MEETING THE CHALLENGES FOR TESTING NEXT-GENERATION MOBILE NETWORK EQUIPMENT IN PRODUCTION

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ROHDE&SCHWARZ
Make ideas real

AGENDA

- Trends riding the Infrastructure market
- Key drivers increasing the production efficiency
- Innovative test approaches and solutions

INFRASTRUCTURE MARKET TRENDS

- Extended 5G cycle driven by growth in Enterprise
- Network architectural changes
  - Virtualization
  - Flexible & cost efficient RAN
  - Power efficiency
- Region wise, APAC to see strongest growth
- Supply chain constraints have less effect on BTS market

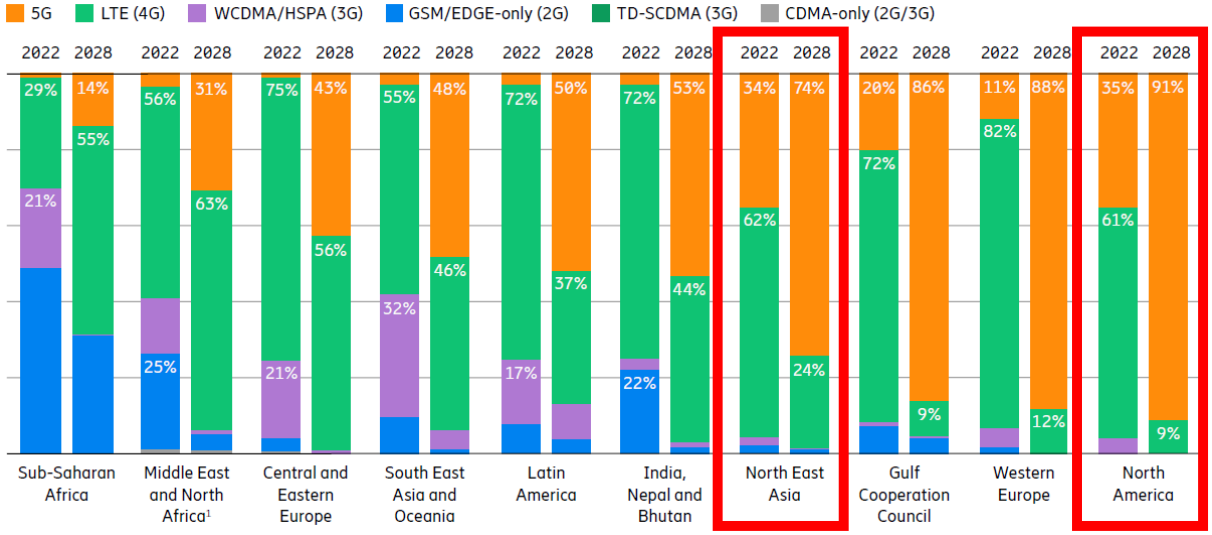


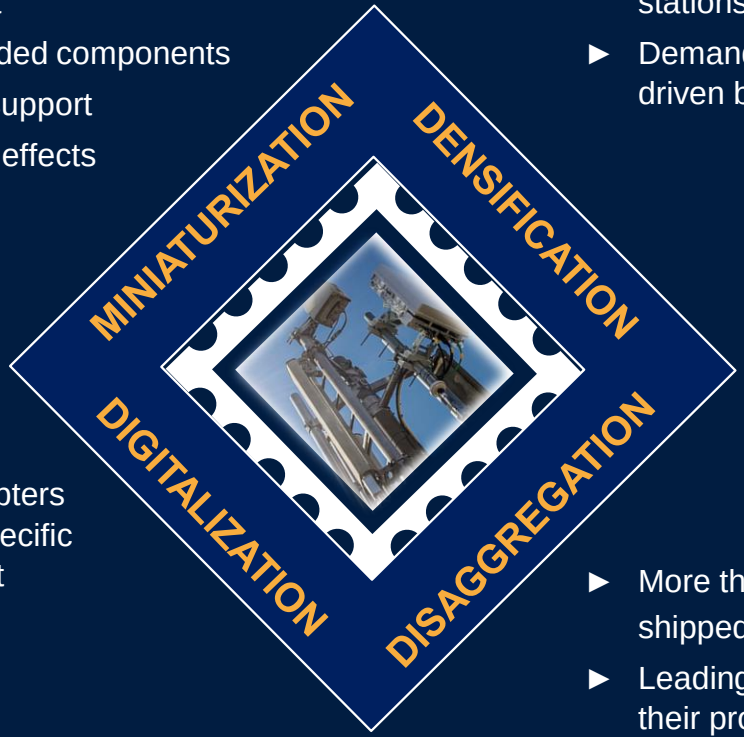
Figure: Mobile subscriptions by region and technology

Source: Ericsson Mobility report, Nov 2022

Added focus on virtualization, cost and power efficiency

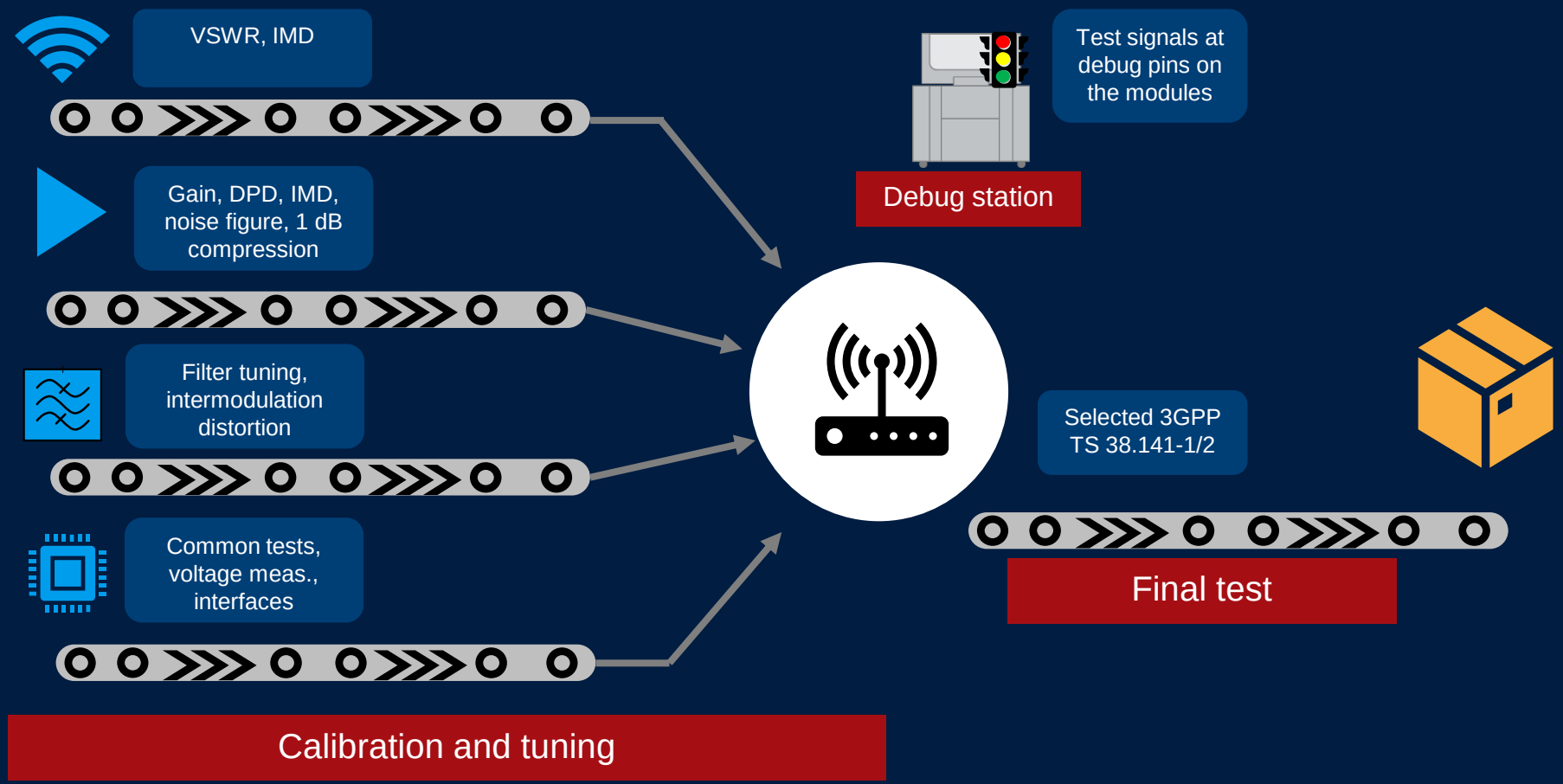
- Growing trend in SiP, AiP, chipset based products serving the infrastructure market
  - Complex assemblies, embedded components
- Reference designs, multi-band support
- Over-the-air (OTA) test, thermal effects
- Power efficiency

