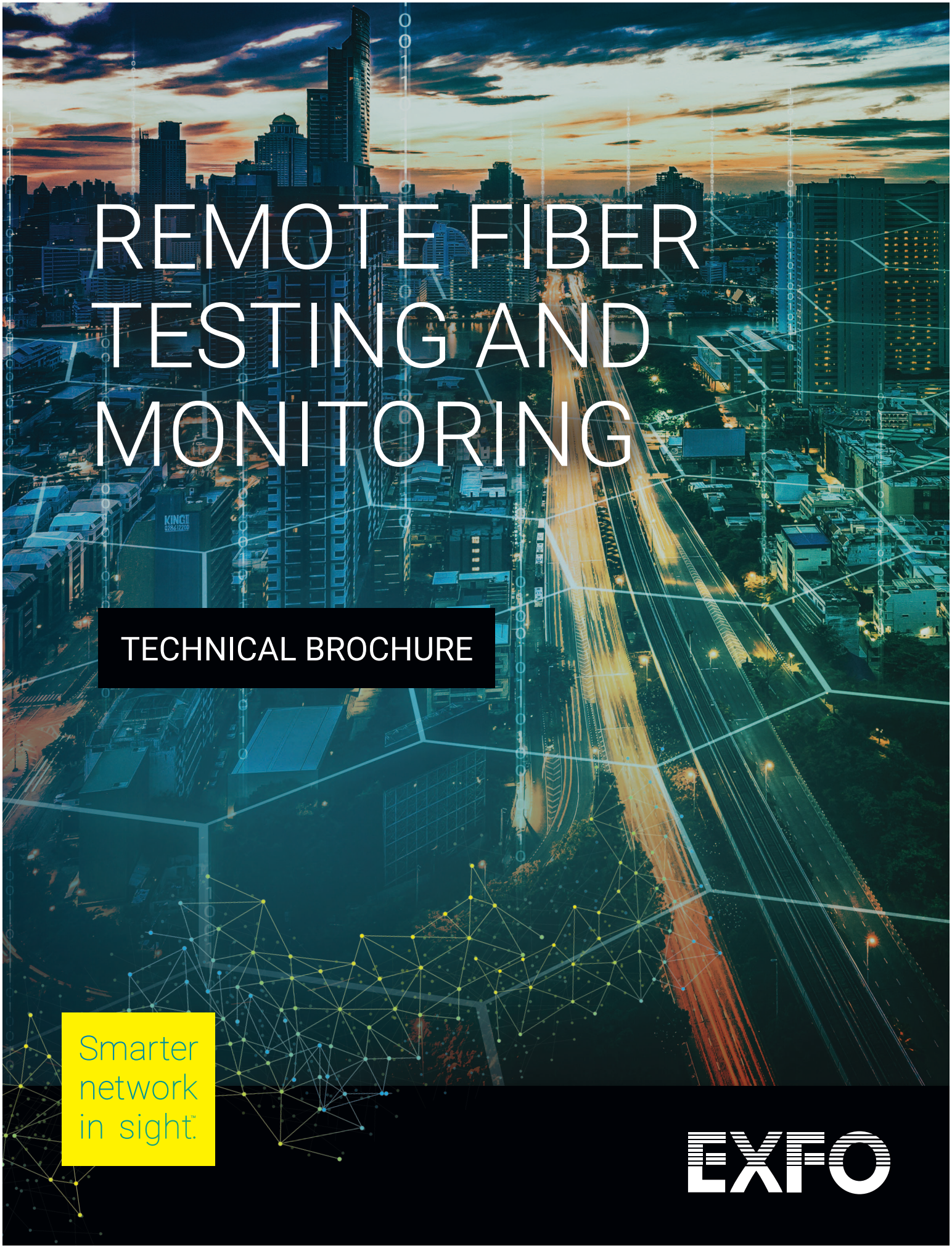


REMOTE FIBER TESTING AND MONITORING

TECHNICAL BROCHURE

Smarter network in sight.™

EXFO

“We're the communications industry's test, monitoring and analytics experts.”

About EXFO

EXFO develops smarter test, monitoring and analytics solutions for the global communications industry. We are trusted advisers to fixed and mobile network operators, hyperscalers and leaders in the manufacturing, development and research sector. They count on us to deliver superior visibility and insights into network performance, service reliability and user experience. Building on our 35 years of innovation, EXFO's unique blend of equipment, software and services enable faster, more confident transformations related to 5G, cloud-native and fiber optic networks.

Table of contents

Industry's leading OTDR[1]-based solution for remote fiber testing and monitoring

Optical fiber networks are everywhere and are continuously evolving, under heightened stress. EXFO's remote fiber testing and monitoring (RFTM) solution provides increased visibility over critical fiber routes by connecting them to fixed and centralized OTDR-based test equipment—from the initial deployment phase to maintenance and field repairs. With this solution, operators can track changes in fiber infrastructure quality, including slow degradations before they noticeably impact services. Equipped operators are always aware of the status of their most critical assets and their customer support can demonstrate a level of control.

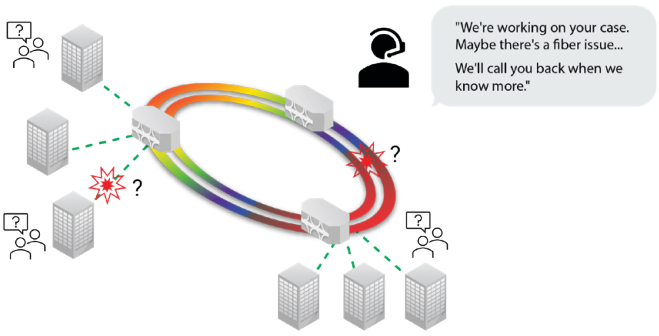


Figure 1: Traditional mode of operation

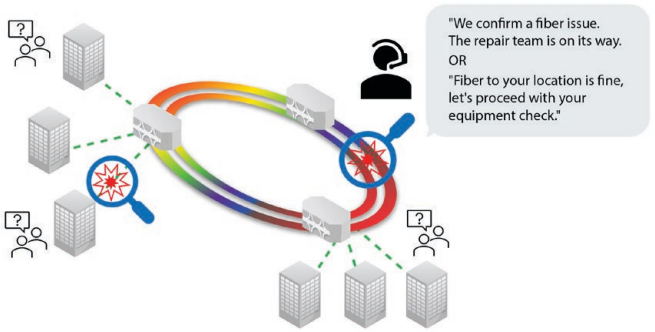


Figure 2: Mode of operation with EXFO's monitoring solution

Tired of waiting hours to find a field technician with the right equipment for troubleshooting a possible fiber outage?

For most types of fiber deployments, EXFO's remote fiber testing and monitoring solution can eliminate that waiting time by immediately pinpointing the nature of the fault, and providing all relevant parties with the comprehensive information they need to trigger immediate restoration or discard fiber or cable health as a cause.

Traditional remote fiber test systems are no longer suited for addressing the scale and criticality of fiber networks. A solution that cannot scale or whose performance degrades as the number of fiber links rises is no longer sustainable. Likewise, a solution that only gives you access to a remote OTDR instrument for an expert to troubleshoot will just move your problem, not solve it. EXFO's RFTM solution solves both these issues.

The capability for integration into existing systems (e.g., NMS, OSS) or new workflows is a must today. EXFO's solution goes the extra mile with a truly open and scalable platform for running OTDR tests at any time and from any system. The result? Quick and complete test reports that are easy to interpret and bear value for further investigations throughout the fiber lifecycle.

EXFO's remote fiber testing and monitoring solution provides 24/7 visibility over critical fiber assets and is designed to be used by non-experts so that experts can be dispatched only where and when really needed—saving time and maximizing efficiency.

1 To learn more about OTDR technology: EXFO.com/en/resources/glossary/optical-time-domain-reflectometer-otdr

Why EXFO?

EXFO develops smarter test, monitoring and analytics solutions for the global communications industry. We are trusted advisers to fixed and mobile network operators, hyperscalers and leaders in the manufacturing, development, and research sector. Our customers count on us to deliver superior visibility and insights into network performance, service reliability and user experience. Building on 35+ years of innovation, EXFO's unique blend of equipment, software and services enable faster, more confident transformations related to 5G, cloud-native and fiber-optic networks.

Whether you operate a small network (municipality, private networks, small MSOs, etc.) or a countrywide network, EXFO can help you with the right type of OTDR-based centralized testing and monitoring to meet your return-on-investment targets.

If you are looking for the highest performance and density together with the fastest testing, the RTU-2 powerhouse is designed for you. Or would you prefer an OTDR white box? The new OTH-7000 is exactly that—it gives hyperscalers, NEMs and system integrators great value for the price without any compromise on the OTDR unit's ability to detect and monitor the optical infrastructure's weaknesses and degradations before they become critical and require urgent restoration.

EXFO's solutions for remote fiber testing and monitoring deliver key functions and innovative capabilities that are yet unmatched:

- Automation of OTDR measurements using patented Link-Aware™ (iOLM) technology providing detailed end-to-end (E2E) fiber characterization without requiring effort nor OTDR expertise
- Statistical learning after taking fiber reference to dynamically adjust fault detection thresholds, eliminating false events without compromising on sensitivity, resolution or accuracy
- Capability to read and use fiber/cable documentation data, managed externally into alarm workflows
- Fully web-based application, including a GIS function for fault-on-map capability
- Denser solution (up to 1024 ports in 3U) for large FTTH central offices using MPO-type connectors on optical switches
- First and only RFTS solution with phone-home and event-based communication architecture enabling scalability, higher IT security and cloud operability
- Fastest (under 10 seconds), easiest and most accurate E2E PON testing and monitoring using high-reflectance demarcation (HRD) reflectors. Short test times allow each field technician to quickly get results and yield optimal availability for technician crews sharing a centralized OTDR

EXFO can also complement your centralized testing solution and boost technician efficiency in the field thanks to a large portfolio of intelligent and connected handheld test instruments.

Link-Aware™ technology (iOLM)

EXFO's industry-acclaimed iOLM is now available for RFTM solutions[2]. iOLM leverages intelligent algorithms that will automatically define and seamlessly execute complex sequences of acquisition, for optimal accuracy. This technology is also key for achieving greater testing speeds through specialized measurement(s) tailored for specific use cases. iOLM comes with full-fledged, detailed E2E characterization or Optimodes, which are intent-based testing recipes that make the best possible use of the OTDR to obtain optimal speed and performance.

These are just a few of the capabilities and automated processes that can be achieved with iOLM. Our latest solutions for remote fiber testing and monitoring (i.e., RTU-2 and OTH-7000) support iOLM when connected to the fiber management system (FMS) server app.

