



# Air Force Space Command Space and Missiles Systems Center (AFSPC/SMC)

Space Enterprise User Experience Design System (UXDS)

Design Guidance And Specifications For Telemetry, Tracking, and Command (TT&C) Service

March 29, 2019

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# Overview

## Overview

The newly designed TT&C application suite is designed to support ground-to-satellite communication to include transmitting commands, monitoring constellations and maintaining the health of spacecraft. There are three tiers of capability upon which the TT&C applications are built:

### **Monitor**

Allows the operator to monitor status, alerts, health and function of an individual satellite and satellite constellations.

### **Command**

Allows the operator to send and receive streams of data to and from a spacecraft using a set of commands, often referred to as a pass plan.

### **Investigate**

Allows the operator to investigate spacecraft alerts and anomalies and analyze subsystem mnemonics, measurements, limits, etc.

## Overview - User & Use Case

A common use case and user roles were identified in order to understand and organize TT&C system requirements, as well as to ensure that users can effectively and efficiently accomplish task requirements within their respective roles.

### Users

The intended users of the TT&C application suite are operators whose roles can range from entry-level to more advanced engineer-level roles. The primary tasks an operator performs include commanding a pass, monitoring constellation health, and investigating alerts and anomalies.

### Use Case

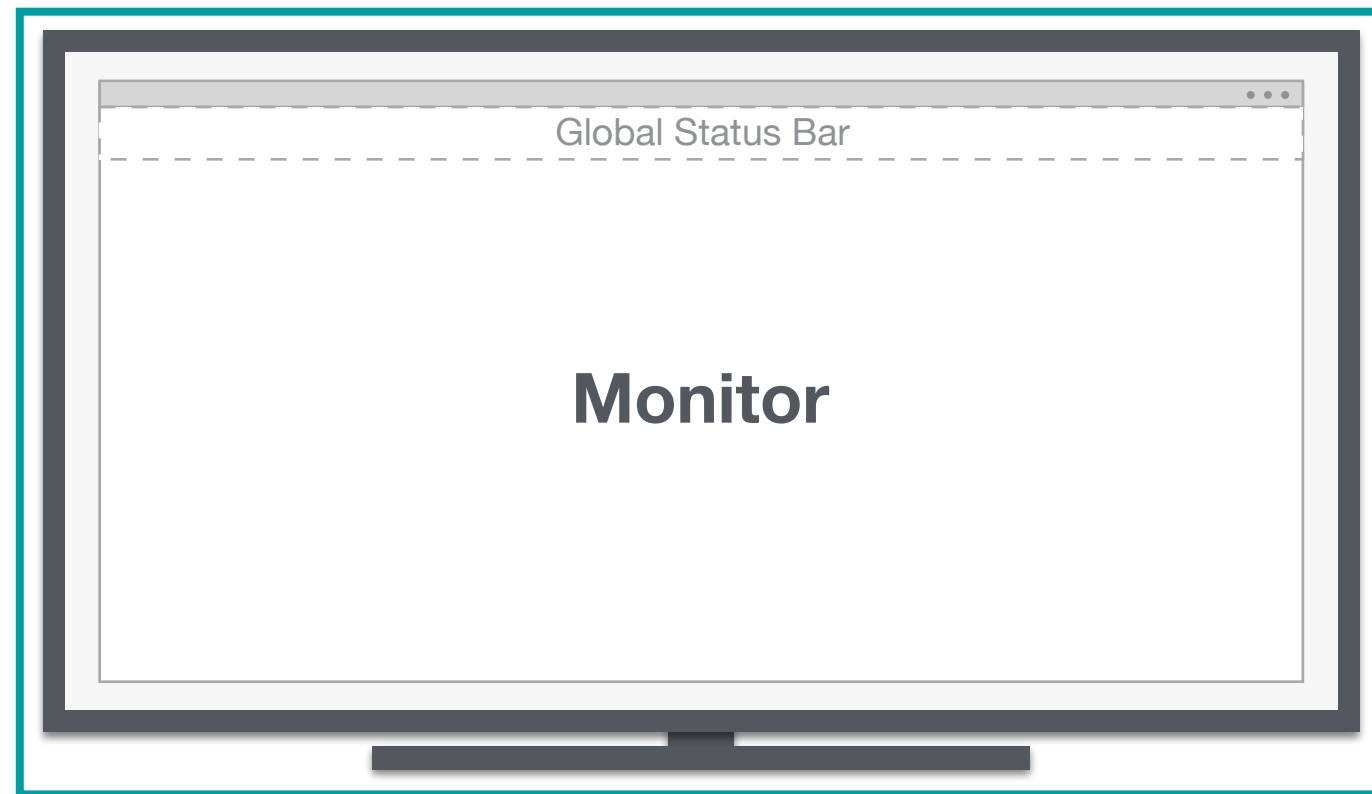
The use case that helped to identify TT&C system requirements was centered around the common operator task of investigating and resolving an alert that occurs during the execution of a pass plan.

## Overview - Information Architecture

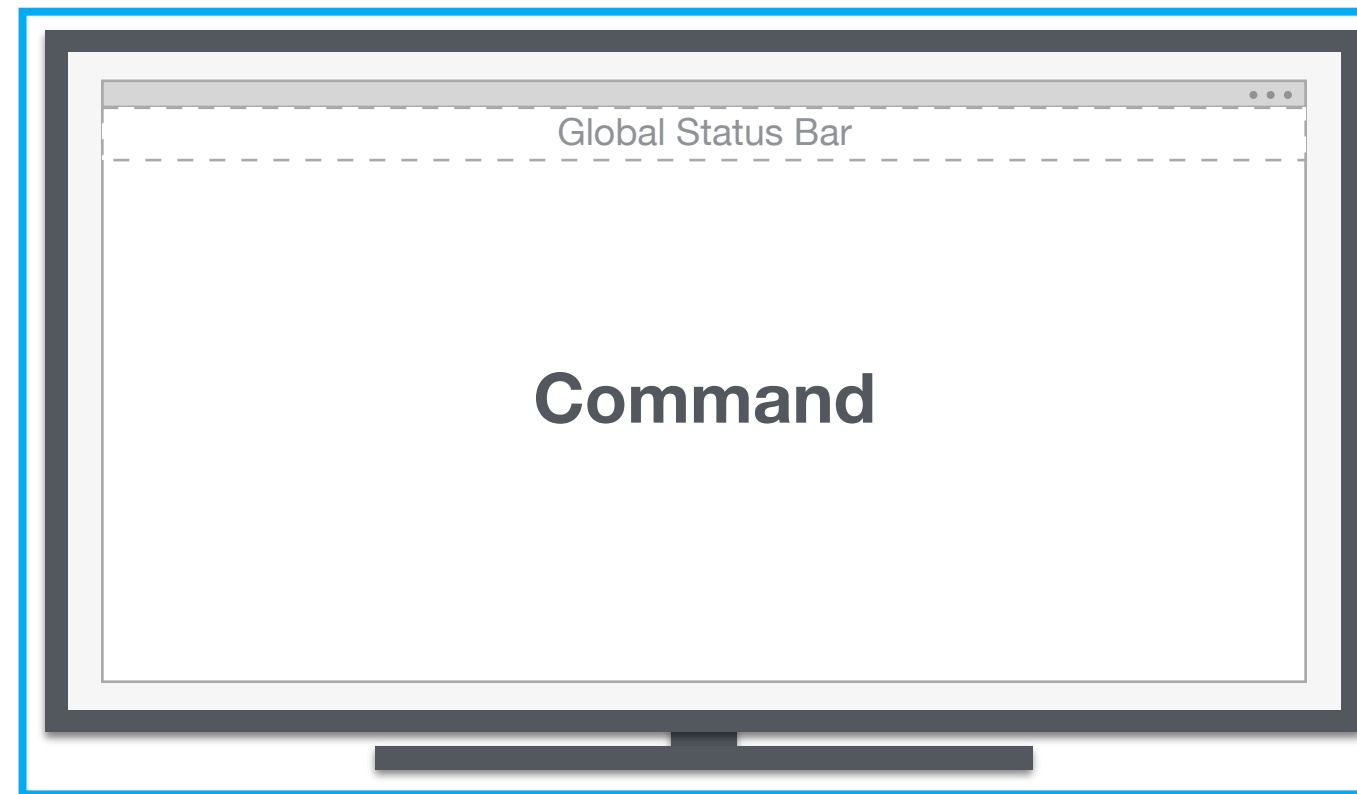
Information has been organized across the TT&C applications based on system requirements and user and use case discoveries. The applications have several interdependencies that provide users better, more efficient usability.

Command	Monitor	Investigate
Global Status Bar		
Contextual Alerts	System-Wide Alerts	Subsystems
Command Line	Constellation	Assembly Schematics
System Health	Watcher	Subsystem Details
Subsystems		
Contextual Watcher		

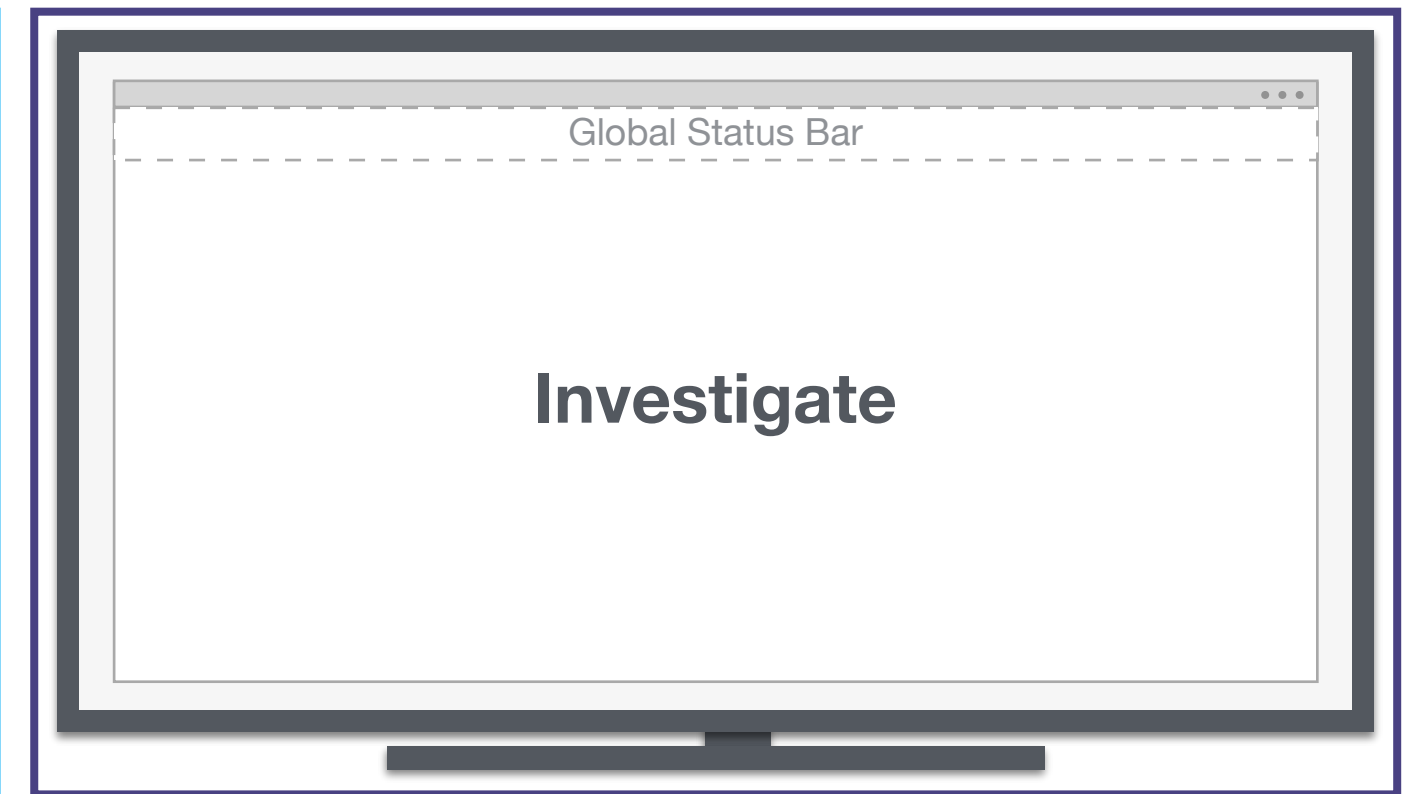
## Overview - Application Suite Paradigm (Multi-Display Setup)



The **Monitor Application** can be launched from the App Switcher Menu and is intended to open at all times.

