SXM Dashboard

User Guide

Version 1.7

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Preface

The intended audience, document organization, and conventions used herein are described. Related documentation is identified, as are instructions for accessing other electronic product documentation.

Audience

This document is intended for technical users who have a basic level of understanding, familiarity and experience with spectrum monitoring and mobile network usage.

Conventions

The following conventions are used in this document.

Convention	Description
Grayed-out Font	Indicates a command or a feature is not available in the current release.
Courier Font	Illustrates an example command or a concept.
Light Blue Font	A clickable hyperlink to a referenced source.
Normal Bold Font	A concept or idea important enough that the reader's attention is being explicitly focused.
Red Font	Additional information for the topic.

Note: This symbol means **take note**. Notes contain helpful suggestions or references for additional information and material.

Caution: This symbol means **be careful**. In this situation, you might do something that could result in loss of settings, data or unintended data behaviour.

Obtaining Latest Documentation and Software

The latest version of this document is available on the Dashboard (sxm.thinkrf.com), in the Help page.

Please visit https://support.thinkrf.com/support/solutions to obtain any other latest product documentation, software and firmware releases where applicable.

Document Feedback

Please send any comments regarding thinkRF documentation to SXMfeedback@thinkrf.com. We appreciate your feedback.

Product Feedback

thinkRF's SXM is constantly evolving to better serve your needs, with new features and enhancements deployed to your network and this dashboard regularly. Submit your input to SXMfeedback@thinkrf.com or use the Dashboard's Feedback box in the Help page.

Obtaining Technical Assistance

For all customers who hold a valid end-user license, thinkRF provides technical assistance 9 AM to 5 PM Eastern Time, Monday to Friday. Contact us at https://support.thinkrf.com/ or by calling **+1.613.271.5451**.

Before contacting support, please have the following information available:

- The operating system and version you are using.
- The browser and its version.
- The Node ID of the specific SXM node you are having issues with if the issues are specific to that node.
- If reporting an issue on the dashboard, please provide a screen shot, with the date range and filter options where applicable, would help us to reproduce the issue easier.

SXM Solution and Dashboard Overview

thinkRF's Spectrum eXperience Management (SXM) solution is a revolutionary real-time wireless network monitoring and intelligence platform, providing analytics and insights at the users' fingertips. In the rapidly changing and evolving landscape of telecommunications with spectrum resource scarcity, SXM solution empowers wireless network operators and national regulatory agencies to characterize, optimize, manage, and protect RF spectrum assets efficiently and conveniently.

The SXM solution comes with a distributed network of powerful thinkRF IoT sensors (aka nodes), which operate 24/7 continuously and autonomously to perform spectrum analysis and send data to the SXM Cloud. The data can then be consumed by the users via SXM API for users' own application or with SXM Dashboard described in this document. The SXM Cloud service will store up to 2 years of data collected from the nodes; the Dashboard will allow users to view the data for up to 1 year of that time frame. Furthermore, the nodes and collected data are segregated by customer accounts; thus, there is no access of collected data across Account and User Access privileges, maintaining privacy and data integrity for the users.

The solution architecture overview is illustrated in the following picture.
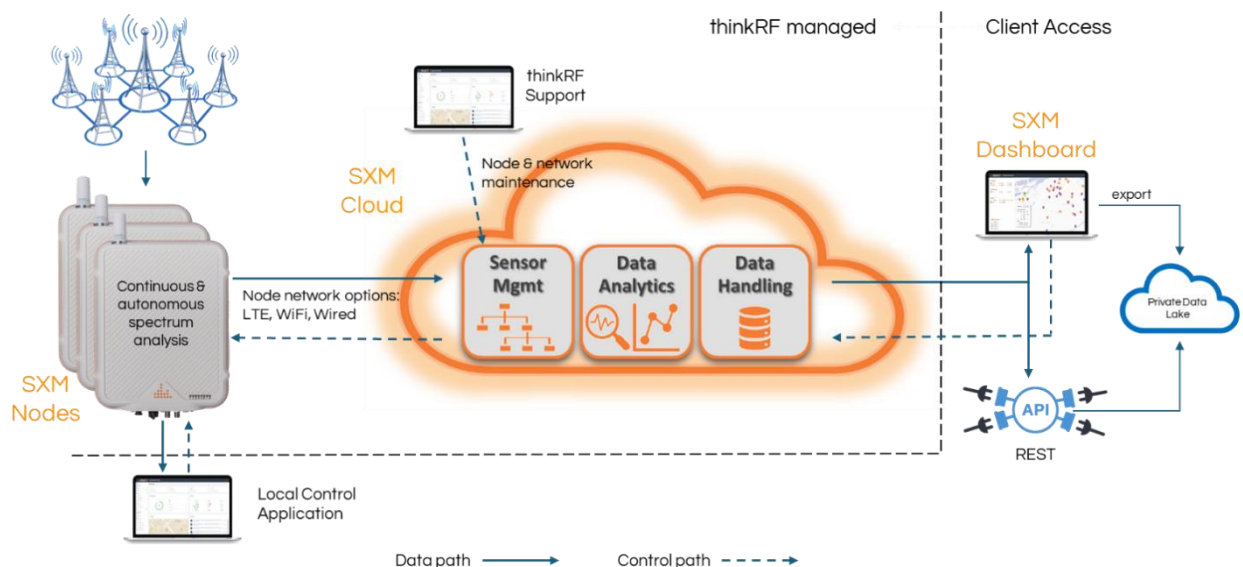
SXM Dashboard (refers to as Dashboard hence forth), hence, is the window to your SXM system from your desktop or tablet. The Dashboard takes cloud data gathered from the nodes, combined with advanced analytics, and presents the data in easy-to-understand insights, metrics, graphs, and summaries.

Furthermore, users can visually explore locations of SXM nodes and base stations via an integrated map feature within the dashboard interface. Settings throughout the dashboard will persist for the next login to maintain seamless experience.

Dashboard GUI

The Dashboard GUI makes use of modern web technologies to provide easy, intuitive, and user-friendly usage. It consists of the main features (applications) or modules navigation bar on the left

side and the content display window on the right, as shown in the following figure. For each featured application dashboard, there may be additional controls to the far-right side.
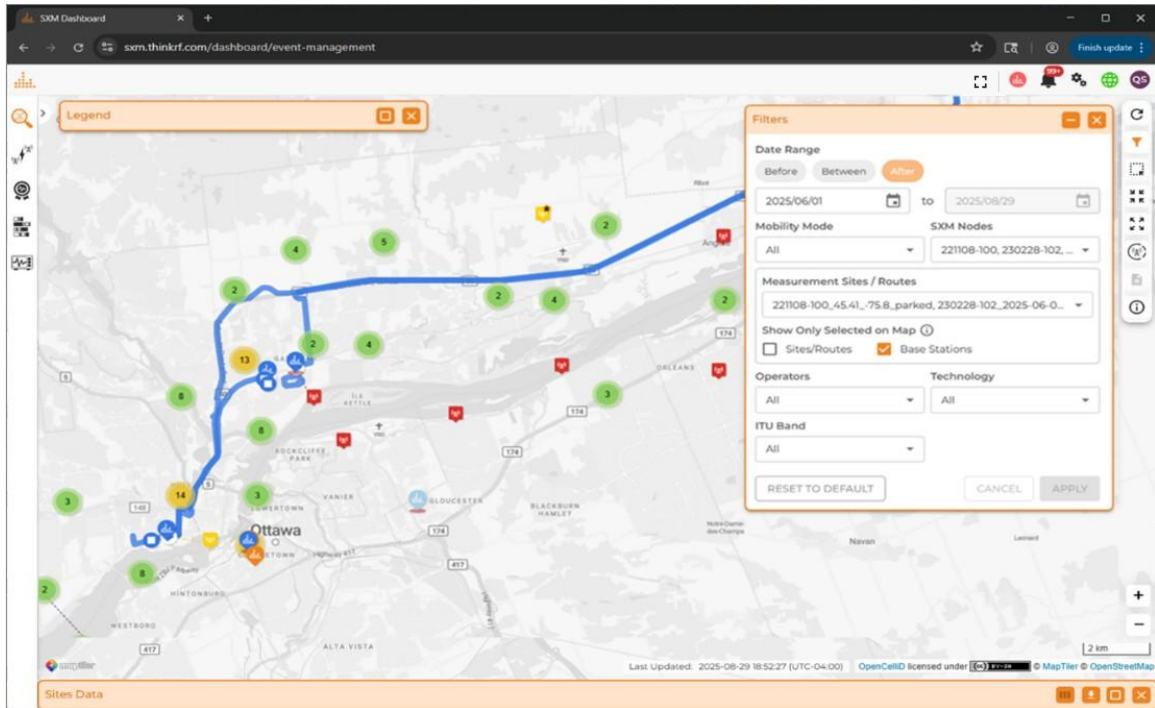
Note: The Dashboard is highly interactive, using mouse over any plotted items to see available hover-text information or additional actions.

Refer to Navigating the Dashboard for more information.

Dashboard Overview

There are three main areas of the SXM Dashboard:

- **Home Page** – this is where a summary of subscribed SXM nodes and data can be found.
- **Applications** – Each Dashboard Application provides different analyses and insights into data collected by SXM nodes. Each application requires an SXM subscription to be accessible.

Important Notes: By default, SXM subscription includes the 3GPP Network Analytics application. To subscribe to additional Applications mentioned in this document, contact your SXM Dashboard business account manager or thinkRF if you are not sure who your account manager is.

- **Administrative** – Information about the user, changing preferences, configuring SXM nodes and administrating other user accounts (depending upon privileges) can be found here.

Getting Started

To use the Dashboard, you must have a valid account first, whether provided by thinkRF or by your corporate account's administrator.

System Requirements

Before accessing and using the SXM Dashboard, please ensure that your system meets the following requirements:

Web Browser Compatibility

SXM Dashboard is compatible with the latest versions of the following web browsers:

1. Google Chrome
2. Mozilla Firefox
3. Apple Safari

For optimal performance and security, ensure that your web browser is regularly updated to the latest version. In addition, ensure the screen size of your device is large enough to easily manage the panels and tables.

Internet Connection

A stable internet connection is required to access the SXM Dashboard. The recommended minimum speed is 1 Mbps for optimal performance.

Accessing the Web Application

- Open your preferred web browser.
- In the address bar, enter the following URL: sxm.thinkrf.com.
- Press Enter to navigate to the login page of the SXM Portal.

Logging In
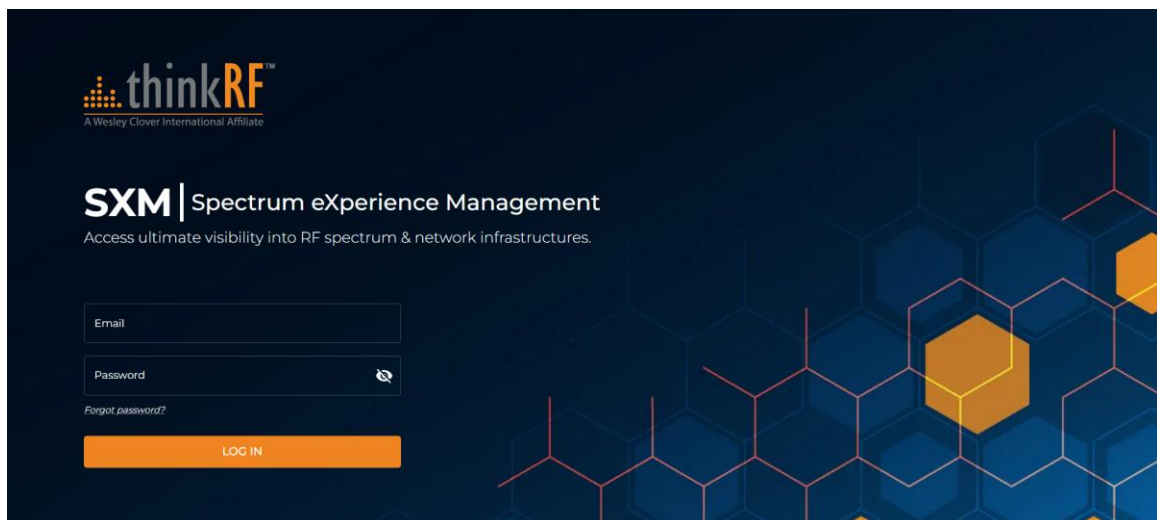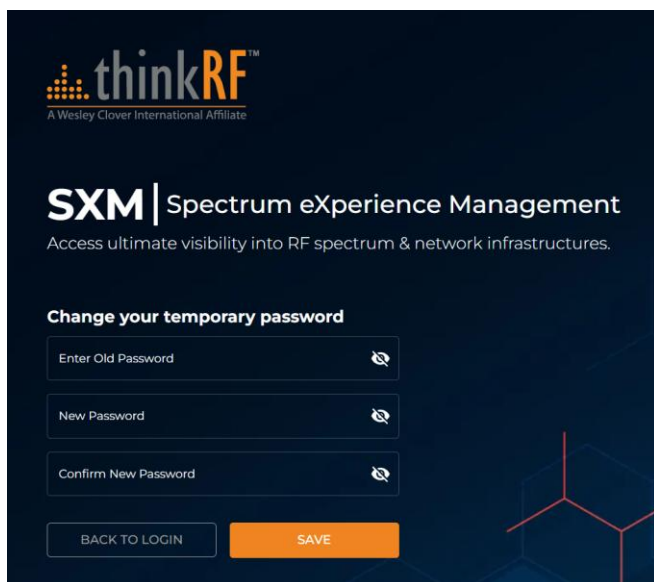
On the login page, enter your credentials:

- **Email** – Your assigned email address.

- **Password** – Your password is associated with your email. Please ensure the accuracy of the characters entered, as passwords are case-sensitive.
  If you have forgotten your password or need a password reset, use the "Forgot password?" option.

Set a New Password

If it is your first time logging in after your administrator provided your temporary password, you will be taken to a page to change your temporary password.

You will be asked to input your temporary password, followed by your new password. Please ensure your password meets the following requirements:

- Minimum 8 characters long
- At least one uppercase letter
- At least one lowercase letter
- At least one number
- At least one special character

If the password requirements above are not met, an error message will be shown.

Navigating the Dashboard

The SXM Dashboard is designed with the users' ease of use and intuitiveness in mind, where the placements of components and functionalities are consistent throughout the whole application.

As shown in the following picture, to the left of the Dashboard are buttons for accessing features on the dashboard (the Navigation Panel). Each selected view when opened will have the content display window on the right (Display Window). Additional control components will be available either to the right or open within the panel itself (Display Controls).
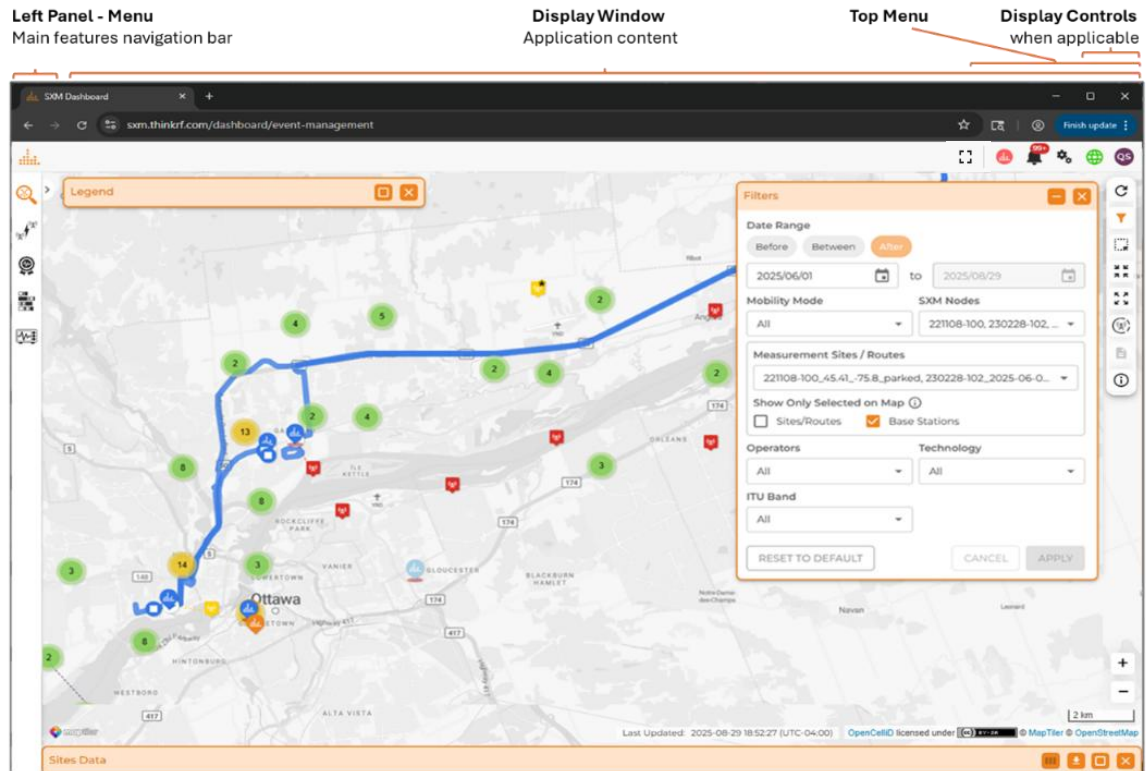
Cursor Actions

When using the dashboard, the mouse cursor might change its shape to provide visual cues or might lead to additional info being displayed depending on which elements it interacts with, as explained in the following Table.

Symbol / Action	Description
Hovering	When hovering the mouse cursor over any of the graphical displays or icons, a small textbox appears under the cursor displaying the values or an information panel will show.
🖐 Grab	The hand symbol means the element can be grabbed and moved. An additional action might occur as a result of the moving.
✥ Move	The move symbol is an indication that this element can be moved.

Symbol / Action	Description
🖑 Clickable	The pointing hand symbol implies that element is "clickable" and might result in additional action when clicked.
↖ Mouse baseline	The arrow symbol indicates that the corresponding area is not "clickable" or no action has resulted.
+ Draw	The crosshair cursor is used for drawing a box for selection of elements within that box, such as the SXM Nodes on the map.

Dashboard Settings

Settings of each dashboard application, where applicable, are automatically saved so that when the users next log-in, they will continue with the same settings for that application. The saved settings behavior is applied to the maps, tables, filters, when applicable.

Note: For the main display map, if the applications utilizing the same nodes and goals (such as 3GPP Network Analytics and License Bands Utilization applications), the map, selected nodes/sites, and the Filter's date range will persist between these two applications.

Navigation Panel

The Navigation Panel in SXM provides convenient access to various modules and features, allowing users to efficiently navigate through the system. It can be expanded or collapsed for ease of use, providing flexibility based on user preferences.
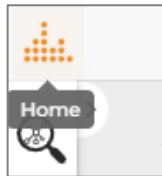
Home

Clicking on the Home icon brings you back to the Home page. See Home Page section for more details.
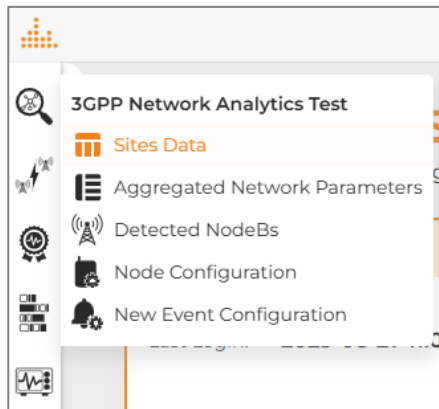
Left Panel – Applications

Icons for each subscribed SXM Dashboard application will appear below the Home icon. Hovering over any application icon will reveal additional options or related sub-applications. Detailed descriptions of each application are provided in this document.

By default, all SXM subscribers are provided with the 3GPP Network Analytics application.

Top Menu Panel
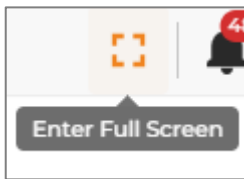
Full Screen

The **Full Screen** button lets users focus on the main display by hiding the side panels. To exit the full screen mode, users can press the **Esc** key or mouse over to the top the screen to bring up the ⊗ button.
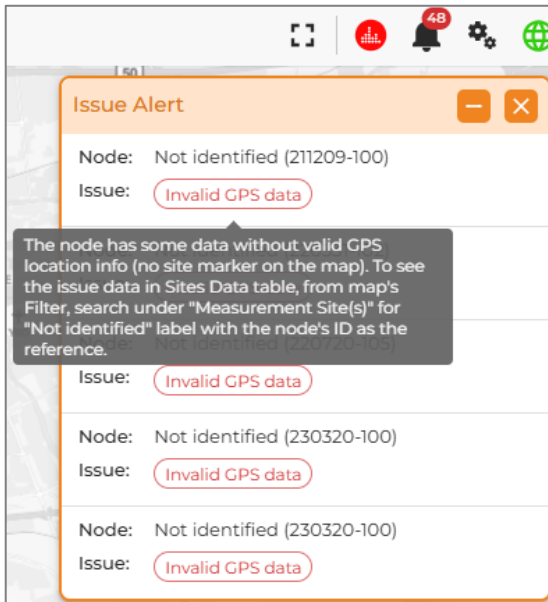
Issue Alert

When available, "Issue Alert" icon serves as a visual cue to draw the users' attention to an issue that happens while using the Dashboard. For example, this typically associates with the data within the map Filters' date range. The icon is invisible until there is an issue. The alert will be dimmed out when the issue is resolved or no longer applied if the map Filters' date range is changed.

When a solution is possible, mouse over the issue "chip" will provide a hover-text with suggestions or instructions for how to deal with the issue.

For example, the alert is visible and shows a list of nodes which have data without GPS location as shown below.

When the node does not have a clear-sky-view to the location satellites, the GPS location values will be invalid in the captured data. Such data will not be associated with a location on the map. Users can access the data by following the hover-text instructions using the map's Filters.
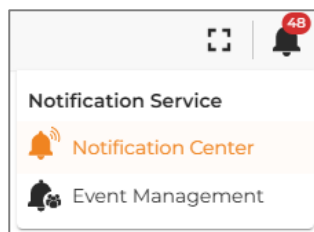
Notification Service

The Notification Service delivers real-time alerts and notifications directly on the dashboard and/or via email, based on user-defined events triggered by activity detected in monitored environments. It includes a centralized **Notification Center** for viewing all generated events, along with the **Event Management** tool for handling events from all supported applications and sources.
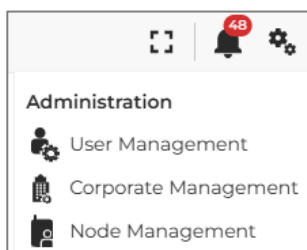
Administration

The Administration provides the account's administrators with access to User Management, Corporate Management (when applicable with the permission level) and Node Management. Through User Management, the administrators will be able to add, delete and manage other users within the same account as the user, depending upon privileges provided to the user.
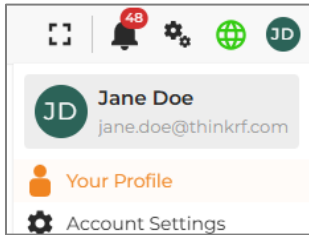
User Profile

The User Profile icon provides user access to details about their information, their corporation, and the SXM account.
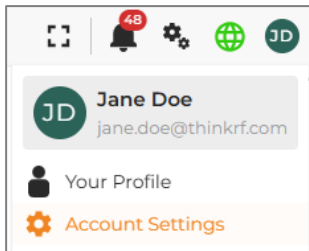
Account Settings

The Account Settings page allows users to set their preferences for Notifications.
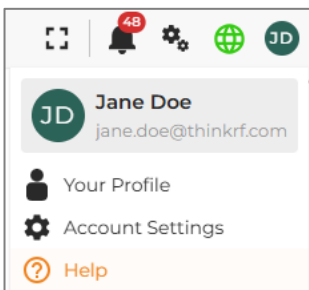
Get Help

The Help page serves as a hub for accessing an application Dictionary, documentation and support resources related to the platform, with direct links to thinkRF's Support and official website for further assistance and information. Users can also provide feedback from this page as well.
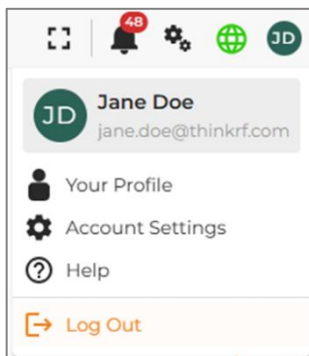
Logout

The logout functionality within the SXM software offers users a secure and streamlined method to conclude their session, thereby safeguarding their confidential data.

To initiate the logout process from the SXM platform, navigate to the "Logout" button situated within the bottom left panel. Upon selection, the application will promptly terminate your session, redirecting you to the login screen.

Users will also be automatically logged out after a period of time since logged in. In this case, an opened access might need a screen refresh to get to the log-in page, if not already automatically redirected.

Display Window

The Display Window provides the bulk of the content associated with the selected application. For most applications, users are provided with an interactive map, on which SXM nodes and other features may be selected. Depending upon the application, additional tables and graphics may be presented. Details associated with the specific application are explained in the associated Application sections.

There are certain common elements and interactions across applications, which are described in the following sections.

Filters

The filtering functionality enables the user to refine the nodes, data and information they see on the map, in the table, or any visual display. The filter feature can be found in the map view (which is the main data filter as shown below), in an application view, or with individual tables.

Map Filter

The main data filter panel from the map provides a list of options for filtering and will update its options based on the date range and the available options. For example, if all SXM Nodes are selected, all Operators, Technology, and Band options will be available; if only a set of nodes are selected, the options in operators, technology, and band dropdowns might be less than when 'all' is selected corresponding to the available data for the selected nodes. Similarly, only nodes that collected data during the selected data range will be available to select.