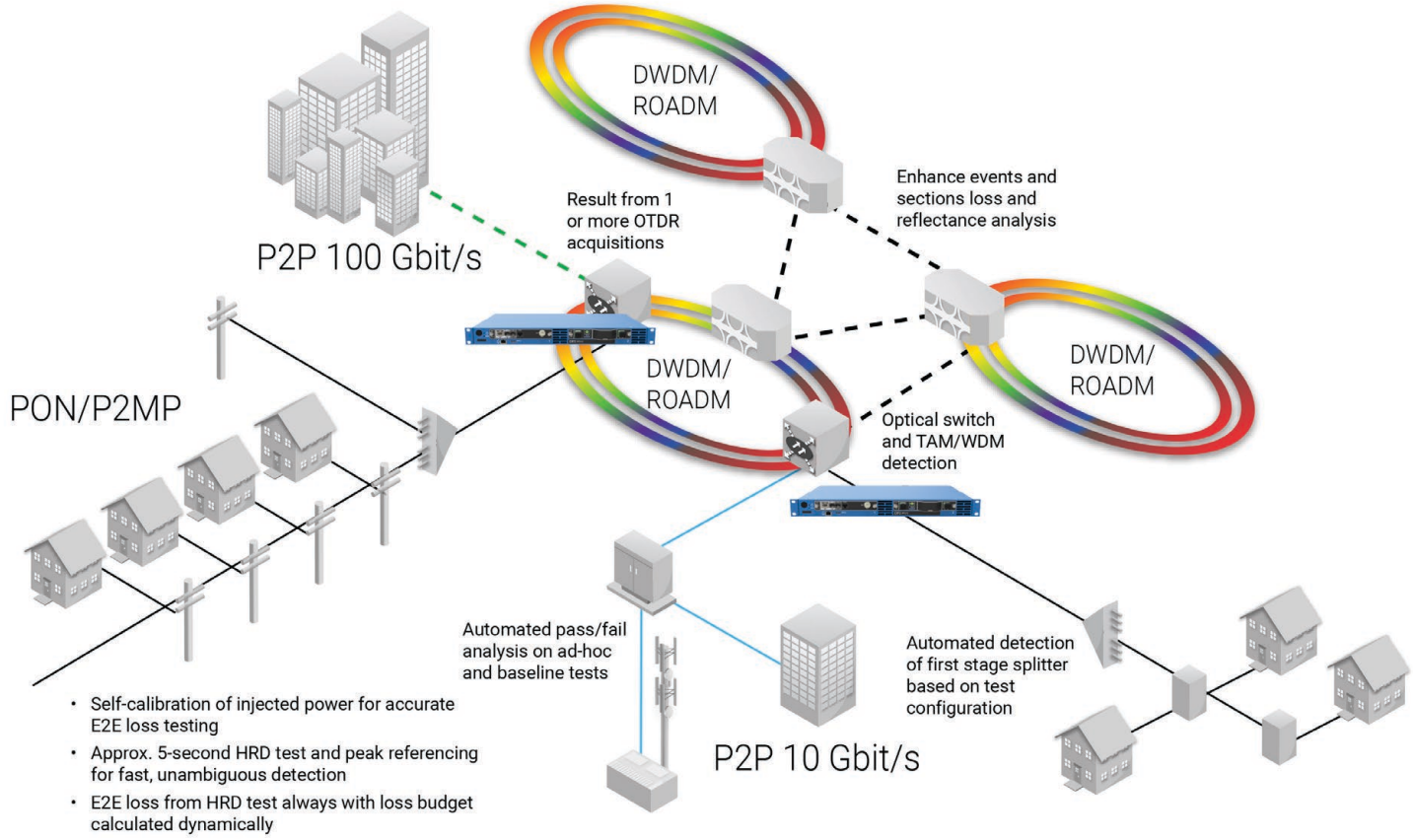


Figure 3: Leveraging iOLM's intelligent automation for optimal measurement on all topologies

2 Except for FG-750 series.

A cloud-native application

By definition, a cloud-native application is software that orchestrates containers as part of a microservice architecture. This enables the server software to operate on virtually any distributed Linux platform (virtualization layer between OS and containers) and to scale as each container is capable of operating into a cluster (multiple nodes). As telecom operators continue or start to move to public or private clouds, EXFO's solution for remote fiber testing and monitoring can gradually fit into their cloudification plans—guaranteeing greater flexibility and efficiency.

The first benefit of cloud-native is the ease of exposing services via RESTful APIs, which are available on all EXFO remote fiber testing and monitoring microservices (not all exposed but present by design). Those APIs are the same used by customers (web, mobile) so this single backend system serves all users—whether they are EXFO, proprietary or third-party applications.

Some remote fiber test systems still propose a desktop/thick client to manage GIS data—or require one physical or VM host per system function or service (e.g., AAA, test functions, GIS, alerting, web server). A cloud-native solution offers a collection of microservices running as containers on a single Linux host (most) or multiple nodes with a single-server application.

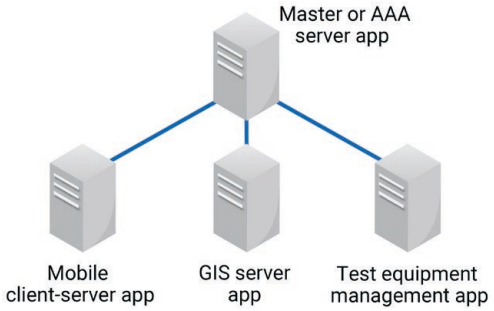


Figure 4: Traditional FMS

Figure 5: EXFO FMS (single cloud-native server app with 2 nodes, for large systems)

EXFO publishes an API guide and a web-accessible description of all its public APIs. Below is an example of one workflow supported by one of the microservices/end points:

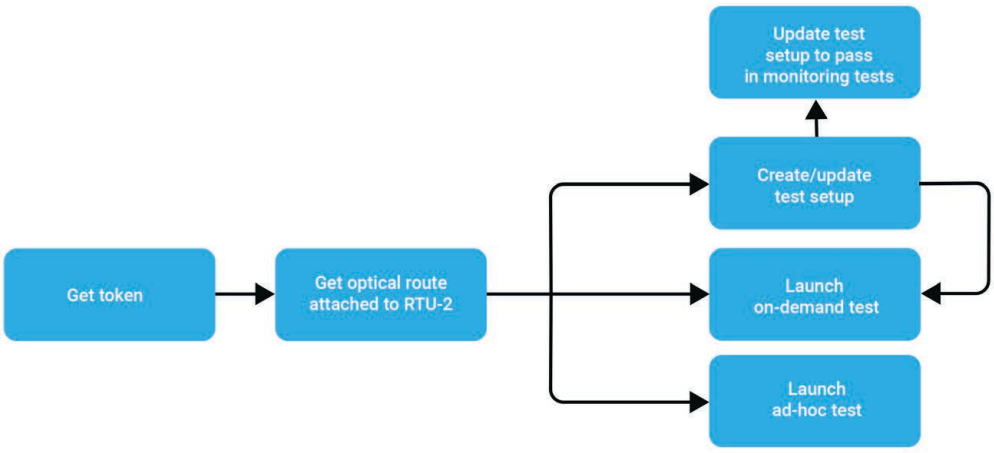


Figure 6: Use case – How to set up and run an iOLM test on P2P optical route (P2P type of route in FMS)

Supported intelligent Optical Link Mapper (iOLM) tests

Propelled by iOLM, EXFO's remote fiber testing and monitoring goes well beyond basic remote OTDR troubleshooting triggered via remote console. Here is a summary of the OTDR-based tests supported for point-to-point (P2P) and point-to-multipoint (P2MP) such as passive optical networks (PONs). All tests and test configuration change requests presented below are available through a RESTful end point: [Base URL: /api/topology]. OTDR ad hoc testing based on customizable test parameters in order to obtain a standard OTDR test result (in .sor format) is available for all route types from the FMS (EMS) web UI and from the aforementioned API.

By default, all tests performed are stored centrally for reporting and further processing. Each test is also added to an open-source, time-series database and can feed time-series dashboard tools.

There are three priority levels for tests on each iOLM unit. If a test is in progress when a higher-priority test is triggered, the lower-priority test is postponed so that the higher-priority test can run immediately. When a high-priority test is already running on any of the routes/ports, and a user launches a test with the same priority, a busy message appears. Queueing is supported such that multiple second priority-level tests on different routes/ports can be launched one after the other. They run on a first-in first-out basis. A test complete message appears once all tests are complete.[3]

P2P FIBERS – iOLM TESTS SUPPORTED IN TABLE BELOW	
Test types	**Test description**
RTU provisioning  P1	• Pass/Fail (P/F) analysis on limited range • Switch detection • Quick test
Test as you build (ad hoc)  P1	• P/F analysis on all link elements • Switch detection • Link loss, ORL, length • Detailed test[4]
Baseline test prior to launch monitoring P2	• P/F analysis on all link elements • Switch detection • WDM (TAM) detection • Detailed test[4]
Troubleshoot on-demand (TOD), automated fault detection P2	• Automatically compares each section and event loss part of the baseline to detect and report an actual change • Detailed test[4]
Proactive monitoring, 24/7 testing P3	• Round robin and continuous testing of a preselected number of routes/ports • Alarm is created if a deviation meets a series of configurable alert rules

 = Also available from mobile app

3 Detailed tests leverage iOLM capability for optimal link evaluation to measure link loss, ORL or length, and identify and measure individual events including diagnosis for recommended corrective actions

P2MP (PONS) – iOLM TESTS SUPPORTED

Test types	Test description		
RTU provisioning  P1	• P/F analysis on limited range • Switch detection • Quick test		
Test as you build (ad hoc)  P1	F1/Spine test: • P/F analysis • Switch detection • Link loss, ORL, length • Detailed test	Remote F2 test (via F1 lead fiber): • P/F analysis on remote fiber after F1 + cord leads • F2 fiber link loss, ORL, length • Detailed test through calibrated lead fiber	F2/F3 E2E test with HRD reflector for continuity, loss, distance from splitter: • P/F for E2E loss against calculated loss budget (dynamic limit) • Fast 5-s test
Baseline test prior to launch monitoring P2	• P/F analysis on all F1/spine link elements • Switch detection • WDM (TAM) detection • Detailed test—any small change can be detected during troubleshooting or monitoring		
Troubleshoot on-demand (TOD), automated fault detection P2	On demand test for: • Verifying F1, F2, F3 fibers (as seen from OLT side) • Detailed test; automatically compares each section and event loss part of the baseline to detect and report any change • Generating alarms if any change exceeds customizable threshold	 Additional capability with HRD reflectors installed on the PON: • Faster on-demand test (approx. 10 s) to verify all end points in a single test • Discriminate individual status/health of each PON legs	
Proactive monitoring, 24/7 testing P3	Round robin and continuous testing of a preselected number of routes/ports with HRD installed on the PON for: • Faster scan test (approx. 10 s) to verify all end points in a single test • Discriminate individual status/health of each PON legs • Generating alarms if any E2E link loss exceeds customizable threshold • Further on-demand troubleshooting to narrow down root cause analysis		

 = Also available from mobile app

Central server management application – key functions and feature of FMS

Fiber monitoring system (FMS) is the element management system (EMS) of all test units provisioned as clients from a client-server architecture. The communication between both are events where FMS maintains the subscribers of all the queues opened by each of the test unit. This ensures scaling and proper load distribution. In case of file transfer during a massive or focused firmware update, the test unit will use a secured https (port 443) to access the necessary files on the server to proceed, as a fully authorized client. The figure below represents the simplified system architecture.