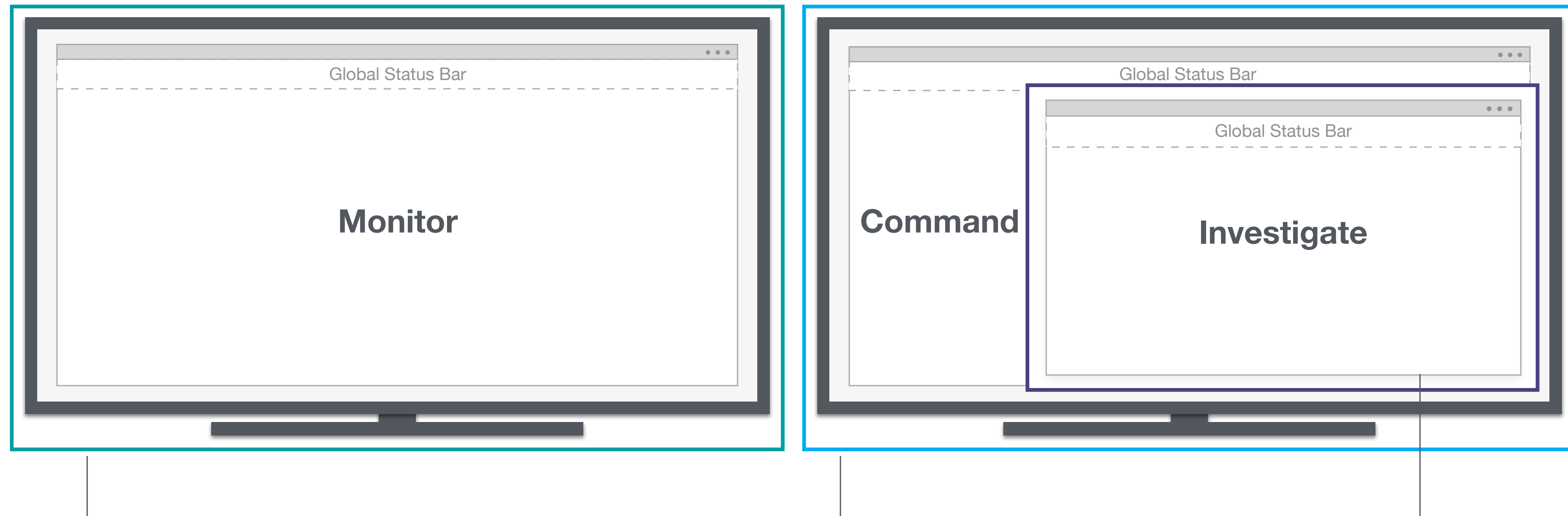


The **Investigate Application** can be launched from the App Switcher Menu as well as from components within the Monitor and Command Applications. Multiple instances of the application can be open at once and would launch in new browser windows.



The **Command Application** can be launched from the App Switcher Menu as well as from components within the Monitor Application. Multiple instances of the application can be open at once and would launch in new browser windows.

## Overview - Application Suite Paradigm (Dual-Display Setup)



The **Monitor Application** can be launched from the App Switcher Menu and is intended to open at all times.

The **Command Application** can be launched from the App Switcher Menu as well as from components within the Monitor Application. Multiple instances of the application can be open at once and would launch in new browser windows.

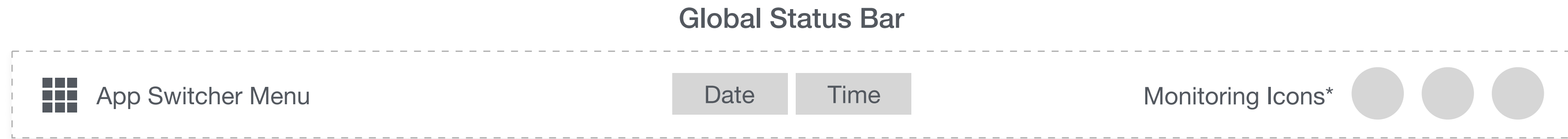
The **Investigate Application** can be launched from the App Switcher Menu as well as from components within the Monitor and Command Applications. Multiple instances of the application can be open at once and would launch in new browser windows.

# Global Components

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## Global Components - Global Status Bar

The Global Status Bar is a full width view across the top of all of the TT&C applications — an area commonly reserved for global status, global command and top-level navigation. The Global Status Bar includes: Application Name, Top Level Navigation, Date & Time, and Monitoring Icons. See the [Astro UXDS guidelines](#) to learn more about the Global Status Bar.



The App Switcher Menu allows the user to launch new instances of different apps, log in/log out, and edit preferences.

The App Name appears directly to the right of the menu.

Date (DOY) and Time (UTC) appear here across all apps.

Monitoring Icons display the highest level of consolidated data along categories specific to each App. Each Monitoring Icon displays a color associated with the status level and a badge to indicate the number of alerts.

*\*Usage and functionality for TT&C Monitoring Icons is to be determined.*



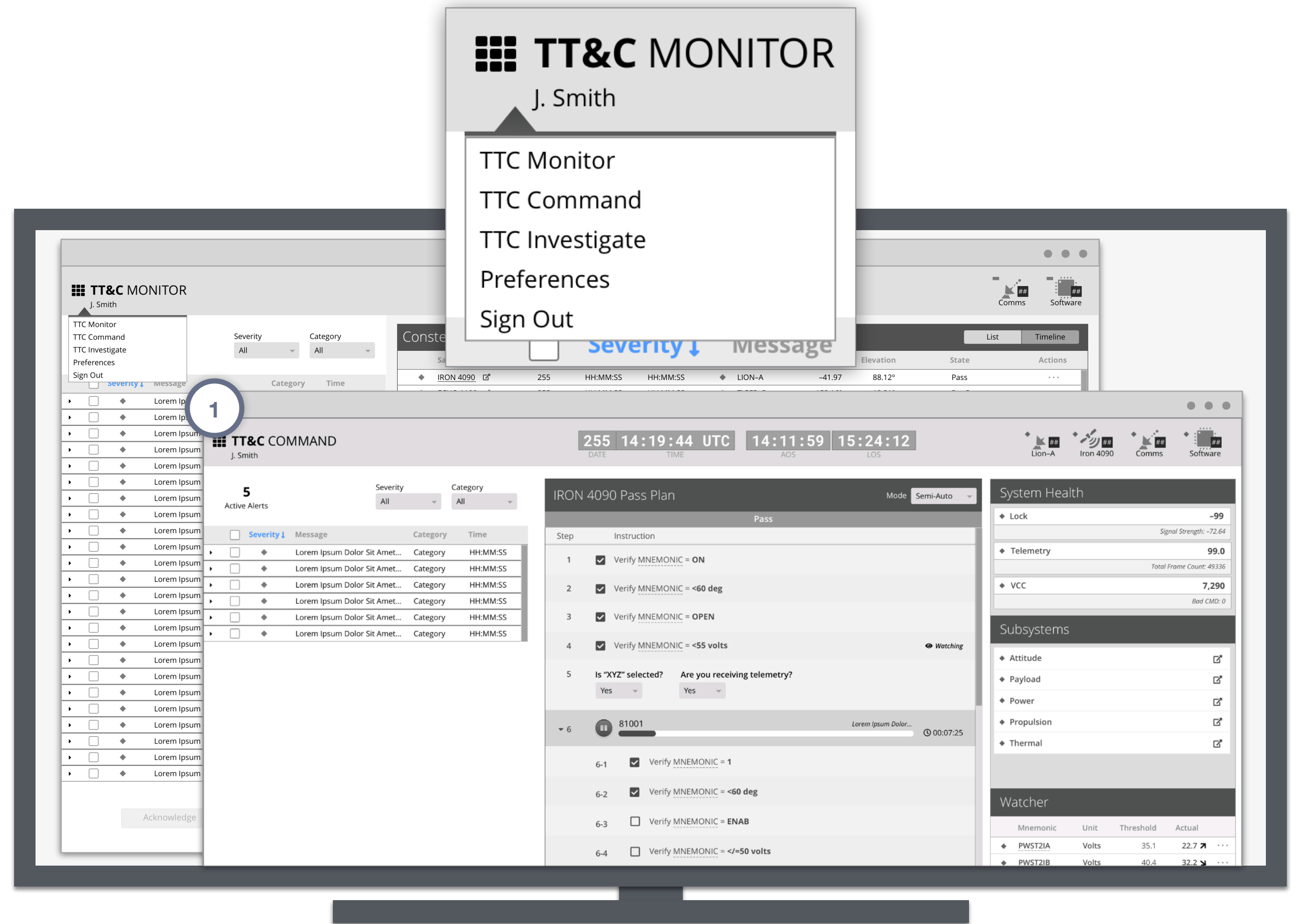
# Global Components - App Switcher Menu (Launching Applications)

## Functionality

The App Switcher Menu allows the user to launch new instances of different TT&C applications, sign in/sign out of the application suite, and edit preferences.

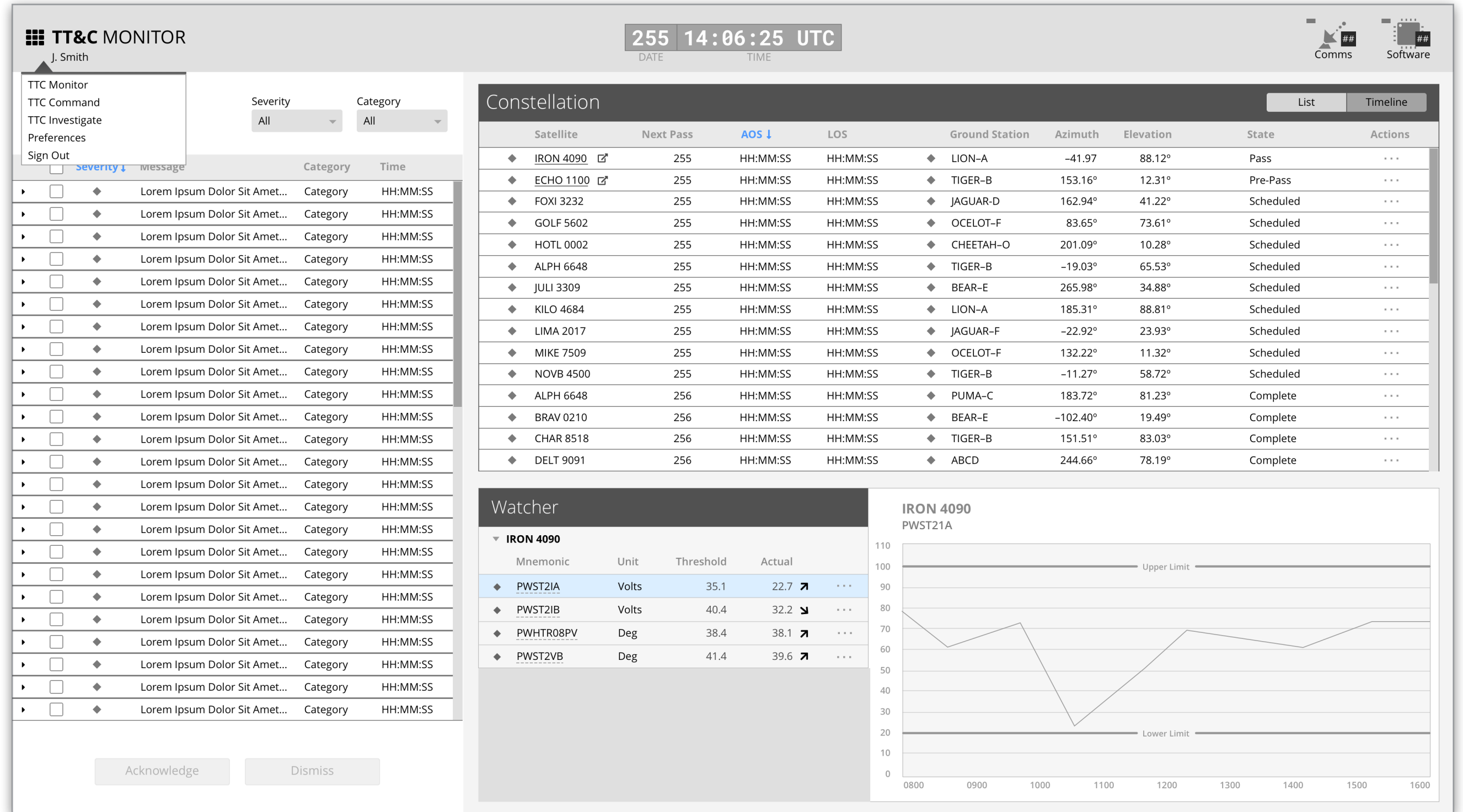
## Features & Interactions

1. Clicking an application in the App Switcher Menu, launches an instance of the application in a new browser window.



# Global Components - App Switcher Menu (Sign In/Sign Out)

Operators can sign in or out of the TT&C Application Suite through the App Switcher Menu, which is accessible in every application/screen by clicking the App Switcher Menu icon in the top left corner.



