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TEMS™ SYMPHONY 7.4
PRODUCT PRESENTATION

[ ]

AGENDA

- **TEMS Symphony Overview**
- Key Features
- What's Next?

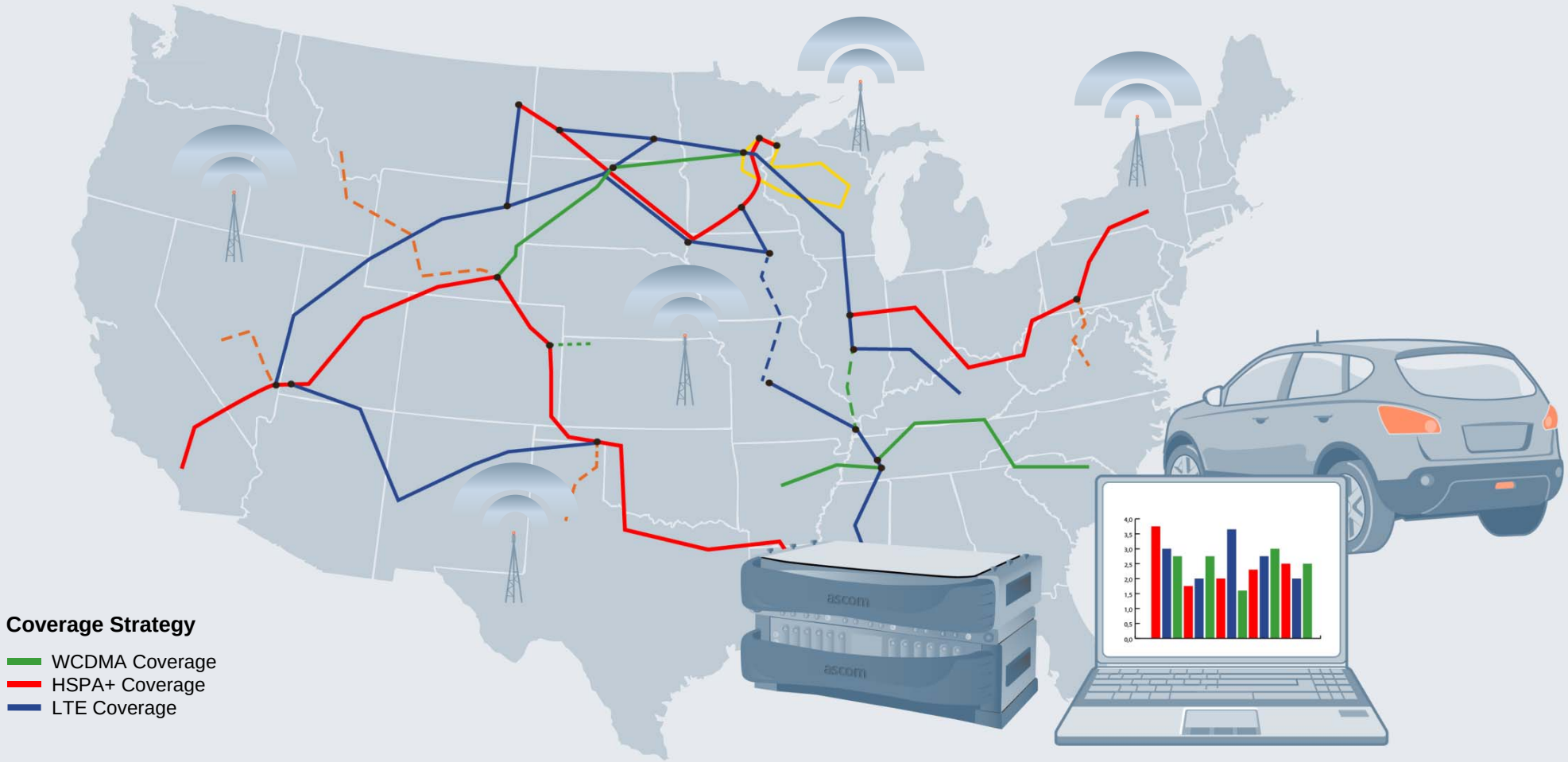
WHAT IS TEMS SYMPHONY?

A multichannel benchmarking platform

- Provides a direct comparison of multiple networks during a single drive test
- Utilizes multiple devices (phones, modems, scanners) all running in parallel
- Uses complex scripting capability to emulate customer activity
- Captures quality and radio parameters from actual subscriber devices
- Evaluates the entire network, end to end, utilizing the devices and services used by customers to provide a true perspective of the user experience

TEMS SYMPHONY

BENCHMARK VOICE & DATA APPLICATIONS ON MULTIPLE CHANNELS SIMULTANEOUSLY



WHY TEMS SYMPHONY

- Quality of service (QoS) is a key differentiator for attracting and retaining subscribers
- Understanding competition is one way to ensure differentiation
- TEMS Symphony measures the same services, from the same location, at the same time
- A direct comparison!

HOW CAN TEMS SYMPHONY IMPROVE DIFFERENTIATION

- **Keep Track of Your Competitors** – TEMS Symphony will quickly give you insight into any changes (good or bad) to your competitors' networks, allowing you to respond, or capitalize
- **Target Optimization Efforts** – By focusing network optimization efforts on those areas where your performance is weakest, you can provide the highest level of perceived service quality, at the *lowest possible cost*
- **Attract and Retain Subscribers** – By making TEMS Symphony part of your continuous network improvement cycle, you can ensure that you are delivering the network quality necessary to appeal to high-revenue customers

