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GMS Station SOH Monitoring Users Guide

Version 1.2 (for GMS 1.13.1 Open Source Release)

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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 ten 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 Missing – an overview of a station's percentage of missing data per channel.

6) SOH Missing Trends – an overview of percentage changes for missing data over time per channel, i.e., the historical trend in percentage missing data.

7) SOH Overview – a high-level summary of all available station and station group's SOH statuses; includes the capability to acknowledge any reviewed station's status.

8) SOH Station Statistics – a detailed summary of the SOH statuses for monitor types (monitors). Currently the monitors are: lag (in seconds), percentage of missing data, and percentage of environmental issues.

9) System Messages – a time-ordered list of when stations need attention, station 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).

The summary displays (SOH Overview and SOH Station Statistics) allow the user to quickly evaluate the SOH status of all stations and station groups. The seven drill-down displays (SOH Lag, SOH Missing, SOH Environment, SOH Timeliness, SOH Lag Trends, SOH Missing Trends, and SOH Environment Trends) help troubleshoot specific issues for a selected station. Finally, 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.

Available station groups and time-intervals used in the calculation of SOH status are specified in the configurable files. Refer to the Configuration documentation for more information on these files.

This document is an in-depth users guide for the current version of the SOH UI, including browser requirements and an overview of each interactive display. It will periodically be updated throughout the project.

2. BROWSER REQUIREMENTS

The UI is currently supported by Chrome (ver. ≥ 78), Firefox (ver. ≥ 68), and the open-source framework Electron (ver. ≥ 5.0.1). Note that docking and undocking tabs are currently not supported in Electron. The UI will also run on Apple's Safari and Microsoft's Edge, but likely with degraded performance.

3. LOGIN

To log into the SOH UI, enter the appropriate URL into a supported web browser. The user will be directed to the login screen (Figure 1).
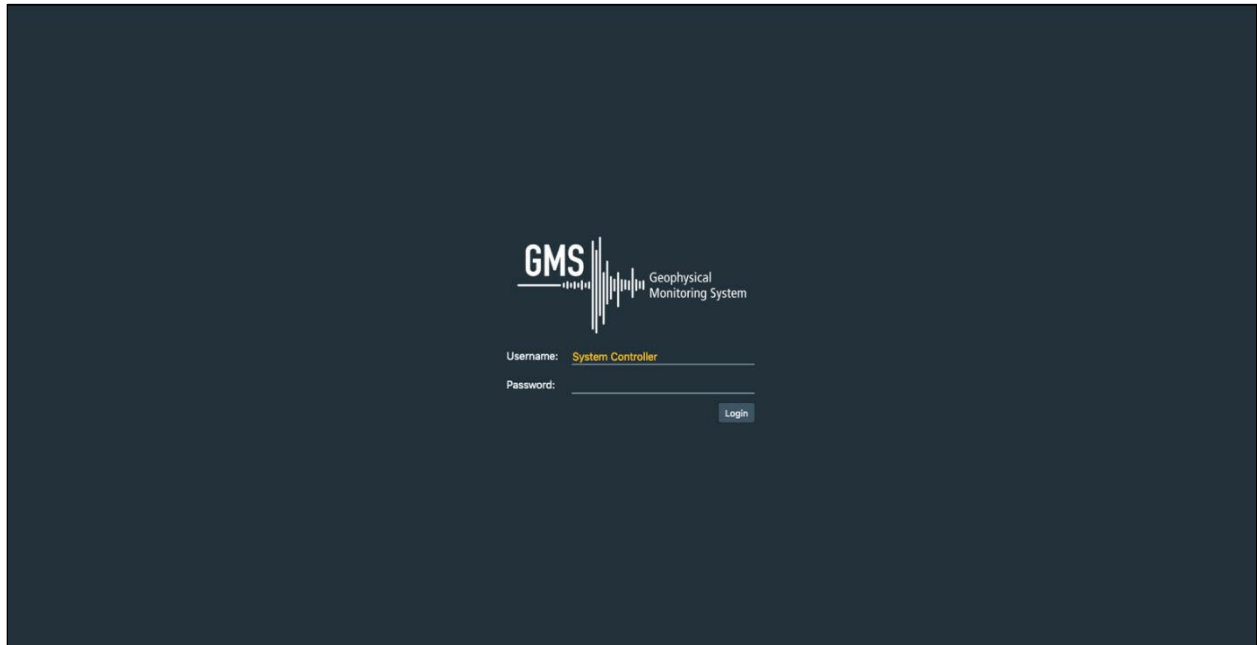
Figure 1. Login Screen for the SOH UI.

At the login page, users should enter any username but leave the password blank, because authentication has not been implemented. Users should not enter credential information, because this information is viewable within log messages.

4. DEFAULT WORKSPACE LAYOUT

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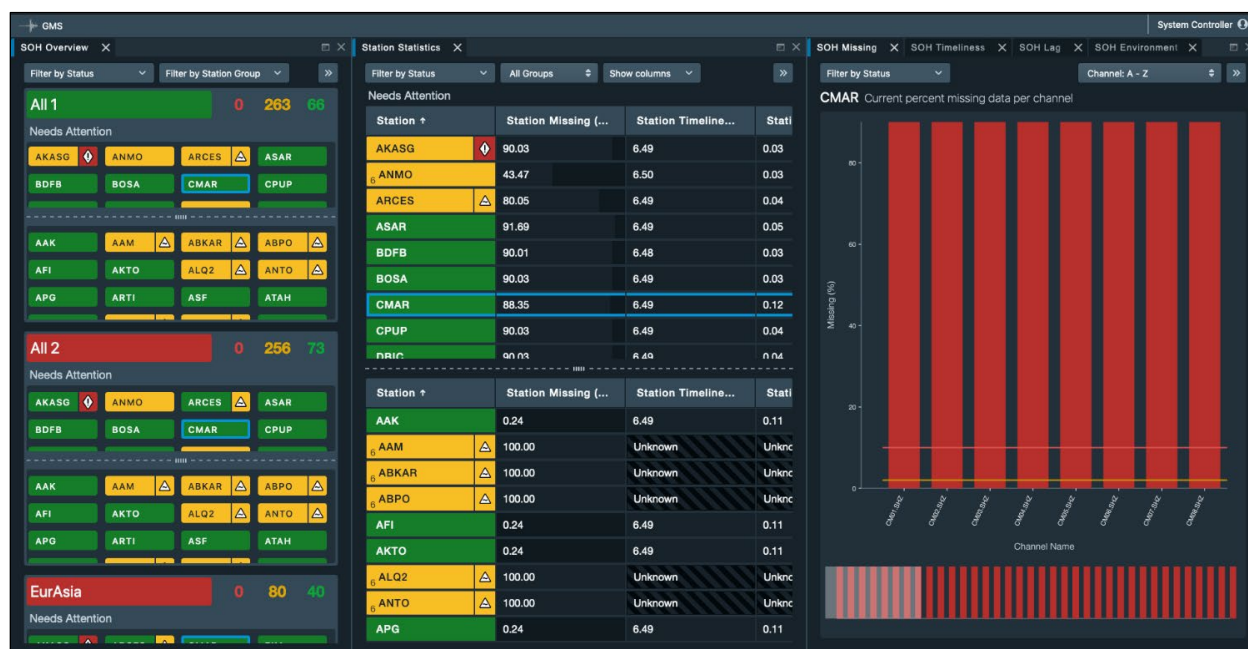
Figure 2. Default Workspace Layout of the SOH UI.

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

- SOH Overview (Figure 2; left)

- SOH Station Statistics (Figure 2; center)

- SOH Missing, SOH Timeliness, SOH Lag, and SOH Environment (Figure 2; right)
  - These displays can be viewed by selecting the corresponding tab.

The default SOH UI also includes an application level menu button in the top right corner (Figure 3).
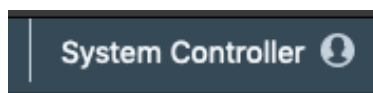
Figure 3. Application Level Menu Button.

The SOH Overview and SOH Station Statistics displays are summary displays that provide high-level station SOH status information. The SOH Lag, Timeliness, Missing, and Environment displays are drill-down displays used to troubleshoot a selected station's channels for specific lag, timeliness, missing data, or environmental issues. Three additional drill-down displays (SOH

Lag Trends, SOH Missing Trends, and SOH Environment Trends) are not shown in the default display and must be added by the user. The System Messages display is also not default. A station must be selected in either of the summary displays to populate the drill-down displays (see Section 5.4).

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

1) An individual display can be moved by clicking the corresponding tab and dragging it to the desired position; this includes placing multiple displays in one window with the display tabs next to each other.

2) An individual display can be expanded to full-screen by clicking the maximize button (i.e., box symbol) in the top right-hand 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 hand 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 or vertically 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) 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-hand corner of the window containing the display. If multiple displays share a window, clicking the x in the window right-hand corner will result in those displays being removed.

6) Once removed, individual displays can be restored 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 Station Statistics

      ii) SOH Environment

      iii) SOH Environment Trends

      iv) SOH Lag

      v) SOH Lag Trends

      vi) SOH Missing

      vii) SOH Missing Trends

viii) SOH Overview

ix) SOH Timeliness

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 SOH Layout (default).

　　i) This restores the workspace layout to the default layout (Figure 2) unless a personalized layout was made default by the user (see Section 5.1).

d) Select Developer Tools, then select Clear Layout

　　i) This restores the default workspace layout (Figure 2). If another workspace layout was saved as the default (see Section 5.1), this will restore 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 an option will provide a tooltip with a brief description.
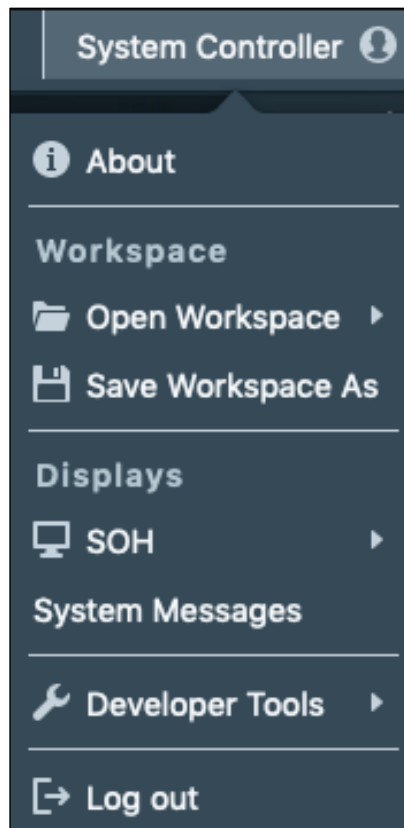
Figure 4. Application Level Menu Options.

Application Level menu options include:

1) About – Displays the version of the SOH UI and its latest commit.

2) Open Workspace – Shows the current user's available workspace layouts. Initially, only the default layout, SOH Layout, is available. More layout options are made available when the user saves them 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 5). A tooltip providing a brief description of each option can be brought up by hovering the cursor over the desired option.
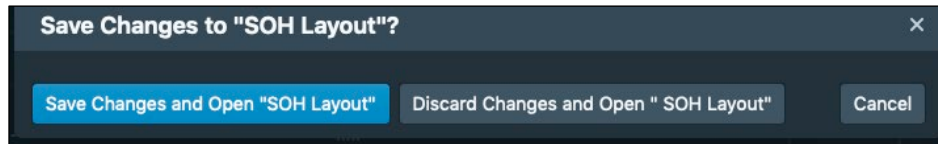
Figure 5. Prompt to Save or Discard Changes.

3) 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 SOH Layout. To discard changes, the user should select Discard Changes and Open SOH Layout. The user can also select Cancel to return back to the current workspace layout.

4) Save Workspace As –Saves a preferred UI layout (see Figure 6).
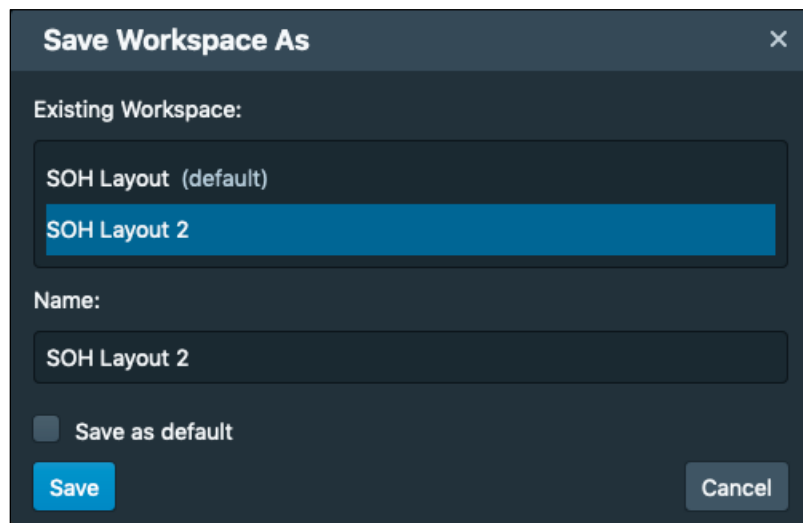
Figure 6. Save Workspace as Menu Options.