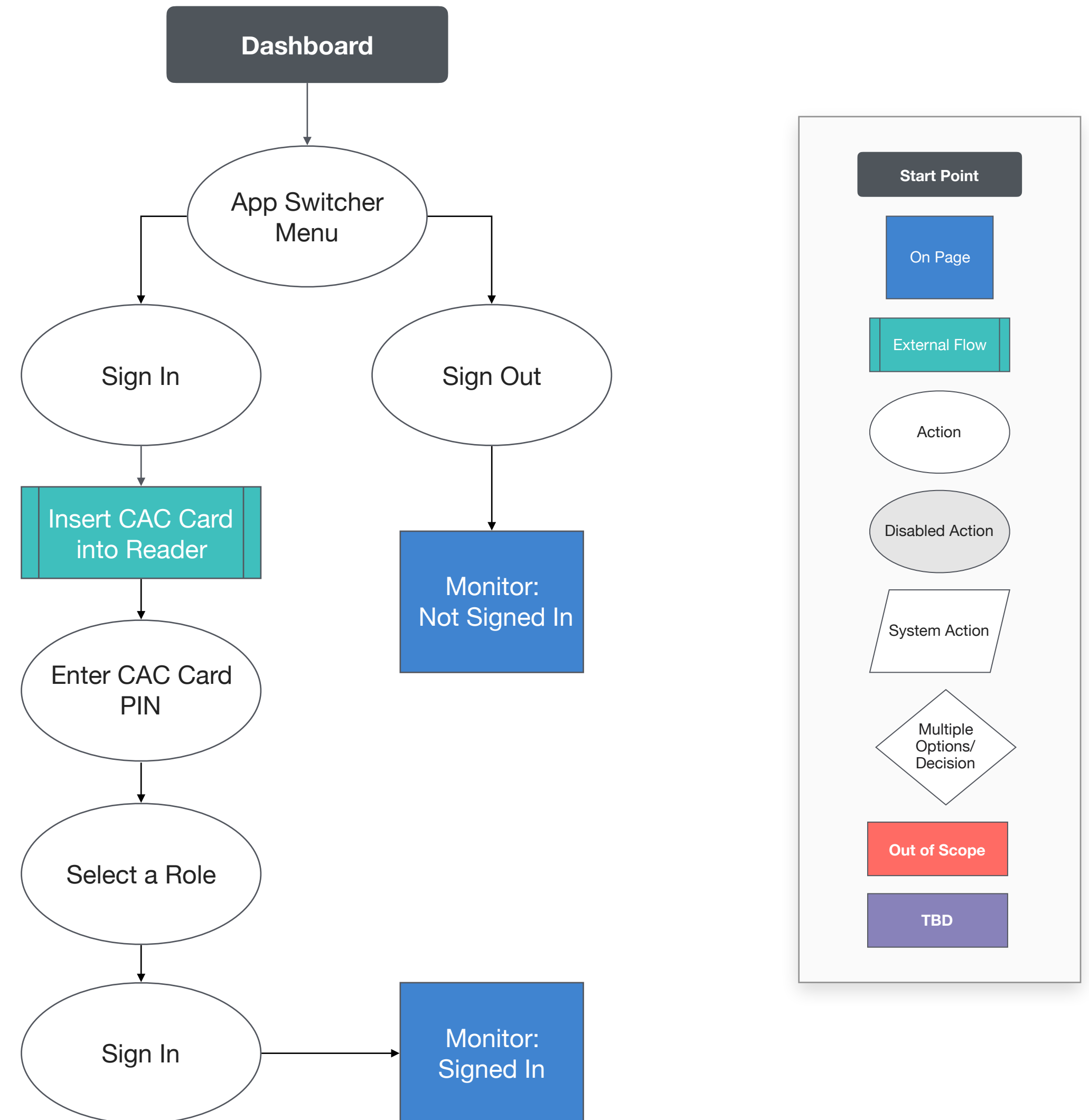
The screenshot displays the TT&C MONITOR interface. At the top, it shows the user 'J. Smith' and the current date and time '255 14:06:25 UTC'. A dropdown menu is open, listing options: TTC Monitor, TTC Command, TTC Investigate, Preferences, and Sign Out. Below the menu is a table of messages with columns for Severity, Category, and Time. To the right, the 'Constellation' table lists various satellites and their ground stations. Below that, the 'Watcher' section shows a table of monitored parameters for the 'IRON 4090' satellite, including voltage and temperature readings. A line graph on the right shows the 'IRON 4090 PWST21A' parameter over time, with upper and lower limits indicated.

Satellite	Next Pass	AOS ↓	LOS	Ground Station	Azimuth	Elevation	State	Actions
IRON 4090	255	HH:MM:SS	HH:MM:SS	LION-A	-41.97	88.12°	Pass	...
ECHO 1100	255	HH:MM:SS	HH:MM:SS	TIGER-B	153.16°	12.31°	Pre-Pass	...
FOXI 3232	255	HH:MM:SS	HH:MM:SS	JAGUAR-D	162.94°	41.22°	Scheduled	...
GOLF 5602	255	HH:MM:SS	HH:MM:SS	OCELOT-F	83.65°	73.61°	Scheduled	...
HOTL 0002	255	HH:MM:SS	HH:MM:SS	CHEETAH-O	201.09°	10.28°	Scheduled	...
ALPH 6648	255	HH:MM:SS	HH:MM:SS	TIGER-B	-19.03°	65.53°	Scheduled	...
JULI 3309	255	HH:MM:SS	HH:MM:SS	BEAR-E	265.98°	34.88°	Scheduled	...
KILO 4684	255	HH:MM:SS	HH:MM:SS	LION-A	185.31°	88.81°	Scheduled	...
LIMA 2017	255	HH:MM:SS	HH:MM:SS	JAGUAR-F	-22.92°	23.93°	Scheduled	...
MIKE 7509	255	HH:MM:SS	HH:MM:SS	OCELOT-F	132.22°	11.32°	Scheduled	...
NOVB 4500	255	HH:MM:SS	HH:MM:SS	TIGER-B	-11.27°	58.72°	Scheduled	...
ALPH 6648	256	HH:MM:SS	HH:MM:SS	PUMA-C	183.72°	81.23°	Complete	...
BRAV 0210	256	HH:MM:SS	HH:MM:SS	BEAR-E	-102.40°	19.49°	Complete	...
CHAR 8518	256	HH:MM:SS	HH:MM:SS	TIGER-B	151.51°	83.03°	Complete	...
DELT 9091	256	HH:MM:SS	HH:MM:SS	ABCD	244.66°	78.19°	Complete	...

Mnemonic	Unit	Threshold	Actual	...
PWST21A	Volts	35.1	22.7	...
PWST21B	Volts	40.4	32.2	...
PWHTR08PV	Deg	38.4	38.1	...
PWST2VB	Deg	41.4	39.6	...

# Global Components - Sign In/Out Flow

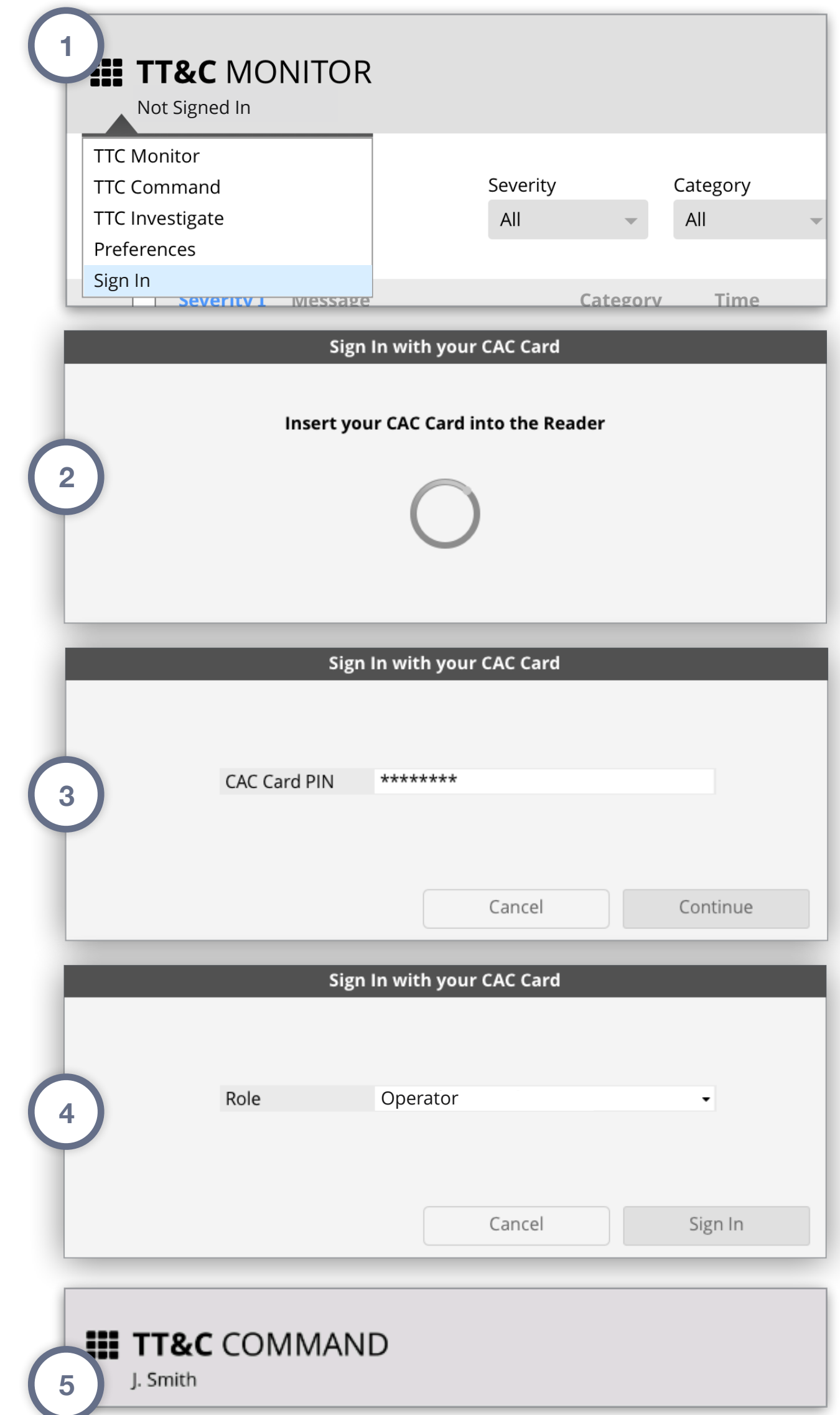
This user flow shows the content and actions involved in signing in or out of the TT&C Application Suite. This flow is available to operators in any of the three TT&C applications via the App Switcher Menu.



