checksum: 29012016, C:\TPT_Fusion\AraSim_Node.dll Package: arasim_node // Version: 01.02.11.000 // Checksum: 20181106, C:\TPT_Fusion\NFSim_Node.dll Package: nfsim_node // Version: 01.02.11.012 // Checksum: 20181128, C:\TPT_Fusion\Log_Node.dll Package: log_node // Version: 01.01.19.088 // Checksum: 20191212, C:\TPT_Fusion\AGP_Node.dll Package: agp_node // Version: 01.01.22.000 // Checksum: 4072018, C:\TPT_Fusion\EDA_Node.dll Package: eda_node // Version: 01.00.09.000 // Checksum: 19012016 |
| Platform mapping | <none> |

1.2 Assesslet Summary

| Assesslet Name | Passed | Failed | Inconclusive |
|--|--------|--------|--------------|
| Manual Abort | ✓ | | |
| Not EDC_057_SoftwareFail | ✓ | | |
| Variant A (in state 'Betriebsart') | ✓ | | |
| Variant ADB (in state '3.4 Firmware laden') | ✓ | | |
| Variant all (in state '1. Open SimConnections') | ✓ | | |
| Variant connect MESA R2 (in state '2. Connect Device') | ✓ | | |
| Variant Disconnect (in state '5. Deinitialisierung') | ✓ | | |
| Variant MESA start (in state '3.3 First Steps MESA') | ✓ | | |
| Variant MesaType, CellId, Network (in state '3.2 MESA Settings') | ✓ | | |
| Watchdog | ✓ | | |

2 Signals

2.1 Parameter

| Name | Value | From | To | Comment |
|--------------------|------------|------|--------|---------|
| AGP_CONNECTION_COM | "COM4";256 | 0s | 657.6s | |

TPT

Comment

| | |
|--|--|
| 6R2_ALL\Fusion_Plattform\001_Validierung_R2\000_4_2_1_1_UIC_Frequenzschema_K | |
| 6R2_ALL\Fusion_Plattform\001_Validierung_R2\001_4_2_1_2_UIC_Frequenzschema_K | |
| 6R2_ALL\Fusion_Plattform\001_Validierung_R2\006_4_3_1_Bedienteil_ein_und_au | |
| 6R2_ALL\Fusion_Plattform\001_Validierung_R2\007_4_3_2_Autsprecherlautstaerke | |
| 6R2_ALL\Fusion_Plattform\001_Validierung_R2\008_4_3_3_Handapparatautstaerke | |
| 6R2_ALL\Fusion_Plattform\001_Validierung_R2\009_4_3_4_Bedienteilheligkeit_e | |
| 6R2_ALL\Fusion_Plattform\001_Validierung_R2\010_4_3_6_TagNachmodus_einstell | |

START SCRIPTS

Start simulator samples

- `Javaw.exe -jar azfsim.jar`
- `Java.exe -classpath res;HMI-Sim-standalone.jar de.hfwk.mesa26.hmi.ui.Logic -x res/mesa26_mmi.xui`
 - `.xui` are different graphical user interface configurations which can be loaded e.g. different types of HMI