DIFFERENTIATE YOUR NETWORK WITH AN EFFICIENT BENCHMARKING PLATFORM

TEMS Symphony

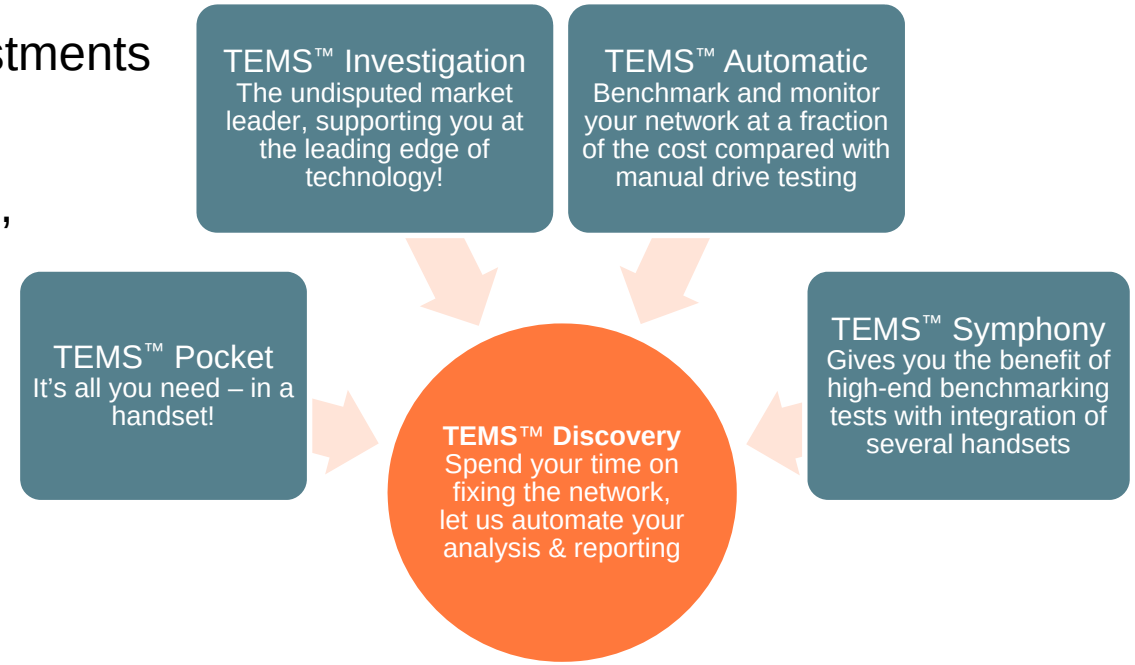
- Powerful, scalable, flexible – The only benchmarking solution you'll ever need

Product:	Benchmarking & Monitoring Tool				
Solution Areas:	Network Rollout	Optimization	Benchmarking	Subscriber QoE	In-building

TEMS SYMPHONY – POWERED WITH THE STRENGTHS OF THE ASCOM TEMS™ PORTFOLIO

Customer Benefits

- Investments – Evolve with your investments shared across the portfolio
- Operational costs – One tool to learn, operate, administrate and support
- Time to market – Developed once, used by many
- Quality – All products share the same core, providing higher quality

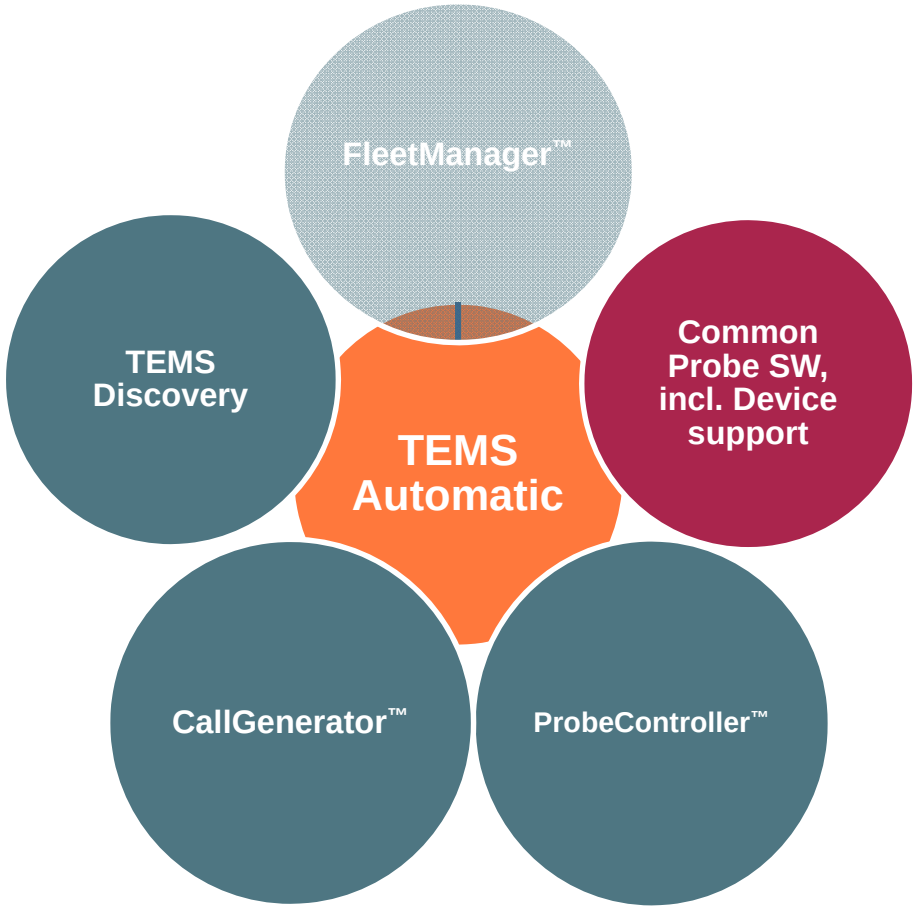


Efficiency…

TEMS SYMPHONY – POWERED WITH THE STRENGTHS OF THE ASCOM TEMS PORTFOLIO

Common Component library used across the Ascom TEMS Portfolio

- Common Probe Software
- Common Device Support
- Common Scripting Tool
- ProbeController™ GUI
- Common Logfile Format (.TRP)
- TEMS Discovery post processing tool
- CallGenerator™
- FleetManager™*



* Requirement candidates for TEMS Symphony

….evolve with your Ascom TEMS Portfolio

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AGENDA

- TEMS Symphony Overview
- **Key Features**
- What's Next?

