Network Testing

TEMS™ Portfolio

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KNOW YOUR NETWORK™

From the team that invented drive testing

- New innovation that will revolutionize Site Verification
  - Working with the largest network infrastructure supplier in the world, we have developed a new tool, TEMS Cloud for Automated SSV, that revolutionises the way new sites will be taken into service.
  - Using AI/ML and access to planning and CM data we have developed a method that will allow acceptance to be outsourced to Uber drivers and drone pilots.

- Cooperation that will make drive testing a key part of any Automated Network Lifecycle
  - Through close cooperation with Planet, VistaInsight and KLERITY, all of the inbuilt intelligence from each can be readily shared and re-used. This unique capability opens many avenues for automation through a better understanding of the underlying network situation.
    For the first time customer experience influences every decision.

Product Portfolio

Generic

Improve competitiveness and time to market by:

- 5G test methodology
- Speeding up device integration
- Workflow automation – Precision drive-testing
- New service testing algorithms

TEMS Investigation

Our market-leading network testing solution

Supports:

- Network troubleshooting and optimization
- Network rollout acceptance
- Network service acceptance

TEMS Paragon

Our premiere drive test system, optimized for mobile network benchmarking projects.

Supports:

- Competative Benchmarking
- Internal Benchmarking
- Semi-Autonomous rollout acceptance

TEMS Discovery

The wireless industry's most comprehensive network analytics and optimization platform

Supports:

- Automatic Report generation
- Detect network issues
- Troubleshoot network faults
- Automatic problem identification
- Guided investigation and root cause analysis

TEMS Director – Fleet

Remotely control and manage a fleet of TEMS probes:

- Remote Probe Management
- Project status and Monitoring
- Report Definition of Done
- Improve automation of workflows
- Real time view of data collection/KPIs

TEMS Pocket

Our premium portable testing solution.

Supports:

- Indoor Network Optimization and troubleshooting
- In-Building Rollout
- Indoor benchmarking

TEMS Director – Analytics

The cloud solution to provide analytics for the entire TEMS Portfolio:

- Real-time Analysis
- Real-Time Route Cause Analysis
- Canned use case reporting – self service in cloud
  - ETSI Score
  - 5G Roll-out Report
  - Site verification Report

TEMS Sense

Designed to implement automated, remote monitoring of service performance:

- Regression Testing
- Service QoE Monitoring
- Wireless SLA Management
- Core network troubleshooting

TEMS Cloud

Enable Site Verification to be performed by unskilled staff:

- Tells the user where to go, what to test and when to stop
- All work-orders can be standardized and stored centrally
- All results can be uploaded in real-time
- Need to re-drive / re-test is avoided
- Exact location of each key point of interest can be defined in advance, and the route to be taken explained to driver

TEMS™ Portfolio overview

TEMS™ Investigation

No 1 software solution for Drive Testing

What is TEMS Investigation?

TEMS Investigation is our market-leading end-to-end network testing solution for verifying, optimizing, troubleshooting and benchmarking your mobile network.

Why TEMS Investigation?

TEMS Investigation, allows you to test every new function and feature in your network. This allows you to better understand Customer Experience and to verify, optimize and troubleshoot your mobile network. Through our close cooperation with equipment vendors, chipset manufactures and device vendors we are able to use all major new devices. This allows us to quickly provide in-depth subscriber (QoE) and the network (QoS) insights to enable you to make better network investment choices.

Whether you are rolling out a new network technology such as LTE or 5G, implementing a new network service like NB-IoT or VoLTE, or optimizing an existing mobile infrastructure, TEMS Investigation gets the job done right the first time. When integrated with TEMS Director, TEMS Investigation becomes a key component of your mobile network test platform.

TEMS™ Investigation – Benefits

Wide range of supported devices

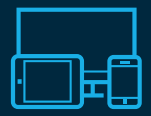
To test the latest technology in your network, TEMS Investigation quickly integrate new devices

Service testing

Besides measuring traditional voice and data services. TEMS allows you to script tests of any OTT service or application available on a network.

Target user experience

Allows the tester to truly test networks and services, end-to-end from a subscriber perspective



Multi-source measurement

TEMS Investigation supports many different types of data collection equipment , such as smartphones, scanners, IoT devices and more

Flexible testing & analysis

Device forcing features, scripting, interface versatility and workflow integration enabling testing of every network feature

Latest technology

Is new technology being deployed in your network? If this requires new devices to supports it – rest assured, TEMS Investigation will support it

Optimize equipment utilization

Via our Global License Server you can monitor and optimize equipment utilization and users can easily share licenses to reduce costs

Standardized test methodology

TEMS employs test methodology recommended by ETSI and ITU-R. All our tools follow the rules laid down by various standardization bodies.

What is TEMS Investigation?

- The industry standard, award-winning test and measurement product for the last 25 years
- Designed for:
  - Radio optimisation and site acceptance
  - Drive-testing
  - Customer experience measurements
  - Troubleshooting network issues
  - Benchmarking via Paragon option
- Fully integrated with the TEMS Portfolio, including remote control via TEMS Director and post-processing platform TEMS Discovery
- Support for the latest devices, including **Samsung Galaxy S21, S21+ and S21 Ultra, iPhone 13, Huawei Mate 40, Xiaomi Mi 11, OnePlus 9, Sony Xperia Pro** the latest smartphones from the leading manufactures, presented as connectable just days after the official release.

New Connectable Devices

- Samsung S22 SM-G901 B/N/U/U1/W/0 (Qualcomm P/Samsung J)
- Samsung S22+ SM-G906 B/N/U/U1/W/0 (Qualcomm P/Samsung J)
- Samsung S22 Ultra SM-G908 B/N/U/U1/W/0 (Qualcomm P/Samsung J)
- Samsung Fold-3 SM-F926B (Qualcomm P)
- Samsung Z Flip 5G SM-F711B (Qualcomm P)
- ASUS Snapdragon Insider 1007D (Qualcomm O)

- ZTE MC7010 (Qualcomm O)
- Quectel EC21-E NBIoT (Qualcomm O)

*) For details, refer to TEMS Support Portal- “Connectable device list”

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New TEMS Devices

- Samsung S22 SM-G901 B/N/U/U1/W/0/ (Qualcomm P/Samsung J)
- Samsung S22+ SM-G906 B/N/U/U1/W/0 (Qualcomm P/Samsung J)
- Samsung S22 Ultra SM-G908 B/N/U/U1/W/0 (Qualcomm P/Samsung J)
- Samsung Fold-3 SM-F926B (Qualcomm P)
- Samsung Z Flip 5G SM-F711B (Qualcomm P)
- ASUS Snapdragon Insider 1007D (Qualcomm O)

Samsung S22 series: AQM POLQA TI24.1, Preview April

Note: For details, refer to TEMS Support Portal- “Connectable device list”

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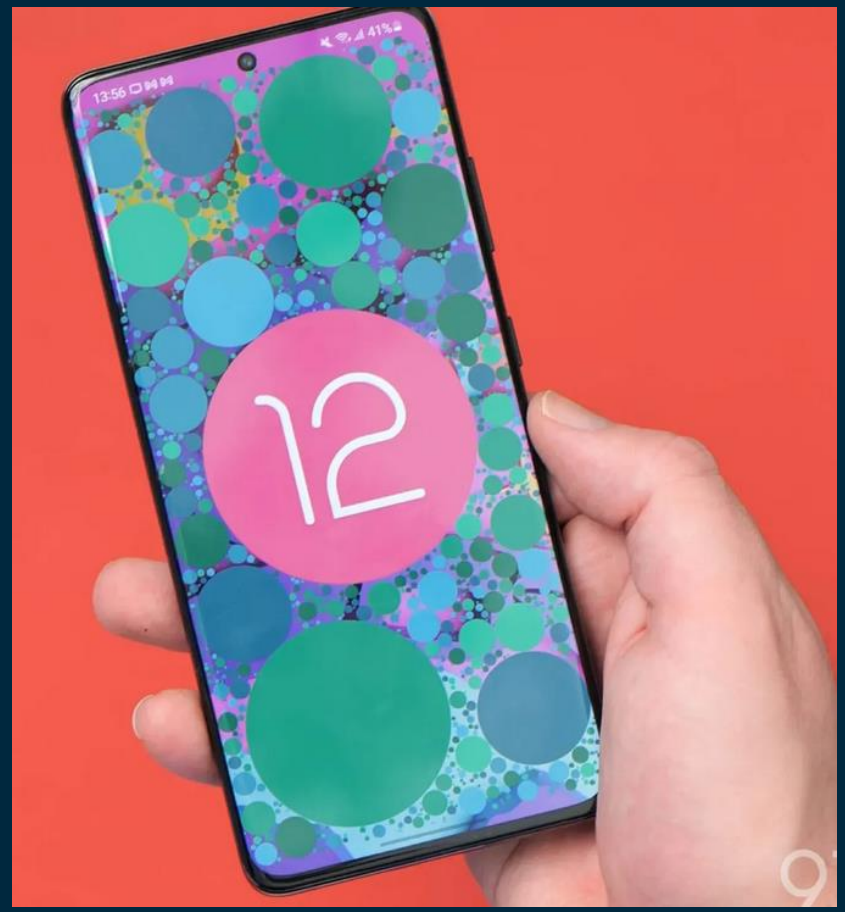
Android 12 support existing devices