Start test case execution

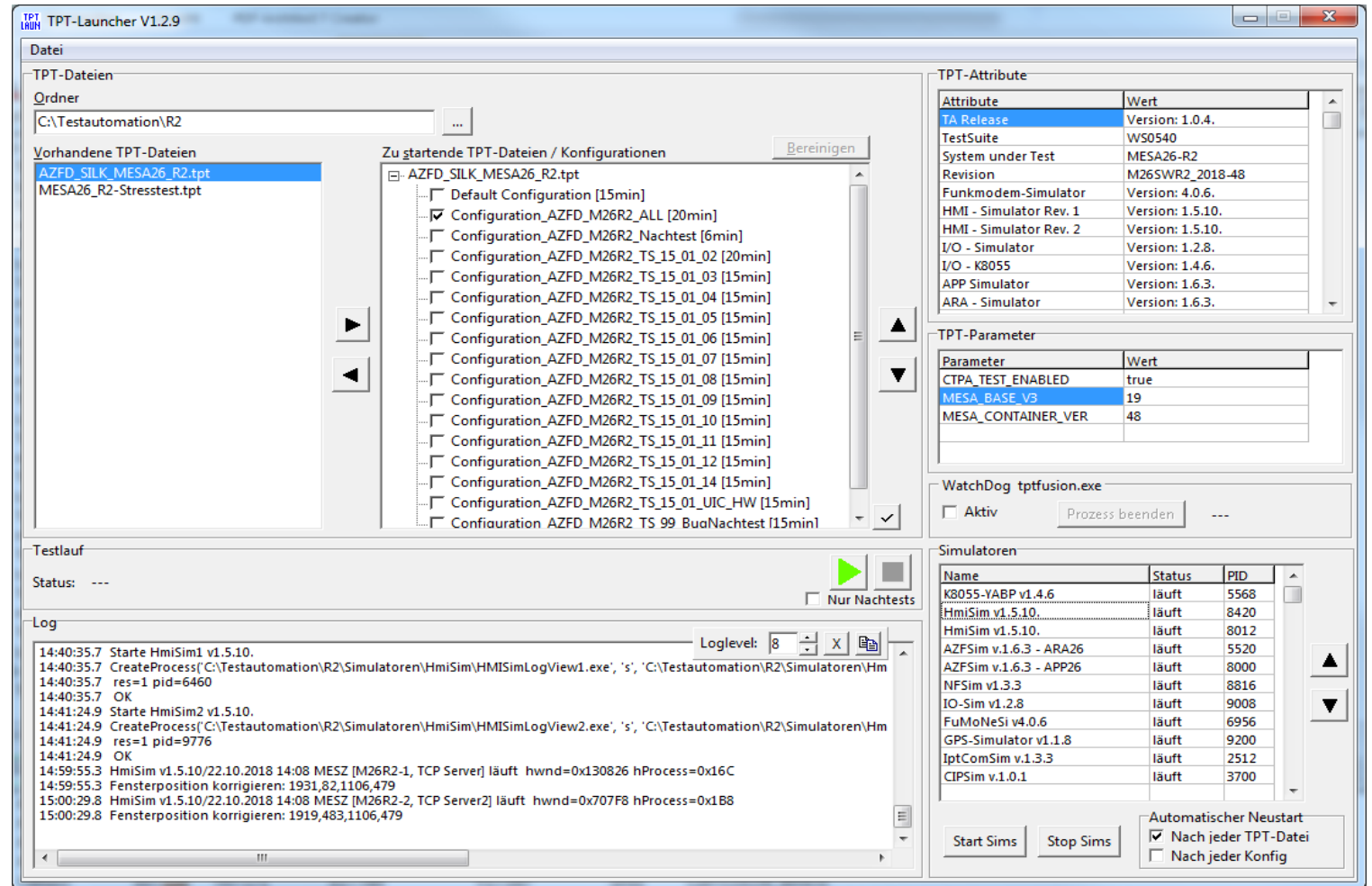
- `tpt.exe --nosplash --run build C:\Testautomation\R2\O-3001_MESA26_R2.tpt Configuration_O3001_M26R2_TS_4.6 -vm-Xmx4g`
- `tpt.exe --nosplash --run build C:\Testautomation\R2\O-3001_MESA26_R2.tpt Configuration_O3001_M26R2_TS_4.7 -vm-Xmx4g`
 - [path to the TPT program]
 - `--nosplash` → suppress the TPT start screen
 - `--run build [path to the stored test catalogue][name of the configuration of the test object]`
 - `-vm-Xmx4g` → blocks physical memory for Java VM (z.B. 4GB)

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TPT LAUNCHER

Required to control different test catalogues including their configurations

Required for the individual start of the (associated) simulators



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MANAGEMENT OF THE TEST ENVIRONMENT

All simulators, nodes, test cases, catalogues and configurations where stored and managed by SVN

- Every component built it's own project with a independent SVN folder
- trunk folder for development
- tags folder for releases
- Test cases are structured in accordance with the project; no independent trunk folder required