TEMS SYMPHONY – KEY FEATURES

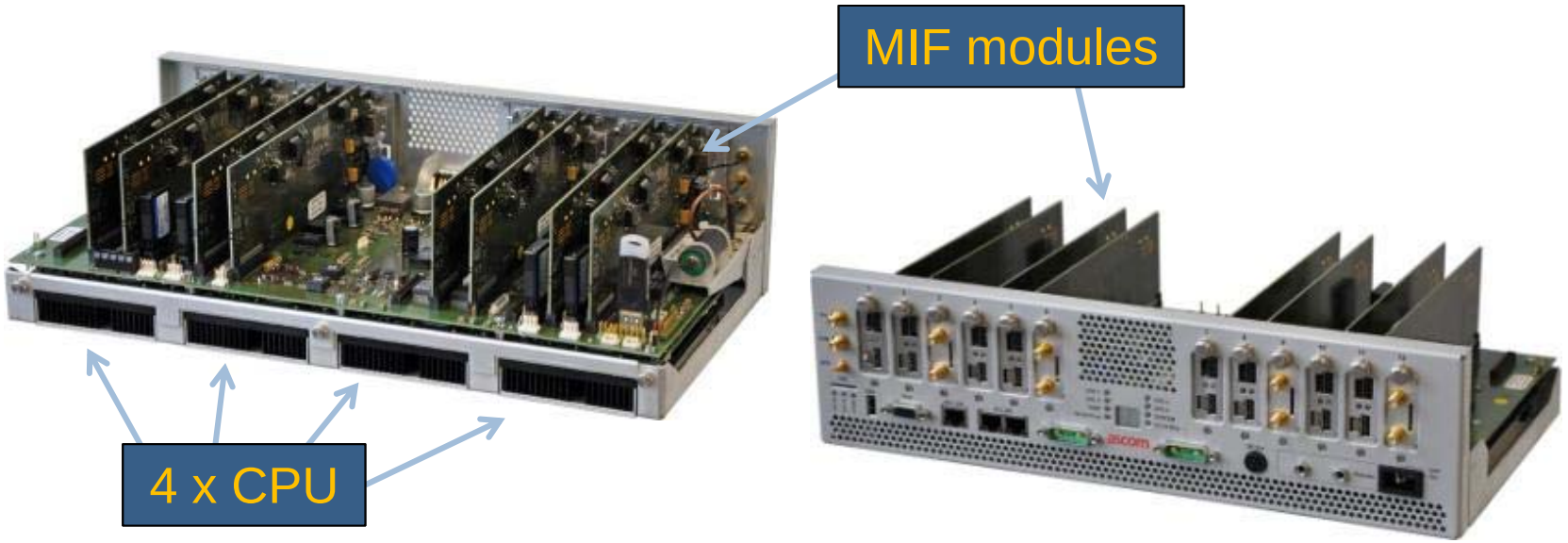
- Diversity of support devices, to match subscriber behavior.
  - Smartphones
  - MiniCards
  - USB sticks
- Diversity of testable services and applications
- Utilizes standardized algorithms, such as PESQ and POLQA, for voice/VoIP and VQmon for streaming service testing.
- Flexible scripting handles each device individually and enables the assignment of parallel tasks.
- Powerful processors for testing LTE data speeds.
- Versatile deployment: Same system can be used in-vehicle, indoor and nomadic.
- User-friendly ProbeController™ speeds data collection via flexible script designer and graphical channel monitoring.
- TEMS Symphony can be combined with other TEMS data collection tools such as:
  - TEMS Pocket
  - TEMS Automatic
  - TEMS Investigation

MTP-4 ARCHITECTURE (1 OF 3)

- One detachable, external PC provides control and updates status during operation (remote wireless control is possible)
- Multiple devices can be simultaneously controlled by each of 4 individual, built-in processors
- Up to 2 x MTP-4 chassis can be daisy-chained, supporting up to 8 processors simultaneously
- The same hardware can be used for an indoor and in-car solution
- An isolation chamber for test phones is available for the in-car solution

MTP-4 ARCHITECTURE (2 OF 3)

- MTP-4 mainboard contains 4 powerful processors and different measurement interface modules (MIFs)
- CPU type: Intel Core i7-2610UE dual core



MTP-4 ARCHITECTURE (3 OF 3)

- Up to 12 media interface modules (MIFs) are supported per chassis
- The following types of MIFs are currently available:
  - **Phone MIF:** module to control test phones via USB interface, audio interface, SIM card slot. Provides power, and resets the phone if necessary
  - **USB 12V MIF:** module with 2 power-cycled USB interfaces and one switched 12VDC output to connect commercial USB modems and RF scanners
  - **MiniCard MIF:** module with Mobile Radio PCI-e MiniCard for Mobile Communication 2G/3G/4G, SIM card slot, 2 antenna jacks are provided

ADDITIONAL HARDWARE FEATURES (1 of 2)

- 4 powerful CPUs (Intel Core i7 with 4GB RAM) on board
- 2 chassis may be daisy-chained, supporting 8 processors
- Up to 24 parallel testing channels (voice + data)
- Optional phone mounting platform (up to 5 phones each)
- Optional isolation chamber (up to 5 phones each)
- Vehicle kit with quick and easy installation of MTP-4 modules
- Portable kit for indoor measurements
- Easily accessible SIM card slots for all test devices
- Sensitive GPS on board
- Optional “Dead Reckoning” module

ADDITIONAL HARDWARE FEATURES (2 of 2)

- Ruggedized (handling, shock, vibration)
- Extended input voltage range: 10 to 28VDC (continuous, short dips to 6VDC)
- Wide temperature range (0 to 60^{o}C)
- Primary and backup power sources with integrated UPS functionality
- Hot swappable batteries may be exchanged during operation
- DC output for auxiliary equipment
- Easily accessible connectors
- Mechanical protection of cables and interfaces

TEMS SYMPHONY – SUPPORTED DEVICES (1 OF 3)

- Smartphones
  - Samsung GT-i9505 (Galaxy S 4 – EMEA) GSM 850/900/1800/1900, WCDMA/HSPA+ 850/900/1900/2100, LTE 800 (B20) / 850 (B5) / 900 (B8) / 1800 (B3) / 2100 (B1) / 2600(B7)
  - LG VS870 (Lucid 2 – Verizon) CDMA 850/1900, EV-DO 850/1900, LTE 700 (B13)
  - Samsung GT-i9305 (Galaxy S III – EMEA) GSM 850/900/1800/1900, WCDMA/HSPA+ 850/900/1900/2100, LTE 800 (B20) / 2600(B7)
  - Samsung SGH-I747 (Galaxy S III – AT&T) GSM 850/900/1800/1900, WCDMA/HSPA+ 850/1900/2100, LTE 700 (B17) / AWS (B4)
  - Samsung SPH-L710 (Galaxy S III – Sprint) CDMA 850/1900, EV-DO 850/1900, LTE 1900 (B2)
  - Samsung SGH-T999L (Galaxy S III – T-Mobile US) GSM 850/900/1800/1900), WCDMA/HSPA+ 850/1900/AWS, LTE AWS (B4)
  - Samsung SCH-I415 (Stratosphere II – Verizon) CDMA 850/1900, EV-DO 850/1900, LTE 700 (B13)
  - Samsung SCH-R530 (Galaxy S III – U.S. Cellular) CDMA/EV-DO 850/1900/AWS, LTE 700 (B12) / 850 (B5) / 1900 (B2) / AWS (B4)