- Number of small cells to outgrow macro base stations by 2026
- Demand for sub-6 GHz infrastructure is driven by deployments in C band



- Infrastructure equipment manufacturers among early adopters of smart manufacturing, raise specific demand on Test & Measurement
  - Cloud based test architecture
  - Asset Management
- Machine learning (ML) and AI to optimize test process flow

- More than **60%** of the 5G base stations shipped will support O-RAN by 2027
- Leading to new players – flexibility in scaling their production inline with demand.
- New test approaches and industry consensus required to keep the “Cost of Test” low.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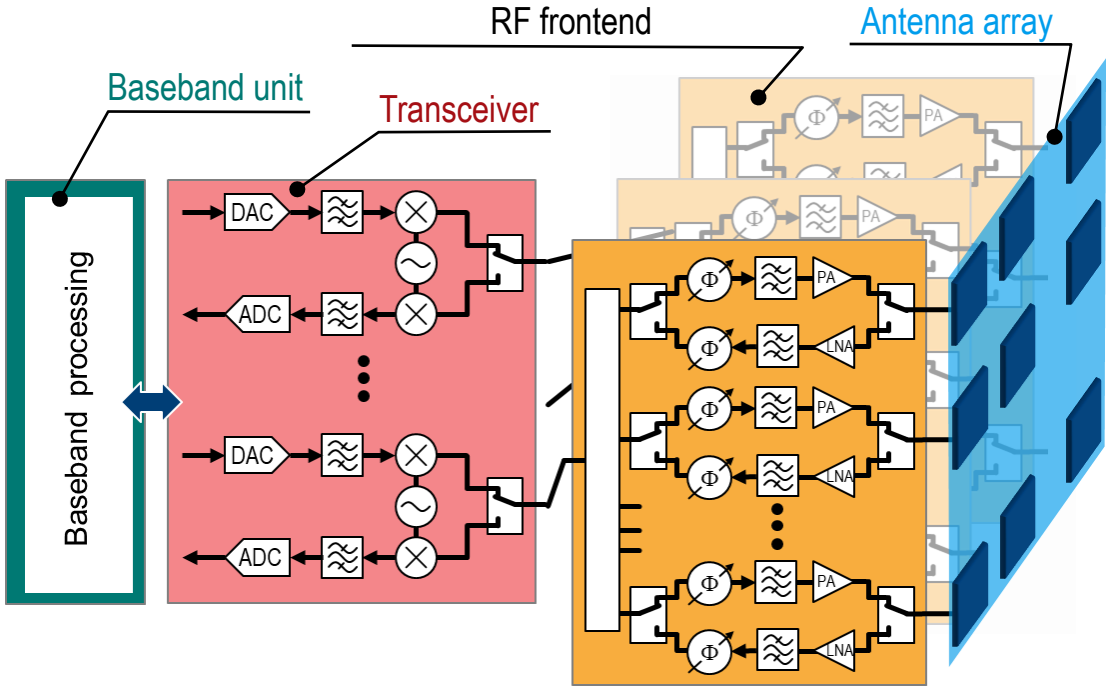
BUILDING BLOCKS OF A SMALL CELL
IN A NUTSHELL