# Global Components - Sign In Flow Steps

## Steps

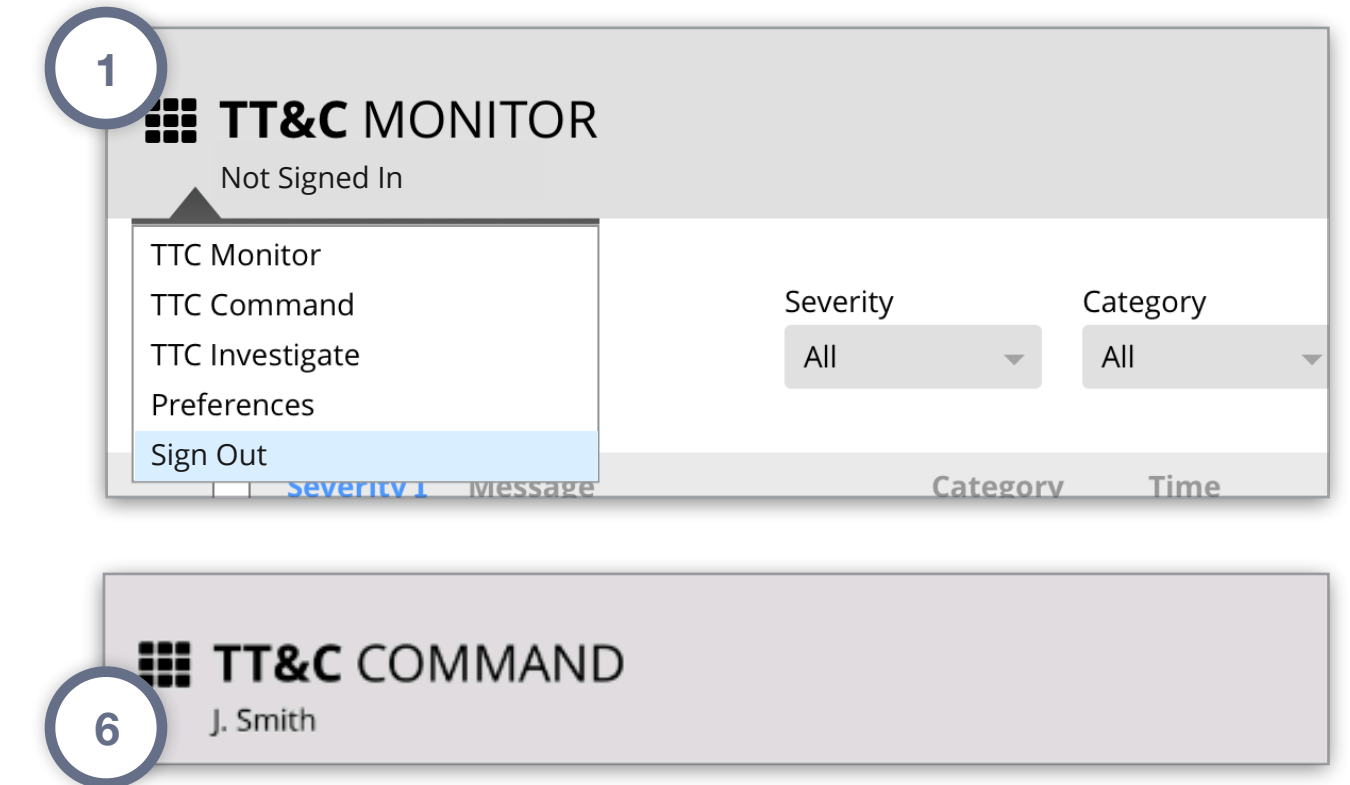
1. Click the App Switcher Menu icon, then click “Sign In”.
2. Insert a CAC Card into the Reader (external to the TT&C Application Suite).
3. Enter a CAC Card PIN.
4. Select role, then click “Sign In”.
5. The operator name appears below the application title, indicating that they are signed in.



# Global Components - Sign Out Flow Steps

## Steps

1. Click the App Switcher Menu icon, then click “Sign Out”.
2. The operator name under the application title changes to “Not Signed In”.



*TT&C Wireframes.pdf, page 2*

# Monitor

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# Monitor - Alerts



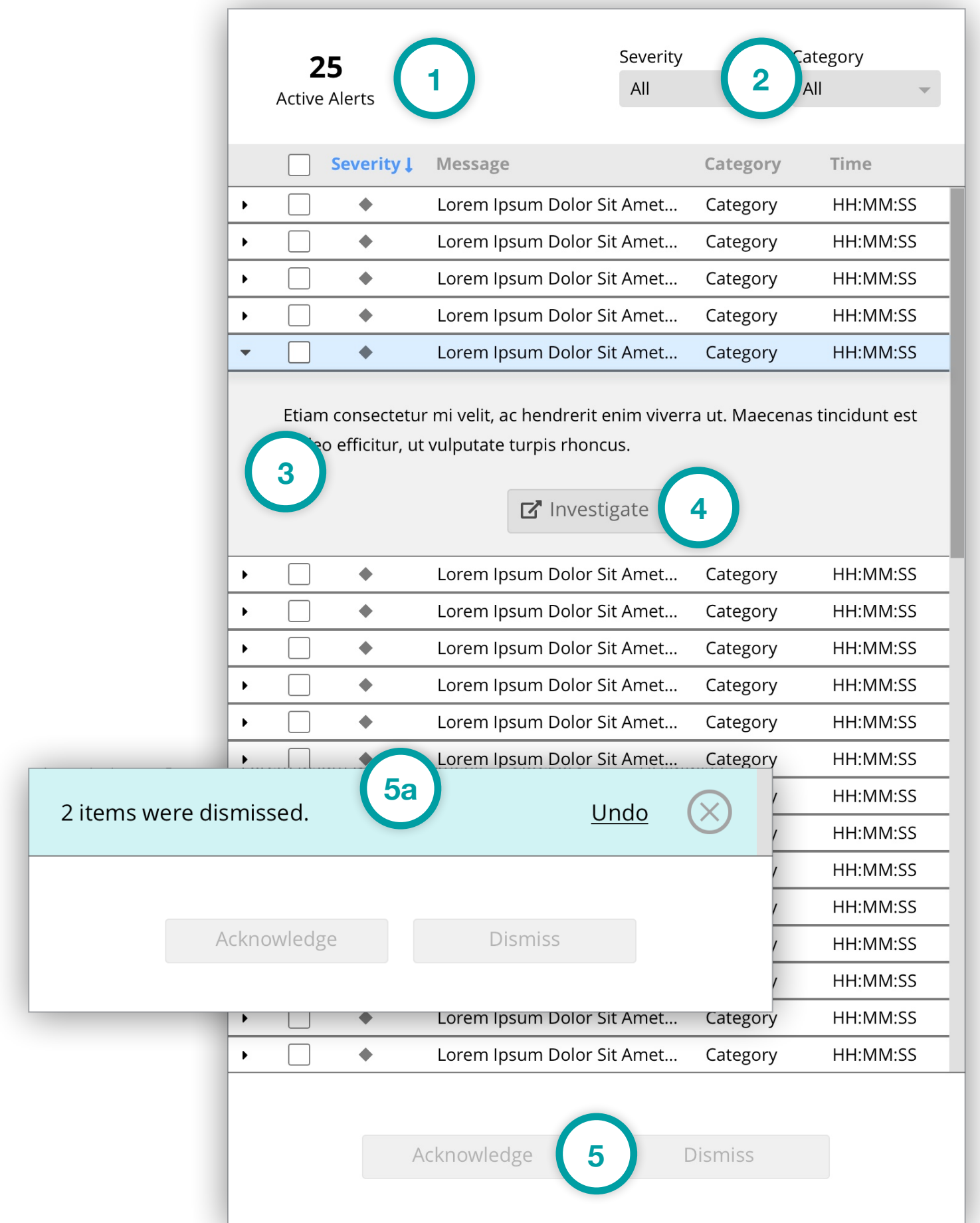
## Functionality

The Alerts component houses a roll-up of system-wide alerts — including software, communications, ground and spacecraft alerts.

## Features & Interactions

1. **Active Alert Aggregate Number**  
Shows number of active alerts.
2. **Filter Drop-downs**  
Filters alert list by Severity (All, Critical, Caution, Serious) and Category (All, Communications, Ground, Software, and Spacecraft).
3. **Expandable List Items**  
Expands to show alert details and Investigate Button, if applicable.
4. **Investigate Button**  
Launches an instance of the Investigate Application.
5. **Acknowledge/Dismiss Button\***  
Acknowledges or dismisses alerts.
  - a. Dismissed alerts can be undone and added back to the queue.

*\*Further functionality to be determined.*



TT&C Wireframes.pdf, page 2



# Monitor - Constellation List View



## Functionality

The list view of the Constellation component gives an overview of spacecraft status — including, but not limited to contextual details like next pass, ground station and AOS LOS, azimuth, elevation and current state (Pass, Pre-Pass, Scheduled, Complete).

## Features & Interactions

### 1. Status Symbols

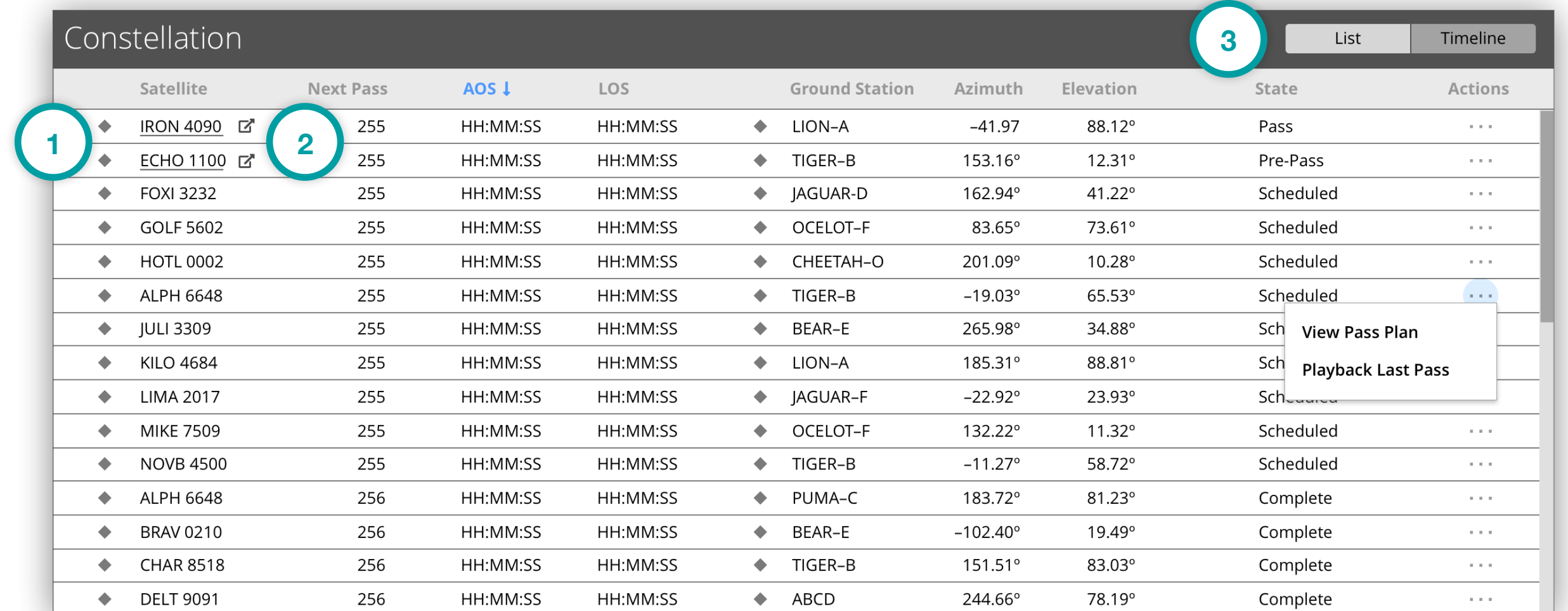
Indicates current status and severity.

### 2. Command Quick Launch

Launches an instance of the Command Application for spacecrafts in an active or upcoming pass state. This interaction is indicated by the solid underline and external link icon.

### 3. View Switch

Switches between List and Timeline views.