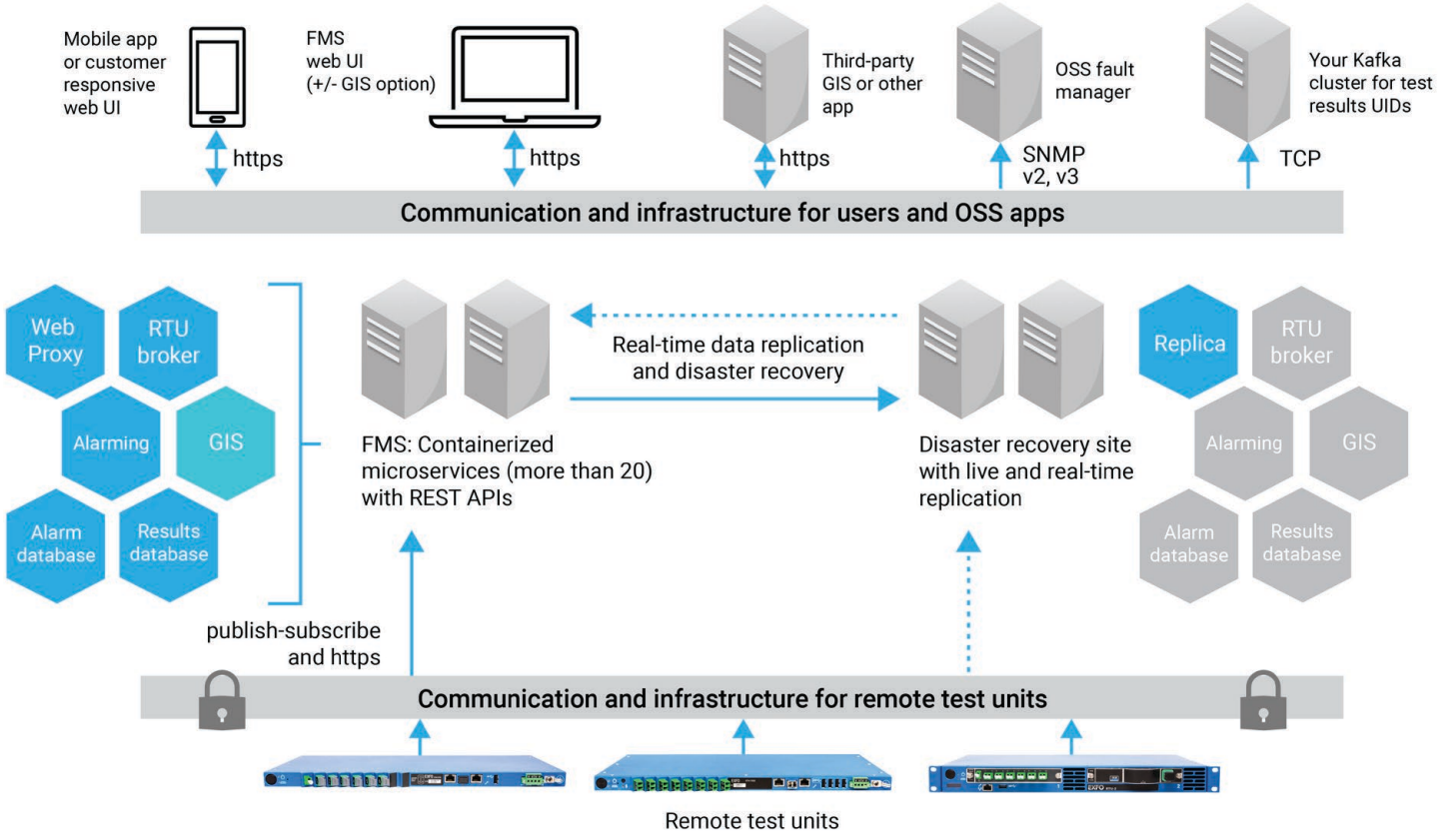


Figure 7: FMS architecture

The FMS provides numerous functions across the following areas:

- Central user and client management i.e., authentication, authorization and auditing (AAA) with connectivity to various identify providers
- Routing to the right RTU of all ad hoc and on-demand test requests; unique entry point for UIs and OSS, external app
- Result viewing (OTDR traces, tables, iOLM icon-based views, etc.)
- Test equipment registration mechanism
- Test equipment listing and status along with extractable report
- Test equipment firmware updates; massively up to 100 units per day or selectively a few units at a time
- Build and connect centralized test configuration management including pass/fail criteria
- Monitoring centralized test configuration management, including monitoring thresholds
- Alarm creation and lifecycle management based on configurable rules with reporting
- Notifications via email to domains
- Status view over network topology by region/domain/diagram
- Equipment and server health supervision with integrated dashboards
- Real-time fiber health metrics from an open-source time series interface into dashboards (see Figure 8)
- Fault mapping into an optional GIS fully integrated with the base web UI
- Back-ups, real-time database and files replication with disaster recovery capability
- SNMP notifications mapped to alarms

Figure 8: Platforms (RTU) metrics are captured in real time providing comprehensive health checks to all test units

Cybersecurity attributes

EXFO's solution goes beyond the basic and mandatory IT security measures to protect your data and your IT infrastructure. Built on cloud-native technologies, it meets the cybersecurity level required to operate in a cloud, where all clients must establish trusted (with support of certificates) and encrypted communication channels with the server(s) they are connecting to. All remote test equipment used with this solution are such clients. They always initiate the communication and request authorization to connect based on their validated identity. A phone-home architecture enables remote test units as clients to use an outbound secured connection only, which is fundamental in blocking unwanted attempts of inbound connection. Our solution supports the following key protection measures:

- Within the cloud-native FMS server application, all communication between containers is encrypted
- Token-based authentication prior to consume FMS Web APIs
- All secrets are stored in a safe vault
- Complete IAM/AAA functions including two-factor authentication, password policies, audit logs, session time-outs
- Supports external authentication by means of LDAP and Kerberos
- Customizable security banner on log-on screens
- Radius server connection add-on/option (customization required)
- IPV6 support
- Client certificate on RTU-2 and OTH-7000 (optional) is part of the registration process
- Massive change of remote test units' local administrator credentials from FMS
- Real-time streaming of audit logs from RTU to FMS

Remote test units – types and attributes

Remote test units are OTDR-based test heads. Combined with local or remote switches, they scale up for testing from a few ports to thousands. OTH-7000 and RTU-2 units (shown below) run EXFO's patented Link-Aware™ technology and are thus referred to as iOLM test units. They both support link validation from the mobile application in P2P and PON configurations.

OTH-7000

The OTH-7000 (where OTH stands for optical test head) is only ½U in rack height. Combined with an external high-density optical switching unit that is also ½U in rack height, one can provision up to 256 optical testing and/or monitoring ports in only 1U of space with fanless operation, low-power consumption and all-in-front access.

Figure 9: OTH-7000

The OTH-7000 is shipped with a standard test agent configuration, i.e., connectable through RESTful APIs to the client management tool as a multiple-port OTDR unit. Within minutes, OTDR testing capability can be added to the client software or management suite at a very competitive price compared to all the low-end OTDRs for remote troubleshooting. It can easily scale from the 4-port typical configuration (2 west and 2 east live fibers) to larger fiber nodes typically found in metro and access networks. The unit can test dark or live fibers through a high-performance OTDR and provides a dynamic range of 42 dB, meeting all core-to-access network requirements based on P2P-type links.

With EXFO's FMS as management software, the OTH-7000 can then be turned into an iOLM device for testing during or after fiber buildout and/or for monitoring. This maximizes the number of test cases supported by OTH-7000—and the return on investment.

RTU-2

The RTU-2 is a 1U-rack-size remote test unit. It is modular (two module slots) and compatible with EXFO's FTBx modules used in portable and manufacturing test applications. The unit provides fast on-board analysis and large local storage. The unit can also support up to four RTUe-9120s switches, scaling the number of test ports up to 1024. An optional junction panel is available so that all connections are available at the front of the unit (see Figure 10 with the ½U shelf underneath the RTU-2 unit).

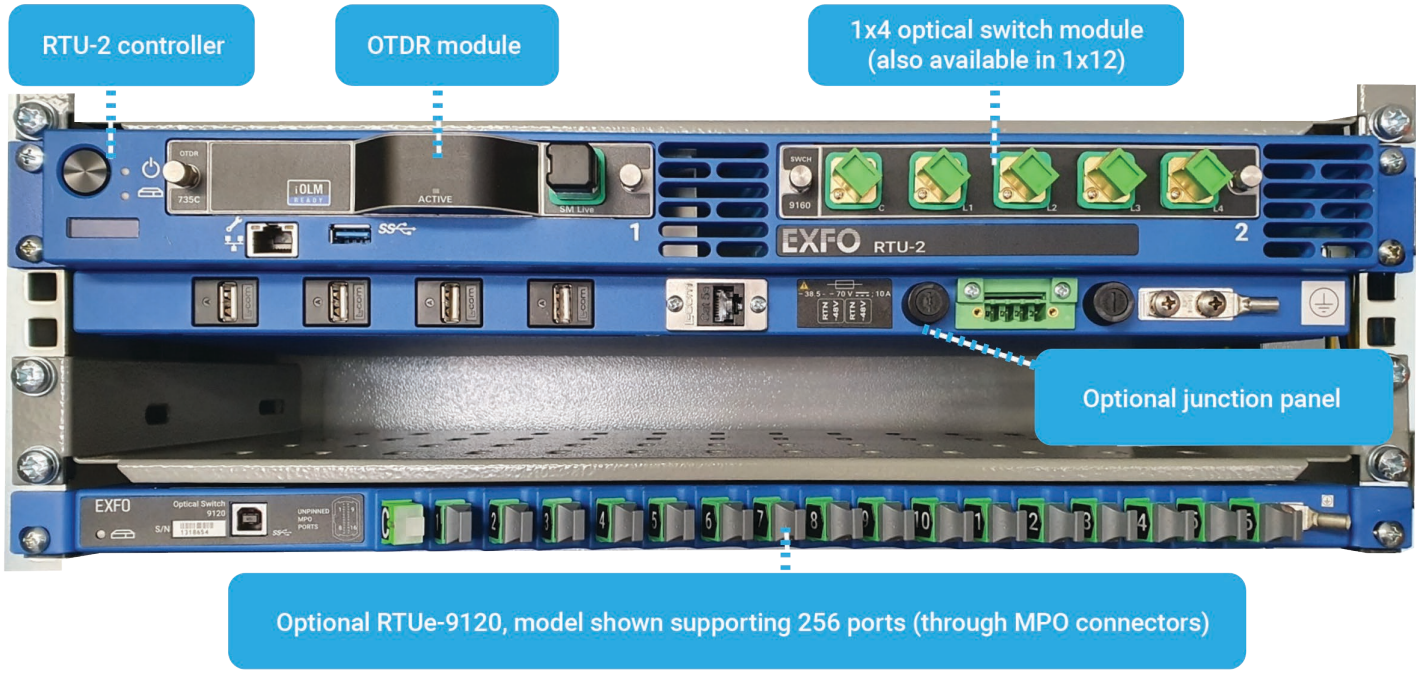


Figure 10: RTU-2 with OTDR module, first stage 1x4 switch and optional junction panel and second stage switch to support 256 ports

RTU-2 was designed to be used in large and dense central offices dedicated to FTTx applications, which typically run on PONs. This unit can conduct E2E testing in dark and live PONs using HRD filter testing. It can then monitor reflective ends that only reflect strongly at 1650 nm, the out-of-band wavelength used for the test. RTU-2 can run an E2E test on a PON with a loss of up to 30 dB in under 5 seconds (test head time utilization); typically, this means a wait time of only 10 seconds for the field technician launching the test from the mobile app.

The unit can also be connected to P2P links (either backhaul or access type) to provide both build and connect testing, as well as 24/7 monitoring.

RTUe switches

Based on reliable and cost-effective MEMS technology, the RTUe-9120 units are external optical switches for connecting an OTH-7000 or an RTU-2 to large quantity of fibers terminating in the same hub. It is low power consumption (typically 1W per unit) and very dense (up to 1x256 in ½ U). It uses MPO connectors to interface with the fiber route to be tested/monitored. Models are available in 1x32, 1x64, 1x128 and 1x256 fitting most OLT port configurations, both being based on multiples of 16. Each MPO connector (see Figure 11) based on standard MPO 24-fiber ferrule, exits 16 ports (2x8 on the middle rows) and is therefore compatible with most MPO cleaning and inspection tools[4].