- Samsung S21/ S21+/ S21 Ultra (99xB/N/ U/ U1/W/0)
- Samsung S21 FE (990B/N/ U/ U1/W)
- Samsung A52F/B & Samsung A52s B
- Samsung S20 series
- Sony Xperia 1 III (BC42/BC52/BC62/BC72/BC42)
- OnePlus9 (LE2111/21, LE2113/23, LE2115/25, LE LE2117/ LE2127)
- Xiaomi 11T Pro (2107113SG)



*) For details, refer to TEMS Support Portal- “Connectable device list”

iPhone with Apple FW

New device models, using “Apple license option”:

- iPhone 13 mini (A2481, A2626, A2628, A2629/ A2630)
- iPhone 13 (A2482, A2631, A2634, A2633, A2635)
- iPhone 13 Pro (A2483, A2636, A2638, A2639, A2640)
- iPhone 13 Pro max (A2484, A2641, A2643, A2644, A2645)

Further enhanced: Latest carrier built IoS 15.4 is now availble- Contact IV Supply for help

Note: Apple FW delivered by us (IV) or Apple, and it requires an Apple agreement!

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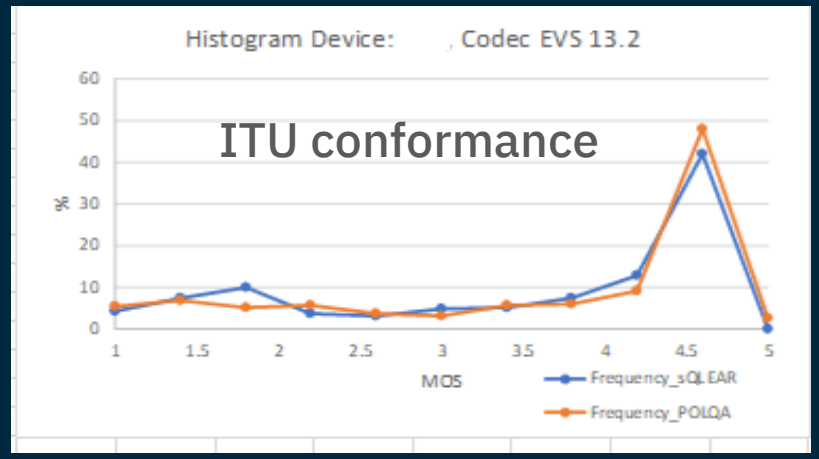
Audio testing - sQLEAR (Speech Quality by Machine Learning)

Network centric AQM scoring solution

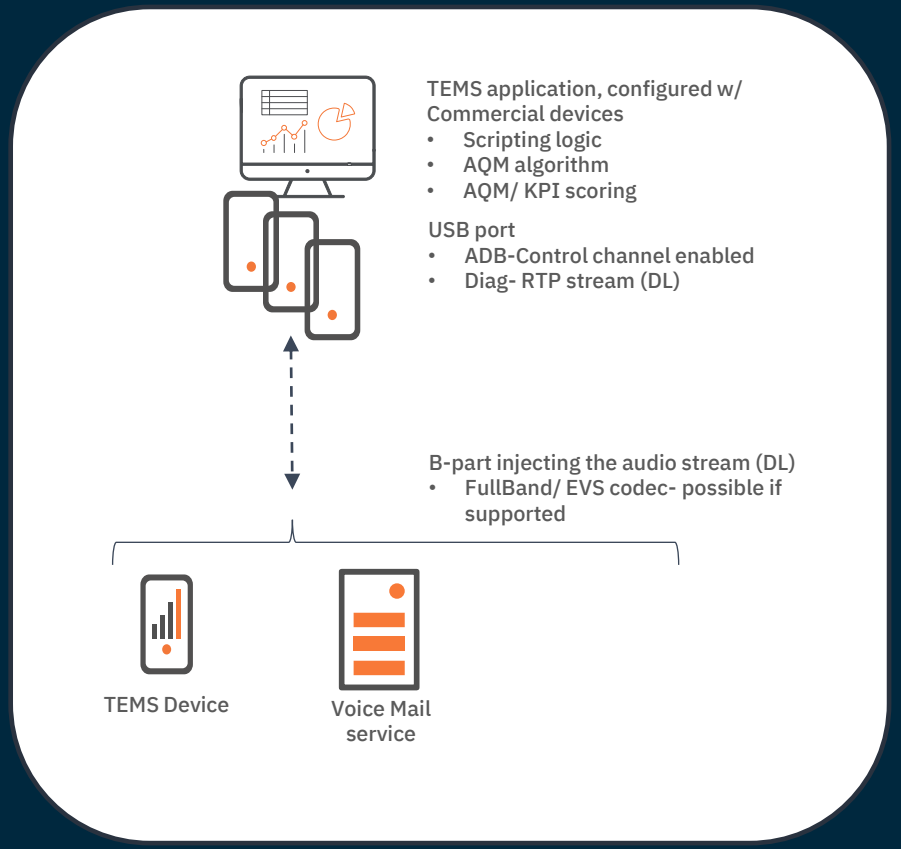
- sQLEAR P565.1- Intellectual property of Infovista
  - Trained by machine learning using the RTP stream
- A network centric AQM scoring solution
  - Not impacted by the device
- VoNR/ VoLTE/ VoIP and OTT, including Full Band support



Audio testing- AQM RTP DL testing

SW based solution for DL AQM testing with Commercial Connectable Devices

- VoNR/ VoLTE/ VoIP , works with IMS based services
- MoToMO DL testing, using TEMS Device (B-side)
- MoToFix DL AQM testing using voice mail service
  - Customer's own voice mail service
  - Infovista IMS/ Cloud call generator (Empirix- Hammer solution)
- sQLEAR AQM using the RTP stream, with Full band support
- Commercial Connectable Device (Android)
  - IPhone IoS TI 24.1