5) The new workspace layout can be saved under the name of an existing workspace layout by highlighting its name in the Existing Workspace dialog box or by typing the entry in the name field. The user can make the new workspace layout the default by checking the Save as default option at the bottom of the menu. Once saved, the new workspace layout can be accessed by going to Open Workspace (see bullet 2).

6) 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 7, the SOH Overview display is grayed because it is already open.
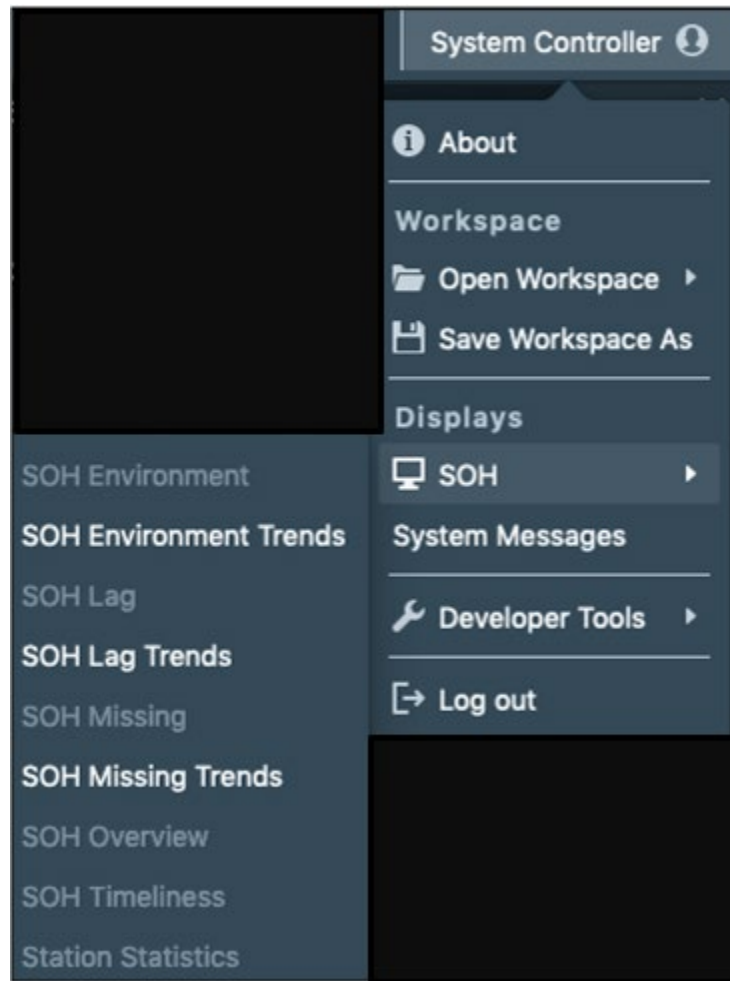
Figure 7. SOH Menu Options.

7) System Messages – Adds the System Message display (see Section 5.5).

8) Developer Tools – Gives the user two options.

   a) Logs – Lets the user view searchable logs tracked in the UI (debug, info, warn, error, fatal, etc.).

   b) 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 does not have a default custom layout.

9) 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 8). A tooltip providing a brief description of each option can be brought up by hovering the cursor over the desired option.
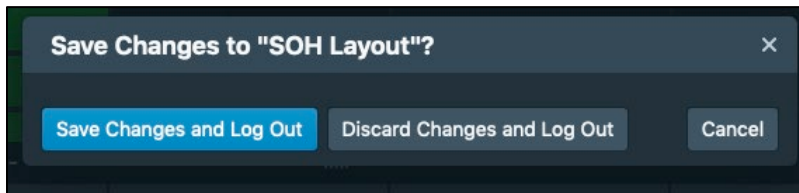
Figure 8. Log Out Menu Options.

5.2. SOH Overview Display

The SOH Overview display (Figure 9) 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 and

2) Overall SOH status inherited from the station's worst channel/monitor (worst-of SOH status).

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

Figure 9. The SOH Overview Display.

In Figure 9, capability-based SOH status is indicated by the station tile color:

- green = good
- yellow = marginal
- red = bad
- dark gray = 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 typically good. In rare cases, no badge may indicate that no data were received or that the station was not configured to receive a worst-of SOH status.

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

In the SOH Overview display, stations are sorted into one or more groups defined by a configuration file (see Configuration documentation). In each group, stations are sorted alphabetically. Groups can be any combination of stations and can share stations between them (e.g., station AKASG is a member of both groups in Figure 9).

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, see Figure 9, and checking all desired groups (Figure 10). Only station groups defined in the current configuration are shown in this dropdown.
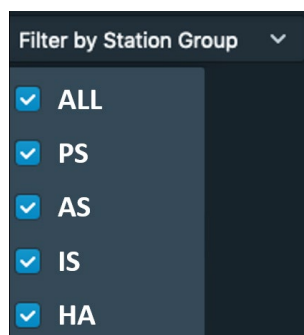
Figure 10. SOH Overview Filter by Group Dropdown.

A group's capability-based SOH status is indicated by the group's name color (e.g., Group PS has a good capability-based status in Figure 9). If a group is configured to not have a capability-based SOH status, all station tiles within the group and the group name will appear dark gray. 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 (e.g., AKASG is always marginal in Figure 9).

In each group, the number of stations in a capability-based SOH status category is shown in the upper-right hand corner, where number color indicates the category (red = bad, yellow = marginal, and green = good). For example, in Figure 9, Group PS has 3 bad stations, 2 marginal stations, and 34 good stations. Stations that were not configured to have a capability-based SOH status (dark gray tile) or did not receive data and hence did not have a capability-based status available (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 hand corner will show as gray zeros. Note that 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 time-stamp indicates the most recent status update, i.e., the time the most recent channel is processed by GMS (Figure 11).

Last Updated: 2020/10/23 16:06:39 Update Interval: 20 seconds

Figure 11. Time Stamp and Update Interval of Last Station/Capability-Based SOH Status Update.

Depending on the width of the Overview display, the user may need to click the double-arrow symbol to view the update interval and/or the Last Updated time-stamp (see Figure 9). With each update, a station's reported worst-of SOH status or capability-based SOH status may change.

As shown in Figure 12, each station group is further subdivided into two sub-categories: Needs Attention (Figure 12, top) and an unlabeled category (Figure 12, bottom). These categories separate stations that have not been acknowledged by the user, (Figure 12, top), and stations that have been acknowledged (Figure 12, bottom). Acknowledgement will be addressed in the next section.

Figure 12. SOH Overview Display for Group PS.

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 12) 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.

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 the desired stations then perform the steps above or

- Click the initial desired station, press and hold Shift, and click again on the final desired station. This selects all stations between and including the initial and final clicked stations. Once the selections are made, perform one of the steps above.

If a station in multiple groups is acknowledged, that station will be moved to the bottom category in all groups.

By selecting Acknowledge Station Status With Comment, the user can comment on the selected station(s), see Figure 13.
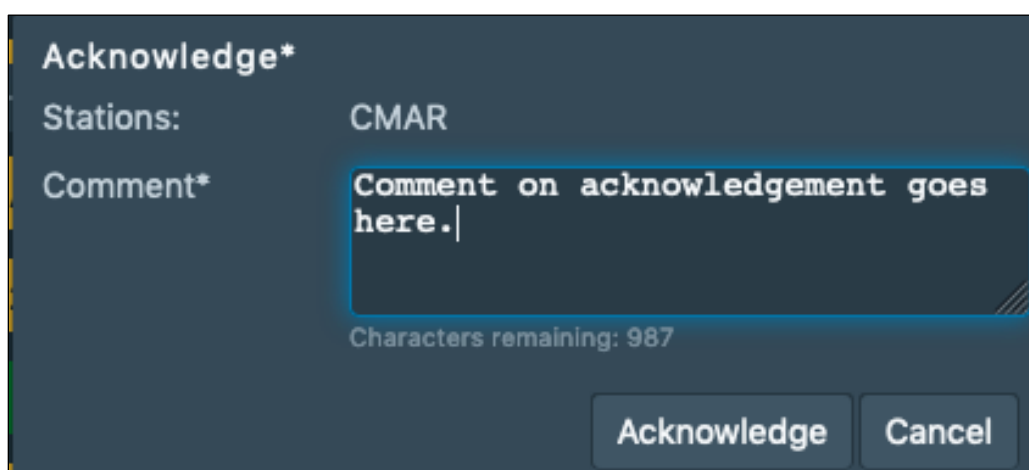
Figure 13. Text Area to Add Comment to Acknowledged Station.

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 selects the Acknowledge button, the selected stations 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 5.5).

Once stations are in the unlabeled category, the user can view capability-based SOH statuses by clicking the Filter by Status dropdown in the top left corner of the SOH Overview display (Figure 14). Note that None is a special capability-based SOH status that occurs when 1) a station is not configured to have a capability-based SOH status or 2) a station does not receive data and hence no capability-based SOH status is available. Station tiles with a status of None will appear dark gray if not configured for a capability-based SOH status or dark gray and hash-marked if no data were received.
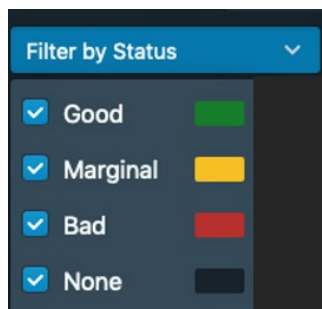
Figure 14. SOH Overview Filter by Status Dropdown Menu.

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 drill-down displays (see Section 5.4.8).

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 5.4.8) 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 5.4.1, 5.4.5, and 5.4.8 for more details.

The SOH Overview display is synchronized with the SOH 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. SOH Station Statistics Display

The SOH Station Statistics display (Figure 15) 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).

Station ↑	Station Missing (%)	Station Timelines...	Station Lag (s)	Station Issues (%)	Channel Missing ...	Channel Timeline...	Channel Lag (s)	Channel Issues (...
AKASG	0.25	41.61	41.96	0.05	0.25	41.61	100.08	21.31
2 AKTO	100.00	1,381.61	Unknown	Unknown	100.00	1,381.61	Unknown	Unknown
2 CFA	100.00	1,381.61	Unknown	Unknown	100.00	1,381.61	Unknown	Unknown
CMAR	0.12	31.61	32.15	0.03	1.25	41.84	41.77	11.48
2 ELK	3.84	321.61	49.68	Unknown	3.84	321.61	119.97	Unknown
2 FITZ	100.00	1,381.61	Unknown	Unknown	100.00	1,381.61	Unknown	Unknown
2 H03N	100.00	2,251.59	Unknown	Unknown	100.00	2,251.75	Unknown	Unknown
H11N	0.04	21.59	23.09	0.00	10.00	22.27	51.63	0.00
I11CV	0.25	121.64	109.55	2.10	0.50	121.69	112.55	100.00

Station ↑	Station Missing (%)	Station Timelines...	Station Lag (s)	Station Issues (%)	Channel Missing ...	Channel Timeline...	Channel Lag (s)	Channel Issues (...
2 AAK	100.00	58,981.61	Unknown	Unknown	100.00	58,981.61	Unknown	Unknown
2 ANMO	0.25	41.62	38.90	Unknown	0.25	41.62	64.73	Unknown
ARCES	0.25	41.61	43.38	0.00	0.25	41.61	61.96	0.00
ASAR	0.25	41.61	35.91	0.00	0.50	41.64	36.71	0.00
BDFB	0.10	31.60	34.98	0.00	0.10	31.60	69.60	0.00
BOSA	0.25	31.61	40.92	0.00	0.25	31.61	61.04	0.00
BRMAR	0.12	31.61	44.74	0.00	1.25	41.84	186.39	0.00
BRTR	0.25	31.61	41.93	0.00	0.50	31.64	186.42	0.00
CPUP	0.25	41.61	35.99	0.00	0.25	41.61	36.34	0.00

Figure 15. **The SOH Station Statistics Display.**

The default SOH 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, dark gray = non-defining, hash-marked = no data received). 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 typically good; however, on rare occasions, no badge can indicate that no data were received or the station was not configured to receive a worst-of SOH status.

2) **Station Timeliness (sec)** – The time difference (in seconds) between the current time and the latest data sample time that has been acquired on any channel.

3) **Station Lag (sec)** – 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.