TEMS SYMPHONY – SUPPORTED DEVICES (2 OF 3)

- MiniCards

NEW Sierra Wireless MC7304 (Multi-Carrier – EMEA) GSM 850/900/1800/1900, WCDMA/HSPA+ 850/900/1900/2100, LTE 800(B20) / 900(B8) / 1800(B3) / 2100(B1) / 2600(B7)

NEW Sierra Wireless MC7354 (Multi-Carrier – U.S.) GSM 850/900/1800/1900, WCDMA/HSPA+ 850/900/1900/2100/AWS, EV-DO 850/1900/1700, LTE 700 (B13) / 700 (B17) / 850 (B5) / 1900 (B2) / 1900 (B25) / AWS (B4)

- Sierra Wireless MC7710 (LTE – EMEA) GSM 900/1800/1900, WCDMA/HSPA+ 900/2100, LTE 800(B20)/900(B8)/1800(B3)/2100(B1)/2600(B7)
- Sierra Wireless MC7700 (LTE – Americas) GSM 850/900/1800/1900, WCDMA/HSPA+ DC 850/1900/2100, LTE 700 (B17) / AWS (B4)
- Sierra Wireless MC7750 (LTE – Verizon) EV-DO 850/1900, LTE 700 (B13)
- Sierra Wireless MC8795V (WCDMA Voice – EMEA) GSM 850/900/1800/1900, HSDPA 850/900/1900/2100

- Scanners
  - PCTEL MX
  - PCTEL EX
  - PCTEL EXflex

NEW Rohde & Schwarz TSMW

TEMS SYMPHONY – SUPPORTED DEVICES (3 OF 3)

- USB Modems

Netgear 330U (LTE – Canada & Brazil) GSM 850/900/1800/1900, WCDMA/HSPA+ DC 850/1900/2100, LTE AWS (B4) / 2600 (B7)

Huawei E306 (CMDA – EMEA/APAC) EV-DO Rev. A & B 850/1900

- Huawei E392u-6 (LTE – EMEA) GSM 850/900/1800/1900, WCDMA/HSPA+ 900/2100, LTE 900(B8)/1800(B3)/2100(B1)/2600(B7)
- Huawei E392u-12 (LTE – EMEA) GSM 850/900/1800/1900, WCDMA/HSPA+ 900/1800/2100, LTE 800(B20)/1800(B3)/2100(B1)
- Huawei E398u-1 (LTE – EMEA) GSM 850/900/1800/1900, WCDMA/HSPA+ 900/2100, LTE 900(B8)/1800(B3)/2100(B1)/2600(B7)
- Huawei E398u-15 (LTE – EMEA) GSM 850/900/1800/1900, WCDMA/HSPA+ 900/2100, LTE 800(B20)/1800(B3)/2600(B17
- Sierra Wireless 313U (LTE – Americas) GSM 850/900/1800/1900, WCDMA/HSPA+ DC 850/1900/2100, LTE 700 (B17) / AWS (B4)
- Netgear 341U (LTE – Sprint) EV-DO 850/1900, LTE 800 (B26) / 1900 (B25) / 2500 (B41)
- Pantech UML290 (LTE – Verizon) EV-DO 850/1900, LTE 700 (B13)
- ZTE MF683 (HSPA+ DC – T-Mobile U.S.) GSM 850/900/1800/1900, WCDMA/HSPA+ DC 2100/AWS
- Huawei E397 (LTE – U.S. Cellular) EV-DO 850/1900/AWS, LTE 700 (B12) / 850 (B5) / 1900 (B2) / AWS (B4)
- Huawei E367u-8 (WCDMA EMEA/APAC) GSM 850/900/1800/1900, WCDMA/HSPA+ 850/900/1900/2100
- Huawei E173u-1 (WCDMA EMEA) GSM 850/900/1800/1900, WCDMA/HSDPA 2100

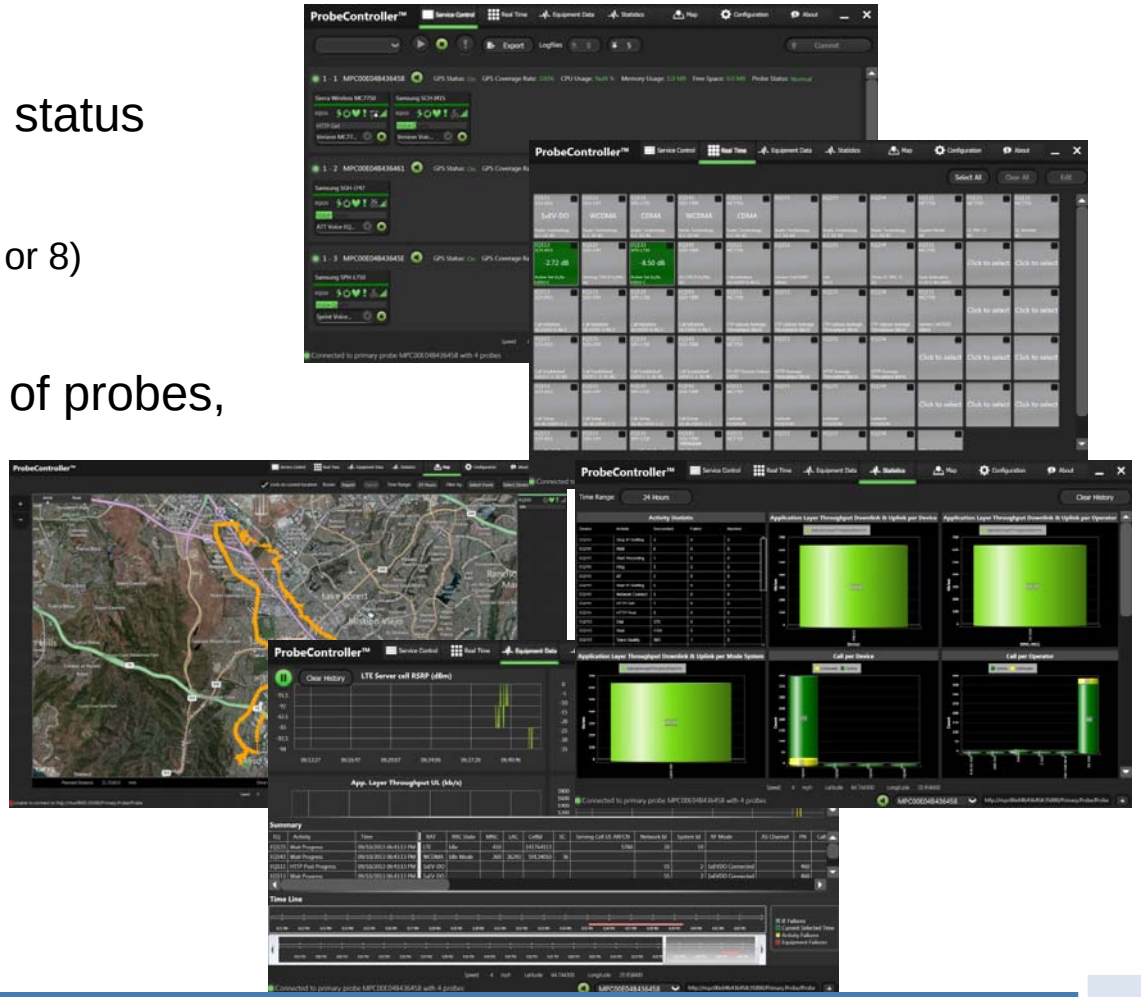
WHAT IS PROBECONTROLLER?