TWAMP- Two Way Active Measurement Protocol

Simplified APP testing, by emulating different traffic behaviors

TWAMP testing TI23.4

- TWAMP framework for data stream testing, similar with iPerf

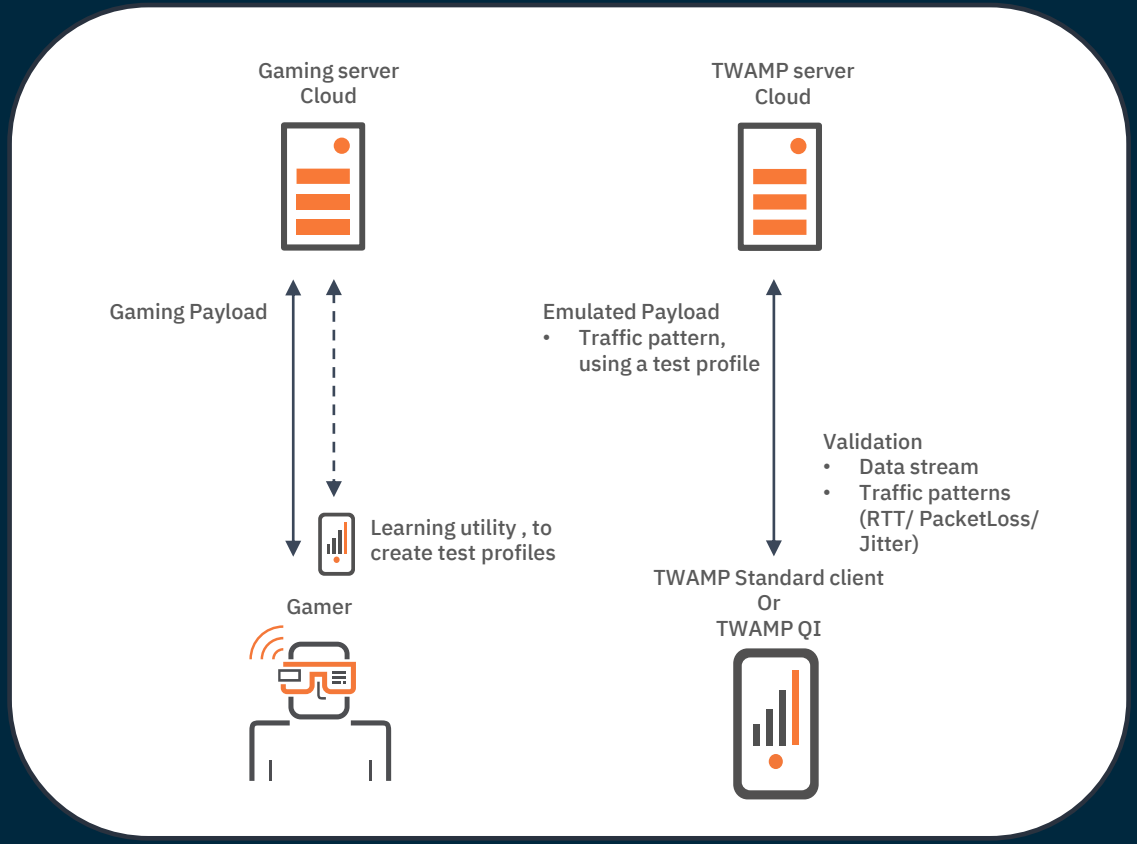
TWAMP QI – (Preview Dec.) TI 24.0

- TWAMP QI edition- ITU proposal “GIntAct”
- Set of pre-defined traffic patterns, e.g Drone control
- Quality scoring using the “G.IntAct” algorithm

TWAMP UX ”Remote control Truck” - TI 24.1

- “Training” utility, to create App specific traffic patterns (user specific scenarios)

How to verify new vertical?



Usability – New Map

MapX replaced by new map solution having support for both Offline and Online maps

Open street map ”Offline”

Default map tiles included (worldwide overview) with:

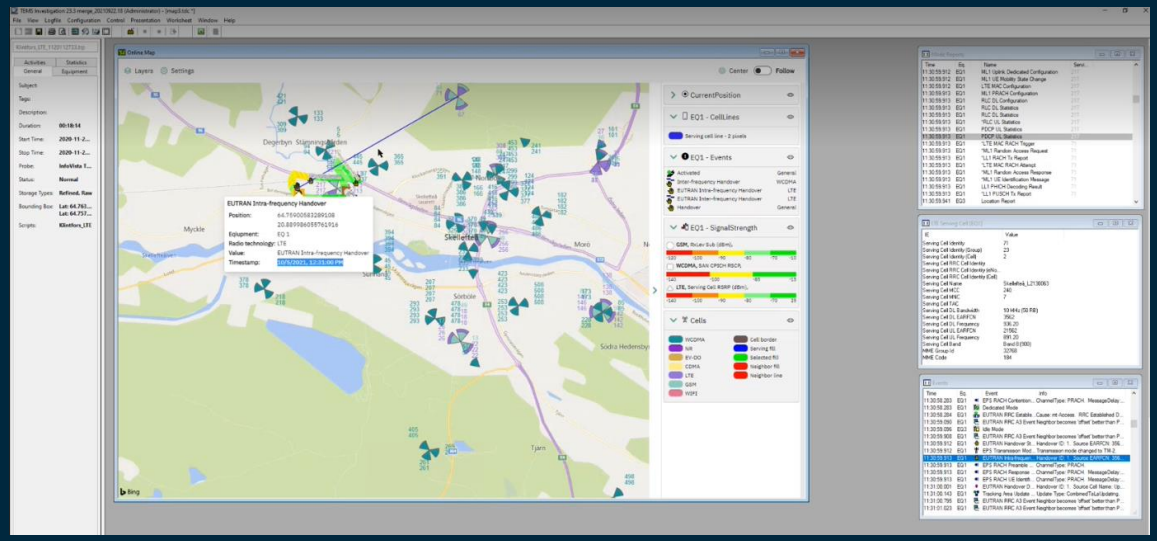
- Additional offline tiles tiles available for download from the web
- Feature compliant comparing MapX: Cell/ Event/ IEs /Serving cell/Position/ Planned route/Pintpoint Visualiz

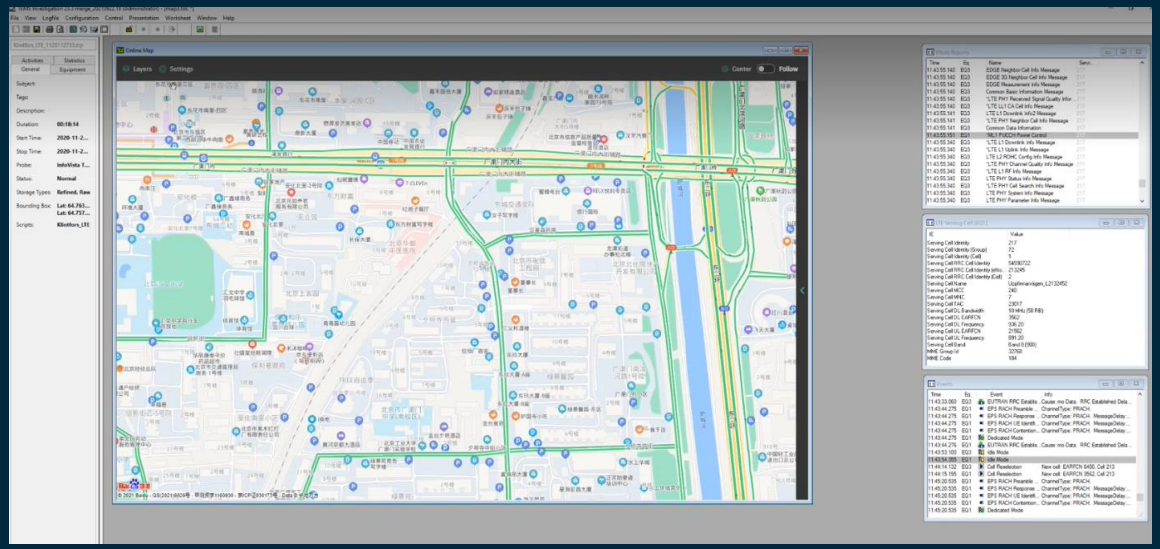
Bing map “Online”

Optional license, purchased separately

Baidu map “Online”

- Optional license, purchased separately

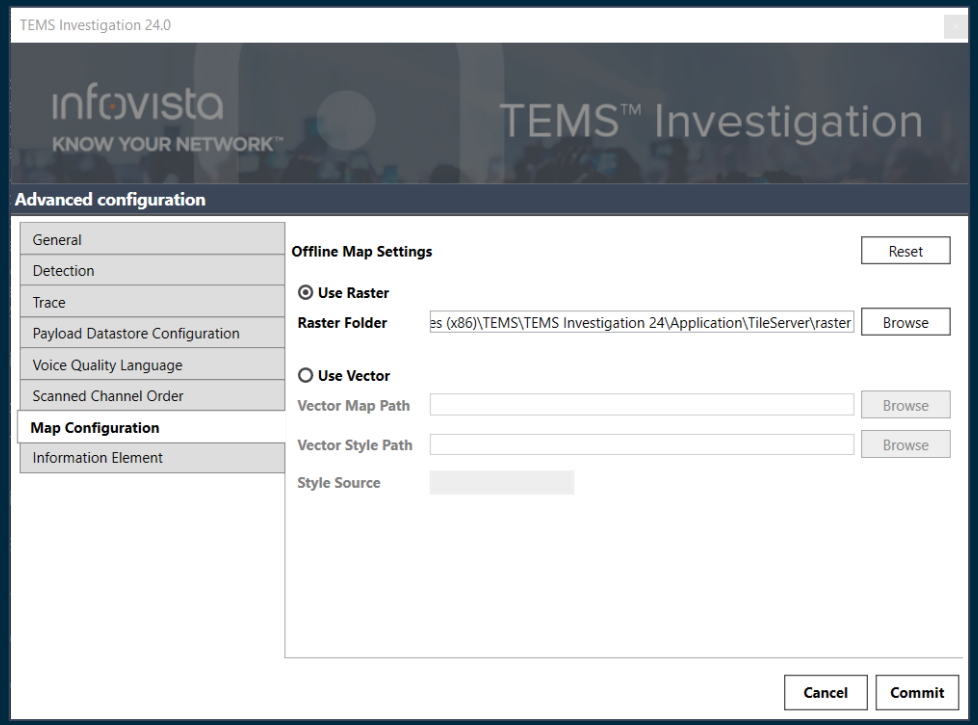




New OpenStreetMap

Basic world map is included with the installation, with support for additional downloads of Tiles (raster/ vector)