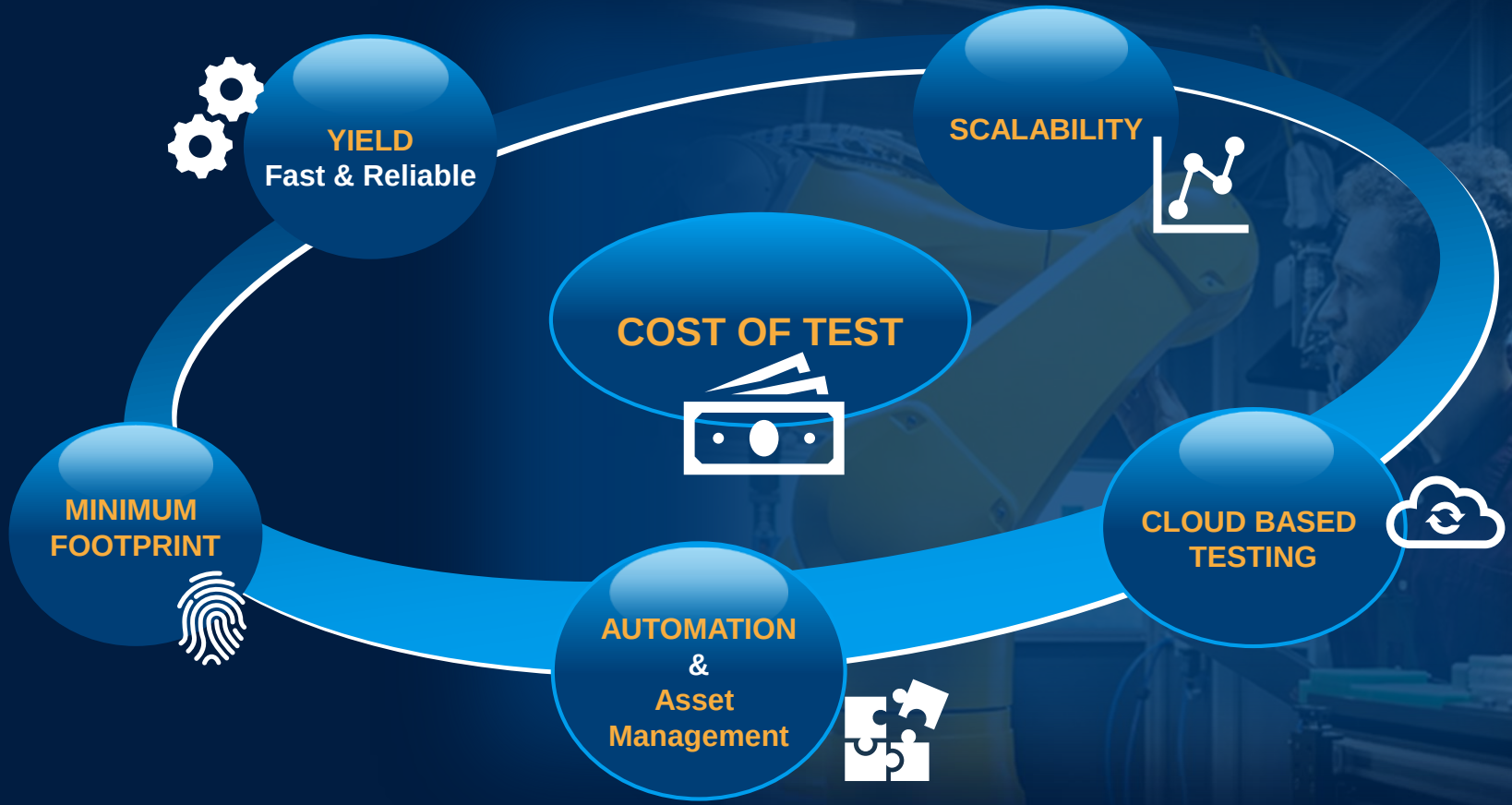
Typical calibration items

- Manufacturer defined test cases
- TX: DC offset
- TX: phased array
- TX: array linearizer
- RX: phased array
- RX: gain

FINAL TESTING – VERIFICATION

Transmitter characteristics	6.2	Base station output power	✓
	6.3	Output power dynamics	✗
	6.4	Transmit ON/OFF power	✗
	6.5	Transmitted signal quality	✓
	6.5.2	Transmitted signal quality - Frequency error	✓
	6.5.3	Transmitted signal quality - Modulation quality (EVM)	✓
	6.5.4	Transmitted signal quality - Time alignment error	✓
	6.6	Unwanted emissions - Occupied bandwidth	✓
	6.6.2	Unwanted emissions - Adjacent channel leakage power ratio (ACLR)	✓
	6.6.3	Unwanted emissions - Operating band unwanted emissions (SEM)	✓
	6.6.5	Unwanted emissions - Transmitter spurious emissions	✗
	6.7	Transmitter intermodulation	✗
Receiver characteristics	7	Receiver characteristics	✓
	7.2	Sensitivity reference level	✓
	7.3	Dynamic range	✗
	7.4	In band selectivity and blocking	✗
	7.5	Out-of-band blocking	✗
	7.6	Receiver spurious emissions	✗
	7.7	Receiver intermodulation	✗
	7.8	In-channel selectivity	✓

KEY DRIVERS ENABLING EFFICIENCY IN PRODUCTION



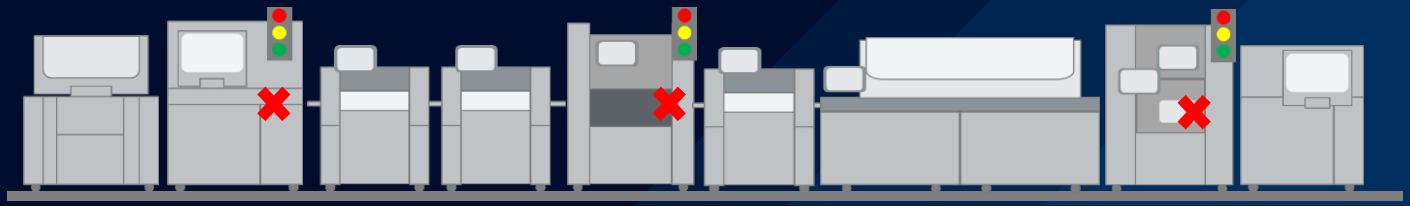
Production efficiency

INCREASING YIELD (THROUGHPUT)

INCREASING YIELD (THROUGHPUT)
PRODUCTION EFFICIENCY

Pass/Fail

The test process is only as good as the detection method



Test fails

Scrap

Expensive

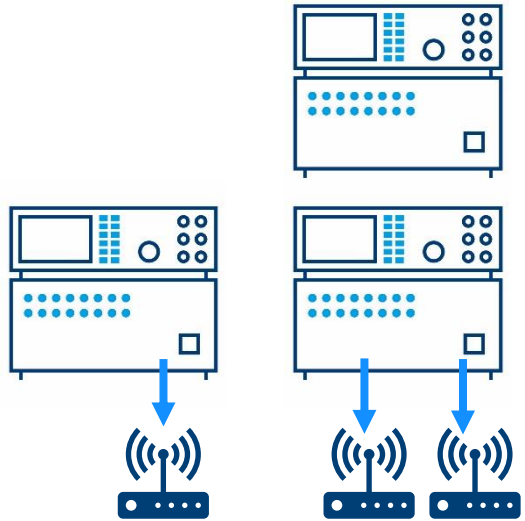
- Additional inspection
- Need to test your manufacturing
- Debug and rework stations
- Build extra to make up yield
- Extra inventory buffers

IMPORTANT RF PERFORMANCE INDICATORS
PRODUCTION EFFICIENCY

- RF performance
  - EVM : Dynamic range of the test instrument
  - Accuracy: Repeatability / Uncertainty / Stability
  - Isolation in case of multi channel instruments
  - Traceability to R&D (faster debugging)

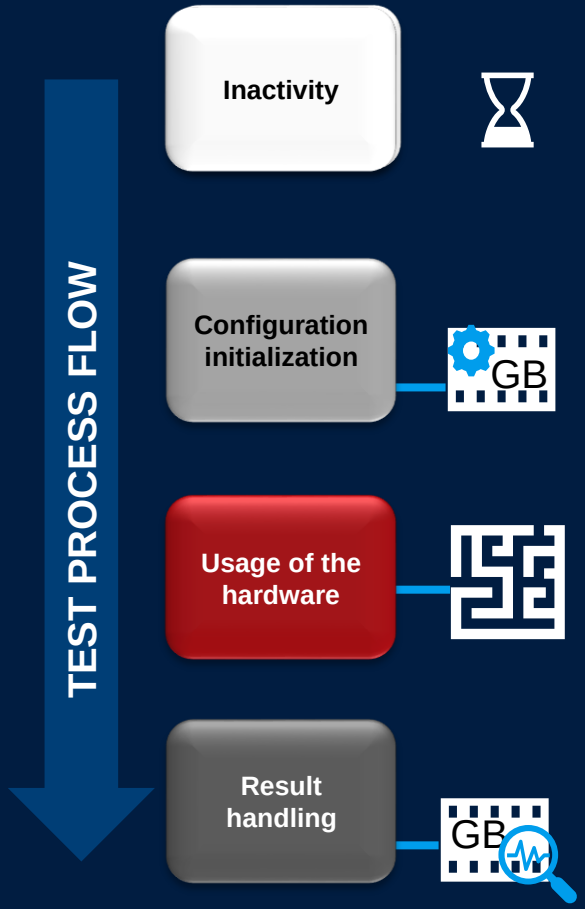
- Mean time between failures (MTBF)
- Gage R&R (repeatability & reproducibility)