- ProbeController is a local GUI application for the mobile environment
- Designed to simplify the complex task of network benchmarking
- Easy to learn, and to use

…mobile display for probe and device status monitoring

PROBECONTROLLER

- Mobile display for probe and device status monitoring
  - Notebook or tablet PC solution (Windows 7 or 8)
  - Up to 24 devices
- Multiple views enable management of probes, device, test scripts
  - Service Control View
  - Real Time View
  - Equipment View
  - Statistical View
  - Configuration View
- Safe Driver Mode – complies with driver safety regulations

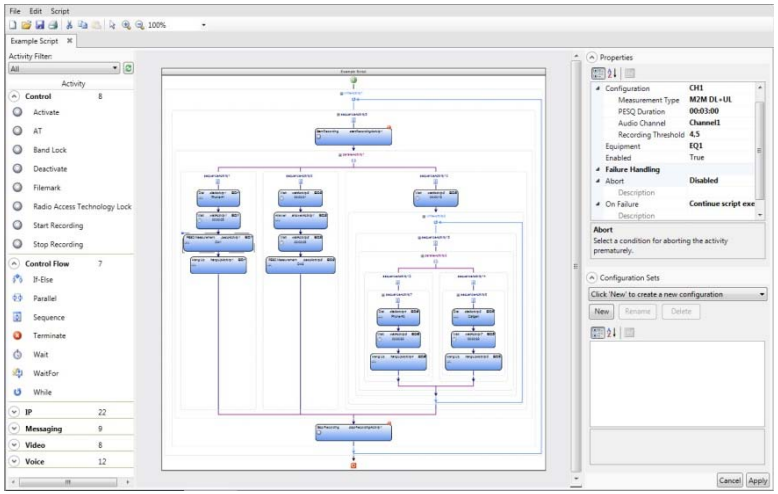


…new generation GUI – flexible and configurable

SERVICE CONTROL SCRIPT DESIGNER

"Work order" handling – Common Portfolio solution already used by TEMS Investigation

- Simplifies data collection and service testing
  - Flexible and efficient creation of advanced test scripts
  - Easy to create, adapt, and reuse scripts
- Based on an intuitive flow chart concept
  - Drag-and-drop activities into workflow pane
  - Toolbox of control logic
  - Application of control functions to devices
  - Library of predefined building blocks
  - Configuration details in separate configuration sets



….. one tool to learn, operate, administrate and support

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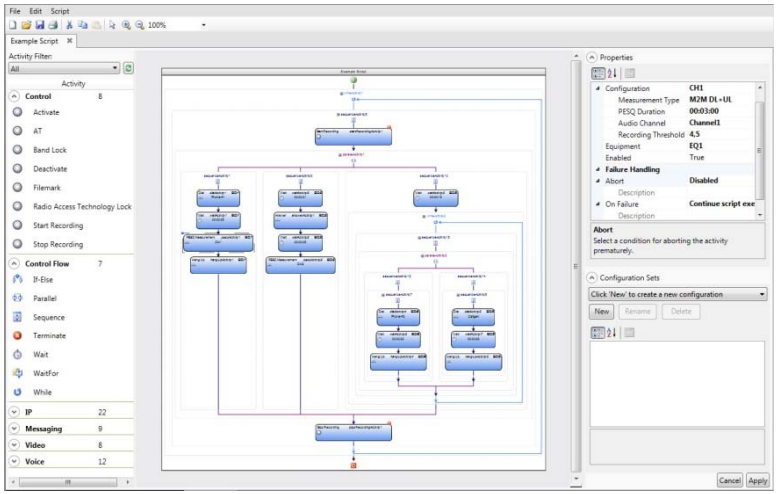
SERVICE CONTROL SCRIPT DESIGNER

Consistent measurements across the Ascom TEMS Portfolio, applying IP trigger points and using our new logfile format

- Supports PS testing
  - FTP UL/DL
  - HTTP TEMS Browser/ IE9
  - HTTP file UL/DL
  - Ping
  - Iperf (TCP/UDP)
- Control functions
  - Lock on RAT
  - AT commands
- Toolbox of control logic
  - If-else
  - Sequence or Parallel
  - Wait (/for)



… flexible framework for recording of data

SERVICE TESTING – DATA TESTS

Data testing using our common flexible and versatile framework for data recording

- HTTP Browser (TEMS Browser / IE9)
  - Browsing
  - HTTP File Upload / Download
  - HTTPS File Download
- FTP DL/UL, with support for load testing
  - Multiple sessions
  - Fixed duration time
- Iperf for enhanced bandwidth testing
  - TCP/ UDP
- Streaming – YouTube
  - Public server, TCP/IP with MOS score – nonintrusive

…shared across the TEMS Portfolio!