4) Station Missing Data (%) – Shows the total percentage of missing data across all channels.

5) Station Issues (%) – Shows the total percentage of 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 at the end of this document.

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 latest data sample time acquired on that channel.

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.

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 issues on a single channel/environmental monitor pair over a configurable period of time.

For the Station column and the Channel columns, green/gray = good, yellow = marginal, red = bad, and dark gray = non-defining, i.e., the monitor does not contribute to the specified SOH status rollup (either capability-based for the Station column or worst-of SOH status for the Channel columns; see Sections 7.1, 7.2).The hash-mark indicates no data were received, with the status' color indicating whether the hash-marked monitor still contributes to the specified SOH status rollup.

The remaining Station columns, missing data (%), timeliness, lag, and 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 rollups.

Specific columns can be selected for viewing by selecting the Show columns dropdown menu at the upper-left of Figure 15. The dropdown menu is shown in Figure 16 below.
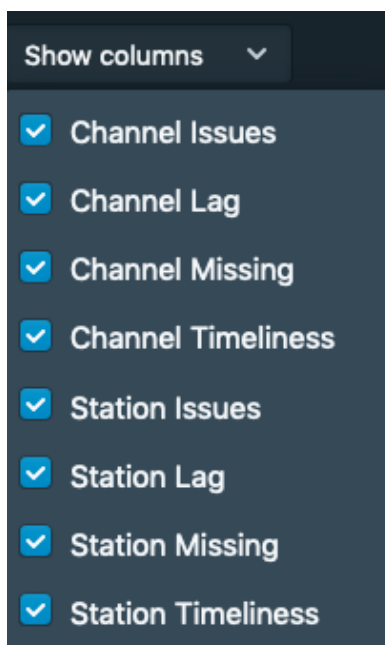
Figure 16. SOH Station Statistics Column Dropdown Menu.

When an option is selected/deselected, the column corresponding to that option will/will not be shown.

For the Station/Channel Missing (%) and Issue (%) monitors, the percentage of missing data or environmental issues is indicated by cell fill as well as by a numerical percentage value (Figure 17). The percentage of cell fill should match the numerical percentage value written on top.
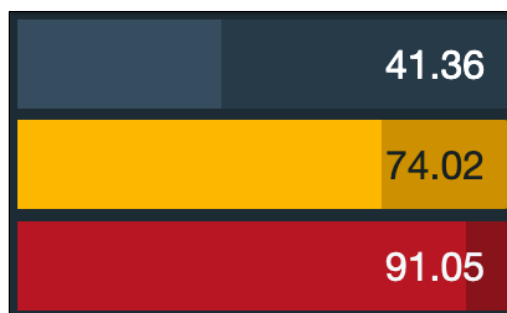
Figure 17. Missing Data and Environment Issues.

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 at least 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 15) 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 18, 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 also 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 BRMAR (Figure 18), whose worst available capability-based SOH status of bad (red tile) is also the only instance of a bad status for BRMAR amongst all groups.

Figure 18. Counts of Bad and Marginal Capability-Based Statuses for Stations ARCES and BRMAR.

To view stations from a select group, the user selects All Groups from the dropdown (upper-left corner of Figure 15) and selects a group to view in the Station Statistics display. When a group is selected, the dropdown button label will change from All Groups to the selected group name, e.g., PS. 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 SOH Station Statistics display is split into two categories: Needs Attention (Figure 15, top) and an unlabeled category containing stations that have been acknowledged (Figure 15, 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 15; see Figure 14 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. SOH Station Statistics Display Workspace Layout

The SOH Station Statistics display shown in Figure 15 represents its default layout. In addition to the layout options described in Section 4, the top (Needs Attention) and unlabeled categories in Figure 15 can be further modified in five 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) 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.

3) Station names can be sorted alphabetically, ascending or descending, by clicking the arrow symbol (Figure 19) 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 19) which is used to open the filter menu (bullet 5).

Figure 19. Sorting Arrow for Station Column.

4) 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 19). 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.

5) Station 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 20).
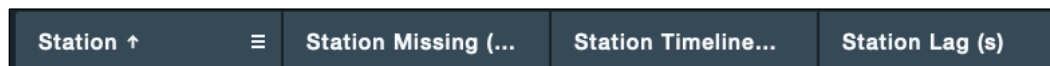

Figure 20. A Close-up of the Bar Symbol Used to Pull Up Filter Menu.

When this button is clicked, it will bring up a filter menu (Figure 21, center). When a value is entered into the filter field, the menu expands giving the option to apply another AND/OR filter (Figure 21, right) with its own filtering options (Figure 21, center). This option can 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).
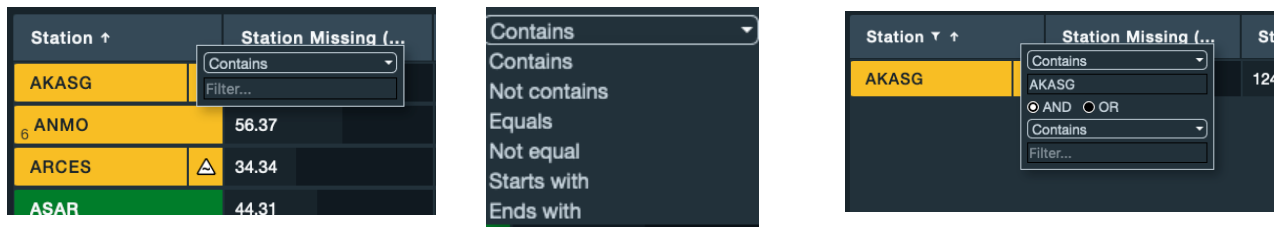
Figure 21. Station Filter Application. (Left); Available Filter Options (Center); Menu Expansion for Applying Another AND/OR Filter (Right).

5.4. SOH Drill-Down Displays

The SOH drill-down 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 drill-down display, the user must first select a station in the SOH Overview or SOH Station Statistics display. Because they are synced, a station selected in the Overview display will also be selected in the Station Statistics display and vice versa. The selected station can come from any group and can be in the Needs Attention category or the unlabeled category containing acknowledged stations. Once selected, the station will then be highlighted in blue in both displays as shown in Figure 22.
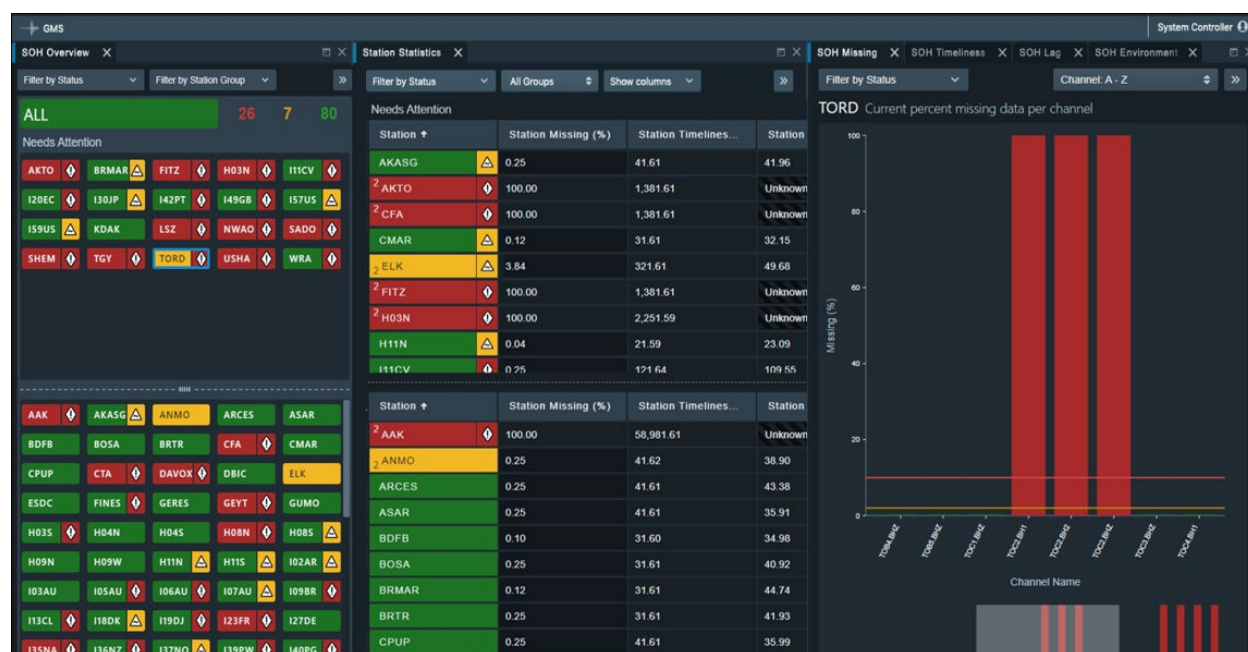

Figure 22. The SOH UI Default Layout with Station TORD Selected.

In Figure 22, station TORD has been selected. Each instance of TORD in the summary displays is highlighted by a blue box. The four SOH UI default layout drill-down displays (right) are populated with the corresponding information for TORD. To view a particular drill-down display, e.g., Missing, click on the desired tab. The SOH Lag Trends and Missing Trends drill-down displays (not shown) will also be populated with station information if they are added to the workspace layout (see Sections 4, 5.1, 5.4.2, 5.4.4). An additional step is required to populate the SOH Environment Trends drill-down display (not shown); this additional step is described in Section 5.4.6.

In the drill-down displays, only one station can be selected at a time. If multiple stations are selected in the SOH Overview or SOH Station Statistics displays, the user will be instructed to select only one station (Figure 23).
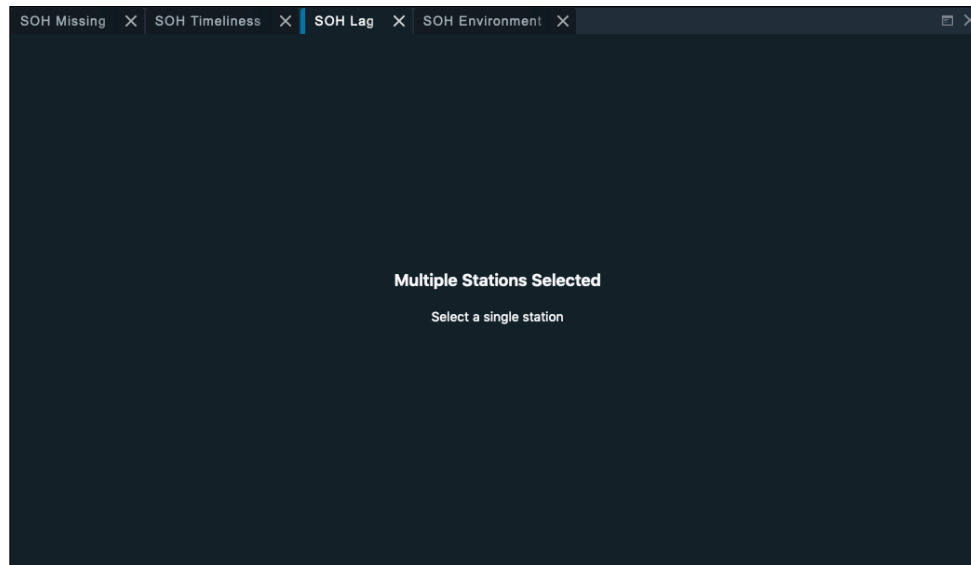

Figure 23. The SOH Lag Display with Multiple Stations Selected.

In the following sections, each drill-down display is described in detail.