“**Test time**” is not the **ONLY** criteria for increased production efficiency

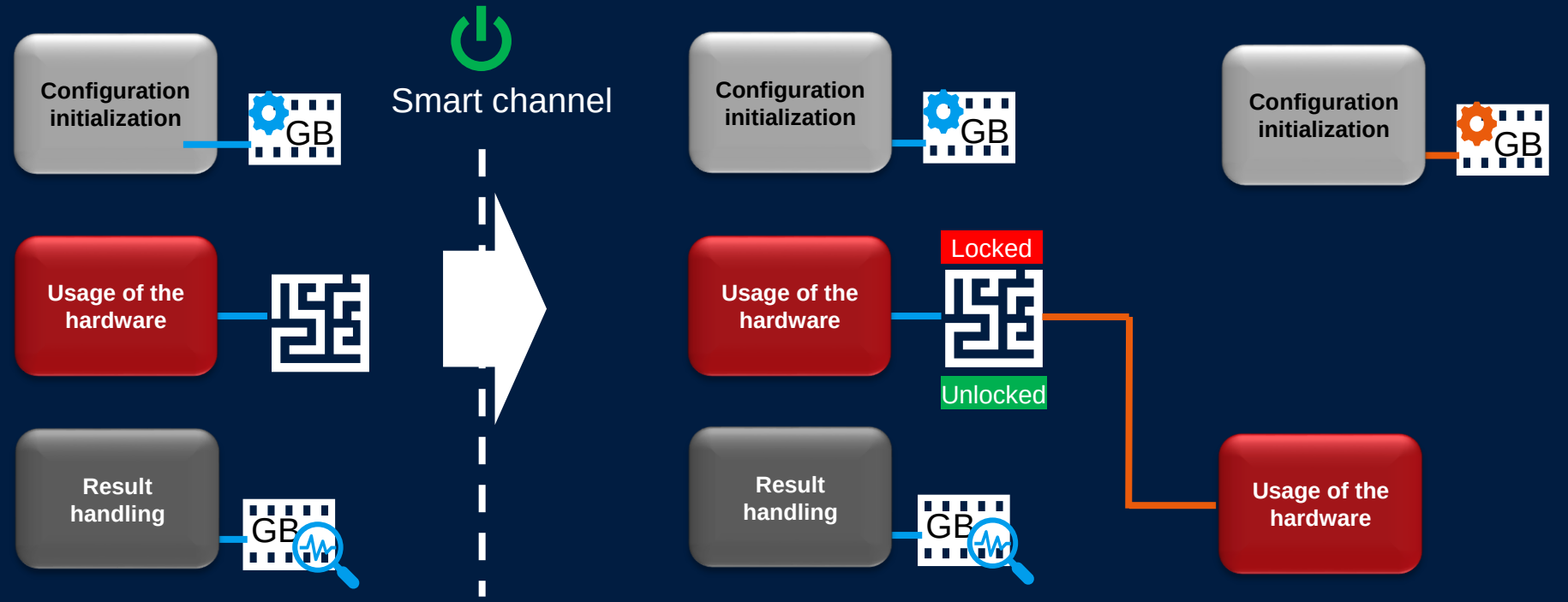


Do more with less

SCALABILITY



- Process relevant steps where the instrument is not engaged
  - DUT is booting
  - EEPROM values are written
  - Non RF tests
- Preparation of the measurement or generator, hardware is still not used
  - Configuration data stored in database and transferred to instrument upon initialization
- Test & measurement hardware is actively used and cannot be shared
  - Often <50% of the total process time
- After the measurement, result needs to be transferred and hardware not in use
  - Communication between the instrument database and automation tool



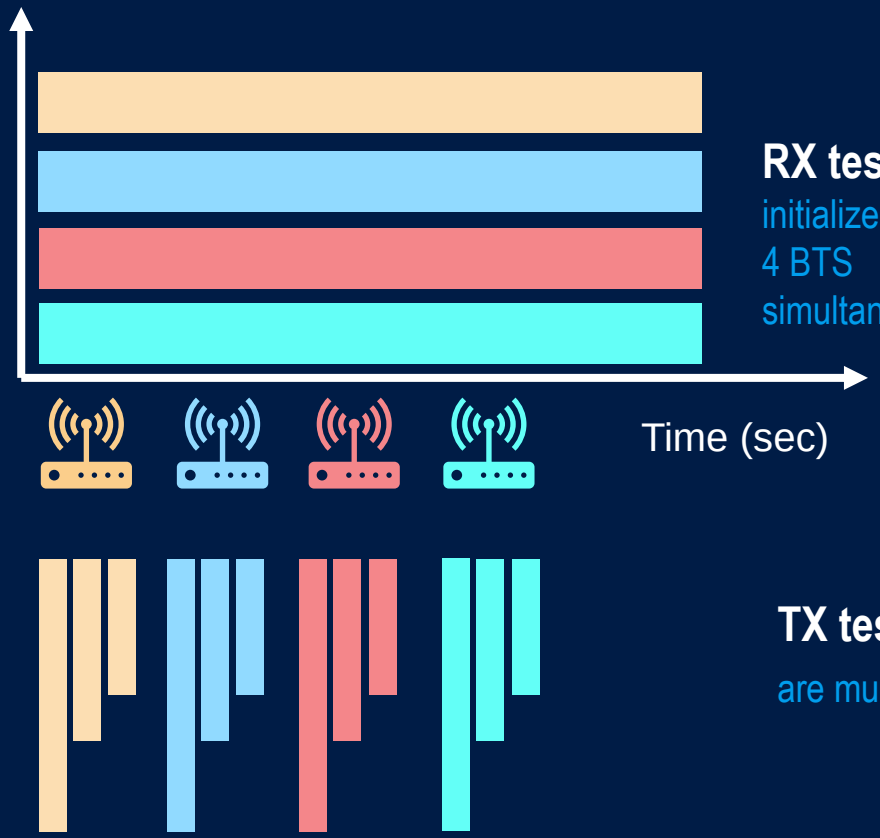
- **SMART CHANNEL**
  - Shares the hardware
  - Multiplies the config database
  - Multiplies result database

Maximize the resource usage

Do more with less !!!