DATA TESTING – SUMMARY

	MTP-4		
Device capabilities	Qualcomm based USB Modems	Sierra Wireless MC77x0	Sierra Wireless MC73xx
FTP DL/UP	✓	✓	✓
HTTP TB browser	✓	✓	✓
HTTP IE browser	✓	✓	✓
HTTP file DL/UL	✓	✓	✓
HTTPS file DL	✓	✓	✓
Ping (ICMP)	✓	✓	✓
SMS		✓	
Video Streaming Throughput	✓	✓	✓
Email (POP3/ SMTP)		✓	
Iperf (UDP/TCP)	✓	✓	✓

SERVICE TESTING – VOICE TESTS

Voice testing solutions:

- Circuit Switched Calls
  - PESQ and POLQA
  - To/From CallGenerator
  - Mobile-to-Fixed (MOC)
  - Fixed-to-Mobile (MTC)
  - Mobile-to-Mobile
- VoLTE Calls
  - POLQA Wideband
  - Mobile-to-Mobile

…New support for VoLTE calls!

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VOICE TESTING – SUMMARY

	MTP-4								
Device capabilities	Samsung GT-i9505	Samsung GT-i9305	LG VS870	Samsung SGH-I747	Samsung SPH-L710	Samsung SGH-T999L	Samsung SCH-I415	Samsung SCH-R530	Sierra Wireless MC8795V
Voice PESQ	✓	✓	✓	✓	✓	✓	✓	✓	✓
Voice POLQA NB/SWB	✓	✓	✓	✓	✓	✓	✓	✓	✓
Mobile-to-Fixed (MOC)	✓	✓		✓	✓	✓	✓	✓	✓
Fixed-to-Mobile (MTC)	✓	✓		✓	✓	✓	✓	✓	✓
Mobile-to-Mobile	✓	✓	✓	✓	✓	✓	✓	✓	✓
VoLTE			✓						
Blixt™ Bandwidth Measurement	✓	✓							

INTRODUCING BLIXT™

- Blixt™ – a patent pending, available bandwidth measurement (ABM) technology
  - Reduce the cost and time required to test network perfomance and deploy new capacity
  - Reduce drive testing requirements related to throughput testing by at least **50%**
    - Each measurement gives UL and DL throughput as well as delay measurements
  - Test capacity on a live network without significantly impacting subscriber service

- Benefits with TEMS Symphony:
  - No capacity limitation on test equipment
  - Multiple networks can be tested simultaneously
  - Suitable for benchmarking campaigns as it will significantly reduce the required amount of transfered bytes.
    Less bytes used = less cost.

”Saved capacity is immediately available to consumers”

The future of available bandwidth measurements!

ASCOM'S BLIXT TECHNOLOGY WINS AWARD

Ascom Network Testing is being recognized for its innovative, industry-leading product, Blixt™

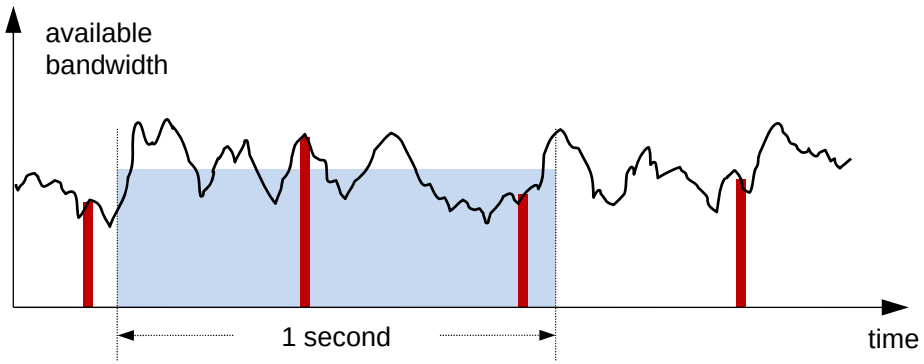
- Winner of 2013 Fierce Innovation Awards: Telecom Edition
  - Unique operator-reviewed awards program from the publishers of *FierceWireless, FierceTelecom,* and *FierceCable*
  - Judges evaluated submissions based on the following criteria: **technology innovation, financial impact, market validation and end-user customer experience**

*"The Fierce Innovation Awards celebrate the companies who are **on the cutting edge of innovation** in the wireless, wireline and advanced TV and network sectors of our industry"*

HOW DOES BLIXT™ WORK

- The trick is to load the data pipe in a clever way
  - The algorithm sends trains of UDP packets in bursts approximately twice per second
  - Peak load reaches maximum throughput of network, utilizing its full bandwidth
  - Automatic adaptation to minimize intrusion level (amount of data needed to obtain accurate metric)
  - Client-server communication in which Ascom initially provides servers per region for easy test setup

”Test capacity on a live network without significantly impacting subscriber service”



BLIXT™ IN TEMS SYMPHONY

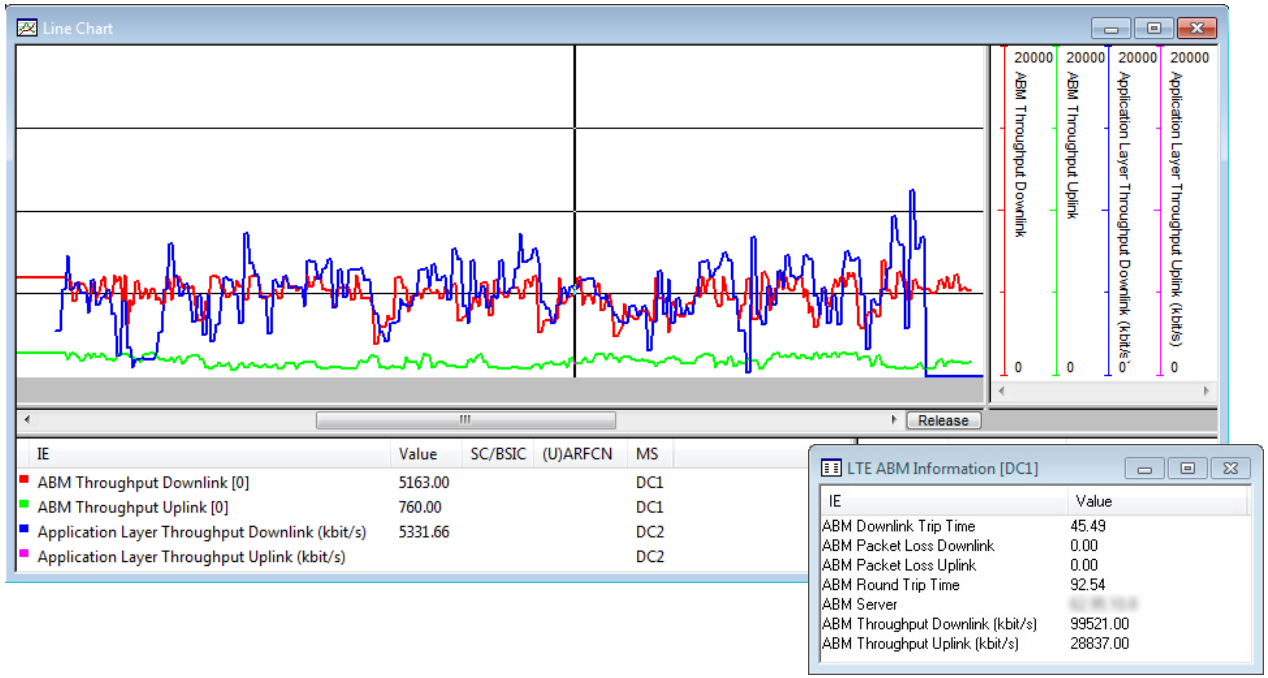
- Comparing ABM and FTP
  - Throughput values for DL correlate very well – ABM vs FTP
  - For ABM UL, throughput and delay are obtained simultaneously