5.4.1. SOH Lag Drill-Down Display

The SOH Lag drill-down display shows the SOH Lag status of all available channels for a selected station (CMAR in Figure 24).
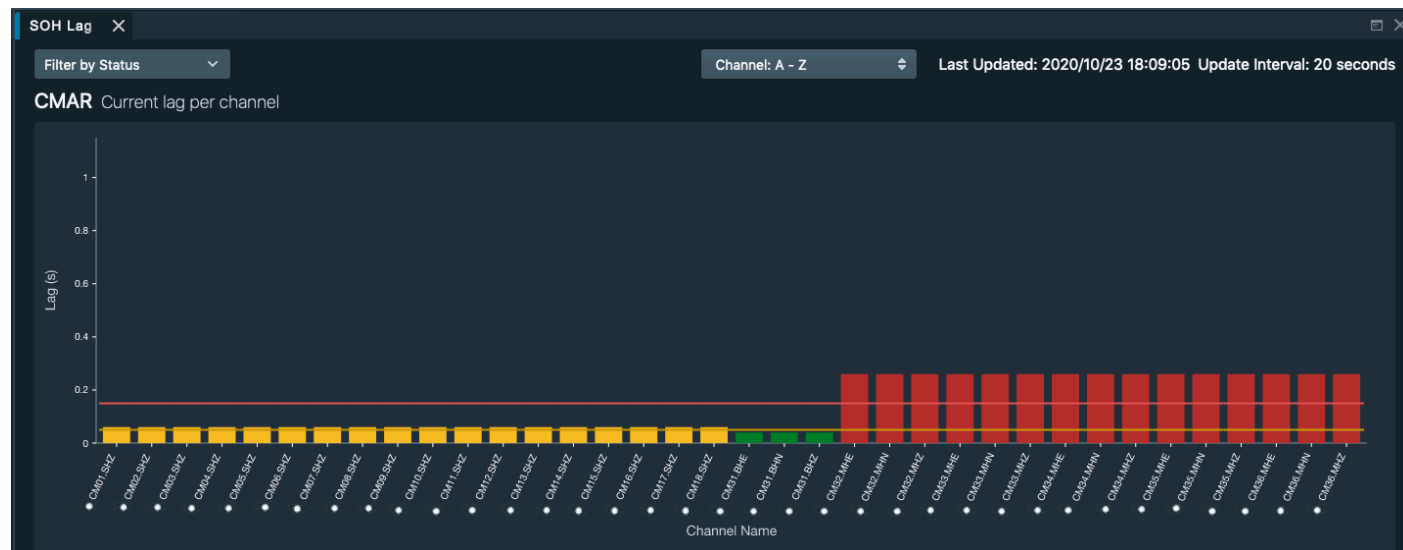

Figure 24. The SOH Lag Drill-Down Display.

Lag is shown on the y-axis and the channel name on the x-axis. Yellow and red horizontal lines indicate marginal and bad thresholds. Vertical bars are colored based on SOH lag status, with green = good, yellow = marginal, and red = bad. Channels not receiving data have no corresponding bar and the name is grayed out. These channels can be configured to have a status of marginal or a special status of None, i.e., the channel does not contribute to the specified SOH status rollup (see Section 7). 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 24) shown in Figure 25 and select from four options:

1) Lag: highest to lowest – Arranges channels from highest to lowest Lag value from left to right.

2) Lag: lowest to highest – Arranges channels from lowest to highest Lag value from left to right.

3) Channel: A-Z – Arranges channels alphabetically ascending from left to right.

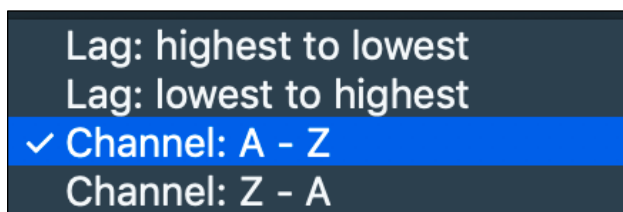4) Channel: Z-A – Arranges channels alphabetically descending from left to right.

Figure 25. Sorting Options in the SOH Lag Drill-Down Display.

When an option is selected, the dropdown button label changes from Channel: A-Z, as shown in Figure 24, to the selected option.

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 24). 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 26.

Figure 26. SOH Lag 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 26 indicates which channels are simultaneously being viewed in the secondary display (Figure 26; bottom) and the main display (Figure 26; top).

By default, this rectangle will 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.

Finally, the secondary display can be automatically removed by increasing the SOH Lag drill-down 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 Lag drill-down display represents a channel's total lag 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 Lag 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 lag 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 lag status is good, and the bar is green. If the bar height is greater than the marginal threshold but below the bad threshold, the channel's SOH lag status is marginal, and the bar is yellow. If the bar height exceeds the bad threshold, the channel's SOH lag status is bad and the bar is red.

The lag value can be viewed via a tooltip by hovering over the channel name. If no data were received for a channel, the tooltip value will be null.

Each channel's SOH lag status is determined and updated at a configurable Update Interval. This time is in the upper right corner of the SOH Lag display (Figure 24). Depending on the display width, the user may need to click the double-arrow symbol to view it.

The user can select which channel SOH lag statuses to view by clicking the Filter Status dropdown at the top left corner of the SOH Lag display and checking all desired statuses (Figure 27).
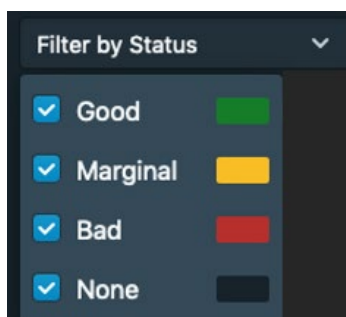
Figure 27. SOH Lag Filter by Status Dropdown Menu.

In the main SOH Lag display, unacknowledged channels are indicated by a white dot next to the channel name (Figure 24). Stations not receiving data are neither considered acknowledged or unacknowledged. They are indicated by a grayed out channel name. 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 occurs, a clock showing the duration of the quiet period appears at the top of every acknowledged channel's bar, see Figure 28. If a bar is too short to accommodate the clock, the clock is displayed above the corresponding bar.
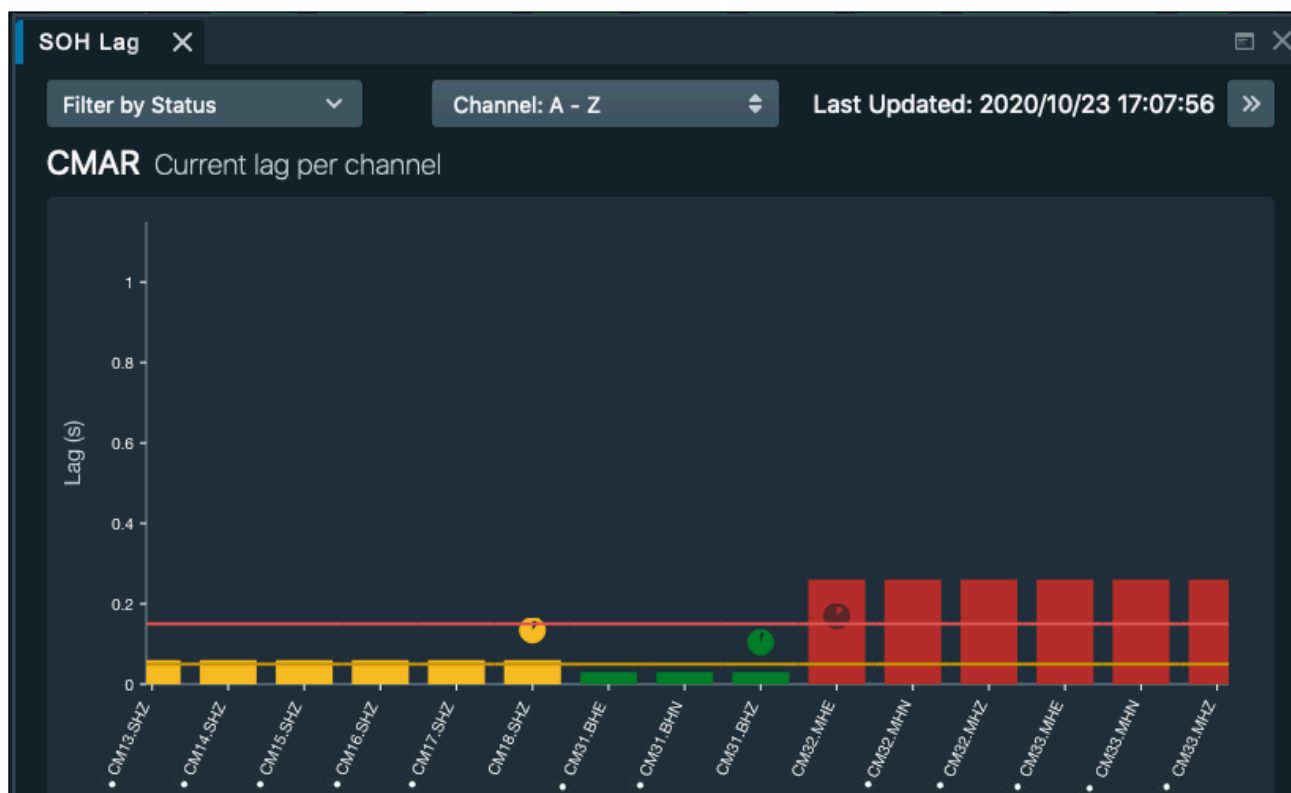

Figure 28. Acknowledged Channels in the SOH Lag Display.

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 28. Any changes in the lag 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 5.4.8.

5.4.2. SOH Lag Trends Drill-Down Display

The SOH Lag Trends drill-down display (Figure 29) 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 SOH Lag Trends from the SOH menu options (Figure 7). See Sections 4 and 5.1 for more detail.
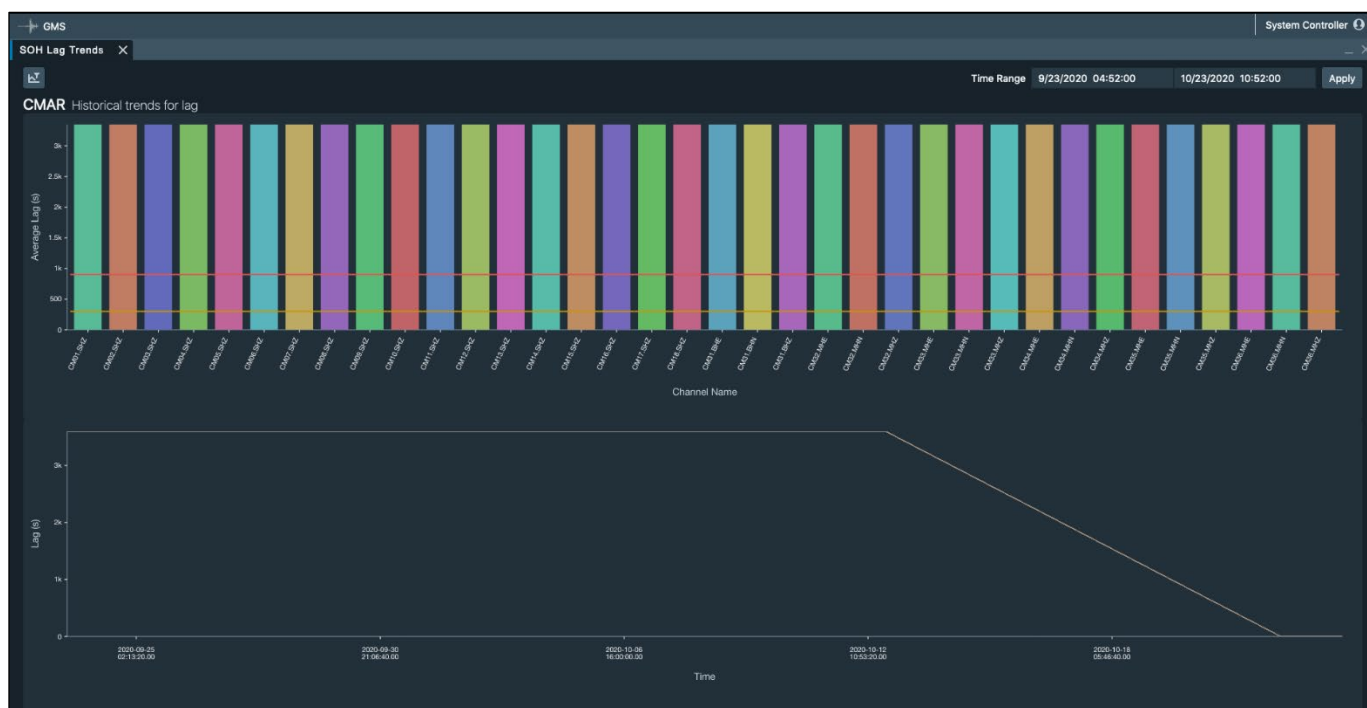

Figure 29. The SOH Lag Trends Drill-Down Display.

The bar chart shows the average lag 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, respectively, the channel is marginal or bad. Unlike the SOH Lag display, the color of the bars do not indicate whether a channel is problematic.

Just as with the the SOH Lag drill-down display (Figure 26), 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 Lag Trends drill-down display. See Section 5.4.1 for details and use.

The time-series plot indicates the change in lag (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 30) located in the upper-left corner of Figure 29. From this menu, a channel's time-series can be removed from the plot by deselecting it.

Figure 30. Lag Trend Time-Series Filter Dropdown Menu.

Each channel in the Lag Trends drill-down 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 and Environment Trends drill-down displays (Sections 5.4.4, 5.4.6).