Figure 11: MPO-24 port configuration with 16 fibers

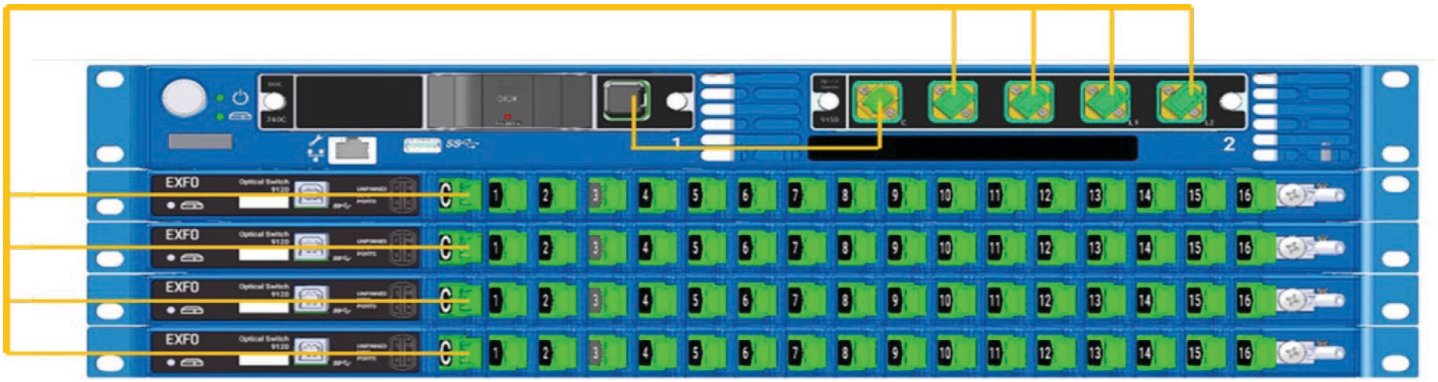
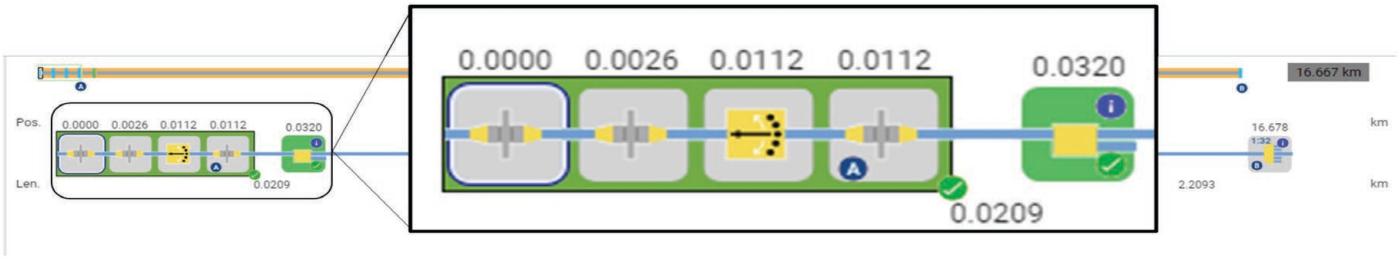


*Figure 12: Four MPO-based RTUe-9120s with 256 test ports each in ½U size for 1024 ports in 2U height.
First stage 1x4 optical switch connects to the 1x256 external optical switch. Excess loss caused by first and second level optical switching is typically 3 dB.
Each unit is powered and controlled from the RTU-2 or OTH-7000 chassis (no need for more DC circuits)*



Type	Pos./Len. (km)	Loss (dB) 1650 nm	Reflectance (dB) 1650 nm	Attenuation (dB/km) 1650 nm	Deviation Loss (dB) 1650 nm	Deviation Refl. (dB) 1650 nm
Σ	0.0000	3.214	-58.4		0.000	---
	0.0000	---	---		---	---
	0.0026	---	-58.4		---	---
	0.0112	---	---		---	---
A	0.0112	---	---		---	---

Figure 13: Thanks to iOLM's patented multipulse technology, even on a 17-km PON with high loss, last stage optical switch port on the front end is properly detected, allowing to set link start accordingly (A) at the output of the last connector, part of the injection

4 Learn more about EXFO's fully automated FIP-500 inspection scope: EXFO.com/en/FIP-500

Fiber Guardian FG-750

The Fiber Guardian FG-750 is an OTDR-based remote test unit that can be operated as an autonomous unit (i.e., not requiring an external application, such as an FMS, hosted on a server for managing the unit). FG-750 offers a local website which can be reached remotely or locally via the management port. It is easy to install, and monitoring of critical fiber assets can be started in minutes. 2U in height, FG-750 can be purchased with 8 ports and can also accommodate additional ports through optical switch cassettes (OSCs) that can be inserted onsite, allowing the unit to host up to 96 ports with the same footprint. The unit can be configured with a built-in wireless modem for SMS and email alerts directly from the unit (SIM card and wireless plan not included).

Figure 14: FG-750

In standalone mode, FG-750 can perform most of the usual tasks typically required for a classical remote fiber test system:

- Monitoring configuration including test parameters, scheduling, thresholds, etc.
- Referencing process
- Automated OTDR fault analysis
- Alerting via various channels (e.g., email, SNMP)
- Remote ad hoc OTDR testing on any port
- Access and view faults and events via embedded web UI
- Local user management
- Access to logs via UI

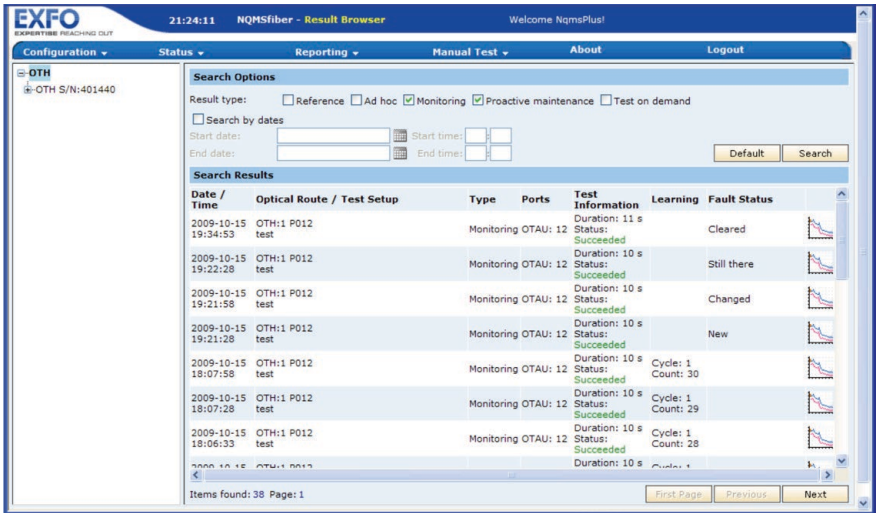


Figure 15: FG-750 GUI in standalone mode

For scalability purposes and central management, the FG-750 can also be connected to EXFO's FMS. In addition, the FG-750 can be delivered with a RESTful API for integration into client workflows or systems.

Remote switching (R-OTAUs)

When multiple lateral links must be checked one by one (while limiting the number of upstream fibers to be used to reach end points), remote switching is required. EXFO's remote fiber testing and monitoring supports those scenarios, leveraging remote optical test access units (R-OTAUs), which are standalone MEMS-based 1xN optical switches. They are installed remotely from the main remote OTDR test unit and communicate with the main OTDR or the FMS either through any available LAN/WAN connection at the edge or remote site or through optical transceiver modules. Distributing OTDR signal to various racks in same or different floors is one example of this type of double-star optical switching.

Models are available in various port count and connector types.

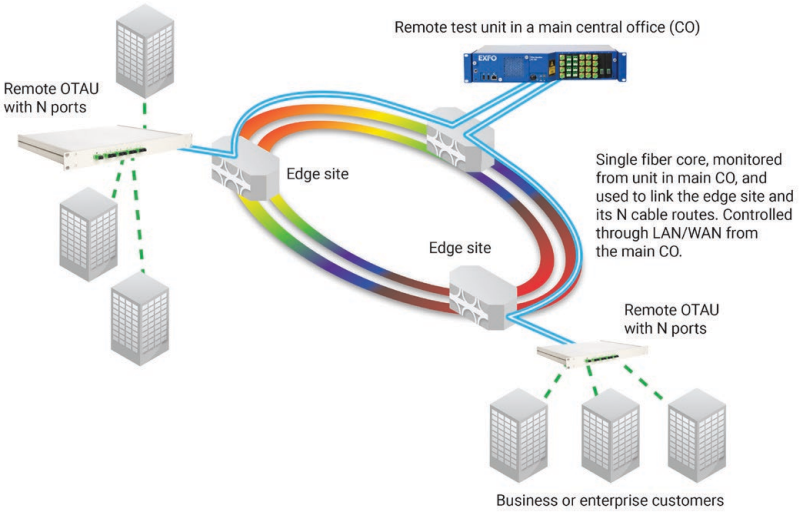


Figure 16: Use case for remote switching. A single remote test unit is used to reach multiple edge sites—each through a single fiber. At the edge site, the remote switch enables testing and monitoring of multiple links

OTAU-9150

Compatible with RTU-2 and OTH-7000, OTAU-9150 is the industry's most compact remote switch—offering up to 1x144 in ½U. OTAU-9150 can be controlled over Ethernet port or SFP port, and requires less than 1 W. OTAU-9150 can also be operated as a local switch with the test head.

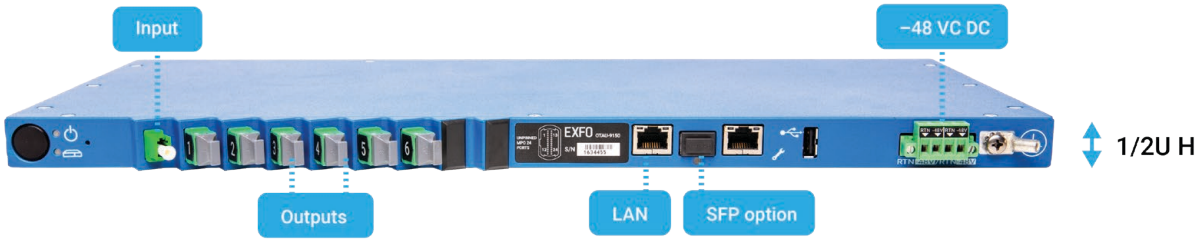


Figure 17: OTAU-9150

Operational up to 65 °C (149 °F), OTAU-9150 can be operated in street cabinets under harsh environmental conditions. With RTU-2, OTAU-9150 is ideally suited for remote OLT-based PONs; while its combination with OTH-7000 is designed to centrally test multiple batches of P2P links at various edge sites.

OTAU-9150 can be configured with LC-APC ports (1x4 or 1x16), or MPO-24 with 24 fibers per connector (1x48, 1x96 or 1x144) or MPO-24 with 16 fibers per connectors (1x64) (see Figure 18). OTAU-9150 can also come in a version combining switching and WDM (for live networks) in a dense ½U single box requesting less fiber management.

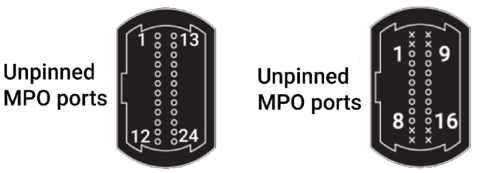


Figure 18: MPO-24 connectors with 24 fibers (left) or 16 fibers (right)

MOTAU

Compatible with FG-750, MOTAU is a MEMS-based remote optical switch offered with various port counts: 1x8 and 1x32 (1U), 1x48 and 1x72 (2U) and 1x96 (4U) with SC-APC ports.