The Filter's fields might also vary depending on the types of application data and insights.

When there are many markers on the map (e.g., Measurement Sites, Routes, and/or Base Stations markers), this checkbox section allows users to filter out unselected markers, making it easier to focus on the ones that are selected.

Notes:

- **Base Stations checkbox** is available only when ((•)) Detected NodeBs is selected in the left menu bar for the 3GPP Network Analytics application.
- When Sites/Routes checkbox is selected *and* Detected NodeBs option is enabled, **Base Stations checkbox** will be selected by default and disabled until users unselect Sites/Routes checkbox.

The **APPLY** button will be available if any change is made to the Filter. Any open Table, Charts or insights will not have the new filter changes until the APPLY button is clicked. Otherwise, a warning message as shown below will be seen in a data panel, until the APPLY or CANCEL button is pressed.

⚠ You've changed the map filters. Apply them to see updated results.

The **CANCEL** button will reset the Filter to the last Filter saved settings.

The **RESET TO DEFAULT** button will reset the Filter to the Dashboard default.

Map Filter's Date Range

All applications' map Filter will have in common the Date Range fields. The **maximum range** is one year, representing the largest sliding time window available. If nodes have collected data for more than a year, access to older data is limited by the subscription plan: standard subscriptions include one year of fast data access and up to two additional years of historical data with slower access times (longer periods may be available with an extended subscription). Therefore, users cannot select a start date earlier than three years ago.

Note: While the maximum range is one year, using a large range (typically over 3 months) in combination with the number of sites/routes selected could result in a performance slowdown due to too much data. A warning will be shown when the filters go beyond certain selection conditions that could result in a potential performance impact.

The Date Range comes with 3 options:

- **Before** – Provide a convenient way to view data up to and including a selected end-date, which is set to a maximum of one year. The start date is automatically adjusted accordingly.
- **Between** – Allow filtering data between a specified start and end date. If the selected dates exceed one year, they will be automatically adjusted.
- **After** – Offer an easy way to view data from a selected start date onward, including all data from each subsequent day, up to the one-year maximum. Once this limit is reached, the start date will be automatically adjusted.

The date range set by the user determines which measurement sites or routes are visible on the map. Only sites or routes with data collected within the chosen date range will be displayed and available for selection in the filter list. To view the maximum number of sites and/or routes, set the date range to its widest possible span, typically up to one year as mentioned above.

Display Control Options

For most applications, a set of options are available to manage interaction with the Display Window. These settings will be found in the upper right of the Display Window, and include the following:

Refreshes the current Display Window. It might cause the closing of the open panels.

Select objects in the Display Map Window.

Select one object in the Display Map Window. It is for certain applications only.

Bring up the map's filter window, enabling filter of displayed data.

Zoom in to the selected Nodes.

Zoom out to all the nodes which have with data available from the Filter's data range.

Enable/Disable the option to drag estimated Base Stations to adjust their location.

Bring up a window with options for generating a report specific to the selected Application. This feature will be available in the near future release.

Display the Legend for objects shown in the Display Window.

Data Tables

Insights Tables

For Sites Data and Insights applications that provide tabular data, the table's content dynamically adjusts in response to data filter parameters. Also, the tables are automatically refreshed every 5 minutes to update their content.

Users have the option to manage columns 🎚️, or download the tabulated data ⬇️ in Comma-Separated Values (CSV) for manipulation and analysis by other tools. The table can be resized by dragging the top border of the table vertically.

Users can also minimize ➖ and maximize 🔲 the 'floating' table view.

To further tailor the data or the view of the table, users can also apply to the column additional below.
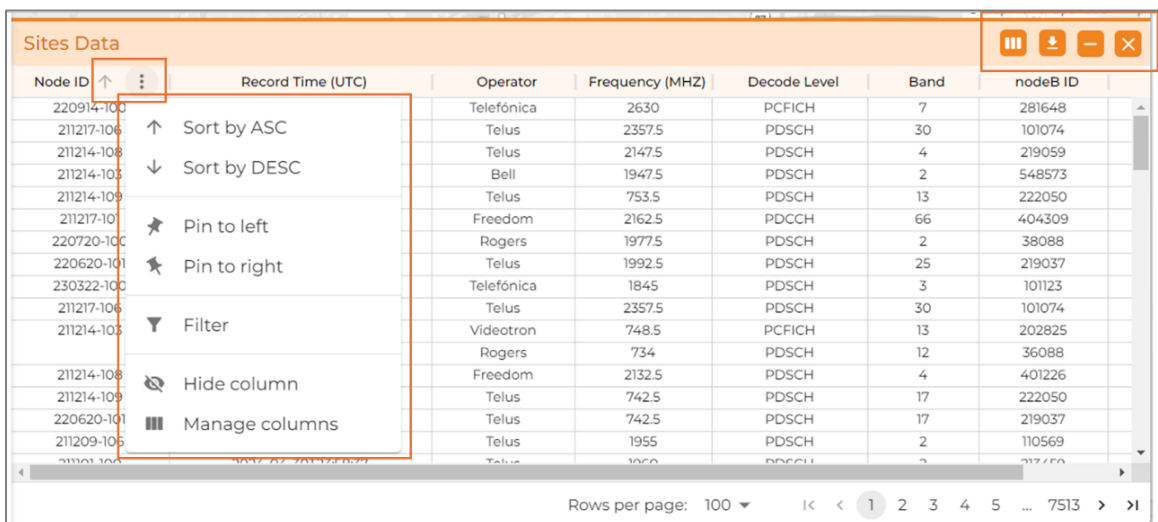
A rich set of filters is provided as shown below, with different filter operators depending on whether the parameter is a string or number type.
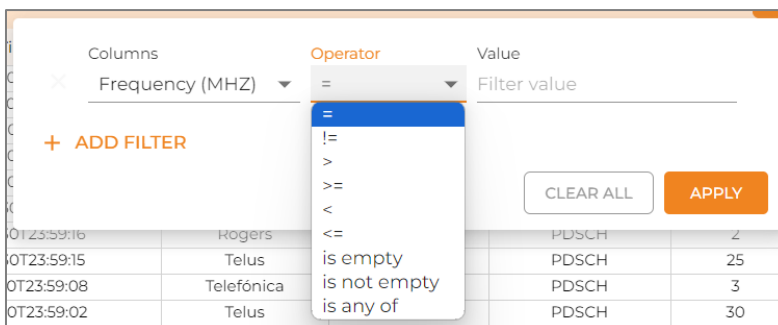
Hint: "**is any of**" filter takes in many values. To keep adding additional values, press 'Enter' after each input value.

Administrative Tables

Administrative tables such as User Management or Node Management tables have similar usage behaviors as the Insights tables mentioned in the previous section, regardless of the different look-and-feel or placements of the orange icons.

Additionally, they have FILTERS and REFRESH icons on top of the table as shown in the picture. The Filters icon is for quick access and only applied to open columns. The Refresh icon is for performing a refresh right away instead of waiting for the 5 minutes auto refresh interval; with the exception of the Node Management table, which is automatically refreshed every 1 minute due to the statuses reporting.

The handy Search bar is case insensitive and will search across the opened columns.

Column Customization

Users have the flexibility to customize the columns displayed in the table according to their preferences. The columns can be resized using the separator by the header name or rearranged by directly dragging a column header to a desired location. They can also be pinned left or right to freeze the column's data while scrolling horizontally across.

The column arrangement will be saved at each change so that the arrangement will persist when users switch away from the application view or log out.

Warnings: The following rules are applied to a column to prevent confusion with the data available for display:

• Only visible columns can be filtered.

• A filtered column will have the filter removed when 'hide' is applied to the column. Bringing that column back will not bring back the filter.

• When changing a column into hidden mode, if that column is the primary sorting column, the sorting will be removed from that column. Bringing that column back will not bring back the sorting order.

Charts Exploration

Some applications provide Chart Panel (such as Channel Occupancy or Interference Management), which can be made larger or smaller by mouse over the top edge of the panel until the vertical expand icon ⇕ becomes visible.

The Charts use dynamic and customizable displaying features, each chart can be shown or hidden *when applicable* using the "Manage Charts", located in the top right of the Chart Panel.

Each chart can be resized by dragging on the four corner icons ⌐⌐ or moved using the Move icon ═ to another location within the panel as desired.

When the chart is a Table type, *Export Data* button is available at its top right for generating CSV data file.

For graph chart type, at the top right within each chart is the chart's control menu

with the explanation as shown in the following table.

Symbol	Description
📷	To Download the Graph as a Picture
🔍	Zoom
✛	Pan/selection
➕ ➖	Zoom In/Zoom Out
⟦X⟧	Auto scale to rescale the chart
🏠	Reset chart and axes to its original size

Pop-up Information Panel

When clicking an item on the map, such as the SXM Node marker or detected Base Station marker, a panel containing detailed information will appear as shown in the pictures below. Additionally, the color of the selectable item will change, providing visual feedback to indicate its selection.

The panel will disappear automatically under the following conditions:

- Clicking the same item again.
- Clicking anywhere outside the item or the panel, which includes clicking a different item.
- Clicking the Close Popup icon ❌ on the panel.

The panel can be pinned to view the information by clicking the Pin icon 📌. The pinned panel will stay open and won't close automatically unless one of the following happens:

- The Close Popup icon is clicked.
- The Unpin icon 📌 is clicked.
- The associated Base Station marker becomes clustered (the popup will reappear when the marker is de-clustered). See the Detected NodeBs section for more information.
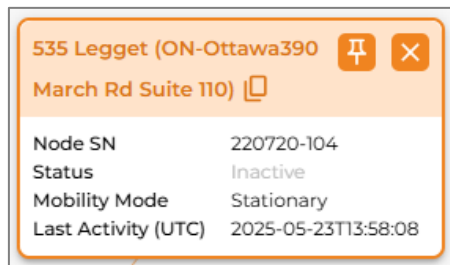
SXM Node's Information   Base Station's Information
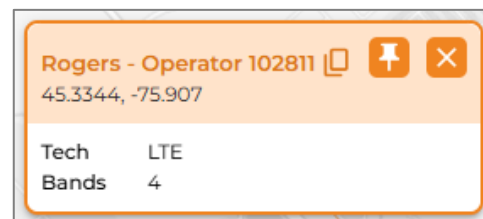
The header text of the panel can be handily copied by using the copy button 🗐.

SXM Node's Functions Relating to Dashboard

The ThinkRF SXM Node serves as the IoT hardware component of the Spectrum eXperience Management (SXM) solution. It operates autonomously and continuously, conducting real-time spectrum analysis 24/7. When an internet connection is available, the node securely transmits collected data and analytics to the SXM Cloud for further processing and visualization.

Designed for versatility, SXM Nodes can be deployed in fixed locations, temporary installations, or mobile environments such as vehicles, for drive-testing applications. Each node captures and records critical spectrum data, including GPS coordinates and timestamps, enabling precise geospatial mapping within the SXM Dashboard.

Due to their portability, a single SXM Node can be associated with multiple predefined data collection sites or route configurations. The SXM Dashboard provides an intuitive interface that visually represents these data locations through markers and mapped routes, ensuring streamlined analysis and enhanced spectrum monitoring capabilities.
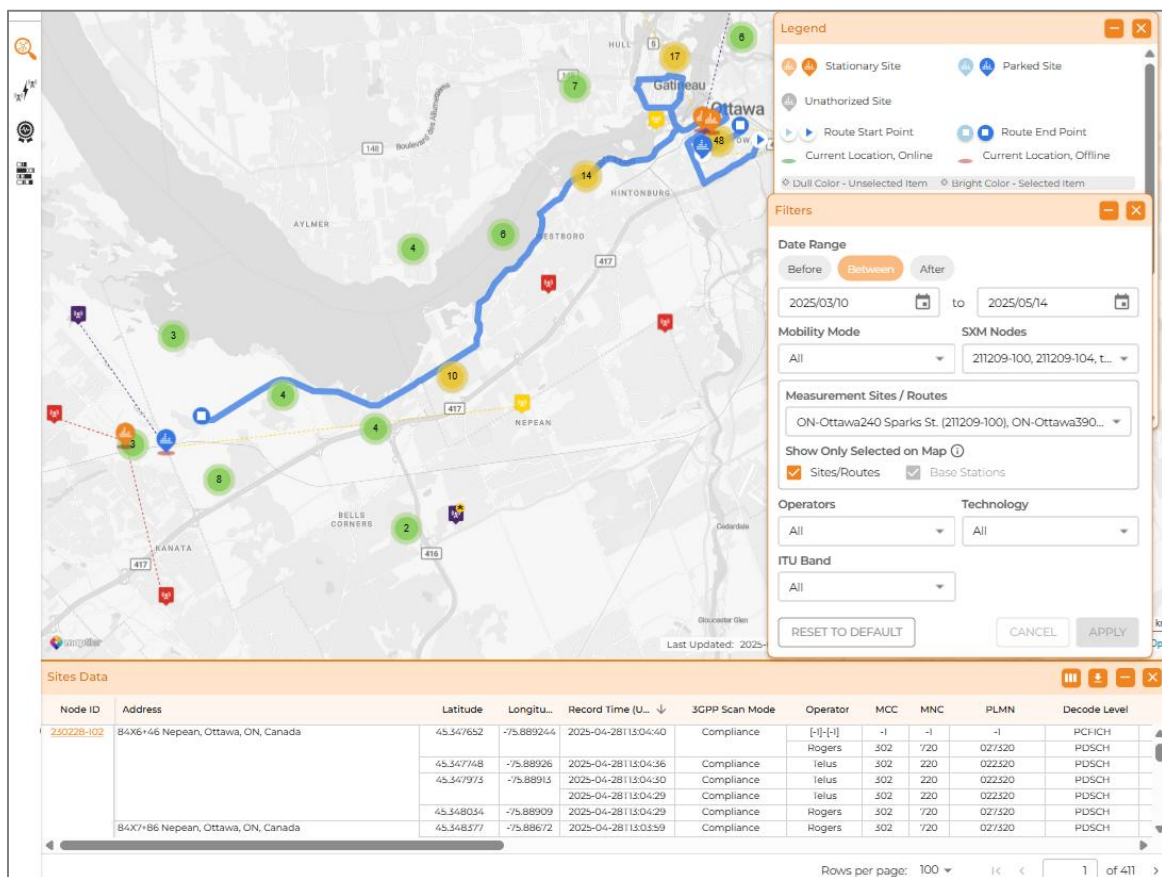
This chapter focuses on functions pertaining to the nodes' deployment method and their associated collected data in relation to the SXM Dashboard.

Mobility Mode, Sites and Routes

The term "**Mobility Mode**" is used to classify the data associated to the node deployment method, basing on the GNSS settings as such:
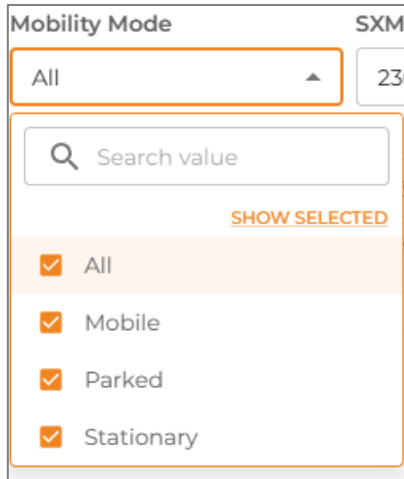
- **Stationary** – Refer to data from a node configured to have *Stationary* GNSS mode. The marker for this data on the map will have thinkRF's orange color marker icon. The marker is plotted on the map using a reduced 2-decimal-points latitude/longitude data to reduce the impact of any fluctuation in the GPS sensitivity.
- **Mobile** – Refer to data from a node configured to **Automotive** GNSS mode, and its GPS location has changed as a result of the node deployed in a moving vehicle. The data will be drawn as **blue routes** on the map. This option might not be available for some applications due to its non-static data nature, such as in Interference Management application.
- **Parked** – Refer to data from a node configured to **Automotive** GNSS mode but the node has not been in motion for 30 minutes or more. In other words, if a node is in a moving vehicle and is static for under 30 minutes, the data for this static duration will be part of the route. This mode applies to nodes positioned in an office or any fixed location as well if its GNSS mode is Automotive. The marker for this data on the map will have a blue marker icon and has the same stationary marker's reduced 2-decimal-points latitude/longitude rule.

See the next sub-section for more information pertaining to these modes.

Warning: If a **Stationary** node is used in a moving vehicle, it will result in many orange markers across the map. These markers apply the same stationary marker's reduced 2-decimal-points latitude/longitude rule.

Across the document, the data location terminology, hence, is often used interchangeably as "**SXM Nodes**" or "**Measurement Sites / Routes**" (with or without (no longer there) the physical node presents at the location).

Data Locations Mapping

The output data from SXM Nodes includes GPS location metadata, enabling geospatial mapping of measured spectrum data. Within the SXM system, this data is visually represented as site markers or routes on the interactive map interface.

The "Location" mini-map, accessible from the Home page, provides users with a quick overview of available Measurement Sites and Routes. Users can filter the displayed data based on a selected time range—1, 7, 14, or 30 days from the current date—ensuring efficient access to relevant spectrum monitoring insights.

As described in the previous sub-section, depending on the Mobility mode, the data options for selection on the map are displayed as orange or blue markers for static "**measurement sites**" or as blue "**routes**" from a drive-test deployment.

Stationary Data Sites Mapping

Stationary Sites with thinkRF's orange color marker icon are plotted on a map using a 2-decimal rounding scheme of the longitude and latitude values to reduce the location variation on the map. This rounding has an effect of ~1km coverage range. If the node has been moved more

than ~1km away, a new measured site will be generated. The source data shown in Sites Table etc., however, retains the original values without any rounding.

The SXM system creates a unique node's label used for mapping, filter options and data association as following:

- With a given label: **<node label> (<region-city-short address>)**. Example: 240 Sparks (ON-Ottawa390 March Rd Suite 110).
- Without a given label: **<region-city-short address> (<node SN>)**. Example: ON-Ottawa390 March Rd Suite 110 (220801-106).
- If there is no location identified due to lost GPS signal, the label used is: **Not identified (<node SN>)**.

Important Note: Any 'drive-test' measurements deployed **before March 18** will have many orange markers mapped along the driven routes since Dashboard 'route mapping' feature was not available at the time.

Site Statuses

An orange stationary site (or blue parked site) might or might not have a status-colored shadow shown with the location marker. These markers are to be interpreted as such:

- This stationary node at this Measurement Site is active (online), might or might not be doing measurement.

- This stationary node at this Measurement Site is offline (power off or lack of internet). It might or might not be doing measurement. If measurement is running while there's no internet, the data will be cached for up to 1GB, after which old data will be dropped, replacing with new data. The cached data will be uploaded to the cloud at the next internet availability.

- This Measurement Site no longer has the physical node at the location, just past measured data.

Note: If the stationary (or parked) node is moved to another location and is **pre-configured** for another application (say Channel Occupancy**) while it was offline**, then the last used application (say 3GPP) will not have the last known physical location (no site with the red circle).

240815-102 Jordan3 (ON-Ottawa390 March Rd Suite 110)

Node SN	240815-102
Status	Active
Mobility Mode	Stationary
First Activity (UTC)	2025-07-08T16:23:04
Last Activity (UTC)	2025-07-08T21:33:57

All Stationary site related items on the map including the pop-up information panel are displayed in thinkRF's orange color, as shown in the following figure as an example.

See the Node's Information Panel from each application's map for more details on the site.

Mobile Routes Mapping
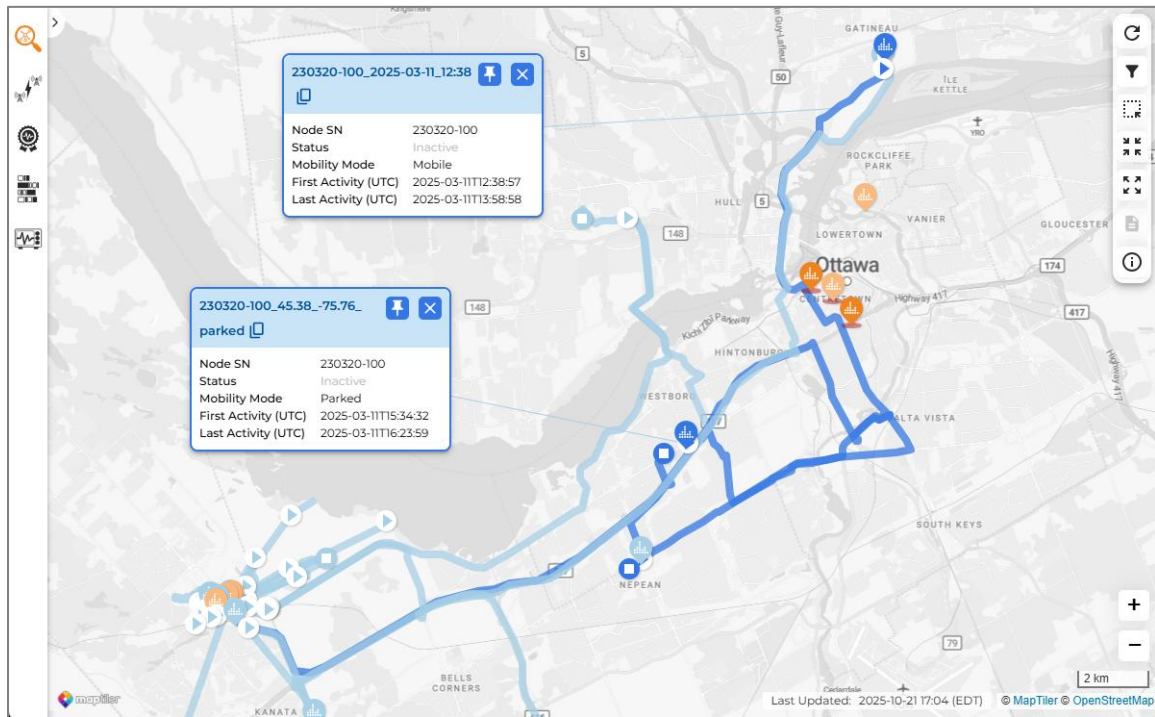
When a node is deployed in a moving vehicle and is programmed to the GNSS *automotive* mode, the data along a drive path will be plotted as a route using the snap-to-route mapping method, as shown in the figure above. To clearly distinguish from a Stationary Site, all route related items on the map including the pop-up information panel are displayed in blue color.

As shown in the map, a route consists of these parts:

- The starting point.

- The current or endpoint of the route.

-
- The route between those two points. When selected, it will have a strong blue, and light blue for unselected.

- The Parked site, identifying a node has stopped at a location for 30 minutes or more.
    - The Parked site also has the same statuses as with the Stationary site, as mentioned in Site Statuses.

The SXM System automatically creates new Routes or Parked sites for a node with GNSS *automotive* mode based on these rules:

- The mobility type is changed when a node's GNSS mode is changed from Stationary to Automotive.
- A new **Route** is generated when:
    - the node is moving from its Parked or Stationary location.
    - there is a 15-minute gap or more between the timestamp of two consecutive data points.
    - there is an 8 Km gap or more between two consecutive data points.

- A **Parked site** is generated when the location data has not changed for the last 30 minutes by checking the 2 decimal points of the latitude and longitude values. The creation of a Parked site will signal the end of a route as well.

Notes:

   - The 8 Km gap and 30 minutes Parked rule are identified as the most 'optimal' values after calibrating many studied routes during the design of this feature.

   - If a route crosses the day (UTC time), SXM system will show the entire route of both days for mapping, filtering, data table or charts calculation.

For map and filter identification, a node with automotive GNSS mode does not use the given label nor the address identification as with a Stationary route. The unique label is generated as follows:

- Parked site's label: **<node_id>_lat_long_parked**. Example 220806-106_45.10_39.11_parked. **Lat**itude and **Long**itude are presented with two decimal places to represent the location. These values are intentionally rounded (from the source data) to reduce the number of sites displayed. As a result, the location may not be pinpoint-precise, but the data itself remains accurate.
- Mobile route's label: <node_id>_<start-date>_<HH:MM>, where the start-date and "HH:MM" refer to the date and time the route is started, for convenience reference. For example, 220806-106_2024-11-07_20:30.
- If there is no location identified due to lost GPS signal, the label used is: **Not identified (<node SN>)**.

The route information panel, as shown below as an example, includes the First and Last Activities, indicating the start and end time of that route or Parked site.

230320-100_2025-03-11_12:38	
Node SN	230320-100
Status	Inactive
Mobility Mode	Mobile
First Activity (UTC)	2025-03-11T12:38:57
Last Activity (UTC)	2025-03-11T13:58:58

230320-100_45.38_-75.76_ parked	
Node SN	230320-100
Status	Inactive
Mobility Mode	Parked
First Activity (UTC)	2025-03-11T15:34:32
Last Activity (UTC)	2025-03-11T16:23:59

        Route Info Label   Parked Site Info Label

Data Location Selection and Filtering

The selection availability of "only one" or multiple data locations (Sites or Routes) depends on the application and the type of measurements and insights. For example, 3GPP Network Analytics allows multiple locations selected for viewing network insights across areas of interest, while Channel Occupancy supports only one location at a time to assess band utilization in that specific location.

Selection using Map Filter

From the map's Filters (as shown in the left figure for example), first ensure the desired Mobility Mode is chosen, then users can select the Measurement Sites / Routes in two ways:

- by using the "Measurement Sites / Routes" directly. The associated node(s) under "SXM Nodes" will be selected automatically as well.
- by selecting the node(s) under "SXM Nodes" first, then select the desire "Measurement Sites / Routes".

"Show Only Selected on Map" section allows users to focus only on the selected items for better visibility when the map might be too busy with many markers.