- Open street map OSM data (free)
- Offline support
- Raster Tiles and Vector Tiles
- QGIS Desktop (free) for creating offline tiles
  - Export utility for Raster or Vector tiles



Roadmap

TEMS Investigation 24.1/ TEMS Paragon 6.1 (June)

- Technology:
  - 5GNR IEs/ legacy/ 3GPP- updates , e.g:
    - Additional IEs: Root Cause Analysis “Per carrier/ Beams”
    - Additional IEs: Root Cause Analysis “RRC failure”
    - Rel 16 updates: TBD
- Chipset
  - Mediatek- preparation (candidate)
- New devices
  - TEMS Samsung S22 SM-S901/ S906/ S90 Data/ Audio
  - TEMS Xiaomi 12
  - Huawei P50 QC (Connectable)
  - Cradlepoint R1900 ruggedized 5G router (Connectable)
- Service testing, including OTT
  - TWAMP UX: Counter strike- subjectively trained
  - OTT Media: File transferring/ File sharing
  - Video Quality scoring- FoM (ITU standard)
  - DCU HW- AQM solution Connectable device - Pre-view April
  - IoS (iPhone): IP recording
  - IoS (iPhone): AQM with sQLEAR- Pre-view April
- Scanning
  - PCTEL Gflex: Blind scan- Pre-view April
  - PCTEL Gflex: NR Mobile Blind scan (candidate)
- Usability
  - TEMS Fleet Cloud: WO creation/ WO reservation (TEMS Paragon)

TEMS™ Pocket

No 1 solution for Indoor and Private Network Testing

What is TEMS Pocket?

TEMS Pocket is a compact, ultra-portable solution for testing and benchmarking network performance and subscriber experience indoors (buildings), underground (subways), and densely populated pedestrian areas (urban sidewalks).

Why TEMS Pocket?

The majority of mobile voice and data connectivity happens in indoor environments, which is why Infovista's industry-leading TEMS Pocket is the ideal ultra-portable walk-testing solution for measuring QoS and QoE performance and quality everywhere mobile subscribers walk, run, work and congregate.

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TEMS™ Pocket – Benefits

Test in any location

Operators can easily test locations such as inside restaurants, shopping malls, subways, trains, boats, event venues

Target user experience

Allows the tester to truly test networks and services, end-to-end from a subscriber perspective

For the entire Private Network deployment

Integrates with indoor planning and design solutions for efficient preliminary network surveys, all the way to design tuning

Optimize equipment utilization

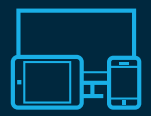
Via our Global License Server you can monitor and optimize equipment utilization and users can easily share licenses to reduce costs

Smart testing

Workflows and automation to reduce time and enable for non-technically skilled users to perform tests

Small, convenient form factor

Captures a range of data that normally requires laptops or even larger tools



Multi-device measurement

Controller – Agent Solution allows users to operate and control multiple devices through a single interface. Offers a multi-device measurement environment.

Commercial devices

Allows users to operate and control commercial (unrooted) devices through the common TEMS Pocket interface. Commercial devices can be used in Controller-Agent way too!

Implemented on a range of handsets

Supports the widest range of device brands on the market. One of the first air interface test and measurement tools to support the Android OS.

TEMS™ Pocket – Use cases supported

Spectrum tuning

TEMS Pocket can control PCTEL Scanners to enable spectrum clearance and spectrum tuning

Initial tuning

Is a labour-intensive, network optimization activity, aiming to prepare the network for commercial launch. Network design, hardware installation and parameter settings are evaluated and tuned.

Network acceptance

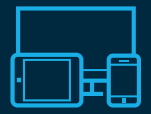
Field measurements from a user's perspective are performed on a cluster basis, and key performance indicators (KPIs) are calculated and reported

Indoor trouble-shooting

Findings related to site verification, initial tuning, optimization and service quality campaigns and present solutions. Investigate issues raised by O&M/OSS systems and customer complaints.

Indoor benchmarking

Simple competitive benchmarking can be performed with TEMS Pocket Controller-Agent solution. Reliability is now guaranteed with the new TEMS Pocket Backpack.



Multi-source measurement

Enables a better understanding of the impact individual smartphones have on the performance

Single Site Verification

TEMS Pocket – SSV option provides all necessary features to enable SSV to be performed effectively. TEMS Director can be used to organize workflow.

Customer experience verification

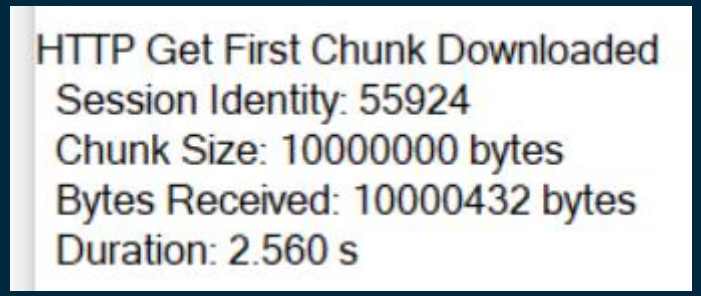
TEMS ensures that network provides a high customer experience as recommended by ETSI and ITU-R. All our tools follow the rules laid down by various standardization bodies.

TEMS Pocket 24.0 (Mar 18th)

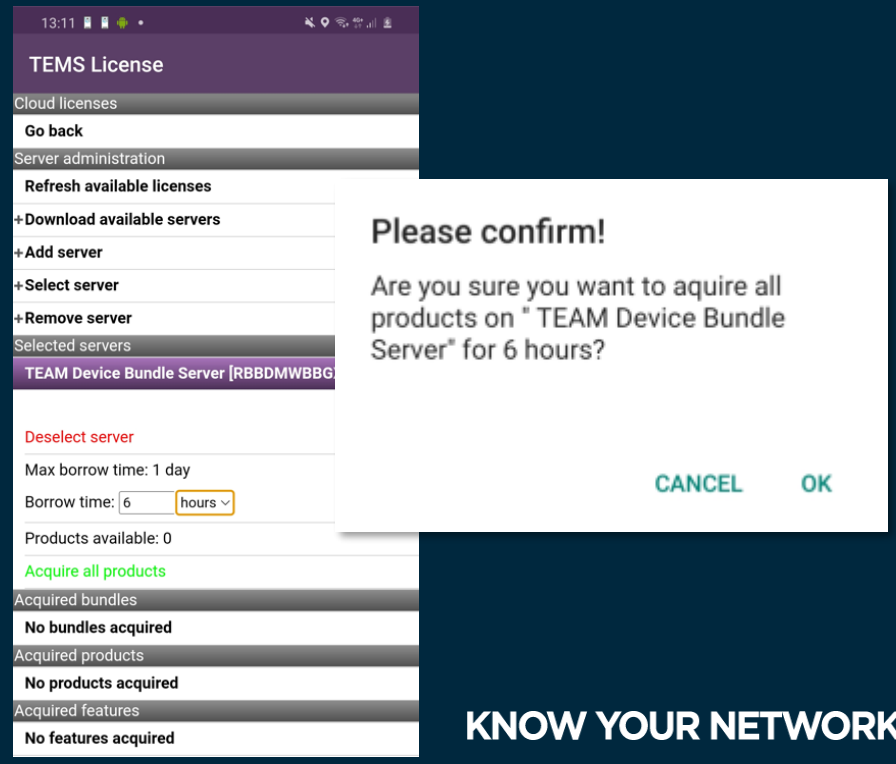
- 5G Enhancements
  - Enhanced controlfunctions for NR testing – Qualcomm devices
    - NR Locking (SA testing)
    - LTE and NR band locking combined
- Thermal mitigation indication
- Backpack solution GPS enhancements (USB GPS with CPU to Backpack agents/remote)
  - Fallback to internal GPS if external source is lost
- sQLEAR ODM support
- Strengthen remote monitoring
  - Channel / BSIC / UE TX Power reported 1/s
- Android 12 support for Samsung, OnePlus, Xiaomi, Sony devices
- Support for Raw / refined logfile recording (reduce logfile size)
- ODM Ping support, phase 2 (RAT Indication)
- RAT /Band lock information in .trp
- IP Capture on Commercial Android device
- New TEMS Devices
  - Samsung Galaxy S22 5G series (SM-S901/906/908 B/E/U/U1/W/0)
  - Samsung Galaxy S21 5G FE (SM-G990B)
  - Samsung Galaxy Z Flip 3 5G (SM-F711B)
  - Samsung Galaxy Fold 3 5G (SM-F926B)
  - PCTEL MXFlex support