By default, the time range of the bar chart and time-series plot is set to be the last 6 hours. The user can specify another time range via the drop-down menu shown in Figure 31. The menu is

brought up by clicking the start date in the upper-right corner (see Figure 29). The user can either select a default time range at the left of the menu (last 6 hours, last 12 hours, or last 1 day) or select a start and end date via the calendars below.
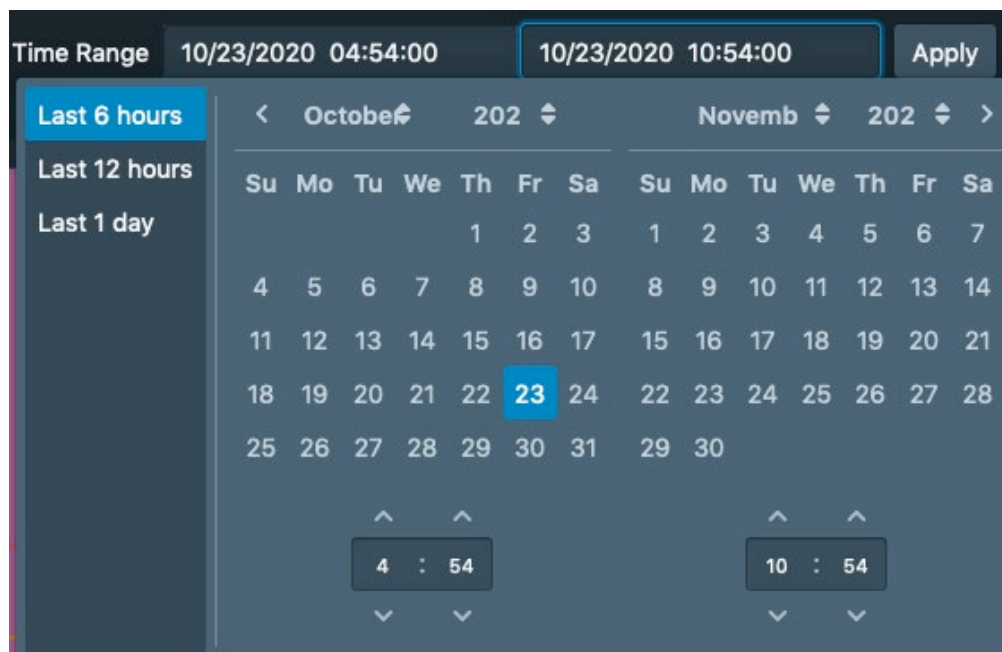

Figure 31. Time Range Dropdown Menu.

To select dates via the calendars, the user selects the desired start and end date. The selected time range will be highlighted in blue. The time range can be narrowed further by specifying the hour and minute of the start and end times. This action is performed via the left (start time) and right (end time) text boxes below each calendar. If a desired time range spans two or more months, the user can select a start date using the left calendar and an end date using the right calendar. If a time range spans less than a month, the entire time range can be selected using just one of the calendars. As an alternative, the user can also directly enter in a time range by double-clicking the start and end dates and manually typing in the desired times in as *yr/mo/dy hr:min*. Once a time range has been selected using either method, it will be shown in the text boxes at the upper-right corner of Figure 29 in *yr/mo/dy hr:min* format.

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. If an incorrect time range is selected (e.g., the start time is later than the end time), the text boxes are highlighted red and the Apply button is disabled. Depending on the display width, the user may need to click a double-arrow symbol to view the time range dropdown menu.

Finally, if no data are available during the time range selected, the display will indicate there are no data as shown in Figure 32.
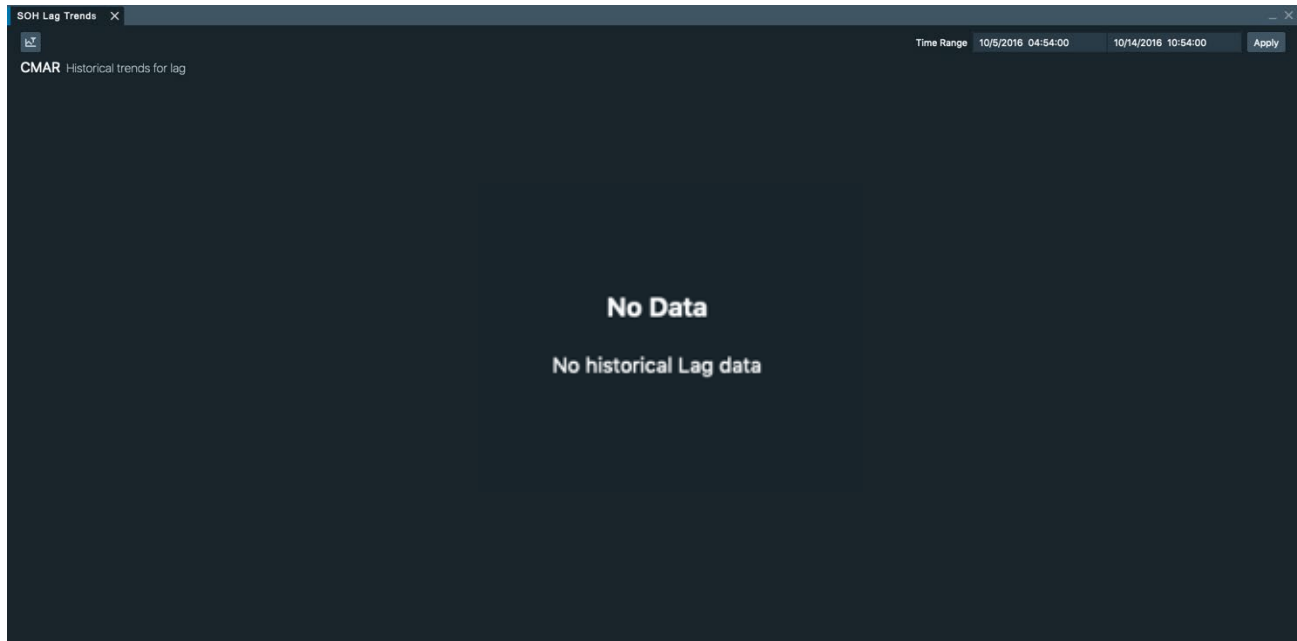

Figure 32. The SOH Lag Trends Drill-Down Display with No Data Available.

5.4.3. SOH Missing Drill-Down Display

The SOH Missing drill-down display (Figure 33) 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).
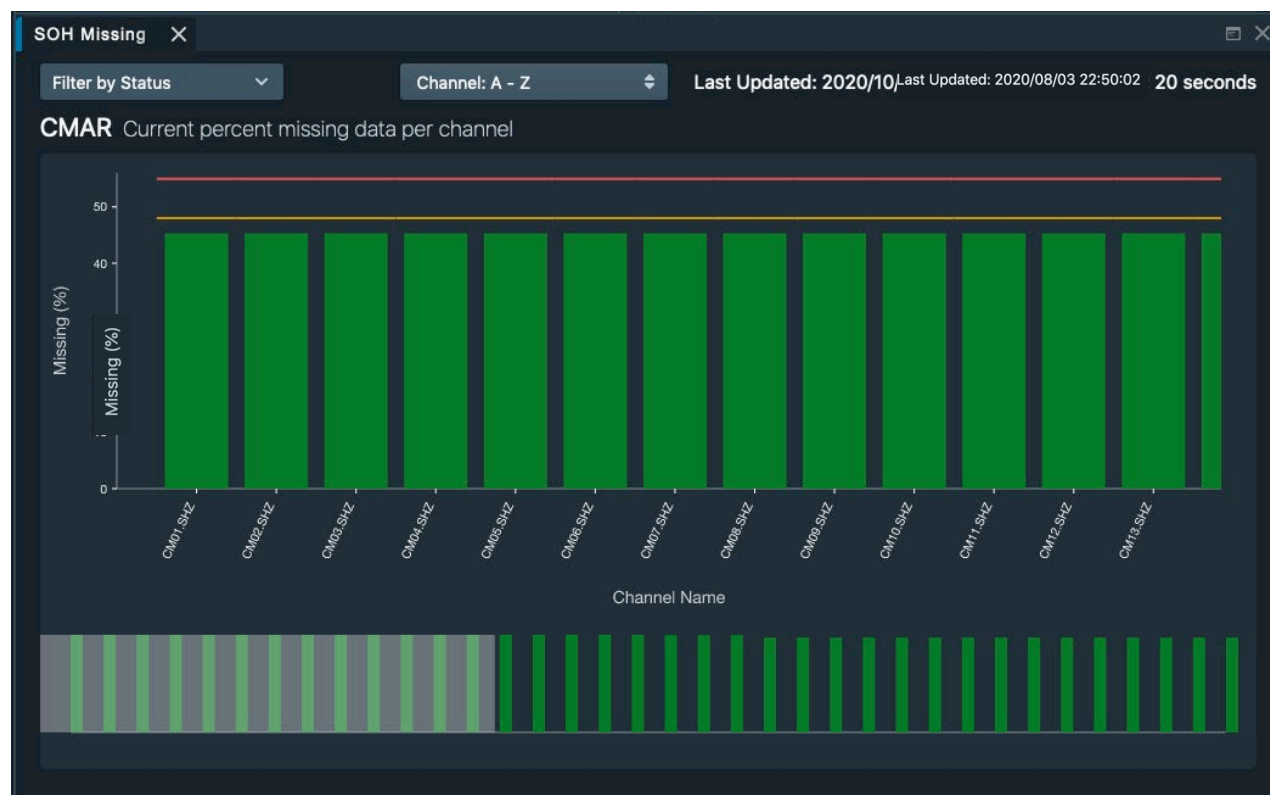

Figure 33. The SOH Missing Drill-Down Display.

In the SOH Missing drill-down 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 drill-down display functions like the SOH Lag drill-down display; however, it is used for troubleshooting the Missing (%) monitor rather than the Lag monitor. See Section 5.4.1 for display information.

5.4.4. SOH Missing Trends Drill-Down Display

The SOH Missing Trends drill-down display looks and functions like the (Figure 34) Lag Trends drill-down display; 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 5.4.2 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 SOH Missing Trends from the SOH menu options (Figure 7). See Sections 4 and 5.1 for more detail.

Figure 34. The SOH Missing Trends Drill-Down Display.

5.4.5. SOH Environment Drill-Down Display

The SOH Environment drill-down display (Figure 35) shows the Environment (%) SOH status of all available channels for a selected station.

Figure 35. The SOH Environment Drill-Down Display.

From left to right, the SOH Environment display shows the following information for the specific station shown in the upper-left corner (CMAR in Figure 35):

1) Monitor Type – Lists specific environment issues and their worst-of SOH status where green = good, yellow = marginal, red = bad, dark gray = non-defining, and hash-marked = no data received. The hash-marked monitor type color indicates whether it contributes to the specified SOH status rollup (can be yellow/marginal or dark gray/non-defining). A list of monitor types is provided at the end of this document.

2) Channels – The remaining columns show the environmental issues value and SOH status of each monitor type for each channel (CM01.SHZ, CM02.SHZ, CM03.SHZ, etc. in Figure 35), where gray = good, yellow = marginal, red = bad, and dark gray = non-defining. Hash-marked = no data received, with color indicating whether the hash-marked monitor still contributes to the specified SOH status rollup (yellow/marginal or dark gray/non-defining). The channel's worst-of Environment (%) SOH status is shown by the channel name's color, with green = good, yellow = marginal, red = bad, and dark gray = non-defining. Hash-marked = no data received, with color indicating whether the

hash-marked monitor still contributes to the specified SOH status rollup (yellow/marginal or dark gray/non-defining).

Similar to the SOH 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 36). The percentage of cell fill should match the numerical value written on top.

Figure 36. Percentage of Environmental Issues.

The user has two filter options: Filter Monitors by Status and Filter Channels by Status. These 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 (see Figure 27).

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 CM01.SHZ in Figure 35 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 channels are placed in a quiet period and the white/black dots disappear. At this time, a clock indicating the duration of the quiet period appears to the left of the acknowledged environmental issue value, see Figure 37.
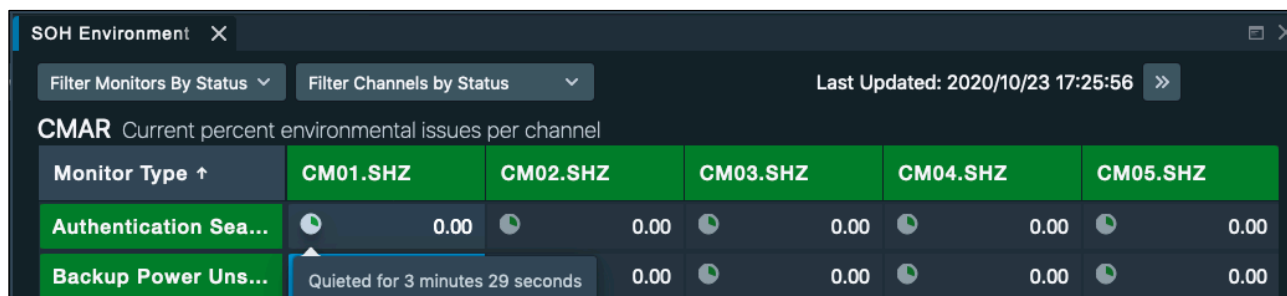

Figure 37. An Acknowledged Channel/Monitor Type Pair in the SOH Environment Display.