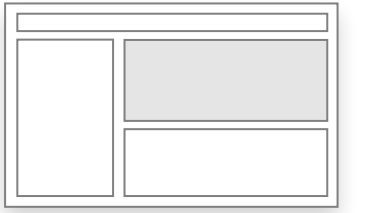


Constellation									
3 List Timeline									
1	Satellite	Next Pass	AOS ↓	LOS	Ground Station	Azimuth	Elevation	State	Actions
◆	<u>IRON 4090</u> ↗	255	HH:MM:SS	HH:MM:SS	◆ LION-A	-41.97	88.12°	Pass	...
◆	<u>ECHO 1100</u> ↗	255	HH:MM:SS	HH:MM:SS	◆ TIGER-B	153.16°	12.31°	Pre-Pass	...
◆	FOXI 3232	255	HH:MM:SS	HH:MM:SS	◆ JAGUAR-D	162.94°	41.22°	Scheduled	...
◆	GOLF 5602	255	HH:MM:SS	HH:MM:SS	◆ OCELOT-F	83.65°	73.61°	Scheduled	...
◆	HOTL 0002	255	HH:MM:SS	HH:MM:SS	◆ CHEETAH-O	201.09°	10.28°	Scheduled	...
◆	ALPH 6648	255	HH:MM:SS	HH:MM:SS	◆ TIGER-B	-19.03°	65.53°	Scheduled	...
◆	JULI 3309	255	HH:MM:SS	HH:MM:SS	◆ BEAR-E	265.98°	34.88°	Scheduled	...
◆	KILO 4684	255	HH:MM:SS	HH:MM:SS	◆ LION-A	185.31°	88.81°	Scheduled	...
◆	LIMA 2017	255	HH:MM:SS	HH:MM:SS	◆ JAGUAR-F	-22.92°	23.93°	Scheduled	...
◆	MIKE 7509	255	HH:MM:SS	HH:MM:SS	◆ OCELOT-F	132.22°	11.32°	Scheduled	...
◆	NOVB 4500	255	HH:MM:SS	HH:MM:SS	◆ TIGER-B	-11.27°	58.72°	Scheduled	...
◆	ALPH 6648	256	HH:MM:SS	HH:MM:SS	◆ PUMA-C	183.72°	81.23°	Complete	...
◆	BRAV 0210	256	HH:MM:SS	HH:MM:SS	◆ BEAR-E	-102.40°	19.49°	Complete	...
◆	CHAR 8518	256	HH:MM:SS	HH:MM:SS	◆ TIGER-B	151.51°	83.03°	Complete	...
◆	DELT 9091	256	HH:MM:SS	HH:MM:SS	◆ ABCD	244.66°	78.19°	Complete	...

TT&C Wireframes.pdf, page 2



# Monitor - Constellation Timeline View

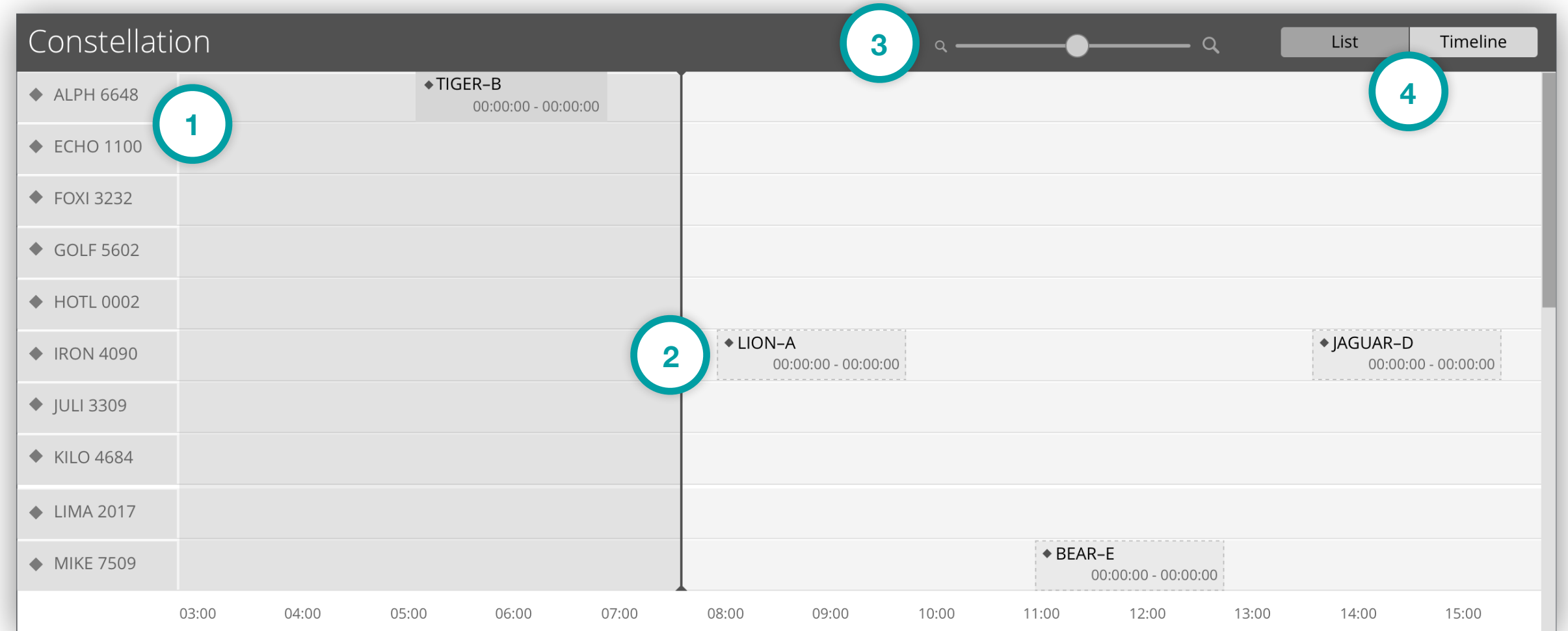


## Functionality

The timeline view of the Constellation component shows a schedule of contacts for the constellation.

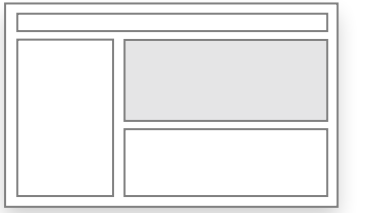
## Features & Interactions

1. **Spacecraft Names & Status Symbols**  
Indicates spacecraft and current status and severity.
2. **Time Blocks**  
Shows contact/pass duration and respective ground station and ground station status. Clicking a time block also launches the Contact Details Slide-In Pane (see next page) where you can view contact details.
3. **Zoom Tool**  
Zooms in and out of the timeline, magnifying the time blocks and stretching and the space between time increments.
4. **View Switch**  
Switches between List and Timeline views.



*TT&C Wireframes.pdf, page 12*

# Monitor - Contact Details Slide-In Pane



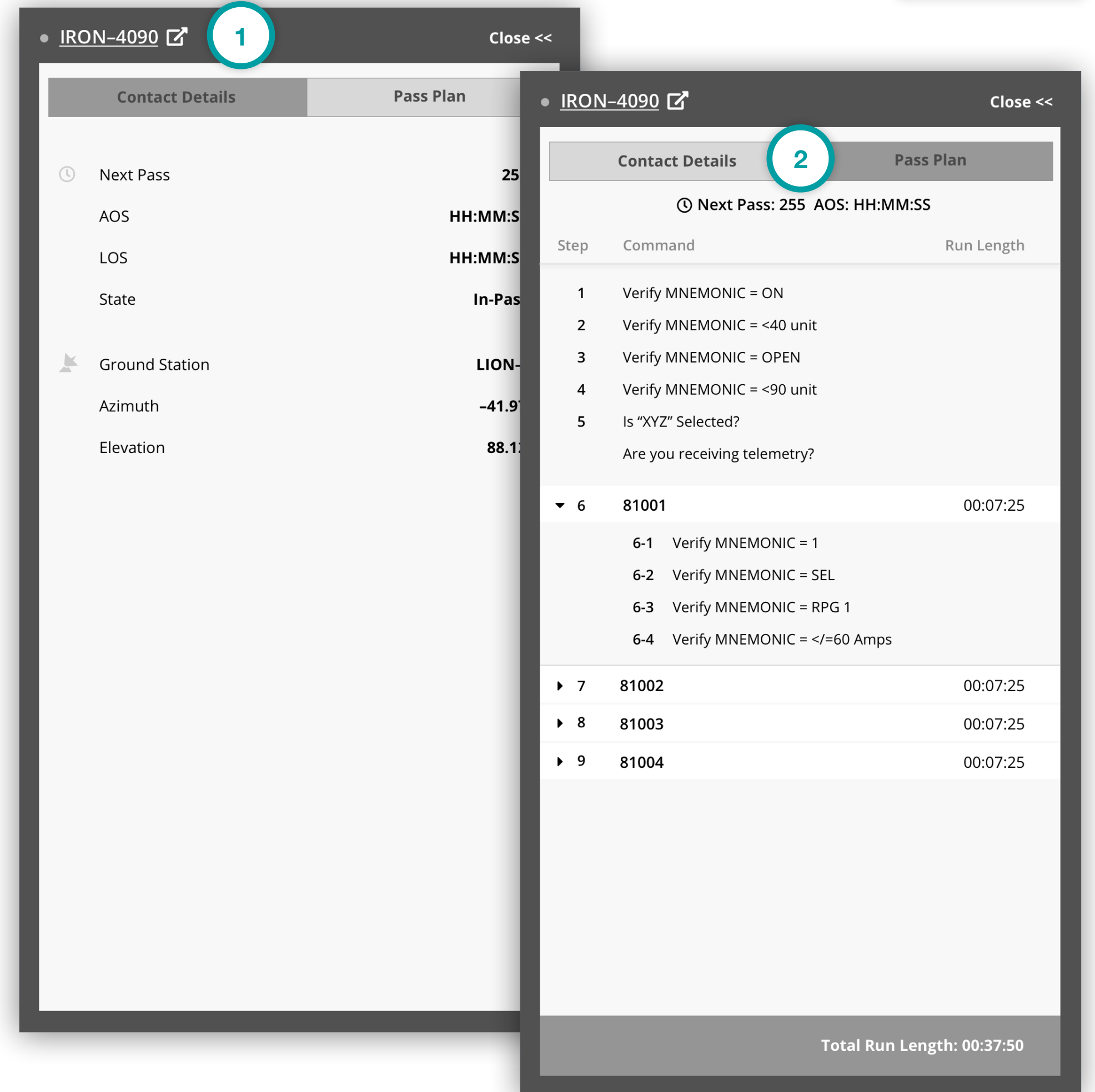
## Functionality

The Contact Details Slide-In Pane allows the operator to view contact details for a spacecraft — including but not limited to next pass time, AOS/LOS, state of contact as well as ground station details like name, azimuth and elevation.

The operator can also view the pass plan for the spacecraft’s current/upcoming pass which includes but is not limited to details like AOS commands, steps, and run lengths.

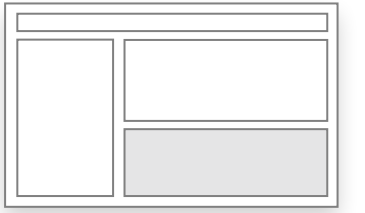
## Features & Interactions

1. **Command Quick Launch**  
Launches related Command Application Window.
2. **View Switch**  
Switches between Contact Details and Pass Plan views.



TT&C Wireframes.pdf, pages 14 & 15

# Monitor - Watcher\*



## Functionality

The Watcher component allows the operator to flag and watch specific telemetry trends over time such as changes in battery levels and other mnemonic values. Mnemonics are monitored for actual value in relation to the assigned value threshold.

*\*Further functionality of the Watcher to be determined.*

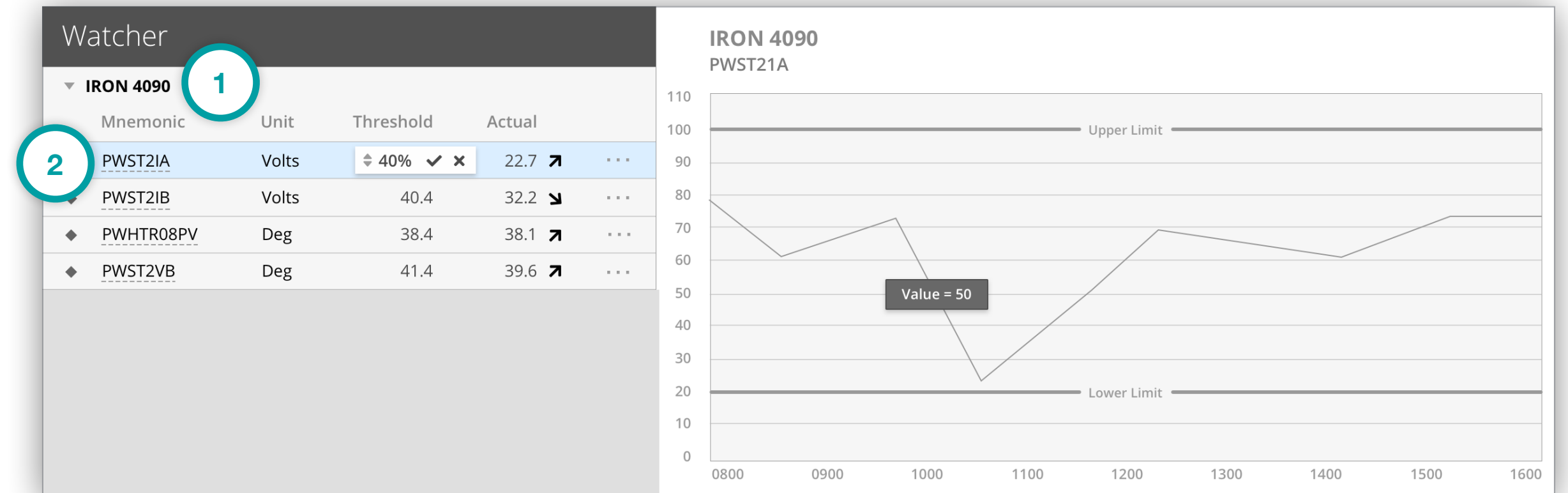
## Features & Interactions

### 1. Collapsible Item List

Items in the watcher are categorized by spacecraft and can be collapsed or expanded to show the subsequent list of mnemonics being monitored.