TEMS Pocket 24.0.1 (Apr 5th)

- Event for HTTP First 1000 Kb Downloaded

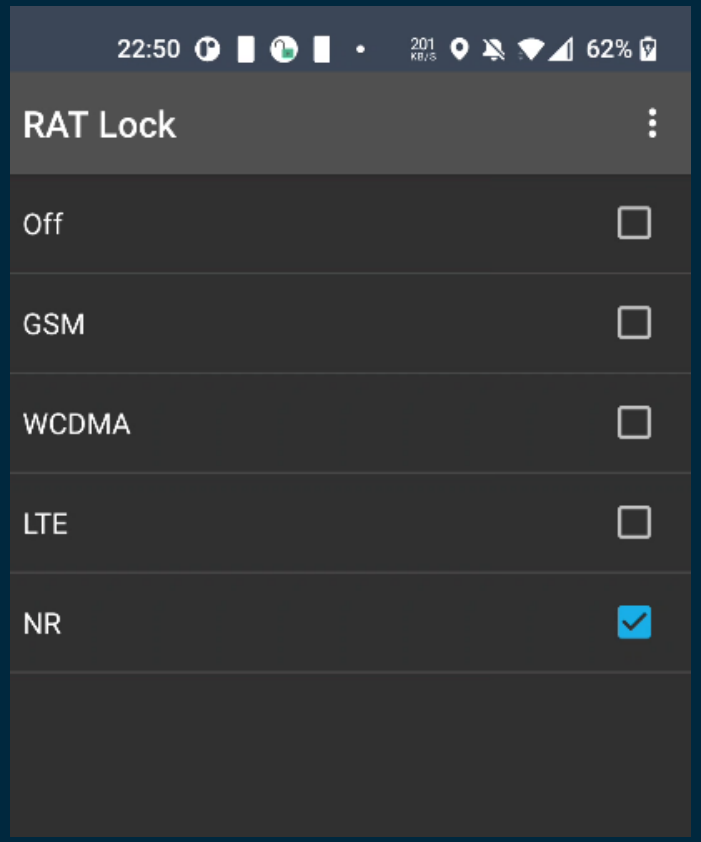


- Support Borrow Time in Days and/or Hours
  - Requires Cloud Access License Token
  - Device does not have to be online for the license to be returned

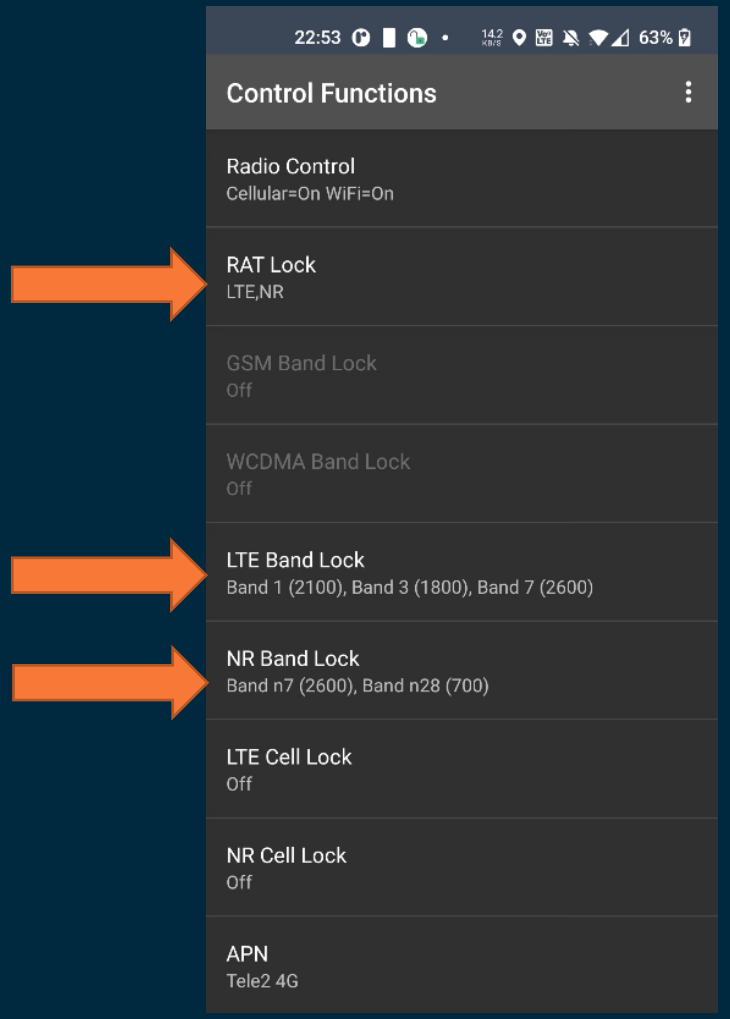


Enhanced Controlfunctions for NR (Qualcomm)

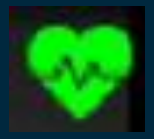
RAT Lock for NR (SA)



Band lock for NSA testing while using NR/LTE RAT lock



Thermal mitigation indication



- Grey - No information available
- **Green - No or light throttling,** test result isn't impacted
- **Yellow - Moderate throttling,** test result isn't greatly impacted
- **Red - Severe throttling,** test is largely impacted

Samsung Galaxy S22 / S22+ / S22 Ultra

High-end device

- Device capabilities
  - Android 12
  - Exynos 2200 and Qualcomm SM8450 Snapdragon 8 Gen 1. (X65)
  - 5G Support (NSA / SA)*
  - VoNR support*
- Testing capabilities**
  - RAT lock 2G/3G/4G/5G NSA / 5G SA***
  - Band lock 2G/3G/4G/5G
  - Frequency lock 2G/3G/4G
  - Cell lock (PSC/PCI) 3G/4G/5G**
  - Start on charging***
  - AQM Support*** – TP 24.1

Chipset	S21 (SM-G99x)	S22 (SM-S90x)
Exynos (B/N)	Korea, Europe, CIS ,S.E.Asia, S.W.Asia , Midde East, Africa, Latin America	Europe, CIS
Qualcomm (U/U1/W/0/E)	China, Japan, North America	China, Japan, North America, Korea, Latin America, S.E. Asia, S.W. Asia, Midde East, Africa

*Based on network / FW capabilities
** Commercial device (RAT / Band and NR PCI)
***Only QC modem / TEMSified device

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Samsung Z Flip 3 / Fold 3

High-end feature devices

- Samsung SM-F711B / SM-F928B
  - Qualcomm Snapdragon 888
  - AQM Support – Not implemented
  - Lock 2G/3G/4G/5G NSA/5G SA
  - Band lock 2G/3G/4G/5G
  - Frequency lock 2G/3G/4G
  - Cell lock (PSC/PCI) 3G/4G/5G
  - Start on charging

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TEMS™ Discovery

No 1 software solution for TEMS logfile Post-processing

What is TEMS Discovery?

TEMS Discovery is the worlds leading tool for reporting and analyzing data collected by TEMS equipment, but can be used to improve analysis of other vendors too. Fault-finding, trouble-shooting and report generation is automated by the tool.

Why TEMS Discovery?