As in the SOH Lag drill-down display, 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/environmental issue 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 5.4.8.

The SOH Environment display shown in Figure 35 is the default layout. In addition to the layout options described in Section 4, the SOH Environment drill-down display can be modified using the layout options described in Section 5.3.1.

5.4.6. Environment Trends Drill-Down Display

The SOH Environment Trends drill-down display (Figure 38) 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 7). See Sections 4 and 5.1 for more detail.

Figure 38. The SOH Environment Trends Drill-Down Display.

Like other drill-down displays, a station must be selected from the SOH Overview or SOH Station Statistics display prior to viewing information in the SOH Environment Trends drill-down display; however, to populate the Environment Trends drill-down 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 drill-down display (Figure 35) or select a monitor type from the dropdown menu (Figure 39) in the upper-left corner of Figure 38.
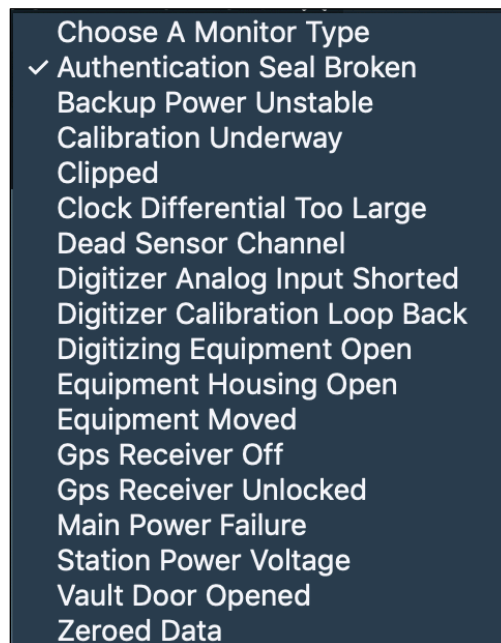

Figure 39. Monitor Type Dropdown Menu.

If no monitor type is selected, the user will be prompted to choose a monitor type (Figure 40).
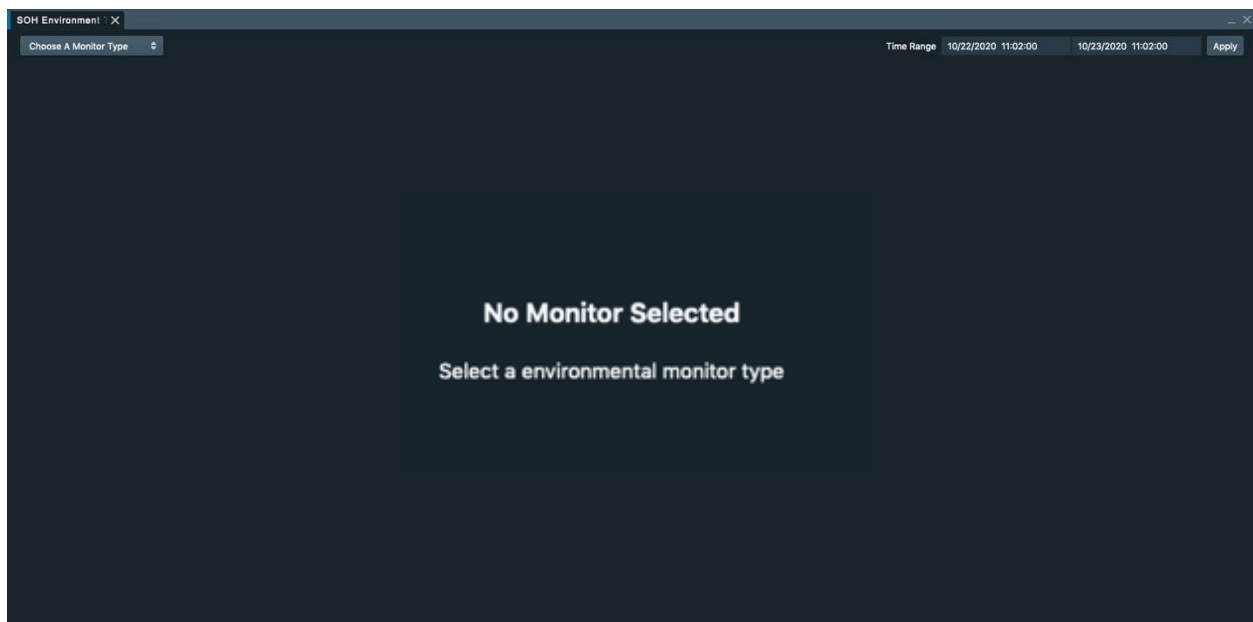

Figure 40. The SOH Environment Trends Drill-Down Display with No Monitor Selected.

Currently, 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 start and end time boxes in the upper-right. In Figure 38, the time period shown is 05 Aug 2020 03:25:19.3130 + 3 hours 15 minutes 25 seconds. Two environmental issues, Clock Differential in Microseconds and Last Gps Sync Time, are not Boolean and thus cannot be viewed in this display. If a non-Boolean monitor type is selected, the user will be prompted to select another monitor type (Figure 41).
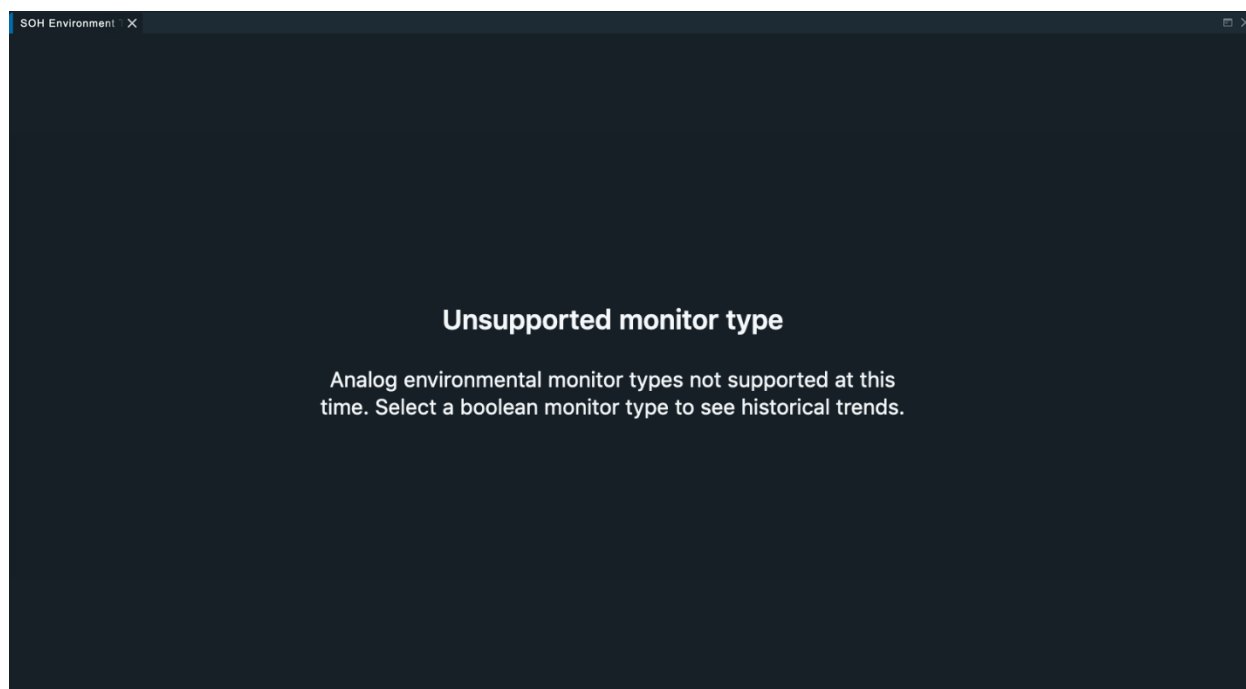

Figure 41. The SOH Environment Trends Drill-Down Display with an Analog Environmental Monitor Type Selected.

The user can zoom into a portion of the Envirement Trend drill-down display using the cursor shown as a vertical white bar (see Figure 38). To zoom, continuously holding the Ctrl key (Command on Mac) while clicking and dragging the cursor. 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 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 MK01.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 Configuration documentation). For example, the Channel/Monitor Type pair MK01.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 drill-down display is done the same way as the prior two trend drill-down displays, see Section 5.4.2 and Figure 31.

5.4.7. SOH Timeliness Drill-Down Display

The SOH Timeliness drill-down display (Figure 42) shows the timeliness status of all available channels for a selected station. The bar color indicates a channel's timeliness status (green = good, yellow = marginal, and red = bad).
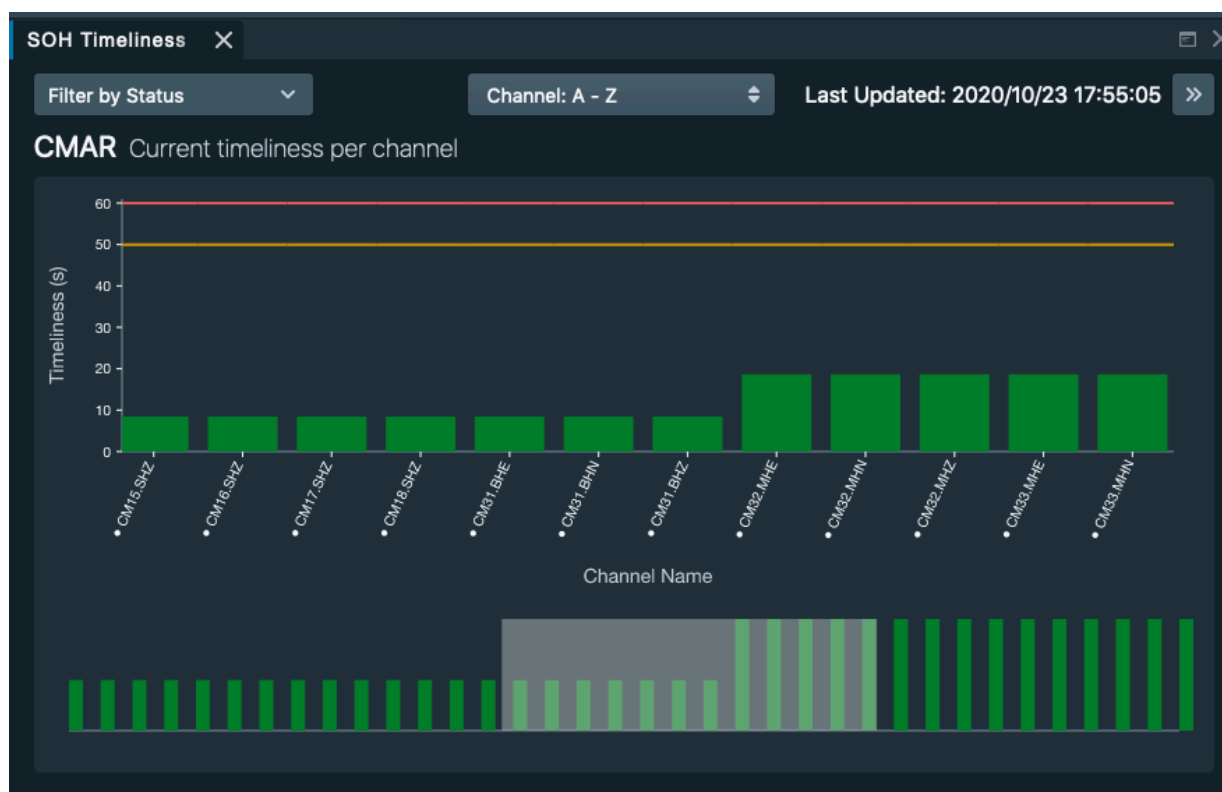

Figure 42. SOH Timeliness Drill-Down Display.

In the SOH Timeliness drill-down display, the timeliness is shown on the y-axis in seconds. The channel name is on the x-axis.

The SOH Timeliness drill-down display functions like the SOH Lag drill-down display; however, it is used for troubleshooting the Timeliness monitor rather than the Lag monitor. See Section 5.4.1 for display information. 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 Timeliness from the SOH menu options (Figure 7). See Sections 4 and 5.1 for more detail.