Hint: If "All" is selected under "Measurement Sites / Routes", especially with the "After" date range option used, this will have all new sites or routes selected automatically when they become available. This method is useful for when a node is being moved around with new locations created over time.

Selection from The Map

1. For 3GPP Network related applications, users can select multiple Measurement Sites / Routes of one or more nodes on the map in two ways:

   o by holding down the SHIFT key while clicking on individual sites. Note that applying SHIFT key on an already selected location will deselect it, or
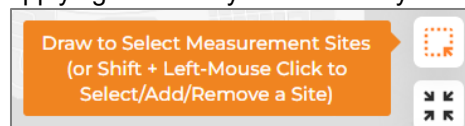
   o by drawing a selection box around them (as shown in the following figures).
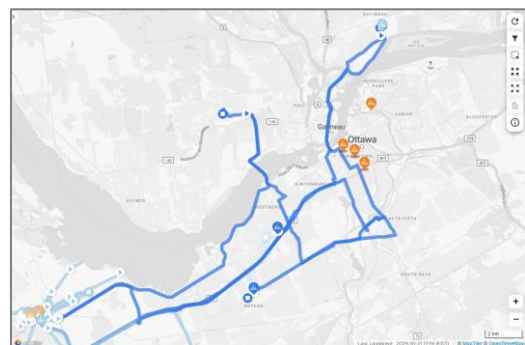
Note that selecting a part of a route will result in selecting the whole route. This method is to make it easier for users, not having to make a large drawing across the map to select the whole route.

2. For applications allowing only one site selection (such as Channel Occupancy), this selection icon will be shown [Select/Deselect a Measurement Site (or Shift + Left-Mouse Click)]. Similarly, the SHIFT key selection in this case will select or deselect a selected location.

After selecting the sites or routes, their data will be reflected in the map Filter's fields and Tables.

Node's Application Configuration Usage

Administrators and Authors users can configure the nodes for subscribed applications easily from the dashboard. The 'Node Configuration' form is accessible handily within most applications; applications (such as License Bands Utilization) using collected and aggregated data in the cloud for the analysis will not have this form under its hierarchy.

Depending on the application, the configuration form will have different input fields as explained in the "Node Configuration" section of each application chapter. This section focuses on the commonalty actions and functions of the form regardless of the application.

Hint: Users can use the "Load Saved Configuration(s)" from one node to apply a saved configuration to another node(s).

Submit a Configuration

When the SUBMIT button is pressed, the following actions will occur:

1. a warning screen will pop up *if there is an active* configuration running, users can choose to proceed or cancel the submission.
2. if the submission is proceeded, this configuration will be saved to a *unique* file name, which has the following format:

> *<Config Name>_YYYYMMDD_HHmm - <status>*

where:
  <Config Name> is the user's given name
  <status> indicates what the saved configuration's state is with these possible states:

- **Pending** – The configuration is created and is pending to be sent to the node.
- **Not started** – the configuration is not running yet due to the node either is offline or has received the configuration but has yet to start the configuration.
- **In Progress** – the configuration is running
- **Completed** – the configuration has completed its analysis period (such as with Channel Occupancy's Study Period) or was taken over by another configuration.

Note: By using the date time appendix to the file name automatically, this will guarantee uniqueness of each configuration, especially when "Config Name" could be the same. Also, this is to allow for associating which the configuration with which data, by using "Config Name" in "Sites Data" table.

The configuration status can be viewed from the "Load Saved Configurations" of the Node Configuration form, from the "Config List" filter, or the Node Management in a near future release.

If a node is not online at the submission time, the SXM cloud system will apply the configuration when the node next comes online. However, if another configuration is issued, the 'not started' configuration will remain as such.

Note: After the node is powered up or configured to perform a signal analysis, the data will typically be available in the cloud approximately five minutes or longer, depending on the availability of the RF/spectrum signals of interest at the monitoring site.
The node's measured data is time-stamped the moment the receiver's raw data is captured, not when the analysis is done on the raw data.

Load Saved Configurations and Modify

When only one node is selected from the "SXM Configurable Node" list and the node has one or more configurations saved previously, the grey "LOAD SAVED CONFIGURATION(S)" button will change to an orange color as shown in the following picture, indicating there are saved configurations for loading.

Caution: When a saved configuration from the list is selected, its content will be populated on the form, erasing any unsaved values on the form.

Users can then modify the form's values including changing the node before submitting. As mentioned in the previous section, the configuration will have a new unique name when the same "Config Name" upon submission.

When the form's configuration is complex, additional editing fields will be available as needed, such as those of the Channel Occupancy shown.

This option is not available for when multiple nodes are selected.

Monitoring and Administration

While thinkRF manages the nodes (as shown in "the solution architecture overview" of the SXM Solution and Dashboard Overview section), users can also view and manage the nodes where applicable. Refers to Node Management section for more information.

In the absence of the internet where users won't be able to use SXM Dashboard to work with a node, thinkRF also provides the "SXM Local Control Application" (LCA) as an alternative but with limited Dashboard functions. This web-based application is to be used with a known IP from the node, typically coming from the node connecting directly to the user's computer or via a Local Area Network (LAN).

With this software, users have visibility of the node's and running application's statuses, can change configuration, and perform limited monitoring functions to ensure its proper functions. The data collected in the node would be stored in an on-board storage drive and uploaded to the cloud when the internet is available. Refer to this LCA User Guide for usage information.

Home Page

The Dashboard's main page, as shown below, provides a quick brief overview of

- the user's and corporate information,
- quick application access from Available Applications,
- various summaries and metrics with few handy day ranges, and
- recent activities/News.

Furthermore, users can visually and interactively explore available node's data locations via an integrated map feature within the dashboard interface. See Data Locations Mapping for more information.
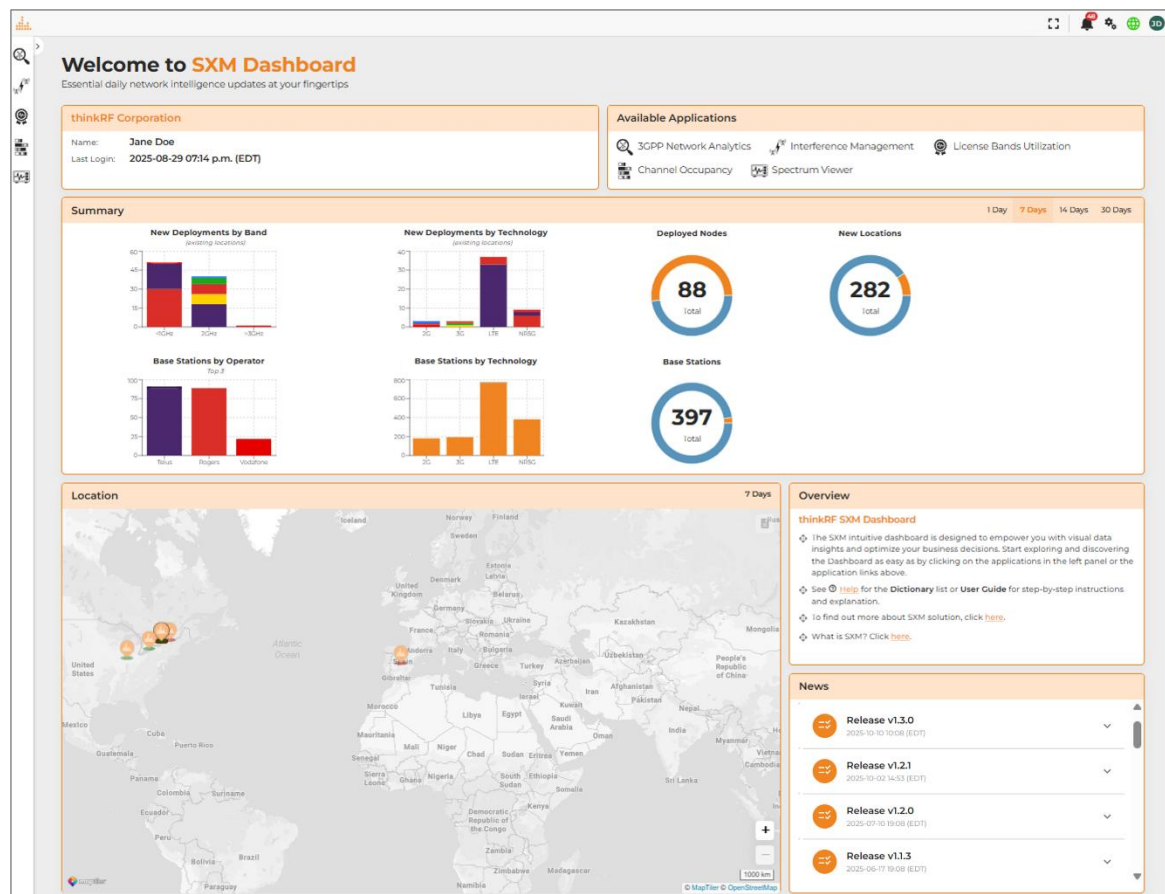
Summary Charts

The Summary section provides quick insights into the node deployments and their collected data. The data for each chart is influenced by the selected period: 1, 7, 14 or 30 days.

The table below describes each of the summary charts, going from left to right and top to bottom.

Application	Summary Chart	Description
3GPP Network Analytics (and 3GPP associated applications)	**New Deployments by Band**	Number of newly (first) detected channel grouped by Band during the selected period. The Bands are classified based on the frequency range of the band and categorized into three groups: 1GHz or less, 2GHz, and 3GHz or more. A 'new deployment' is computed based on a newly detected downlink center frequency and RAT type at *existing locations*. Newly detected cells at preexisting center frequencies are not considered new deployments.
	New Deployments by Technology	Similarly to By Band above but grouped by Technology types: 3G, LTE (4G) and NR5G
	Base Stations by Operator	The number of existing and new base stations detected for the top 3 operators for the selected period. • **New** – the number of new base stations detected at locations that existed prior to the selected period.
	Base Stations by Technology	Similarly, the number of existing and new base stations detected for the three Technology types for the selected period.
	Base Stations	The total existing and new base stations detected for the selected period.
Node Management	**New Locations**	The number of new locations (measured sites) where stationary nodes have been reported from. A node might have multiple locations if it has been moved more than ~1 km. • **New** – the number of locations that reported data during the selected period and did not report data in any previous period.
	Deployed Nodes	The activity state of all subscribed SXM nodes assigned to the account. • **Active** – the number of nodes that reported data during the selected period. • **Inactive** – the number of nodes that did not report data during the selected period. Note that a node may be powered on but still be considered inactive during a period if it either: 1. did not detect any 3GPP infrastructure, or 2. did not have an active internet connection.

News

The News panel lists the change logs for each release, general announcements or news pertaining to SXM Solutions.

The articles are displayed collapsing by default. They can be expanded to see more information or collapsed by simply clicking on the heading. Each article is dated to indicate the time it was issued or edited.

3GPP Network Analytics

The 3GPP (3rd Generation Partnership Project) Network Analytics dashboard provides in-depth analysis and insights derived from captured 3GPP network data. This application has a core interactive map for viewing the Measurement Sites (aka data locations with or without (no longer has) physical SXM nodes present) and base stations, their relationship, as well as making nodes selection. The user will only be able to view nodes that they are authorized to see.

This chapter will go over the features available with the application, starting with the 3GPP application's Node Configuration. Related terminologies are described on the Help page.

Refer also to Appendix A – SXM 3GPP Parameter Description for the description.

Node Configuration

The nodes can be configured to perform 3GPP measurement at desired ITU 3GPP band(s) and/or custom range(s) by using the "Node Configuration" form from the left panel as shown in the next picture.

Note: Configuring for 3GPP measurement will impact data for the 3GPP Network Analytics and License Bands Utilization applications, with the latter utilized the collected data stored in the cloud.

Refer to Node's Application Configuration Usage for more usage details.

3GPP Scan Mode

This selection field in the Node Configuration form allows users to select which 3GPP scan mode to use for the detection. The modes could be deployed with stationary or mobile nodes.

There are two modes provided currently:

- **Infrastructure Scan Mode** – This mode performs a comprehensive blind scan of the ITU FR1 bands or custom frequency ranges, decoding all 3GPP parameters. It is ideal for detailed spectrum analysis and monitoring in environments requiring in-depth data collection.
    - It is recommended for stationary scanning due to its comprehensiveness; thus, longer analysis time compared to other scan modes.
    - When choosing this mode, GNSS Dynamic Mode defaults to "Stationary".
- **Compliance Scan Mode** – This mode scans the ITU FR1 bands or custom frequency ranges rapidly, targeting compliance and interference checks by decoding essential System Information Block Type 1 (SIB1) parameters, such as base station ID and bandwidth usage, with minimal user configuration required. This scan mode does not provide the following LTE uplink (UL) parameters: ARFCN, bandwidth (BW), and center frequency. It is also insufficient for informing NSA/SA operation of NR5G.
    - Though it can be used with stationary deployment, this mode is recommended for mobile nodes, supporting speed of up to 100 km/hour.
    - When choosing this mode, GNSS Dynamic Mode is defaulted to "Automotive".

GNSS Dynamic Mode

The SXM node has an onboard GPS/GNSS module, providing GPS location information for the measurement data. The options for "GNSS Dynamic Mode" are to be used as such:

- If the node is to be mounted to a fixed location, the "**Stationary**" mode is recommended for the "GNSS Dynamic Mode". In this mode, velocity is restricted to 0 m/s and zero dynamics assumed.

- If the node is to be used in a drive test scenario, the "**Automotive**" mode is recommended. In this mode, low vertical acceleration is assumed. This mode has a slightly higher deviation error than the "Stationary" mode.
- "**Airborne<1g**" mode has been added to support low flying aircraft or applications with a higher dynamic range and greater vertical acceleration than a passenger car. It supports speed less than 360 km/hour and has large position deviation error.

Notes:

- For the GPS module to provide accurate location information, **the node must have a clear sky view**. Without a good line of sight to the sky, the GPS module will either not get a lock (resulting in no GPS data) or the GPS data is wildly reported, resulting in many nodes' measured sites shown on the map (as explained below).

- If "Automotive" or "Airborne<1g" is used for a stationary node, its sensitivity to certain speed can cause miss representation of a GPS 'lock/fix' signal, leading to invalid GPS data.

- The mode configuration is tied with the Set Node Location in the Node Management. When a manual address correction is active for the selected node(s), a warning message will be issued as shown below. Users can click on the "Node Management" in the warning message, which will open a new browser tap to make the changes without losing the current Node Configuration settings.

⚠ Warning: Manual Address Correction is active and will affect new data. Disable it in Node Management if needed. when a single node is selected.

⚠ Warning: Make sure no nodes have Manual Address Correction enabled to prevent incorrect addresses used in new analysis data. Check Node Management to verify. when multiple nodes are selected.

Scan Sensitivity and Output Optimization

As SXM 3GPP Signal Analysis software can detect very fast, achieving more than 15000 detections per day, this amount of data contains some detection that might not be valuable to users. Thus, two new configurations are added to allow users to reduce the output data without losing important detection:

- **Output Optimization** – Refer to the process of refining decoded results to focus on "unique cells," defined by distinct parameters like frequency, PCI, and RAT type. It prioritizes results – completed at the end of the detection analysis – that show significant differences in power or decoding levels compared to their unique counterparts, filtering out unimportant results.
  This process resets with every 2 km change in the node's position. Setting this option to FALSE will result in all detected data being sent without any reductions.
- **Scan Sensitivity** – Refer to the blind scanner's detection sensitivity to RF activities at the node's surrounding environment, such as in-door (recommend 200) or outdoor (100). A higher value implies greater sensitivity for the carrier detection. The default setting is 100.

Data Location Selection

Refer to SXM Node's Functions Relating to Dashboard section for how to perform Sites or Routes selection.

Selection using Map Filter

Refer to the Map Filter's Date Range section for the Date Range information.

The selected Date Range determines the values shown for the other fields shown in the Filter.

- Refer to SXM Node's Functions Relating to Dashboard section for information on **Mobility Mode**, **SXM Nodes** and **Measurement Sites / Routes**.
- **Operators** – A list of Mobile System Operator (MSO).
- **Technology** – A list of the Radio Access Technology (RAT) type.
- **Band** – A list of 3GPP band values for LTE or 5G from SIB1.

Node's Information Panel

Clicking on a site or route marker opens a panel providing detailed information about the selected data location. This information includes:

- Name
- Node Address
- Node Serial Number
- Mobility Mode
- Various Statuses or Activity Date and Time.

In addition, users can Pin the panel to persist the view and use the copy button to copy the node's text.

Refer to Data Locations Mapping for more details.

Sites Data

SXM nodes continuously scan all configured FR1 bands, identifying and characterizing any detected 3GPP infrastructure. Whenever a node confirms a 3GPP cell, it characterizes it and uploads what it has learned tagged with time of detection and location. The amount of information (or level of characterization) extracted about that cell depends upon the quality of the detected cell (signal strength, noise, interference, etc.). The node will report as much as it has learned, and as frequently as it has been configured to.

The Sites Data table presents the most basic perspective on the data collected by subscribed SXM nodes. For selected nodes or sites, each time-stamped data record is provided in a tabulated format that enables filtering, organizing and exporting. Users have the flexibility to

customize the displayed columns, tailoring the view to their specific needs and preferences. See Data Table section for the usage.

Note: SXM will populate any fields with "-1" when the underlying data was not available or not relevant. For example, if SXM was unable to extract the SIB (Secondary Information Block) fields associated with a cell during a particular decode event, all those fields (eg PLMN, MCC, MNC, NodeBID, CellBarred, etc) will be populated with "-1". Subsequent decode attempts for the same cell may be more successful and will populate those SIB fields.
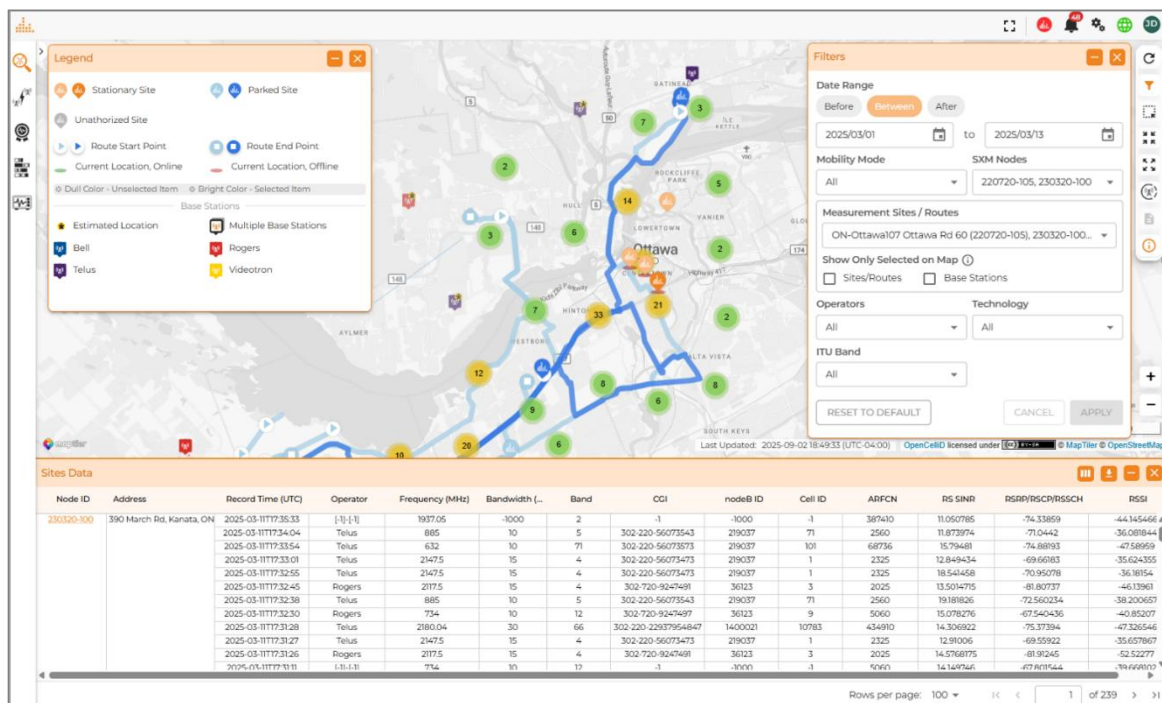
Aggregated Network Parameters

The Aggregated Network Parameters table offers a comprehensive, aggregated overview of 3GPP channels associated with the selected nodes and date range. This is the table that provides a summary of everything that has been learned by SXM about the local 3GPP infrastructure.

RAT	Band	Frequency (M...	Operator	Secondary Oper...	ARFCN	Bandwidth	Duplexing	Reserved for Operat...
3G	2	1947.5	Telus	Bell	487	5	FDD	-1
		1982.5	Telus	Bell	662	5	FDD	-1
	5	887.5	Telus	Bell	1087	5	FDD	-1
LTE	-1	723	Telus	Bell	9720	10	FDD	-1
		742.5	Telus	Bell	5815	5	FDD	-1
		753.5	Telus	Bell	5255	5	FDD	-1
		882.5	Telus	Bell	2535	5	FDD	-1
		1960	Telus	Bell	900	20	FDD	-1
		2147.5	Telus	Bell	2325	15	FDD	-1
		2660	Telus	Bell	3150	20	FDD	-1
		2680	Telus	Bell	3350	20	FDD	-1
	2	1960	Telus	Bell	900	20	FDD	1

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Different perspectives on that infrastructure can be seen by customizing the displayed columns, their order, and their filtering. For example, to summarize how C-band is being used by various

operators in an area, display the Operator, Frequency, Bandwidth and Band columns, and filter the Band to only show "78":

Or to reveal which channels Telus has "Reserved for Operator" (i.e. invisible to UEs), add the Reserved for Operator field, and filter it for "0":

See Data Table section for more details on the usage.

Detected NodeBs
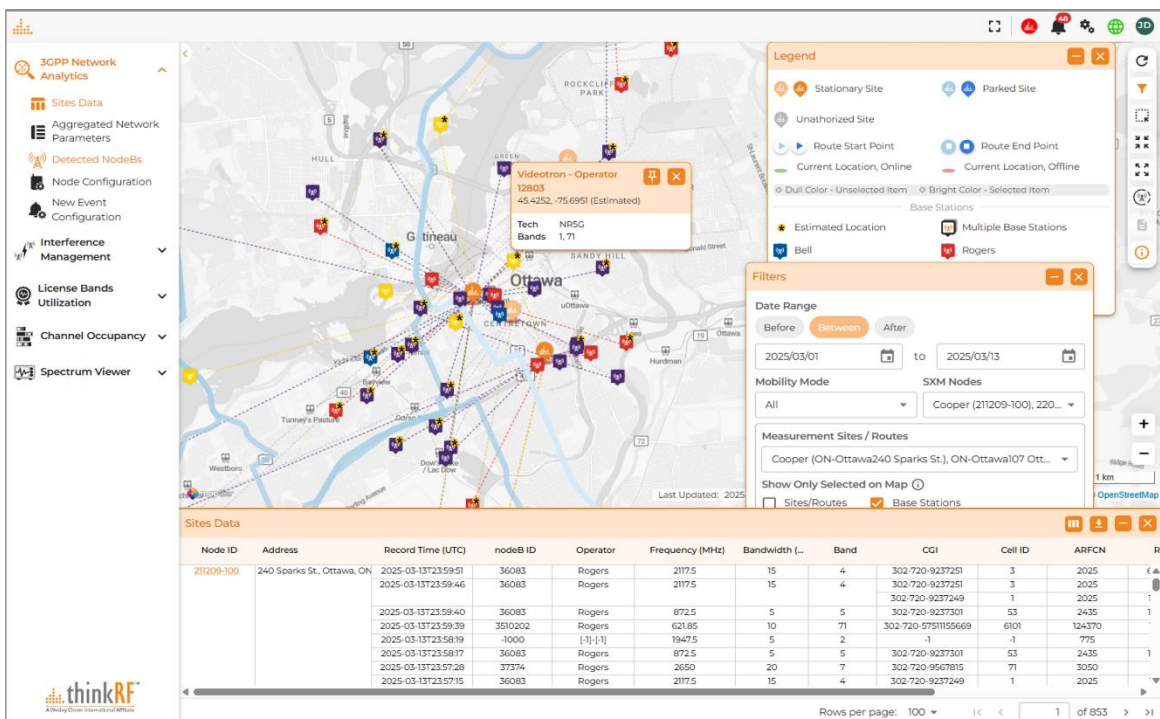
The Detected NodeBs (or Base Station) option within the software platform offers a visual representation on the interactive map of the nodes and their corresponding detected base stations (nodeBs), as shown above. Each nodeB marker is colored according to its associated operator with a legend provided on the right.

Users can identify relationships between nodes and nodeBs through visual cues and access detailed information by interacting with the interface. For example, each selected node is visually connected to its corresponding nodeB(s) by a dashed line or vice versa from a focused nodeB to nodes. The lines linking nodeBs to selected nodes will have a stronger focus than those that don't.

Placement of Base Station Markers

Note: SXM does not geolocate base stations. It uses SXM derived nodeB ID's correlated with a third-party dataset to approximately locate that nodeB on the map. Locations may be subject to error, and newer base stations may not yet exist in any 3rd party datasets.

The nodeB (Base Station) markers have two display modes:

- Operator marker without an asterisk – Indicates a base station with a known location, sourced from third-party data.
- Operator marker with an asterisk – Represents a location that has been randomly estimated. The estimation process will randomly place base stations without known locations within a circular radius of 0.5 to 3 km around the nodes.

This enables users to clearly view all detected Base Stations on the map.

For the estimated Base Stations, Admin and Author users can adjust their position on the map by clicking on this button located on the right side of the map
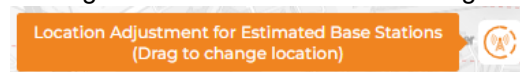
. All estimated NodeB markers will visually be vibrating to indicate they are movable. The new location is limited to a maximum of 15 km. If a user moves a marker beyond this range, it will be adjusted to remain within a 15 km radius, preserving the same direction of movement.