BROADCAST MODE

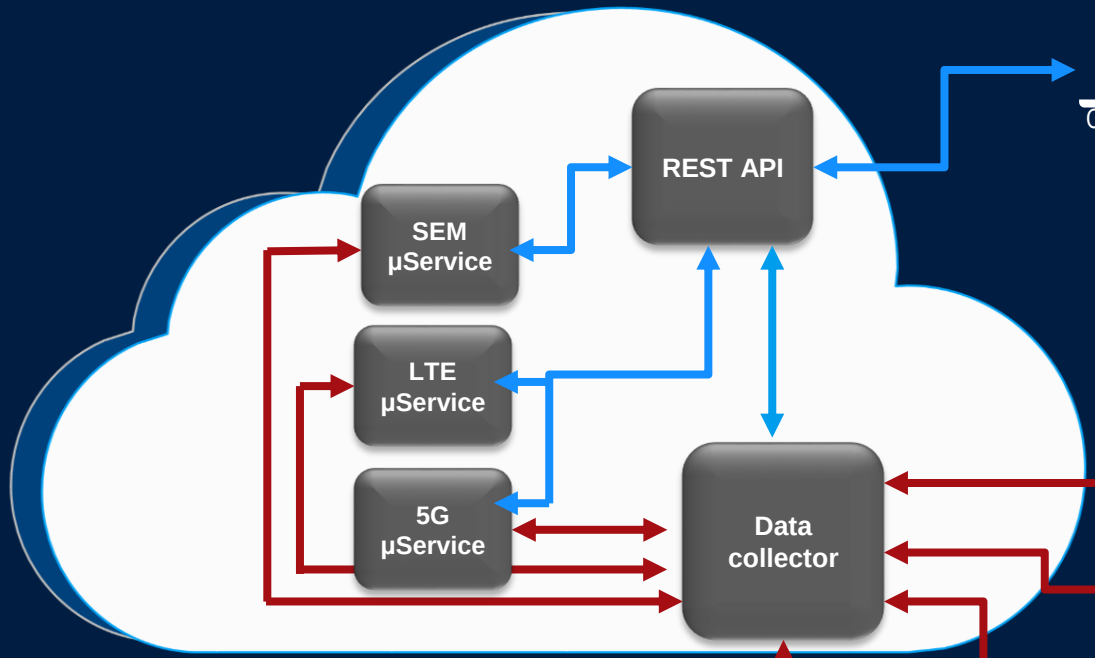
- Generator broadcast mode:
  - Receiver tests takes longer than TX tests
  - Generator signal can be switched to multiple ports, enabling parallel RX tests
  - TX tests can be multiplexed to be done one after the other
- All DUT's are synchronized at the start of the measurements



Smart Manufacturing

DIGITALIZATION

R&S®SERVER BASED TESTING



Separation of IQ data capture by h/w and data processing by the SBT

R&S® NRPxxSN

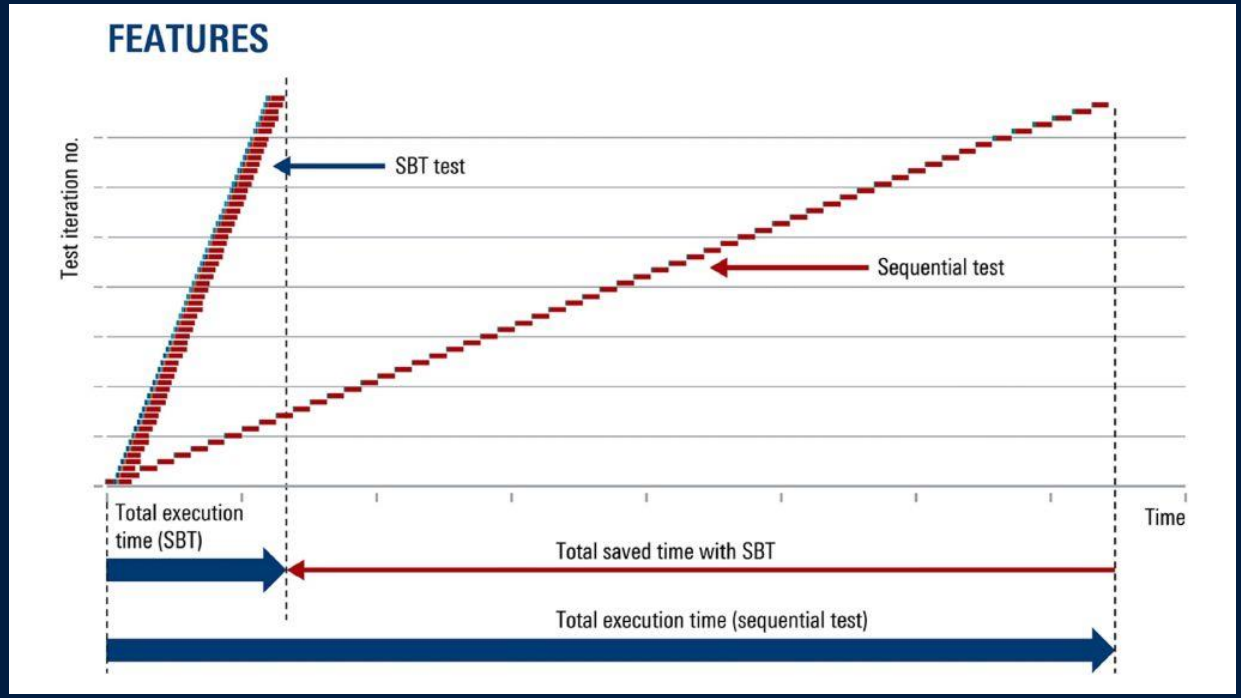
R&S® FSVA3000

R&S® CMP200

Data storage

R&S®SERVER BASED TESTING

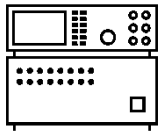
- R&S®SBT is optimized for speed
- Improves high value instrument utilization ratio
- Easy to integrate in existing environments through industry standard REST- API
- Best in-class performance for highly automated scenarios such as 5G base station production



ASSET MANAGEMENT

- **Health and Utilization Monitoring System (HUMS)**

- Stability
- Return on investment
- Productivity
- ML and AI have become integral part of smart manufacturing for
  - CI/CD for new test introduction / optimization



Device information

Serial number, IP, OS, BIOS, status, revisions
Maintain system levels and updates, asset management

Security

Which software is installed, virus, malware
Incident history

Status

Internal resource usage, temperature, HD, switch, license
How hard is the instrument working, is it balanced

Utilization

Insights into instrument use, technology use, 5G FR1, LTE
On, off, standby, resource utilization, RF head utilization

Service

History, due date, type of history
Service record, incidents

WHAT MATTERS FOR THE CUSTOMER?

Performance & scalability matter

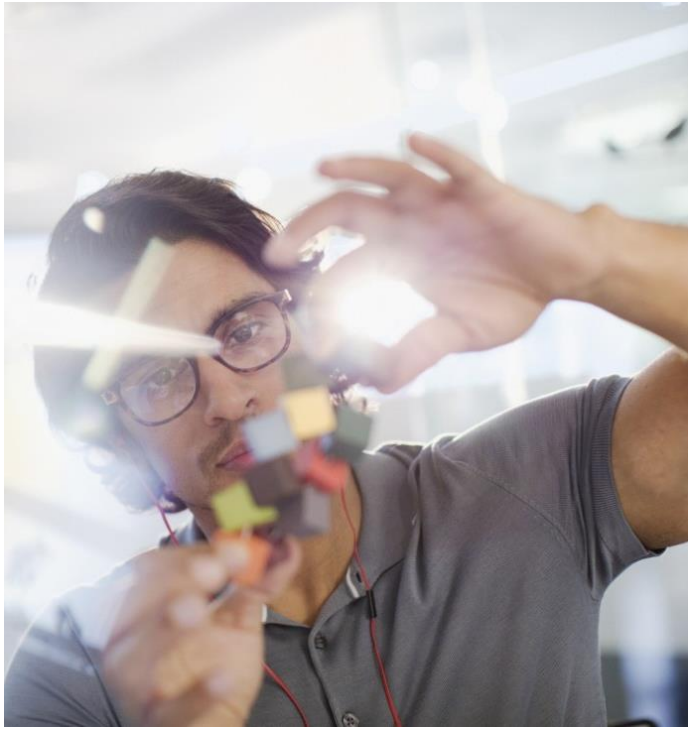
Fast and efficient test execution incl. accurate run of vendor specific procedures like calibration