TA-Release

- Contains all required components for a release version of the test environment
- Copy of the associated tags into the integration project
- Inno-setup script for test automation (TA)-release of the test environment (simulators and nodes)
- Inno-setup script for TA-test case-release for test catalogues
- As a result an installation package will be generated which contains all required functionality needed for executing automatized tests (TPT, JAVA, DLL's)

Laboratory validation

- Every TA-release will be validated by the Funkwerk laboratory (this includes review of the test steps, integration test with installation on a hosting machine, test runs and evaluation of test reports; negative tests in accordance with the defined laboratory and development processes of Funkwerk)
- Results will be reported in official laboratory validation reports which are stored in the TA-release content in SVN

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LIMITATIONS & MANUAL TESTING

Current limits of the test automation

- Signalising tones below 5 seconds of duration; to clearly detect an audio signal in frequency and amplitude the Keithley 2016-P needs a stable signal of 5 sec duration.
- Control of external measurement equipment e.g. parameter measurement of ATR (RF power, used channel frequencies, evaluation of frequency deviation)

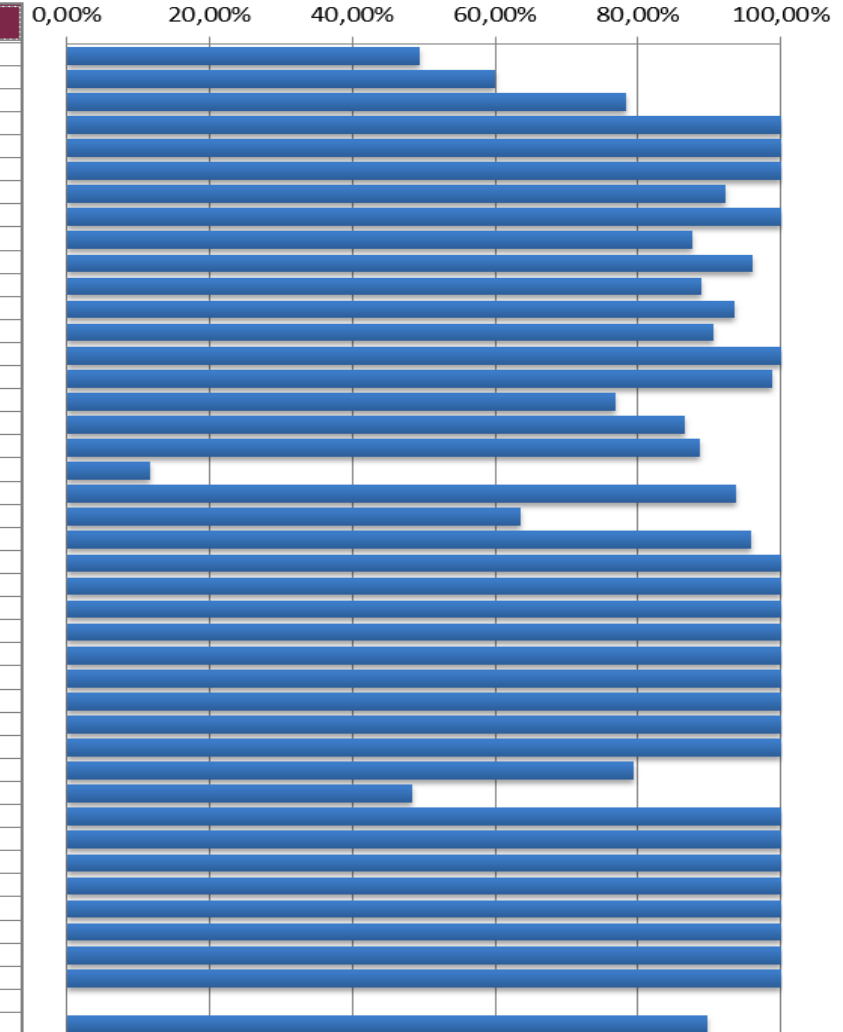
For identification of manual tests in the data base we use a flag for filtering

Effort & benefit. Some tests are easy for manually execution but very tricky for automation.