Has been designed in collaboration with the largest vendor in the world to post-process network test campaigns according to industry standards (e.g. ETSI, ITU) in less time and with fewer personnel. TEMS Discovery can be used for simple projects, or as an enterprise solution handling data from hundreds of projects in dozens of countries.

Complete flexibility means that any report format or analysis template can be applied on all data, forcing standardization and improved efficiency.

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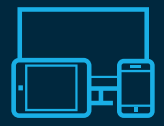
TEMS™ Discovery – Benefits

Quickly identify and solve network issues

Using TEMS Discovery analytics dashboards, reports and RF diagnostics tools to uncover issues affecting subscribers quicker resulting better subscriber experience and improved efficiency



Part of a complete test environment

Works with TEMS network testing solutions such as TEMS Investigation, TEMS Pocket, TEMS Sense, as well as network test solutions from other vendors

Enable deep-dive into network test data

To drill down in-depth into any of the data collected during the network tests, at the device, application or network level to troubleshoot the most difficult network problems

Managing large network test data

Automating data processing functions, from the file import to script execution, categorization of problem sets to the generation and sharing of reports

TEMS Discovery Key Capabilities

Automation

Automate and reduce the time associated with the data processing function, from file import, to script execution, categorization of problem sets, to the generation and sharing of reports.

Analytics

Make sense of the data collected from the network by analyzing measurements and then visualizing this information using GIS mapping, and other visualization methods.

Customizatio n

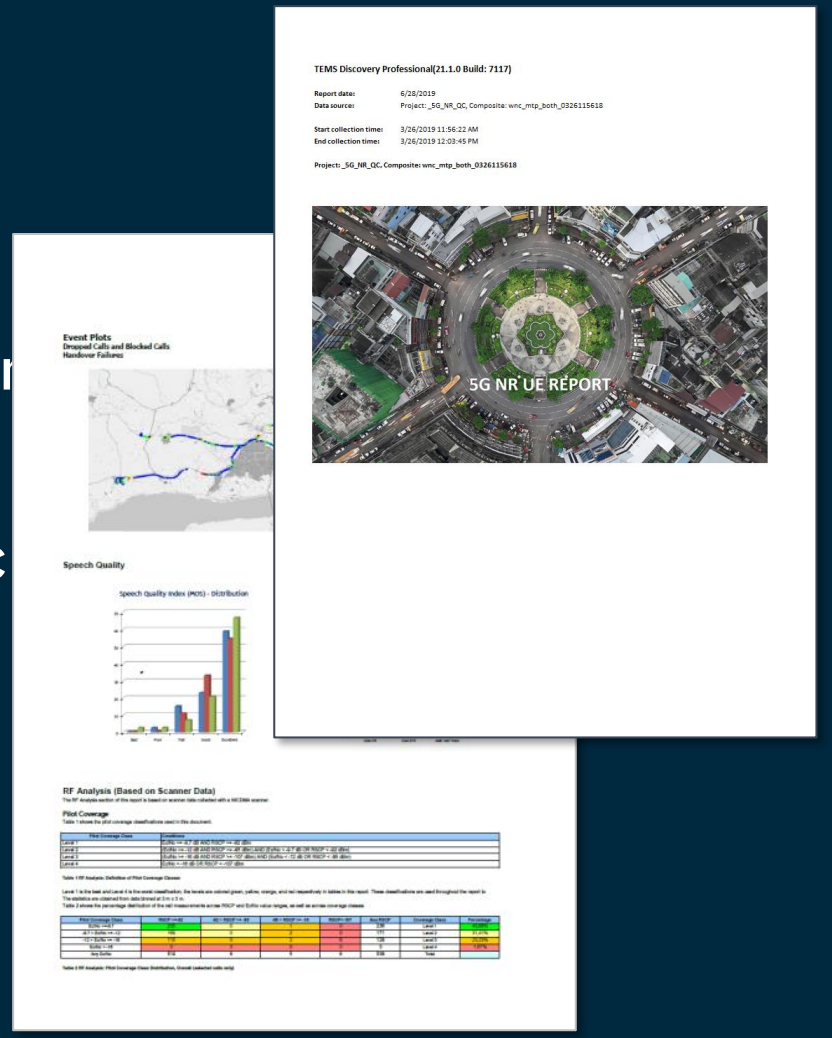
Customize and share the most up-to-date scripts and reports in order to standardize processes, share best practices, and improve ways of working across the organization

Reporting

Easily create reports that include both out-of-the-box and predefined KPIs to view network performance across multiple dimensions, troubleshoot and optimize network issues.

Reporting

- Predefined and user-defined report templates
- Generate report on any projects, files or devices
- Scheduled or immediate generation of report based on selected template
- Create your own tailored report templates for specific interests and needs



TEMS™ Paragon

No 1 software solution for network Benchmarking

What is TEMS Paragon?

A solution designed for comprehensive network test campaigns according to industry standards (e.g. ETSI, ITU) in less time and with fewer personnel.

Why TEMS Paragon?

TEMS Paragon is a network test software designed to achieve high-efficiency, multi-device QoS and QoE data-collection for all network performance testing and mobile network benchmarking campaigns, no matter how large or small.

TEMS Paragon, allows you to compare every new function and feature in your network. This allows you to better understand Customer Experience and to verify, optimize and troubleshoot your mobile network. Through our close cooperation with equipment vendors, chipset manufactures and device vendors we are able to use all major new devices. This allows us to quickly provide in-depth subscriber (QoE) and the network (QoS) insights to enable you to make better network investment choices.

Whether you are comparing new network technology such as LTE or 5G, implementing a new services like NB-IoT or VoLTE, or optimizing an existing mobile infrastructure, TEMS Paragon gets the job done right the first time. When integrated with TEMS Director, TEMS Paragon becomes a key component of your automated mobile network test platform.

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TEMS™ Paragon – Benefits

Wide range of supported devices

To test the latest technology in your network, TEMS Paragon quickly integrate new devices

Scalable to target user experience

Allows the tester to truly test networks and services, end-to-end from a subscriber perspective. Scalable to handle multiple devices safely.

Flexible testing & analysis

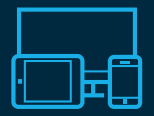
Designed for autonomous use, yet including device forcing features, scripting, interface versatility and workflow integration enabling testing of every network feature

Utilizing Definition of Done

TEMS Paragon can be operated from the cloud, where the routes, work-orders and a definition of Done (DoD) can be standardized. This significantly improves drive-test efficiency.

Service testing

Besides measuring traditional voice and data services. TEMS allows you to script tests of any OTT service or application available on a network



Multi-source measurement

TEMS supports many different types of data collection equipment, such as smartphones, scanners, IoT devices and more.

Latest technology

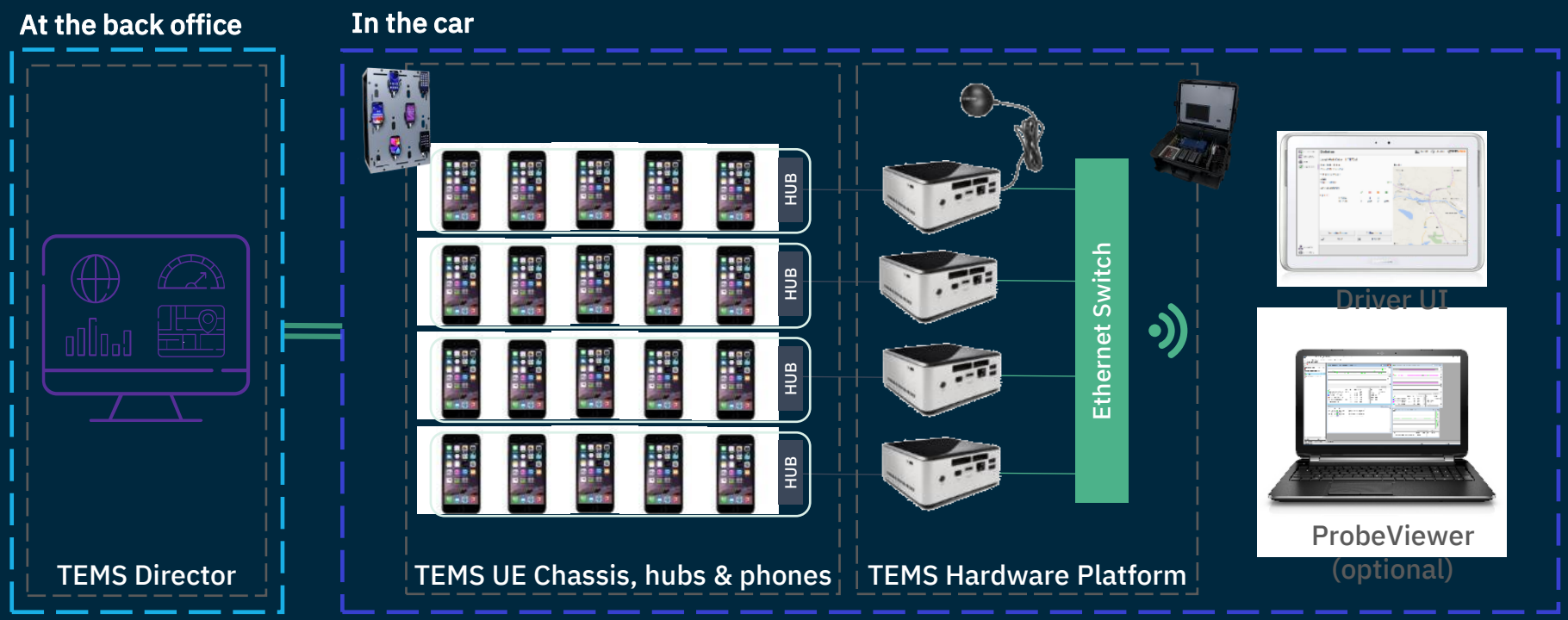
Is new technology being deployed in your network? If this requires new devices to supports it – rest assured, TEMS will support it.

