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GMS Station SOH Monitoring User's Guide

Version 1.23 (for GMS PI 23 Open Source Release)

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ABSTRACT

This document is a user's manual for the Geophysical Monitoring System (GMS) Station State of Health (SOH) Monitoring User Interface.

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CHANGES FOR VERSION 1.23

All sections – Figures updated.

Section 3 – Now describes login using Keycloak.

Section 5.1 – Updated description of saving workspace layouts for clarification.

Section 5.3 – Updated description of cell colors to account for corrections made to how environmental issues statuses are reported.

Sections 5.3, 5.5.1 – Added description to include meaning of semi-transparent colors.

Sections 5.5.1, 5.5.3, 5.5.5 – Updated figures, description to detail that channel name labels are now colored based on status. Updated description of values printed to screen via tooltip to show that Unknown is now reported as Unknown rather than zero and that rounding to 2 significant figures is applied.

Sections 5.5.1, 5.5.2, 5.5.5, 5.5.6 – Flipped order of drilldown display descriptions so that Sections 5.5.1, 5.5.2 are now describing Timeliness and Sections 5.5.5, 5.5.6 describe Lag. This change was made because Timeliness is configured to be the only bar chart drilldown display to show dirty dot behavior.

Section 5.5.7 – Updated description of the Environment drilldown display table to update descriptions of cell colors and clarify the different rollups available.

Section 6 – Color legend figures and description updated.

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1. GENERAL OVERVIEW

The Geophysical Monitoring System (GMS) State-of-Health User Interface (SOH UI) is a web-based application that allows a user to view and acknowledge the SOH status of stations in the GMS system.

The SOH UI will primarily be used by the System Controller, who monitors and controls the system and external data connections. The System Controller uses the station SOH UIs to monitor, detect, and troubleshoot problems with station data availability and quality.

The SOH UI has 12 displays:

- 1) SOH Environment – an overview of station environmental issues by percentage per channel.
- 2) SOH Environment Trends – an overview of environmental issue changes over time per channel for each monitor type, i.e., the historical trend of an environmental issue.
- 3) SOH Lag – an overview of station lag per channel (in seconds).
- 4) SOH Lag Trends – an overview of changes in lag over time per channel, i.e., the lag's historical trend.
- 5) SOH Map – a map of station locations, where station color indicates worst-of or capability-based station SOH status.
- 6) SOH Missing – an overview of a station's percentage of missing data per channel.
- 7) SOH Missing Trends – an overview of percentage changes for missing data over time per channel, i.e., the historical trend in percentage missing data.
- 8) SOH Overview – a high-level summary of all available station and station group's SOH statuses, includes the ability to acknowledge any reviewed station's status.
- 9) System Messages – a time-ordered list of when stations need attention, SOH status changes/issues, user acknowledgements/quieting of station SOH status, and user comments.
- 10) SOH Timeliness – an overview of station timeliness per channel (in seconds).
- 11) SOH Timeliness Trends – an overview of changes in timeliness over time per channel, i.e., the timeliness's historical trend.
- 12) Station Statistics – a detailed summary of the SOH statuses for monitor types (monitors) and aggregate values. The monitors are lag (in seconds), percentage of missing data, timeliness (in seconds), and percentage of all environmental issues. Includes the ability to acknowledge any reviewed station's status.

The summary displays (SOH Overview and Station Statistics) allow the user to quickly evaluate the SOH status of all stations and station groups. The eight drilldown displays (SOH Lag, SOH Missing, SOH Environment, SOH Timeliness, SOH Lag Trends, SOH Missing Trends, SOH Environment Trends, and SOH Timeliness Trends) help troubleshoot specific issues for a selected station. The System Messages display provides real-time notifications for SOH related actions occurring within the system and is utilized for provenance purposes to assess the health of a station and what actions were taken during an interval of time. The Map display provides a visual of station locations and their SOH status.

SOH status calculation configurations are specified in files that can be modified using the SOH Config Tool. Refer to the SOH Config Tool documentation for more information on these files.

This document is an in-depth user's guide of the SOH UI, including browser requirements and an overview of each interactive display.

2. BROWSER REQUIREMENTS

The UI is currently supported by Chrome and Firefox. Chrome is the preferred browser, while Firefox is no longer being tested. The UI will also run on Apple Safari and Microsoft Edge, but with degraded performance.

3. LOGIN

To log into the SOH UI, enter the following URL generated during the build process into a web browser. It should look something like:

<https://soh-intergration.machine.domain/>

This URL will vary depending on where GMS is installed.

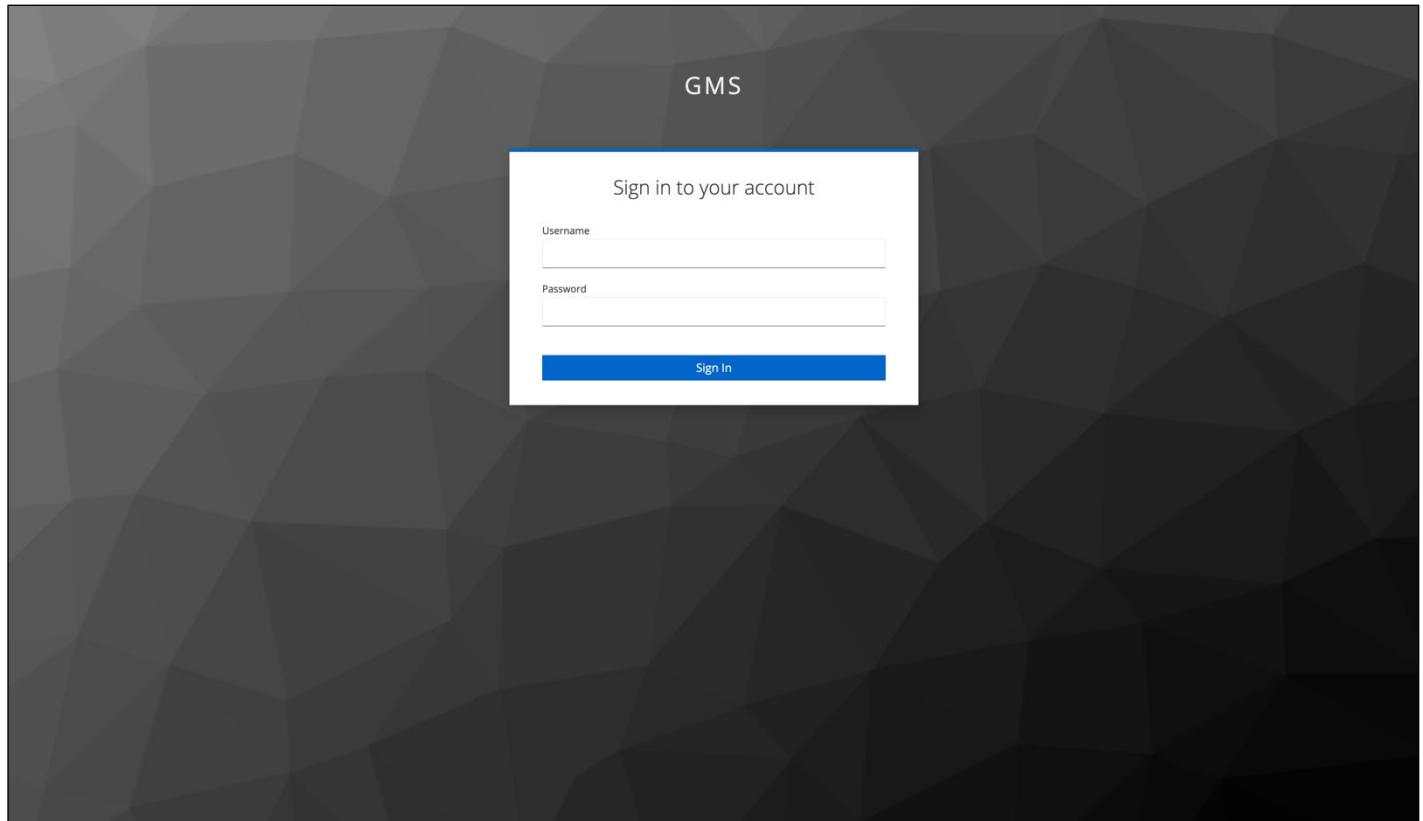


Figure 1. Login Screen for the SOH UI.

After entering the URL, the user will be directed to the login screen (Figure 1), where the user enters their username and password.

4. DEFAULT WORKSPACE LAYOUT

After logging in, the user will be taken to the default SOH UI workspace layout (Figure 2).

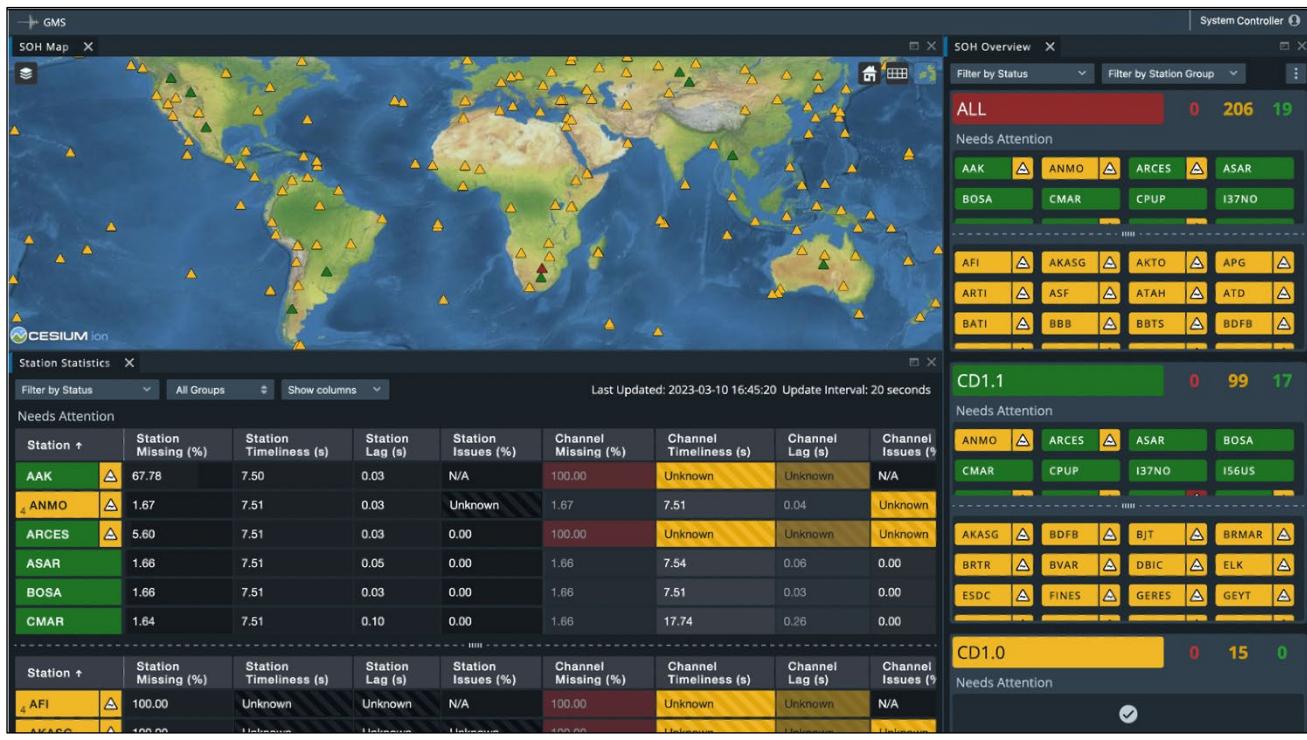


Figure 2. Default Workspace Layout of the SOH UI.

The default SOH UI workspace layout consists of three synchronized displays:

- SOH Map (Figure 2, top-left)
- Station Statistics (Figure 2, bottom-left)
- SOH Overview (Figure 2, right)

The default SOH UI also includes an application-level menu button labelled with the user's username in the top-right corner (Figure 3).



Figure 3. Application-Level Menu Button.

The SOH Overview and Station Statistics displays are summary displays that provide high-level station SOH status information. Four drilldown displays (SOH Lag, SOH Missing, SOH Environment, and SOH Timeliness) and four historical trend drilldown displays (SOH Lag Trends, SOH Missing Trends, SOH Environment Trends, and SOH Timeliness Trends) are not shown in

the default display and must be added by the user. A station must be selected in either of the summary displays (SOH Overview, Station Statistics) to populate the drilldown displays (see Section 5.5). Finally, the System Messages display is also not default and must be added by the user.

The default layout and any other user-defined layout can be modified by the user in seven ways:

- 1) An individual display can be moved by clicking the corresponding tab and dragging it to the desired position; this action includes placing multiple displays in one window with the display tabs next to each other (e.g., Figure 2, right).
- 2) An individual display can be expanded to full-screen by clicking the maximize button (i.e., box symbol) in the top-right corner of the display. Once full-screen, it can be returned to its original size by clicking the minimize button (i.e., dash symbol) at the top-right corner.
- 3) The horizontal dividers within the SOH Overview and Station Statistics displays, shown as dashed lines, can be shifted up and down by clicking and dragging the dashed line to the desired position; when a divider is selected, it will be highlighted blue. This action will vertically widen or shorten the category beneath the divider.
- 4) Displays can be widened horizontally by hovering the cursor over their window edge; when the window edge is highlighted blue, click, and drag the edge to the desired position.
- 5) The overall size of the workspace can be modified by enlarging or shrinking the browser window. Note that if a workspace layout is shrunk down, buttons and text that no longer fit in a display will be placed under a dropdown menu shown as three vertical dots,  while display tabs will be placed under a dropdown menu shown as an arrow icon, . Both icons will be in the upper right corner of any visible displays.
- 6) An individual display can be removed from the default layout by clicking the x next to the display name or the x in the top-right corner of the window containing the display. If multiple displays share a window, clicking the x in the window's right corner will result in those displays being removed.
- 7) Individual displays can be restored or added to the default layout by selecting one of the following options from the application-level menu:
 - a) Select SOH from the Displays section of the application-level menu, then select one of the following display names:

- i) SOH Environment
- ii) SOH Environment Trends
- iii) SOH Lag
- iv) SOH Lag Trends
- v) SOH Map
- vi) SOH Missing
- vii) SOH Missing Trends
- viii) SOH Overview
- ix) SOH Timeliness
- x) SOH Timeliness Trends
- xi) Station Statistics

This action will be described in greater detail in Section 5.1.

- b) Select System Messages from the Displays section of the application menu. This action will be described in greater detail in Section 5.1.
- c) Select Open Workspace from the Workspace section of the application-level menu, then select a desired layout.
 - i) From this menu the user can select the Overview layout, which restores the workspace to the default layout (Figure 2), an alternative layout provided with the UI (e.g., the All Data layout), or a personalized layout made by the user, if applicable. Workspace layouts are described in detail in Section 5.1.
- d) Select Developer Tools, then select Clear Layout
 - i) This option restores the default workspace layout (Figure 2). If another workspace layout was saved as the default (see Section 5.1), this action will restore the SOH UI to the saved default layout.

5. DISPLAY INTERACTIONS

5.1. Application-Level Menu

The application-level menu is shown in Figure 4. In the software, hovering over the About, Workspace, or Developer Tools options will provide a tooltip with a brief description.

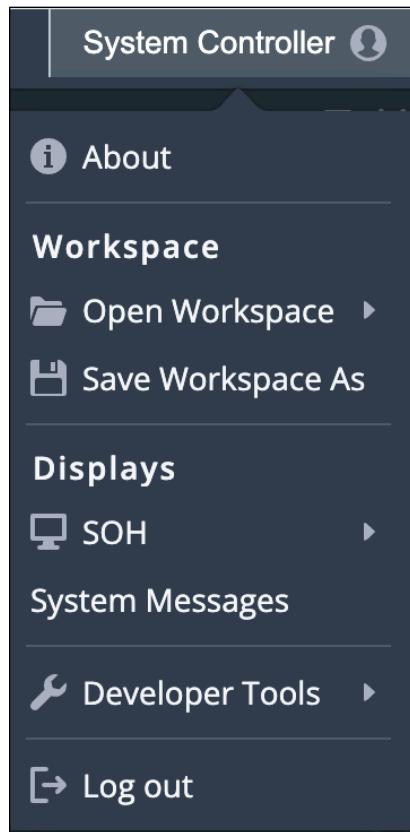


Figure 4. Application-Level Menu Options.

Application-level menu options include:

- 1) About – Displays the version of the SOH UI and its latest commit. The latest commit is used by system developers for troubleshooting.
- 2) Open Workspace – Shows the user's available workspace layouts (Figure 5).

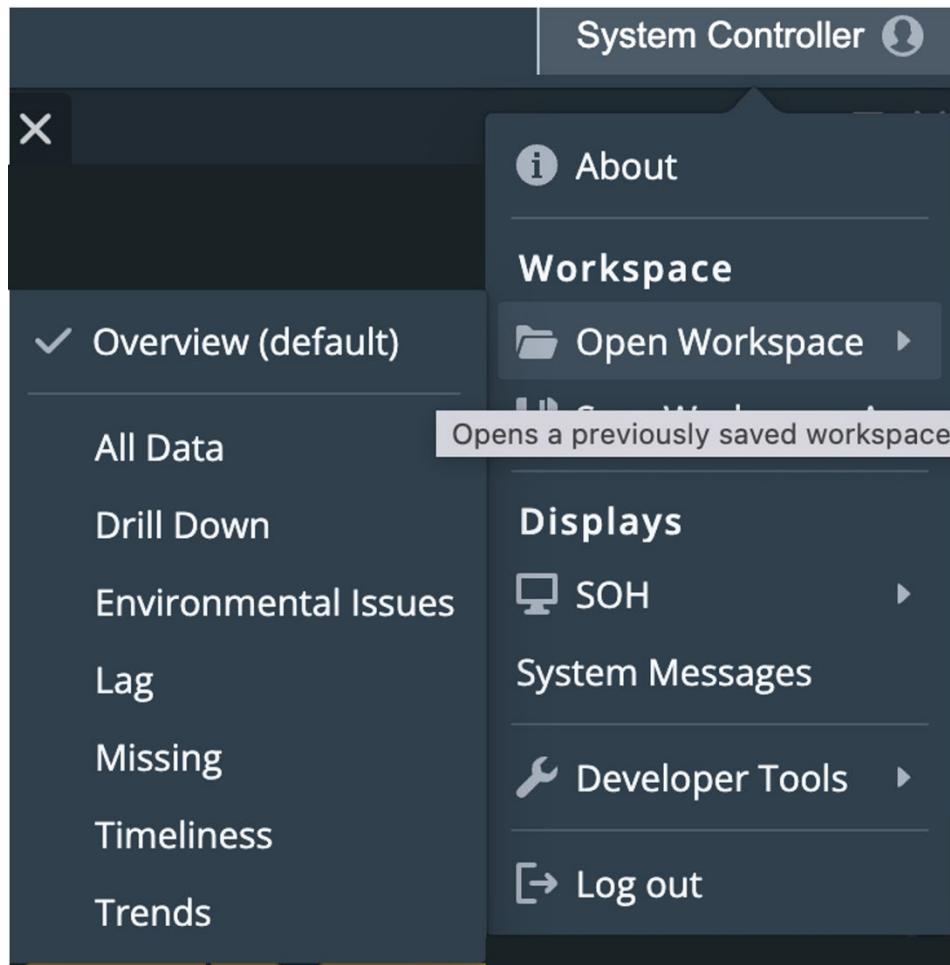


Figure 5. Open Workspace Menu Options.

In addition to the default Overview workspace shown in Figure 2, seven other layouts are provided. Each layout is designed to enhance viewing of a particular SOH feature.

The All Data layout (Figure 6) is designed to show all data for available stations by showing the SOH Overview display at left, all drilldown displays at center, and all historical trends displays at right.

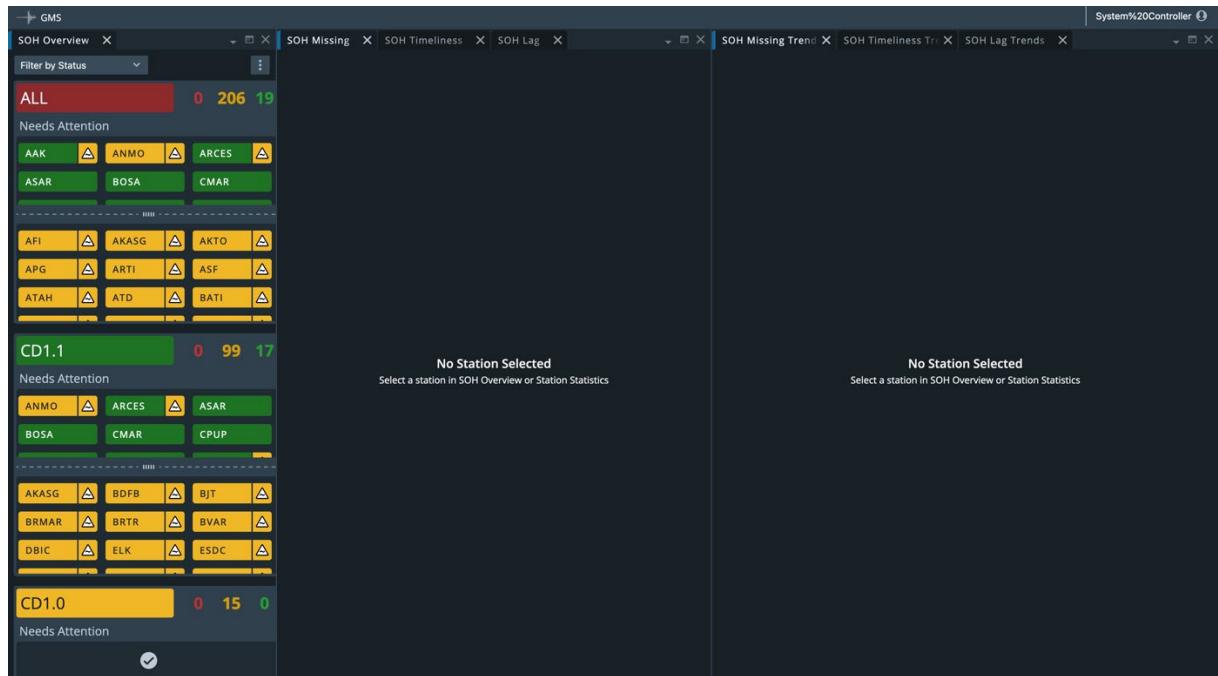


Figure 6. All Data Workspace Layout.

The Drill Down workspace layout (Figure 7) enhances viewing of the drilldown displays, with Station Statistics and SOH Overview shown at left and all drilldown displays shown at right.