Mobile application

Mobile application enables a single technician with a mobile phone to run a specialized or purposely built OTDR test in the form of an iOLM Optimode. From the mobile application, the field technician can first launch a fiber identification test to ensure he is on the right fiber. This function works by injecting a tone into a given route, for a predetermined time to avoid blocking other users. The tone can then be picked up by the technician in the field with a handheld instrument[5]. Thereafter, four Optimode tests are available to verify the fiber under test. Standard ad hoc iOLM test: the complete fiber link from the OTDR port to the endpoint(s) is the fiber under test (FUT). Remote iOLM test: the FUT is a specific section of the link further out from the OTDR.

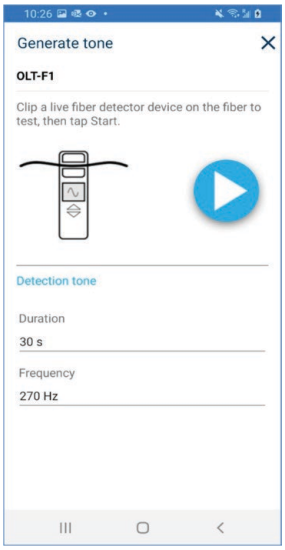


Figure 19: Tone activation for fiber identification

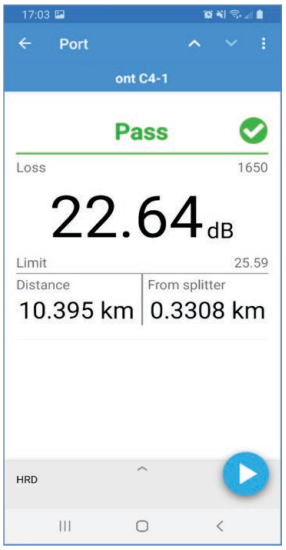


Figure 20: HRD test result on a live PON

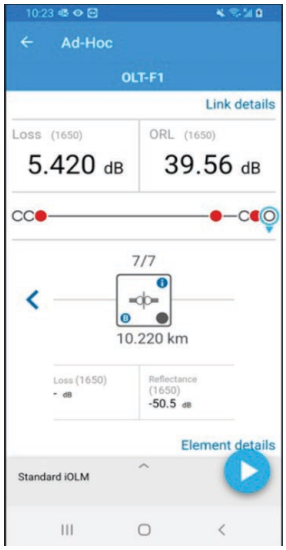


Figure 21: Standard ad hoc iOLM result

In this scenario, iOLM leverages an existing fiber infrastructure as an extended launch fiber that will then be connected on a remote fiber span. This launch fiber is calibrated to be excluded from measurement analysis and pass/fail, but still considered to optimize the test parameters according to its length and loss. The same launch fiber can be re-used multiple times to connect to N remote FUTs and characterize them.

As this application is iOLM-based, it is compatible with the RTU-2 and the OTH-7000 for both P2P and P2MP (PON) fiber topologies. Available for download on Apple and Google public stores, it connects easily and securely to your FMS application.

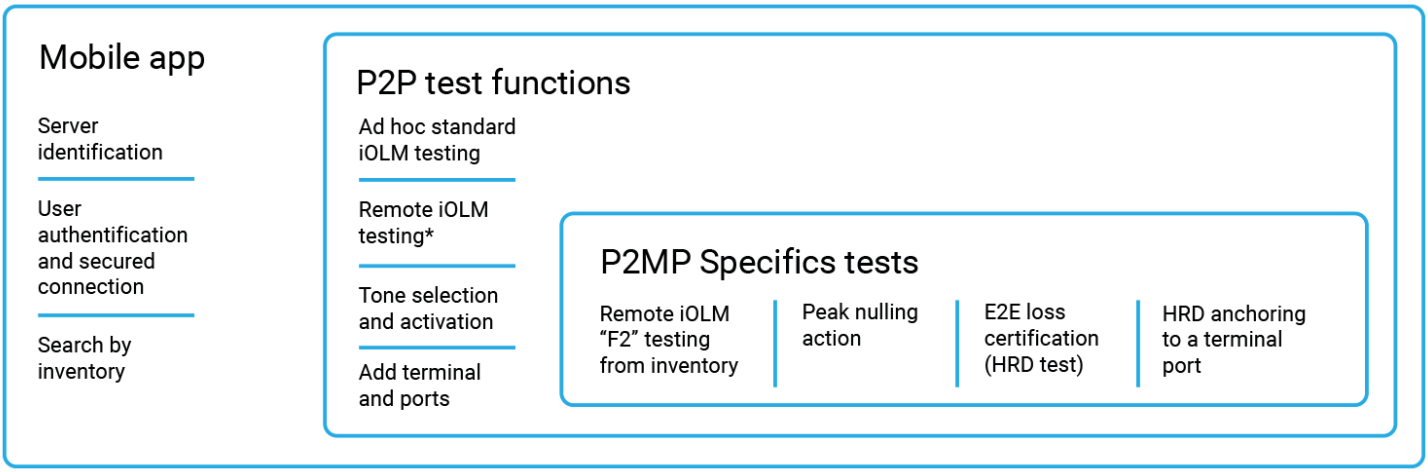


Figure 22: Summary of mobile app functions

5 A live fiber detector (LFD) can be used to identify the tone within a fiber jumper without disconnecting any fiber, or tone can be picked out of an open fiber connector with an optical power detector device (e.g., an optical fiber multimeter or an optical power meter).

Automated and simplified OTDR fault geomapping (FMS-GIS option)

The GIS (FMS-GIS) feature is a software option that provides additional container images, which when installed, enable further functions and features:

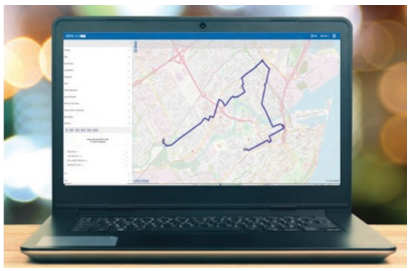


Figure 23: Import, draw and edit routes from any workstation through web browser

- Draw cable routes and interconnecting sites directly over the background map from any device on a web browser (no dedicated workstation application required) by any authorized user (Figure 23)
- Import optic cable routes in batch from georeferenced datasets (.kml and .kmz) and edit them locally as needed from a web browser
- Use background maps either from online or offline services
- View fiber fault locations at the street level
- Email notification with mapping information
- Support diagrams to scale from monitoring few critical sites to countrywide topologies. A diagram regroups a customer-defined batch of monitored optical routes together (e.g., a specific region) to allow users to focus only on routes relevant to their needs and navigate from one to another. Optical routes of diagrams can be automatically organized into schematic topological views: Radial view, Organic view, Orthogonal view (Figure 24)

Within seconds, FMS-GIS automatically converts optical length fault measurement into a physical location on a network map. The software is a web application that integrates background maps (from internal or public clouds), which makes the drawing and setup of new fiber routes easier and smarter. The option works with all EXFO remote test units (i.e., FG-750, RTU-2 and OTH-7000).

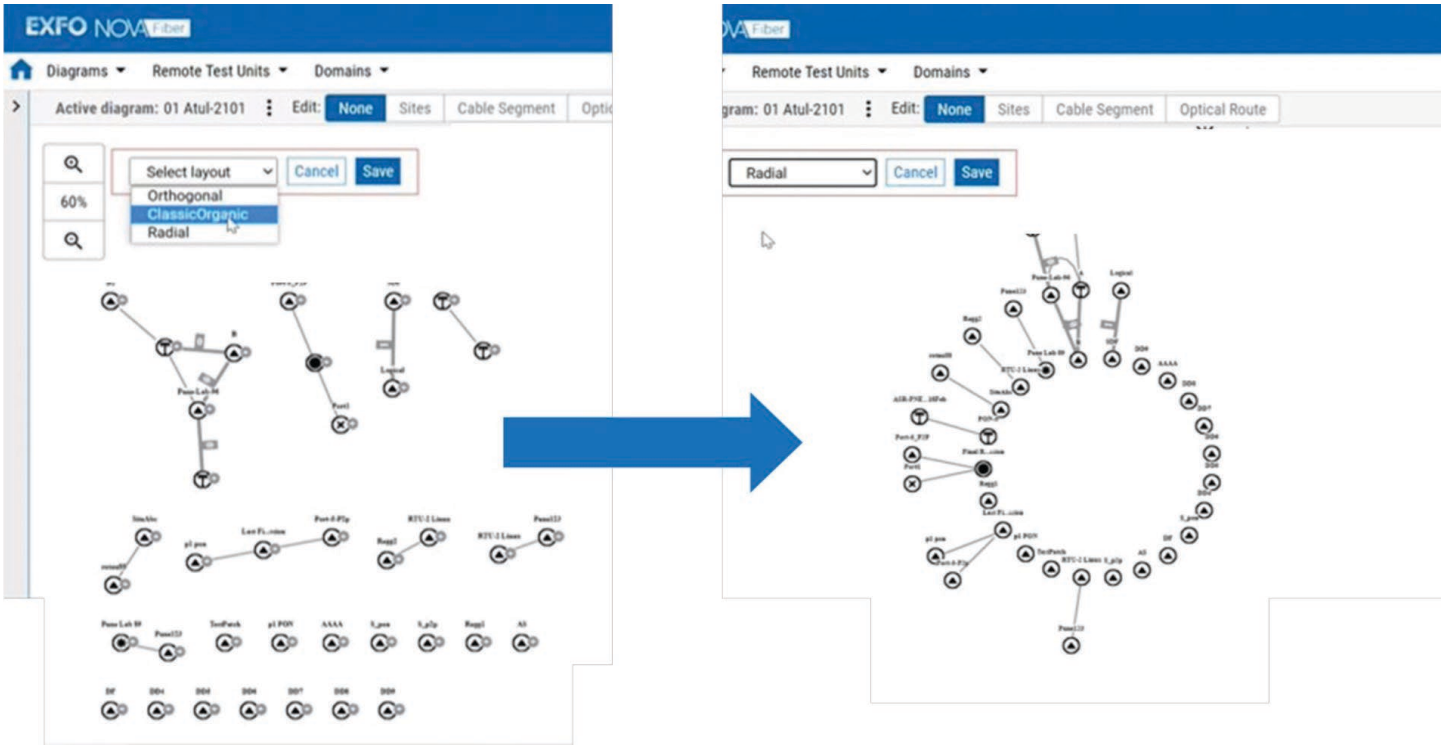


Figure 24: Organizing elements of a diagram in radial view within a single action