### 2. Mnemonics

*Hovering* over a mnemonic value shows the longhand version of its name. This interaction is indicated by the dashed underline. *Clicking* a mnemonic/watcher item changes the graph on the right to reflect how the values have trended over time.



TT&C Wireframes.pdf, page 2



# Monitor - Watcher (Continued)



## Features & Interactions

### 3. Editable Threshold Value

Threshold can be edited by clicking on the field, setting the desired value and saving changes by clicking the checkmark icon. To clear the custom value from the field, click the “x” icon.

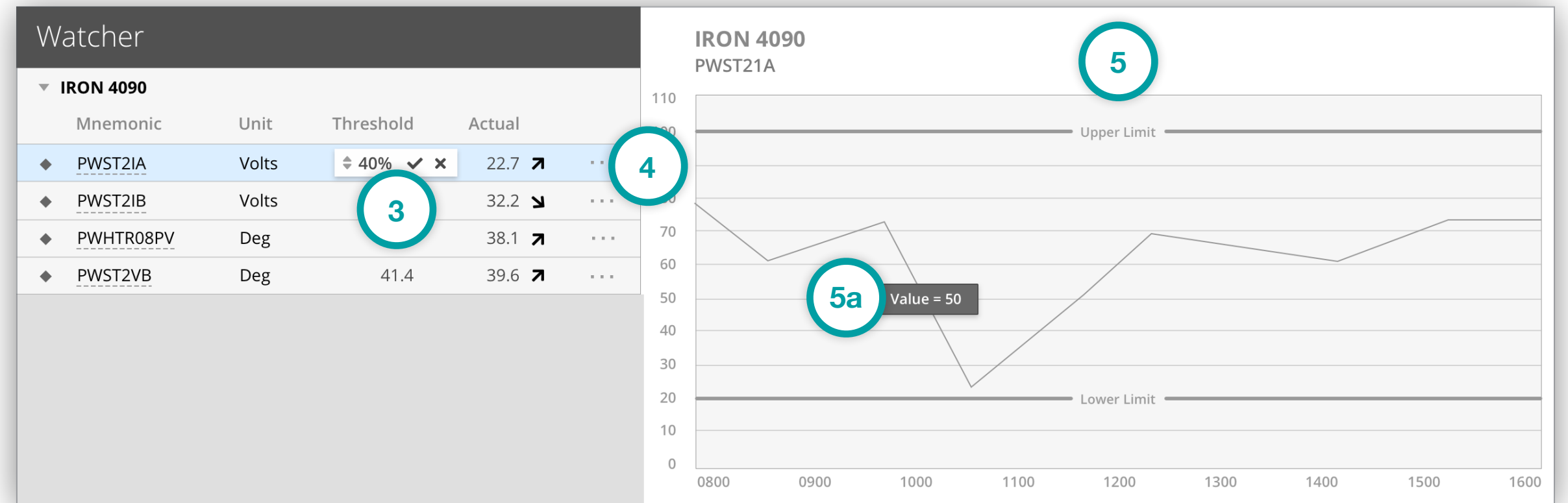
### 4. Action Menu

Allows operator to remove items from the watchlist and/or investigate them in the Investigate application.

### 5. Graph

Show mnemonic value trends over time.

- a. Hovering over the trending line shows the mnemonic value at that specific point in time.



TT&C Wireframes.pdf, page 2

# Command

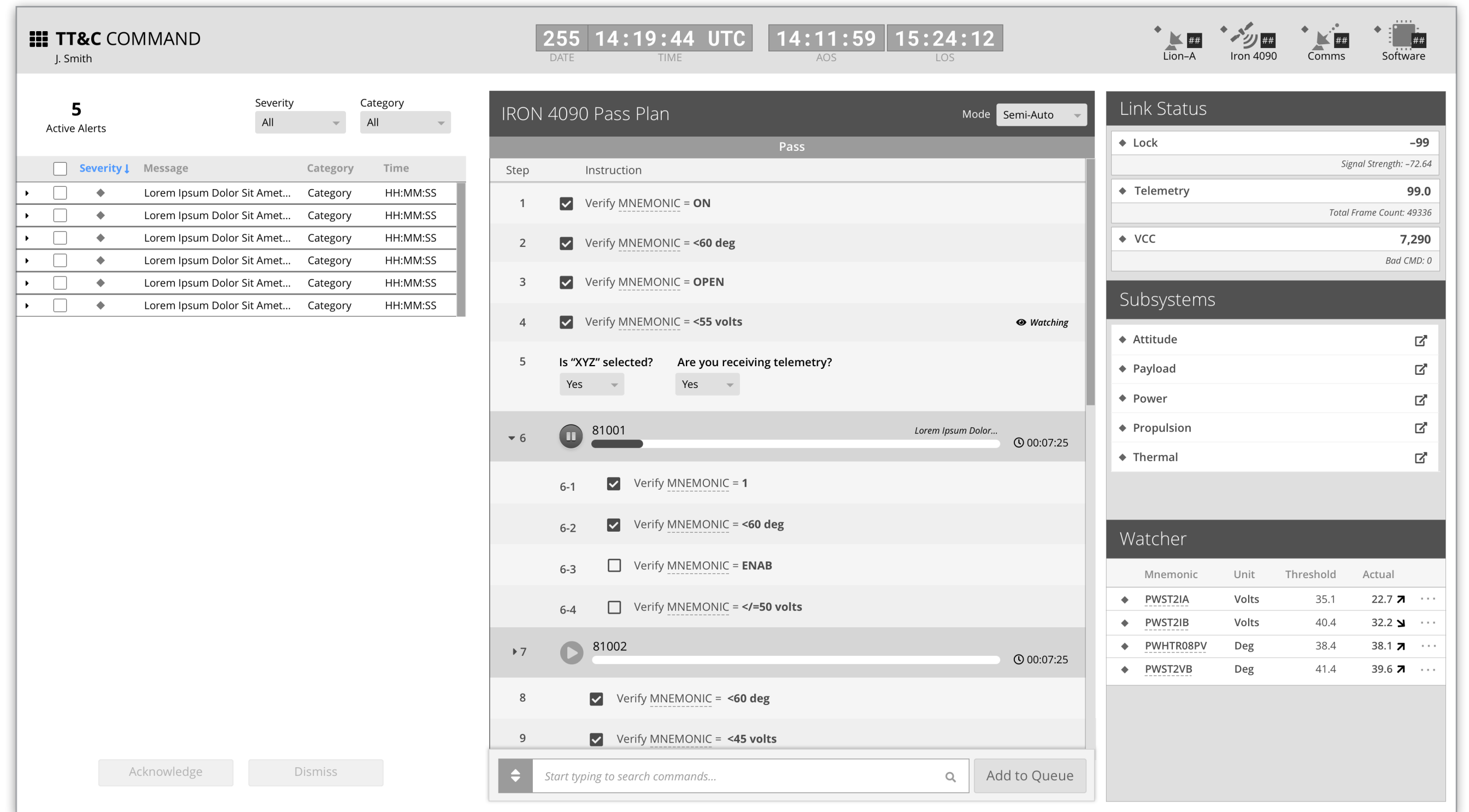
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# Command Overview

The Command Application allows users to maneuver and monitor a spacecraft and its telemetry.

Data roll-ups suggested include: spacecraft specific alerts, Link Status, including Lock and Signal Strength values, Telemetry and Total Frame Count, Vehicle Command Count, Subsystem statuses and contextual watcher items.

These roll ups can be configured by operational needs to determine the highest level of situational data needed to accomplish the mission.



**TT&C COMMAND**  
J. Smith

255 14:19:44 UTC 14:11:59 15:24:12  
DATE TIME AOS LOS

5 Active Alerts

Severity	Message	Category	Time
Severity 1	Message	Category	Time
▶	◆	Lorem Ipsum Dolor Sit Amet...	Category HH:MM:SS
▶	◆	Lorem Ipsum Dolor Sit Amet...	Category HH:MM:SS
▶	◆	Lorem Ipsum Dolor Sit Amet...	Category HH:MM:SS
▶	◆	Lorem Ipsum Dolor Sit Amet...	Category HH:MM:SS
▶	◆	Lorem Ipsum Dolor Sit Amet...	Category HH:MM:SS
▶	◆	Lorem Ipsum Dolor Sit Amet...	Category HH:MM:SS

**IRON 4090 Pass Plan** Mode: Semi-Auto

Step	Instruction
1	Verify MNEMONIC = ON
2	Verify MNEMONIC = <60 deg
3	Verify MNEMONIC = OPEN
4	Verify MNEMONIC = <55 volts <span>Watching</span>
5	Is "XYZ" selected? Are you receiving telemetry? Yes Yes
6	81001 <span>00:07:25</span>
6-1	Verify MNEMONIC = 1
6-2	Verify MNEMONIC = <60 deg
6-3	Verify MNEMONIC = ENAB
6-4	Verify MNEMONIC = <=50 volts
7	81002 <span>00:07:25</span>
8	Verify MNEMONIC = <60 deg
9	Verify MNEMONIC = <45 volts

Acknowledge Dismiss

Start typing to search commands... Add to Queue

**Link Status**

- Lock -99 Signal Strength: -72.64
- Telemetry 99.0 Total Frame Count: 49336
- VCC 7,290 Bad CMD: 0

**Subsystems**

- Attitude
- Payload
- Power
- Propulsion
- Thermal

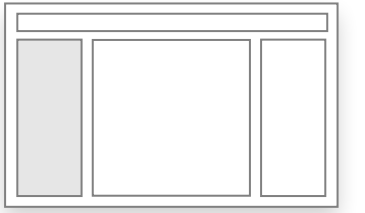
**Watcher**

Mnemonic	Unit	Threshold	Actual
◆ PWST2IA	Volts	35.1	22.7 ↗ ...
◆ PWST2IB	Volts	40.4	32.2 ↘ ...
◆ PWHTR08PV	Deg	38.4	38.1 ↗ ...
◆ PWST2VB	Deg	41.4	39.6 ↗ ...