FTP intrusiveness= 100%
ABM intrusiveness* = 5%

Same test case
and result utilizing

95%*

less resources



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BLIXT™ ACCURACY

Effective zone of Blixt™

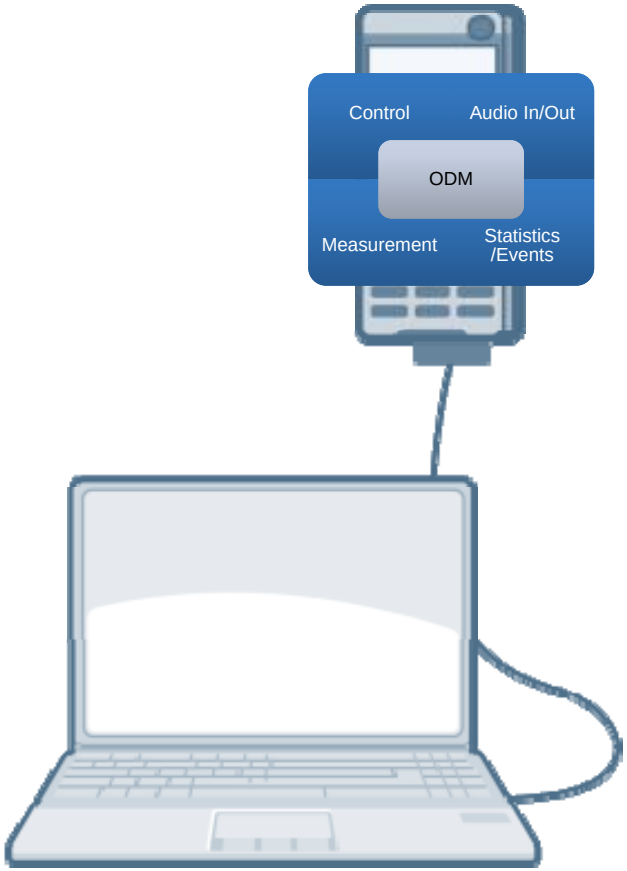
Less suitable

Technology	# Packets in Packet Train	Level of Intrusiveness (%) (typical) (DL / UL)	ABM Maximum Error (%)
EGPRS	15	8.7% / 68%*	8.7%
GPRS	10	17% / 68%*	7%

Measurements done in a perfect radio environment

FEATURING VOLTE TESTING

- Ascom's flexible solution includes a VoLTE testing node (On-Device Measurement Module, or ODM) inside the terminal
- Raw IP logging from Qualcomm chipset can be decoded and monitored in real-time
- Full IP trace logging during VoLTE calls
- Captures the true end-user experience



The Ascom TEMS solution is commercially deployed and in use for VoLTE testing on commercial LTE networks

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SERVICE TESTING – PCTEL SCANNING

Scanning support for PCTEL SeeGull family, including:

- PCTEL MX scanner (WCDMA/CDMA/LTE), multiband, multitechnology scanning
- PCTEL EXflex (WCDMA/CDMA/LTE) programmable multiband, multitechnology scanning
- PCTEL EX scanner (WCDMA/CDMA/LTE)

Capability/device	PCTEL EX	PCTEL EXflex	PCTEL MX
GSM scanning capabilities			
RSSI scanning – static ARFCN set	✓	✓	✓
RSSI scanning – BSIC decoding	✓	✓	✓
RSSI scanning – C/I measurement	✓	✓	✓
RSSI scanning – system info decoding	✓	✓	✓
Spectrum analysis	✓	✓	✓
WCDMA scanning capabilities			
Pilot scanning – Top N	✓	✓	✓
Pilot scanning – SIB decoding (continuous)	✓	✓	✓
Pilot scanning – high speed/high dynamic	✓	✓	✓
P-SCH + S-SCH	✓	✓	✓
Max number of UARFCNs	12	12	12
RSSI scanning	✓	✓	✓
Spectrum analysis	✓	✓	✓
LTE scanning capabilities			
RSSI scanning	✓	✓	✓
Signal scanning	✓	✓	✓
Spectrum scanning	✓	✓	✓
MIMO scanning option			✓

…shared across the TEMS Portfolio!

FEATURING PCTEL EXFLEX

- The next step in the evolution of the PCTEL EX platform – provides the flexibility operators need to adapt to increasing network complexity.
- Support for the main technologies utilized by carriers today
  - TD-LTE, LTE(FDD), WCDMA, GSM, CDMA, EV-DO, TD-SCDMA
- Supports any cellular band between 300 MHz to 3.8 GHz
- Advanced scanning capabilities with low power consumption (20 W)
  - High Dynamic Range
  - Fast scan speeds for greater data density
  - GSM/WCDMA Layer 3 information
- Support for Wideband spectrum analysis
  - 300 MHz to 3.8 GHz
  - Test signal power of Wi-Fi or Public Safety networks

Variable band PCTEL EX scanner

PCTEL EXFLEX BENEFITS

- Single hardware platform
  - 06900 – Base hardware platform, bands and technologies added separately
  - 06900S – Super configuration supporting all bands and technologies
- No band limitations
  - Support for all 3GPP defined bands (300 MHz to 3.8 GHz range)
  - E-UTRA bands available as UL and DL pairs
- Simplified expansion and upgradeability
  - Band and technology available as software upgrades
  - New additions can be done remotely
- EX-based receiver
  - EX is a field proven platform for the past 5 years
  - EXflex performance is the same or better that EX
- All accessories included
  - Power Cable, Car lighter (9'), USB data Cable
  - GPS Antenna, 698-3000 MHz Multi-Band Mag Mount Antenna (12')