Base Station Markers Clustering

To smoothly handling geographic markers or pins efficiently with fast rendering and load performance, map marker cluster technique is used for displaying the detected Base Stations (NodeB IDs). Clusters have a specific radius around the center point, and this radius can vary based on the zoom level to control how far apart markers must be before they're grouped together. At higher zoom levels, clusters break apart to reveal individual markers; at lower zoom levels, markers combine into larger clusters. SXM Base Stations clustering behaviours are described in the following subsections.
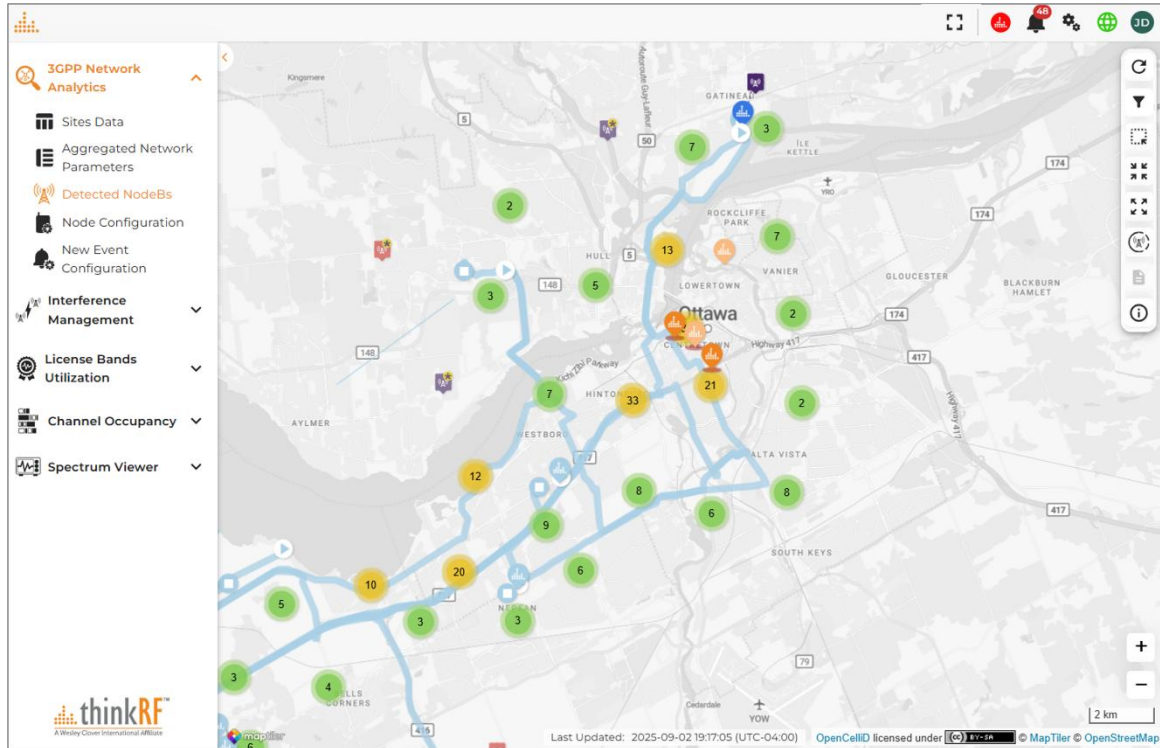
Clustering Behavior

- **When the map zoom level is above 1km**, base station markers are clustered to improve performance and usability.
- Cluster colors indicate the number of markers within each cluster:
    - **Green cluster**: 1 – 9 markers
    - **Yellow cluster**: 10 – 99 markers
    - **Orange cluster**: 100 – 999 markers
    - **Red cluster**: 1000+ markers
- Interactive behavior
    - Hovering over a cluster reveals the boundaries that enclose its markers.
    - Clicking a cluster will zoom the map to the boundaries of the clustered markers.
- When a **Base Station marker is part of a cluster**, the following elements will not be displayed:
    - The connection Line linked to that marker.
    - The pinned information panel.
    - The Interference related display information, when applicable.

These elements will automatically reappear once the marker is un-clustered (e.g., by zooming in).

Non-Clustering Mode

- When the **map zoom level is 1km or lower**, clustering is disabled.
- In this mode, only base station markers that fall within the current map view are rendered to optimize performance.
- As a result, you may observe Base Station markers appearing or disappearing as you pan or move the map.

Base Station's Information Panel

Hovering over a base station marker opens a panel displaying comprehensive information about the selected base station. This information includes:
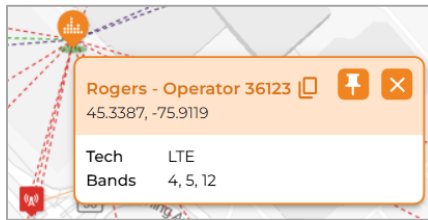
- Operator name
- Base station ID
- Location (latitude, longitude)
- Technology types and band

In addition, users can pin the panel to persist the view and use the copy button to copy the Operator text.

Event Configuration and Description

SXM provides a Notification Service allowing users to create alert events to detect any 3GPP deployment changes with the SXM captured data. This section will go over the 3GPP available events in specific. For viewing the logs generated from these events and performing events management, refer to the Notification Service chapter.

Creating and Managing a 3GPP Event

To create a new event, from the Left menu bar, select "**New Event Configuration**" as shown in the following picture. "3GPP Network Analytics" is selected by default for the **Source** field.

Follow the instructions of Create a New Event of the Notification Service for more details.

To manage the created event, refer to the Event Management section.

List of Events

The section provides explanatory information for each 3GPP event defined by thinkRF. Each event will be described with the following information:

Description	A brief description of the Event. It might have more explanation details than the brief description provided on the Dashboard.
Default Alert Type	thinkRF's predetermined Alert level for convenience. Users could change the level during the Event creation or editing to fit their needs. Refer to Supported Event and Alert Types for more information on the types.
Additional User Input Field(s)	Some Events require additional input from users to tailor the Event to their needs.
Alert Logic	The algorithm or comparison logic that leads to an alert trigger and, thus, the log generation and notification.
Baseline Building Period	The historical data timeframe defines how the baseline for event triggering is established. If a period is specified, it will be the time range preceding the event creation date. Some events use the first incoming data record as their baseline, while others require the use pre-accumulated historical data to minimize false alerts during the initial baseline formation. **Note:** A node deployed at a new location will likely trigger many new events as its historical data does not exist at that location.
Log Output	The message to be provided in the log capture. The log includes values of some key relevant parameters from the new captured data record for quick reference.

Notes:
   - Unless specified in the explanation, 3GPP events used fully decoded SIB1 data with Decode Level **PDSCH** to avoid providing false alerts.
   - The same data record can lead to more than one event alert if it contains values satisfying the events' conditions.

MIMO Configuration Change with Fully Decoded Data

Description	This event detects changes in MIMO / Antenna configuration from 2x2, 4x4, or higher to any other configuration (and vice versa) of a NodeB with PDSCH decode level.
Default Alert Type	Info
Additional User Input Field(s)	No
Alert Logic	For each unique operator, NodeB ID and Cell ID combination, compare the Antenna values for each downlink Frequency.
Baseline Building Period	First new data record is used as the baseline.
Log Output	Detected Antenna change from <old> to <new> (MCC <val>, MNC <val>, NodeB ID <val>, Cell ID <val>, Frequency <val> MHz). Example: Detected Antenna change from 2 to 4 (MCC 320, MNC 20, NodeB ID 12345, Cell ID 20, Frequency 2450.1 MHz).

MIMO Configuration Change for All Decode Level

As this event is not restricted to fully decoded SIB1 data, triggered events with non-PDSCH level should be used with caution.

Description	This event detects changes in MIMO / Antenna configuration from 2x2, 4x4, or higher to any other configuration (and vice versa) of a NodeB with any Decode Level.
Default Alert Type	Info
Additional User Input Field(s)	No
Alert Logic	For each unique operator, NodeB ID and Cell ID combination, compare the Antenna values for each downlink Frequency of any Decode Level.
Baseline Building Period	First new data record is used as the baseline.
Log Output	Detected Antenna changes from <old> to <new> (MCC <val>, MNC <val>, NodeB ID <val>, Cell ID <val>, Frequency <val> MHz). Example: Detected Antenna change from 2 to 4 (MCC 320, MNC 20, NodeB ID 12345, Cell ID 20, Frequency 2450.1 MHz).

Cell Barring Status Change per NodeB

Description	This event detects whether a base station (NodeB ID) or a specific sector changes its "cell barring" status, which determines whether user equipment (UE) is allowed to access it.
Default Alert Type	Info
Additional User Input Field(s)	No
Alert Logic	For each unique operator, NodeB ID and Cell ID combination, compare Cell Barring values for each downlink Frequency. "Invalid" Cell Barring value is not considered.
Baseline Building Period	First new data record is used as the baseline.
Log Output	Detected Cell Barring state changes from <old> to <new> (MCC <val>, MNC <val>, NodeB ID <val>, Cell ID <val>, Frequency <val> MHz). Example: Detected Cell Barring state changes from Y to N (MCC 320, MNC 20, NodeB ID 12345, Cell ID 20, Frequency 2450.1 MHz).

Spectrum Allocation Change per NodeB

Description	This event detects Spectrum Allocation changes at a base station (NodeB ID) for: 1. Newly deployed downlink frequency (which might indicate an ITU band has changed), or 2. Any shifts in the allocated bandwidth (BW) of a downlink center frequency.
Default Alert Type	Info
Additional User Input Field(s)	**Baseline Audit Period** – This input allows for specifying how often the baseline "Frequency" list should be updated to remove frequencies that no longer exist within that period, so that they can be treated as 'new' if they reappear later. Options: 1, 2, 3, 6, 12 months. Default 1.

	The audit is carried out on the 1st day of the month. For example, if the event is created on April 12th and 2 is selected for the audit period, then the next auditing days are June 1st, Aug 1st, and so on.
	
	When the audit is performed, if any frequency values are missing from the data records during the audit period, a log entry will be generated as such:
	      Frequency <val> MHz is not detected in the past <val> month[s].
	or:
	      Frequencies <val>, ..., <val> MHz are not detected in the past <val> month[s].

Alert Logic	For each unique operator and NodeB ID combination, 1. **New frequency detection**: An event is triggered when a newly captured data record contains a downlink frequency that is not present in the baseline. 2. **Bandwidth change detection**: For a given downlink frequency, detect for any BW value change. Note that for NR5G data, if its Downlink NR Frequency is -1, the data record is not used for checking. Note: The Bandwidth of the new Frequency will not trigger an alert.
Baseline Building Period	90 days preceding the event creation date. When the Frequency baseline is created, the Bandwidth baseline of each Frequency is established as well.
Log Output	Detected a new **Frequency** <val> MHz at NodeB ID <val> (MCC <val>, MNC <val>, RAT <val>, Band <val>). Example: Detected a new Frequency 2180.5 MHz at NodeB ID 12345 (MCC 320, MNC 20, RAT NR5G, Band 4). or: Detected a **Bandwidth** change from <old> to <new> MHz at NodeB ID <val> (MCC <val>, MNC <val>, Frequency <val> MHz, RAT <val>, Band <val>). Example: Detected a Bandwidth change from 10 to 20 MHz (MCC 320, MNC 20, NodeB ID 12345, Frequency 2450.1 MHz, RAT NR5G, Band 4).

NodeB (Base Station) Change per Operator

Description	This event detects any new base station deployment by an Operator using NodeB ID. Note that this change might indicate a change in the RAT as well.
Default Alert Type	Info
Additional User Input Field(s)	**Mobility Mode** Options: Mobile, Parked & Stationary. Default options: Parked & Stationary. <u>Note:</u> We recommend avoiding Mobile mode unless it is intended, as a node in a moving vehicle is likely to detect new NodeB IDs frequently, which can result in many alerts being triggered.
Alert Logic	For each unique operator (new or existing), check for a new base station (NodeB ID) that does not exist in the baseline database. When an event is first created, the list of known NodeB IDs is built using the baseline period (90 days) and continues to accumulate throughout the event's lifetime.

Baseline Building Period	90 days preceding the event creation date.
Log Output	Detected a new NodeB ID <val> for [name] operator with MCC <val> and MNC <val> (RAT <val>, Frequency <val> MHz, Bandwidth <val> MHz, Band <val>). Note: [name] is added only if the operator's name is known. Example: Detected a new NodeB ID 12345 for operator with MCC 1 and MNC 200 (RAT NR5G, Frequency 2450.1 MHz, Bandwidth 10 MHz, Band 4).

RAT Protocol Change per Operator

Description	This event detects any change in the RAT protocol by an Operator within a frequency range (defined by Frequency and Bandwidth).
Default Alert Type	Info
Alert Logic	For each unique operator, check for any RAT protocol change within a frequency range (which is downlink Frequency +/- Bandwidth/2). Note: no alert is triggered for the BW of a new operator.
Baseline Building Period	90 days preceding the event creation date.
Log Output	Detected RAT change from <old> to <new> for [name] operator with MCC <val> and MNC <val> (Frequency <val> MHz, Bandwidth <val> MHz, NodeB ID <val>[, *and <old_DSS> to <new_DSS> or both of DSS type*]). Note: […] text is conditional on the existence of the value, as such: • [name] is added only if the operator's name is known. • [DSS info] if DSS value exists in the data. Examples: Detected RAT change from LTE to NR5G for operator with MCC 1 and MNC 200 (Frequency 2450.1 MHz, Bandwidth 10 MHz, NodeB ID 12345). Or with DSS change: Detected RAT change from LTE to NR5G for operator with MCC 1 and MNC 200 (Frequency 2450.1 MHz, Bandwidth 10 MHz, NodeB ID 12345, and notDSS to DSS).

Interference Management

> **Note:** This application is only available to subscribed users. Contact your SXM Dashboard business account manager or sales@thinkrf.com for any subscription queries.

In the rapidly evolving landscape of mobile communications, the deployment of 3GPP networks has been instrumental in driving forward global connectivity and technological innovation. However, as network deployments become denser and cross-national borders, the complexity of managing and mitigating interference between base stations has significantly increased. This complexity is further magnified when different operators within the same country share overlapping frequencies, leading to potential disruptions in service quality and network performance.

For example, in cellular networks based on 3GPP (4G LTE, NR5G) standards, a User Equipment (UE) (such as a smartphone or IoT device) selects and maintains a connection with the best available serving base station (BS) based on signal measurements. However, interference from a nearby non-serving base station can degrade the link quality, leading to connection failures, call drops, or handover issues.

Interference issues, particularly those that transcend national borders or involve multiple operators, pose unique challenges that require sophisticated detection and resolution strategies. Traditional methods often fall short in addressing these challenges due to their reactive nature and limited scope of analysis.

Designed with modern technologies and ease-of-use focus, SXM Interference Management solution empowers users to proactively and effectively assess misalignment-based interference insights between BSs, facilitate the management of network performance and prevention of service degradation; thus, maintaining the integrity and efficiency of 3GPP network operations.

The Interference Management is classified into two applications:

- Cellular → Cellular Network interferences
- Cellular → Non-Cellular Network interferences

How Does Cellular → Cellular Network Interference Work?

The solution is engineered to continuously monitor and analyze in real-time the interference in LTE and 5G networks autonomously, without the need for manual input. The SXM system collects real-time 3GPP data from active base stations and measuring parameters such as RSSI, RSRP, RSRQ, and SINR. It continuously monitors frequency, bandwidth, FDD and TDD frame structures and identifies misalignments between neighboring base stations. It analyzes uplink and downlink transmissions to pinpoint cases where overlapping frequencies cause interference, particularly when the uplink of one base station interferes with the downlink of another.

By scanning spectrum usage in real time, SXM detects timing mismatches, unauthorized frequency usage, and conflicts between different operators or networks, including cross-border interference. Once an issue is detected, SXM provides real-time alerts and detailed insights, enabling operators and regulators to take corrective actions such as resynchronizing TDD frames or adjusting frequency allocations to minimize disruption and maintain network performance.

How Does Cellular → Non-cellular Network Interference Work?

While traditional cellular-to-cellular network interference often involves complex synchronization, timing, and power control misalignments between adjacent base stations, interference between 3GPP (e.g., LTE, 5G) and non-3GPP cellular systems (e.g., fixed satellite services, radar, or aviation systems) is predominantly driven by frequency overlap. These conflicts arise when newly deployed 5G base stations operate within or adjacent to bands historically allocated to non-cellular services, such as satellite downlinks or air traffic control systems.

In these scenarios, non-3GPP cellular systems — which are not designed to coexist with modern cellular emissions—can experience severe performance degradation due to the proximity or leakage of high-power cellular signals into their sensitive operating frequencies.

The thinkRF SXM solution addresses this challenge by enhancing its 3GPP interference detection application to include non-3GPP cellular spectrum analysis. SXM continuously scans and captures real-time 3GPP signal data—including frequency, bandwidth, and power characteristics—from multiple nodes deployed throughout the region. It performs frequency overlap analysis by cross-referencing the detected 3GPP signal footprints with the pre-definded or user-defined non-3GPP spectrum allocations, identifying where emissions from cellular base stations intrude into protected or co-allocated bands.

Using the Interference Management Application
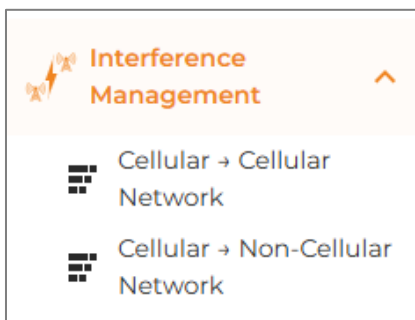
The Interference Management application is accessible from the left menu, as shown in the left figure. This section will go over the usage in detail.

The data source used for the analysis of this application is from 3GPP Network Analytics. Related terminologies are described in the Dashboard's Help page.

Data Location Selection

Refer to SXM Node's Functions Relating to Dashboard section for how to perform Sites selection. This section will go over selection and filter details specific to this application's usage.

Map's Node Selection

Node selection method is similar to that of 3GPP Network Analytics with the exception that "Cellular → Cellular Network" interferences only works with static data sites (Stationary or Parked sites from a driving route), not Routes of a moving (mobile) node.

Map Filter Selections

Cellular → Cellular Filters

Refer to Map Filter's Date Range section for the **Date Range** information. The selected Date Range determines the values shown for the other fields shown in the Filter.

- Refer to SXM Node's Functions Relating to Dashboard section for information on **Mobility Mode**, **SXM Nodes** and **Measurement Sites**.
- **Interfered Operator** – Select which "Interfered" Operator should be presented. This is the Operator of the Base Station that is being impacted by the Interfering Base Station.
- **Interferer Operator** – Select which "Interferer" Operator should be presented. This is the Operator of the Base Station that is causing the Interference.
- **Technology** – A list of the Radio Access Technology (RAT) type.

- **ITU Band** – A list of 3GPP band values for LTE or 5G from SIB1.

Cellular → Non-Cellular Filters

 Refer to Map Filter's Date Range section for the **Date Range** information. The selected Date Range determines the values shown for the other fields shown in the Filter.

- Refer to SXM Node's Functions Relating to Dashboard section for information on **Mobility Mode**, **SXM Nodes** and **Measurement Sites**.
- **Interfered Band of Interest** – Select a predefined Band or create your own custom band.
    - **Start/Stop Frequency** – The range of frequency associated with the selected band.
    - **Add Custom Band** – Create a new custom band for the interference detection. Admins can create Corporate custom bands visible to all users, while both Admins and Authors can create Private custom bands.
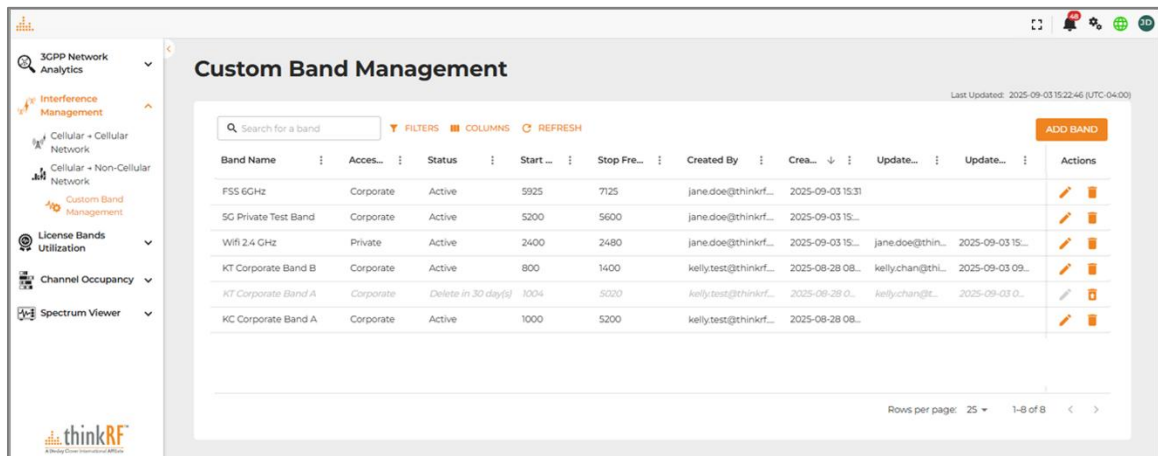
Once created, the process may take up to 15 minutes to generate results, if any are available.

- **Interferer Cellular Network** – Select which "Interferer" Operator network should be presented. This is the Operator of the Base Station that is causing the Interference.
  - **Technology** – A list of the Radio Access Technology (RAT) type.
  - **ITU Band** – A list of 3GPP band values for LTE or 5G from SIB1.

Managing Custom Bands for Non-Cellular Interference

The **Custom Band Management** page is a centralized location for creating a new custom band and editing or deleting an existing band. The table aligns with the SXM Dashboard's administrative table layout, offering search and filter options for the details, column management, and automatic refresh every five minutes.
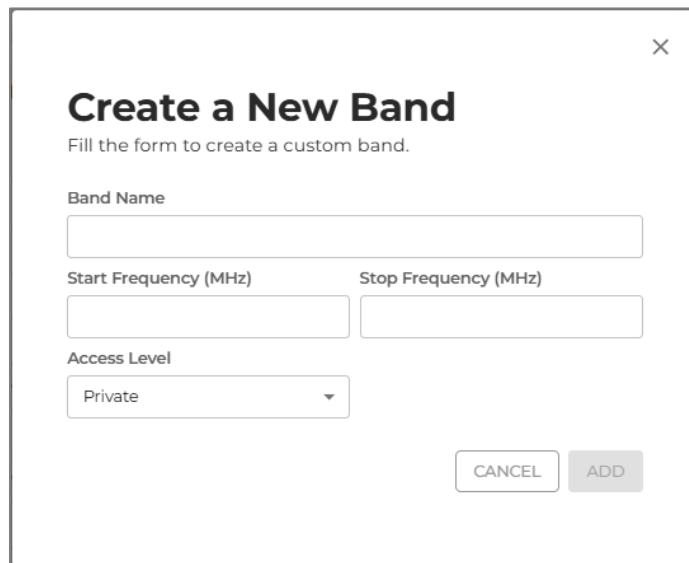
Created / Updated Date and **Create / Updated By** columns provide handy information of who created or edited the event and when. Other columns provide quick information view and status of the bands.

Create a Custom Band

Users can create a new Event in two ways:

- Using **ADD BAND** button from the Custom Band Management page or
- By clicking on the **+ Add Custom Band** in the "Cellular → Non-Cellular" tab of the map Filter panel.

A new Band form is as shown below.

- **Band Name** – Allow for assigning a custom name to the band for easy identification. Use a meaningful description to help identify this band among others in the band list.
- **Start/Stop Frequency** – The frequency range of interest for the band, in MHz.
- **Access Level** – Provide two visibility access levels:
  - **Corporate** mode – A custom band with the Corporate access level can be seen and used by all users of that corporate. It has the following attributes:
    - Only Admin users can create a Corporate band type, which can be modified by another administrator.
    - Corporate bands will remain available even if the Admin user, who created the band, has been deactivated or changed to a lesser role.
  - **Private** mode – Private band type is available for Admin and Author users who want to monitor their own bands. These bands are only visible to the event creator.

Update a Custom Band

From the Custom Band Management page, click on the Edit ✎ button to bring up the Edit form.

Delete a Custom Band

From the Custom Band Management page, click on the Delete 🗑 button to delete a band. A prompt panel will appear, informing you that thinkRF provides a 30-day grace period before the custom band and its data is permanently removed from the SXM system. The Band will appear in a *light grey, italicized font* in the table for easy identification from the other bands

In addition, the Status column in the table will show how many days until the Band is permanently deleted as shown below.

Band Name	Acces...	Status	Start ...	Stop Fre...	Created By	Cre... ↓	Update...	Update...	Actions
FSS 6GHz	Corporate	Delete in 30 day(s)	5925	7125	jane.doe@thinkrf...	2025-09-03 15...	jane.doe@thi...	2025-09-03 16...	✎ 🗑

An Event pending deletion within the 30 days grace period can be restored by clicking on the orange Restore 🗑 button. The detection will continue during this period such that when restored, no data is missed.