5.4.8. Quieting

In the SOH Lag, Missing, and Environmental drill-down displays, the user can manually quiet individual channels/monitors. When a channel/monitor is quieted, the user will not be notified of any changes in SOH status during the quiet period. This 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 Lag and Missing drill-down displays) or a specific channel/environmental monitor type pair (Environmental drill-down display) to bring up the option menu for quieting shown in Figure 43. Multiple channel/environmental monitor type pairs can be quieted in the Environmental drill-down display by holding the Ctrl key (Command on Mac) while clicking on the desired stations, then right-clicking one of the selected stations to bring up the menu (see Figure 43).
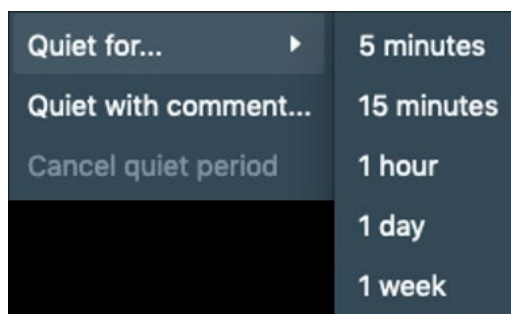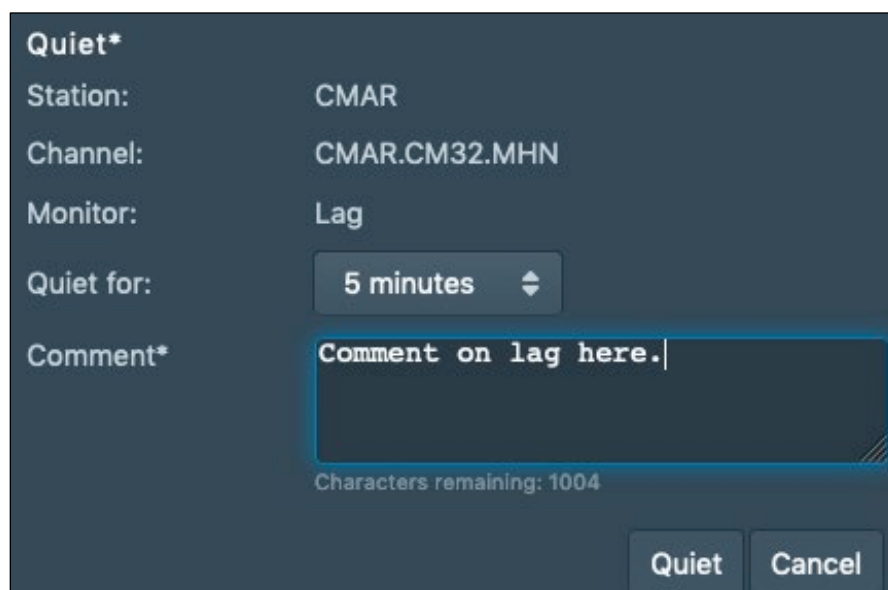

Figure 43. Quieting Option Menu.

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 min, 15 min, 1 hr, 1 day, and 1 week. The list of available quiet period durations is configurable (see Configuration documentation).

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 44.

Figure 44. 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 5.5).

Finally, the user can manually overwrite or cancel a previously applied quiet period by right-clicking the quieted channel's bar or specific environmental issue and selecting either a new quiet period duration or canceling the quiet period; this 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 and Missing drill-downs) or to the left of a quieted channel's percentage environmental issue value (Environmental drill-down). Because these manual quiet periods are individually applied rather than automatically applied by acknowledgement, each quiet period may differ in duration, see Figure 45. 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.
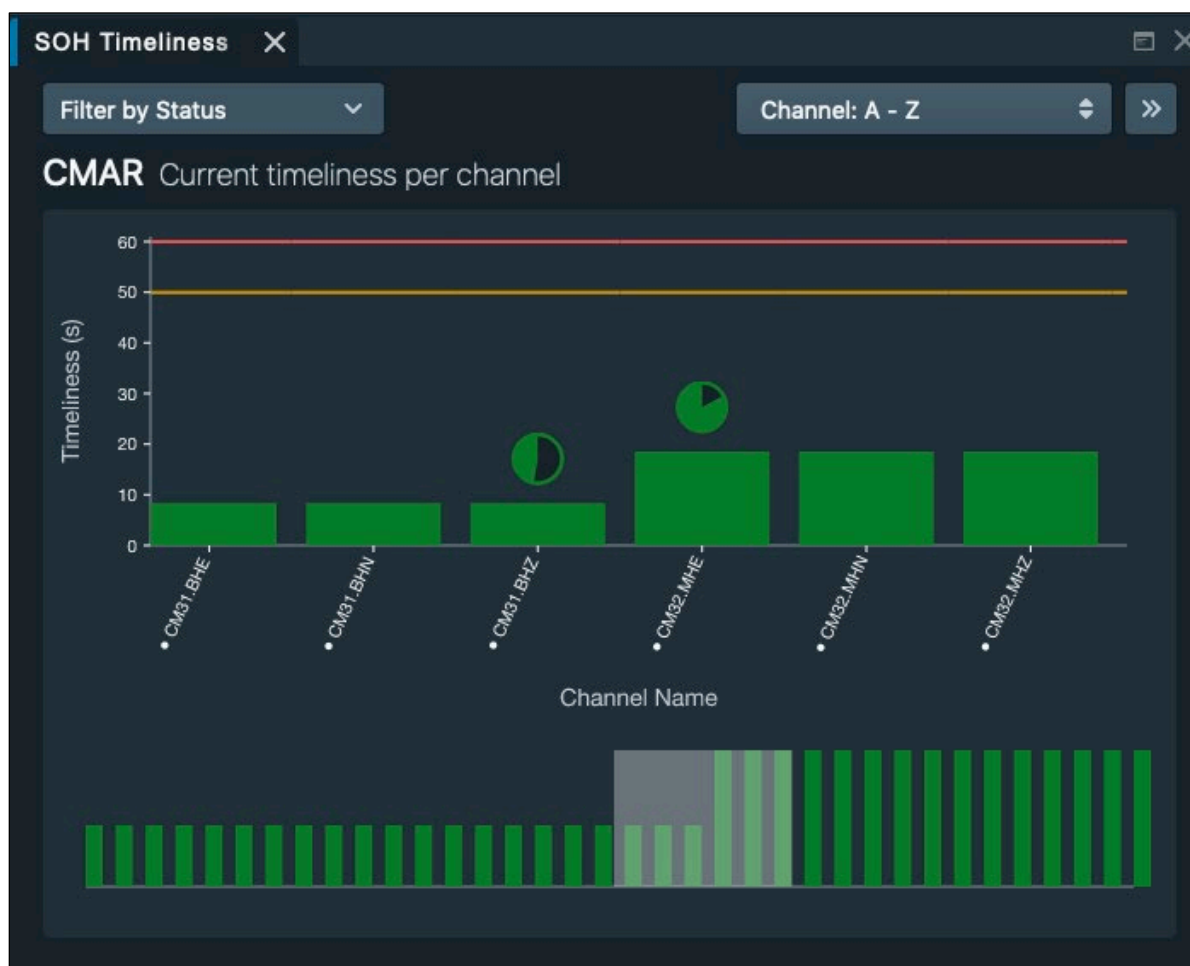
Figure 45. Manually Quieted Channels in the SOH Lag Drill-down Display.

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 channels/monitors are not acknowledged. As shown in Figure 45, 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.

Finally, it is possible to use manual quieting to acknowledge a station's general SOH status by quieting every unacknowledged channel/monitor in all three drill-down displays. When this 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.

5.5. System Messages Display

The System Messages display (Figure 46) provides a scrolling list of messages output by the system in real time.

Figure 46. 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 46) 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. 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, 5.2.1), changes to station or channel/monitor SOH status (Section 7.1), changes to station or station group capability-based rollup status (Section 7.2), the acknowledgement or quieting of a channel/monitor pair (Sections 5.2.1, 5.4.8), or the cancellation or expiration of a quiet period (Section 5.4.8).

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, etc. Currently, SOH is the only available category.

3) Subcategory – A subcategory indicating whether the message resulted from a change in station 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 46. 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 rollup 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 message display is paginated, with each page showing a maximum of 100 messages. The number of messages, page number, and page navigation buttons are located in the lower-right corner of the System Messages display (Figure 46). A maximum of 2000 messages can be saved. When the total number of messages exceeds this value, the last 3 pages of messages will be deleted. The maximum number of messages shown per page and the maximum number of messages saved are configurable (see Configuration documentation).

The System Messages display in Figure 46 shows 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 SOH Station Statistics display (see Section 5.3.1).

Incoming messages can be assigned unique audible notifications by clicking on the Configure sounds button in the upper corner of Figure 46 to bring up the menu shown in Figure 47.
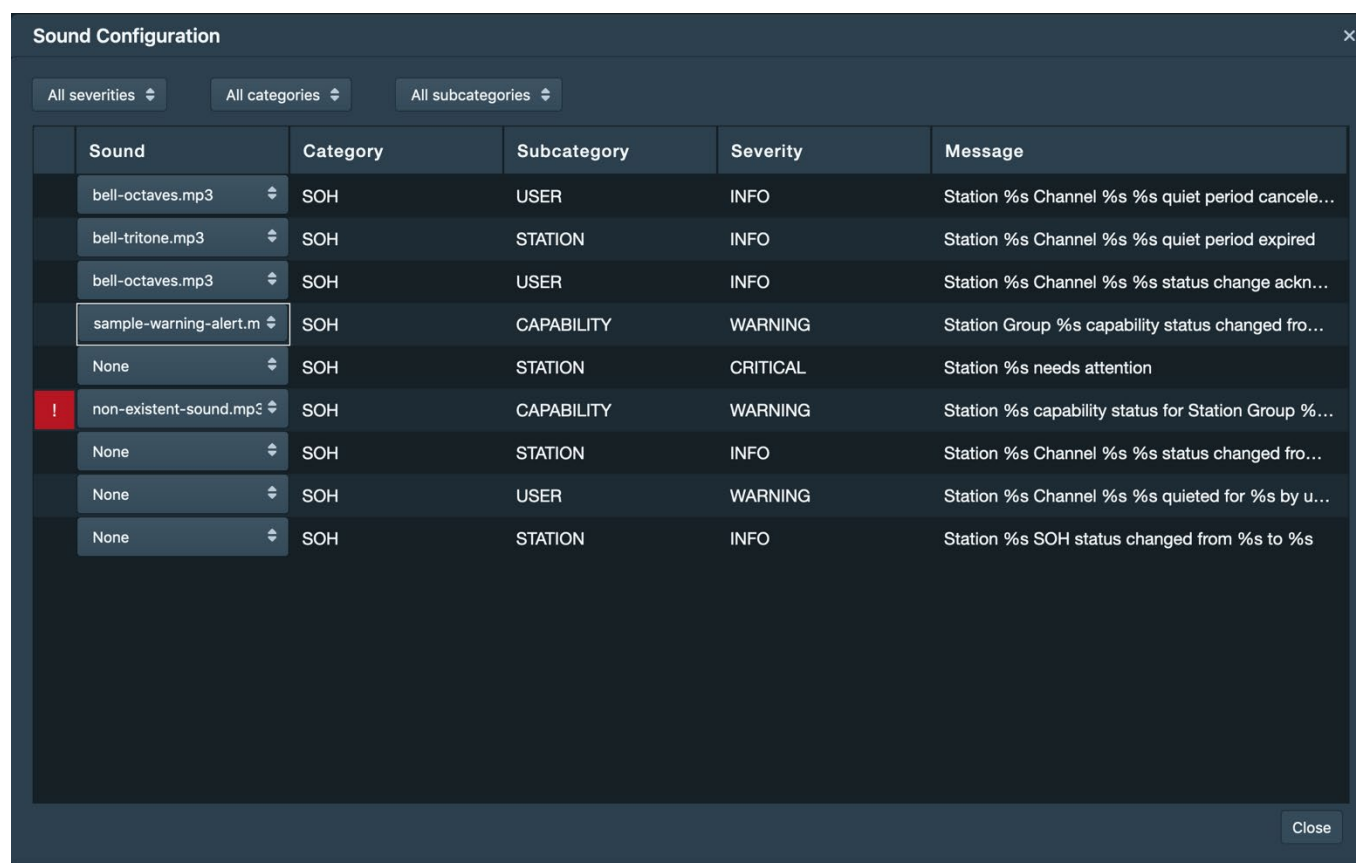

Figure 47. Sound Configuration Menu.

Each row of the sound configuration menu represents a system message type that can be received in the System Messages display (see System Message Definitions at end of document for full list of types). System message types can be filtered based on severity, category, or subcategory using one of the 3 drop-down menus in the upper-left (see Figure 47).

The Sound column on the left (Figure 47) 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 48).
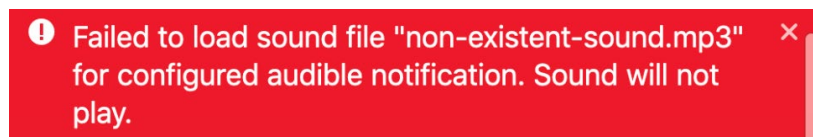

Figure 48. Failed to Load Sound Warning Message.