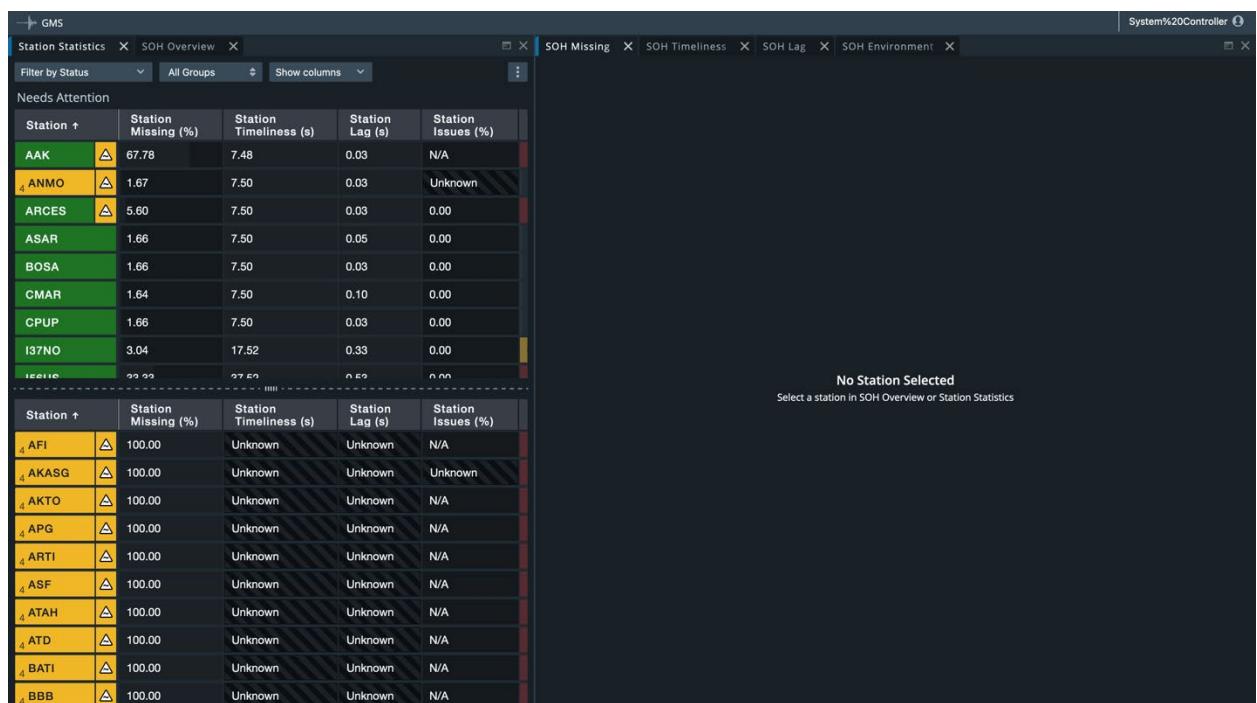


Figure 7. Drill Down Workspace Layout.

The workspace layouts Environmental Issues, Lag, Missing, and Timeliness are designed to enhance viewing of each monitor type, respectively. In Figure 8, the Lag workspace layout is shown, with Station Statistics and SOH Overview displays at left and the SOH Lag and SOH Lag Trends displays shown at center and right, respectively.

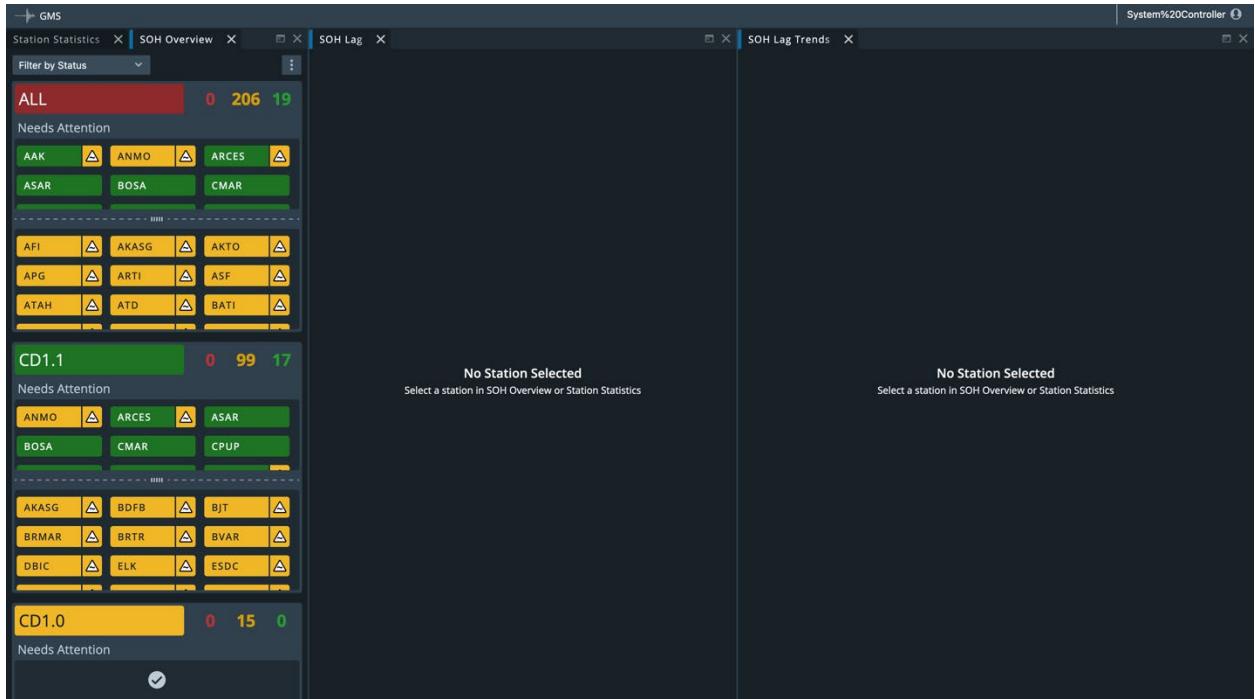
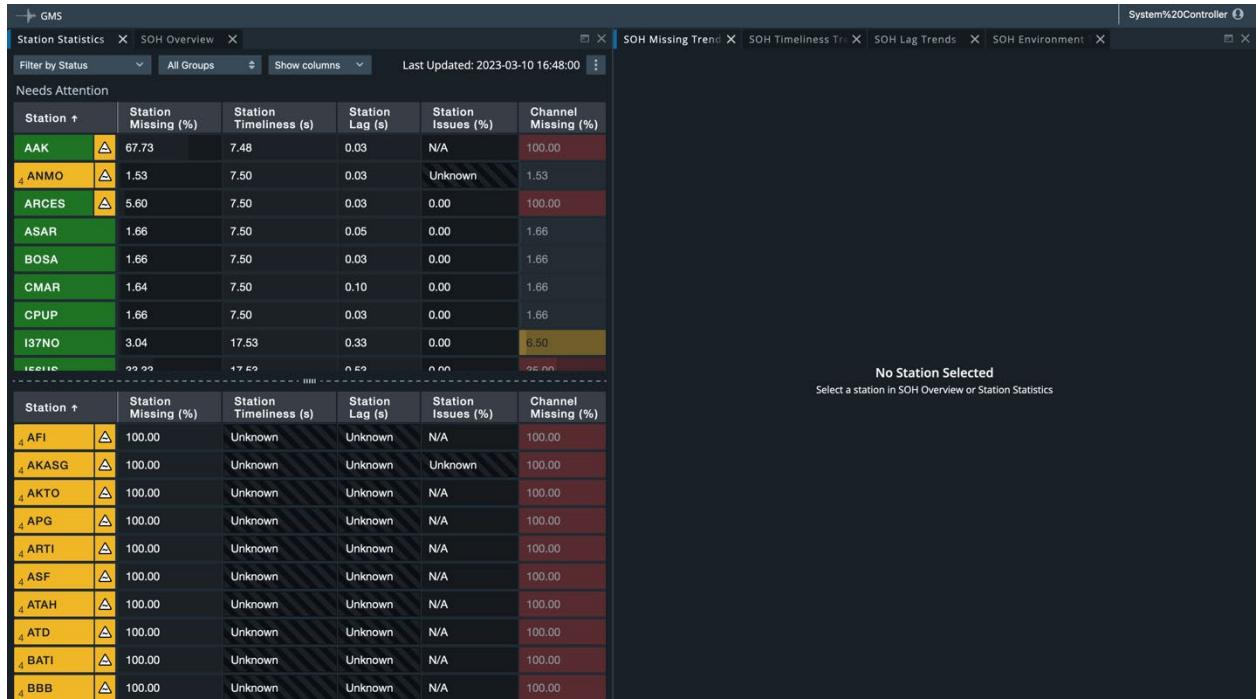


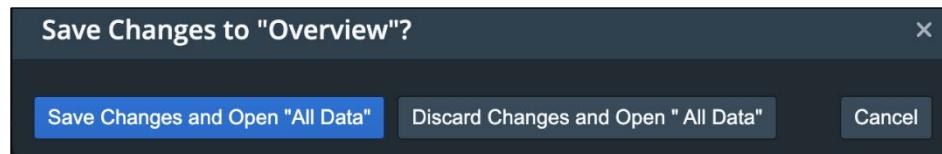
Figure 8. Lag Workspace Layout.

The Environmental Issues, Missing, and Timeliness layouts are identical to the Lag workspace layout.

Finally, the Trends workspace layout (Figure 9) is designed to enhance viewing of all historical trends displays, with Station Statistics and SOH Overview displays at left and the four trends displays shown at right.

**Figure 9. Trends Workspace Layout.**

The user can create more workspace layouts by modifying the workspace as described in Section 4 and saving the new layouts by selecting Save Workspace As. If the user makes changes to the current workspace layout and does not save it, they will be prompted to save or discard the changes when attempting to open another workspace (see Figure 10). A tooltip providing a brief description of each option can be brought up by hovering the cursor over the desired option.

**Figure 10. Prompt to Save or Discard Changes.**

From the prompt, the user can choose to open a new workspace layout while either saving or discarding the changes. To save the changes, the user should select Save Changes and Open “Layout Name,” e.g., Save Changes and Open “All Data” in Figure 10. To discard changes, the user should select Discard Changes and Open “Layout Name”. The user can also select Cancel to return to the current workspace layout.

- 3) Save Workspace As –Saves a preferred UI layout (see Figure 11).

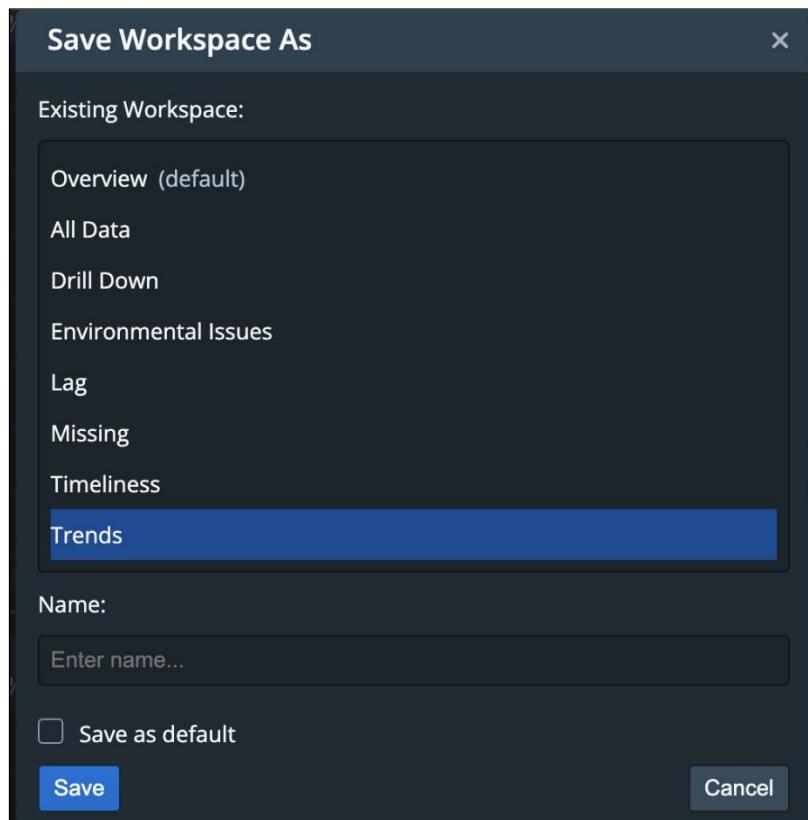


Figure 11. Save Workspace as Menu Options.

A new workspace layout can be saved under a new name by typing the desired name into the Name field and clicking Save. Alternatively, a new workspace layout can be saved under the name of an existing workspace layout by 1) highlighting its name in the Existing Workspace dialog box or 2) by typing its name in the Name field, then clicking Save. Note that this action will automatically overwrite the existing workspace layout with the new layout and cannot be undone. Once saved, the new workspace layout can be accessed by going to Open Workspace (see bullet 2).

The user can make any desired workspace layout the new default by defining the layout to be made default (either by entering a desired name into the Name field or selecting a workspace layout from the Existing Workspace list), checking the Save as default option at the bottom of the context menu, then clicking Save. The default label (seen to the right of Overview in Figure 11) will now appear to the right of the new default layout.

Finally, clicking Cancel will result in no actions being taken.

- 4) SOH – Adds workspace displays. Only one display instance can be open at a time. Displays already open are grayed out within the SOH submenu. For example, in Figure 12, the Station Statistics display is grayed out because it is already open.

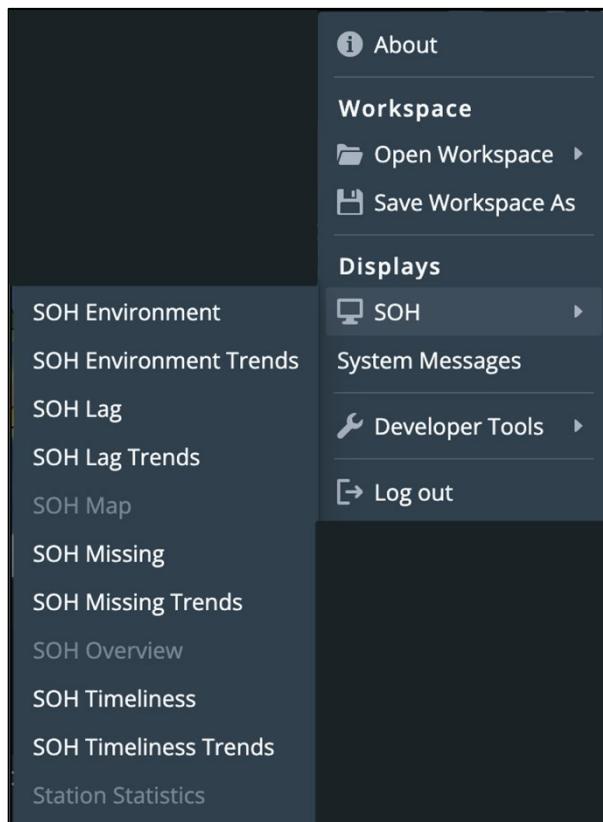


Figure 12. SOH Menu Options.

- 5) System Messages – Adds the System Message display (see Section 5.6).
- 6) Developer Tools – Provides the user two options:
- Logs – Lets the user view searchable logs tracked in the UI (debug, info, warn, error, fatal, etc.).
 - Clear Layout – Resets the UI display to the default layout. This option resets the UI to the layout shown in Figure 2 if the user did not make an alternative layout the default (see bullet 3).
- 7) Log Out – Logs the user out of the SOH UI. If any changes were made to the open workspace layout, the user will be prompted to save or discard the changes before logging out (see Figure 13). A tooltip providing a brief description of each option can be brought up by hovering the cursor over the desired option.

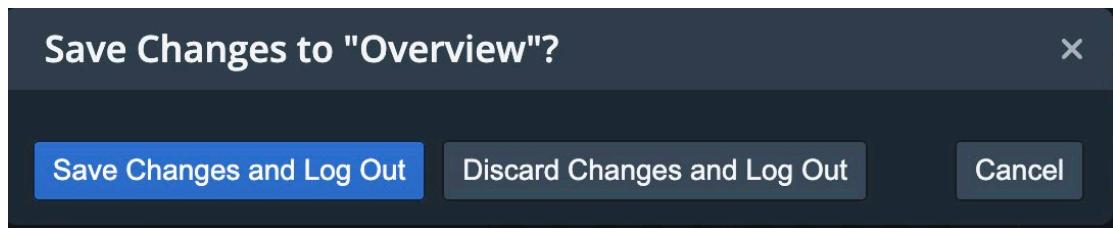


Figure 13. Log Out Menu Options.

5.2. SOH Overview Display

The SOH Overview display (Figure 14) provides a high-level overview of station SOH status. In this display, two types of SOH status are indicated:

- 1) Capability-based SOH status is used to prioritize which stations or station groups to troubleshoot first based on their importance to a configured capability.
- 2) Worst-of SOH status inherits from the station's worst channel/monitor.

How these SOH statuses are determined is detailed in Section 7.

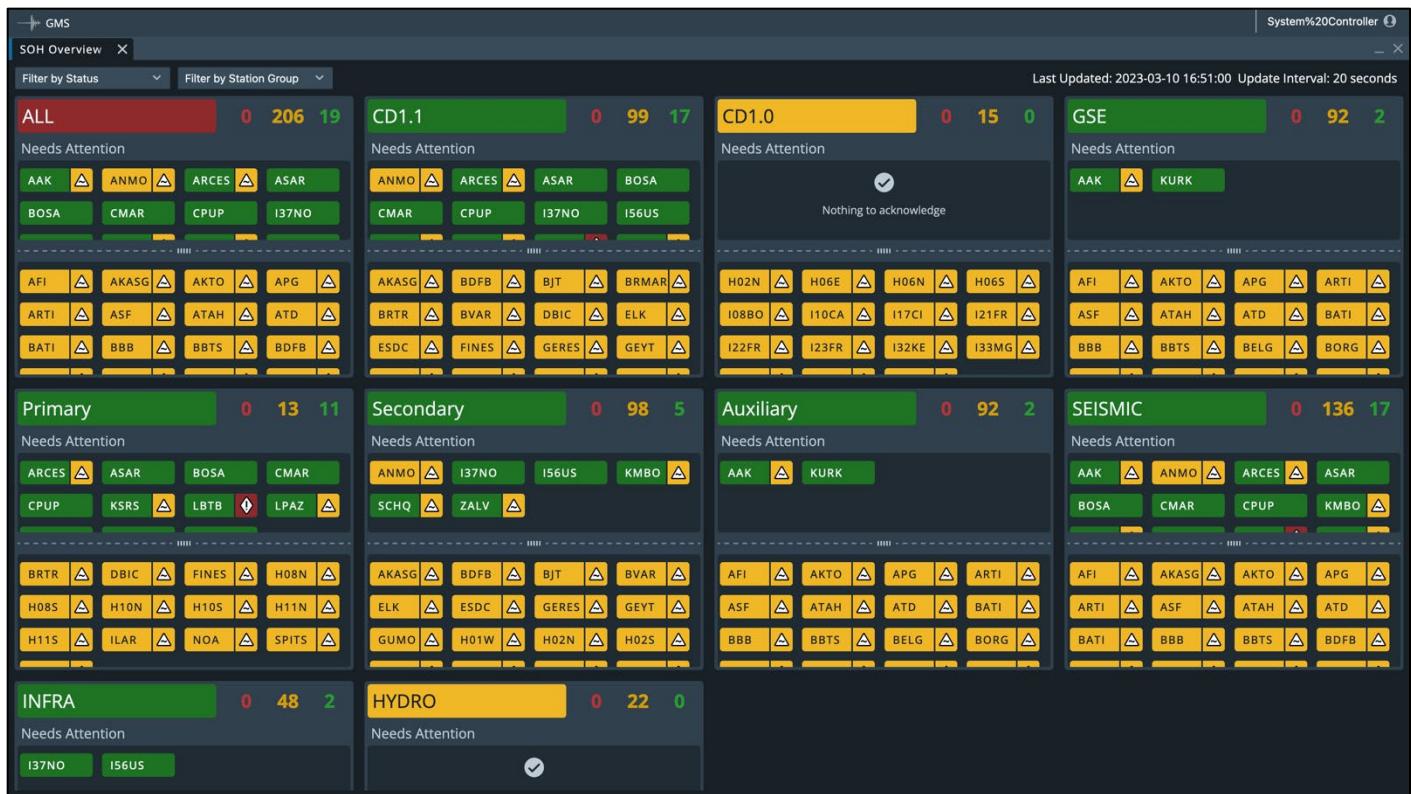


Figure 14. The SOH Overview Display.

In Figure 14, capability-based SOH status is indicated by the station tile color (see color legend in Section 6):

- green = good
- yellow = marginal
- red = bad
- dark gray/hash-marked = not configured to have a capability-based SOH-status

Worst-of SOH status is indicated by the color and shape of the badge at the right of each station tile. The badge will only be displayed if the overall station SOH status is marginal or bad.

1) yellow triangle = marginal = 

2) red diamond = bad = 

If no badge is shown, the worst-of SOH status is good.

The capability-based status or worst-of SOH status can be viewed on the screen by hovering the cursor over the desired tile or badge, respectively.

In the SOH Overview display, stations are sorted into one or more groups defined by a configuration file (see SOH Config Tool documentation). In each group, stations are sorted alphabetically. Groups can be any combination of stations and can share stations between them.

By default, all available station groups are shown in the SOH Overview display. The user can select which station group(s) to view by selecting the station group filter dropdown in the upper-left corner of the SOH Overview display (Figure 14) and checking all desired groups

(Figure 15). Only station groups defined in the current configuration are shown in this dropdown.



Figure 15. SOH Overview Filter by Group Dropdown.

A group's capability-based SOH status is indicated by the group's name color (e.g., Group CD1.1 has a good capability-based status in Figure 14). Also, a station shared between groups may

have a different capability-based SOH status depending on how its status was determined under a given capability configuration (see Section 7).

Worst-of SOH status works differently. Stations are always configured to have a worst-of SOH status, but a station group is not assigned a worst-of SOH status (see Section 7.1). The worst-of SOH status for a station shared between groups will not vary between groups.

In each group, the number of stations in a capability-based SOH status category is shown in the upper-right corner, where number color indicates the category (red = bad, yellow = marginal, and green = good). For example, in Figure 14, Group ALL 1 has 0 bad stations, 206 marginal stations, and 19 good stations. Stations that were not configured to have a capability-based SOH status (dark gray, hash-marked tile) will not contribute to this count. Thus, a group may have more stations than indicated. If a station group was configured to not have a capability-based SOH status, the three categories in the upper-right corner will show as gray zeros. The number of stations in a worst-of SOH status category is never shown.

Both worst-of SOH status and capability-based SOH status are repeatedly updated at a configurable interval. The rough duration of this update interval is shown in the upper-right corner. To the left of the update interval, a Last Updated timestamp indicates the most recent status update, i.e., the time the most recent channel is processed by GMS (Figure 16).

Last Updated: 2023-03-10 16:52:00 Update Interval: 20 seconds

Figure 16. Time Stamp and Update Interval of Last SOH Status Update.

With each update, a station's reported worst-of SOH status or capability-based SOH status may change. Depending on the display width, the user may need to click the three vertical dot icon to view it.

As shown in Figure 17, each station group is further subdivided into two sub-categories: Needs Attention (Figure 17, top) and an unlabeled category (Figure 17, bottom). These categories separate stations that have not been acknowledged by the user (Figure 17, top), and stations that have been acknowledged (Figure 17, bottom). Acknowledgement will be addressed in the next section.