TT&C Wireframes.pdf, page 18



# Command – Alerts



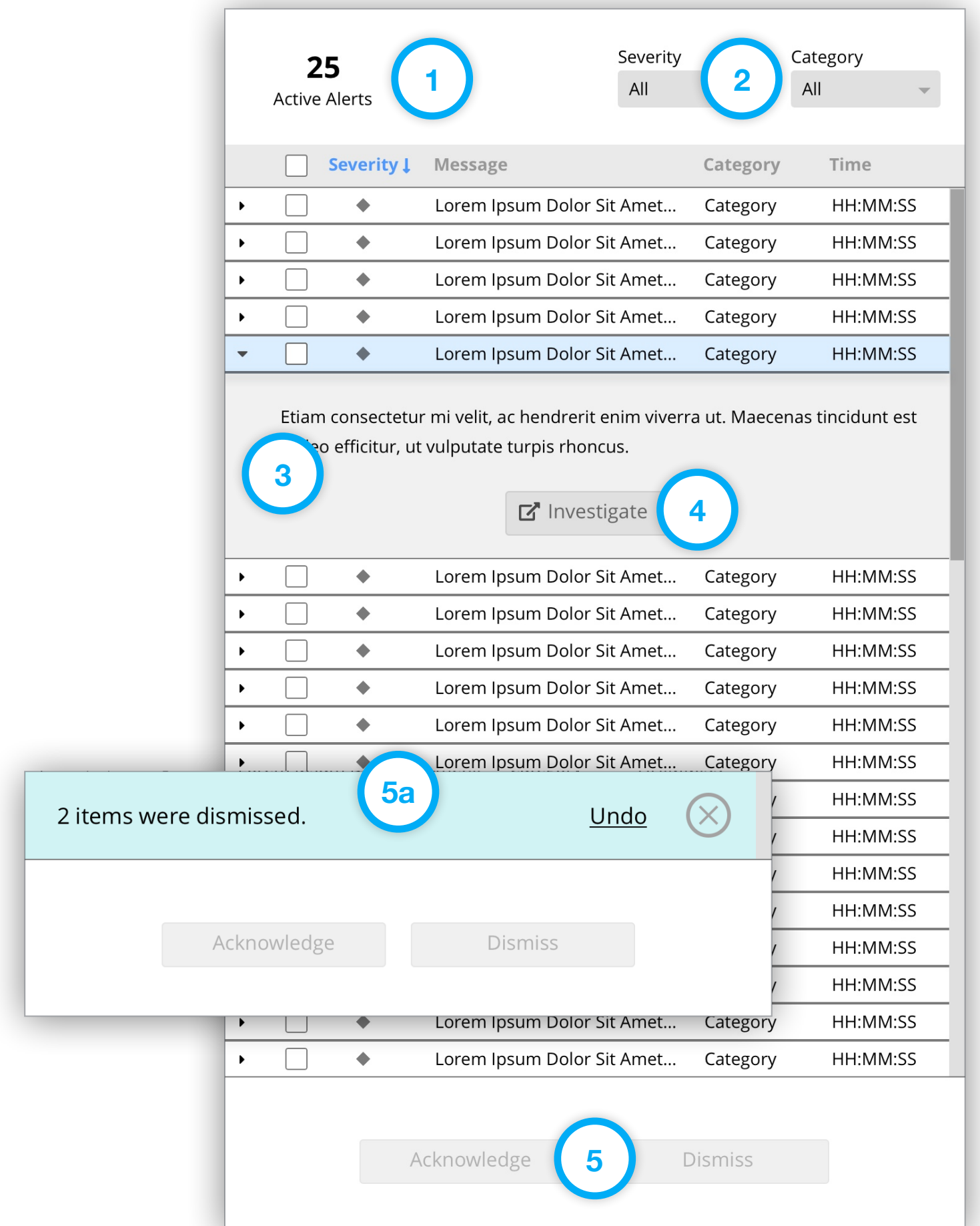
## Functionality

The Alerts component houses a roll-up of spacecraft specific alerts, as well as communications, software, and its assigned ground station.

## Features & Interactions

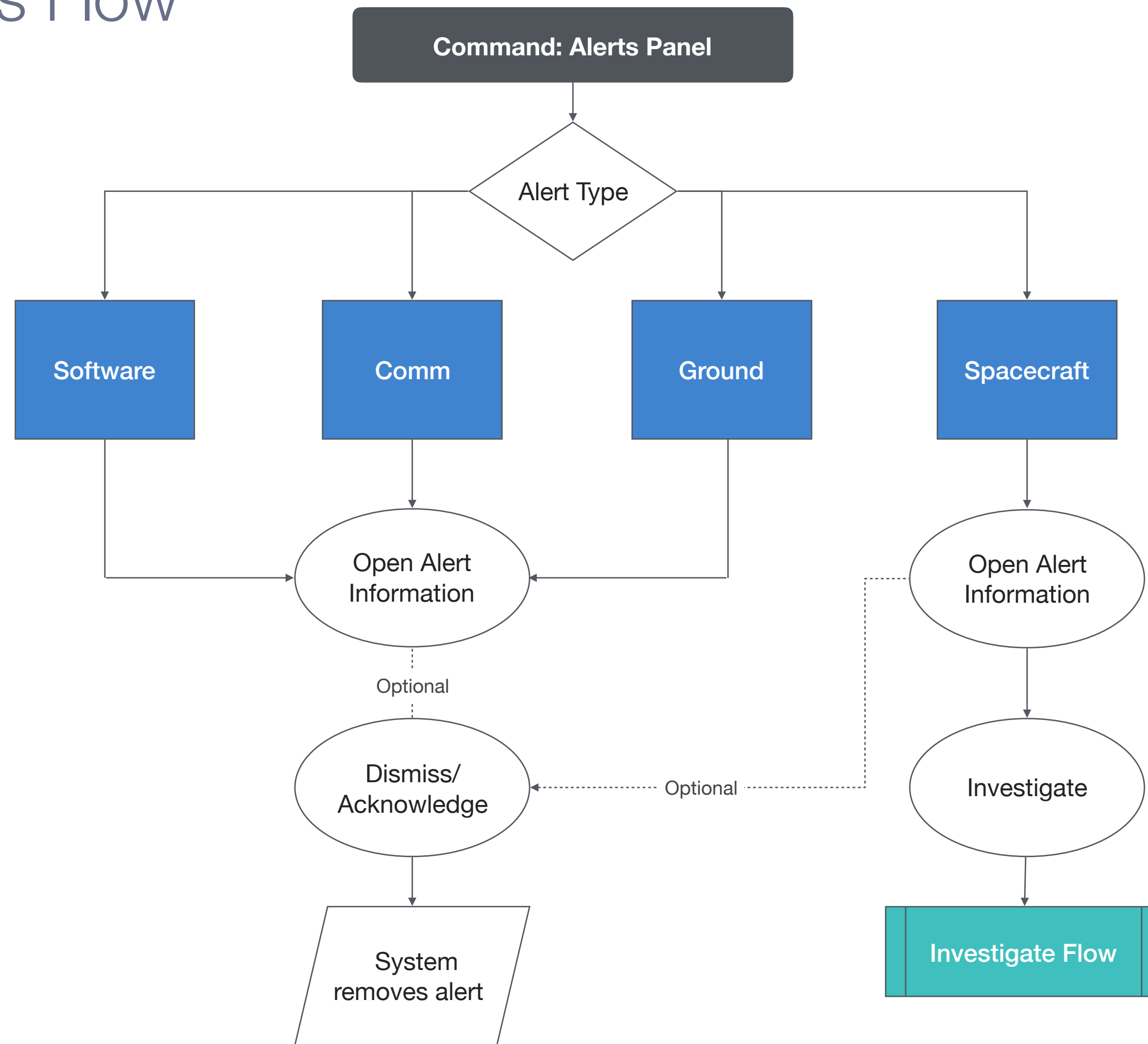
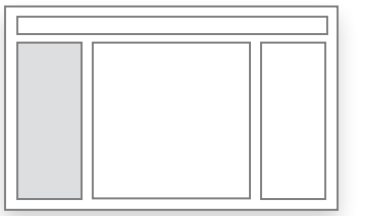
1. **Active Alert Aggregate Number**  
Shows number of active alerts that have not been dismissed.
2. **Filter Drop-downs**  
Filters alert list by severity (All, Critical, Caution, Serious) and category (All, Communications, Ground, Software, and Spacecraft). Categories may be configured from operation to operation.
3. **Expandable List Items**  
Expands to show alert details and Investigate Button, if applicable.
4. **Investigate Button**  
Launches an instance of the Investigate Application.
5. **Acknowledge/Dismiss Button\***  
Acknowledges or dismisses alerts.
  - a. Dismissed alerts can be undone and added back to the queue.

*\*Further functionality to be determined.*

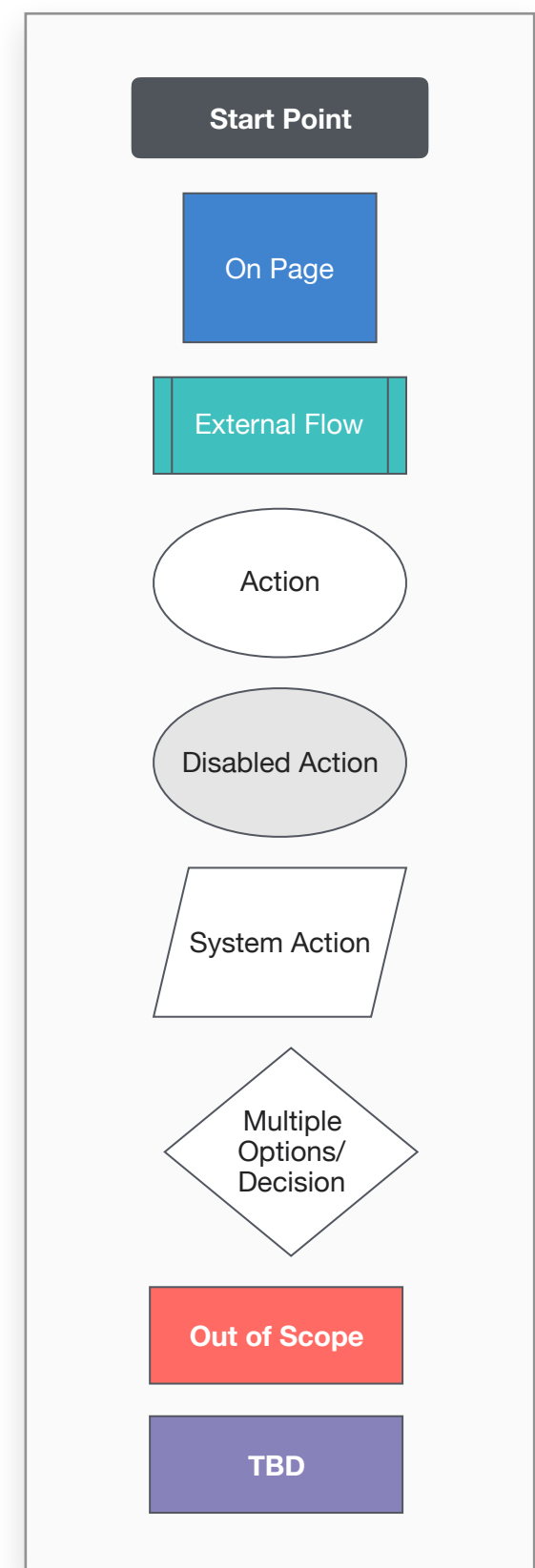


TT&C Wireframes.pdf, page 18

# Command – Alerts Flow



## Key



# Command – Pass Plan

## Functionality

The Pass Plan feature allows a user to verify telemetry values and/or execute instructions, as well as play commands during the duration of a contact.

## Features & Interactions

### 1. Mode\*

Allows users who have access to set the plan to run in Manual, Semi-Auto, or Automated mode.