Understanding Interference Map and Charts
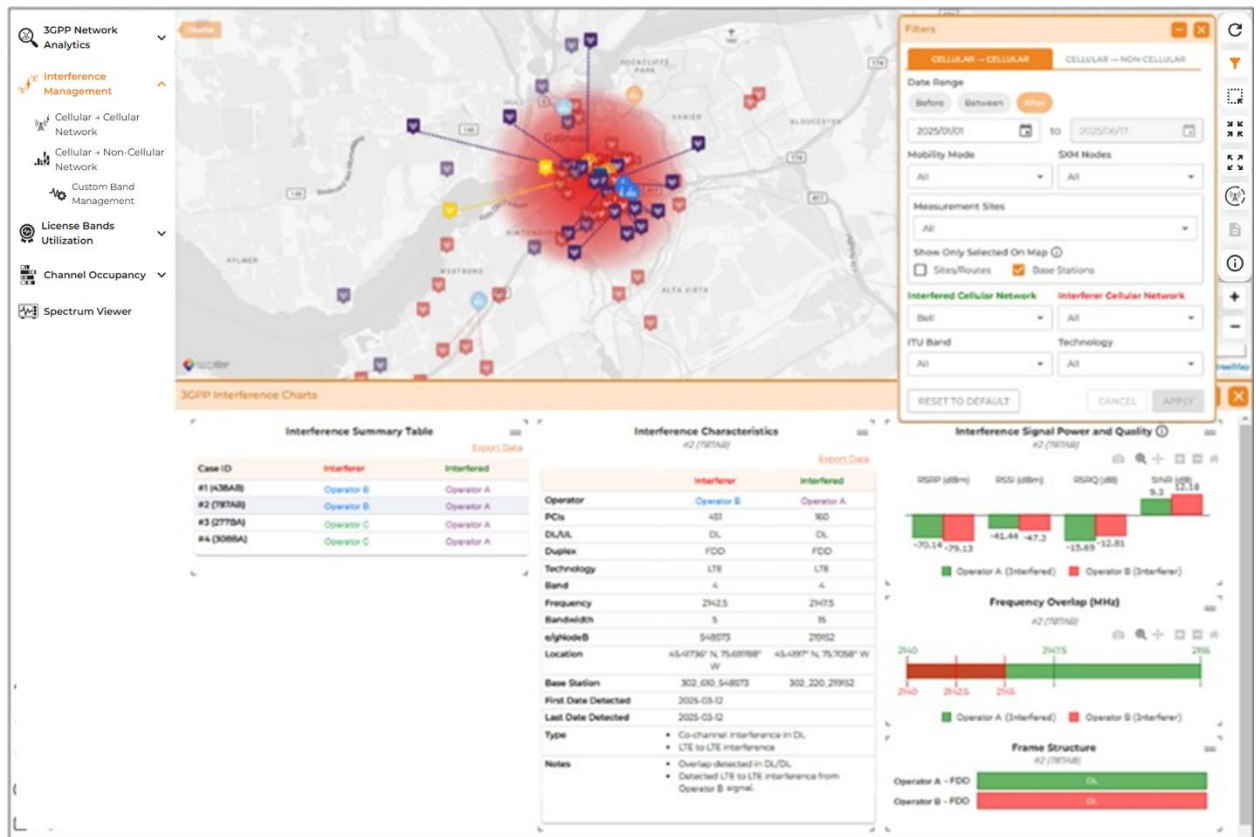
The Cellular → non/Cellular Network interference charts (as shown above for example) provide a visual representation of detected interference situations across cellular/3GPP (2G, 3G, LTE, 5G) and non-cellular networks, displaying interference levels, signal quality, and affected base stations or non-cellular bands. These charts help users quickly identify interference sources, analyze severity, and understand network misalignments. Refer to Base Station Markers Clustering for details regarding the Base Stations clusters usage.

The SXM System automatically detects Cellular → Cellular/non-Cellular Network interference situations (such as due to network misalignments) and generates these charts based on the map Filter settings, historical data and/or real-time measurements. The map Filter settings must be configured at first usage. When interference issues are detected, users will be presented with the Interference cases as shown in the previous figure, displaying:

- Analysis data and charts,
- Involving Base Station and Measure site markers **with bouncing effect** for quick visual identification,
- A concentric red circle, surrounding the interfering base station, represents the **Potential Interference Zone**. The zone is an estimated region where network performance may be degraded due to the misalignment. The range of the red circle is correlated with the interference frequency as such:

Frequency (MHz)	Technology	Average Coverage Estimate (km)
600-990	LTE/5GNR	4.5
1500-2290	LTE/5GNR	2.5
2300-2800	LTE/5GNR	1.25
3300-3900	LTE/5GNR	0.7

Note: The **Average Coverage Estimate** values represent projected cell coverage by combining data from Dense, Urban, and Suburban areas but do not reflect actual real-world frequency coverage, serving only as a general reference on the map.

When there are no interference issues for the filter settings, a message will be displayed in the chart as shown below.

3GPP Interference Charts

Interference Summary Table

No interference detected for the current filters
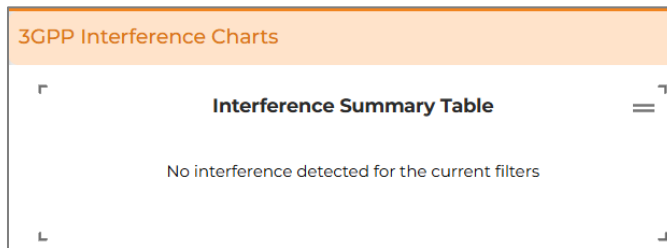
Understanding the "Potential Interference Zone"

The Potential Interference Zone is determined using a first-order assessment that takes into account:

- **Received Power (RSSI/RSRP)** – Measured at the SXM node location to estimate the interfering base station's signal strength.
- **Frequency Band in Use** – Lower frequency bands (e.g., Sub-1 GHz) generally result in wider interference zones due to their increased propagation range.
- **Geographic and Network Context** – The area impacted is influenced by surrounding network conditions, such as cell density and terrain are not considered in this assessment.

Cellular → Cellular Network Charts

This section will go over the charts displayed in detail.
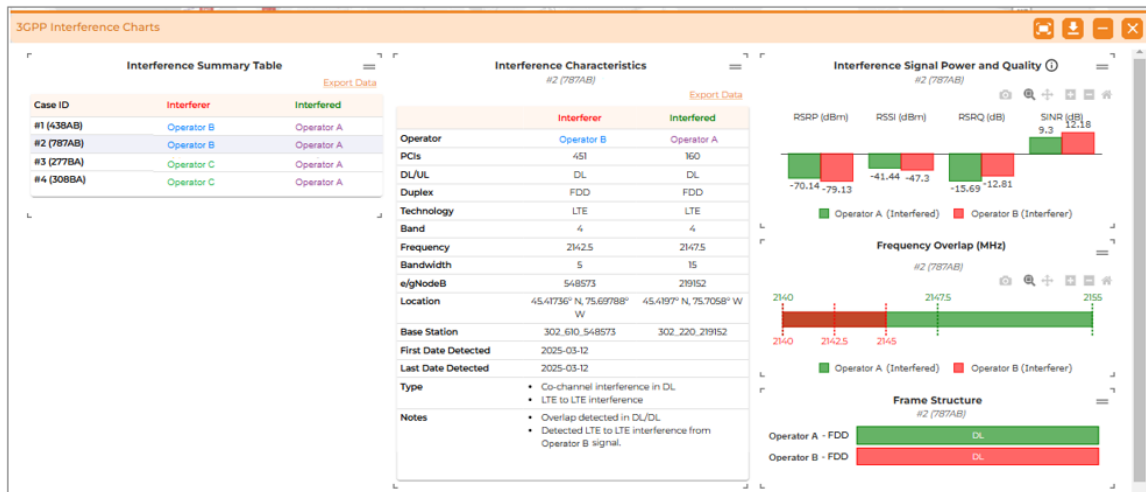
Refer to Charts Exploration section for the usage information. Data in the charts could be exported using the export button [icon] locate on the top right of the panel.

Interference Summary Table

This table displays a list of detected interference cases, showing:

- **Case ID** – a unique ID for identifying the case detected at the time for analysis. This ID is important for report to thinkRF for any support request.
- **Interferer** – source of interference, an operator's base station.
- **Interfered** – impacted operator (its base station).

Interference Characteristics Table

This table displays the following technical attributes of the decoded RF from a selected interference event for both operators/base stations:

- **Operator** – Interfering and interfered operators
- **PCIs** – Physical Cell Identifiers of the base stations
- **DL/UL** – Downlink (DL) or Uplink (UL) path involved in the interference
- **Duplex Mode** – FDD or TDD mode of interference, revealing if there is a mismatch
- **Technology** – LTE or NR5G technology
- **Band** – The ITU band number
- **Frequency** – The operating frequency of both networks
- **Bandwidth** – The spectrum width of the interfering and interfered base stations
- **Location** – Geographical position of the base stations
- **Detection Dates** – When the interference was first and last detected
- **Type** – Report the types of interference detected, which include:
    - LTE to LTE interference
    - NR5G to LTE interference
    - NR5G to NR5G interference
    - Co-channel interference in DL
    - Co-channel interference in UL
    - Adjacent interference in DL
    - Frame structure mismatches
- **Notes** – Provides suggestive insights into overlaps or mismatches causing interference

Interference Signal Power and Quality Chart

This chart indicates signal strength metrics as seen from the SXM Node location, such as:

- **RSRP** (Reference Signal Received Power) – Measures specific cell signal strength.
- **RSSI** (Receive Signal Strength Indicator) – Measure total received power.
- **RSRQ** (Reference Signal Received Quality) – Measures quality of the received reference signal, including interference effects.
- **SINR** (Signal-to-Interference-plus-Noise Ratio) – Measures the overall signal quality in a noisy environment.

When "Weak signal detected; no power values" message is displayed, this means interference is present, but signal measurements are insufficient to quantify the exact impact.

Frequency Overlap Chart

This bar chart provides a visual comparison of the frequencies and bandwidths of the interfering and interfered operators/base stations. The dotted vertical lines indicate start and stop frequencies, showing where the overlap occurs, causing interference.

Frame Structure Chart

This bar chart provides a quick usual aid for the frame structure mismatch when it occurs. An additional example of Frame Structure mismatch between FDD to TDD:
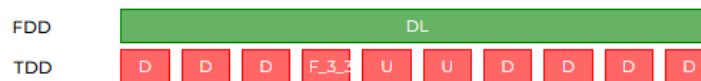
Cellular → Non-Cellular Network Charts
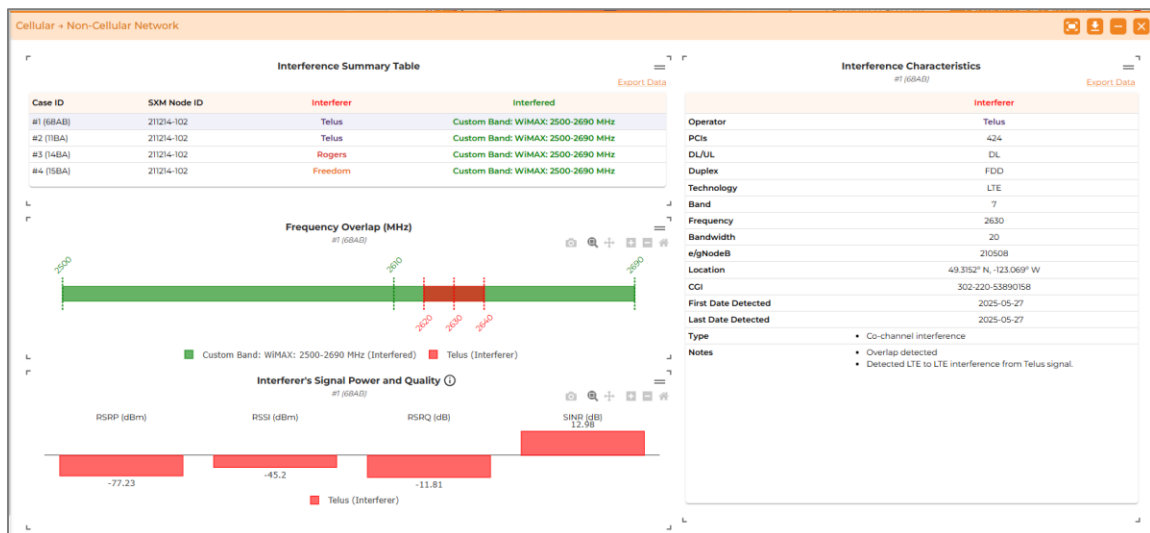
Interference Summary Table

This table displays a list of detected interference cases, showing:

- **Case ID** – a unique ID for identifying the case detected at the time for analysis. This ID is important for report to thinkRF for any support request.
- **Interferer** – source of interference, an operator's base station.
- **Interfered** – impacted Bands.

Interference Characteristics Table

This table reveals the following technical decoded RF attributes from the Interferer operator of a selected interference event:

- **Operator** – Interfering operator
- **PCIs** – Physical Cell Identifiers of the base stations
- **DL/UL** – Downlink (DL) or Uplink (UL) path involved in the interference
- **Duplex Mode** – FDD or TDD mode of interference, revealing if there is a mismatch
- **Technology** – LTE or NR5G technology
- **Band** – The ITU band number
- **Frequency** – The operating frequency of the interfering network
- **Bandwidth** – The spectrum width of the interfering base station
- **Location** – Geographical position of the base station
- **Detection Dates** – When the interference was first and last detected
- **Type** – Report the types of interference detected, which include:
  - LTE to <band name> interference
  - NR5G to <band name> interference
  - Co-channel interference in DL
  - Co-channel interference in UL
  - Adjacent interference in DL
- **Notes** – Provides suggestive insights into overlaps causing interference

Interference Signal Power and Quality Chart

This chart indicates signal strength metrics of the interfering operator as seen from the SXM Node location, such as:

- **RSRP** (Reference Signal Received Power) – Measures specific cell signal strength.
- **RSSI** (Receive Signal Strength Indicator) – Measure total received power.
- **RSRQ** (Reference Signal Received Quality) – Measures quality of the received reference signal, including interference effects.
- **SINR** (Signal-to-Interference-plus-Noise Ratio) – Measures the overall signal quality in a noisy environment.

When "Weak signal detected; no power values" message is displayed, this means interference is present, but signal measurements are insufficient to quantify the exact impact.

Frequency Overlap Chart

This bar chart provides a visual comparison of the frequencies and bandwidths of the interfering operator and interfered Band. The dotted vertical lines indicate start and stop frequencies, showing where the overlap occurs, causing interference.

Interpreting Interference Results

Cellular → Cellular Network

Key Observations from Node-Based Measurements

1. Node is near the interfered BS (strong RSRP, good RSRQ/SINR from the interfered BS)
   a. High RSRP of interfered BS suggests strong coverage.
   b. Good RSRQ/SINR means minimal interference, allowing reliable connection.

2. Node is between the interfered and interfering BSs (Moderate to High RSRP, Moderate to Good RSRQ/SINR from the interfered BS).
   a. Moderate RSRP, RSRQ and SINR provide acceptable services.
   b. Users may experience some deterioration in busy hours or when the cell is congested.
3. Node is between the interfered and interfering BSs (Moderate to High RSRP, Poor RSRQ/SINR from the interfered BS)
   a. RSRP is still acceptable, but RSRQ/SINR is poor due to interference.
   b. Users may experience service deterioration, signal drops, or forced handover.
4. Node is near the interfering BS with High RSRP (Low RSRP, Poor RSRQ/SINR from the interfered BS)
   a. RSRP from the interfered BS is weak, making connection difficult.
   b. Bad service access and user experience.

These insights allow operators to predict key areas where user's experience would be downgraded and if immediate action should be taken.

Auto-Insight Provided from Multiple-Measurements Locations

The SXM system continuously monitors and analyzes signals from both interfering and interfered base stations, offering deep insights into network misalignment and coverage overlap.

This will visually demonstrate how interference changes based on node placement.

Key Takeaways

The comprehensive SXM 3GPP Cellular → Cellular network interference detection provides:

1. Potential Connection Predictions
   a. Using RSRP, RSRQ and SINR trends, the system predicts whether a UE can maintain a reliable connection at a given location.
   b. By identifying poor RSRQ and SINR zones, operators can pre-emptively optimize cell parameters before users experience disruptions.
2. Optimized Handover and Resource Allocation
   a. Identifying high-interference areas allows operators to adjust handover thresholds, redefine neighbor lists, and fine-tune power settings to prevent unnecessary UE handovers.
   b. Frequency planning adjustments can be made to mitigate interference hotspots.
3. Proactive Spectrum Management
   a. Regulators and spectrum managers can use these insights to monitor cross-border interference, detect rogue transmissions, and enforce compliance with licensing policies.

Auto-Insights of the **SXM 3GPP Cellular → Cellular Network interference detection** feature provide a proactive and intelligent approach to interference assessment in LTE and 5G networks. By leveraging real-time measurements of RSSI, RSRP, SINR and RSRQ, this feature enables operators to visualize interference dynamics, predict UE connection success, and optimize network performance before service degradation occurs.

Cellular → Non-Cellular Network

Key Observations from Node-Based Measurements

1. SXM Node is near a 3GPP BS (supporting 5G/LTE in this releases) emitting into a non-cellular band (RSSI/RSRP reported, matching frequency overlap)
   a. The SXM node detects strong received signal power from the nearby cellular base station.
   b. Frequency overlap with nearby non-cellular services (e.g., satellite or LMR) is identified.

      c. High probability of interference impacting sensitive non-cellular systems operating in adjacent or co-allocated frequencies.
2. Node is within the Potential Interference Zone (Moderate RSSI/RSRP, frequency overlap detected)
      a. Interfering signal strength is moderate, but SXM confirms frequency leakage into non-cellular band.
      b. Impact severity depends on non-cellular receiver sensitivity and coexistence capability.
3. Node detects low-level emissions within protected non-cellular band (Low RSSI/RSRP, still measurable interference)
      a. Emissions from distant or lower power 3GPP sources are still measurable within non-cellular allocations.
      b. This could contribute to cumulative degradation, particularly in satellite or aviation systems with low-noise requirements.
4. No significant interference observed (Low RSSI/RSRP, no frequency overlap)
      a. SXM node shows no signs of in-band or adjacent band interference.
      b. Visual chart indicates a "No Interference" message per map filter settings.

The SXM system extends conventional 3GPP interference detection capabilities by adding the ability to analyze and interpret interference within non-cellular frequency bands. It identifies interference where cellular emissions intrude into protected bands, using frequency footprint matching and map-based analytics.

Key Takeaways

The SXM system offers a robust solution for detecting interference between 3GPP cellular and non-cellular networks:

1. Predictive Interference Mapping
      a. Real-time and historical data allow prediction of potential interference in sensitive non-cellular bands.
      b. SXM maps enable proactive protection of aviation, satellite, and public safety services.
2. Policy and Compliance Support
      a. Spectrum managers and regulators can detect violations of band co-existence rules or unauthorized emissions.
      b. Supports investigations into cross-border, out-of-band.
3. Mitigation and Engineering Optimization
      a. Helps MNOs refine frequency planning and down-tilt, power, or filtering to reduce spillover.
      b. Assists in coordinating coexistence strategies between 3GPP and non-cellular systems.

The **SXM Cellular → Non-Cellular Network Interference Detection** offers a powerful, automated feature for identifying and mitigating conflicts between modern mobile networks and legacy or critical infrastructure systems. Using real-time spectrum analytics, operators and regulators gain a shared visibility into coexistence challenges and can act before service disruptions arise.

License Bands Utilization

The License Bands Utilization provides a graphical summary of 3GPP spectrum licenses in the area, who is using them and what they are being used for. When nodes are selected on the Dashboard, the license jurisdiction(s) involved will be shown on the map. Two complementary perspectives are provided to analyze spectrum license usage:

- License Occupancy by Band
- License Usage by Band

The Application compares spectrum licenses that have been compiled from the relevant national regulatory authority with what SXM has confirmed at that location. This perspective enables regulators and associated authorities to evaluate:

- Are licensees in compliance with the terms of their license?
- Are public spectrum assets being efficiently used?
- Should existing licenses be reallocated to other licensees or applications?
- Should existing licenses or policies be re-evaluated and if so, how should they change?

Meanwhile, mobile operators and others can:

- Identify opportunities for expanding networks into a new spectrum.
- Identify what spectrum is available for private networks.
- Characterize competitive strategies for spectrum usage and perhaps use this to lobby authorities for changes.

Hint: Use mouse over any plotted items of this Application, be it on the map or in the table, to see available hover-text information.

Map's Node Selection

Node selection method is the same as that of 3GPP Network Analytics as both applications use the same map, nodes, and source measured data.

License Occupancy by Band

This table summarizes how well used the various allocated spectrum licenses are at the specified site(s), organized by the Band Names, which may vary from country to country.

Note: Band Name refers to the designation or label assigned by thinkRF to enhance the comprehensibility and presentation of licensed frequency bands. These bands may conform to standards set by organizations like ITU/3GPP or may be established by a country's regulators without adhering to any specific standard or regulation.

3GPP licensees at the selected site(s) are listed, along with how much of their licenses have been in use during the specified date range. The *Allocated BW* column shows the total amount of spectrum licensed in MHz, along with the amount in use. To the right, that is further broken down specifically by band, showing how much of the licensee's license is being used.

Note: The Licensee may not be the same as the operator for any specific license. For example, Bell's 3500B license (ITU bands 49, 78) may show 100% occupied but it may have been sublicensed to Telus for usage. Details on who is using each license can be found in the License Usage by Band table, which is explained in the following section.
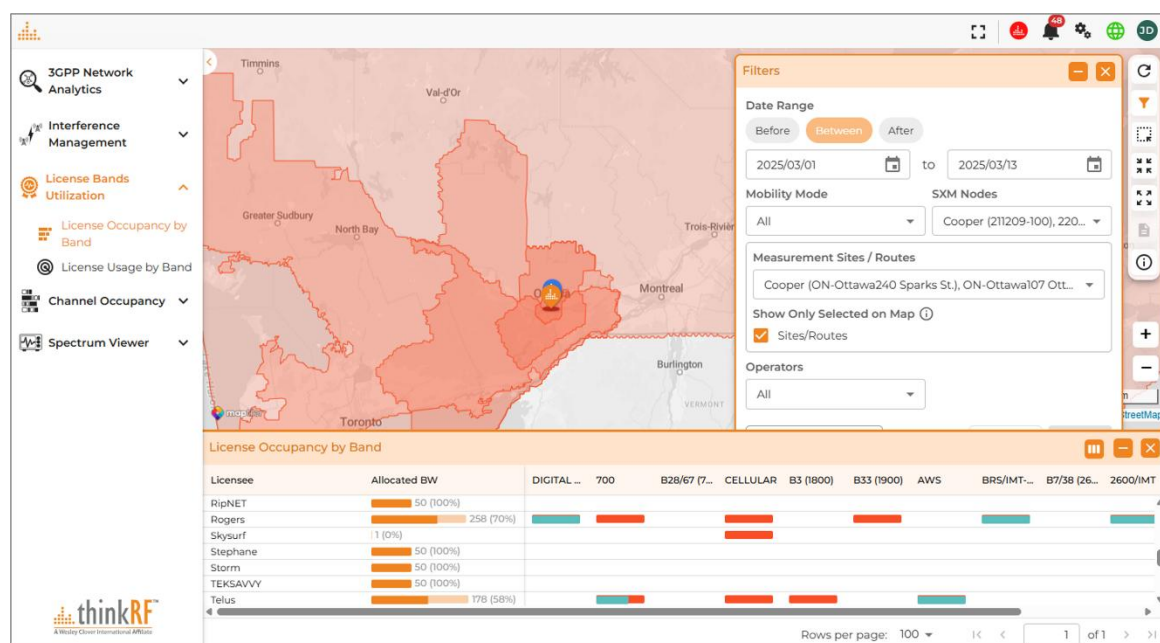
License Usage by Band

This table provides further breaks down information about license usage at selected site(s), complementing what the License Occupancy table shows for the same site(s). The license usage is organized and grouped by Band Names and the license jurisdictions involved.

For each Band Name, a chart is plotted showing

- which licensee owns which license spectrum (the frequency range) within the Band, and
- which operator is using which specific portions of each license and for what technology.

The licensee or operator shown in the chart are given distinct colors, typically matching their brand's dominant color when possible. See the following picture as an example.

Each chart shows at the base the "Licensee" row, with the licensee(s) and its portion of the band licensed outlined. Above the Licensee is a line for each technology being used in that band (2G, 3G, LTE or NR5G). Should the band be completely *unoccupied*, there will be no technology listed above the Licensee.

Similar to the Licensee line, for each technology line each Operator using that band is shown along with the portion of the spectrum being broadcast on. Note that the Licensee may not match the Operator depending on specific sub-licensing implementation in the jurisdiction.

If SXM was unable to definitively determine the Operator (e.g. for some versions of 5G NSA or if the channel was of insufficient quality to fully decode), the Operator using that spectrum range will be listed as "Unknown", with a default grey color.