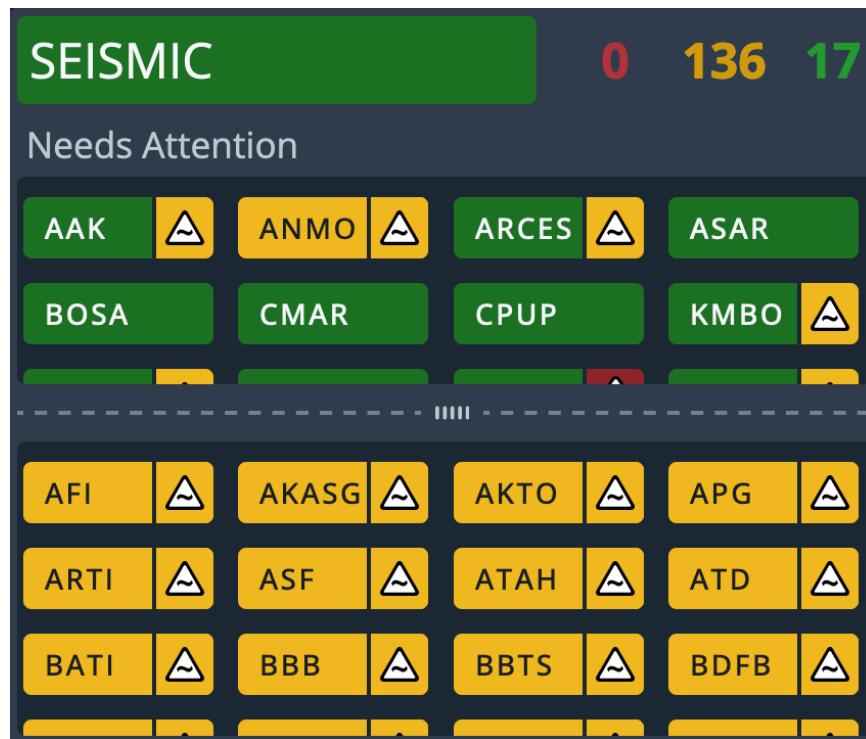


Figure 17. SOH Overview Display for Group SEISMIC.

If no stations in a station group need attention (i.e., all stations have been acknowledged), it will be reflected in the SOH Overview display (Figure 18).

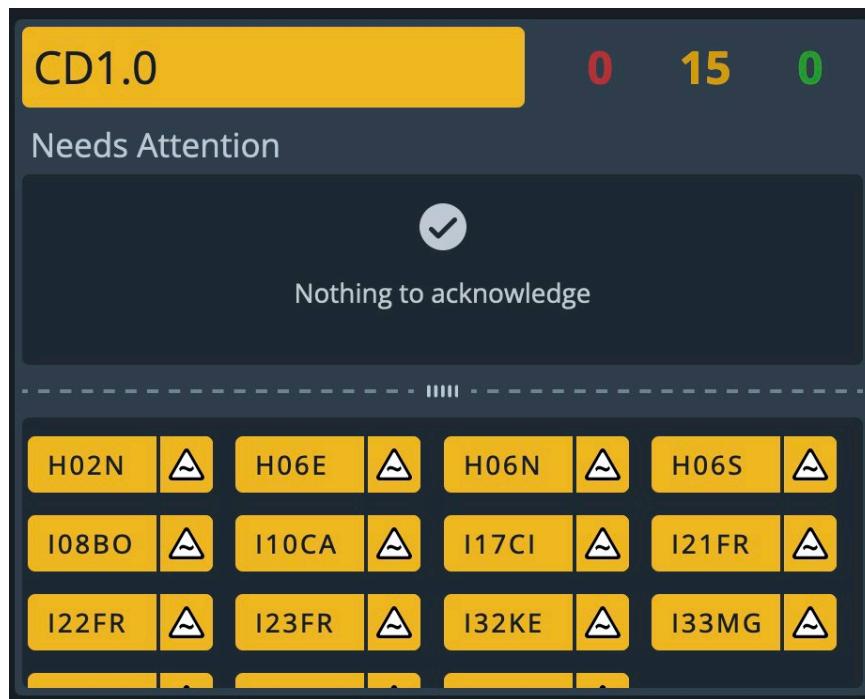


Figure 18. SOH Overview Display for Group CD1.0 with Nothing to Acknowledge.

5.2.1. Acknowledgment

When the SOH UI starts receiving data, all stations are placed in the unlabeled category at the bottom of the display (Figure 17) regardless of their initial SOH status (both capability-based and worst-of). Each station's SOH status is repeatedly determined (see Section 7) and updated at a predetermined interval (i.e., Update Interval).

If a station's SOH status changes during an update, the station will be placed in the Needs Attention category. Stations placed into Needs Attention will be assessed by the user. The user will acknowledge the station's status change by placing it back into the bottom category. If a station belonging to multiple groups is acknowledged, that station will be moved to the bottom category in all groups.

To place a station into the bottom category, the user can

- Click the desired station and drag and drop it in the bottom category,
- Right-click the desired station and select Acknowledge station, or
- Right-click the desired station and select Acknowledge station with comment.

To place multiple stations at once into the bottom category, the user can

- Hold the Ctrl key (Command on Mac) while selecting desired stations from one or more station groups then perform the steps above or
- Click the initial desired station, press, and hold Shift, and click again on the final desired station; the initial and final stations must be in the same station group and category, (e.g., CD1.1 and Needs Attention). This action selects all stations between and including the initial and final clicked stations. Once the selections are made, perform one of the steps above.

If acknowledgment of multiple stations via right-click is performed, the number of stations being acknowledged will be shown in the menu (e.g., Acknowledge 4 stations, Acknowledge 4 stations with comment). Or if multiple stations are dragged to the bottom category, a tooltip indicating the number of stations selected will be printed to screen.

By selecting Acknowledge station status with comment, the user can comment on the selected station(s); see Figure 19.

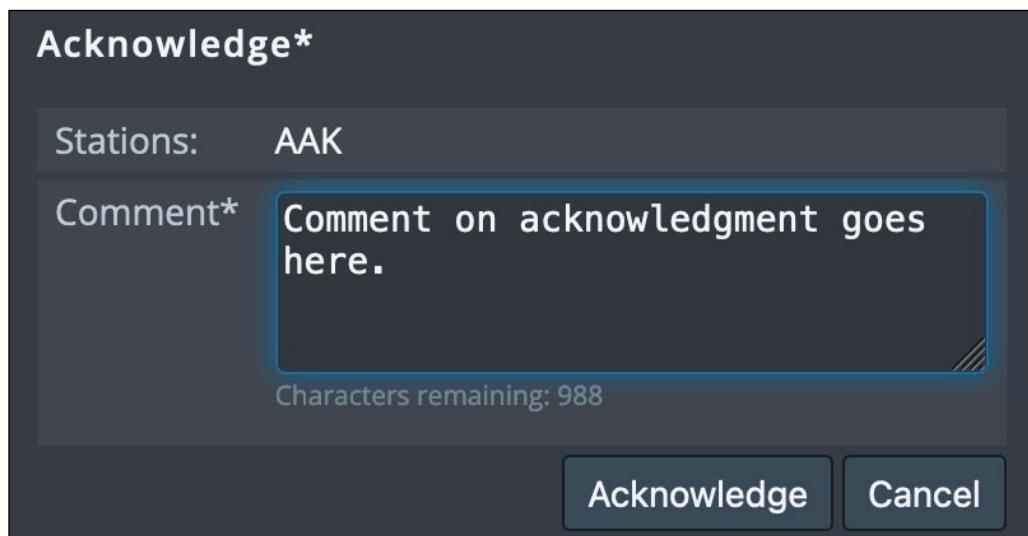


Figure 19. Text Area to Add Comment to Acknowledged Station.

The user's comment has a 1024 character limit. The characters remaining are listed beneath the text block. Once the comment is entered and the user clicks the Acknowledge button, the selected station(s) are acknowledged, and the related comment is stored in a database with the station(s) name, the comment timestamp, and the username (for provenance). The comment information is viewable in the System Message display (Section 5.6). If the user clicks the Cancel button, no action is taken.

Once stations are in the bottom category, the user can view specific capability-based SOH statuses in the bottom category by clicking the Filter by Status dropdown in the top-left corner

of the SOH Overview display (Figure 20). Note that None is a special status that occurs when a station is not configured to have a capability-based SOH status. Station tiles with a status of None will appear dark gray and hash-marked.

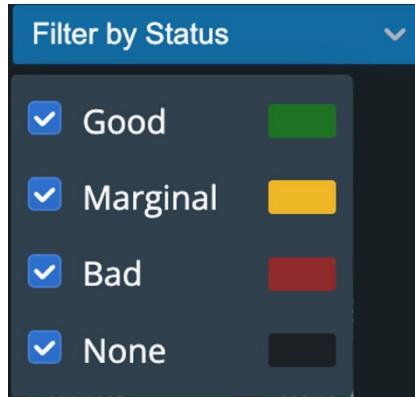


Figure 20. Filter by Status Dropdown Menu.

When a station's status is acknowledged in the SOH Overview display, all unacknowledged channel/monitor statuses for that station are acknowledged and quieted for a configurable period of time. During this quiet period, the user will not be notified of any additional status changes from the acknowledged channels/monitors. This quiet period can be cancelled or overwritten for one or more channels/monitors in the drilldown displays (see Section 5.5.9).

After the quiet period expires, there are several possibilities:

- 1) If no changes to the acknowledged channels/monitors occurred during the quiet period, the station remains in the bottom category.
- 2) If one or more changes occurred during the quiet period, the station is placed into Needs Attention after the quiet period expires.
- 3) If one or more unacknowledged channel/monitor statuses that were not manually quieted (see Section 5.5.9) change during the quiet period, the station is immediately placed in Needs Attention, even if the acknowledged channels/monitors are still in a quiet period.

An individual channel/monitor status can be quieted in the drilldown displays without being acknowledged. Quieting without acknowledgment has a different behavior than described here. See Sections 5.5.1, 5.5.7, and 5.5.9 for more details.

The SOH Overview display is synchronized with the Station Statistics display (see Section 5.3). Any changes to station status or acknowledgement in the Overview display will be reflected in the Station Statistics display and vice versa.

5.3. Station Statistics Display

The Station Statistics display (Figure 21) shows the capability-based SOH statuses of all available stations along with the worst-of SOH status of a station's worst available monitors (see Section 7).

The screenshot shows a GMS interface titled "Station Statistics". At the top, there are filter options: "Filter by Status" (set to "All Groups"), "Show columns", and a timestamp "Last Updated: 2023-03-10 16:54:00 Update Interval: 20 seconds". Below the filters, a section titled "Needs Attention" is visible. The main area contains two tables of data, each with nine columns: Station, Station Missing (%), Station Timeliness (s), Station Lag (s), Station Issues (%), Channel Missing (%), Channel Timeliness (s), Channel Lag (s), and Channel Issues (%). The data is color-coded by SOH status: green for good, yellow for marginal, red for bad, and dark gray for not configured.

Station	Station Missing (%)	Station Timeliness (s)	Station Lag (s)	Station Issues (%)	Channel Missing (%)	Channel Timeliness (s)	Channel Lag (s)	Channel Issues (%)
AAK	67.78	7.48	0.03	N/A	100.00	Unknown	Unknown	N/A
ANMO	1.67	7.50	0.03	Unknown	1.67	7.50	0.04	Unknown
ARCES	5.60	7.50	0.03	0.00	100.00	Unknown	Unknown	Unknown
ASAR	1.66	7.50	0.05	0.00	1.66	7.52	0.06	0.00
BOSA	1.66	7.50	0.03	0.00	1.66	7.50	0.03	0.00
CMAR	1.64	7.50	0.10	0.00	1.66	7.72	0.26	0.00
CPUP	1.66	7.50	0.03	0.00	1.66	7.50	0.03	0.00
I37NO	3.09	7.52	0.33	0.00	8.67	8.47	1.01	0.00
JESSIE	91.76	27.50	0.59	0.00	99.60	99.47	1.00	0.00

Station	Station Missing (%)	Station Timeliness (s)	Station Lag (s)	Station Issues (%)	Channel Missing (%)	Channel Timeliness (s)	Channel Lag (s)	Channel Issues (%)
AFI	100.00	Unknown	Unknown	N/A	100.00	Unknown	Unknown	N/A
AKASG	100.00	Unknown	Unknown	Unknown	100.00	Unknown	Unknown	Unknown
AKTO	100.00	Unknown	Unknown	N/A	100.00	Unknown	Unknown	N/A
APG	100.00	Unknown	Unknown	N/A	100.00	Unknown	Unknown	N/A
ARTI	100.00	Unknown	Unknown	N/A	100.00	Unknown	Unknown	N/A
ASF	100.00	Unknown	Unknown	N/A	100.00	Unknown	Unknown	N/A
ATAH	100.00	Unknown	Unknown	N/A	100.00	Unknown	Unknown	N/A
ATD	100.00	Unknown	Unknown	N/A	100.00	Unknown	Unknown	N/A
BATI	100.00	Unknown	Unknown	N/A	100.00	Unknown	Unknown	N/A
BBB	100.00	Unknown	Unknown	N/A	100.00	Unknown	Unknown	N/A

Figure 21. The Station Statistics Display.

The default Station Statistics display shows nine columns/statuses:

- 1) Station – Station name and its capability-based SOH status as indicated by color (green = good, yellow = marginal, red = bad, and dark gray = not configured to have a capability-based SOH status). The station's worst-of SOH status is indicated by a badge to the right of the station name when the worst-of SOH status is marginal (yellow triangle) or bad (red diamond). If no badge is shown, the worst-of SOH status is good.
- 2) Station Timeliness (s) – The time difference (in seconds) between the current time and the most recent time a data sample has been acquired on any channel. Timeliness indicates how old the most recent data in GMS are. For instance, if GMS received its most recent data at 21:00 and it is now 22:00, the Station Timeliness would be $22 - 21 = 1 \text{ hr} = 3600 \text{ seconds}$. Long timeliness values can result from dead stations/channels or because data are intentionally withheld for a period of time.

- 3) Station Lag (s) – Average transmission time (i.e., lag) across all channels over a configurable period of time. Lag is defined as the time difference (in seconds) between when data are recorded at a remote site and when they are acquired by the GMS system. Lag indicates how quickly data are transmitted from a station to GMS. For instance, if a station records data at 21:00:00 and the data are received by GMS at 21:00:30, the lag is 30 seconds.
- 4) Station Missing Data (%) – Shows the total percentage of missing data across all channels.
- 5) Station Issues (%) – Shows the total percentage of environmental issues across all channels and environmental monitors over a configurable period of time. Environmental monitors provide information related to station functionality in the field, e.g., whether backup power is unstable. A list of potential environmental monitors is provided in Appendix A. When a Station is not configured for any environmental issues, its Station Issues value will be N/A.
- 6) Channel Timeliness (s) – Timeliness value and worst-of SOH status of the channel with the longest timeliness. A channel's timeliness is defined as the time difference (in seconds) between the current time and the most recent time a data sample was acquired on that channel. Channel timeliness indicates how old the most recent data are on that channel. See bullet 2 for an example of a timeliness calculation.
- 7) Channel Lag (s) – Lag value and worst-of SOH status of the channel with the longest lag, i.e., transmission time. Lag is defined as the time difference (in seconds) between when data are recorded at a remote site and when they are acquired by the GMS system. Unlike Station Lag, which is the average lag as defined in bullet 3, Channel Lag is the worst lag within the configurable time period. See bullet 3 for an example of a lag calculation.
- 8) Channel Missing Data (%) – Shows the percentage missing data value and worst-of SOH status of the channel with the highest percentage of missing data over a configurable period of time.
- 9) Channel Issues (%) – Shows the percentage issues data value and worst-of SOH status of the channel with the largest percentage of environmental issues on a single channel/environmental monitor pair over a configurable period of time. When a station is not configured for any environmental issues, its Channel Issues value will be N/A.

For the Channel columns (bullets 6-9), the worst-of SOH status for each monitor type/station pair (e.g., Channel Timeliness for station CMAR in Figure 21) is indicated by color (see color legend in Section 6):

- gray = good,
- yellow = marginal,
- red = bad,
- dark gray, N/A = the station is configured to not receive environmental data
- yellow/hash-marked = marginal/Unknown, i.e., a station configured to receive data for a monitor type never receives the expected data or a station lacking an environmental monitor type(s) is still configured to receive data from that environmental monitor type(s)

Note that if a cell in the Channel columns has an SOH status value that could contribute to an SOH status rollup calculation (either worst-of or capability), but it is configured not to contribute, the cell's color will be shown as semi-transparent, as shown in Figure 22 below.

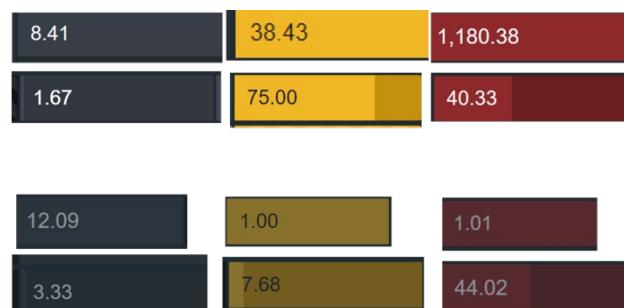


Figure 22. Comparison of Cell Color Shades.

For the Station column, which does not contain data but rather the SOH statuses of a station, a station's capability-based SOH status is indicated by color (see color legend in Section 6):

- green = good,
- yellow = marginal,
- red = bad,
- dark gray = non-defining, i.e., the station does not contribute to the calculation of station group capability rollups

The remaining columns, Station Missing data (%), Station Timeliness (s), Station Lag (s), and Station Issues (%), represent aggregate values for the station and are considered statistics only. These columns' cells are gray; this color does not represent any SOH status since these columns do not contribute to any SOH status calculations. If expected data are not received to calculate an aggregate, these cells will be colored dark gray/hash-marked and labeled as Unknown.

Otherwise, if the station is configured not to receive data to calculate the environmental aggregate, the cell will be dark gray and labeled as N/A.

Specific columns can be selected for viewing by selecting the Show columns dropdown menu at the upper left of Figure 21. The dropdown menu is shown in Figure 23 below.

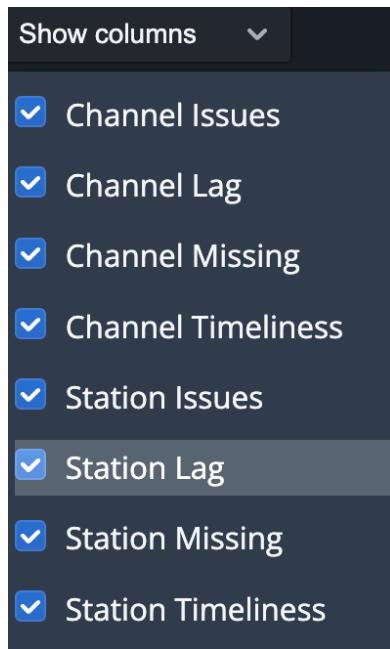


Figure 23. Station Statistics Column Dropdown Menu.

When an option is selected/deselected, the column corresponding to that option will/will not be shown. By default, all columns are shown in the Station Statistics display.

For the Station Missing (%), Station Issues (%), Channel Missing (%), and Issue (%) columns, the percentage of missing data or environmental issues is indicated by cell fill as well as by a numerical percentage value (Figure 24). The percentage of cell fill should match the numerical percentage value written on top.

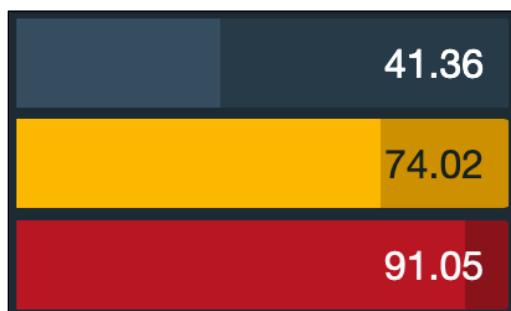


Figure 24. Percentage Cell Fill in Channel Missing and Issues (%) Columns.

By default, the above information is shown for all available stations from all available station groups. Stations in multiple groups are only shown once. Thus, the SOH status shown in the Station column represents a station's worst available capability-based SOH status amongst all groups. This status should correspond to one of the capability-based SOH statuses shown for the same station in the Overview display.

The numbers left of the station name in the Station column (Figure 21) indicate the number of groups in which a station has a bad (top number) or marginal (bottom number) capability-based SOH status. For example, in Figure 25, station ARCES has a bad capability-based status in 4 groups and a marginal capability-based status in 1 group.

If a station's worst available capability-based SOH status is the only instance of a bad or marginal status amongst all groups, the corresponding bad or marginal count will be blank. An example would be station CMAR (Figure 25), whose worst available capability-based SOH status of bad (red tile) is also the only instance of a bad status for CMAR amongst all groups. Note in this example that because a bad SOH status is worse than marginal, a value of 1 is shown in the marginal count for CMAR, even though it is the only instance of a marginal status for CMAR amongst all groups.



Figure 25. Counts of Bad and Marginal Capability-Based Statuses for Stations ARCES and CMAR.

To view stations from a select group, the user selects the dropdown menu labeled All Groups (upper-left corner of Figure 21) and selects a group to view in the Station Statistics display (Figure 26).

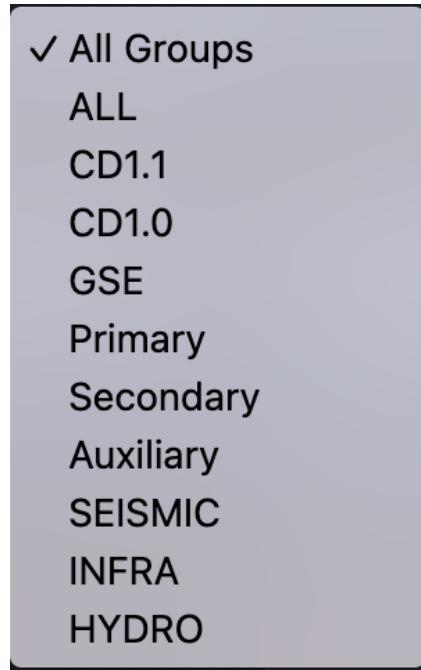


Figure 26. Station Statistics Filter by Group Dropdown.

When a group is selected, the dropdown button label will change from All Groups to the selected group name, e.g., CD1.1. The tile color in the Station column now represents the capability-based SOH status of the station for that group. It should match the station status shown in the corresponding group in the Overview display. The counts on the station name's left will no longer be shown. The badges indicating worst-of SOH status will remain the same, since station worst-of SOH status does not vary by group.

Similar to the SOH Overview display, the Station Statistics display is split into two categories: Needs Attention (Figure 21, top) and an unlabeled category containing stations that have been acknowledged (Figure 21, bottom). The unlabeled category can be filtered by capability-based SOH status by selecting one or more statuses from the Filter by Status dropdown menu (upper-left corner of Figure 21; see Figure 20 for the menu).

These categories, and station acknowledgement in general, function similarly to the SOH Overview display. Please refer to Section 5.2.1 for more information.

5.3.1. Table Layouts

The Station Statistics display shown in Figure 21 is in the default table layout. This table and any other table in the SOH UI can be modified in six ways:

- 1) The columns' position can be rearranged by clicking anywhere in the column title cell and dragging the column to the desired position.
- 2) Columns can be pinned such that they remain in place while scrolling. For instance, in the Station Statistics display the Station column is pinned by default as indicated by the white divider between it and the Station Missing (%) column in Figure 21. To pin columns, drag a desired column to the far left or far right of the table, then hold until a pushpin icon appears (Figure 27).

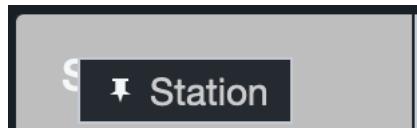


Figure 27. Pushpin Icon.

Once the pushpin appears, release the column: this action will generate a pinned area of the table indicated by a white divider. Two pinned areas can be made at the same time – one to the far left and one to the far right. The user can now place as many columns as desired in the pinned area(s) by dragging and dropping a desired column to the left (or right) of the divider(s).

The horizontal scroll bar will shrink as columns are placed in the pinned area(s). Further, the scroll bar will be placed to the right (or left) of the divider(s). These changes to the scroll bar are used to indicate which columns can still be scrolled through.

To remove the pinned area(s), drag and drop each column in the pinned area(s) to a desired position on the right (or left) of the divider(s) until all columns have been moved and the divider(s) is no longer visible.