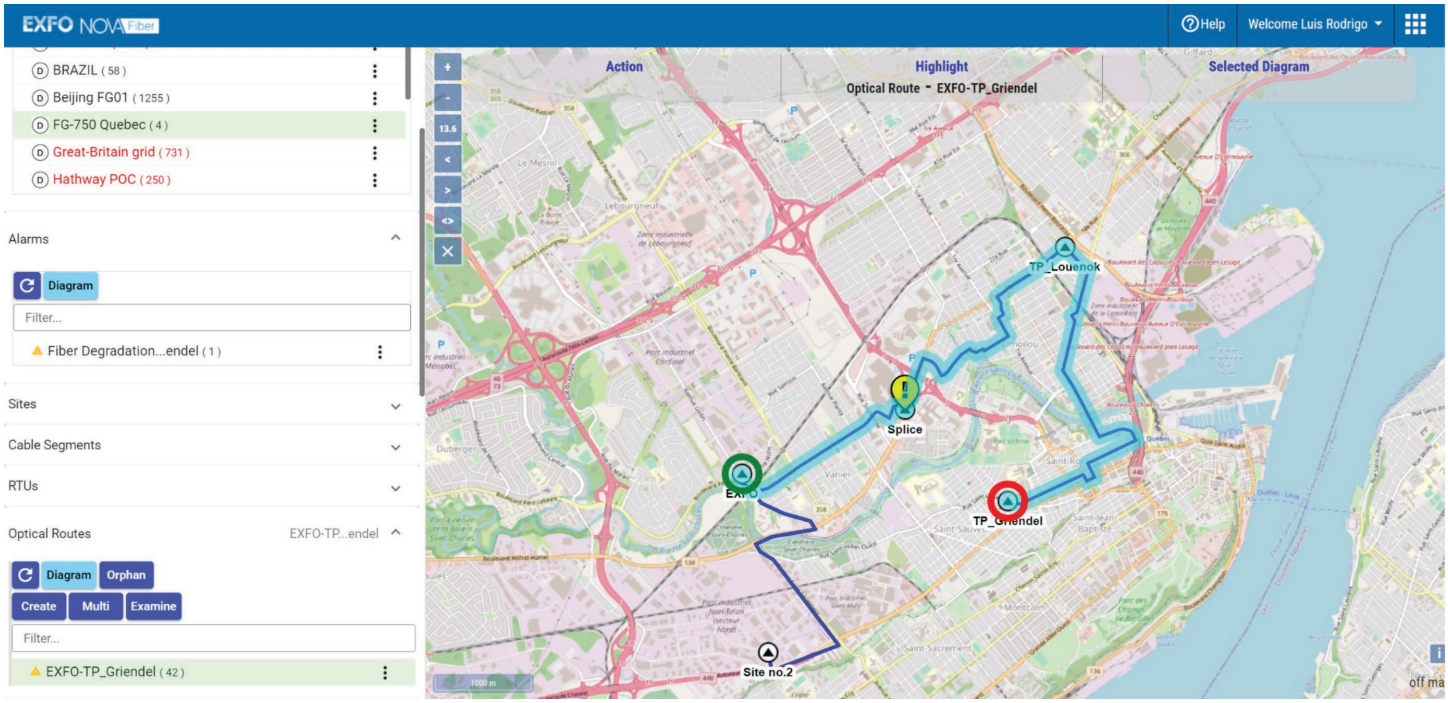


Figure 25: FMS-GIS view showing optical path (highlighted in blue) with start point (green circle) and end point (red circle) as well as fault alarm (exclamation mark)

FMS-GIS view displays fiber faults using an intuitive color scheme based on alarm severity: minor (yellow), major (orange) and critical (red).

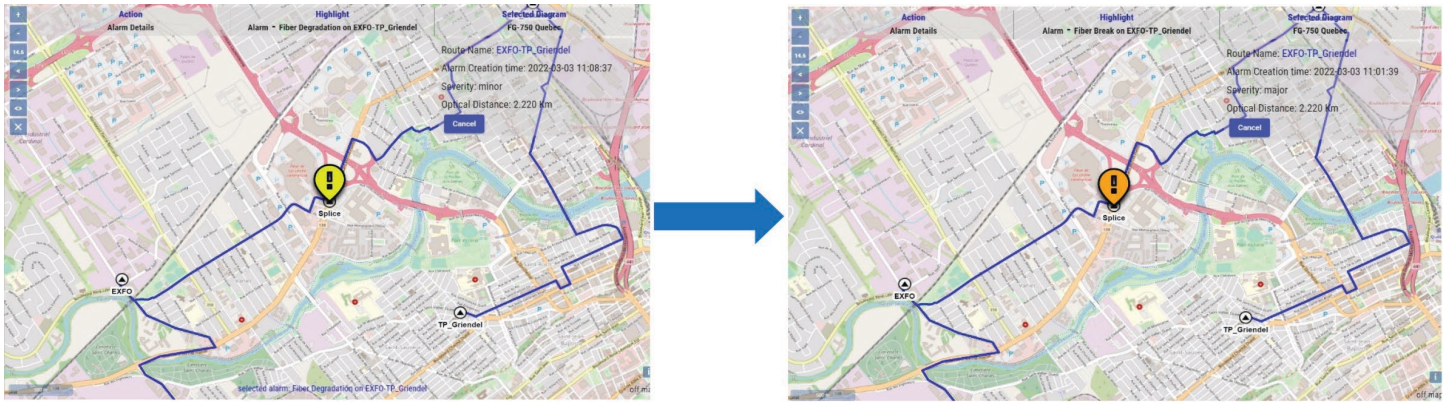


Figure 26: Icons change color to show changes in status (minor alarm on left and major alarm on right)

Entry and maintenance of optical fiber GIS documentation

Within FMS-GIS, the user can easily draw cable route segments and position connectivity infrastructure (e.g., cross connect site, splice enclosures) on the map. Users can then correlate optical event information from an OTDR result with the geographical position of all these locations. For enhanced fault mapping accuracy, users can document slack loops to further improve the physical to optical correlation and obtain better fault accuracy on lines that have long looping.