In addition, a red exclamation point will appear left of the sound that failed to load (see Figure 47).

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 47). Once done, the user can close the Sound Configuration window by clicking Close (see bottom right of Figure 47). The newly configured sounds can be muted/unmuted using the speaker button in the upper-right corner (see Figure 46).

6. COLOR LEGEND

In the SOH Overview and Station Statistics displays (Sections 5.2 and 5.3), the color legends in Figure 49 show a station's capability-based SOH status (left) and whether the data are received (right). Alternatively, for channel/monitor pairs in the Station Statistics and Environment drill-down displays, the left color legend in Figure 49 represents a channel/monitor pair's worst-of SOH status. Note that channels/monitors that did not receive data (hash-marked tiles in Figure 49) will have a value of Unknown.
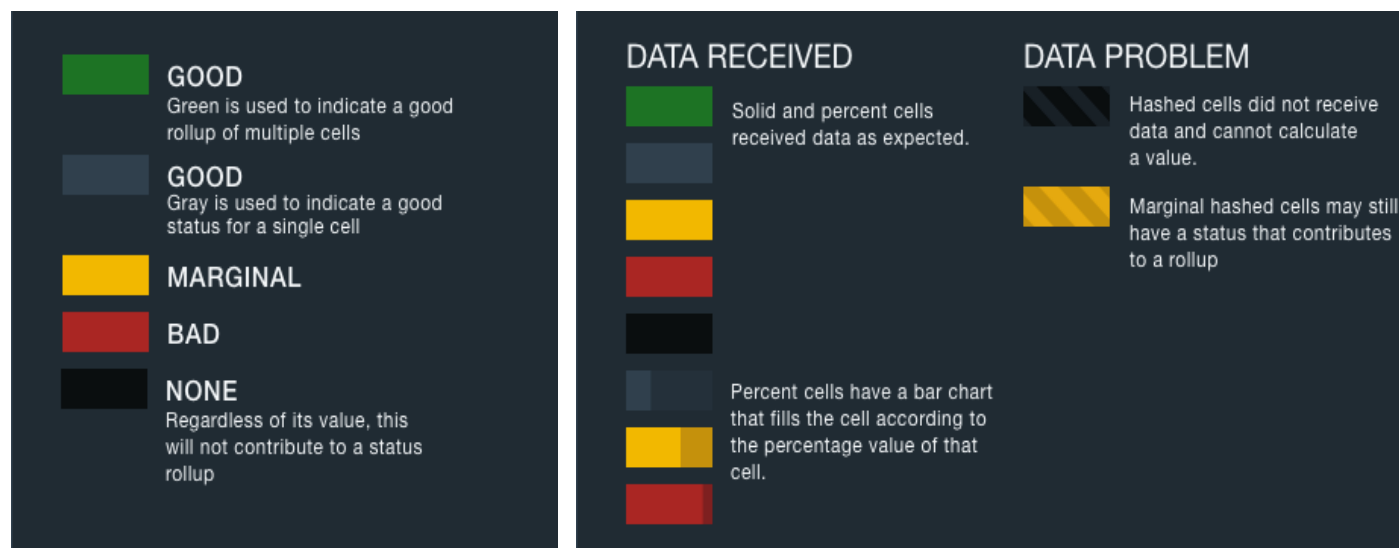
Figure 49. Capability-based SOH Status (Left) and Data Received (Right) Color Legends Shared Across Displays.

The color legend in Figure 50 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 50. 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 51. 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.

Figure 51. 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 SOH 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

The worst-of SOH status is a rollup of all monitors within a channel and all channels within a station. It provides an overall worst-of station SOH status. Calculation begins by determining the SOH status of each channel's monitors, see the right side of Figure 52. In the following examples, only lag, missing data, and environmental SOH monitor types are considered for simplicity. As shown in Figure 52, all environment SOH monitor types are shown as a single box.
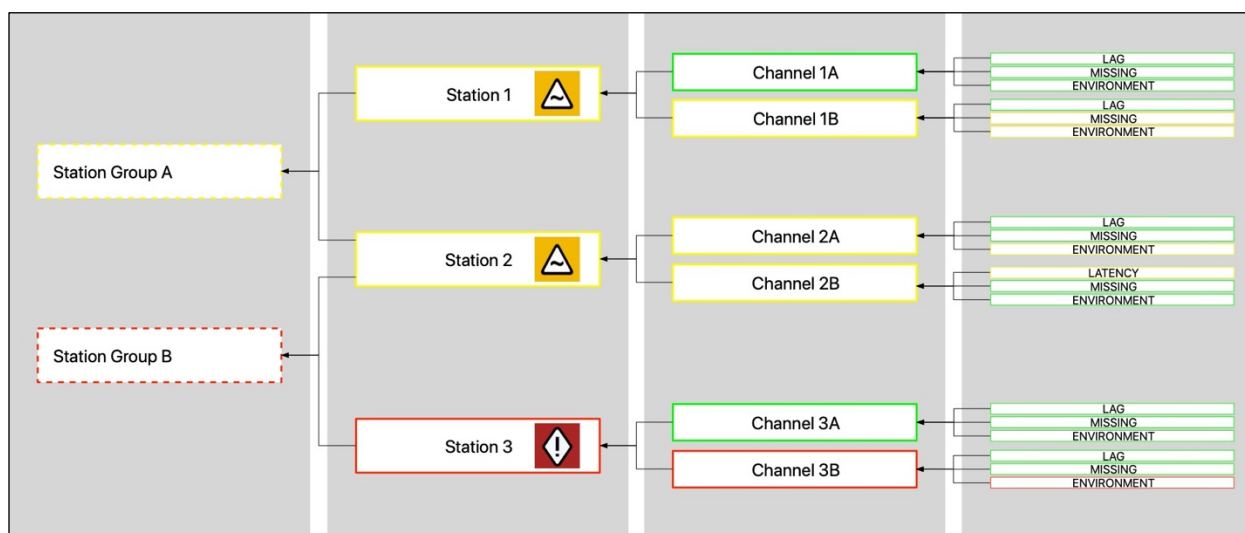
Figure 52. Flowchart Example of Worst-Of SOH Status Rollup.

After the SOH status of all a channel's monitors has been determined, the monitors' SOH statuses are compared, and the SOH status of the worst monitor is inherited by (rollup) the channel. This rollup is calculated for each channel until all channels have an assigned worst-of SOH status. The channels' worst-of SOH statuses are compared and the SOH status of the worst channel is rolled up to the station. Worst-of SOH status in the Overview and Station Statistics displays (Figure 9, Figure 15) is indicated by color and icon, with marginal = yellow triangle and bad = red diamond. A good worst-of SOH status does not have an icon; thus, for the purposes of describing the flow chart, good = green.

For example, in Figure 52, Station 1 obtains an overall marginal SOH status (as indicated by the yellow diamond badge). Channels 1A and 1B contribute to the worst-of SOH status of Station 1, both with three monitor types: lag, missing data, and environment. Channel 1A's worst-of SOH status is green because all of its monitors have good SOH statuses. Channel 1B's worst-of SOH

status is marginal, because its worst monitor status is marginal. Therefore, Station 1's worst-of SOH status is marginal, because Channel 1B's worst-of SOH status is inherited.

Monitors or channels 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. If a station only has channels/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 channels/monitors are a mix of marginal/Unknown and marginal with a numeric value, the station will inherit the worst-of SOH status of the channel/monitor with the worst numeric value. In all cases, these inherited values can be seen in the SOH Station Statistics display for a specific monitor.

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 53. 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 SOH Monitors column in Figure 53. Currently, only lag, missing data, and environment SOH monitor types are considered in the GMS system. In Figure 53, all environment SOH monitor types are denoted as a single box.
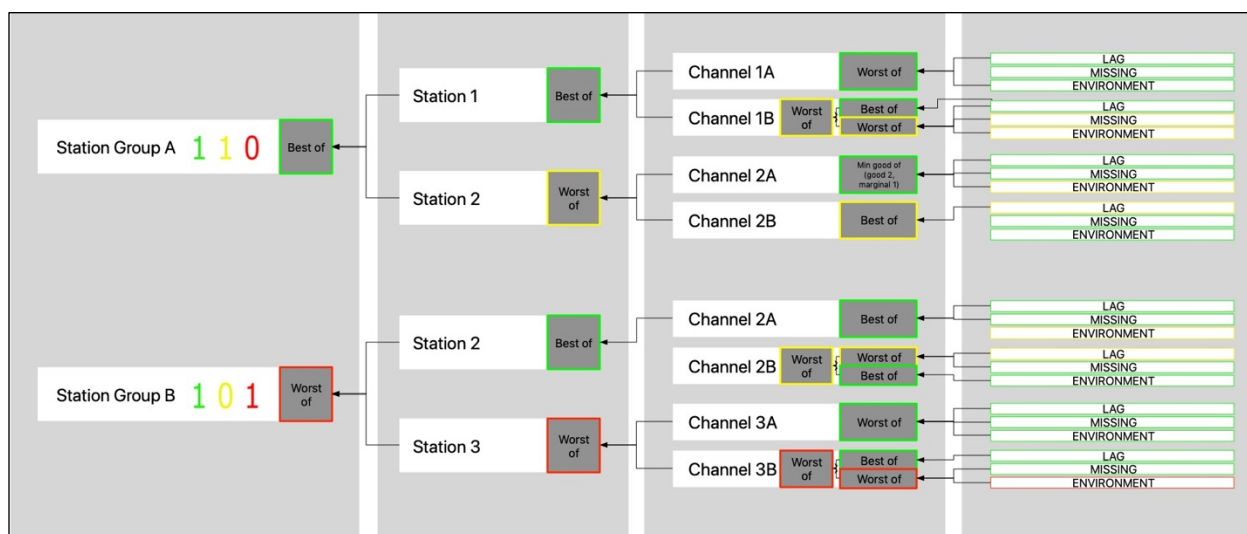
Figure 53 depicts an arbitrary capability-based SOH status rollup, starting with monitors on the right and ending with station groups on the left. Arrows indicate which monitors, channels, or stations are input into a rollup operator (Worst-Of, Best-Of, or Min-Good-Of). Capability-based SOH status is indicated by color in the SOH Overview and Station Statistics displays (Figure 9, Figure 15), with good = green, marginal = yellow, bad = red.

Unlike the worst-of SOH status rollup, where the worst monitor status is rolled-up to its channel, 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 52).

Figure 53 demonstrates how the capability-based SOH status rollup and the rollup operators work. In this figure, Channel 2A has three monitors, lag, missing data, and environment, while Channel 2B only has lag, as indicated by the single arrow.

A Min-Good-Of operator was applied to all 3 monitors in Channel 2A. The Min-Good-Of operator is defined with two thresholds, Good: 2 and Marginal: 1. This can be seen in the

Channel 2A box under the Channel Capability SOH Rollup column. These thresholds indicate that the Min-Good-Of operator will return:

- A good SOH status when 2 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 53, the lag and missing monitors have a good SOH status and therefore Min-Good-Of returns a SOH status of good for Channel 2A. The Best-Of operator is only applied to the Lag monitor in Channel 2B; it returns a marginal SOH status for Channel 2B.

Sometimes a channel's capability-based SOH status can be further rolled up by another operator. This is the case for Channel 1B, which applies another Worst-Of operator to the returned SOH statuses from Best-Of (good SOH status) and Worst-Of (marginal SOH status) operators, before returning a marginal SOH status. 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 (good) and 2B (marginal) resulting in a marginal capability-based SOH status for Station 2.

The capability-based SOH status rollup is repeated for each station until every station has a capability-based SOH status. The rollup operators are applied to all stations until a station group capability-based SOH status is obtained. In Figure 53, 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 53, 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 54, left). Depending on the display width, the user may need to click a double-arrow symbol to view the Last Updated timestamp. This double-arrow symbol will also turn red to indicate no data are being received(Figure 54, right).
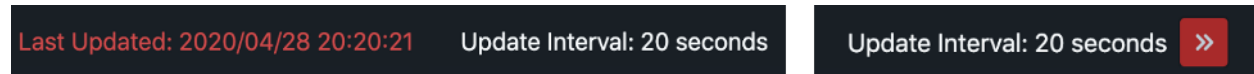

Figure 54. Red Last Updated Time Stamp (Left) and Double Arrow Symbol (Right).

Currently, users may run into performance issues if more than 24 hours duration worth of data are requested for viewing in the historical trend displays (Sections 5.4.2, 5.4.4, 5.4.6).

Appendix A.   List of Environmental Issues

This 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-based 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

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

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