- 3) Column width can be modified by hovering over a column title edge until a double-arrow symbol appears. Then the user can click and drag the column edge to the desired width.
- 4) Columns can be added or removed by deselecting the column from the Show columns dropdown menu (see Figure 23). Note that the Station column cannot be removed.
- 5) Station names can be sorted alphabetically ascending or descending by clicking the arrow symbol (Figure 28) to the right of the Station column title. By default, station lists are sorted ascending (arrow points up). To change to descending, click once anywhere in the column title, except on the bar menu button (far right of Figure 28) which is used to open the filter menu (bullet 5).



Figure 28. Sorting Arrow for Station Column.

- 6) Stations can be sorted by increasing or decreasing Station/Channel Timeliness, Lag, Missing (%), or Issues (%) by hovering over the respective column title and clicking to bring up an arrow symbol (similar to Figure 28). The arrow will point up for increasing value, down for decreasing value. By default, these columns are not sorted. When sorting by one of these monitors (columns), the position of a station in the list may change with every update as the monitor value changes. The arrow symbol will only be visible in the column being sorted.
- 7) Rows can be filtered to show one or more desired stations by hovering to the far right of the Station column title to bring up a bar menu button (Figure 29).



Figure 29. A Close-up of the Bar Symbol Used to Pull Up a Filter Menu.

When this button is clicked, it will bring up a filter menu (Figure 30, left). When a value is entered into the filter field, the menu expands giving the option to apply another AND/OR filter (Figure 30, center) with its own filtering options (Figure 30, right). The option to apply another AND/OR filter can only be used once. Once the values are entered, click anywhere in the display to hide the filter. A funnel shaped symbol will appear to the right of the Station column title, indicating a filter is in place. To remove the applied filter, bring up the filter menu once more and delete the entered value(s).

Rows can also be filtered by any of the station or channel column values (e.g., Station Timeliness, Channel Missing). The actions are the same as described for the Station column.

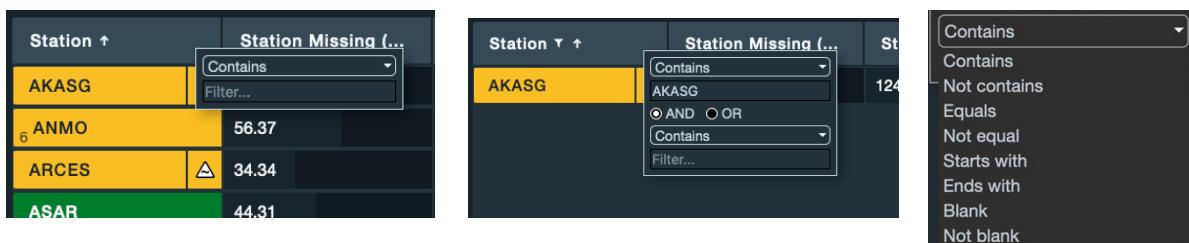


Figure 30. (Left) Station Filter Application (Right) Menu Expansion for Applying Another AND/OR Filter (Center) Available Filter Options.

5.4. SOH Map Display

The SOH Map display (Figure 31) provides a map showing station locations, where each station is represented as a triangle icon. If zoomed in sufficiently, all station names will appear next to their corresponding icon.

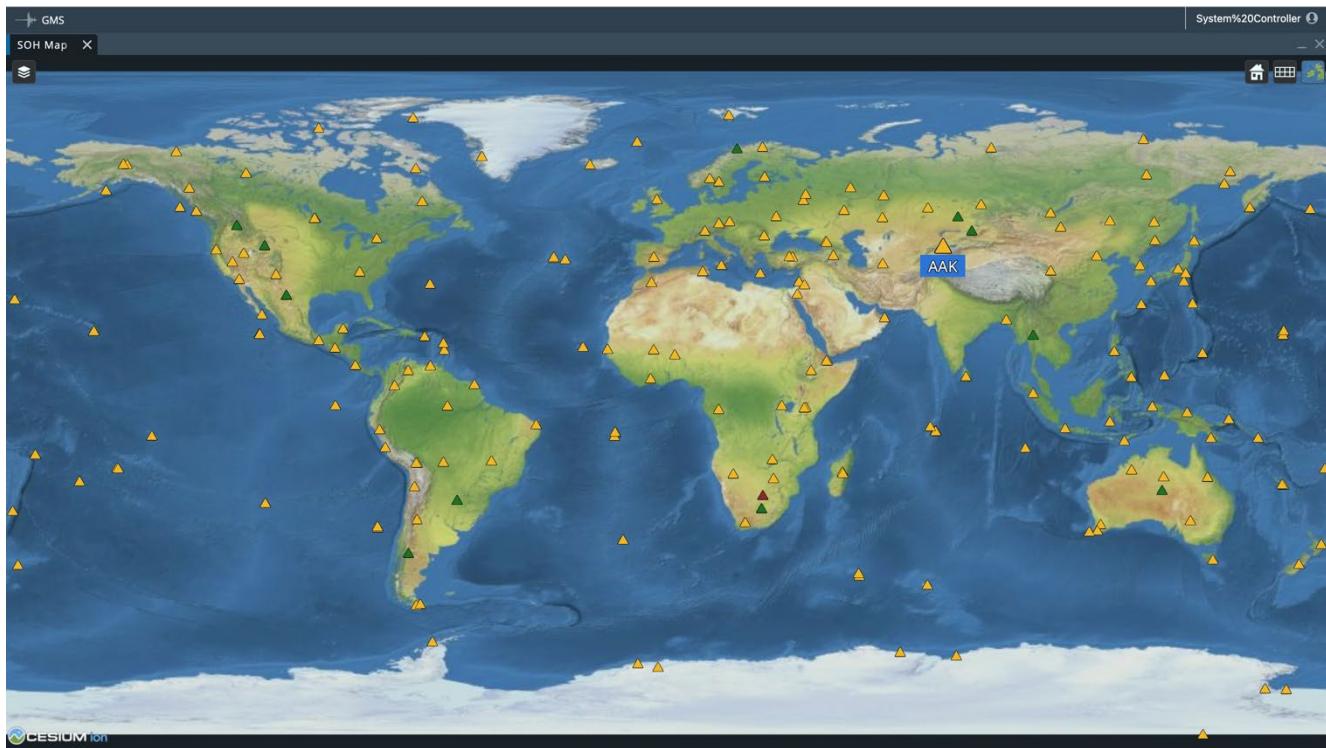


Figure 31. SOH Map Display.

By default, all stations from all groups are shown on a 2D projection, with station color indicating a station's current worst-of SOH status (green = good, yellow = marginal, and red = bad). In this default projection, the user can click and drag to pan across the map. The user can also zoom in and out by 1) using the mouse scroll wheel (scroll forward to zoom in, scroll back to zoom out) or 2) using a two-finger drag on a touch pad (drag towards the user to zoom in, drag away from the user push away from the user to zoom out).

To select a particular station group(s) for viewing, click on the layers button in the upper-left corner to bring up the dropdown menu in Figure 32.

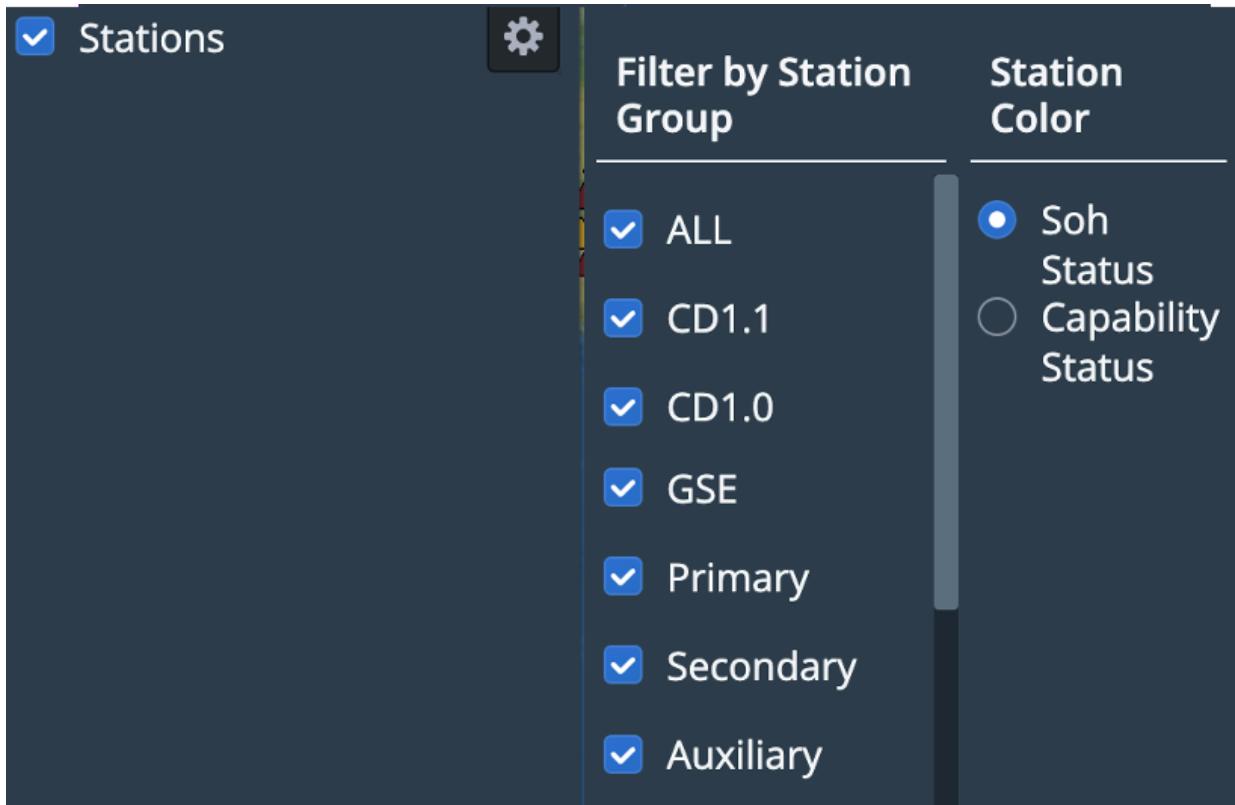


Figure 32. Map Stations Dropdown Menu with Options Menu Open.

In this menu, the user can choose to remove all station icons from the map by deselecting the Stations option. To add/remove certain station groups to the map, the user clicks the gear wheel to the right of Stations. This action will bring up a list of station groups that can be added or removed. Since the worst-of SOH status does not vary among station groups (Section 5.3), station color will not change with group selection.

In addition, this menu can be used to color station icons based on their capability-based SOH status instead of by their default worst-of SOH status (called Soh Status in Figure 32). This action is performed by selecting Capability Status from the Station Color column. If capability-based status is shown on the map while multiple station groups are selected for viewing, a station's color will indicate its worst capability-based status amongst all selected groups. As with worst-of status, green = good, yellow = marginal, and red = bad. In addition, stations can have a special status of None that occurs when a station is not configured to have a capability-based SOH status. In this case, station markers will be black as show in Figure 33.



Figure 33. Map Marker with a Capability-Based Status of None.

The SOH Map display is synced to the SOH Overview and Station Statistics displays (Sections 5.2, 5.3) such that when a station is selected in the SOH Map display, that station will be highlighted in blue in all three displays (see Figure 37). Further, the four drilldown displays (Sections 5.5.1, 5.5.3, 5.5.5, 5.5.7) will be populated with data from the selected station if the displays were added to the workspace layout by the user (Section 5.1). Unlike the SOH Overview and Station Statistics displays, the user can only select one station at a time in the SOH Map display.

In addition, a selected station's icon will appear larger than other icons as seen in Figure 31 where station AAK has been selected. Note that acknowledgement (Section 5.2.1) and quieting (Section 5.5.9) cannot be performed in the Map display.

Three other buttons are provided in the upper-right corner of the Map display (Figure 31) as shown in Figure 34.



Figure 34. Map Display Buttons.

From left to right, the buttons are the View Home button, Projection button, and Imagery and Terrain button. Hovering over a button with the cursor will provide a tooltip briefly describing that button.

When the user clicks the View Home button, the map will automatically be positioned over the United States regardless of starting position. Note that if the map is already optimally positioned over the United States, clicking on the View Home button will result in no change.

When the user clicks the Projection button, a dropdown menu with alternative projections is provided (Figure 35, left). Hovering the cursor over each option in the dropdown menu will

provide a tooltip briefly describing the projection. In addition to the default 2D projection a 3D globe (Figure 35, right) is provided.

In the 3D globe projection, click and drag to rotate the sphere; to zoom, perform the same actions described for the default 2D projection.

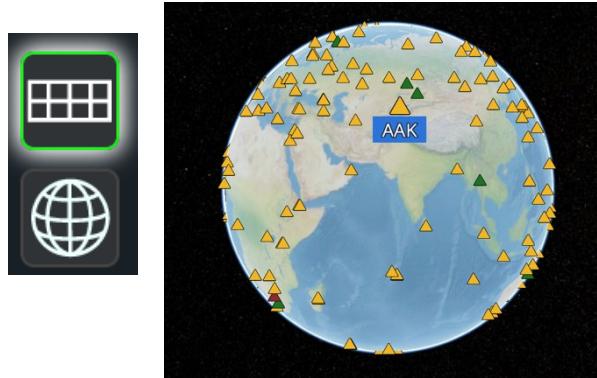


Figure 35. Projection Dropdown Menu (Left) and 3D Globe Projection (Right).

When a projection option is selected, the Projection button label changes to the current projection being viewed.

The Imagery and Terrain button provides a dropdown menu (Figure 36) allowing the user to select the appearance of the map and the ellipsoid to be used to define the terrain.



Figure 36. Imagery and Terrain Dropdown Menu.

Currently, only default options are provided for imagery and terrain (see Section 8). These defaults are automatically applied to the map and cannot be changed or removed.

5.5. SOH Drilldown Displays

The SOH drilldown displays troubleshoot specific monitors for a selected station. Currently, these monitors are Lag, Timeliness, Missing (%), and Issues (%), i.e., Environmental Issues, which were defined in Section 5.3.

To populate a station drilldown display, the user must first select a station in one of the displays discussed so far: SOH Overview (Section 5.2), Station Statistics (Section 5.3), SOH Map (Section 5.4). The selected station can come from any group and can be in the Needs Attention category or the bottom category containing acknowledged stations. Once selected, the station will be highlighted in blue in displays with tables (e.g., SOH Overview, Station Statistics), while the corresponding station icon in the SOH Map display will increase in size, with its name highlighted in blue, as shown in Figure 37.

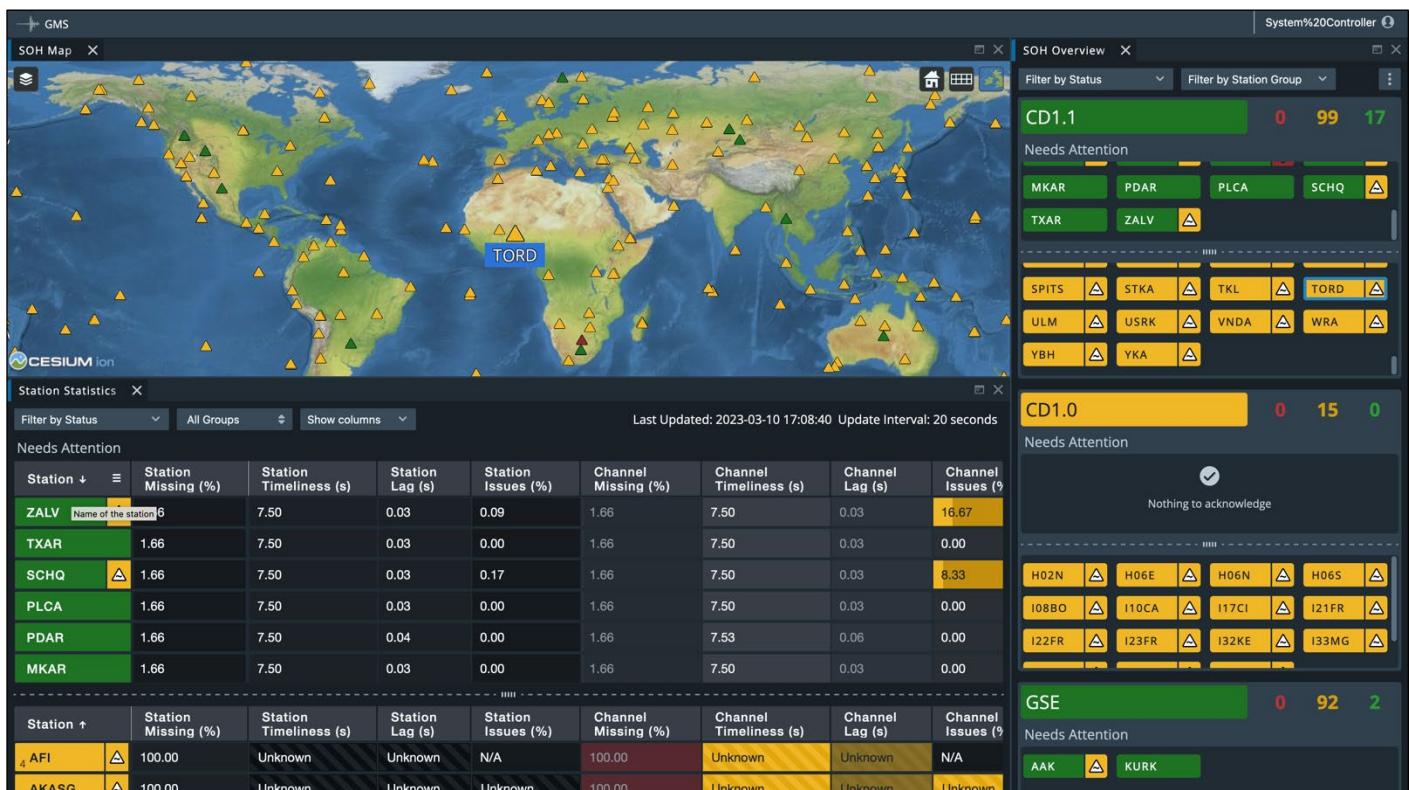


Figure 37. The SOH UI Default Layout with Station TORD Selected.

In Figure 37, station TORD has been selected. Each instance of TORD in the summary displays is highlighted by a blue box. To see the effect of selection on the drilldown displays, the layout is switched to the Drill Down workspace layout in Figure 38.

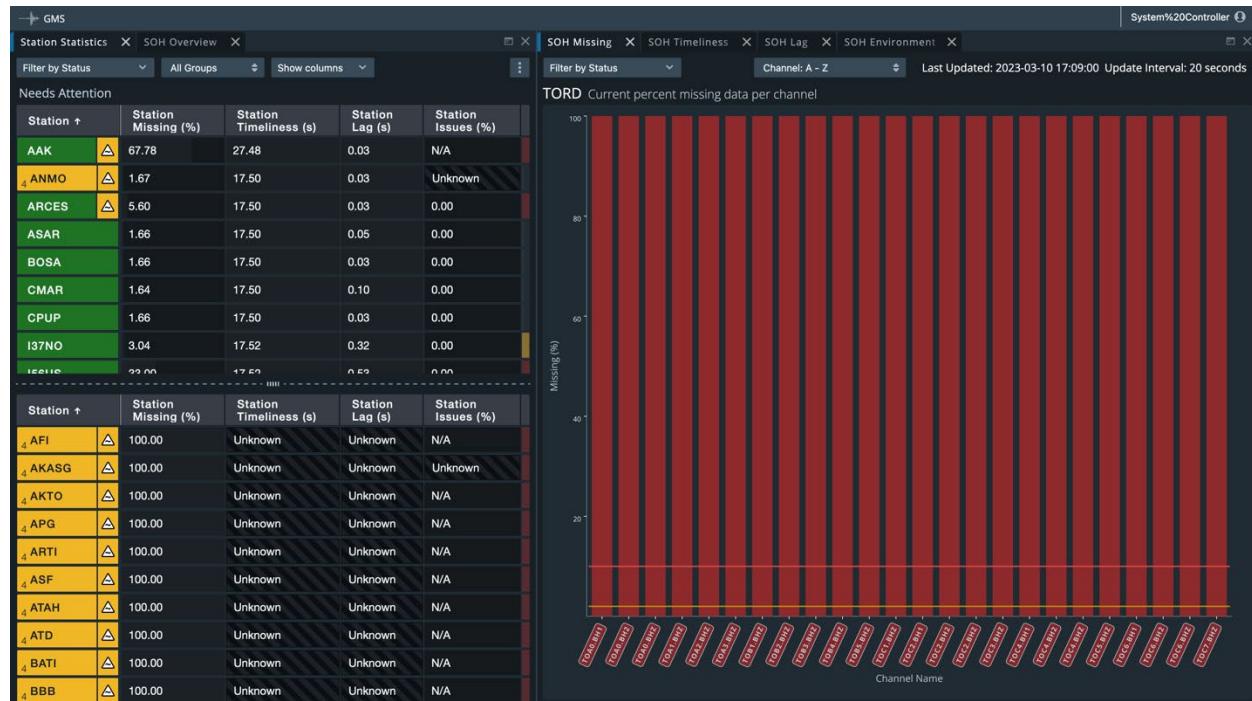


Figure 38. The SOH UI Drill Down Layout with Station TORD Selected.

Here we see that the SOH Missing display at right (as well as the other drilldown displays, not shown) is populated with the corresponding information for TORD. To view a particular drilldown display, e.g., SOH Lag, click on the desired tab or switch to a relevant workspace layout (Section 5.1).

The SOH Lag Trends, Timeliness Trends, and Missing Trends drilldown displays will also be populated with station information if they are added to the workspace layout (see Sections 4, 5.1, 5.5.2, 5.5.4). An additional step is required to populate the SOH Environment Trends drilldown display; this additional step is described in Section 5.5.8.

In the drilldown displays, only one station can be selected at a time. If multiple stations are selected in the SOH Overview or Station Statistics displays, the user will be instructed to select only one station (Figure 39).



Figure 39. The SOH Lag Display with Multiple Stations Selected.

In the following sections, each drilldown display is described in detail.

5.5.1. SOH Timeliness Drilldown Display

The SOH Timeliness drilldown display shows the SOH Timeliness status of all available channels for a selected station (CMAR in Figure 40).