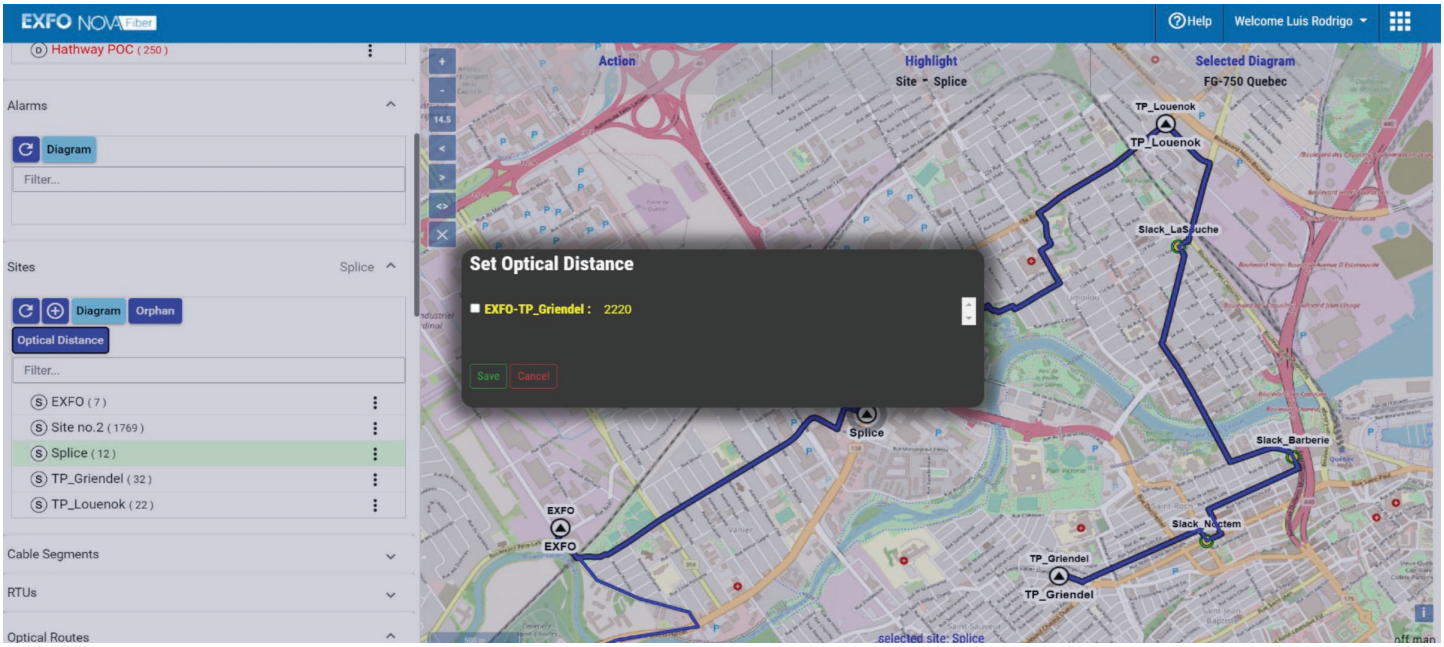


Figure 27: Setting optical distance to a physical site or location

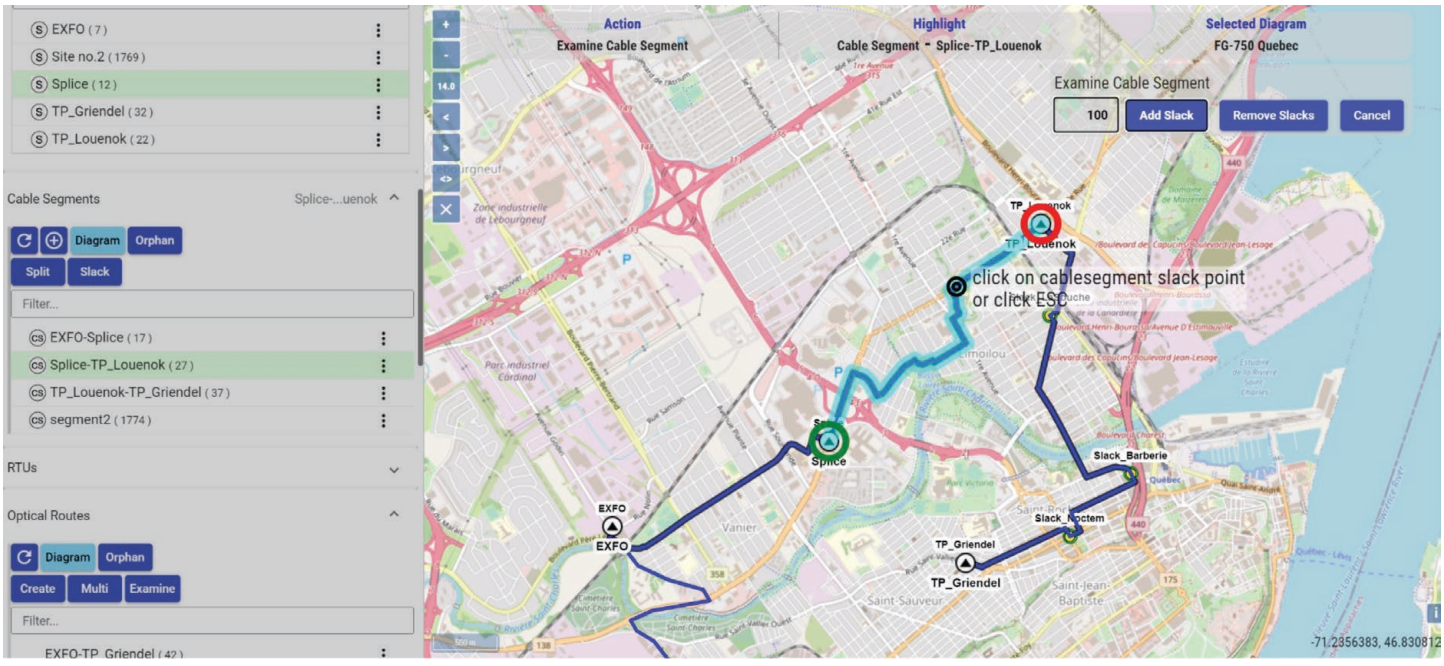


Figure 28: Adding slacks capability

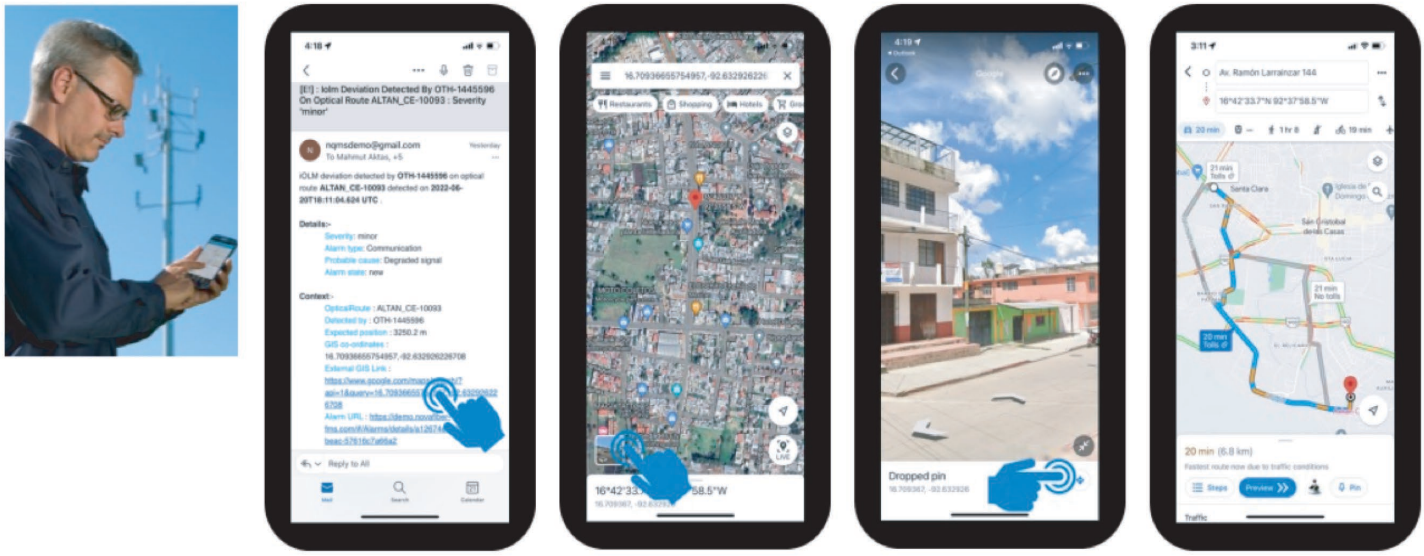
KML import

By uploading KML or KMZ files, FMS-GIS can automatically import object types such as lines and points. Those objects can then be turned into cable spans and sites in a few clicks. FMS-GIS includes editing tools as part of the KML import such as:

- Adding nodes
- Collapsing multiple nodes
- Splitting cables
- and more

Email notification with fault coordinates and callback URLs

The FMS triggers alarms whenever a fault occurs. Along with the GIS add-on, the notification includes GPS coordinates of the fault, as well as a Google Map link to open the location in your browser or from a smartphone:



Email notification with a Google Maps™ links to the point of failure

Visualization of the point of failure within Google Maps™ mobile app

Street view of the point of failure within Google Maps™ mobile app

Drive to fault directions within Google Maps™ mobile app

Figure 30: From email notification to drive-to-fault directions

The email also contains a URL to access alarm details from the FMS web UI. Alarm details include important information such as:

- Fault coordinates
- OTDR trace(s)—reference and current
- OTDR table of events

Online and offline maps

FMS-GIS uses open-source maps, such as Open Street Maps (OSM), as background maps. Additionally, some offline maps are available to be used along with FMS-GIS when internet connectivity is a security issue, or if not available. In those cases, FMS-GIS can still use offline maps as background (contact your EXFO representative for more details).

Supported scenarios for fault-on-map function

The FMS can natively provide the web-based GIS function including cable path edition and automation in mapping OTDR or iOLM faults. Some operators prefer to maintain a single source and update their fiber-optic network documentation only in one place; this is why EXFO has developed various integration schemes depending on customer requirements and budget, from event-based posting to a server that can consume and process the various alarms issued to a more complete client-server integration (RESTful based) where few services are typically needed and exposed to FMS software so that various integrated workflows are enabled:

- Physical to logical linkage, i.e., obtain from your inventory a list of the paths or routes UIDs to which the remote test unit will be physically connected
- Automatic OTDR length tracing from your own GIS, i.e., upon new alarm being opened with above UID, query the external GIS service for geo-tracing of the fault in response
- FMS to create alerts (email, SNMP notifications) with the information provided by the external GIS so that similar information can be available whether the GIS is external or not
- Additional workflows are possible such as enabling testing from your inventory/GIS software (contact your EXFO representative for more details)

EXFO supports integration with various third-party fiber network inventory systems and has successfully deployed multiple integration projects over the last decade.

Test access module kits and FWDMs for testing on live fibers

When testing on a live fiber link, the OTDR signals needs to be injected with live traffic and then extracted on its way back. For that, the OTDR uses an out-of-band wavelength which is multiplexed with the traffic wavelength(s).

The multiplexing, as seen in Figure 31, is handled by a test access module kit (TAMK), offered in ½U or 1U full-wide rack units. Typical out-of-band wavelength(s) used for OTDR in this implementation are 1610 nm, 1625 nm or 1650 nm (depending on applications). EXFO's remote fiber testing and monitoring offers a wide variety of configurations from single path WDM with SC/FC connectors to 128 WDMs in a 1U rack space. The 1U TAMKs use a mix of LC connectors and MPO 24f ferrules where 16 or 24 ports can be quickly connected to EXFO's RTUe-9120 and OTAU-9150 optical switch units and to line (Tx/Rx or OLT) as illustrated in Figure 32.

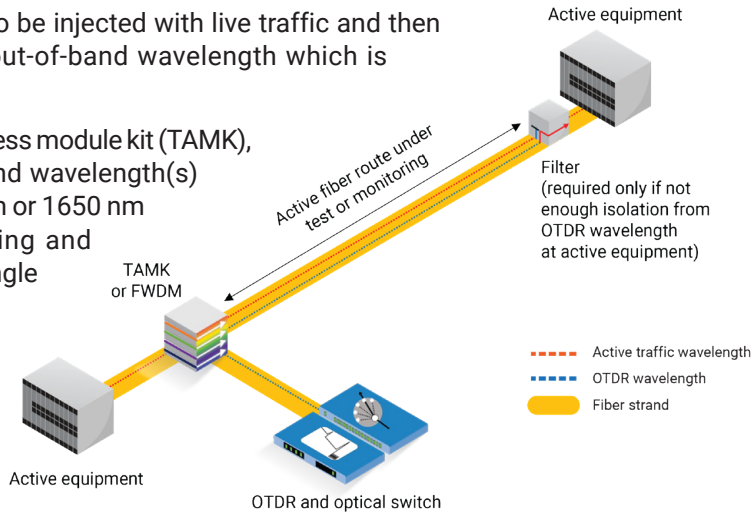


Figure 31: Use of a test access module kit and a blocking filter on a P2P schematic example

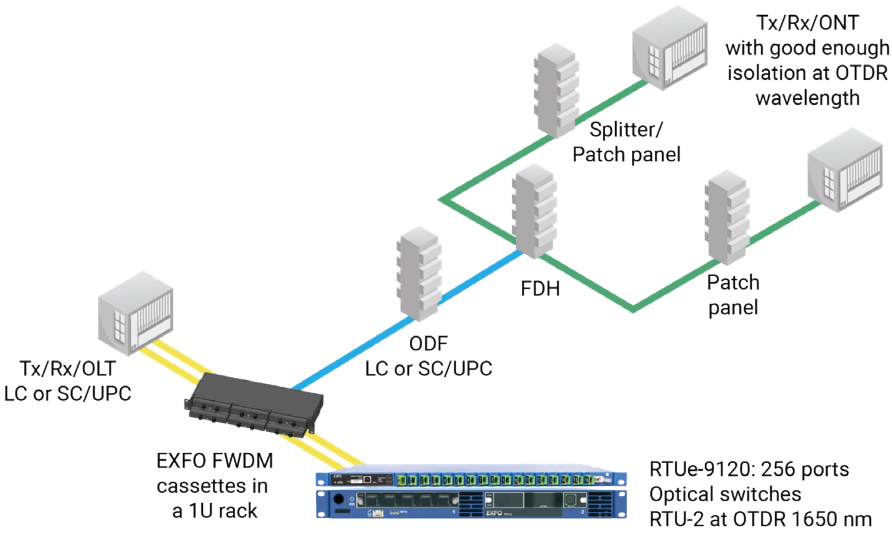


Figure 32: P2MP (PON) example

Optical transport equipment from network equipment manufacturers (NEMs) now often integrate an OTDR port; although great in theory, these ports have to let the entire OTDR emitting power pass through and must present high-enough directivity, low reflectance (APC recommended) and enough isolation so that the return loss from the fiber and connectors hit by a strong OTDR signal are filtered out by the WDMs before they could reach a receiver. In comparison, EXFO WDMs typically provide:

- Low loss for traffic and OTDR—less than 0.8 dB for the device itself
- Isolation larger than 30 dB on the line port at the OTDR wavelength
- Directivity larger than 50 dB
- Various cut-off wavelengths between traffic and OTDR to ensure specifications are optimized for the application

Test access module kit (TAMK)

A TAMK is ½U or 1U full-size rack, in typical configurations of 12, 24, 32, 48, 64, 96 and 128 WDMs. Low-density units are ideal for use with FG-750 or OTH-7000 equipped with more than 12 ports while denser units such as 48, 64 and above are preferred for use with RTU-2 or OTH-7000 combined with RTUe-9120s. Different types are available upon request with volume pricing available.

Figure 33: TAMK-NS3209: 1/2U, 64 WDMs all in front

Low-density units are ideal for use with FG-750 equipped with more than 12 ports while denser units such as 48, 64 and above are preferred for use with RTU-2/RTUe-9120s. Different types are available upon request with volume pricing available.

Models:

- TAMK-WDM-GA-24-XX: 1U, 24 WDMs SC-APC for line and common (front) with 3-m pigtails (different connectors) for the OTDR (rear)
- TAMK-WDM-GA-48-MPOC-104: 1U, 48 WDMs LC-APC for line and common (front) with MPO -24/16f (3) for OTDR (rear)
- TAMK-NS3089: 1U, 128 WDMs LC-APC common ports (front) with MPO -24/16f (8) for OTDR and MPO -24/16f (8) for line (rear)
- TAMK-NS3209: 1/2U, 64 WDMs all in front. LC-APC ports for common, MPO-24/16f (4) ports for line and 1.5m pigtails MPO-24/16f (4) terminated for OTDR

FWDM: Single fiber

LGX compatible modules and rack-mounting kits are also available and are ideal for the 2- and 4-fiber configurations that need to be connected to testing and monitoring equipment. In these models, the front SC or FC connectors are removable from the front, giving access to the ferrule for ease of inspection and safe cleaning.

Models:

- FWDM-234: regular 1310-1550 nm with 1625 nm for the OTDR
- FWDM-NS2065: 1310-1550 nm with 1650 nm for the OTDR

Figure 34: FWDM

FWDM: Bypass assembly – single path

To enable the OTDR signal to bypass or jump over an active equipment (e.g., a traffic re-gen) or an optical add-drop multiplexer (OADM) site, EXFO offers a similar FWDM configuration but with the monitor ports of two WDMs spliced together so that it bypasses a transmission gear, an amplification equipment, or an OADM with minimal loss added to the link.