Operators may have overlapping spectrum regions. This may happen if multiple sites are selected where spectrum usage varies. It may be particularly common in license jurisdiction

border regions where operators from the other jurisdiction may be detected using the same spectrum as local operators.
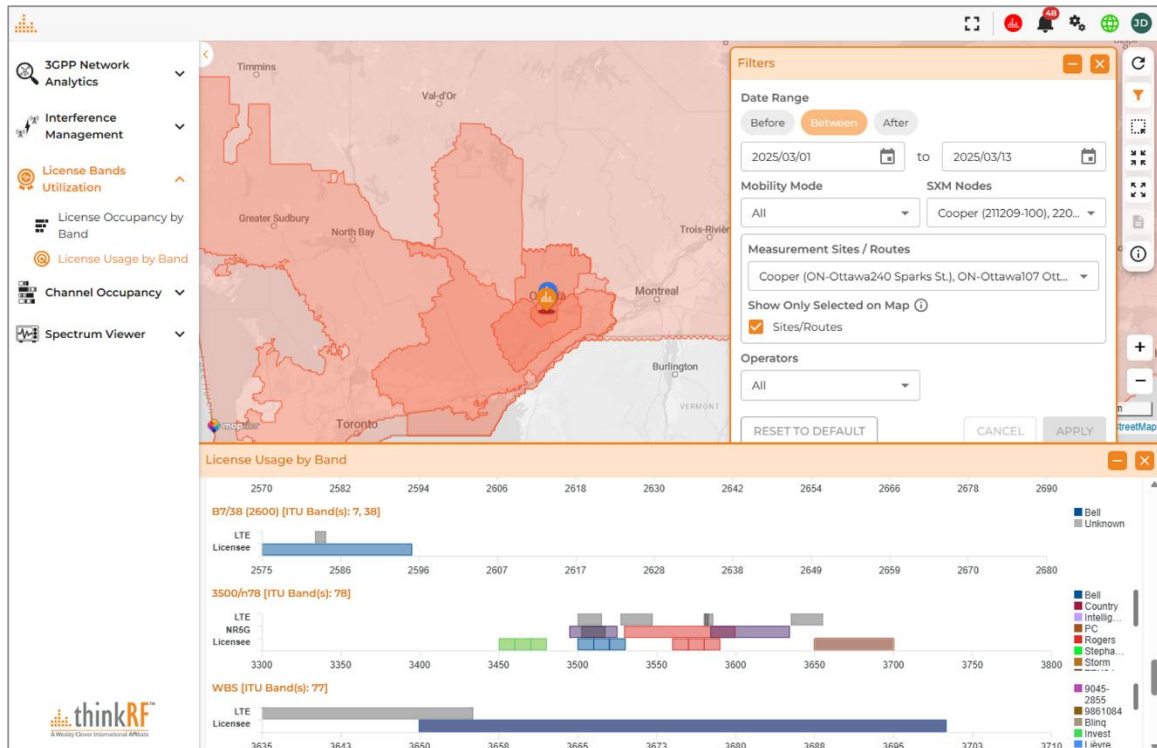
Hints: The chart is highly interactive with these mouse actions available:

   - hover over a line to see all the licensees/operators and the frequency range information associated with that line.

   - hover over the licensee/operator's name on the right side of the chart to see its plotted bar(s) visibly shown in the chart while the others will be dimmed out.

   - clicking on the licensee/operator's name on the right side of the chart to enable or disable its bar(s) from the chart.

Channel Occupancy

Note: This application is only available to subscribed users. Contact your SXM Dashboard business account manager or sales@thinkrf.com for any subscription queries.

The SXM Channel Occupancy application monitors and analyzes in real-time the frequency channel usage over a desired period at a fixed location, enabling proactive management. The results and insights are displayed in the user-friendly dashboard. Thus, providing an essential tool for RF engineers, spectrum managers, and communication service providers to monitor or optimize radio frequency (RF) spectrum utilization. With growing demand for wireless services, understanding of localized wireless service utilization is critical for efficient spectrum usage.

Channel Occupancy dashboard provides two main insightful and graphical data representations:

- **Sites Data** – source data as provided by the SXM sensor nodes.
- **Channel Occupancy Charts** – intuitive graphical insights to the collected data.

This chapter will cover the usage of the Channel Occupancy application, starting from configuring a node for a specific Channel Occupancy study.

Related terminologies are described on the Help page.

Node Configuration

To configure a node for the Channel Occupancy application, the user needs to access the "Node Configuration" form via the left menu under the "Channel Occupancy" application as shown in the following picture.

Refer to Node's Application Configuration Usage for the common usage details and notes.

Configuration Input Parameters

- **SXM Configurable Node** – Contain the nodes available for configuration, whether active or not.
- **Config Name** – Allow for assigning a custom name to the configuration for easy identification. Use meaningful description (such as band name or frequency range) to help distinguish this configuration among a list of configurations later.
- **Integration Time** – The analysis time (5,10,15 20, 30, 60 mins) to spend over the specified band(s). If the analysis is able to complete at least one cycle for the specified band(s), the channel data will be generated at the end of this "Integration Time". The default value is "15 mins" as recommended by ITU; however, by overserving the "Revisit Time (sec)" output from the Sites Data table, this time can be adjusted accordingly using the Node Configuration.
- **Study Settings** – Determine the analysis evaluation duration to spend on a configuration. There are two options listed below:
    - **Continuous** – The system will continuously monitor and measure the signal until a new configuration is applied.
    - **Study Period (Hours)** – A specific finite duration for the study, which can be interrupted if a new configuration is applied before the specified period is completed. Minimum is 1 hour.
- **Detection Threshold (dBm)** – The threshold above which the detected signal will be calculated for channel occupancy. Signals below this threshold will be considered as noise and ignored. The users can set the desired threshold for the noise floor or use "Auto Threshold" option.
    - **Auto Detection Threshold** – This method uses the power threshold level determined from the SXM receiver's factory-calibrated noise floor level,

supplemented by the user-defined **Squelch** (marginal) value in dB. When a channel's power exceeds this combined threshold, it is considered occupied.
- **Specification Option** – Provide 2 ways to configure a band:
  - **Range** – Support using a frequency range as the specification
  - **Center Frequency** – The channels are specified using center frequency and channel width as the specification method

  A configuration could have a mix of both specification types.
- **Channel Width (kHz)** – Determine the bandwidth of each channel, in KHz.
- Specification by **Range**:

Specification Options

Range

Band Type	Channel Width (kHz)
Known	1000

Band Name

Start Frequency (MHz)   Stop Frequency (MHz)

+ Add Subband

CLEAR   ADD

  - **Band Type** – Users specify either "Known" (predefined) bands or a "Custom" range of frequency band.
    - If "**Known**" band is selected, a list of predefined bands will be provided under **Band Name**. This list might be unique to each country; if a known band is missing, let us know using the Feedback form under the Help page.
    - If "**Custom**" band is used, provide a useful custom **Band Name**" (for easy identification in the application) and the **Start Frequency** (MHz) & **Stop Frequency** (MHz) for the band.
  - **Add Subband** – Allow adding particular frequency range(s) (subband(s)) within the band to narrow down the frequency range of study. The subband's frequency range, hence, cannot exceed the Band's range.
- Specification by **Center Frequency**:

  - **Band Name** – A useful name for easy identification of this center frequency setting in the application.
  - The frequency range for this method will start with **Start Center Frequency** (MHz), which is the center frequency of the first channel.
  - If there is more than one channel is desired, specify the **Frequency Spacing** (MHz) from one channel to the next and the **Number of Channels**. If only need 1 channel, *set Frequency Spacing to 0*.

Note: The number of channels calculated is determined by the Channel Width, the Band's frequency range, plus the Sub-band ranges when available.

When the **ADD** button turns orange, this implies the users can add the current band's settings to the **Bands List**. In the Bands List, each band will have the **Edit** and **Delete** buttons beside it, allowing for easy editing or removal of that band.

When the **START MEASUREMENTS** button turns orange, this indicates the configuration is ready for execution. Pressing this button will invoke a checking to see if there is an actively running configuration in the node or not. If there is, a warning panel will pop up asking the users to proceed or not; otherwise, the submission will be acknowledged.

Refer to Node's Application Configuration Usage for more usage details and the LOAD SAVED CONFIGURATION(S) feature.

Map's Node Selection

The node or "Measurement Site" selection for Channel occupancy, unlike that of 3GPP Network Analytics, allows the selection of **only one** node at a time to view its analytics data. Thus, the "Draw to Select" option is not available in Channel Occupancy's map.

A site in Channel Occupancy map can be selected in two ways:

- from the "SXM Node" selection list of the map Filter 🔻, or
- from the map using the mouse while holding down the SHIFT key. A previously selected node will automatically be deselected. Clicking on the currently selected node with the SHIFT key will deselect it as well.
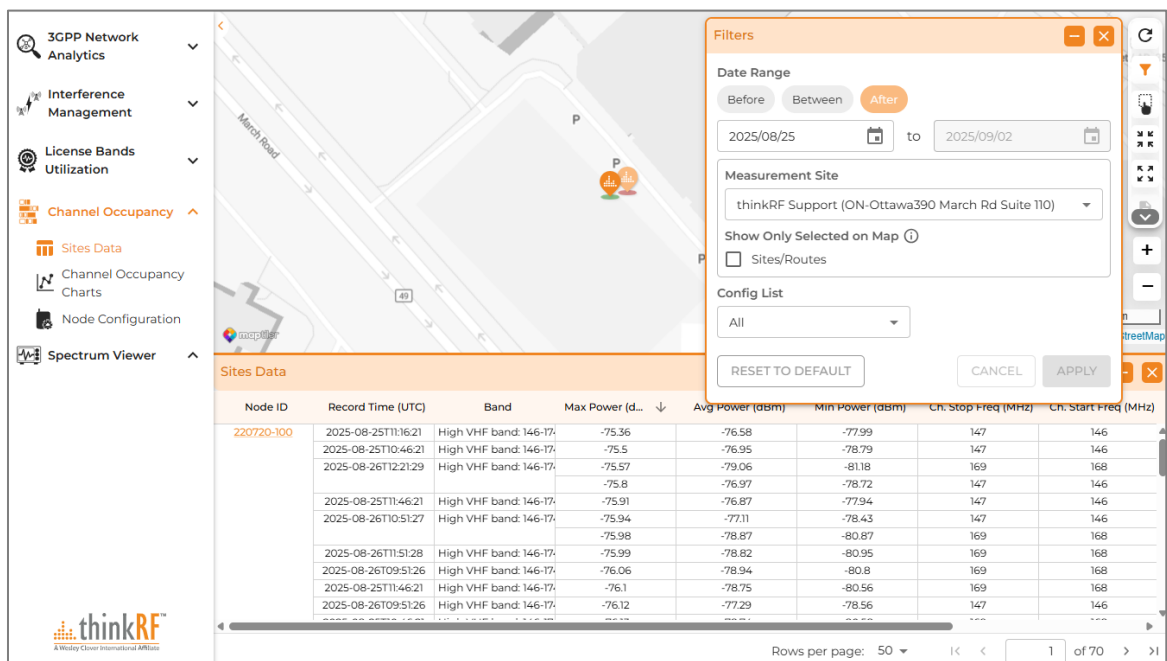
After selecting the site, their information will be reflected in the map Filter's fields and Tables.

To understand the "Measurement Sites", refer to SXM Node's Functions Relating to Dashboard and its subsection.

Sites Data

Once the node is configured (see Node Configuration) to monitor the desired band(s) (or frequency range(s)), the data is collected and sent to the cloud at the end of each Integration Time. When a node is selected on the Channel Occupancy map or in the map's filter, the Sites Data table displays the collected data for that node, based on one or more configurations, depending on the selected date range in the map's Filters. In other words, the 'Date Range' of the map Filter dictates which configuration's data records are to be shown, not from a configuration start or end date which is beyond the Filter's 'Date range'.

The "Config Name" column will show which data belongs to which configuration. Users can either filter the configuration using "Config Name" column or "Config List" of the map's Filter.

Each timestamped data record is provided in a tabulated format that enables filtering, organizing and exporting. Users have the flexibility to customize the displayed columns, tailoring the view to gain different views and insights. See Data Table section for more details on the usage.

For each record time (which represents the start of the integration time), a list of corresponding channels of a band is shown. The number of channels available is calculated based on the frequency range of the configuration's Band (or Sub-bands) and the "Channel Width" (see Node Configuration section).

Channel Occupancy Charts

The Channel Occupancy Charts view is a graphical representation that displays the extent to which specific channels are utilized over a specified period for a given configuration. It shows the percentage of time each channel is occupied by transmissions, providing insights into usage patterns such as:

- **Peak Usage Time** with hourly breakdown,
- **Peak Traffic** summary of that study period,
- **Channel Power** measured at each channel over time, and
- **Peak and Average Occupancy** with hourly breakdown for each channel.

These charts are useful in network management and telecommunications for optimizing channel allocation and enhancing network performance.

Notes: It is important to note that The date list of the data records range used for each chart is bounded by the Date Range from the map's Filter, meaning that if the configuration's start or end date is beyond that date range, the chart will show only the dates fitting within the Filter's Date Range from the map, not that of the configuration. In other words, if the selected configuration started before the map's Filter start date or runs beyond the map's Filter end date, the "Date" list will not show or include those dates.

Note that the name of the configuration has the start date and time, adjust the Filter's Date Range accordingly from the map if a configuration's start date is to be included.

Clicking on the "Channel Occupancy Charts" from the left menu bar opens the chart panel. Refer to Charts Exploration section for the usage information.
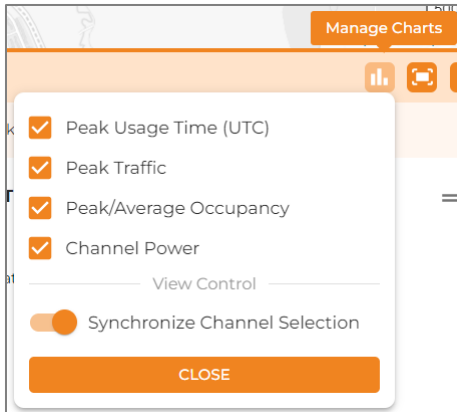
Channel Occupancy chart panel utilizes the "Manage Charts", located in the top right as shown in the left figure, to allow showing or hiding a chart.

"**Synchronize Channel Selection**" will be turned on by default to make it convenient for the users to synchronize a channel selection for the charts where a Channel List is available. For example, selecting channel 10 in "Peak/Average Occupancy" chart, "Channel Power" chart will have channel 10 selected automatically. If this option is turned off, users can set each channel in each chart separately.

Chart Panel's Elements

Locate at the top left of the chart panel is the "Config List" and "Band" drop down fields. Once a node is selected, these 2 fields will be filled with the node's configurations and their associated Band(s) available for a given Data Range specified in the map's Filter.
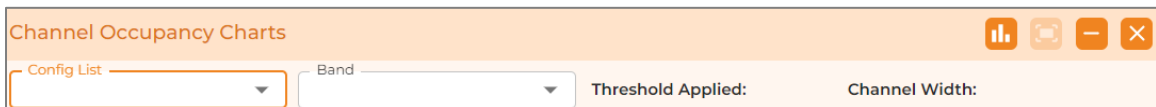
By default, the most recent configuration will be selected in the "Config List". A band will be selected by default as well from the "Band" list if there's more than one.

"**Threshold Applied:**" and "**Channel Width:**" will show the values or option as set in the selected configuration such that the users can easily cross reference with the charts data.

Note: You will notice that beside each configuration is a status message indicating 'Not started', 'In progress', or 'Completed'. These statuses provide quick knowledge about a configuration's state. 'Not started' status implies that either the configuration is not started yet or is never started due to another configuration having taken over.

Peak Usage Time (UTC) Chart

The Peak Usage Time chart provides a clear visual representation of when each channel is most utilized across the day, summarizing the peak usage time pattern across the study period. The following picture shows an example of a configuration that starts at 14:00 pm UTC and has been running for 6 hours.

Data Presentation:

- **Columns** – Represent different times of the day, from 00:00 to 23:00 *in UTC* format.
- **Rows** – Represent all the channels available from the configuration, with incremental ID starting from 1.

Peak Usage Time (UTC)

| Channel (MHz)	00:00	01:00	02:00	03:00	04:00	05:00	06:00	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00	18:00	19:00	20:00	21:00	22:00	23:00
Ch1: 450.500	96	99	100	99	97	96	96	82	81	98	99	100	100	100	99	97	98	98	99	98	95	92	93	96
Ch2: 451.500	87	95	96	95	89	88	86	68	68	69	73	91	93	93	90	92	95	95	96	95	86	85	85	87
Ch3: 452.500	76	89	88	85	72	74	71	64	64	66	66	84	88	89	84	83	90	89	89	88	79	82	81	80
Ch4: 453.500	72	81	79	72	68	63	62	61	61	62	63	74	75	76	74	78	75	76	73	74	71	72	73	72
Ch5: 454.500	70	79	77	70	67	62	61	59	60	61	61	71	74	74	72	77	72	75	71	72	70	71	71	71
Ch6: 455.500	95	100	100	100	95	93	92	89	89	100	100	100	100	100	99	94	97	96	97	97	97	94	96	95
Ch7: 456.500	28	55	53	45	34	30	31	32	33	33	40	69	73	71	69	56	55	57	58	58	58	45	44	34
Ch8: 457.500	11	34	33	29	13	12	15	14	16	16	22	66	71	72	66	32	33	34	36	35	34	23	22	13
Ch9: 458.500	6	31	30	23	9	8	9	10	11	11	14	65	71	72	61	30	29	28	29	30	26	15	11	6
Ch10: 459.500	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Ch11: 460.500	74	95	94	91	71	73	70	65	66	75	100	100	99	97	87	85	86	84	84	80	77	72	72	72
Ch12: 461.500	41	80	77	64	25	24	25	25	28	27	36	74	82	82	78	72	67	70	62	65	61	36	30	27
Ch13: 462.500	14	81	79	63	9	9	9	9	10	15	20	63	71	67	58	32	31	45	26	34	26	14	9	6
Ch14: 463.500	4	85	88	67	4	4	5	5	4	26	35	69	74	72	56	19	18	30	14	21	17	7	6	7
Ch15: 464.500	6	91	94	83	8	10	11	2	5	49	68	87	88	89	75	26	26	36	22	22	26	7	4	3
Ch16: 465.500	12	88	90	79	6	7	7	6	7	53	74	94	98	99	87	41	40	53	27	42	59	13	10	11
Ch17: 466.500	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Ch18: 467.500	4	16	16	8	0	0	0	0	0	0	0	17	23	24	13	3	5	2	3	2	6	2	3	3
Ch19: 468.500	2	17	20	13	1	1	0	0	0	0	0	4	8	16	5	1	2	1	1	1	1	0	1	1
Ch20: 469.500	24	48	51	43	25	24	22	16	18	16	13	40	48	65	52	30	45	41	26	36	48	16	21	20

The occupancy data presented in each cell represents the *peak* **occupancy** percentage detected at that hour each day of all the Date Range specified for each channel. For example, if there are 10 days of data collected as shown above, the peak occupancy for channel 1 (Ch1) at 18:00 hour over the 10 days is 83%, Ch2 71%, and so on. Each channel has 1MHz Channel Width as specified during the configuration.

Note: The "NA" value indicates no data is available for those times and channels due to no measurements having occurred.

**Peak Usage Time (UTC)**
< 1 2 3 4 >
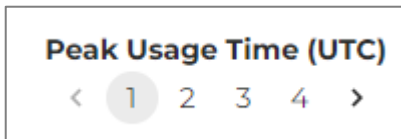
When there are more than 25 channels for a band, the data table will be split into many pages, with the 'page' options shown under the chart title as shown below.

Peak Traffic Chart

The Peak Traffic chart provides information about which channel has the peak occupancy at which hour(s) of each day in the "Whole Range" display option, allowing users to identify the busy hours. Users could switch to view the hourly measurements using the "Per Day" option to better understand the usage of that day.

Display Type
Whole Range ▲

Whole Range ✓

Per Day

The date list of the "**Whole Range**" or the "Date" field of "**Per Day**" is bounded by the Date Range from the map's Filter as previously explained. The "Date" list will not show the configuration's dates go beyond the Date Range.
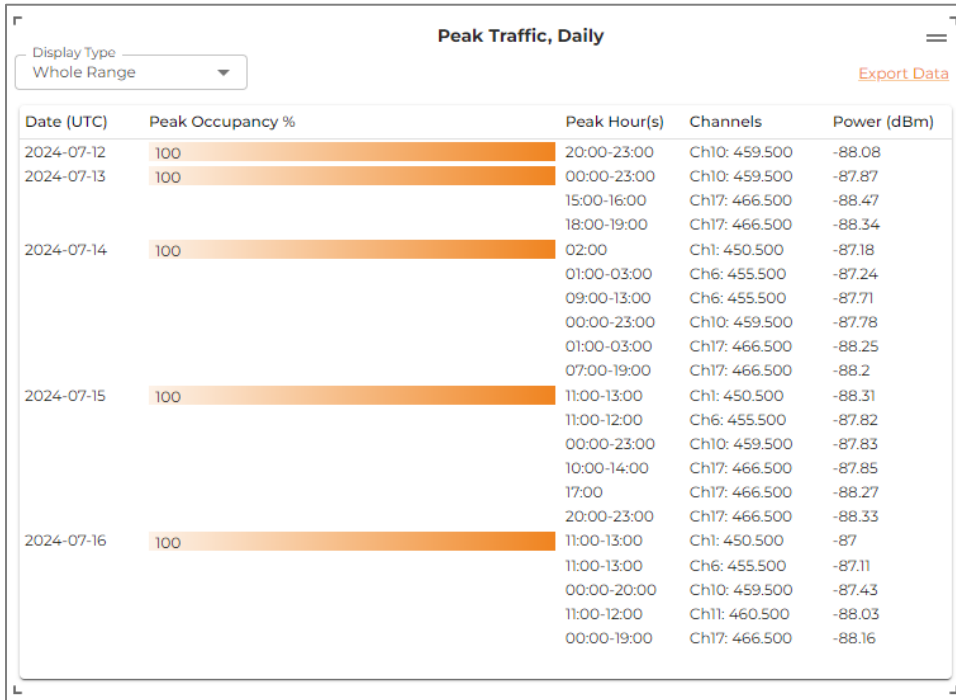
When "**Per Day**" is selected, the "Date" field will become visible, showing the available data dates for viewing.
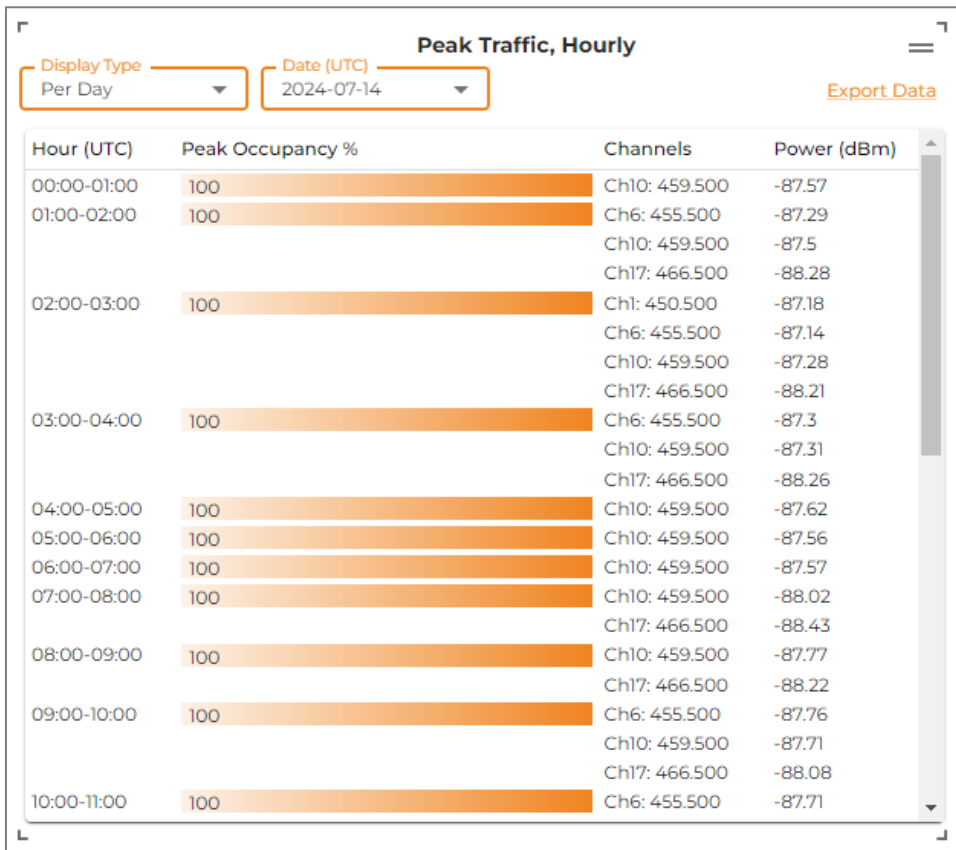

Export Data – An option to export data in a CSV file format is available with this chart.

Data Presentation:

- **Date/Hour (UTC)** – List time intervals daily with the busiest period **Peak Hour(s)** and **Channel(s)** identified or hourly segments for each day with which busiest Channel(s).
- **Peak Occupancy %** – Shows the peak occupancy percentage for each time interval. The 100 percentage indicates full utilization during these hours.
    - o **Color Coding** – The bars representing peak occupancy are color-coded in shades of orange, with darker shades indicating higher occupancy.
- **Channels** – List the channel(s) most occupying resources at the detected time.
- **Power (dBm)** – Displays the power level in decibels-milliwatts at that peak occupancy.