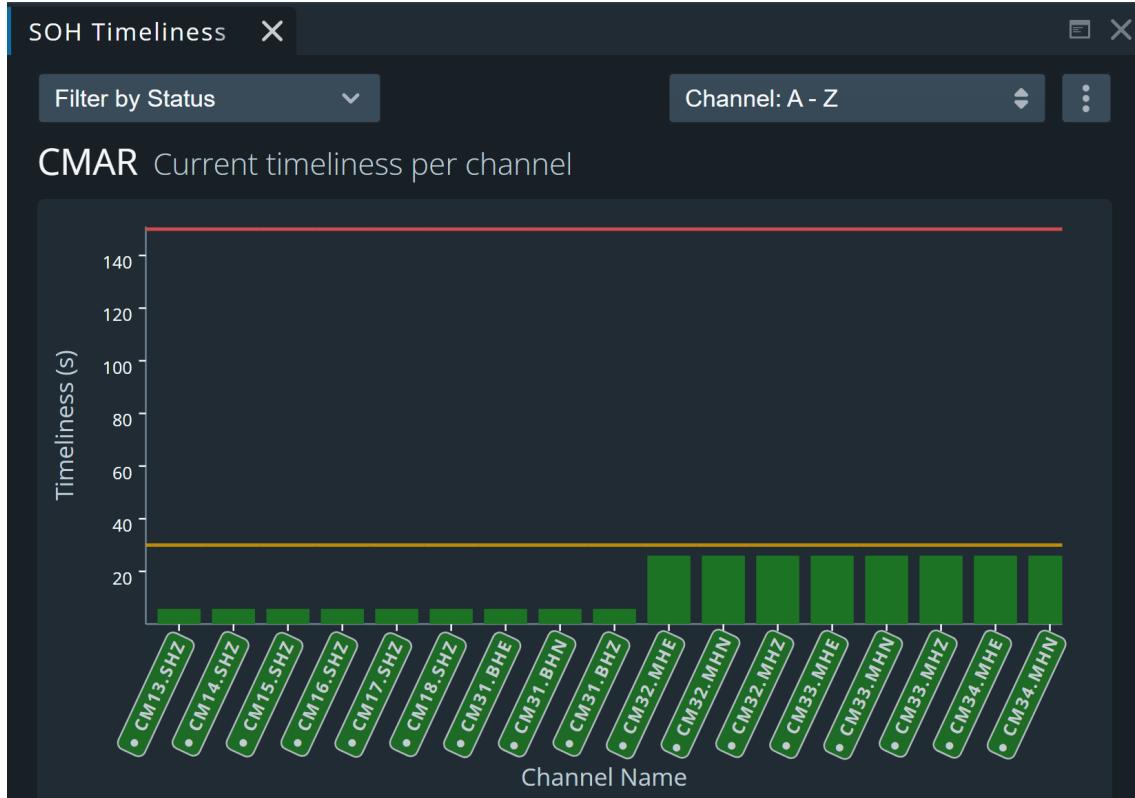


Figure 40. The SOH Timeliness Drilldown Display.

Timeliness (in seconds) is shown on the y-axis and the channel name is shown on the x-axis. Yellow and red horizontal lines indicate marginal and bad thresholds. Vertical bars as well as channel labels are colored based on SOH timeliness status, with green = good, yellow = marginal, and red = bad. Channels with a value of Unknown, i.e., had no data received and were configured to receive data (see Section 7), are indicated by a yellow, hash-marked channel name with no bar and have a status of marginal. Similar to the Station Statistics display, a semi-transparent bar and/or channel name is an indicator that the associated channel is configured not to contribute to SOH rollup calculations (see Section 5.3, Figure 22).

By default, channels are sorted alphabetically by channel name ascending from left to right. To rearrange channels by different criteria, the user can click the drop-down menu (upper-right dropdown of Figure 40) shown in Figure 41 and select from four options:

- 1) Timeliness: highest to lowest – Arranges channels from highest to lowest timeliness value from left to right.
- 2) Timeliness: lowest to highest – Arranges channels from lowest to highest timeliness value from left to right.
- 3) Channel: A-Z – Arranges channels alphabetically ascending from left to right.
- 4) Channel: Z-A – Arranges channels alphabetically descending from left to right.

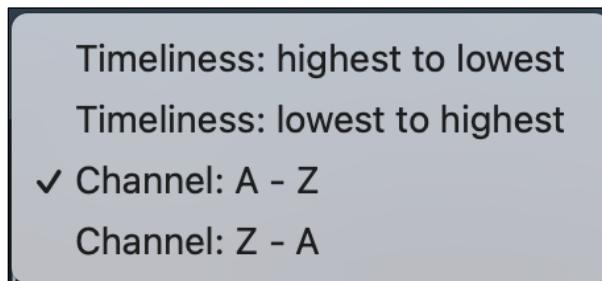


Figure 41. Sorting Options in the SOH Timeliness Drilldown Display.

The selected option will be indicated by a checkmark in the Sorting Options dropdown menu. Note that when an option is selected, the dropdown button label will change to that selected option, e.g., Channel: A-Z in Figure 40.

Channels shown in the display are station specific, with broadband 3-component stations only having three channels and station arrays having more than 3 channels (e.g., CMAR in Figure 40). If a station has more channels than can be viewed in the current window, a secondary display will appear beneath the main display as shown in Figure 42.



Figure 42. SOH Timeliness Display with Secondary Display Shown at Bottom.

The secondary display shows the channels on a modified scale, allowing all available channels to be viewed at once. A white rectangle in Figure 42 indicates which channels are simultaneously being viewed in the secondary display (Figure 42, bottom) and the main display (Figure 42, top). By default, this rectangle will initially be positioned at the far left of the secondary display. To view other channels, the rectangle can be dragged to a new position.

A new rectangle can be generated at a desired position by clicking a point on the secondary display and holding while dragging the cursor to the right. When the rectangle is the desired width, release the mouse/touchpad to set the new rectangle.

After the rectangle is set and positioned, the user can update its width by hovering over one of the rectangle edges until a double-arrow appears. When the double-arrow is visible, click and hold while dragging the rectangle edge to the desired width. Release the mouse/touchpad to

set the new rectangle length. Note that while the rectangle can be modified, it cannot be removed from the secondary display.

The secondary display can be automatically removed by increasing the SOH Timeliness drilldown display's width until all channels are visible. For station arrays with a large number of channels, e.g., ARCES, the secondary display is always shown.

The height of each vertical bar in the main SOH Timeliness drilldown display represents a channel's total timeliness in seconds, with that channel's configurable marginal and bad thresholds (see Configuration documentation) indicated by yellow and red horizontal lines, respectively. A channel's SOH timeliness status is determined by comparing bar height to these thresholds. To keep the thresholds visible on screen, the maximum y-axis value is set to either the maximum timeliness value or the maximum threshold value depending on which is larger.

If the channel's bar height is below both the marginal and bad thresholds, the channel's SOH timeliness status is good, and the bar and channel name are green. If the bar height is greater than the marginal threshold but below the bad threshold, the channel's SOH timeliness status is marginal, and the bar and channel name are yellow. If the bar height exceeds the bad threshold, the channel's SOH timeliness status is bad, and the bar and channel name are red.

The timeliness value, rounded to 2 significant figures, can be viewed via a tooltip by hovering over the channel name. If no data have been received for a channel, the tooltip value will be Unknown.

Each channel's SOH timeliness status is determined and updated at a configurable Update Interval (Figure 16). This time is in the upper-right corner of the SOH Timeliness display (Figure 40). Depending on the display width, the user may need to click the three vertical dot icon to view it.

The user can select which channel SOH timeliness statuses to view by clicking the Filter Status dropdown at the top-left corner of the SOH Timeliness display and checking all desired statuses (Figure 43).

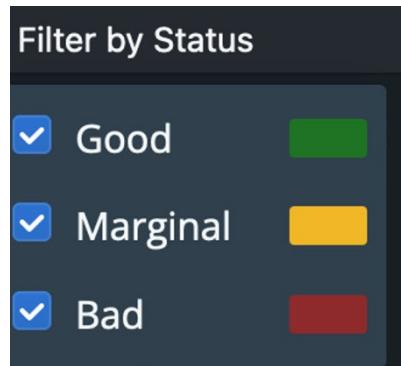


Figure 43. SOH Lag Filter by Status Dropdown Menu.

In the main SOH Timeliness display, unacknowledged channels are indicated by a white dot next to the channel name (Figure 40). When a station is acknowledged in the SOH Overview or Station Statistics display (Section 5.2.1), the channels are placed in a quiet period and the white dots disappear. When this state occurs, a clock showing the duration of the quiet period appears at the top of every acknowledged channel's bar; see Figure 44. If a bar is too short to accommodate the clock, the clock is displayed above the corresponding bar.

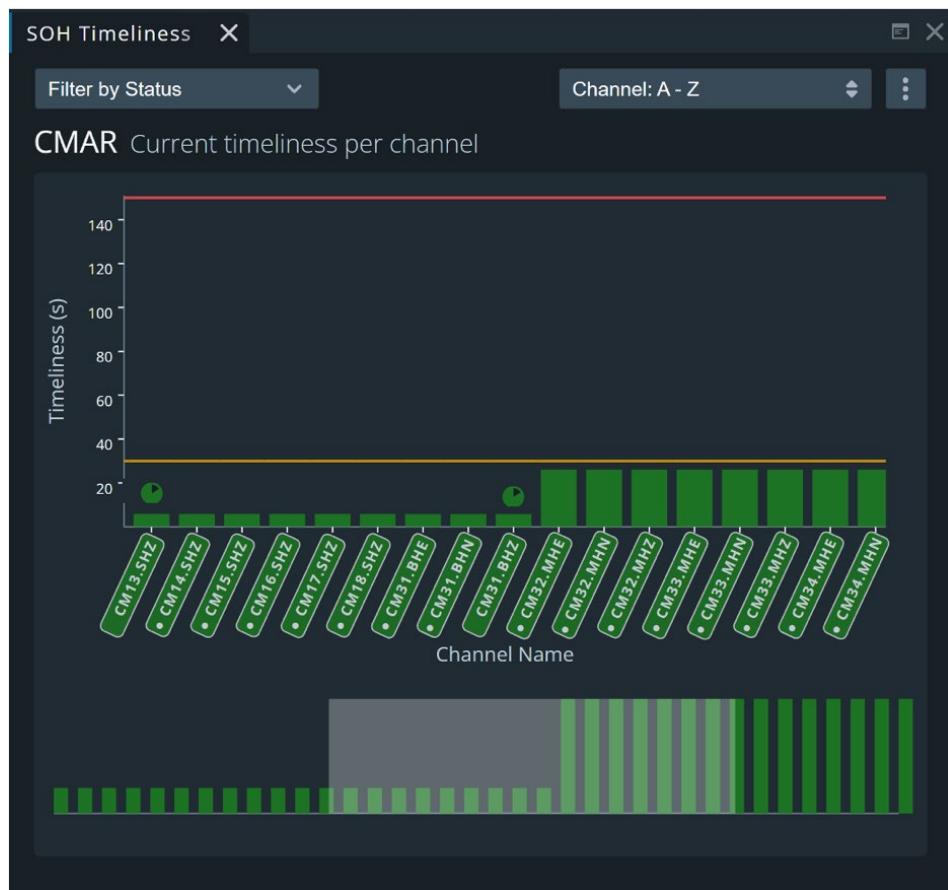


Figure 44. Acknowledged Channels in the SOH Timeliness Display.

The quiet period's remaining time is indicated by the amount of fill in the clock. The user can hover their cursor over the clock to view a tooltip with the remaining time. All acknowledged channels are automatically placed into a quiet period at the same time; hence their quiet period durations are equal as can be seen in Figure 44. Any changes in the timeliness status of a channel during this quiet period will result in the station being placed back into Needs Attention after it expires (see Section 5.2.1).

Channels can be manually quieted by right-clicking the bar or channel name and selecting a duration from the option menu. While similar, quieting is not the same as acknowledgement. Quieting will be described in detail in Section 5.5.9.

5.5.2. SOH Timeliness Trends Drilldown Display

The SOH Timeliness Trends drilldown display (Figure 45) consists of a bar chart and a time-series plot. It shows lag trends over a specified time range for all available channels of a specific station. This display is not part of the default workspace layout, but can be added by clicking the application-level menu button (Figure 3) and selecting a workspace that includes SOH Timeliness Trends or directly selecting SOH Timeliness Trends from the SOH menu options (Figure 12). See Sections 4 and 5.1 for more detail.



Figure 45. The SOH Timeliness Trends Drilldown Display.

The bar chart shows the average timeliness per channel (in seconds) over the specified time range. Each channel's current marginal and bad thresholds (see Configuration documentation) are shown as yellow and red horizontal lines, respectively. If a channel's average lag exceeds one or both thresholds, the channel is marginal or bad, respectively. Unlike the SOH Timeliness display, the bar colors do not indicate whether a channel is problematic.

Just as with the SOH Timeliness drilldown display (Figure 42), a secondary display showing all channels on a modified scale is visible if the number of channels exceeds what can be shown in the main Timeliness Trends drilldown display. See Section 5.5.1 for details and use.

The time-series plot indicates the change in timeliness (in seconds) per channel over the same specified time range as the bar chart. By default, all channels' time-series will be shown in the plot with the same colors as in the bar chart. Individual channels can be hidden to improve viewing via the dropdown menu (Figure 46) located in the upper-left corner; see Figure 45. From this menu, a channel's bar chart and time-series can be removed from the display by deselecting it.



Figure 46. Timeliness Trend Time-Series Filter Dropdown Menu.

Each channel in the Timeliness Trends drilldown display will have a unique color to ensure the bar and time-series of a specific channel are easily identifiable. Note that this unique channel

color will also be used in the Missing Trends, Lag Trends, and Environment Trends drilldown displays (see Sections 5.5.4, 5.5.6, and 5.5.8 for these displays).

The user can zoom into a portion of the time-series plot using the cursor shown as a vertical white bar (see Figure 45). To zoom, continuously hold the Ctrl key (Command on Mac) while clicking and dragging the cursor. A white window indicating the new time interval to zoom to will be shown. While performing this action, a pop-up showing the date and time marked by the vertical white cursor as well as the duration of the white window are shown (Figure 47).

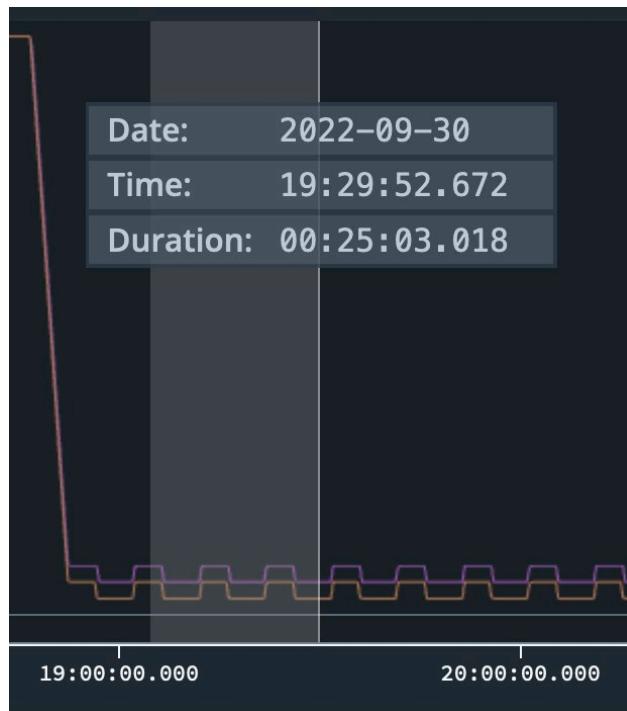


Figure 47. Window Indicating Time Interval to Zoom into With Pop-Up Showing Window Information.

Once the desired window length is highlighted, release Ctrl + click. To zoom back out to the original window, double-click the left mouse button. Alternatively, the user can zoom in and out by holding the Ctrl key and scrolling (Command and scroll on Mac). Note that zoom can only be applied a limited number of times. A pop-up message will be displayed in the lower-right corner if the maximum zoom has been reached.

The user can also print the pop-up shown in Figure 47 by clicking and holding the left mouse button only. By dragging the white vertical cursor across the screen while continuing to hold the left mouse button, the user can view different specific times in the series. The duration

shown will be the difference in time between the current cursor location and the initial cursor location when the user began performing the described action.

By default, the time range of the bar chart and time-series plot is set to be the last 6 hours. The total time period being viewed is indicated at bottom-left and in the time range shown at upper right. In Figure 45, the time period shown is 2022-09-30 16:42:00.581+ 6 hours.

The user can specify another time range via the dropdown menu shown in Figure 48. The menu is brought up by clicking the edit button in the upper-right corner (see Figure 45). The user can either select a default time range at the left of the menu (last 6 hours, last 12 hours, last 1 day, or last 7 days) or select a start and end date via the calendars and/or dialog boxes below.

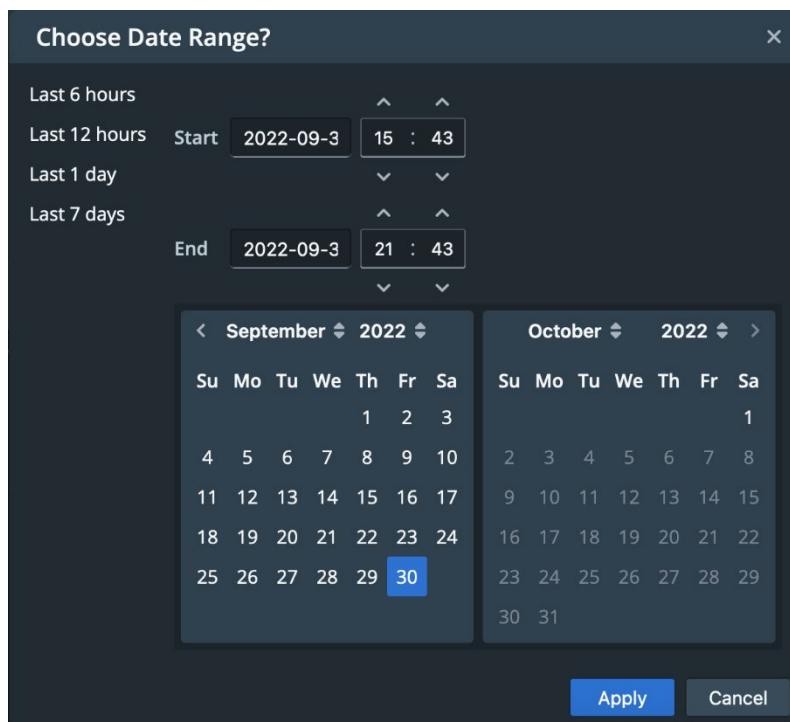


Figure 48. Time Range Dropdown Menu.

When using the calendar, the user can set the months to view by using the horizontal arrows to the far left and far right of the months/years shown. For instance, in Figure 48, clicking on the horizontal arrow to the left of September 2022 will cause both calendars to go back by a month, such that an August 2022 calendar is shown at left and a September 2022 calendar is shown at right. Clicking on the horizontal arrow to the right of October 2022 in this example would cause both calendars to jump forward by a month if those times were in the system. However, in this example November 2022 exceeded the current date; thus, the arrow to jump forward in time was grayed out. Alternatively, if the user clicks on the month or year above a

calendar entry (e.g., September 2022 or October 2022 in Figure 48) dropdown menus listing the available months and years will be shown (Figure 49) and can be used to set the month and year, respectively.

Note that the two calendars are synced such that they always show adjacent months, with the calendar at left always being one month earlier than the calendar at right. For instance, if the user selects the month of February in the left calendar, the right calendar automatically updates to March of that same year. Further, if the user changes the year in either calendar, both calendars will automatically be set to that year. For instance, if the year shown in Figure 48 is changed from 2022 to 2021, the calendars dates would update from January 2022/February 2022 to January 2021/February 2021. Thus, the calendars cannot be used to set a time range greater than two months duration; the Start and End context boxes must be used instead.



Figure 49. Open Anything Month and Year Dropdown Menus.

Once the user has set the calendars to the desired months/years, the user will click on a desired start date to begin setting the time range via the calendars. This action will cause the date to be highlighted in blue. The user then clicks on another date to set the end time, which is also highlighted in blue. If the user selects a start date that occurs later than the end date, the SOH UI will automatically rearrange the dates such that the earliest date is the start date. However, if the user chooses the same day to be the start and end date via the calendar, a warning will be displayed and the Apply button will be grayed out until valid dates are selected.

Any dates between the start and end dates selected are shown in light blue. The Start and End hours and minutes still need to be modified using their respective context boxes. To select a

new time range using the calendars, the user can click on another desired start/end date and repeat the same actions as above.

Alternatively, the user can set the time range via the Start and End context boxes above the calendar (Figure 48). The Start and End context boxes and calendar are synced such that manual entries in the Start and End context boxes will cause the corresponding dates to be highlighted on the calendar. Alternatively, selecting a start and end date with the calendar will fill the Start and End options with the corresponding start/end dates and times selected.

When entering times into the Start and End options, click the Start and/or End date and type in the desired date in **YYYY-MM-DD** format. If a different format is entered, e.g., 2021:09:12 or 09-12-2021, the date will automatically be converted to the default format. If an invalid date is entered, the value will revert to the last valid value entered. Also, if the end date is set equal to or earlier than the start date, a warning will be displayed and the Apply button will be grayed out until a valid date is entered. The hour and minute can be set by either clicking on the hour and/or minute context box and manually entering in a value or using the up and down arrows to increase or decrease the hour/minute, respectively. If an incorrect value is manually entered into the hour/minute box, the box will be highlighted in red. The user must either enter in a new value or click anywhere to have the value revert to the last valid value entered.

Once a time range has been chosen, the user clicks the Apply button to apply the new time range to the bar graph and time-series plots. Depending on the display width, the user may need to click the three vertical dots icon to view the history interval, i.e., time range, dropdown menu. Note that the number of available data points displayed in the time-series plot (as seen at the top left of Figure 45) will decrease, i.e., be decimated, for long time ranges to keep the plot readable.

If no data are available during the time range selected or all data are Unknown, the display will indicate there is no data or all data were returned unknown, respectively (Figure 50).



Figure 50. The SOH Timeliness Trends Drilldown Display with No Data Available.

5.5.3. SOH Missing Drilldown Display

The SOH Missing drilldown display (Figure 51) shows the Missing (%) status of all available channels for a selected station. The bar color indicates a channel's Missing (%) status (green = good, yellow = marginal, and red = bad).

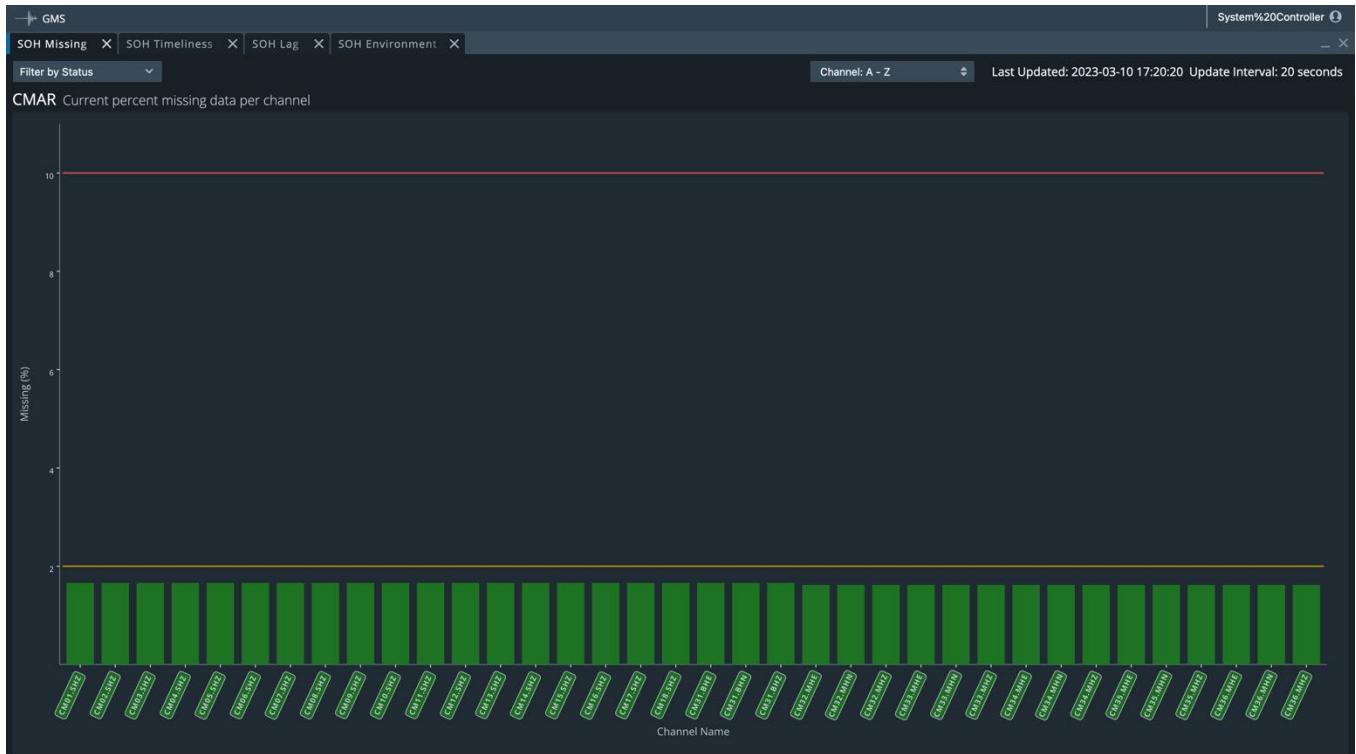


Figure 51. The SOH Missing Drilldown Display.