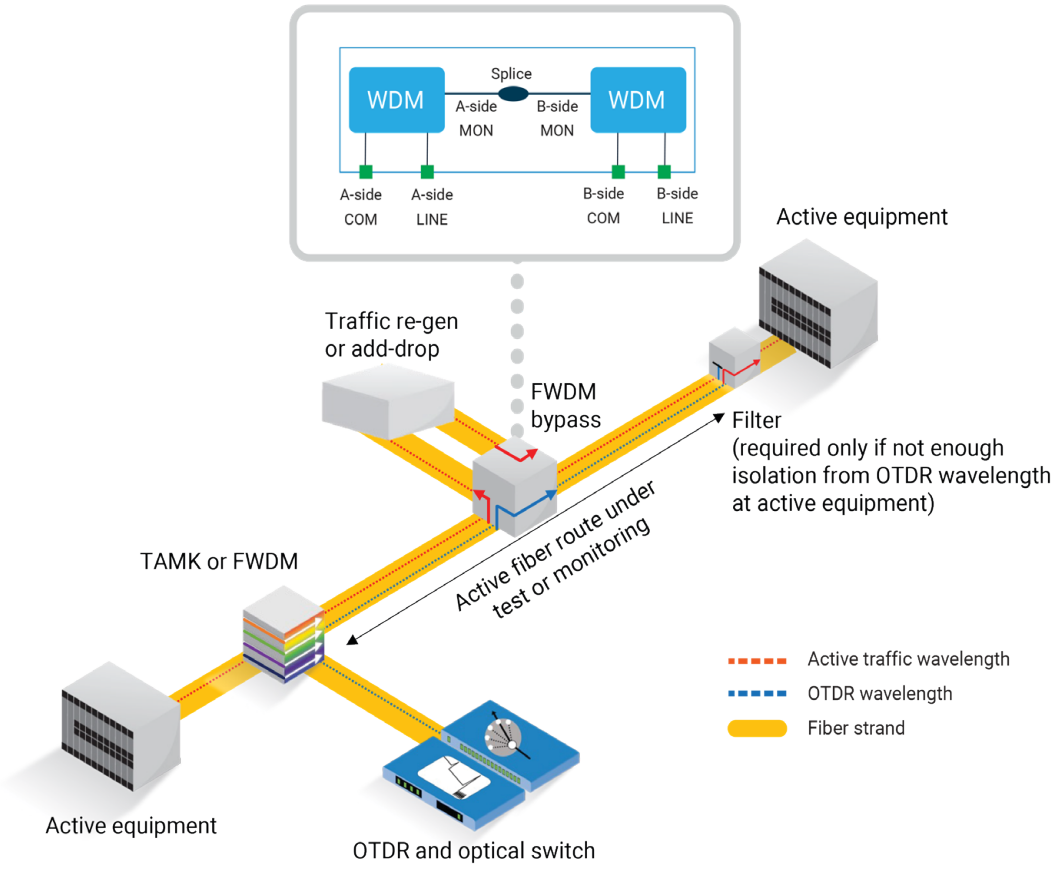


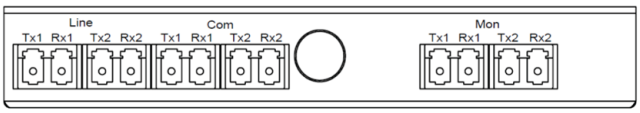
Figure 35: Schematic example using an FWDM bypass to monitor a fiber route including traffic regen or add/drop module

Model: FWDM-NS1734

Low-density FWDM cassettes

Ideal companion for OTH-7000, for EAST-WEST TX/RX live fiber monitoring

- FWDM-NS3191 -1/2 U cassette, all ports in front. 4 WDMs for the monitoring of up to 4 live fibers. 2x duplex LC/UPC connector for 'Line' ports, 2x duplex LC/UPC connector for 'Common' ports, 2x duplex LC/UPC connector for 'Monitor' ports.
- RMK-NS3115: 1/2U holder module hosting up to 3x FWDM cassettes.



High-density FWDM cassettes

MPO 24f APC ferrules are used to terminate more fiber ports into high-density fiber racks. These cassettes can replace single-fiber connector patch panels already used to link up OLTs to ODFs, while offering an OTDR test access without a larger footprint.

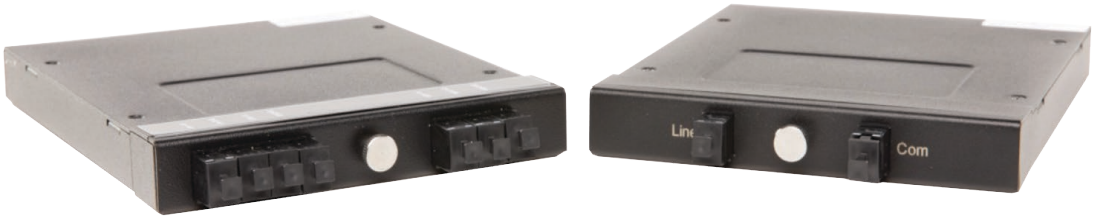


Figure 36: MPO-based high-density FWDMs

Models:

- FWDM-NS2919: 48 WDMs, all in front MPOs, maximum 288 WDMs per 1U in scaling steps of 48x
- FWDM-NS2944: 16 WDMs, front/rear MPOs, maximum 96 WDMs per 1U in scaling steps of 16x
- Rack-NS2919: 1U size, 6-slot chassis for holding up to six (6) high-density FWDMs

Other passives

- Rejection filters for P2P fibers in jumpers or bulkhead adapters
- WDM in small and ruggedized package with various jumper lengths and connector types
- HRD devices to be used as 1650-nm reflectors for FTTH/PON testing and monitoring applications (HRD devices are available in various formats and pricing depending on volume)
- Bulkhead adapter for insertion onto an existing infrastructure such as at the ONT port or an inside an existing jack
- Pigtails for splicing into a jack or at any of the terminals
- Multiport terminal (MPT) termination depending on manufacturer (contact your EXFO representative for more details)

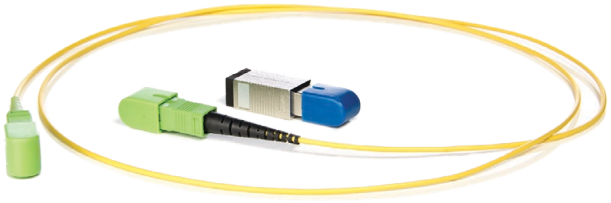


Figure 37: Example of HRD in a test jumper and in a bulkhead adapter

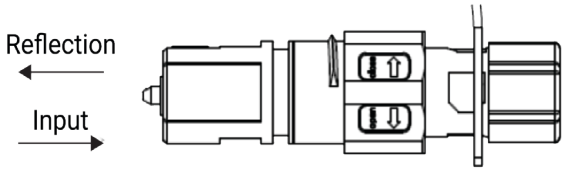


Figure 38: single turn quick-connect terminated HRD for Corning's OptiTap® MPTs

FMS software and minimum requirements

EXFO's FMS can be installed on virtual machines (VMs) or bare metal Linux hosts. Linux operating systems supported are as follows:

- Ubuntu 18.04 or 20.4
- RedHat Enterprise 7.x, 8.x
- CentOS 7.x
- Oracle Enterprise Linux (OEL) 7.x

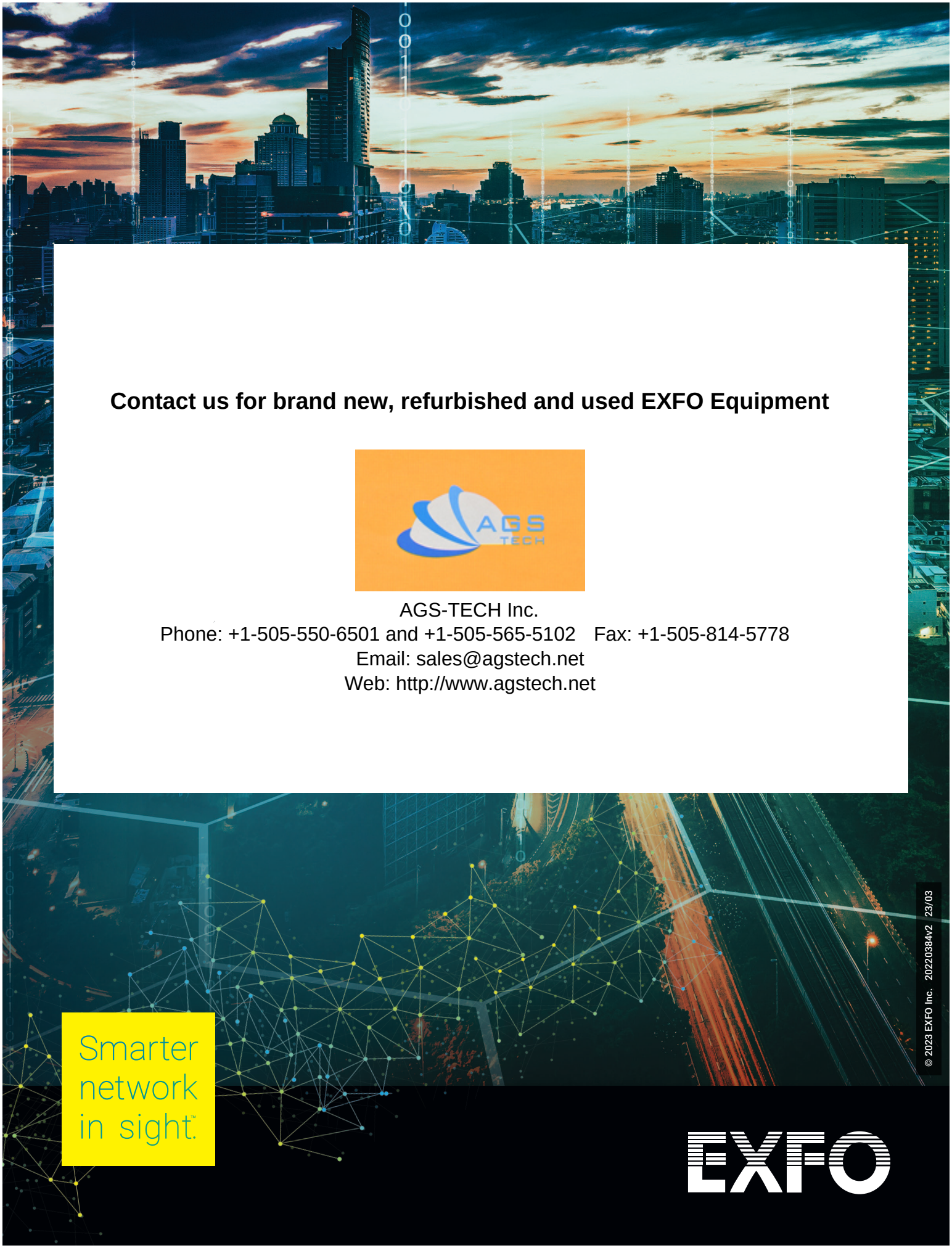
Minimum FMS operating requirements for a small number of connected remote test units:

- 4-core CPU, with SSE4.2 support. SSE4.2 is supported on Intel Core i7 (Nehalem), Intel Atom (Silvermont core), AMD Bulldozer, AMD Jaguar or later processors
- RAM: 24 GB
- Disk space: 500 GB

The solution architecture allows for horizontal scaling by adding more nodes to cope with additional units and users, thus ensuring that performance will not be impacted as the system expands. Typically, a single node (with adequate resources) will be able to cope with a few hundred remote test units, while 500 or more will typically require dual-node cluster.

Additional resources may have to be planned for proper sizing (contact your EXFO representative for more details):

- SSD-type storage media for larger systems
- Daily backup-related storage space
- Extra server for data replication (replica server)
- Storage for daily back-ups from replica server
- Disaster recovery site option with replication
- NFS for multi-node cluster storage, ideally external to the application cluster



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