Integration & support make the difference

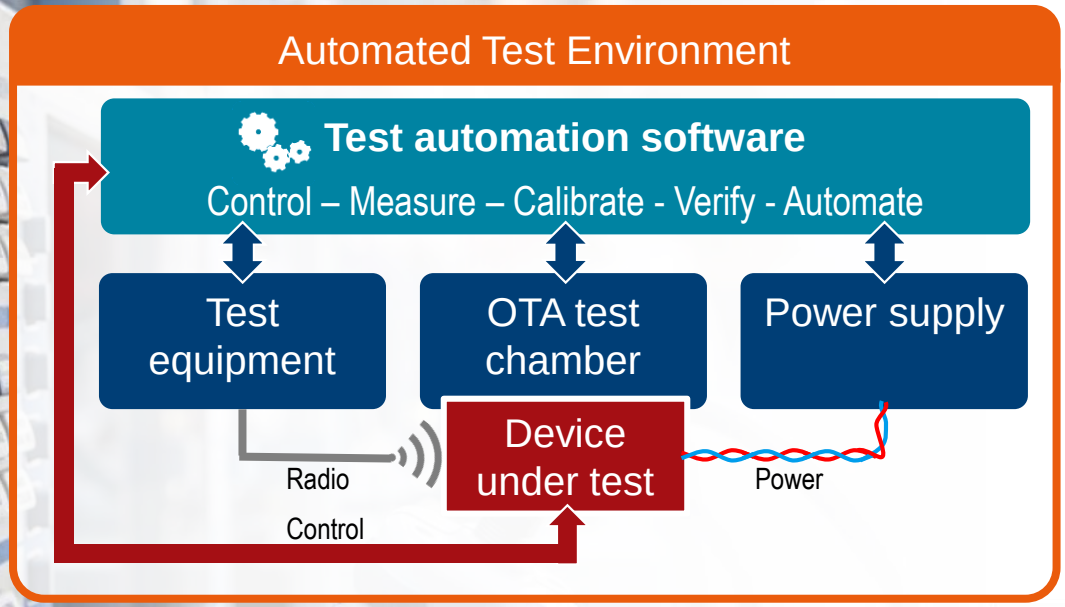
Easy integration of test solutions into their very specific automated test environment in R&D or production

Test intelligence becomes fundamental

Data about performance, usage and health of the automatic test equipment system are of high interest



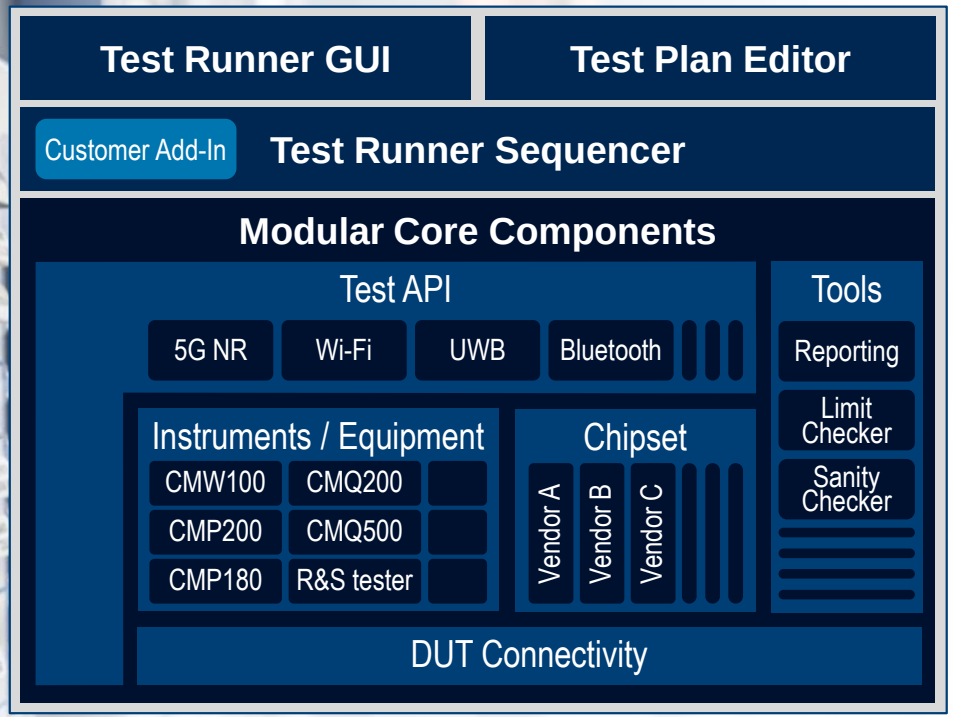
AUTOMATION
WHAT IS CHANGING?



- Purpose build test automation software implemented by manufacturer
- Using chipset vendor tooling to build an individual setup
- Fully customized solution from the test & measurement vendor (e.g. R&S®WMT)

AUTOMATION
"WIRELESS AUTOMATED TEST" FRAMEWORK

Wireless autoMated tesTing



Tailored for production testing and non-signaling R&D applications

- **Flexible integration** into any automated testing environment
- **Fully customizable** from a basic test tool to a full-blown turnkey solution incl. Python based customer add-ins.
- **Field-proven** speed of test execution
- **High efficiency** by broadcasting and interleaving (smart channel)
- Insightful and easy **customizable GUI** for sequencing and test plan creation

Making non-signaling tests fast, accurate and easy, providing the **"Time to Market"** advantage