In the SOH Missing drilldown display, the percentage of missing data (Missing %) is shown on the y-axis, and the channel name is on the x-axis.

The SOH Missing drilldown display functions like the SOH Timeliness drilldown display; however, it is used for troubleshooting the Missing (%) monitor rather than the Timeliness monitor. Note that Missing is currently configured not to have the white dot indicating unacknowledged channels. See Section 5.5.1 for display information. This display is not part of the default workspace layout and must be added by clicking the application-level menu button (Figure 3) and selecting one of the workspace layouts containing SOH Missing display or selecting SOH Missing directly from the SOH menu options (Figure 12). See Sections 4 and 5.1 for more detail.

5.5.4. SOH Missing Trends Drilldown Display

The SOH Missing Trends drilldown display (Figure 52) looks and functions like the Timeliness Trends drilldown display (Figure 45); however, it is used to show the average missing data (%) per channel (bar chart) and the change in missing data (%) per channel (time-series plot) over a specified time range. See Section 5.5.2 for display information. This display is not part of the default workspace layout and must be added by clicking the application-level menu button (Figure 3) and selecting one of the workspace layouts containing SOH Missing display or selecting SOH Missing directly from the SOH menu options (Figure 12). See Sections 4 and 5.1 for more detail.



Figure 52. The SOH Missing Trends Drilldown Display.

5.5.5. SOH Lag Drilldown Display

The SOH Lag drilldown display (Figure 53) shows the lag status of all available channels for a selected station. The color of the bar and channel name indicates a channel's lag status (green = good, yellow = marginal, red = bad, yellow/hash-marked = marginal Unknown).

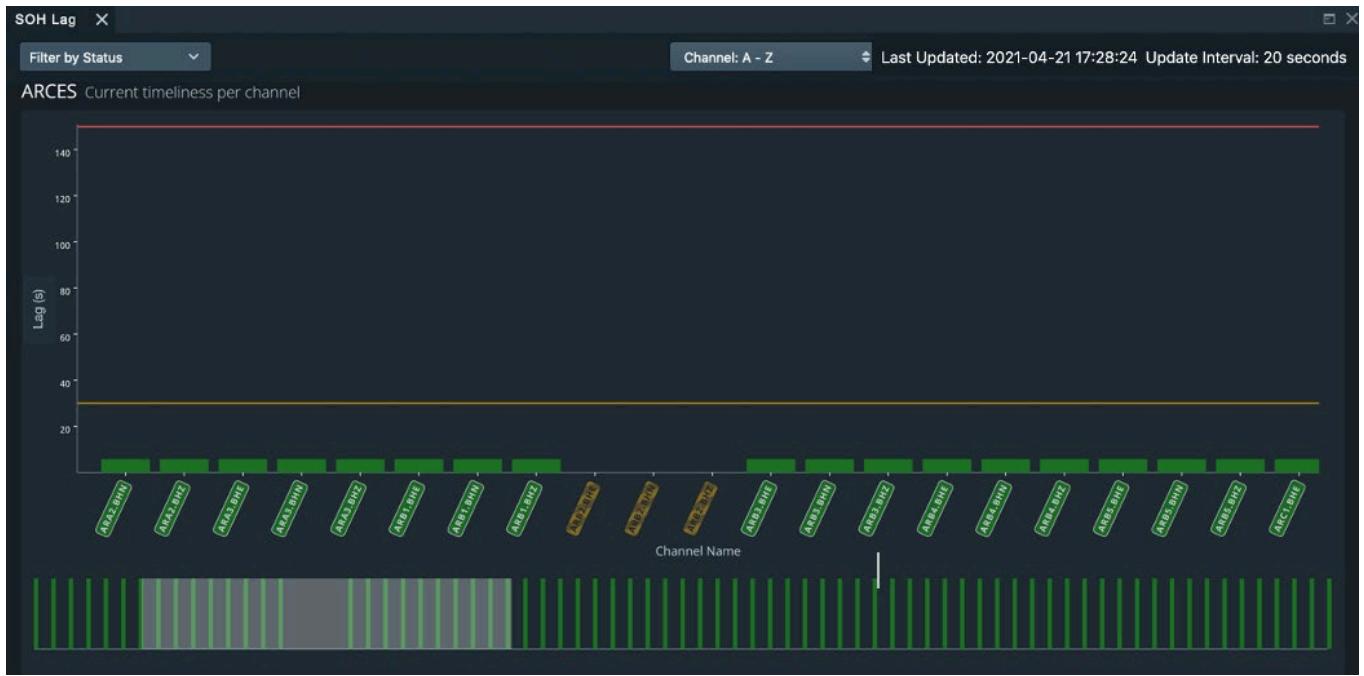


Figure 53. The SOH Lag Drilldown Display.

In the SOH Lag drilldown display, the lag is shown on the y-axis in seconds. The channel name is on the x-axis.

The SOH Lag drilldown display functions like the SOH Timeliness drilldown display; however, it is used for troubleshooting the Lag monitor rather than the Timeliness monitor. Note that Lag is currently configured not to have the white dot indicating unacknowledged channels (see Configuration documentation). See Section 5.5.1 for display information. This display is not part of the default workspace layout and must be added by clicking the application-level menu button (Figure 3) and selecting one of the workspace layouts containing the SOH Lag drilldown display or selecting SOH Lag directly from the SOH menu options (Figure 12). See Sections 4 and 5.1 for more detail.

5.5.6. SOH Lag Trends Drilldown Display

The SOH Lag Trends drilldown display (Figure 54) looks and functions like the Timeliness Trends drilldown display (Figure 45); however, it is used to show the average lag per channel (bar chart) and the change in lag per channel (time-series plot) over a specified time range. See Section 5.5.2 for display information.

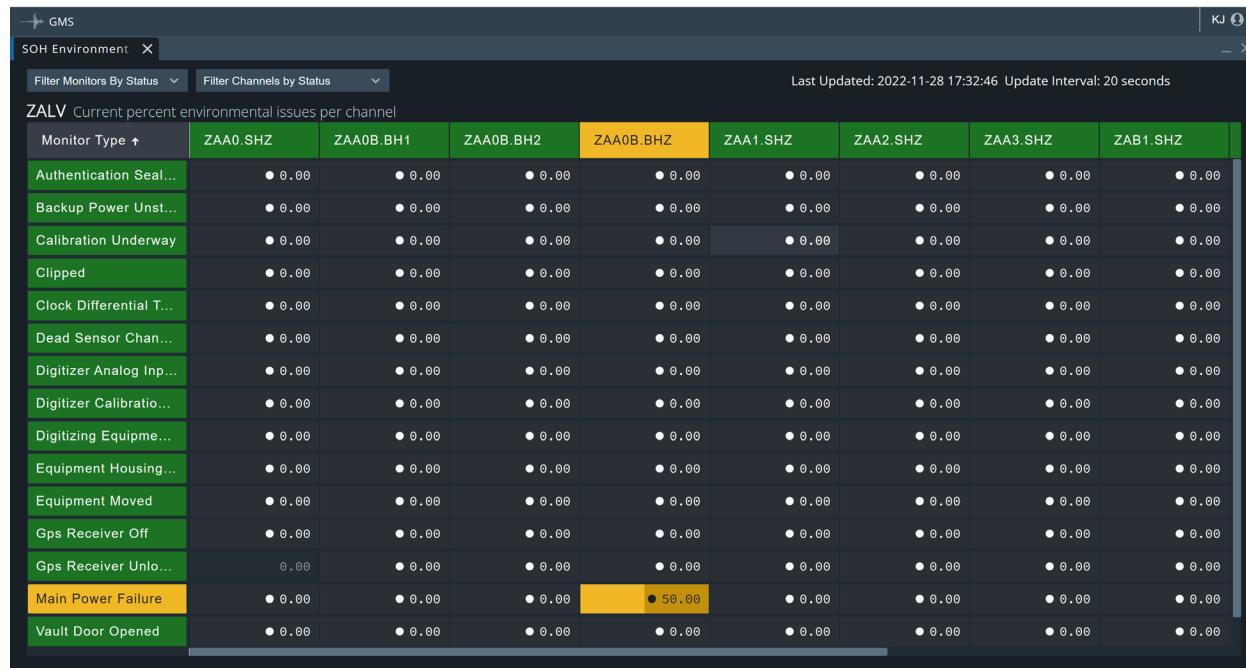
This display is not part of the default workspace layout and must be added by clicking the application-level menu button (Figure 3) and selecting one of the workspace layouts containing SOH Lag Trends or selecting SOH Lag Trends directly from the SOH menu options (Figure 12). See Sections 4 and 5.1 for more detail.



Figure 54. The SOH Lag Trends Drilldown Display.

5.5.7. SOH Environment Drilldown Display

The SOH Environment drilldown display (Figure 55) shows the Environment (%) SOH status of all available channels for a selected station. Typically, only CD1.1 stations will be configured to report environmental issues and report Environment (%) SOH status.



The screenshot shows a software interface titled "SOH Environment" with a sub-section "ZALV". The interface includes a toolbar with "Filter Monitors By Status" and "Filter Channels by Status" dropdowns, and a timestamp "Last Updated: 2022-11-28 17:32:46 Update Interval: 20 seconds". The main area is a table with the following columns: Monitor Type, ZAA0.SHZ, ZAA0B.BH1, ZAA0B.BH2, ZAA0B.BHZ, ZAA1.SHZ, ZAA2.SHZ, ZAA3.SHZ, and ZAB1.SHZ. The rows list various environmental issues. A color legend at the bottom indicates: green for good, yellow for marginal, red for bad, and gray for no data received or not contributing to SOH calculations. The "Main Power Failure" row is highlighted with a yellow background.

Monitor Type	ZAA0.SHZ	ZAA0B.BH1	ZAA0B.BH2	ZAA0B.BHZ	ZAA1.SHZ	ZAA2.SHZ	ZAA3.SHZ	ZAB1.SHZ
Authentication Seal...	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00
Backup Power Unst...	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00
Calibration Underway	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00
Clipped	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00
Clock Differential T...	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00
Dead Sensor Chan...	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00
Digitizer Analog Inp...	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00
Digitizer Calibratio...	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00
Digitizing Equipme...	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00
Equipment Housing...	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00
Equipment Moved	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00
Gps Receiver Off	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00
Gps Receiver Unlo...	0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00
Main Power Failure	● 0.00	● 0.00	● 0.00	● 50.00	● 0.00	● 0.00	● 0.00	● 0.00
Vault Door Opened	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00	● 0.00

Figure 55. The SOH Environment Drilldown Display.

From left to right, the SOH Environment display shows the following information for the specific station shown in the upper-left corner (ZALV in Figure 55):

- 1) Channel/Monitor pair – The cells showing the data value and SOH status of each channel/environmental issue combination, i.e., channel/monitor pair, where gray = good, yellow = marginal, red = bad, yellow/hash-marked = no data received or environmental issues were not reported in the received data (see color legend in Section 6). When an environmental channel/monitor type pair does not contribute to SOH status calculations, the cell is shown as semi-transparent (e.g., Figure 22).
- 2) Monitor Type – The rightmost column listing specific environmental issue types and their worst-of SOH status where green = good, yellow = marginal, red = bad (see color legend in Section 6). Only channel/monitor pairs configured to contribute to SOH status calculations are used to calculate the worst-of SOH statuses shown in the Monitor Type column. When a monitor type does not contribute to SOH status calculations, the

monitor type is shown as semi-transparent (e.g., Figure 22). A list of monitor types is provided in Appendix A.

- 3) Channel – The topmost row listing the selected station's channels and the status of each of these channels (ZAA0.SHZ, ZAA0B.BH1, ZAA0B.BH2, etc. in Figure 55), where green = good, yellow = marginal, red = bad, and dark gray/hash-marked = channel has no channel/monitor pairs that contribute to SOH status calculations. Only channel/monitor pairs which contribute to SOH status calculations are used to calculate the status of a channel column.

Similar to the Station Statistics display in Section 5.3, the percentage of environmental issues for a specific monitor type is shown by the percentage of cell fill as well as by a numerical percentage value (e.g., Figure 56). The percentage of cell fill should match the numerical value written on top.



Figure 56. Percentage of Environmental Issues.

The user has two filter options: Filter Monitors by Status and Filter Channels by Status. These options are accessed through dropdowns in the top-left corner of the display. Monitors or channels can be filtered by status in the dropdown menus by checking the desired statuses using the same type of dropdown menu as in Figure 20. Note that unlike the Lag, Missing, and Timeliness drill downs, the Environmental Issues drill down includes a status of None for channels. A status of None will occur when no environmental issues (i.e., no channel/monitor pairs) contribute to a channel's SOH status. Note that because the SOH Configuration Tool enforces the requirement that at least one channel's SOH status be included for each Monitor Type, None is not included in the Monitor Type filter; see SOH Configuration Tool User's Guide for details.

Unacknowledged channel/monitor type pairs are indicated by a black or white dot to the left of the percentage environmental issue value. For example, the monitor type Authentication Seal Broken has not been acknowledged for channel ZAA0.SHZ in Figure 55 as indicated by the white dot to the left of its percentage value of 0.00. The different dot colors are for visual ease and do not indicate any channel/monitor status.

When stations are acknowledged in the SOH Overview or Station Statistics display, their newly acknowledged channel/monitor pairs are placed in a quiet period and the white/black dots disappear. At the same time, a clock indicating the duration of the quiet period appears to the left of the acknowledged environmental issue value; see Figure 57.

Monitor Type ↑	CM01.SHZ	CM02.SHZ	CM03.SHZ	CM04.SHZ	CM05.SHZ
Authentication Sea...	0.00	0.00	0.00	0.00	0.00
Backup Power Uns...	0.00	0.00	0.00	0.00	0.00
Calibration Under...	0.00	0.00	0.00	0.00	0.00
Clipped	0.00	0.00	0.00	0.00	0.00

Figure 57. An Acknowledged Channel/Monitor Type Pair in the SOH Environment Display.

As in the previous drilldown displays, the quiet period's remaining time is indicated by the amount of fill in the clock; it can also be viewed via a tooltip by hovering the cursor over the clock. Any changes in a channel's environmental issues during this quiet period will result in the station being placed back into the Needs Attention category after the quiet period expires (see Section 5.2.1).

One or more of a channel's environmental issues can be manually quieted by right-clicking the cell(s) corresponding to the channel/monitor pair and selecting a duration from the option menu. While similar, quieting is not the same as acknowledgement. Quieting will be described in detail in Section 5.5.9.

The table in the SOH Environment display is shown in its default layout in Figure 55. In addition to the table layout options described in Section 4, the table in the SOH Environment drilldown display can be modified using the table layout options described in Section 5.3.1, with the exception that columns cannot be removed from the Environment display.

5.5.8. SOH Environment Trends Drilldown Display

The SOH Environment Trends drilldown display (Figure 58) shows the raw data for a selected environmental monitor type for all available channels over a chosen period of time. This display is not part of the default workspace layout, but can be added by clicking the application level menu button (Figure 3) and selecting SOH Environment Trends from the SOH menu options (Figure 12). See Sections 4 and 5.1 for more detail.



Figure 58. The SOH Environment Trends Drilldown Display.

Like other drilldown displays, a station must be selected from the SOH Overview or Station Statistics display prior to viewing information in the SOH Environment Trends drilldown display. However, to populate the Environment Trends drilldown display, a monitor type must be selected in addition to a station. The user can either select a monitor type from the Monitor Type column in the SOH Environment drilldown display (Figure 55) or select a monitor type from the dropdown menu (Figure 59) in the upper-left corner of Figure 58.

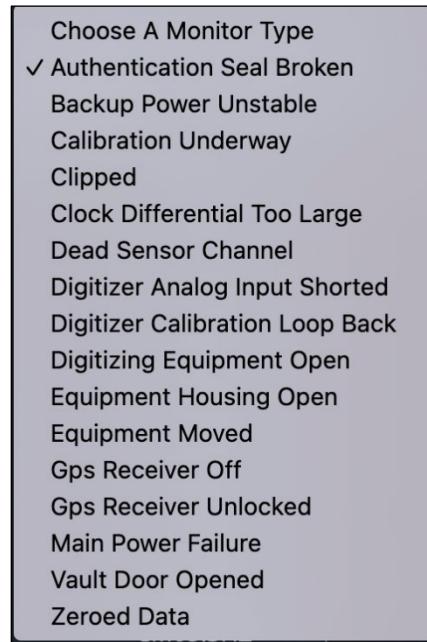


Figure 59. Monitor Type Dropdown Menu.

If no monitor type is selected, the user will be prompted to choose a monitor type (Figure 60).

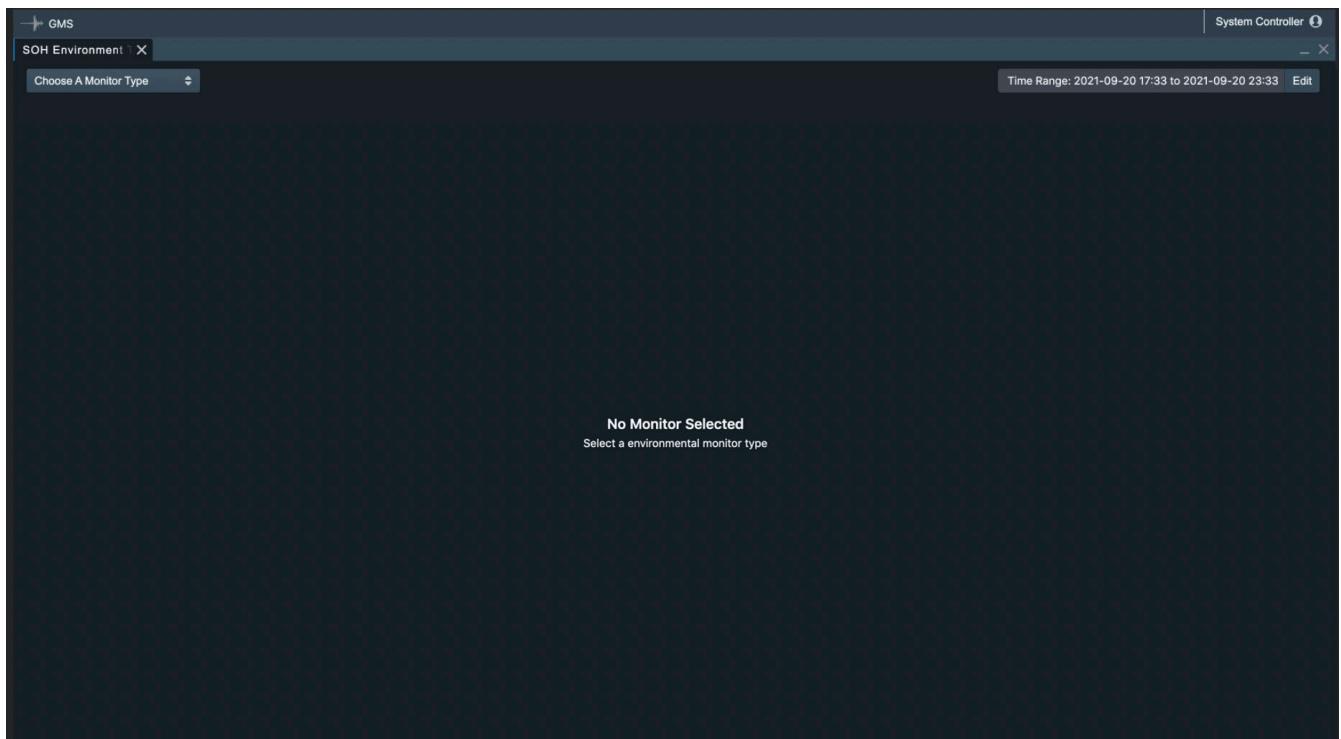


Figure 60. The SOH Environment Trends Drillodown Display with No Monitor Selected.

The only raw data type being reported in the historical trend interface for channel/monitor pairs are Boolean data. For example, the Vault Door Open monitor type will only report 1 or 0, i.e., the door was open or the door was closed. The Boolean data plots will appear as square waves, with the y-axis having a value of either 0 or 1 and the x-axis representing the time. The total time period shown in the window is indicated at the bottom-left and in the time range at upper right. In Figure 58, the time period shown is 2023-03-10 11:22:45.570 + 6 hours.

Like the other Trends displays, the user can zoom in and out by continuously hold the Ctrl key (Command on Mac) while clicking and dragging the cursor, creating the white window seen in Figure 47. Once the desired window length is highlighted, release Ctrl + click. To zoom back out to the original window, double-click the left mouse button. Alternatively, the user can zoom in and out by holding the Ctrl key and scrolling (Command and scroll on Mac). The user can also print a specific time above the cursor on the time series plot by clicking and holding (see Section 5.5.2).

The square wave's height indicates whether the raw data were in a good state (square wave = 0) or a bad state (square wave = 1). The square wave's length indicates the percentage of time that the channel/monitor pair were in that state. For example, if the Vault Door Open monitor type for Channel CM01.SHZ was in a bad state for 18.33% of the past 24 hours, the plotted square wave would show a value of 1 for 18.33% of that time period.

If a channel/monitor pair remains in a bad state longer than the configurable threshold, that channel/monitor pair will have a marginal or bad SOH status depending on configuration (see SOH Config Tool User's Guide). For example, the Channel/Monitor Type pair CM01.SHZ/Vault Door Open can be configured to take on a marginal status when the raw data value = 1 for more than 50% of the past 24 hours.

Selecting a time range to view in the Environment Trends drilldown display is done the same way as the prior historical trend drilldown displays, see Section 5.5.2 and Figure 48. Note that there is no channel filter available, unlike other trends drilldown displays (see Figure 45). All channels will always be shown in the Environmental Trends display.

5.5.9. Quieting

In the SOH Timeliness, Lag, Missing, and Environmental drilldown displays, the user can manually quiet individual channels/monitor pairs. When a channel/monitor pair is quieted, the user will not be notified of any changes in SOH status during the quiet period. This action prevents a user from being repeatedly notified of a station with issues that can't be fixed quickly.

To quiet a channel/monitor pair, the user right-clicks a channel's corresponding bar/channel name (SOH Timeliness, Lag, and Missing drilldown displays) or a specific channel/monitor type pair cell (Environmental drilldown display) to bring up the option menu for quieting shown in Figure 61.

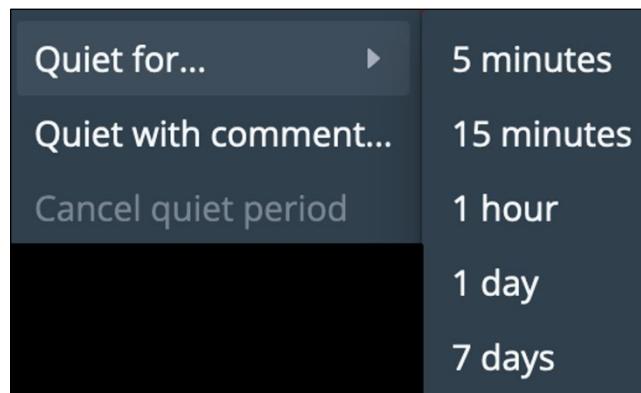


Figure 61. Quiet Option Menu.