Standardized test methodology

TEMS employs test methodology recommended by ETSI and ITU-R. All our tools follow the rules laid down by various standardization bodies.

TEMS Paragon – End-to-End Solution

Efficient benchmarking from an end-user perspective using the same devices and services as regular network users, optionally controlled and managed by TEMS Director.



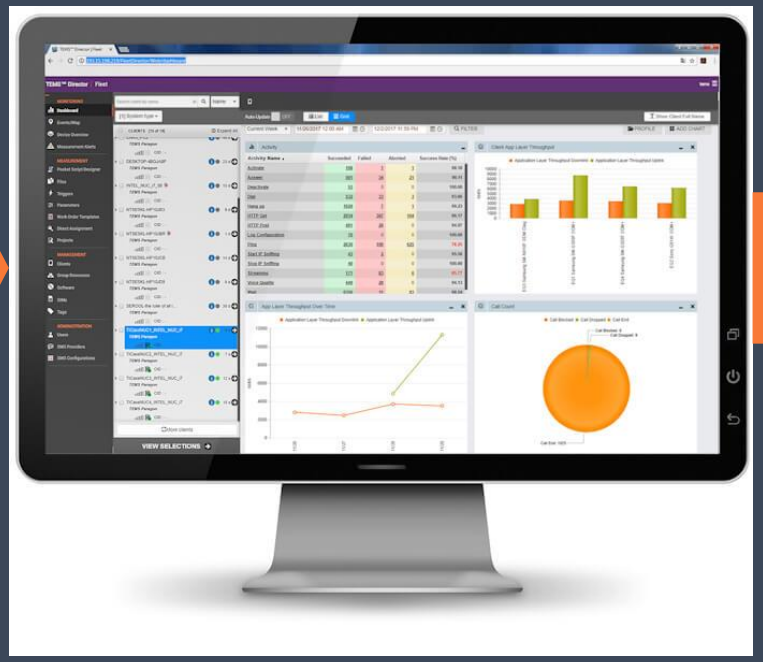

TEMS Director Details
KNOW YOUR NETWORK™

TEMS Director - Architecture

Data Collection

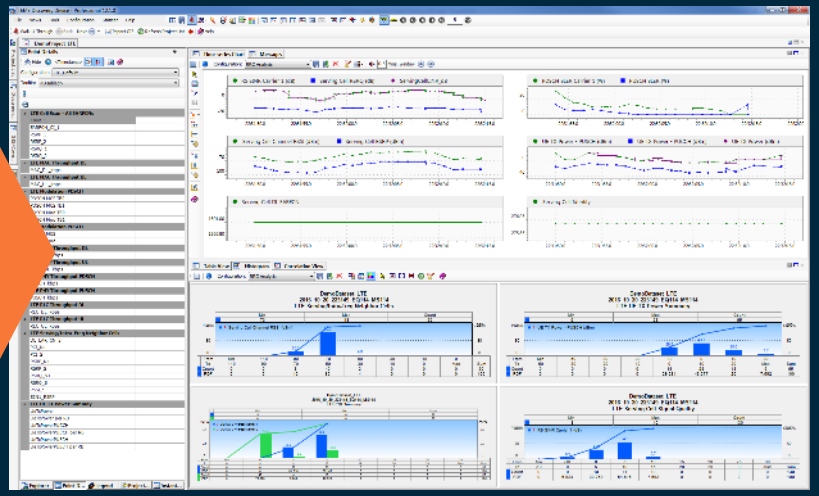
Data is collected via a number of collection devices

Real-time Test Orchestration
TEMS Director



All tests can be managed centrally, with real-time data analysis & reporting

Analytics & Post-Processing

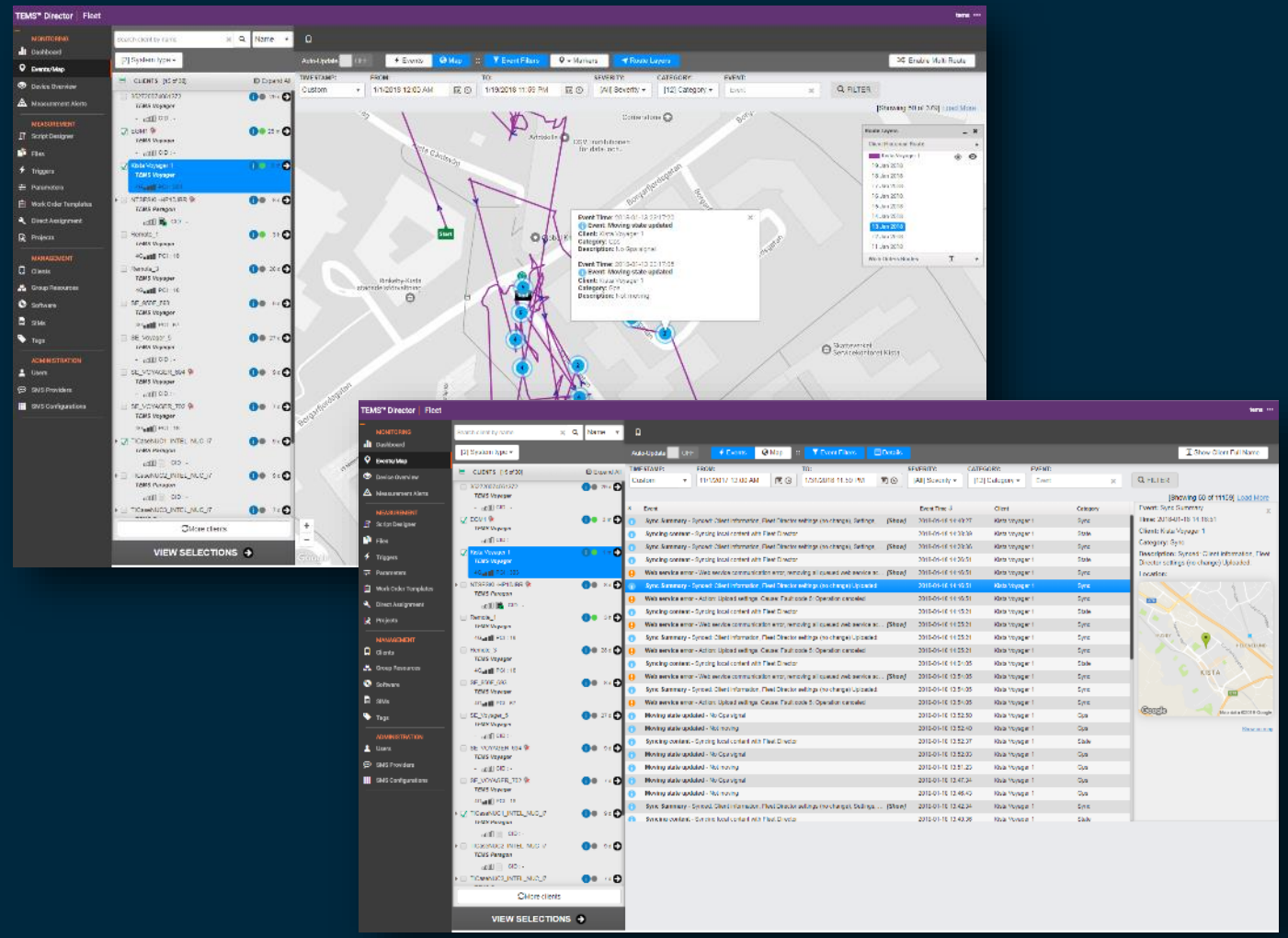


Collected data is further exploited using TEMS Discovery or 3rd party solutions

TEMS Director – Track and View Devices and Events on the Map

View current and historical probe location and movements on the map, including all captured events.