Rethink production testing

PERFORMANCE VECTOR TESTER

Demonstration

R&S®PVT360A

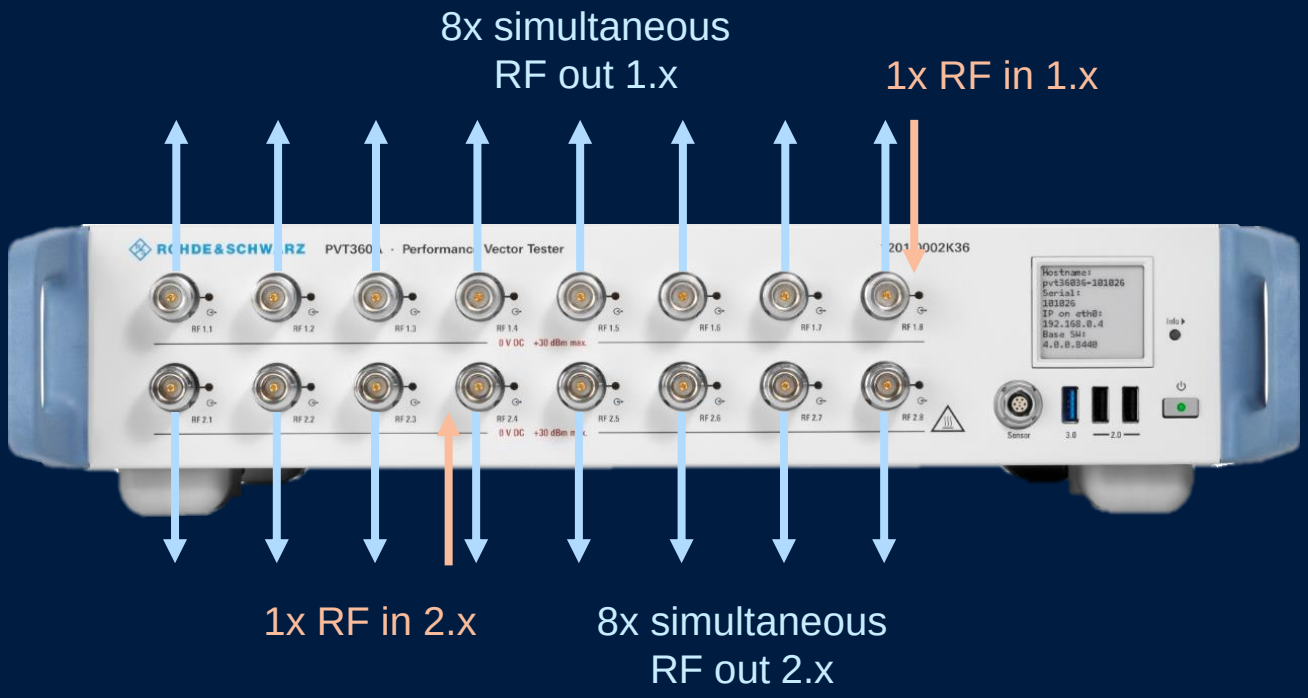
R&S®PVT360A PERFORMANCE VECTOR TESTER

- Combined vector signal generator and analyzer in one instrument
- Two independent TRX channels cover frequency bands up to 8 GHz
- Multi-port operation
- 500 MHz analysis bandwidth
- Dedicated measurement and signal generation applications
- Great EVM performance

R&S®PVT360A – DEMONSTRATIONS

- Generator broadcast mode
- Smart channels
- RF performance
- BTS 5G DL testing with R&S®VSE

R&S®PVT360A – SWITCH MATRIX



R&S®PVT360A – SMART CHANNELS

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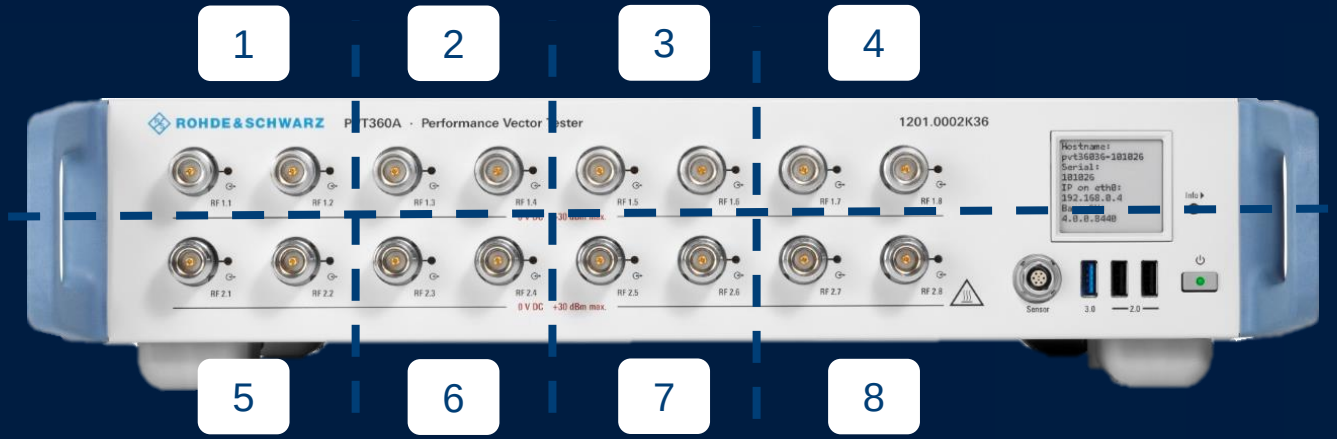
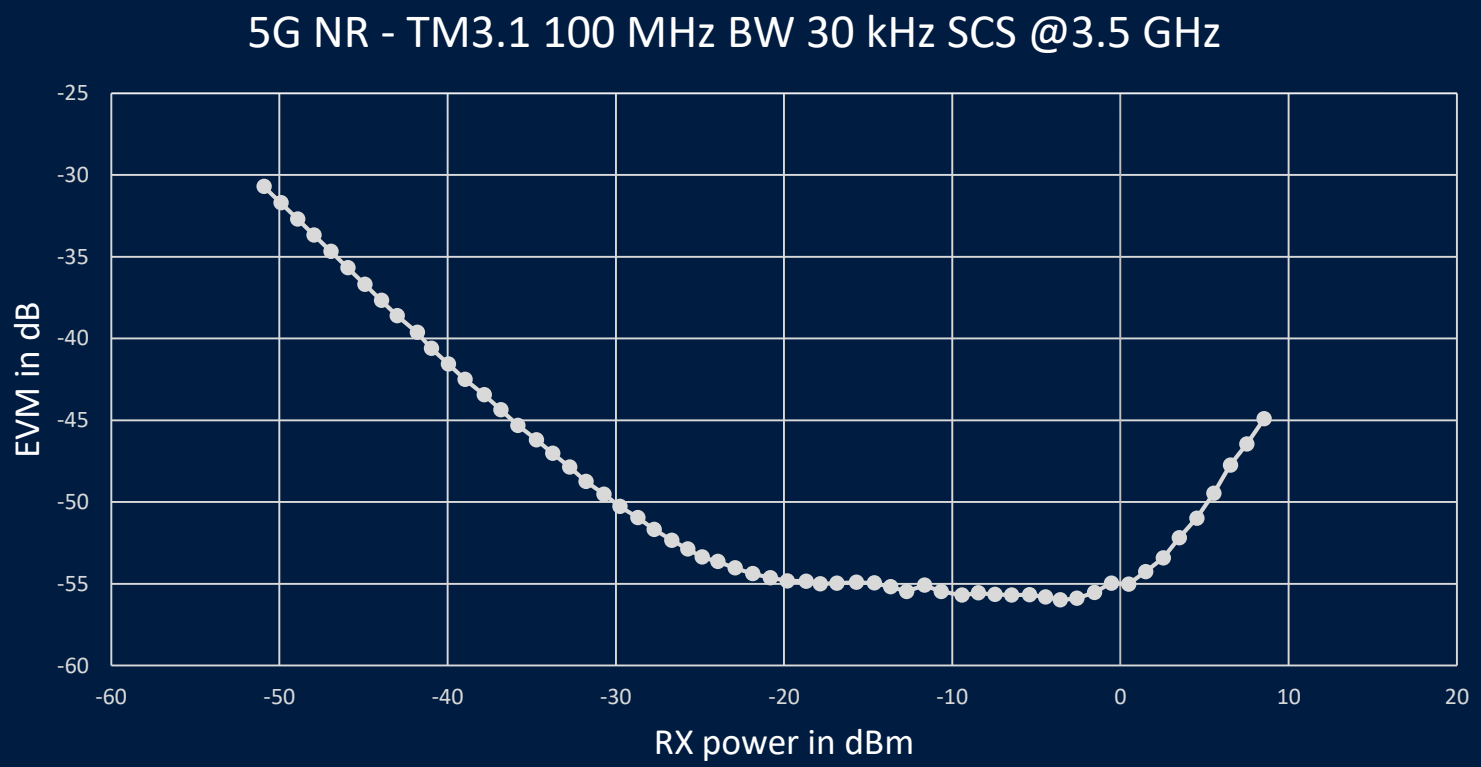
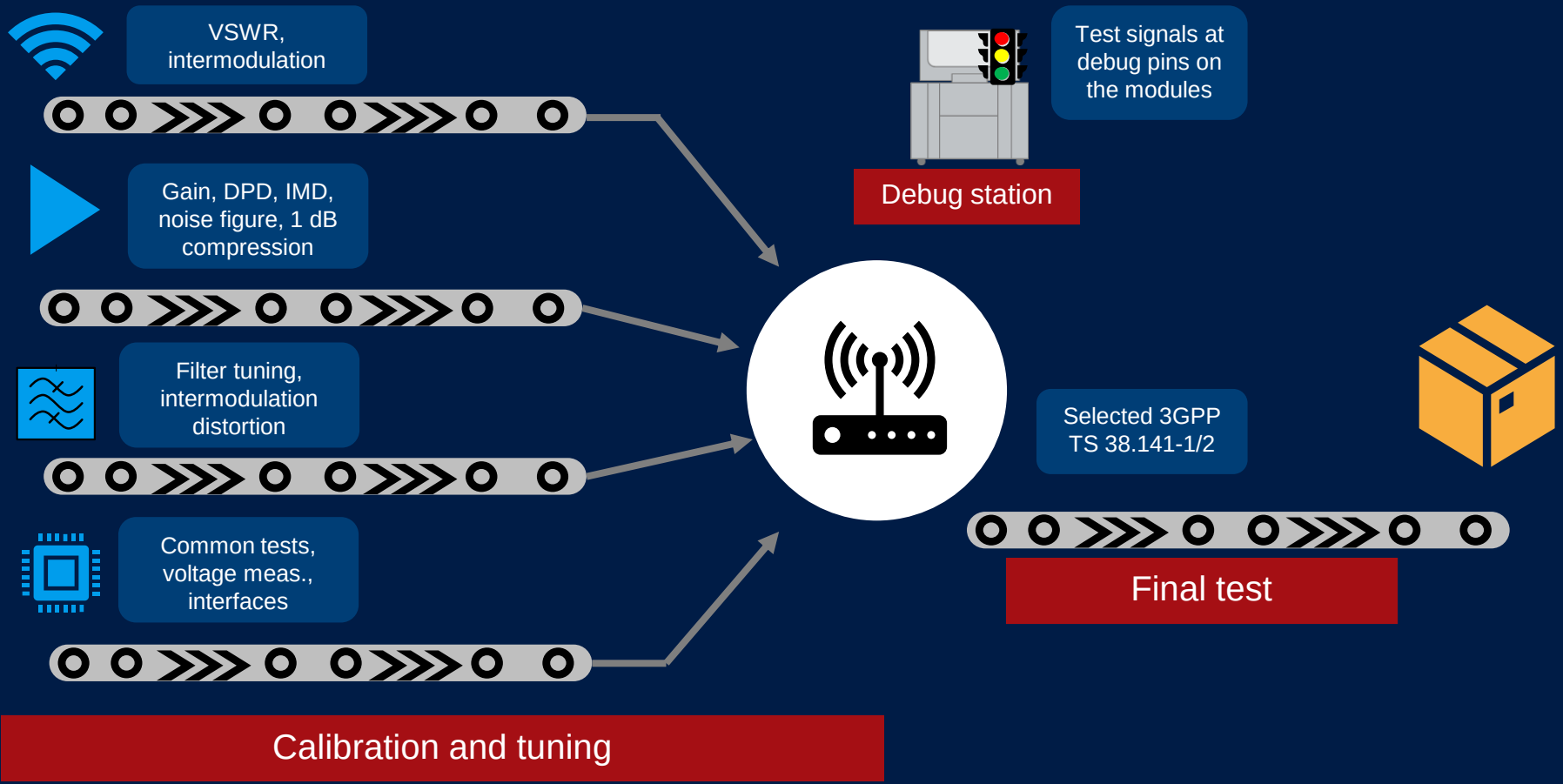