Peak/Average Occupancy Chart

The Peak/Average Occupancy chart shows the measured peak and average percentages of channel occupancy at each hour in the 24-hour period over a date range bounded by the map's Filter. The X-axis represents time in UTC, breaking down by hour, while the Y-axis represents the occupancy percentage.
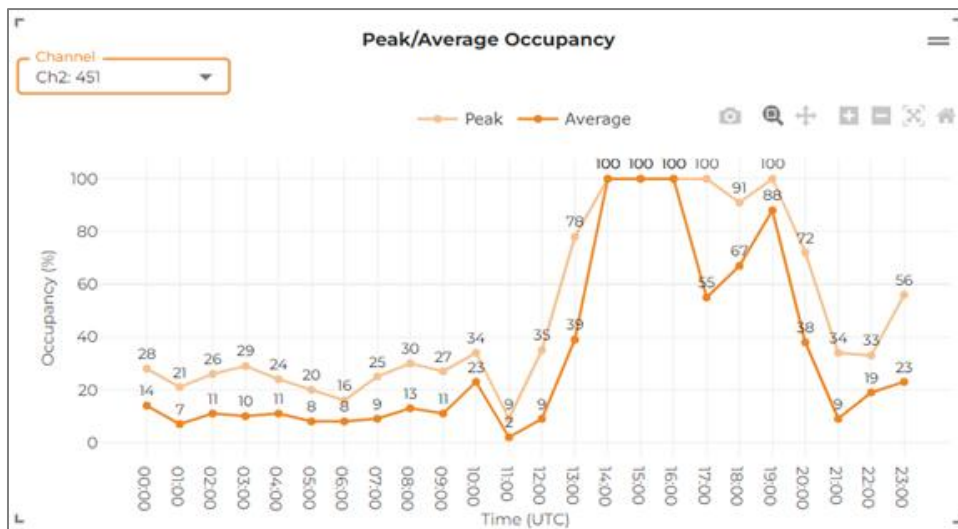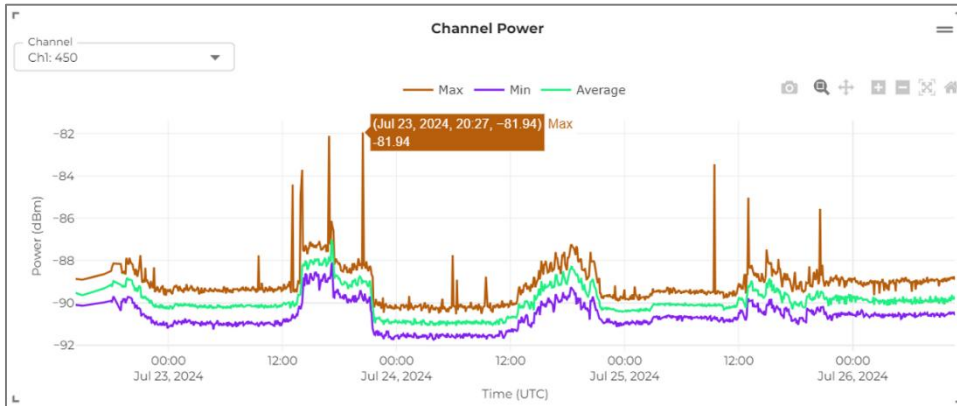

Data Presentation

- **Peak Occupancy** – This lighter orange line shows the highest occupancy percentage recorded at any point during each hour over a given period of data.
- **Average Occupancy** – This darker orange line indicates the average occupancy percentage for each hour over a given period of data.

The **Channel** selector is located at the top left of the graph. This dropdown menu allows users to select the specific channel they wish to view their respective occupancy data.

Channel Power Chart

The Channel Power chart displays over a specified time three distinct lines corresponding to the maximum, minimum, and average power levels (measured in dBm) for a selected channel from the top left of the chart. The X-axis time is dictated by the Date Range of the map's filter and the configuration's study period as explained previously.

Data Presentation:

- **Max** (brown) line – Show the peak power levels for the selected channel over time, indicating periods of higher power.
- **Min** (purple) line – Indicate the lowest power levels recorded during the same time period.
- **Average** (green) line – Display the average power level, typically positioned between the max and min values.

User Profile

The User Profile page in SXM provides a snapshot of your account information, settings, and access permissions. While most information is not editable and is provided by the account administrator during user creation, you have the option to update your password for added security.

Below is an overview of the user account information displayed on the User Profile Page:

1. **Personal Details** – Your personal information as registered by the administrator.
   a. **Roles** – Your designated role or user type within the system, which determines your access permissions and privileges. See User Roles for the description of the various roles.
2. **Reset Password** – Change your password, which is recommended to be changed every three months.
3. **SXM Details** – Details associated with your SXM Dashboard account, including when you last used the Dashboard.
   a. **Subscribed Applications** – The application modules that you are authorized to view in the dashboard. This information outlines the specific functionalities and features accessible to you within SXM.
4. **Corporate Details** – Your corporate information and the number of devices owned.
5. **Account Administrator(s)** – List of administrators from your company, who you can reach out for any administrative functions.

Notification Service

The Notification Service is an essential capability of the SXM Solution system, enabling real-time awareness and response to specific events based on information detected of the monitored environments. Events can range from simple conditions, such as power level thresholds crossing, to more complex scenarios like changes in wireless network configurations. This service ensures prompt identification and notification of occurrences and triggers notification actions, such as updating dashboards and sending alerts via email. This functionality is especially valuable in dynamic and ever evolving telecommunications and RF spectrum monitoring services, where proactive and swift responses to evolving conditions are crucial for operational efficiency and user satisfaction.

Built on event-driven architecture, the Notification Service framework incorporates filtering and aggregation, transforming raw data into actionable insights. With Event Management and available tailored events by thinkRF, users can quickly create events, enlist participants on demand, and choose preferred notification methods. Email notifications can be configured to trigger immediately, or on a daily or weekly basis, with the latter options offering accumulated email reports to minimize email overload. All created events and detected logs are stored and easily accessible in the centralized Notification Center, ensuring users can efficiently track and manage their notifications.

The SXM Notification Service will continue to evolve, offering enhanced capabilities to help users stay proactive in their monitoring activities. If users require specific events not currently available through the Notification Service, they can submit a request via the "**Submit Feedback**" in the Help page.

Who can use the Notification Service?

The Notification Service can be seen by all SXM users but only Admin(istrator) and Author users can create events, with additional control options for administrators to manage the events as they see fit. Readers and all other users can be enlisted by the administrators to any corporate events. The options and usages will be explained in this chapter.

Supported Event and Alert Types

SXM Notification Service enables a Corporate to manage their Events efficiently and allows users to handily select from a range of predefined standard events from applications supported by SXM. Some Events are conditioned with parameters that are known to be useful for spectrum or 3GPP monitoring, while others allow users to input custom values.

SXM provides two convenient visibility **Access Level** modes of operation:

- **Corporate** mode – Corporate Events allow administrators (and only administrators) to enlist multiple users (subscribe) to an event with the following attributes:
    - A Corporate Event created by one administrator can be modified by another administrator.
    - Corporate Events will remain available even if the Admin user who created the event has been deactivated or changed to a lesser role.
    - Corporate Events are visible to all users in the Event Management page, allowing anyone to join if they wish. However, only Admin users can modify any corporate events, while non-admin users (Author or Reader) who wish to subscribe to a corporate event they are not already part of (or to unsubscribe) can request an Admin user to make the change.

- o   Only subscribed users will see the event logs in the Notification Center Page.
- **Private** mode – Private Events are available for Admin and Author users who want to monitor their own Events. These Events are only visible to the event creator.

The Events are classified with the following alert types:

- **Info**rmation – Informational events, typically no action required.
- **Low** – Minor events for information, monitoring is recommended but no immediate action required.
- **Medium** – Events with potential issue requiring investigation but does not require urgent attention as they are not immediately disruptive.
- **High** – Significant events requiring prompt attention to prevent the issues from escalating.
- **Critical** – Critical events indicate that SXM system has detected a condition requiring immediate attention.

The action to take might be suggested in the log note where applicable; otherwise, it is at the discretion and understanding of the users.

Notification Methods

The Notification Service is designed with a user-friendly interface and experience, offering flexible options to suit individual preferences. When creating an Event, users can choose to receive notifications via email, Dashboard push notifications, or both.

Only users subscribed to the corporate Events or their own private Events will receive the notification.

Dashboard Notifications

New event activities are captured and displayed in the Dashboard in two ways:

- Number emphasis on the Notification Service icon of the left menu bar, as such
- Push notification pop-up message in the applicable application when the users are using it. Users can mute this option in the Event edit form (when applicable).

Email Notifications

For email delivery, users can select one of these notification frequencies:

- **Immediate** – Email will be sent as right after the new event change detected.
- **Daily** – Email will be sent at the next 00:00 am UTC time if there are any new events detected.
- **Weekly** – Email will be sent on Monday at the next 00:00 am UTC time if there are any new events detected.

When Daily or Weekly is selected, multiple events are grouped together to minimize the number of notifications received.

Users will receive event alert emails in the format shown below, designed for easy viewing and quick understanding. Each email includes each activity description containing some key information in the Event Log table, along with the event's description to remind what the event is about. The same content—except for the source data—will also be available in the Notification Center.

Note: The viewing of an email event does not change the "seen" (read) status of an event in the Notification Center's main table.

Notification Center Page

The Notification Center serves as a centralized hub for monitoring alerts and events and viewing historical event logs. It consolidates notifications from various event sources, providing a clear and organized tabulated overview of the events and their logs. *However, only subscribed users to an event can see the event logs in this view.*

The main Event table displays events by their names and includes a collapsible embedded table to show the log activities for each event. This design enables quick navigation through events without overwhelming the users with detailed logs. The table aligns with the SXM Dashboard's administrative table layout, offering search and filter options for the main event details (excluding logs), and column management.

Note: The Notification Center page does not support auto-refresh as seen in other Dashboard pages, as it may interfere with certain page functionalities. Since events typically do not occur frequently, **manual refresh is considered sufficient**.

The information shown in this main Event table is:

- **Event Name** – The name of the event as provided by the users when creating an event.
- **Alert Type** – The level of alert for the event, be it Info, Low, Medium, High or Critical. See under Supported Event and Alert Types for more information.
- **Count** – The number of activities detected since the creation of the event. All events start with the "created" activity, hence, a count of 1. When the event is reactivated from
- **Last Triggered** – The time of the most recent activity for the event.
- **Access Level** – The visibility access level of the event, which support Corporate or Private options. See the description for "Access Level" under Create a New Event for more information.
- **Status** – List whether the event is Active, Delete Pending (grace period of 30 days before permanently deleted), or Inactive (deactivated, no longer track the event).
- **Source** – Which application the event's source data is derived from.

Events with new activities that have not yet been viewed will appear in **bold blue font**. When the event is expanded by clicking the + sign, the new activities will be marked as "seen" (read), causing the event name to revert to a regular black font.

Each event table, when expanded as shown in the previous picture, reveals the following information:

- **Time** – The events are time-stamped with either the system time (e.g., creation time) or the detected data time when the change occurred.
- **SXM Node ID** – The list of node(s) that has the Event change detected.
  - When an event change that is detected by more than one node, as long as the conditional parameters have the same values, only the node with the first change detection will be listed.
- **Location** – The address or location information of the above SXM Node ID.
- **Description** – A tailored log description will be provided for each event occurrence, including a few relevant key parameters to help users verify the changes in the source data.
- **Action** column – This column provides actionable buttons, such as "Source Data" button for viewing both the pre- and post-change data records when applicable, useful for quick review and analysis. An example of the Source Data panel is as shown in the next figure

Note: The Source Data, when applicable, is not available for the email notification report, only within the Notification Center.

Source Data

Event Name	thinkRF Validation
Time	2025-04-14 15:56
SXM Node ID	220720-104
Location	390 March Rd, Kanata, ON K2K 0G7, Canada
Log Note	Detected Antennas change from 2 to 4 (MCC 302, MNC 220, eNodeB ID 219133, Cell ID 30, Frequency 723.00 MHz).

	Before	After
Node ID	220720-104	220720-104
Address	390 March Rd, Kanata, ON K2K 0G7, Canada	390 March Rd, Kanata, ON K2K 0G7, Canada
Record Time (UTC)	2025-04-14T19:22:36.387392	2025-04-14T19:56:09
Config Name	Default Configuration - Manual Freq range_20250218_1848	Default Configuration - Manual Freq range_20250218_1848
3GPP Scan Mode	infrastructure	infrastructure
Antennas	2	4
ARFCN	9720	9720
ARFCN (Uplink)	-1	-1
Band	29	29
Bandwidth	10	10
Bandwidth (Uplink)	-1	-1
Beam Index	-1	-1
BL CE	notSupported	notSupported
Cell Active	true	
Cell Barring	0	0
Cell ID	30	30

In the above Source Data panel,

- a summary of the event is shown at the top of the table,
- the Log Note will highlight what the detected changes are as shown in the red font, and
- in the 'After' column of the table, red font is used to highlight all values that differ from the 'Before' values, providing a quick visual reference for the analysis.

Event Management

The Event Management page is a centralized location for creating a new event as well as administering all the events created. The table aligns with the SXM Dashboard's administrative table layout, offering search and filter options for the event details, column management, and automatic refresh every five minutes. The "**Show Not Active**" is for showing any "Inactive" and "Delete Pending" events. It is selected by default.

Most of the column headers are described in detail in various sections of this chapter. **Created / Updated Date** and **Create / Updated By** provide handy information of who created or edited the event and when.

Create a New Event

Users can create a new Event in two ways:

- Using   **ADD EVENT**   button from the Event Management page or
- By clicking on the   **New Event Configuration**   heading in the left menu of the intended application, when available.

A new Event form is as shown below.

- **Event Name** – Allow for assigning a custom name to the event for easy identification. Use a meaningful description to help identify this event among others in the Notification Center.
- **Access Level** – Provide two event visibility access levels, Corporate and Private, as described in the Supported Event and Alert Types section.
- **Source** – The application source of data from which an event will be based on.
  o When the news event form is started from an application's "New Event Configuration", the Source will have the application chosen by default.
- **Event Rule** – A predefined set of events established by thinkRF, some of which may require the user to fill in additional fields in the form. If extra input is needed, it will be explained in the "New Event Configuration" section of the selected source application chapter.
- **Alert Type** – A list of alert type for users to assign to the event. tThinkRF applies a suggested default automatically in the creation form for users' convenience. Refer to the Supported Event and Alert Types section for the types.
- **SXM Nodes** – The event can be applied to one or more nodes.
- **Notification Method** – The notification options as described in the Notification Methods section.
- **Email Frequency** – The frequency of receiving email notification as described in the Email Notifications section. This field is visible only when the Email option is selected in the "Notification Method".
- **Recipients** – List of users available to be enlisted to the event. When all users are selected, only existing users are subscribed to the event; new users can be added as needed by editing the event.
- **Status** – This field lets users set an event to Active (to start tracking) or Inactive (to stop tracking). When set to Inactive, the event's logs and information remain available in the Notification Center until the event is permanently deleted.

Update an Event

From the Event Management page, click on the Edit ✏ button to bring up the Edit form. The **Access Level**, **Source** and **Event Rule** cannot be edited as these change the behavior of the event. All other fields can be edited as needed.

Delete an Event

From the Event Management page, click on the Delete 🗑 button to delete the Event. A prompt will appear, informing you that thinkRF provides a 30-day grace period before the Event is permanently removed from the SXM system. The Event will appear in a *light grey, italicized font* in the Event Management Table for easy identification from the other events. Ensure the "**Show Not Active**" box is selected to see this pending delete Event.

In addition, the Status column in the Event Management table will show how many days until the Event is permanently deleted as shown below. Meanwhile, the Status in the Notification Center will simply show "Delete Pending" for this event.

Event Name		Event Rule		Status		Mode		Source	
Event to notify Cell Barri...		*Cell Barring Status Chan...*		*Delete in 28 day(s)*		*Public*		*3GPP Network Analytics*	

The Alert process is stopped during the Delete Pending period, which implies no alert checking nor email notification is sent.

An Event pending deletion within the 30 days grace period can be restored by clicking on the orange Restore 🗑 button.

Deactivate an Event

1. From the Event Management page, click on the Edit ✏ button to bring up the Edit form.
2. Select "Inactive" for the Status field.

This event will no longer track for any changes, and all notifications will cease.

Administration

The Administration dashboard is accessible exclusively to users with admin privileges. This feature allows administrators to oversee and manage user accounts and nodes within the system efficiently. From viewing the entire list of users to creating new users, editing existing ones, and performing deletions as necessary, administrators have comprehensive control over user management operations.

Sale partners might also see additional administration features available to them, which will not be documented in this document.

User Management

The User Management feature enables the Administrator to manage the users of their account. It encompasses the seamless coordination of user's roles and functions by ensuring that the right individuals have the appropriate level of access to the system, safeguarding control and information access while maintaining operational efficiency.

User Roles

There are three user roles for Corporate users as described below.

- **Admin** – Administrator of the corporate or partner account, who can
  - add/modify/remove users,
  - modify user's or corporate information,
  - access to node management to configure the nodes and change a node's label,
  - create/modify/remove public saved settings, and
  - manage alert events
  - other administrative duties.
- **Author** – Users who can
  - configure the nodes,
  - create/modify/remove public saved settings, and
  - manage alert events.
- **Reader** – Users who can only use the application and manage their own personal information or privately saved settings.

View Users

Upon accessing the User Management page, administrators are presented with a comprehensive list of all user accounts registered within the system. This list provides essential details about each user, including their email address, first name, last name, assigned role, last active, and authorized applications.

Create New User

Administrator users can create new user accounts using the interface provided on the User Management page. When adding a new user, administrators are required to input the following information:

- **Email** – The email address that will serve as the user's unique identifier within the system.
- **Temporary Password:** A temporary password is generated for the new user, for which they will be prompted to change upon their initial login for security purposes.
- **First Name** – The first name of the new user.
- **Last Name** – The last name of the new user.
- **Role** in the System – Administrators assign a specific role to the new user, defining their access permissions and privileges within the system.
- **User Type** – Various users will only be available for Sale Partner's users, separating Sale users from the customer's users.
- **User's Company** – When available, administrator users can specify which corporate company the new user will belong to, granting them access to relevant data and resources.

Edit User Account

Administrators can edit user accounts, enabling them to update information such as first and last names, change the permission role, and corporate account associations. This functionality ensures that user details remain accurate and up to date as organizational needs evolve.

Note: When an Admin user modifies the password of another user, an email will be sent to that user with a temporary password.

Delete User Account

In instances where user accounts need to be removed from the system, administrators can initiate account deletions directly from the User Management page. This action deactivates the user's account and associated data from the system, helping maintain data integrity and security.

The deactivated users will have an 'Inactive' status, visible only to the administrators. They can be reinstated as needed, with their profile information retrieved but not the system's data.

Node Management

The Node Management dashboard is a user friendly, intuitive, and centralized platform designed for users to comprehensively monitor and manage (if authorized) the nodes the users owned or subscribed to. Its functions vary depending on the users' role and permission. All users can view the list, the information and status, only Admin users can make changes or use the actionable buttons. This flexibility in function customization based on roles and permissions enhances the security within the organization.

The tabulated view, as shown above, presents a quick view of key information for each node:

- the node itself (ID, label, and address),
- the node's online status and last activity timestamp,
- the subscribed application(s) and their status, and
- actionable buttons for administrators and/or authors to perform and the results (when applicable).

Each row can be expanded to view additional details about the node as mentioned in the Node Information.

Navigating the Node Management Table

The columns shown in the picture above are the default view. Columns can be added or removed as needed using the COLUMNS button above the table, in addition to rearranging by dragging the column name on the table. The table and column usage is similar to the usage mentioned in the Data Table section.

The rows are expansible to view more detailed information of each node, including checking and managing the password for the Local Control Application (LCA) access. LCA a simplified dashboard application used with the node in the absent of the internet, as mentioned under Monitoring and Administration section.

The Node Management table is automatically refreshed every 1 minute due to the statuses reporting.

Important Note: While the table refreshed every minute to bring statuses update for all the nodes on the list, *each node will send statuses every 5 minutes*.
When a reboot is sent, this might give the node's Status a false indicator of 'online', making it seems as if reboot does not work. It is recommended to not issue a reboot within less than 5 minutes apart.

Node Information

The following information is reported for each node:

- **Node ID** (serial number) – necessary for reporting to support.
- **Node Label** – customized label for easy identification.
- Current **address** and **location** information – these are obtained using the GPS data collected from the node.
- Node's network **status** – whether it is currently online or offline.

Note: The status is reported every 5 minutes, so its actual status might have been delayed.

- **Last Activity** – the time of the last heartbeat or data sent, whichever comes first.
- Its **Application Information** – refer to the next section for more the explanation.

In the Expanded view, further General Information could be seen for the node.

- The **IP Address** and **MAC Address** are only available when the **Local Connection** is Active, ready for LCA access.
- **GNSS** group provides detailed information of the GPS information of the node, including the GNSS mode it is currently configured to.
- **Software Information** group lists the current version of the software components running in the node.

- **Local App Password** shows or hides the password to be used for applications loaded directly from the node (such as the Local Control and Spectrum Analysis applications). Only Admin could make changes to the password so that it is unique to the customers, instead of using thinkRF provided default password. All users type could see the password.

Application Information

The "App Information" column informs the users which signal analysis (SA) application(s) are available (subscribed) and running on a node. The status of that application is shown under the application name and has three possible statuses:
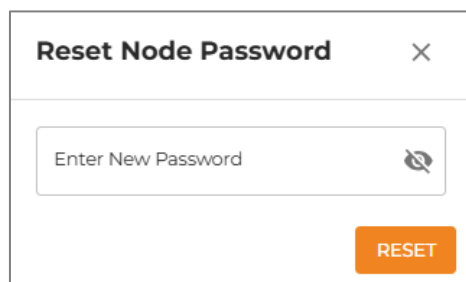
- available – the application is available but not doing any processing, either because it is not configured or has completed the analysis period.
- started – the SA is started and proceeding to apply configuration to start the processing.
- processing – the application is running the current configuration.
- failed – the application reached an error state and will report the error code and message.
- undefined – the application is in an unknown state. When seeing this state and the application doesn't recover within 10 minutes, users should notify thinkRF's Support right away.

Managing Local Control Application's Password

Refer to Monitoring and Administration section for a brief description of the LCA. As the application requires password access for security, the password can be changed by the Administrators in the Node Management view for each node.

To make the password change, the node needs to be powered on and has access to the internet.

1. Power on the Node.
2. Ensure it has internet connection access either through its SIM or via a local network access.
3. Log-in to the SXM Dashboard and open the Node Management view.
4. Locate the Serial Number of the node, by using Search for example.
5. Click on the Edit button of this node 🖉 to bring up the **Edit Node** panel.
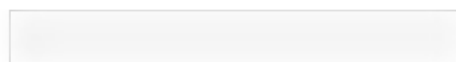
6. Click on [RESET NODE PASSWORD] to open the following panel to perform the reset.

7. An Information panel will be shown when RESET is submitted. If the node is offline, the password will be stored in the cloud and will be applied the next time the node comes online again.
8. The password can be viewed by users in the expanded node view by clicking on the blurred text field.

Local App Password

For Local Control and Spectrum Analysis Applications

Although only SXM Dashboard Administrators can change the password, Admin and Author users with access to the Node Management view can view the password, enabling them to manage node operations efficiently without needing to wait for an administrator to provide it.

Actionable Functions

Node Management provides conveniently a list of actionable buttons as shown in the following table for admin and/or author users to perform on each node. The table also shows which user types have access to which buttons and a brief description of each button function.

Action Button	User Permission Level	Description
✏ **Edit Node**	Admin	Set a label, change password, and optionally provide a description
🖊 **Set Node Location**	Admin, Author	Provide an address to be applied to the captured data when GNSS is not getting a good lock.
⬙ *System Configuration*	*Admin, Author*	*Available to SXM GO product model only.* Configure the hardware settings, such as configuring multiple antenna ports.
☑ **Built In Self-Test** (BIST)	Admin, Author	Run a BIST or view its results, useful for verifying the node's operation status.
⏻ **Reboot Node**	Admin, Author	Perform a hardware reboot if it seems not operating properly.
⏸ **Pause Updates**	Admin	Request a Node's updates pause.

Node Management feature will show the status of the request and the information (if available) of the usage results for all users along with a timestamp of when the request is issued.

Set Node Location

For stationary nodes with limited GPS satellite visibility (e.g., indoor installations), location data may be inaccurate. The **Set Node Location** 🖊 feature allows users to manually input coordinates, ensuring that the correct location information is applied to the data.

This feature is available only when the GNSS Mode in the active application's Node Configuration is set to **Stationary**. The button will be disabled in all non-stationary modes. If users change the GNSS Mode while manual address correction is active, a warning will appear in the Node Configuration panel to inform the users to take an action accordingly; the address correction will not be turned off.

Note: In the current release, users can only apply the feature to new incoming data without an end date. A date range selection feature is planned for the near future, which will allow users to pre-program addresses for specific periods starting from the time of the submission or no end date. Backfilling historical data with location corrections is complex and may impact other insights tied to location information, so this feature is still under evaluation. In the meantime, for any data location corrections beyond this feature, users can contact support@thinkrf.com.

Configure Node Address

Manually configure the node address to ensure precise mapping for new data records.

SXM Node ID

220720-109

SXM Node Label

220720-109

🔘 Enable Manual Location Correction   (Currently Automatic)

Latitude

-90 to 90

Longitude

-180 to 180

GET GEOLOCATION

Geolocation Found

Latitude

90.000000

Longitude

180.000000

Address

Address will be provided here

City

City

Region

Region

Country

Country

CANCEL   SUBMIT

After entering the Latitude and Longitude coordinates, click **GET GEOLOCATION** to retrieve the corresponding address and verify its accuracy. If the address isn't converted correctly, users can manually adjust it without affecting the original coordinates. However, if the address is incorrect, it is strongly recommended to update the input coordinates instead, using an external online map to get the new coordinates.

The "Set Node Location" button will change its look and tooltip text message depending on the usage as follows:

-   Set Node Location is available.

-   The location correction is running (active).

-   The location correction is running; however, the GNSS mode is not "stationary". Users will need to review this usage state.

-   Set Node Location is disabled as the GNSS mode is not stationary.

-   The GNSS mode is not readable. This is a rare issue case, requiring attention from ThinkRF support, reachable at support@thinkf.com.

Built In Self-Test Tool

When the BIST button is pressed, the users either get to see the results of the last BIST run request or to perform a new BIST run. If a BIST run is initiated, this will invoke the BIST tool in the node to run an extensive health checking of the following node's functions:

- Various hardware's health, including the receiver's.
- On-board computer's health.
- Network components' health.

- Application's health.
- Essential services and daemon.

For the first time usage, a clean BIST form with no BIST requested before will be seen.