LIMITATIONS & MANUAL TESTING

- Increase the state of reached grade of automation (main line product)
- End-2-end tests
 - System tests with air interface as limitation
 - MT-Node (GSM-R modem termination)
 - FESA and FESA-simulator (ATR base station)
- Parameter measurement with CMS50, CMA180
- Evaluation of new test catalogues
- LTE or 5G integration

| Anzahl Testfälle | gesamt | automatisiert | Automatisierungsgrad |
|-------------------------------|--------|---------------|----------------------|
| AP 1.1 - EIRENE | 229 | 113 | 49,34% |
| AP 1.2 - EIRENE QoS | 10 | 6 | 60,00% |
| AP 1.3 - Add-On R2 Features | 92 | 72 | 78,26% |
| AP 1.4 - GSM-R Belgien | 93 | 93 | 100,00% |
| AP 1.5 - GSM-R UK | 40 | 40 | 100,00% |
| AP 1.6 - LTE | 50 | 50 | 100,00% |
| AP 2 - Shunting | 52 | 48 | 92,31% |
| AP 3 - SMS | 64 | 64 | 100,00% |
| AP 4.1 - AZF-DE | 241 | 211 | 87,55% |
| AP 4.2 - AZF-AT | 77 | 74 | 96,10% |
| AP 4.3 - AZF-RO | 18 | 16 | 88,89% |
| AP 4.4 - AZF-SK | 109 | 102 | 93,58% |
| AP 4.5 - AZF-HU | 96 | 87 | 90,63% |
| AP 4.6 - AZF-BG | 102 | 102 | 100,00% |
| AP 4.7 - AZF-HR | 82 | 81 | 98,78% |
| AP 4.8 - AZF-RS | 95 | 73 | 76,84% |
| AP 4.9 - AZF-LU | 52 | 45 | 86,54% |
| AP 4.10 - AZF-CS | 97 | 86 | 88,66% |
| AP 4.11 - AZF-PL | 95 | 11 | 11,58% |
| AP 4.12 - AZF-P | 80 | 75 | 93,75% |
| AP 5 - Störbeeinflussung | 22 | 14 | 63,64% |
| AP 6.1 - AGP | 70 | 67 | 95,71% |
| AP 6.2 - IPTCom | 37 | 37 | 100,00% |
| AP 6.3 - EXPERT2 | 10 | 10 | 100,00% |
| AP 6.4 - EDA | 65 | 65 | 100,00% |
| AP 6.5 - DSD | 10 | 10 | 100,00% |
| AP 6.6 - ZUB262 | 8 | 8 | 100,00% |
| AP 6.7 - GPS | 6 | 6 | 100,00% |
| AP 6.8 - CIP | 44 | 44 | 100,00% |
| AP 9.9 - CONVEL | 8 | 8 | 100,00% |
| AP 6.10 - DK F-BANE | 2 | 2 | 100,00% |
| AP 6.11 - SibasPN | 29 | 23 | 79,31% |
| AP 6.12 - TRDP | 29 | 14 | 48,28% |
| AP 6.13 - EBISTAR | 10 | 10 | 100,00% |
| AP 6.14 - OTMR | 43 | 43 | 100,00% |
| AP 6.15 - ZFM21M | 30 | 30 | 100,00% |
| AP 6.16 - CGR3000 | 16 | 16 | 100,00% |
| AP 6.17 - MVB | 72 | 72 | 100,00% |
| AP 6.18 - FZPF | 71 | 71 | 100,00% |
| AP 7 - Stresstests + Bugzilla | 1085 | 1085 | 100,00% |
| AP 8 - Komponententests | 8 | 8 | 100,00% |
| Summe | 3449 | 3092 | 89,65% |



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LIMITATIONS & MANUAL TESTING

| Jahr | Testfälle | Automatisiert | Automatisierungsgrad | Differenz |
|------|-----------|---------------|----------------------|-----------|
| 2016 | 803 | 696 | 86,70% | |
| 2017 | 2114 | 1831 | 86,60% | 1311 |
| 2018 | 2764 | 2468 | 89,30% | 650 |
| 2021 | 2996 | 2645 | 88,28% | 232 |
| 2022 | 3449 | 3092 | 89,70% | 453 |

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Thank You!

We look forward to your questions!