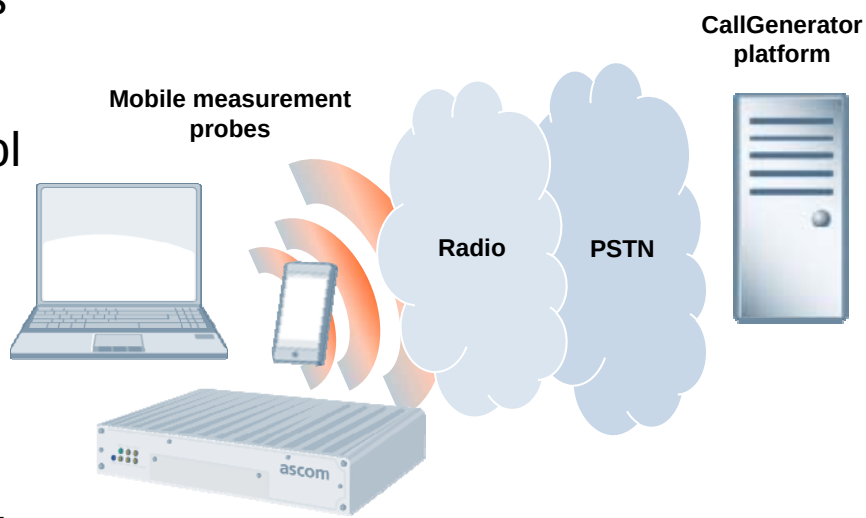
Variable band PCTEL EX scanner

WHAT IS CALLGENERATOR

CallGenerator is a stationary, fixed, landline probe. Offering functionality for advanced speech quality testing of mobile-to-fixed networks from end to end by calculating PESQ & POLQA scores to mimic human speech perception.

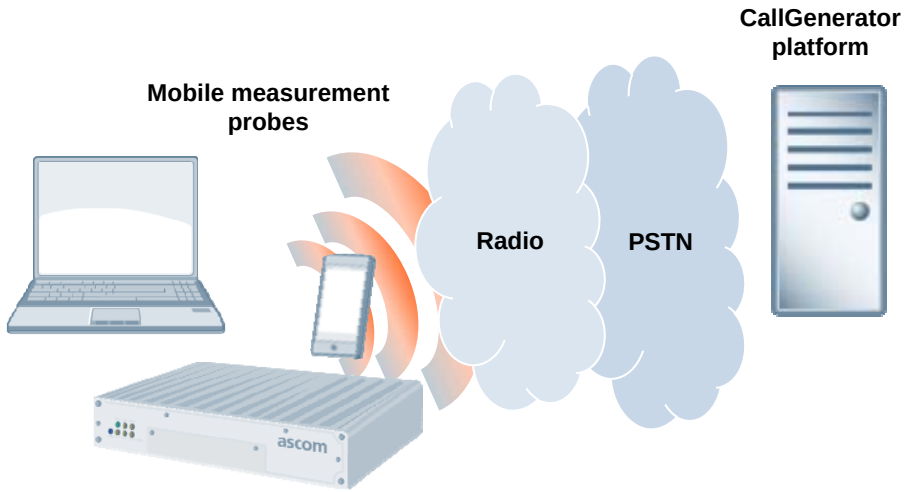
Throughout voice test calls, a speech sentence is played on the voice channel uplink and downlink.

- The probe controls the CallGenerator via control signaling (DTMF) at test start-up.
- CallGenerator calculates test scores on the uplink, while ...
- Probe calculates test scores on the downlink.
- Part of post processing, uplink and downlink values are merged and correlated with each other.



CALLGENERATOR

- Ascom reintroduces its improved CallGenerator supporting PESQ/POLQA measurements common for all TEMS products
- Flexible configuration supporting 1-90 channels
- Server hardware and calling cards for PSTN, ISDN, E1 or T1 interface can be supplied from Ascom
- Porfoliowide implementation
  - TEMS Investigation
  - TEMS Pocket
  - TEMS Automatic
  - TEMS Symphony



CallGenerator 1.2 – a multitalented voice tester

CALLGENERATOR STANDARDS

The PESQ or POLQA algorithm calculates a quality score by comparing the transmitted sentence with the undistorted reference, resulting in a calibrated MOS score used for reporting.

- PESQ (Perceptual Evaluation of Speech Quality) algorithm, standardized as ITU Recommendation P.862 (along with P.862.1, 2, and 3)
  - To support testing of NB (narrowband, 300-3400 Hz)
- POLQA (Perceptual Objective Listening Quality Assessment) algorithm, standardized as ITU Recommendation P.863
  - To support testing of NB (narrowband, 300-3400 Hz) or SWB (super-wideband, 50-14000 Hz)

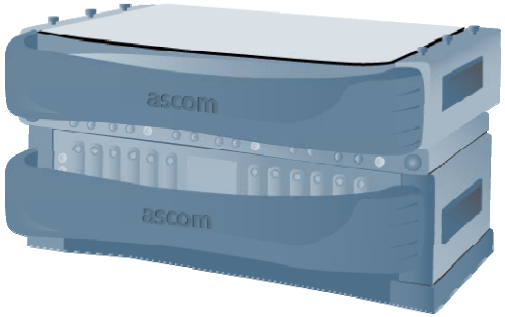
[ ]

AGENDA

- TEMS Symphony Overview
- Key Features
- **What's Next?**

ON-DEVICE SERVICE TESTING

- Moving service testing to the terminals
- Captures the true end-user experience
- Enables testing of proper user equipment QoS settings and IP stack characteristics
- Maintains control and coordination through service control scripts for multiple devices (repeatable testing)
- *IP throughput using on-device HTTP service testing will be available for specific smartphones in TEMS Symphony 7.4.1*



Measurements from a user's perspective

TEMS SYMPHONY 7.5

For the latest updates on planned features, please refer to the TEMS SYMPHONY ROADMAP presentation.

TEMS™ DISCOVERY

For further details on the post processing of TEMS Symphony logfiles, please refer to TEMS Discovery product information.

LEGAL DISCLAIMER

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THANK YOU!