R&S®PVT360A – EVM MEASUREMENT PERFORMANCE

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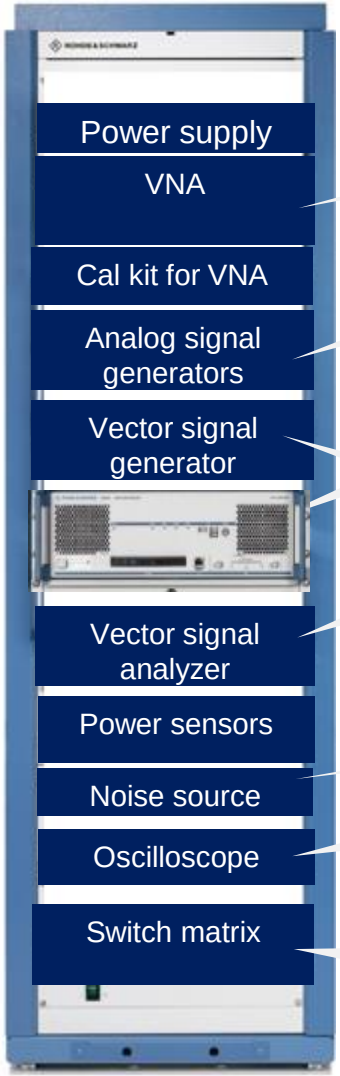
Filter tuning, intermodulation distortion
Common tests, voltage meas., interfaces
Calibration and tuning
Test signals at debug pins on the modules
Debug station
Selected 3GPP TS 38.141-1/2
Final test

TYPICAL AUTOMATED TEST EQUIPMENT (ATE) FOR PRODUCTION

- Base stations are more ASIC based. So, the ATE's are custom built to test the subsystems and the complete base station
- Test setup varies for different base station architectures
- Also depends on frequency supported (e.g. FR1 or FR2)



VNA for antenna characterization, filter tuning, VSWR

2x analog signal generators for intermodulation distortion, blocking test

Controller PC with automation software

VSG, VSA for TRX RF calibration

Noise figure measurement

Check signals at test points, debugging failures

Routing the signals from different instruments in accordance with the test case

YOUR ONE STOP FOR ALL PRODUCTION TEST NEEDS

Chambers

R&S®CMQ200

Design validation test

R&S®SMM100A
R&S®FSW

R&S®PVT360A

Mass production

R&S®PVT360A

R&S®CMP200

R&S®SMCV100B
R&S®FSV

R&S®ZNB

R&S®OSP

R&S®SBT

Calibration and tuning

R&S®NGP824

R&S®RTP

R&S®NRPxxSN

Debug station

CONCLUSION

- Industry trends such as disaggregation, digitalization of production floors calls for robust solutions which are
  - Reliable
  - Scalable
  - Increase efficiency on production floors
  - Reduce the “Cost of Test”

- Rohde & Schwarz with its wide portfolio is your trusted partner offering innovative future ready solutions for all your testing needs on the production floor

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Make ideas real