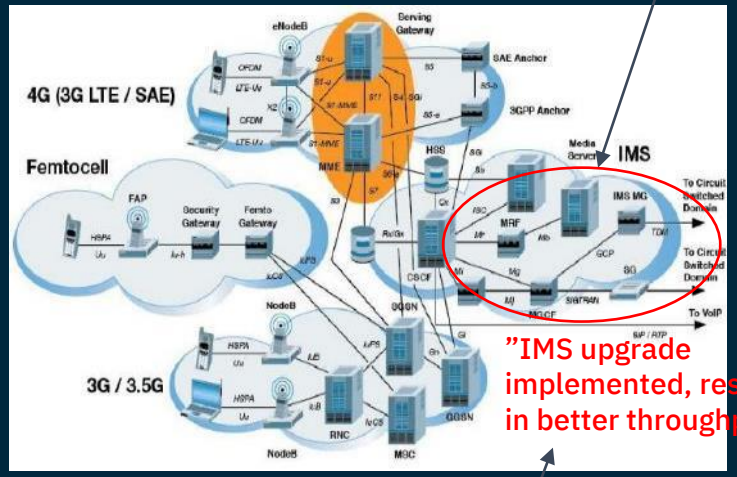
- View generated events in a list or on the map.
- Event details available with one click.

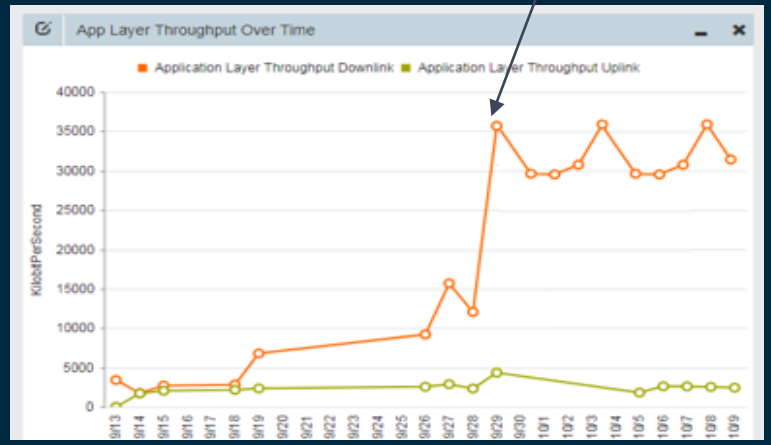


TEMS Director Analytics – Regression Testi

Repetitive active service testing and monitoring:

- The result displayed in the dashboards will give a first glance of the impact on performance as a result of any network changes.
- Drill down capability of collected data to gain deeper understating of changes.





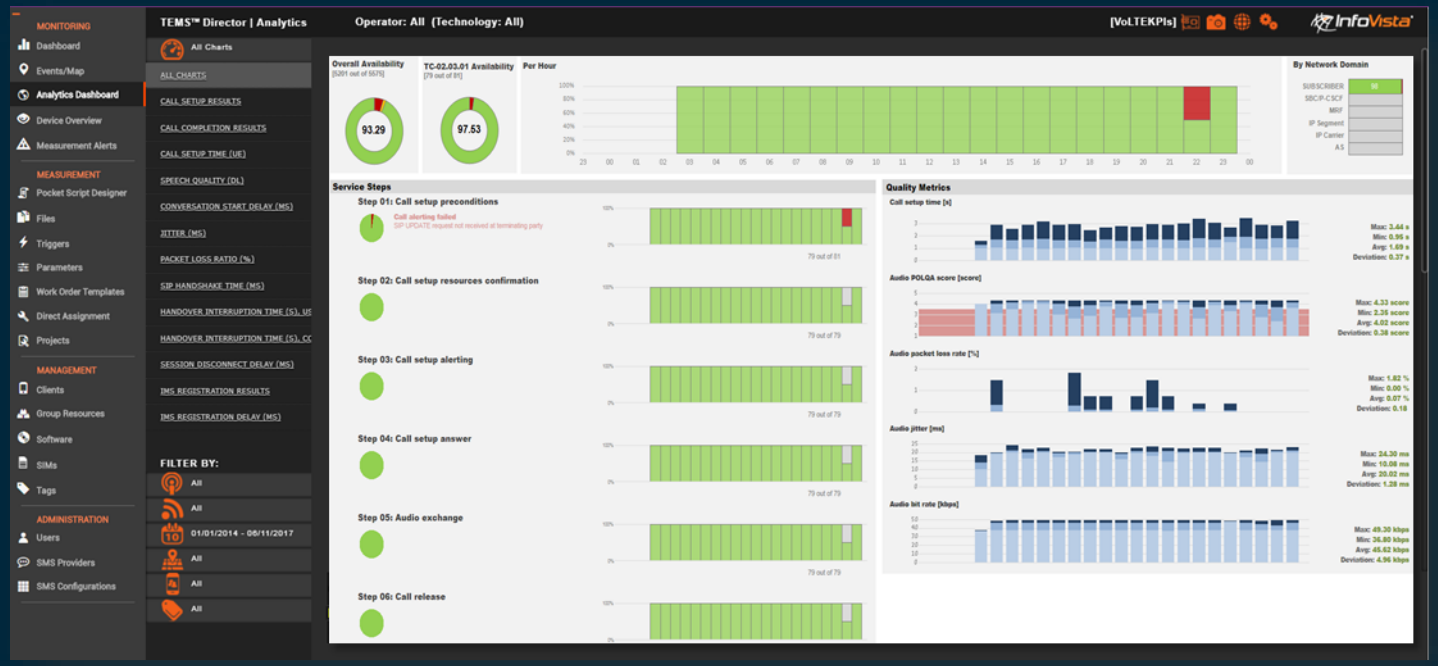
TEMS Director Analytics – Service KPI Monitoring

Statistical quality monitoring dashboard for real time analysis of service KPIs with drill-down capability for detailed troubleshooting.

TEMS Director Analytics – Service Level Monitoring

Time based quality monitoring dashboard for real time analysis of service KPIs with drill-down capability for detailed troubleshooting.

- Service status, trending, historical analytic views, based on collected data over a defined period of time
- Key metrics such as:
  - SIP registration time
  - Call setup time
  - MOS/POLQA score



Customers building the future with Infovista

ERICSSON	*A key strategic partnership today focused on leading in global 5G deployments*
umlaut	*The world authority on benchmarking relies on our network testing capabilities*
HUAWEI	*After using own test tool for decades, this major Asian equipment vendor decided to move to TEMS for all 5G deployments*
T	*This Tier 1 MNO used TEMS to verify their nationwide 5G roll-out in US, and adopted sQLEAR to troubleshoot VoNR issues*

TEMS™ use cases

Lab Testing / Spectrum Clearance
- TEMS Investigation

Site Verification
- TEMS Cloud
- TEMS Pocket
- TEMS Paragon

Regression Testing
- TEMS Sense

Service Quality Monitoring
- TEMS Sense

Tools Management
- TEMS Director

Benchmarking
- TEMS Paragon
- TEMS Sense
- TEMS Investigation
- TEMS Pocket

Data Analytics & Root Cause Analysis
- TEMS Director
- TEMS Discovery

Roaming & Revenue Assurance
- TEMS Sense
- TEMS Investigation
- TEMS Pocket

Regulator Compliance
- TEMS Paragon
- TEMS Sense
- TEMS Investigation

Optimization
- TEMS Investigation
- TEMS Pocket
- TEMS Paragon

Thank you!

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