The user can then select the quiet period's duration or cancel a quiet period if a channel/monitor pair has already been quieted. Available quiet period durations are 5 minutes, 15 minutes, 1 hour, 1 day, and 7 days. The list of available quiet period durations is configurable (see Configuration documentation). Note that multiple channel/environmental monitor type pairs can be quieted in the Environmental drilldown display by holding the Ctrl key (Command on Mac) while clicking on the desired channel/monitor pair, then right-clicking one of the selected pairs to bring up the menu in Figure 61.

The user can also write an associated comment when quieting one or more channel/monitor pairs by selecting the Quiet with comment option. This action will bring up the text area shown in Figure 62.

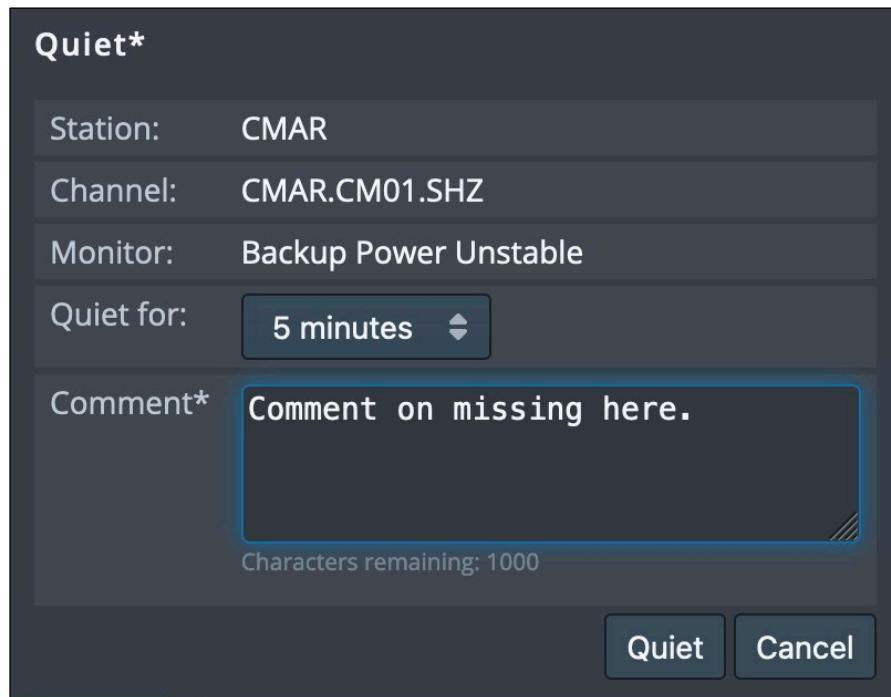


Figure 62. Text Area to Add Comment to Quieted Station.

In the text area, the user can enter a message with a 1024 character limit. The number of characters remaining is beneath the text area. Once a quiet period duration and comment are entered, the user selects the Quiet button, and the channel/monitor pair is quieted. The related comment is stored in a database with the station, channel(s), monitor type(s), comment timestamp, and the username for provenance. This comment information is made viewable in the System Message display (Section 5.6).

The user can manually overwrite or cancel a previously applied quiet period by right-clicking the quieted channel's bar or specific environmental issue cell and selecting either a new quiet period duration or canceling the quiet period; this action can be done regardless of whether the previous quiet period was applied manually or automatically by acknowledgement (Section 5.2.1). An automatic quiet period applied by acknowledgement in the SOH Overview or Station Statistics displays will not overwrite any previous manually applied quiet periods.

Once quieted, a clock symbol showing the quiet period's duration appears at the top of a quieted channel's bar (Lag, Missing, and Timeliness drilldowns) or to the left of a quieted channel's percentage environmental issue value (Environmental drilldown). Because these manual quiet periods are individually applied rather than automatically applied by acknowledgement, each quiet period may differ in duration; see Figure 63. A user can view the

time left within each unique quiet period by hovering over the clock symbol. The clock's remaining fill should match the written time.

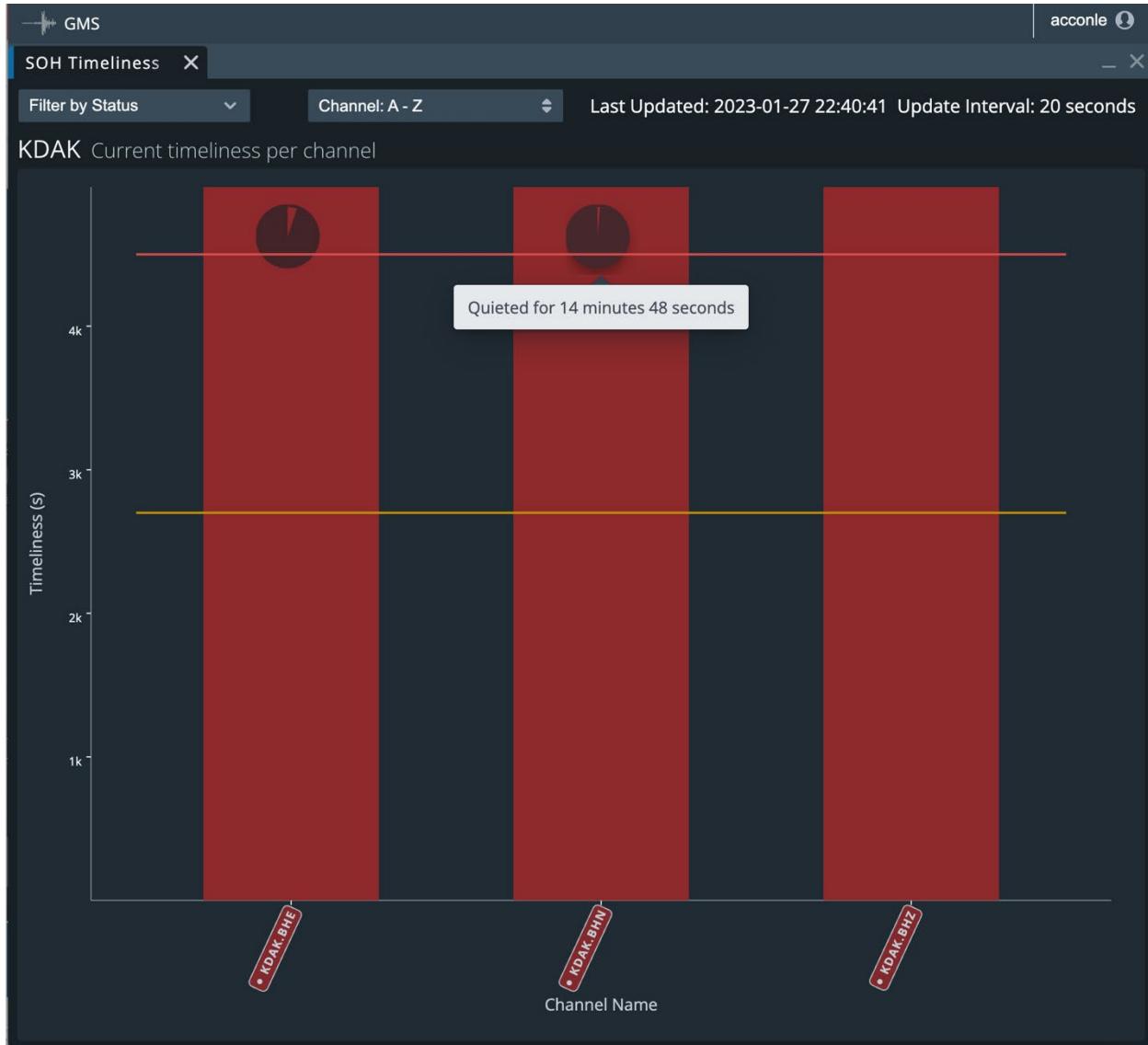


Figure 63. Manually Quieted Channels in the SOH Timeliness Drilldown Display.

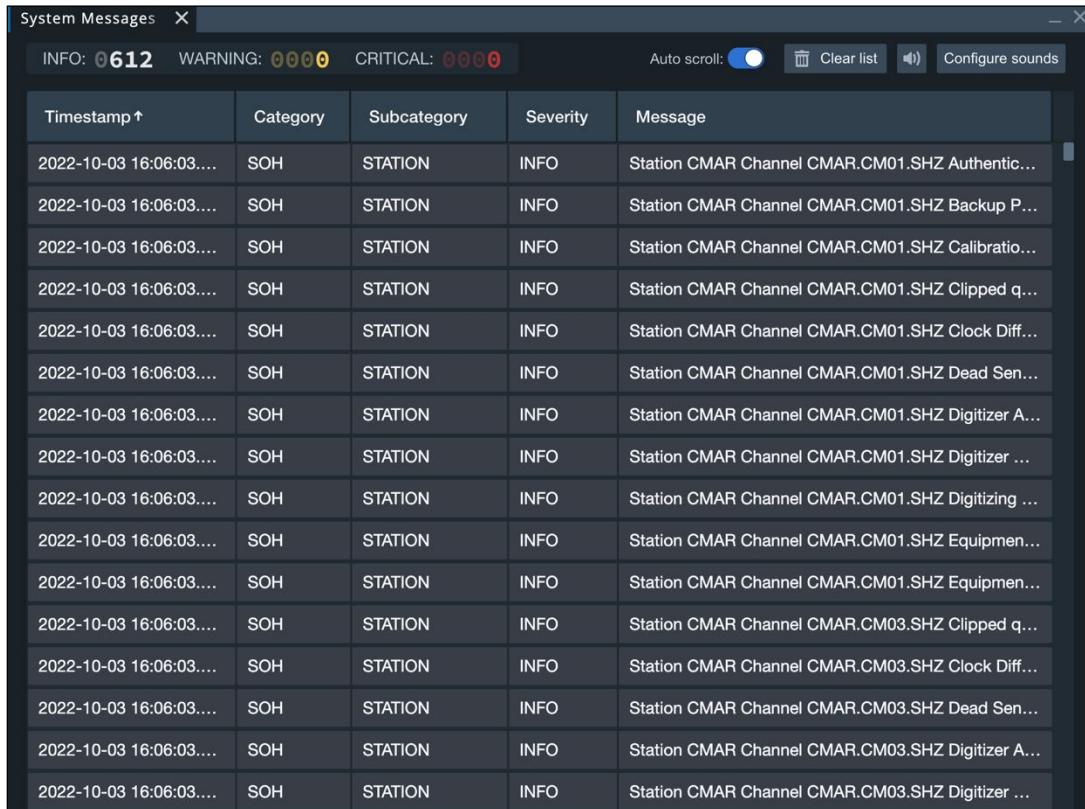
Following the quiet period's expiration, the user is notified of any changes in general SOH status that arose during or after the quiet period as well as any unacknowledged changes that existed prior to quieting.

Manually quieted individual channels/monitors are not acknowledged. As shown in Figure 63, the white dot in front of the channel name indicates it has not been acknowledged. If a user manually quiets one or more channels/monitors and places that station in the unlabeled category indicating acknowledgement, the station will be placed back into Needs Attention when the manually applied quiet periods expire or are cancelled, regardless of the remaining time in the automatic quiet periods applied by acknowledgement.

It is possible to use manual quieting to acknowledge a station's general SOH status by quieting every unacknowledged channel/monitor in all four drilldown displays. When this action is done, the station is placed in the unlabeled category indicating acknowledgement in the SOH Overview and Station Statistics displays automatically; however, once these quiet periods expire, the station will be placed into Needs Attention.

5.6. System Messages Display

The System Messages display (Figure 64) provides a scrolling list of messages output by the system in real time.



The screenshot shows a software window titled "System Messages". At the top, there are three counters: INFO: 0612, WARNING: 0000, and CRITICAL: 0000. To the right of these are buttons for "Auto scroll" (with a toggle switch), "Clear list", and "Configure sounds". The main area is a table with the following columns: Timestamp ↑, Category, Subcategory, Severity, and Message. The table contains 20 rows of data, all sharing the same timestamp (2022-10-03 16:06:03....) and category (SOH). The subcategory is consistently STATION, and the severity is INFO. The messages describe various CMAR Channel status events, such as authentication, backup processing, calibration, clipping, clock differences, dead sensor detection, digitizer activity, equipment status, and clipping quality.

Timestamp ↑	Category	Subcategory	Severity	Message
2022-10-03 16:06:03....	SOH	STATION	INFO	Station CMAR Channel CMAR.CM01.SHZ Authentic...
2022-10-03 16:06:03....	SOH	STATION	INFO	Station CMAR Channel CMAR.CM01.SHZ Backup P...
2022-10-03 16:06:03....	SOH	STATION	INFO	Station CMAR Channel CMAR.CM01.SHZ Calibratio...
2022-10-03 16:06:03....	SOH	STATION	INFO	Station CMAR Channel CMAR.CM01.SHZ Clipped q...
2022-10-03 16:06:03....	SOH	STATION	INFO	Station CMAR Channel CMAR.CM01.SHZ Clock Diff...
2022-10-03 16:06:03....	SOH	STATION	INFO	Station CMAR Channel CMAR.CM01.SHZ Dead Sen...
2022-10-03 16:06:03....	SOH	STATION	INFO	Station CMAR Channel CMAR.CM01.SHZ Digitizer A...
2022-10-03 16:06:03....	SOH	STATION	INFO	Station CMAR Channel CMAR.CM01.SHZ Digitizer ...
2022-10-03 16:06:03....	SOH	STATION	INFO	Station CMAR Channel CMAR.CM01.SHZ Digitizing ...
2022-10-03 16:06:03....	SOH	STATION	INFO	Station CMAR Channel CMAR.CM01.SHZ Equipmen...
2022-10-03 16:06:03....	SOH	STATION	INFO	Station CMAR Channel CMAR.CM01.SHZ Equipmen...
2022-10-03 16:06:03....	SOH	STATION	INFO	Station CMAR Channel CMAR.CM03.SHZ Clipped q...
2022-10-03 16:06:03....	SOH	STATION	INFO	Station CMAR Channel CMAR.CM03.SHZ Clock Diff...
2022-10-03 16:06:03....	SOH	STATION	INFO	Station CMAR Channel CMAR.CM03.SHZ Dead Sen...
2022-10-03 16:06:03....	SOH	STATION	INFO	Station CMAR Channel CMAR.CM03.SHZ Digitizer A...
2022-10-03 16:06:03....	SOH	STATION	INFO	Station CMAR Channel CMAR.CM03.SHZ Digitizer ...

Figure 64. The System Messages Display.

By default, messages are sorted by timestamp with the latest message at the end of the list. The list scrolls continuously, making the latest message visible when the Auto Scroll option (upper-right corner of Figure 64) is enabled (white dot to the right). To pause scrolling for easier viewing, the user can toggle the Auto Scroll off (white dot to left). Auto scrolling will also automatically pause if the user scrolls up or changes pages; new messages received during this time will be indicated by a new message icon at the bottom of the window (e.g., Figure 64). The user can also select the Clear list button to clear current messages from the window.

The messages shown in this display can result from a station needing attention (Sections 5.2 and 5.2.1), changes to station or channel/monitor worst-of SOH status (Section 7.1), changes to station or station group capability-based SOH status (Section 7.2), the acknowledgement or quieting of a channel/monitor pair (Sections 5.2.1, 5.5.9), or the cancellation or expiration of a quiet period (Section 5.5.9).

From left to right, each row of the System Messages display shows the following information:

- 1) Timestamp – The date and time a message was created.
- 2) Category – A category indicating what part of the GMS system caused the message, (e.g., SOH, FK analysis). SOH is the only available category.
- 3) Subcategory – A subcategory indicating whether the message resulted from a change in channel monitor status and/or station worst-of SOH status (Station), a change in capability-based rollup status (Capability), or from a user action such as acknowledgement (User).
- 4) Severity – Indicates the severity of the issue reported in the message; the three categories from least to most severe are Info, Warning, and Critical.
- 5) Message – The system message string for the respective message type. Hover over the Message column to view the full system message via a tooltip.

Each message color is based on its reported severity: informational messages are dark gray, warning messages are yellow, and critical messages are red. The number of messages in each category is shown in the upper-left corner; see Figure 64. By clicking on a number category, the user can filter messages by severity. For example, if the user clicks on INFO: 612 in Figure 64, informational messages will no longer be shown. To remove the filter, click on the same number category again. Note that the colors are configurable (see Configuration documentation).

- Informational messages indicate the general SOH status of a station or channel/monitor pair has changed, a channel/monitor quiet period has expired or been cancelled, or a user has acknowledged a channel/monitor pair status change (with or without a comment).
- Warning messages indicate a change in station or station group capability-based SOH status, or a user has quieted a channel/monitor pair (with or without a comment).
- Critical messages indicate a station needs attention.

A table of message types and their corresponding severities, categories, and sub-categories is provided at the end of this document. Note that the user cannot modify the available message types or their categorizations.

The System Messages display in Figure 64 shows the default layout. In addition to the layout options described in Section 4, the System Messages display can be modified in the same ways as the Station Statistics display, with the exception that columns cannot be removed (see Section 5.3.1).

Incoming messages can be assigned unique audible notifications by clicking on the Configure sounds button in the upper corner (see Figure 64) to bring up the menu shown in Figure 65.

Sound Configuration					
	Sound	Category	Subcategory	Severity	Message
	bell-octaves.mp3	SOH	CAPABILITY	WARNING	Station Group %s capability status changed from %s to %s
	bell-octaves.mp3	SOH	CAPABILITY	WARNING	Station %s capability status for Station Group %s changed fro...
	sad-trombone.mp3	SOH	STATION	CRITICAL	Station %s needs attention
	sample-critical-alert.mp3	SOH	STATION	INFO	Station %s SOH status changed from %s to %s
	sample-warning-alert.mp3	SOH	STATION	INFO	Station %s Channel %s %s quiet period expired
	bell-tritone.mp3	SOH	STATION	INFO	Station %s Channel %s %s status changed from %s (%s) to ...
	None	SOH	USER	INFO	Station %s Channel %s %s status change acknowledged by u...
	None	SOH	USER	WARNING	Station %s Channel %s %s quieted for %s by user %s Station...
	None	SOH	USER	INFO	Station %s Channel %s %s quiet period canceled by user %s

Figure 65. Sound Configuration Menu.

Each row of the sound configuration menu represents a system message type that can be received in the System Messages display (see Appendix B). System message types can be filtered based on severity, category, or subcategory using one of the three drop-down menus in the upper left (see Figure 65).

The Sound column on the left (Figure 65) provides a drop-down list of available sounds that the user can select an audible notification for each message type. The list of available sounds can be modified but not in the Sound Configuration menu (see Configuration documentation). If a configured sound fails to load, the user will be notified via a warning message in the lower-right corner of the SOH UI (Figure 66).



Figure 66. Failed to Load Sound Warning Message.

In addition, a red exclamation point will appear left of the sound that failed to load (see Figure 65).

When a sound is first selected from the drop-down list, the sound will automatically play. The same audible notification can be assigned to more than one message type (e.g., bell-octaves.mp3 in Figure 65). Once done, the user can close the Sound Configuration window by clicking Close at bottom right or the x symbol at top right (see Figure 65). The newly configured sounds can be muted/unmuted using the speaker button in the upper-right corner (see Figure 64).

6. COLOR LEGEND

The color legends in Figure 67 indicate capability-based SOH status (left) and whether data are received and used (right). Note that a dark gray/hash-marked tile, which can appear in the SOH Overview (Section 5.2), Station Statistics (Section 5.3), and Environmental Issues (Section 5.5.7) displays, will have a unique meaning in each display.

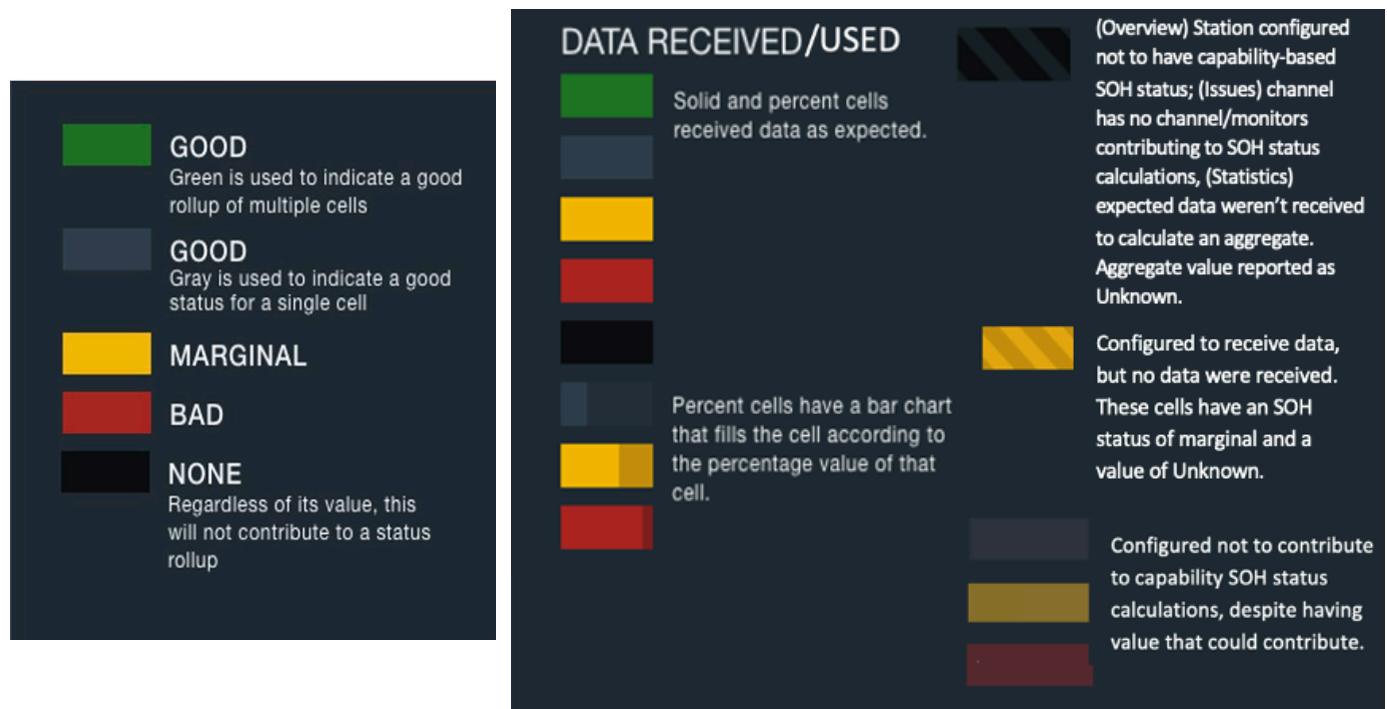


Figure 67. SOH Status (Left) and Data Received/Used (Right) Color Legends Shared Across Displays.

The color legend in Figure 68 shows the icons indicating a station's worst-of SOH status in the SOH Overview and Station Statistics displays (Sections 5.2 and 5.3).



Figure 68. Worst-of SOH status Color Legend in the SOH Overview and Station Statistics Displays.

A matrix illustrating all possible combinations of capability-based and worst-of SOH status symbols in the SOH Overview and Station Statistics displays is shown for station “ABCD” in Figure 69. Matrix rows correspond to capability-based SOH status, and matrix columns correspond to the badge-icons representing worst-of SOH status. Note that there is no badge icon for a good worst-of SOH status.