The RUN BIST button is enabled only when the node is active (orange); otherwise, it would be greyed out and not accessible.

When request is performed, BIST request successfully sent acknowledgement will be shown.

See the BIST column from the Node Management table for the status, as such:

 or

If BIST result is not ready, the output field will display a message indicating the status of the request.

At end of the test run, which could take one or more minutes depending on any issues, a report will be sent back to the could with either "All Good!' message or error codes along with the error message and what action can be taken by the users (as shown below as an example).

Reboot

The Reboot button will restart the node's onboard computer and the receiver, hence, interrupt any running analysis.

When the Reboot button is pressed, a confirmation form will be shown.
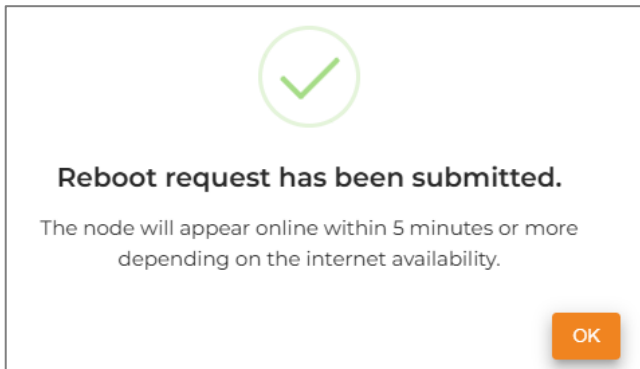
Once proceed, reboot request successfully sent acknowledgement will display with an important message as seen below.
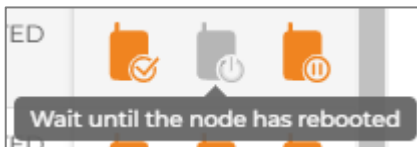
Reboot icon is disabled for around 1 minute after reboot request was sent to prevent users trying to initiate again.

Note: The node will take approximately 1 minute to reboot, the "Online" status might not be reporting correctly due to the 5-minute status report interval.

Pause Updates

The Pause Updates feature allows users to request thinkRF to not update a node for **up to 30 days only** (which include any back-to-back requests). When thinkRF has a release update for the node, the node management team will check this request before applying a deployment or not.

The Pause Update column and form will indicate when the effective Start and End date as well as the status.

Pause Updates form will have the fields as shown. The Start Date will always be today date and the hour of the request. The users can specify the end date and the hour.

Account Settings

The SXM Dashboard displays in-app banner notifications for various updates, as shown in the image below. Users can customize their notification preferences on the **Account Settings** page.

When a news article is released, the News Announcement Bar will be seen at the top of the page. The banner will persist until it is closed. Once closed, the banner won't be shown again. The information can be viewed again in the News section of the Home page.

The banner provides a "View details" link, which will open a full detailed view of the News article. This full view is also available with the article in the News section as well.

Help

The Help page serves as a hub for accessing support and help resources related to the platform. It offers access to the following resources:

- **SXM Dictionary** – a comprehensive dictionary (listed by the application name), containing various terminologies utilized within the SXM platform along with their respective explanations,
- **Documentation** – this User Guide and link to additional thinkRF's resources,
- **User Feedback** – for providing General Feedback, Feature Request, Improvement Request, and Ask a Question, and
- **About and Support information** – with direct links to thinkRF's Support portal and their official website for further assistance and information.

For detailed guidance on utilizing platform features, troubleshooting, or accessing additional resources, please refer to the User's Guide from this page.

Appendix A – SXM 3GPP Parameter Description

The following table lists alphabetically all the detected and decoded 3GPP output parameters from SXM devices as reported by the SXM API, along with their description.

Sites Data Name	API Parameters	Description
ARFCN	**arfcn** number	Absolute Radio Frequency Channel Number. Example: 1075
ARFCN (Uplink)	**uplinkArfcn** number	Uplink Absolute Radio Frequency Channel Number, associated with the LTE UL carrier (when decoded to SIB2 (PDSCH)) or PCell carrier in NR. A value -1 is applied when: • LTE OSI is not activated for LTE and SIB2 is not decoded • NR is not decoded to PDSCH. NR is decoded to PDSCH but the information is not provided in SIB1. Example: 721824
Band	**band** number	Detected 3GPP (ITU) Band ID. References: LTE bands Wikipedia and 5G bands Wikipedia
Bandwidth	**bandwidth** number	Downlink spectral bandwidth measured, in MHz. If Decode Level is not PDSCH, Bandwidth might be -1000 for not fully decoded. The Bandwidth for NR5G only might not be accurate in one of the following cases: • NR is not decoded to PDSCH. • NR is decoded to PDSCH but there is no information about the BW as the carrier is operating in NSA. Example: 10
Bandwidth (Uplink)	**uplinkBandwidth** number	Uplink Spectral Bandwidth measured (in Hz), associated with LTE uplink carrier (when decoded to SIB2 (PDSCH)) or the PCell carrier in NR, in MHz. A value -1 is applied when: • LTE OSI is not activated for LTE and SIB2 is not decoded • NR is not decoded to PDSCH. • NR is decoded to PDSCH but the information is not provided in SIB1. Example: 10
Beam Index	**beamIndex** number	Beam index for NR5G. It is a unique identifier assigned to each beam in a NR5G cellular network and is based on its location and direction. Example: 255
BL CE	**blCe** string	BL/CE flags for LTE carriers of NB-IoT device connection with the following values reported: • **NA** – Not Applicable for NR carriers or 4G LTE. • **supported** – BL/CE operation is supported for NB-IoT. • **notSupported** – BL/CE operation is not supported. Example: notSupported
Altitude Latitude Longitude	**captureLocation** object (dictionary)	SXM node's GNSS location information, consisting of altitude, latitude and longitude. When GPS does not have a valid lock, -1000 value is used. Example: {"alt": 79.03125, "lat": 45.340218, "long": -75.909416}

Sites Data Name	API Parameters	Description
Cell Active	**active** boolean	Current cell's active status with value true (Yes) or false (No). Example: true
Cell Barring	**cellBarring** number	Cell-barred status indicating whether a UE can camp on this channel. It is derived from SIB1 for LTE and MIB for NR, with three values: 1, 0, or -1. Value 1 (or N for Cell Barring in Dashboard) means not barred or 'active', 0 (Y) means barred, and -1 (Invalid) for undetermined or not decoded to the SIB level. Example: 1
Cell ID	**cellId** (CGI group) number	8-bit Cell IDentifier of the 4G ECI or 4 to 14-bit of 5G NCI value, uniquely identify each Base transceiver station (BTS) or sector of a BTS within a location area code (LAC). *Not to be confused with PCI value.* If Decode Level is not PDSCH, Cell ID might be -1 for not fully decoded. Example: 39
Not Applicable	**cellRefPath** string	API resource path to retrieve the current cell data Example: /v1/nodes/211333-100/cells/39 (i.e /v1/nodes/{nodeId}/cells/{cellId}
Center Frequency (Downlink NR)	**nrDownlinkCenterFrequency** number	NR5G downlink center frequency, if decoded to SIB1 (PDSCH), in Hz. Otherwise, -1. **Note:** This is not the same as the value for 5G's centerFrequency paramter (Frequency on Dashboard), which carries the NR5G's SSB carrier frequency. Example: 3624990000
Center Frequency (Uplink)	**uplinkCenterFrequency** number	Uplink detected center frequency of the LTE carrier (when decoded to SIB2 (PDSCH)) or the NR5G's SSB, in Hz. In addition, for NR5G, it is associated with the PCell carrier. A value -1 is applied when: • LTE OSI is not activated for LTE and SIB2 is not decoded • NR is not decoded to PDSCH. • NR is decoded to PDSCH but the information is not provided in SIB1. Example: 3624990000
CFO	**frequencyError** number	The Carrier's Frequency Offset refers to the difference between the transmitted frequency and the frequency at which the receiver detects the signal, in Hz. When Decode Level is Invalid, CFO will be -1. Example: 204.02505
CGI	**cgi** string	Cell Global Identification is a globally unique identifier for a Base Transceiver Station or cells. The field is a computed parameter based on the combination of four source parameters from the node and is presented as such: **mnc-mcc**-eCGI/nCGI. The eCGI and nCGI portion is a combination of bits representation of <**nbId**><**cellId**> (along with **nbIdLength** length for 5G to determine its cellId bit length) and is converted to an integer value. If Decode Level is not PDSCH, CGI might be -1 for not fully decoded. Examples: • **4G** – 302-220-56145469 (with eCGI is calculated from nbId 219318 and cellId 61).

Sites Data Name	API Parameters	Description
		• **5G** – 302-220-22939089951 (with nCGI is calculated from nbId 1400090, cellId 15391, and nbIdLength is 22).
CINR	cinr number	CINR (in dB) is the ratio between the channel impulse response (CIR) power to the noise power. It is an indicator for how observable the channel is. When Decode Level is Invalid, CINR will be -1000 (typically for 2G/GSM and 3G RAT type). Example: -23.29
Decode Level	channel string	Decode level refers to the physical channel level from which the LTE or 5G NR data being decoded from (i.e. PDSCH, PBCH, etc). Example: PDSCH
Cyclic Prefix	cyclicPrefix string	The standard cyclic prefix used in LTE or 5G systems. When it is not LTE or 5G, the value is Invalid.
DCI Format	dciFormat string	Format of Downlink Control Information. If Decode Level is not PDSCH/PDCCH, the value could be Invalid. Example: DCI-1a
DSS	dss string: NA, DSS or notDSS	Dynamic Spectrum Sharing indicator value, which has three possible outcomes: • **NA** – not applicable - DSS operation is not applicable for this carrier. This is the case for LTE carriers or when DSS operation is not detected depending on the SXM signal analysis configuration parameters (such as LTE analysis is not disabled). • **DSS** – The carrier is an NR DSS carrier. • **notDSS** – The carrier is not an NR DSS carrier. Example: notDSS
EVM	evm number	Error Vector Magnitude values. The value of -1000 means EVM is not determined, often applied for 2G/GSM and 3G. Example: 87
Frequency	centerFrequency number	Detected downlink center frequency of the LTE carrier or the NR5G's SSB carrier, in Hz for API & MHz for Dashboard. Example: 2649900000.00 or 2649.9
Is NSA Is SA	isNsa isSa string: NA, ND, NO, YES	These parameters are for NR5G NSA/SA cell operation identification, respectively. When decoded to SIB1 (PDSCH), they will have these values: • **NA** – not applicable (for LTE carriers) • **ND** – not determined • **NO** – not supported • **YES** – supported Example: ND
MCC	mcc number	Mobile Country Code. A unique three-digit (12 bits) identifier that identifies the country. If Decode Level is not PDSCH, MCC might be -1 for not fully decoded. Example: 289
MNC	mnc number	Mobile Network Code. A three-digit (8 to 12-bit) identifier that within a country uniquely identifies an operator. Note that a single operator may have several MNC's associated due to legacy acquisitions and so forth. If Decode Level is not PDSCH, MNC might be -1 for not fully

Sites Data Name	API Parameters	Description
		decoded. Example: 88
Duplexing	**duplexMode** string: TDD, FDD	Duplex mode, TDD or FDD. Example: TDD
Modulation	**modulation** string	Modulation type. Example: qpsk
NodeB ID	**nbId** (CGI group) number	NodeB IDentifier, unique within a PLMN and assigned by an operator to each of its base stations in the network. Equivalent to eNodeBID in LTE and gNodeBID in NR5G. When Decode Level is not PDSCH, NodeB ID might be -1 for not fully decoded. Example: 220078
gNB-ID Length	**nbIdLength** number	The length or how many bits the (g)NB-ID data (22-32 bits) are in the 36-bit NCI of NR5G. When Decode Level is not PDSCH, NodeB ID Length might be -1 for not fully decoded. Example: 8
Node ID	**node** string	SXM edge device (node) unique ID. Example: 210414-001
Antennas	**numberOfAntenna** number	Transmitter's antenna configuration from the PBCH CRC. A value of -1000 is observed when the Decode Level is not PDSCH or is NR5G. Example: 2
Occupancy	**occupancy** number	Spectrum occupancy, in %. Measured bandwidth availability by active connections/transmissions. Example: 20
PCI/PSC/BSIC	**pci** number	Cell identifier code: Physical Cell ID (**PCI**, for LTE/NR5G) - derived from the PSS and SSS of the detected channel with value range 0-503 in LTE, and 0-1007 in 5G NR; Primary Scrambling Code (**PSC**, 3G/UMTS) - derived from PSC and SSC, value range 0-511; Base Station Identity Code (**BSIC**, 2G/GSM) - derived from SCH, value range 0-63. If Decode Level is Invalid, the value will be -1. Example: 314
Operator	*Not Applicable*	Mobile System Operator (MSO), derived from MCC and MNC values. When an operator name is not known (such as due to the new operator name is not in the SXM database system), the default naming is [MCC]-[MNC] (users can open a ticket with thinkRF under Help page to update this name). If Decode Level is not PDSCH, Operator might be [-1]-[-1] for not fully decoded. Example: Telus
PLMN	**plmn** (CGI group) string	Public Land Mobile Network value, uniquely identifies the operator globally. The PLMN value is calculated according to "3GPP TS 24.008" standard as such: given MCC[654] & MNC[321], PLMN is 54f621 ('f' is used) if MNC is 2 digits or 543621 if MNC is 3 digits. If Decode Level is not PDSCH, PLMN might be -1 for not fully decoded. Examples: 025320, 21f320 **Note:** as of API release v1.2.2, **plmn** parameter is changed from number to string type to better present the value as well as supporting the 'f' value.

Sites Data Name	API Parameters	Description
Power	**power** number	The average power across the bandwidth of the SXM receiver's detected carrier, in dBm. If Decode Level is Invalid, Power will be -1000. Example: -50.885082
RAT	**rat** string: LTE, NR5G, 3G, 2G	Radio Access Technology type Example: LTE
Record Time (UTC)	**captureStartTimest amp** string	Raw data's capture start timestamp, in UTC. Example: 2022-03-25T06:47:40
Reserved for Operator Use	**reservedForOperat orUse** number: 0 or 1	An indicator for whether all UEs (User equipment) could connect to the cell or not. Reported per PLMN with the value of 1 (not reserved) or 0 (reserved). If Decode Level is not PDSCH, the value will be -1. Example: 1
RNTI	**rnti** number	Radio Network Temporary Identifier. Example: 65535
RS SINR	**rs-sinr** number	Reference Signal Signal-to-Noise-Ratio (in dB) takes into account both interference and noise, making it a more comprehensive metric that considers the overall signal quality in a noisy environment. If Decode Level is Invalid, RS-SINR will be -1000. Example: 33.89399
RSRP/RSCP/ RSSCH	**rsrp** number	**RSRP** (Reference Signal Received Power): For LTE/NR5G, it measures the cell-specific reference signal average power in one sub-carrier. **RSCP** (Received Signal Code Power): For 3G/UMTS, it represents the signal strength from the pilot channel used for synchronization in UMTS networks. **RSSCH** (Received Signal Synchronization CHannel): A thinkRF's signal power measurement for 2G/GSM, measuring the training sequence of SCH in GSM; it is used to determine the signal strength of a user's connection to the network. The unit is dBm. If Decode Level is Invalid, the value will be -1000. Example: -11.558676
RSRQ	**rsrq** number	Reference Signal Received Quality (in dB) is a power quality measurement of the received signal from a cellular network base station in wireless networks. It is used to determine the signal quality of a user's connection to the network. RSRQ value, in dB. If Decode Level is Invalid, RSRQ will be -1000. Example: -10.332217
RSSI	**rssi** number	Received Signal Strength Indicator (in dBm) is a power measurement of the strength of the received signal for determining the quality of a wireless signal. In 2G/GSM, the known measured signal is called RxLev, which can be calculated from RSSI. RxLev is a quantized value representing the received signal strength (RSSI) in dBm. It is defined in 3GPP TS 45.008. If Decode Level is Invalid, RSSI will be -1000. Example: 17.524155
Sample Offset	**sampleOffset** number	Sample Offset to use for timing offset synchronization between the cells. Example: 287116

Sites Data Name	API Parameters	Description
SCS	**scs** number	Sub Carrier Spacing, in kHz. It has a value of -1000 when RAT is 2G/GSM or 3G. Example: 15
Secondary Operator	**secondaryPLMNs** object (dictionary)	Secondary PLMNs from SIB1. Value of -1 if not fully decoded. In Dashboard, Secondary Operator is a service provider that plays a secondary or subordinate role within a network environment. This could include operators that provide backup services, additional capacity, or supplementary coverage. It is derived from the first operator code from the detected Secondary PLMN of SIB1. Example: {"plmn1": 2174502,"plmn2": 2174100}
SSB Positions	**ssbPositions** string	A bit-map data showing the existing beams and their locations in time for SSB transmission in the NR cell. If RAT is not NR5G, the value is -1. Example: 01000000

SSB with SIB1	**ssbWithSib1**
	number
		A Synchronization Signal Block flag to indicate the existence or not of the scheduled SIB1 in NR5G for a decoded SSB. This flag is used to identify NR NSA/SA operation of an NR cell. It has the following values:
		• **-1** – it is an invalid value used for LTE carriers. This value also applies to RAT type not equal to NR5G.
		• **0** – there is no information for the neighbor SSB having SIB1.
		• **1** – the current decoded SSB has SIB1.
		• any other positive value indicates the following:
		   o the BW around the current SSB has no SSB with SIB1, or
		   o the next SS_REF (SSB center frequency) contains SIB1.
		Example: 1

TAC/LAC	**taCode** number	Tracking Area Code (for LTE/NR5G) or Location Area Code (2G/GSM or 3G/UMTS) derived from SIB3, SIB4, SIB6. It identifies a geographic area within a PLMN. It is used by the network to track and manage mobile devices as they move from one location to another. If Decode Level is not BCCH, the value is -1 for not fully decoded. Example: 29050
TDD Frame Config	**tddFrameConfig** string	A string of characters, representing the downlink-uplink pattern for both LTE and NR5G. If Decode Level is not PDSCH or Duplexing mode is FDD, the value will be -1. Example: D|D|F_6_0|F_0_4|U|U|D|D|D|D
TDD SCS NR	**nrTddScs** number	Subcarrier spacing of the NR TDD pattern when decoded to PDSCH. Otherwise, -1. Example: 30

Document Revision History

This section summarizes document revision history.

Document Version	Release Date	Revisions and Notes
v0.1	04/24/2024	The first document released version for Dashboard v0.1.0.
v0.2	06/01/2024	- Changed names and updated pictures to correspond with the Dashboard release v0.2.0. - Added new Administration hierarchy which provides access to User Management and other administrative features. - New changes to the User Profile page - Added 2 new buttons on the Map view - Removed "Standard" user type and added "Author" and "Reader". See User Roles section.
v0.3	08/15/2024	- Added "Node's Data Location Mappings" with notes on how "Measurement Sites" of a node are being mapped. - Moved "Node Configuration Feature" to its own main section and added new usage details. - Added Node Configuration for 3GPP Network Analytics. - Added Channel Occupancy chapter. - Updated pictures due to new changes and some context changes across the document due to the Dashboard release v0.3.0.
v0.4	09/13/2024	Updated the following for Dashboard release v0.3.2: - Added "Airborne<1g" information for 3GPP's Node Configuration. - Added Issue Alert. - Updated Channel Occupancy with new features and changes to Node Configuration and Charts, with focus on 'center frequency' usage rather than 'range' for bands and channels.

v0.5	10/15/2024	- The following changes applied to Dashboard v0.4.0:
		   + Added new SXM Node's Functions Relating to Dashboard chapter.
		   + Added new Node Management section under Administration chapter.
		   + Added explanation regarding the new "node selection" button for Channel Occupancy's map.
		   + Updated some pictures, especially Channel Occupancy's Charts with "Threshold" plot added to Channel Power Chart.
		
		- Added explanation for the News section under Home Page.
		- Moved the following 2 sections to under SXM Node's Functions Relating to Dashboard chapter.
		   + Changed "Node Configuration Feature" heading to Node's Application Configuration Usage
		  . + Changed "Node's Data Location Mappings" heading to Data Locations Mapping.
		- Minor content wording changes across the documents (some are for better clarity).

v0.6	11/21/2024	- Changed "Map's Node Selection" to Node or Measurement Site Selection and added explanation of the new usage. - Under 3GPP Node Configuration, added new 3GPP Scan Mode section, and added GNSS Dynamic Mode title to the existing section. - Updated info in Obtaining Latest Documentation and Software.
v0.7	12/18/2024	- Added Appendix A – SXM 3GPP Parameter Description list.
v0.8	01/24/2025	- Updated pictures across the document due to changes in the Dashboard release v0.4.3.

Document Version	Release Date	Revisions and Notes

v1.0	03/14/2025	- Changed support phone number.
		- Updated Filters section and added the new section Map Filter's Date Range subsection.
		- Significant change to SXM Node's Functions Relating to Dashboard chapter to explain the addition of "Mobility Modes" and "Routes", with new subsections added for generic explanation regarding data location selection. Added across the document where routes are applicable.
		- Added:
		  + additional support report instructions to help with issue reproduction.
		  + Charts Exploration to describe the usage in general. Removed the "Charts Exploration" under Channel Occupancy and refer to this new section instead.
		  + new 3GPP's Node Configuration image which has Scan Sensitivity and Output Optimization parameters, along with their explanation.
		  + 3GPP Interference Detection chapter.
		  + New "Squelch" field for Channel Occupancy's Node Configuration along with an updated image and explanation around the "Detection Threshold".
		- Changed "Node or Measurement Site Selection" for 3GPP Network Analytics to Data Location Selection and simplify.
		- Updated Node Management section to include the new expansible rows and explanation as well as how to change the node's password for Local Control Application.
		- Corrected which parameters are not available for **"Compliance Scan Mode"** in 3GPP Scan Mode as 3GPP Signal Analysis was able to detect more parameters than originally listed.

v1.1	04/14/2025	- Corrected the format for "Parked site's label". The following changes reflect Dashboard release v1.1: - Added the new chapter called Notification Service. - Updated the definition for "power" in Appendix A – SXM 3GPP Parameter Description. Also added the invalid/exception cases throughout the table where applicable.

v1.2	05/09/2025	- Some changes / correction to Appendix A – SXM 3GPP Parameter Description & corrected 'mode' typo to duplexMode (not an API change).
		- Minor typos correction.
		
		The following changes reflect Dashboard release v1.1.1:
		- Added
		  + brief description for Notification Service in the Navigation Panel section.
		  + Event Configuration and Description section for 3GPP related events.
		  + "Source Data" panel example to Notification Center Page.
		  + Base Station Markers Clustering section to describe the new technique of displaying the Base Stations for optimal performance and usability.
		- Updated:
		  + Pop-up Information Panel with the new usage.
		  + Filters section of the Display Window section to explain the new usage behavior, requiring APPLY to be clicked for the changes to take effect.
		  + Understanding Interference Map and Charts to include bouncing Measurement Sites.

v1.3	05/30/2025	Updated Map Filter for the new "Show Only Selected on Map" checkboxes and the Filter pictures across the document.
v1.4	06/17/2025	The following changes reflect Dashboard release v1.1.3: - Changed "Mobility Mode" of NodeB (Base Station) Change per Operator to available. - Added "Technology" field to the Node Configuration form to allow for RAT type selection.

Document Version	Release Date	Revisions and Notes

		- Changed "3GPP Interference Detection" name to Interference Management, including major updates to the chapter
		    + changed "3GPP Interference and Charts" to "Cellular → Cellular Network" interference and added new "Cellular → Non-Cellular Network" interference (preview release).
		    + changed "Interfering Frequencies and Bandwidths" chart name to "Frequency Overlap (MHz)" for clarity.
		- For Notification Service,
		    + changed "Mode" to "Access Level" (for better text explanation of the function) throughout the chapter.
		        + updated Create a New Event to include "Alert Type". i cna move
		    + enabled Delete and Restore for Delete an Event.
		- Updated Node Management with minor fixes and change for the Node Information panel.
		- With the new 2G detection release, updated Appendix A – SXM 3GPP Parameter Description with label changes to TAC/LAC (from TAC), PCI/PSC/BSIC (from PCI), and RSRP/RSCP/RSSCH (from RSRP).
		        + Also change 'GSM' to include '2G'.

v1.5	07/09/2025	The following changes reflect Dashboard release v1.2.0: - Updated Detected NodeBs section and pictures across the document, where applicable, to include estimated Base Stations and the associated button to move the estimated Base Station markers on the map. - Added more information for Interference Management regarding the new feature Cellular → Non-Cellular interference. - Added DSS log information for RAT Protocol Change per Operator.
v1.6	09/03/2025	The following changes reflect Dashboard release v1.3.0: - Updated pictures to include the new top menu bar and map's control icons, minor wording adjustments as a result. - Added the new section Managing Custom Bands for Non-Cellular Interference for Interference Management. - Updated Node Configuration for Node's Application Configuration Usage, 3GPP Network Analytics and Channel Occupancy to include multiple nodes selection for the configuration. - Added a note to mention an email will be sent for user's password changed by an Admin in Edit User Account.
v1.7	10/23/2025	The following changes reflect Dashboard release v1.4.0: - Modified Table of Contents to display heading level 4. - Updated Navigation Panel with new features and reorganized the sub-sections, including moving Issue Alert to this chapter. - Updated pictures throughout the document, where applicable, for the new changes and the Full Screen button. - Added the mentioning of three years restriction for the Map Filter's Date Range. - Added a note for Site Statuses, which also applied for Parked site. - Added a note regarding GNSS Mode configuration in relation with Set Node Location in GNSS Dynamic Mode. - Updated Node Management with new Action buttons, new information, new access for Author users, and picture changes. - Added the new Account Settings chapter.