		SOH WORST-OF STATUS		
		GOOD	MARGINAL	BAD
CAPABILITY STATUS	NONE	ABCD	ABCD	ABCD
	GOOD	ABCD	ABCD	ABCD
	MARGINAL	³ ABCD	ABCD	² ABCD
	BAD	² ₃ ABCD	¹ ABCD	³ ABCD

Figure 69. Matrix of Capability-Based and Worst-of SOH Status Symbols.

The numbers to the left of the station name in the marginal and bad rows of the matrix are found in the Station Statistics display only (Section 5.3). These numbers are a count of the number of groups in which a station has a bad (top number) or marginal (bottom number) capability-based SOH status. There is no equivalent count for worst-of SOH status. See Section 5.3 for more details.

7. WORST-OF SOH STATUS AND CAPABILITY-BASED SOH STATUS ROLLUPS

This section details how the worst-of station SOH and capability-based SOH statuses are calculated.

7.1. Worst-of SOH Status Rollup

A station's worst-of SOH status notifies the user of the severity of the worst issue on that station. The worst-of SOH status of a station is inherited from the channel/monitor pair with the worst SOH status through a process called rollup. Rollup begins by determining the SOH status of each channel's monitors, see the right side of Figure 70. In the following examples, the available monitors are missing data, timeliness, lag, and environmental issues. Note that all environmental issues monitor types (e.g., Authentication Seal Broken, Clipped) are shown as a single box (labeled ENV_*) in Figure 70.

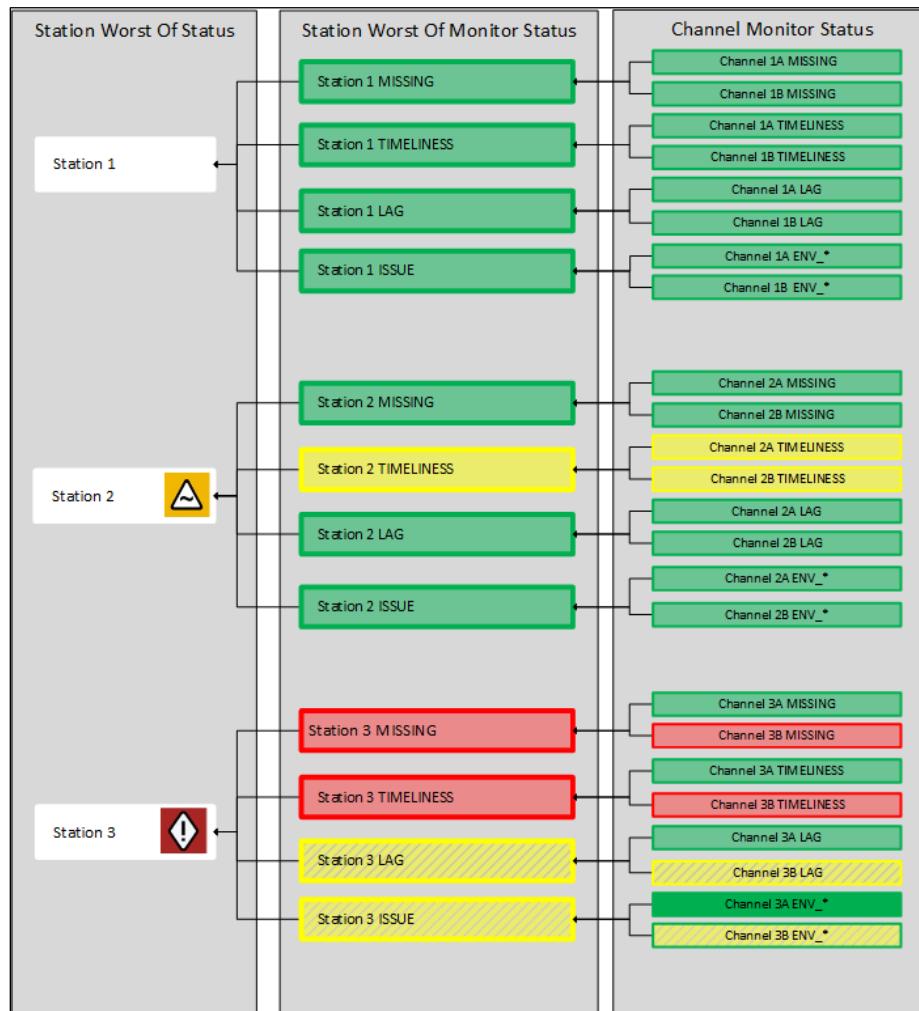


Figure 70. Flowchart Example of Worst-Of SOH Status Rollup.

After the SOH status of all a channel's monitors has been determined, these statuses are rolled up to the Station Worst-of Monitor Status level (middle column in Figure 70). At this level, the SOH status of a specific channel monitor type is compared across all channels, and the worst status is inherited by the station monitor type, resulting in the Station Worst-of Monitor Status. These statuses are displayed in the Station Statistics display as the Channel Missing, Timeliness, Lag, and Issues columns (Figure 21).

The worst SOH status amongst the station monitor type statuses is inherited by the station as its Worst-of SOH status. Worst-of SOH status in the Overview and Station Statistics displays (Sections 5.2, 5.3) is indicated by color and icon, with marginal = yellow triangle and bad = red diamond; see the left side of Figure 70. Note that a good worst-of SOH status does not have an icon.

For example, in Figure 70, Station 2 has two channels, 2A and 2B, each with the monitor types: missing data, timeliness, lag, and environment (right column of Figure 70). The missing data, lag, and environment monitors of Channels 2A and 2B have a good SOH status, while the timeliness monitors have a marginal SOH status. When these monitors are rolled up to the Station Worst-of Monitor status level (center column of Figure 70), the worst available status for the missing data, lag, and environmental issues monitors is good, while the worst available status for timeliness is marginal. Thus, the resulting station monitor types, Station 2 Missing, Station 2 Lag, Station 2 Issue have an SOH status of good, while Station 2 Timeliness has an SOH status of marginal. Finally, the four station monitor types are compared and the station inherits the worst station monitor SOH status as its worst-of SOH status. For Station 2, its overall worst-of SOH status is marginal because the worst station monitor SOH status is the Station 2 timeliness monitor with a status of marginal.

Monitors that are Unknown, i.e., had no data received and were configured to receive data, are classified as marginal worst-of SOH statuses and will contribute to the worst-of SOH Status rollup. An example of this type of status is shown for Station 3 at the bottom of Figure 70, with Channel 3B Lag and ENV_* having an Unknown status. This type of status typically arises if a channel or station are down and no longer transmitting data. If a station only has monitors with worst-of SOH statuses of good and marginal/Unknown, the station inherits a worst-of SOH status of marginal/Unknown; however, if a station's worst available monitors are a mix of marginal/Unknown and marginal with a numeric value, the station will inherit the worst-of SOH status of the monitor with the worst numeric value. In all cases, these inherited values can be seen in the Station Statistics display for a specific monitor under the Channel Missing, Timeliness, Lag, and Issues columns (Figure 21).

When calculating worst-of SOH status rollup, selected monitors and channels can be ignored by configuration (see Configuration documentation).

7.2. Capability-Based SOH Status Rollup

While the worst-of SOH status rollup notifies users of issues with a station, the capability-based rollup helps prioritize which issues to troubleshoot first, based on a station's importance to a configured capability. Capability-based rollups exist for stations and station groups. Station group capability-based rollup represents SOH statuses for a subset of stations in the group, while station capability-based rollup represents SOH statuses for a subset of channels in a station. In both cases, the subset of channels and monitors contribute as long as they meet a set of configured criteria.

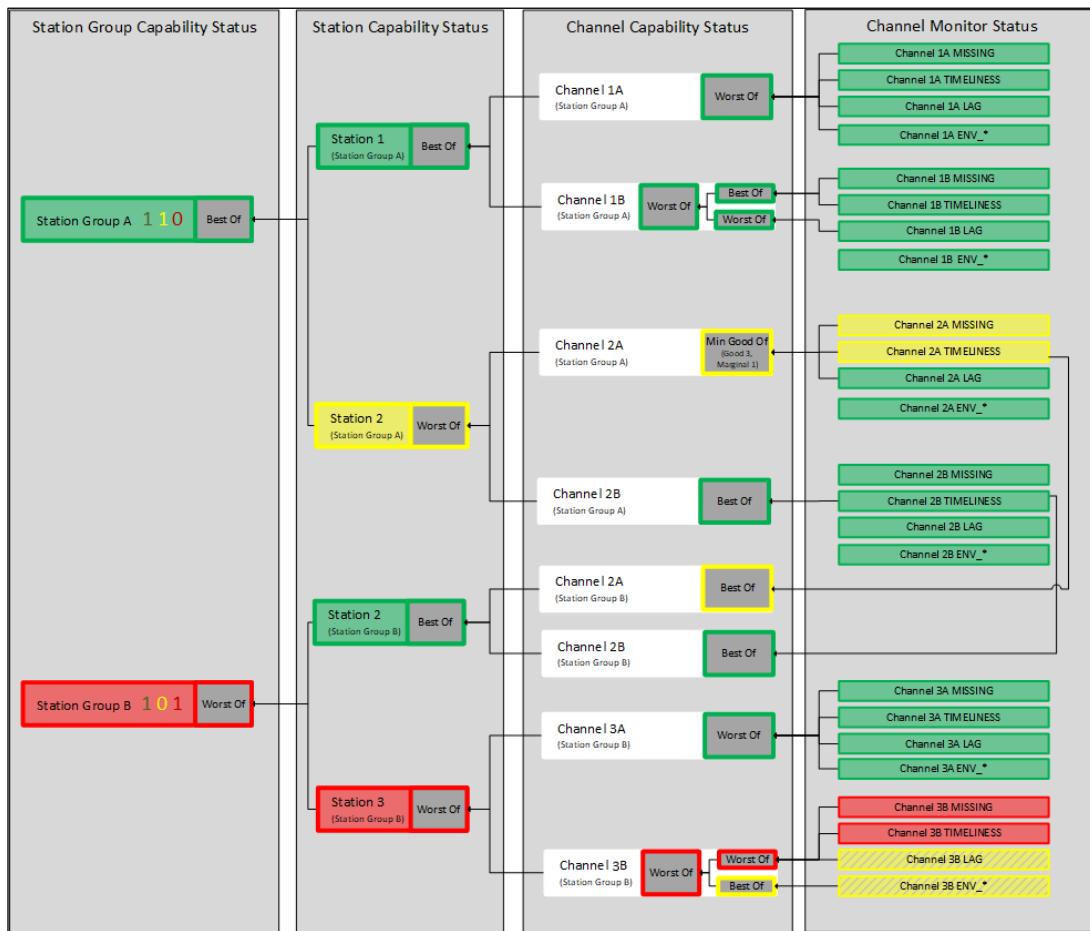


Figure 71. Flowchart Example of Capability-Based SOH Status Rollup.

Capability-based SOH status rollup calculation begins by calculating the SOH status of each channel's monitors, see the Channel Monitor Status column in Figure 71. The monitors include

missing data, timeliness, lag, and environmental issues. In Figure 71, all environment SOH monitor types are denoted as a single box and labeled as ENV_*.

Figure 71 depicts an arbitrary capability-based SOH status rollup, starting with monitors on the right and ending with station groups on the left. Arrows indicate which monitors, channels, or stations are input into a rollup operator (Worst-of, Best-of, or Min-Good-of). Capability-based SOH status is indicated by color in the SOH Overview and Station Statistics displays (Sections 5.2, 5.3) with good = green, marginal = yellow, and bad = red.

A capability-based SOH status is only rolled-up if it meets criteria set by an applied rollup operator. There are three available rollup operators that can be applied to monitors, channels, or stations.

- 1) Best-of – Rolls up the best available monitor, channel, or station.
- 2) Worst-of – Rolls up the worst available monitor, channel, or station.
- 3) Min-Good-of – Rolls up the status of a monitor, channel, or station based on whether that SOH status meets or exceeds the marginal or good thresholds set by the user (see Configuration documentation).

A single operator can only have inputs of a single type, e.g., an input from a rollup operator and a monitor is not allowed. Additionally, rollup operators must obtain their capability-based SOH statuses using the hierarchy of stations, channels, and monitors. For instance, a station cannot get its capability-based SOH status directly from the monitors; it must get its status from the channels, which in turn got their SOH statuses from the monitors. The worst-of SOH status rollup described in Section 7.1 is a special case of the capability-based SOH status rollup described here, where only the Worst-Of operator is applied throughout the flowchart (Figure 70).

Figure 71 demonstrates how the capability-based SOH status rollup and the rollup operators work. In this figure, Channel 2A in Station Group A has three monitors, missing data, timeliness, and lag, while Channel 2B in Station Group A only has timeliness, as indicated by the single arrow.

A Min-Good-Of operator was applied to all three monitors in Channel 2A. The Min-Good-Of operator is defined with two thresholds, Good: 3 and Marginal: 1. These values can be seen in the Channel 2A box under the Channel Capability Status column. These thresholds indicate that the Min-Good-Of operator will return:

- A good SOH status when 3 or more monitors have a good SOH status,
- A marginal SOH status if just one monitor has a good SOH status, or

- A bad SOH status if zero monitors have a good SOH status.

In Figure 71, the lag monitor has a good SOH status, but the missing and timeliness monitors have a marginal SOH status; therefore, Min-Good-Of returns an SOH status of marginal for Channel 2A. The Best-Of operator is only applied to the timeliness monitor in Channel 2B; it returns a good SOH status for Channel 2B.

Sometimes a channel's capability-based SOH status can be further rolled up by another operator. This situation is the case for Channel 3B in Station Group B, which applies another Worst-of operator to the returned SOH statuses from Best-Of (marginal SOH status) and Worst-of (bad SOH status) operators, thus returning a bad Channel Capability status for Channel 3B. The operations described above are repeated until each channel has its own SOH status.

These channel SOH statuses are then input into rollup operators to determine the station's capability-based SOH status. A Worst-of operator is applied to Channels 2A (marginal) and 2B (good) in Station Group A, resulting in a marginal capability-based SOH status for Station 2 in Station Group A.

The capability-based SOH status rollup is repeated for each station until every station has a capability-based SOH status. Note that the same station, e.g., Station 2 in Figure 71, can have a different capability-based SOH status in different groups. In this example, Station 2 has a marginal status in Station Group A and a good status in Station Group B. The rollup operators are applied to all stations until a station group capability-based SOH status is obtained. In Figure 71, a Best-Of operator is applied to Station 1 (good SOH status) and Station 2 (marginal SOH status) to return a good capability-based SOH status for Station Group A.

Similar to channel SOH statuses, a capability-based SOH status of a station or station group can be further rolled up by another operator. Also, multiple operators can be applied to different channels within a station or to different stations within a station group.

As shown in Figure 71, capability-based SOH status rollups can be defined by changing the monitors, channels, or stations used, and also the number of inputs to a rollup operator, the rollup operators applied, and the Min-Good-Of thresholds used; however, further details on these capability-based SOH status rollup configurations are beyond the scope of this document. For more information, see the Configuration documentation.

8. GENERAL LIMITATIONS

If GMS stops receiving data for a configurable amount of time, the user will no longer be able to interact with the UI or any data that had already been loaded into the system. This state will be indicated by the Last Updated timestamp turning red (Figure 72, left). Depending on the display width, the user may need to click a colon symbol to view the Last Updated timestamp. This colon symbol will also turn red to indicate no data are being received (Figure 72, right).

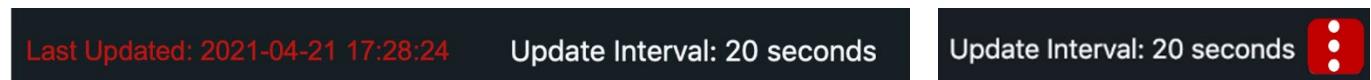


Figure 72. Red Last Updated Time Stamp (Left) and Colon Symbol (Right).

In the Map display (Section 5.4), only the default imagery and terrain options (Natural Earth and WGS84, respectively) can be used.

In the historical trends displays, the number of available datapoints shown in the time-series plots is static such that when zooming in, no new datapoints are retrieved. Thus, highly decimated time-series may not be accurately shown when zoomed in to a certain degree.

In the SOH Environmental Issues display (Section 5.5.7), the monitor types Clock Differential in Microseconds, Last GPS Sync Time, and Station Power Voltage are always dark gray/hash-marked, i.e., they never receive data or contribute to the SOH status rollup.

Appendix A. List of Environmental Issues

This Appendix is a list of available environmental issues in the SOH UI, specifically representative of CD1.1 Station Issues. This list can be configured to include other environmental issues (see Configuration documentation).

- 1) Authentication Seal Broken**
- 2) Backup Power Unstable**
- 3) Calibration Underway**
- 4) Clipped**
- 5) Clock Differential in Microseconds**
- 6) Clock Differential Too Large**
- 7) Dead Sensor Channel**
- 8) Digitizer Analog Input Shorted**
- 9) Digitizer Calibration Loop Back**
- 10) Digitizing Equipment Open**
- 11) Equipment Housing Open**
- 12) Equipment Moved**
- 13) GPS Receiver Off**
- 14) GPS Receiver Unlocked**
- 15) Last GPS Sync Time**
- 16) Main Power Failure**
- 17) Station Power Voltage**
- 18) Vault Door Opened**
- 19) Zeroed Data**

Appendix B. System Message Definitions

Message Type	Severity	Category	Subcategory	Message String	Message Purpose
Station needs attention	Critical	SOH	Station	Station <station> needs attention	Record that a station has been added to the Needs Attention bin on the SOH display.
Station worst-of SOH status changed	Info	SOH	Station	Station <station> worst-of SOH status changed from <previous_status> to <current_status>	Record changes in pure worst-of Station SOH rollup status for every station.
Station capability-based SOH status changed	Warning	SOH	Capability	Station <station> capability status for Station Group <group> changed from <previous_status> to <current_status>	Record changes in station SOH rollup status for every station used in every capability-based rollup.
Station Group capability-based SOH status changed	Warning	SOH	Capability	Station Group <group> capability status changed from <previous_status> to <current_status>	Record changes in station group capability-based rollup status for every station group.
Channel/Monitor Type status changed	Info	SOH	Station	Station <station> Channel <channel> <monitor_type> status changed from <previous_status> to <current_status>	Record changes in SOH Status for every channel SOH monitor
Channel/Monitor Type status change acknowledged	Info	SOH	User	<u>Without comment:</u> Station <station> Channel <channel> <monitor_type> status change	Record channel SOH monitor status change acknowledgements

Message Type	Severity	Category	Subcategory	Message String	Message Purpose
				<p>acknowledged by user <username></p> <p><u>With comment:</u></p> <p>Station <station> Channel <channel> <monitor_type> status change acknowledged by user <username> with comment '<comment>'</p>	
Channel/Monitor Type quieted	Warning	SOH	User	<p><u>Without comment:</u></p> <p>Station <station> Channel <channel> <monitor_type> quieted for <time interval> by user <username></p> <p><u>With comment:</u></p> <p>Station <station> Channel <channel> <monitor_type> quieted for <time interval> by user <username> with comment '<comment>'</p>	Record when the System Controller manually changes or cancels the quieting period for any channel SOH monitor.
Channel/Monitor Type quiet period canceled	Info	SOH	User	Station <station> Channel <channel> <monitor_type>	Record when the quieting period is canceled for any

Message Type	Severity	Category	Subcategory	Message String	Message Purpose
				quiet period canceled by user <username>	channel SOH channel/monitor pair
Channel/Monitor Type quiet period expired	Info	SOH	Station	Station <station> Channel <channel> <monitor_type> quiet period expired	Record when the quieting period expires for any channel/monitor pair

Appendix C. Hot Keys and User Interactions

The following tables list hot keys and user interactions available for each display.

Appendix C.I. Station Overview/Station Statistics Display

Operation	Hot Key/User Interaction	Alternate	Notes
Open Menu to Acknowledge Station	Right Click on Station Label		
Modify (Add or Remove) Current Station Selection	Ctrl/Cmd + Click on Station Label		Use Ctrl on Windows, Cmd (i.e., Command) on Mac
Select Range of Stations	Shift + Click on Station Label		Use Ctrl on Windows, Cmd (i.e., Command) on Mac. Only stations in the same station group and category (e.g., stations in the Needs Attention category of CD1.1), can be selected this way

Appendix C.2. SOH Lag/Missing/Timeliness Drilldown Displays

Operation	Hot Key/User Interaction	Alternate	Notes
Move Brush Window	Click + Drag		Brush window appears as a white rectangle on the secondary display (see Figure 42).
Generate New Brush Window	(Ctrl/Cmd + Click) + Drag to Right		Use Ctrl on Windows, Cmd (i.e., Command) on Mac Release click when window is at desired size
Resize Brush Window	Click + Drag Rectangle Edge		Double-arrow should be visible while dragging. Hover over

			rectangle edge to bring up double-arrow
Open Menu to Quiet Channel	Right-click Bar or Channel Name		

Appendix C.3. SOH Environment Drilldown Display

Operation	Hot Key/User Interaction	Alternate	Notes
Open Menu to Quiet Channel Environmental Issue	Right-click on Desired Cell		Cell will correspond to a specific combination of channel + environmental issue, i.e., a channel/monitor pair

Appendix C.4. SOH Lag/Missing/Timeliness/Environment Trends Drilldown Displays

Operation	Hot Key/User Interaction	Alternate	Notes
Zoom in	(Ctrl/Cmd + Click) Drag	(Ctrl/Cmd + Scroll Wheel)	Use Ctrl on Windows, Cmd (i.e., Command) on Mac
Zoom Out	Double Click	(Ctrl/Cmd + Scroll Wheel)	Use Ctrl on Windows, Cmd (i.e., Command) on Mac
Print Time to Screen	Click + Hold	Click + Drag	If the user does Click + Drag, the time printed out to screen will be the duration from the point where the action began to the current location of the white cursor

Appendix D. Release Notes

Appendix D.I. Fixes

Environmental Drill Down Display

- Added back None Filter Type for Channel Filters in order to fix issues with Channels disappearing when no Environmental Issues where included in the rollup to a Channel

Trend Displays

- Split Trend Display plot into different data segments when Unknown data was encountered thus properly showing gaps in the data

Appendix D.2 New Features

General

- Environmental issues are only calculated for stations configured for them
 - Shows Non-Ideal State messages for Stations not configured to receive Environmental Issues
 - Stations configured for Environmental Issues but with no data in window or which are not reporting environmental issues will show as Unknown/Marginal
- Color coded channel names on drill down display based on status
 - Good = Green
 - Yellow = Marginal
 - Red = Bad
 - Unknown = Yellow Hashed
- Show gaps in Lag Trends when hitting unknown
- Non-contributing monitor types and channels are shown as semi-transparent to indicate their exclusion
- Filters automatically revert after selecting a new station

Appendix D.3 Known Issues

Station Overview Display

- Rendering Issue When Trend Display Open Causes Stations to Show No Capability Status

Station Statistics Display

- Rendering Issue When Trend Display Open Causes Stations to Show No Capability Status

Map Display

- Map stacking order can cause the station color to appear to change.
 - This change is due to how Cesium layers in the 3D map view, sometimes appearing to be alternating colors between stations that are close together. Zooming in reveals there is more than one station and resolves the issue.

Drill Down Displays

- Header row in Environmental Drill Display blinks
- Quiet Timer gets misaligned after changing display size
- Quiet Timer gets misaligned when acknowledging station causing quieting timer on unshown stations

Trend Displays

- Trend displays only show 1 digit of precision

System Messages Display

- System message sound configuration menu does not always play a configured sound when applied to a given SOH message
 - The same sound can be selected for more than one type of SOH message and is heard by user