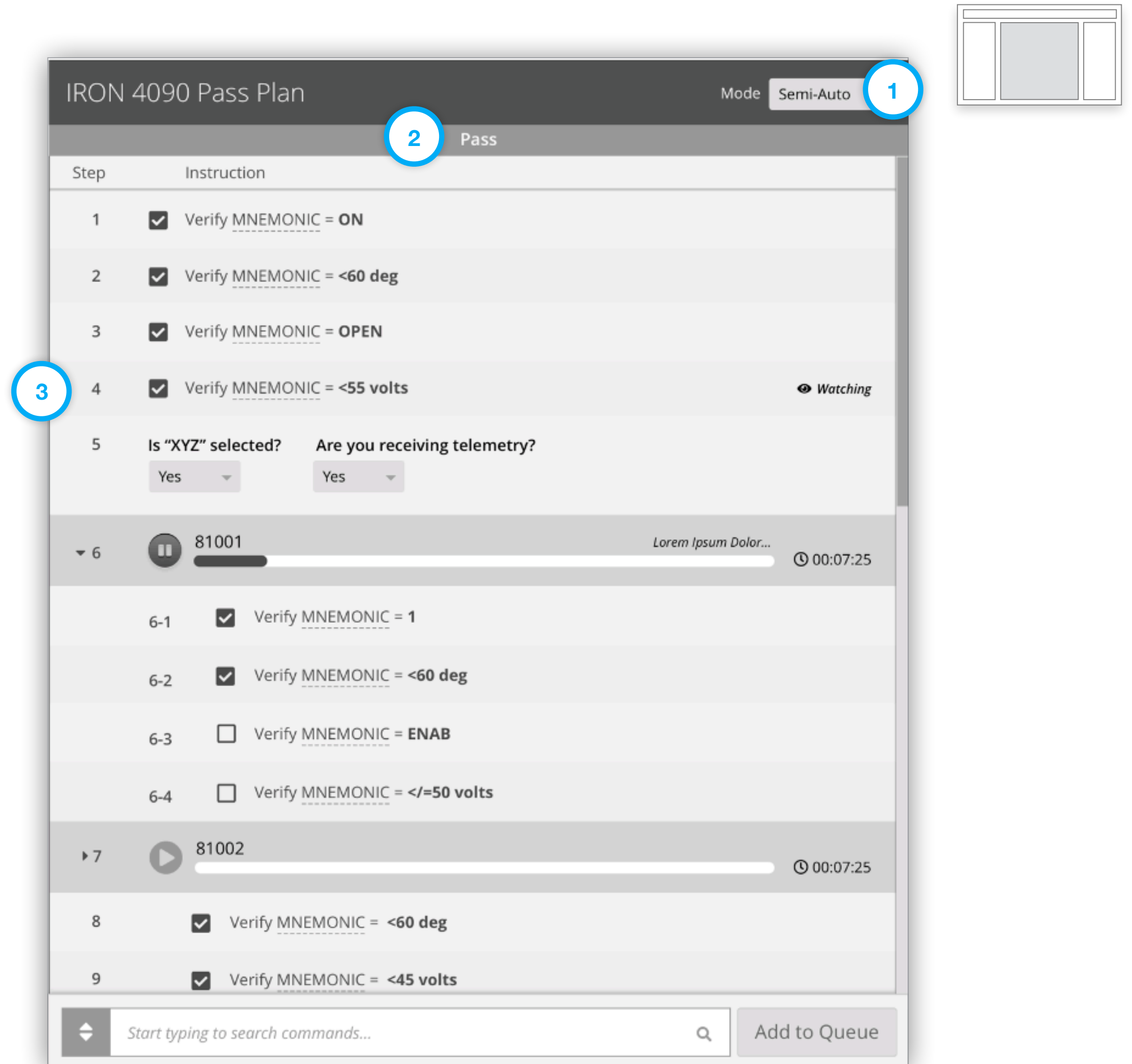
*\*Further functionality to be determined.*

### 2. Pass Indicator

Allows for the user, at-a-glance, to determine if they are in pre-pass, pass or post-pass, in relation to the AOS/LOS for the contact.

### 3. Pass Plan

An interactive checklist of instructions an operator is expected to complete during a pass. This includes, but is not limited to: Checkboxes, drop down selectors and play and pause controls.

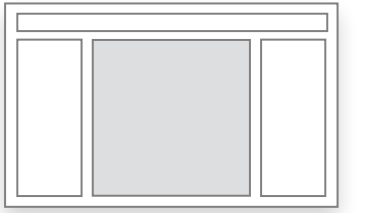


The screenshot displays the 'IRON 4090 Pass Plan' interface. At the top right, the 'Mode' is set to 'Semi-Auto'. Below this, a 'Pass' indicator is shown. The main area contains a list of steps:

Step	Instruction	Status
1	Verify MNEMONIC = ON	Checked
2	Verify MNEMONIC = <60 deg	Checked
3	Verify MNEMONIC = OPEN	Checked
4	Verify MNEMONIC = <55 volts	Checked, Watching
5	Is "XYZ" selected? Are you receiving telemetry?	Yes, Yes
6	81001	Paused, 00:07:25
6-1	Verify MNEMONIC = 1	Checked
6-2	Verify MNEMONIC = <60 deg	Checked
6-3	Verify MNEMONIC = ENAB	Unchecked
6-4	Verify MNEMONIC = </=50 volts	Unchecked
7	81002	Playing, 00:07:25
8	Verify MNEMONIC = <60 deg	Checked
9	Verify MNEMONIC = <45 volts	Checked

At the bottom, there is a search bar with the placeholder text 'Start typing to search commands...' and an 'Add to Queue' button.

# Command – Pass Plan (Continued)



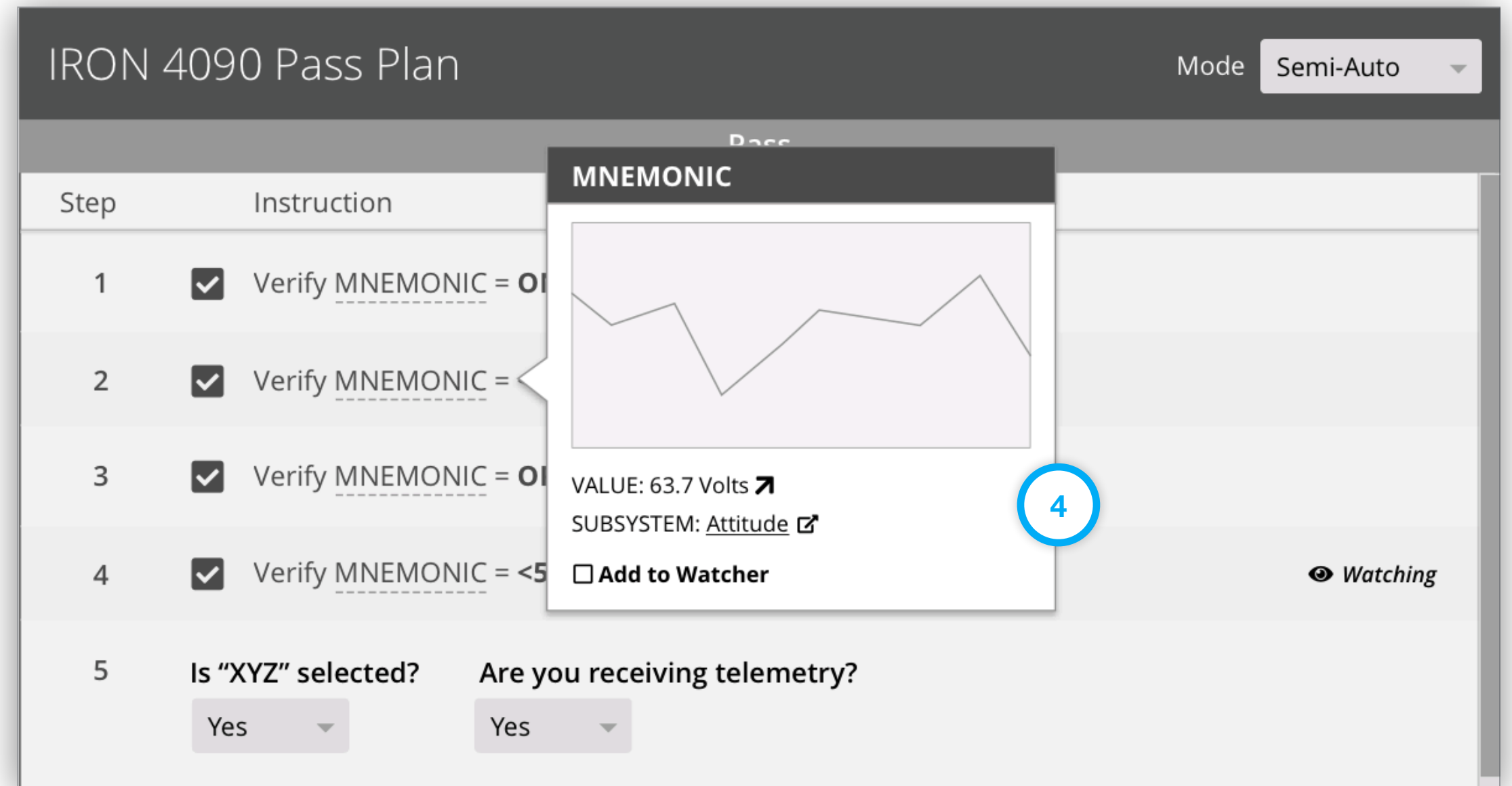
## Features & Interactions

### 4. Mnemonic Snapshot

Allows for users to click a mnemonic they've been instructed to verify the value of via the pass plan. Upon clicking, a "snap shot" shows the user the current value of the mnemonic, as well as the direction it is trending (arrow).

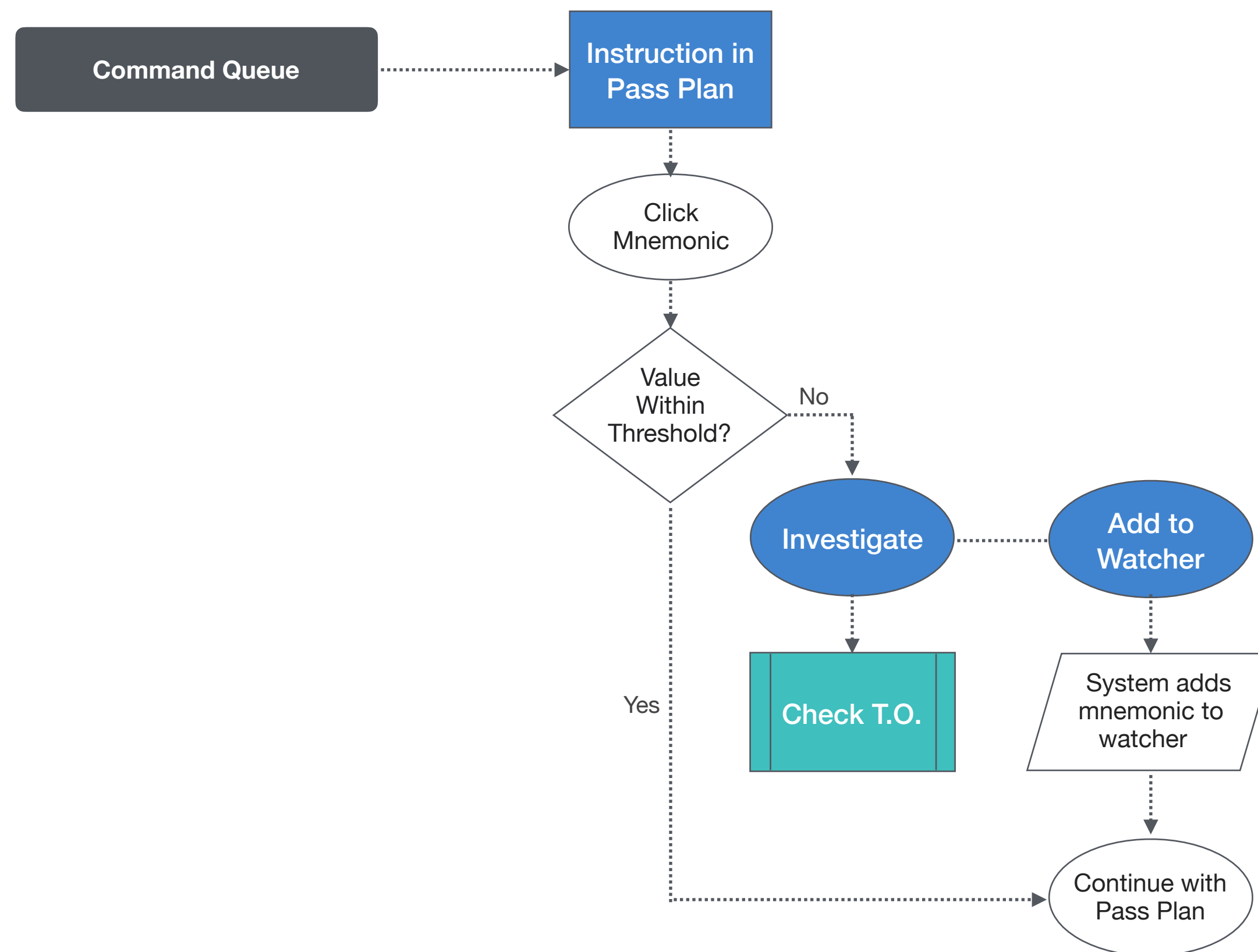
The snapshot also queues the user into which subsystem the mnemonic belongs to, with the capability to quickly access the Investigate application, as well as the ability to add the item to the Watcher list.

If the mnemonic is capable of displaying graph data, a snapshot of the graph can be shown in context with the other data attributes. If the instruction involves a mnemonic of a binary value (on/off, enabled/disabled, 0/1), a graph may not be applicable, in which case, the user would only need to access the attributes of the mnemonic (value, subsystem). If the mnemonic is such that it does not make sense to add it to the watcher, the capability to do so can be omitted for that mnemonic.

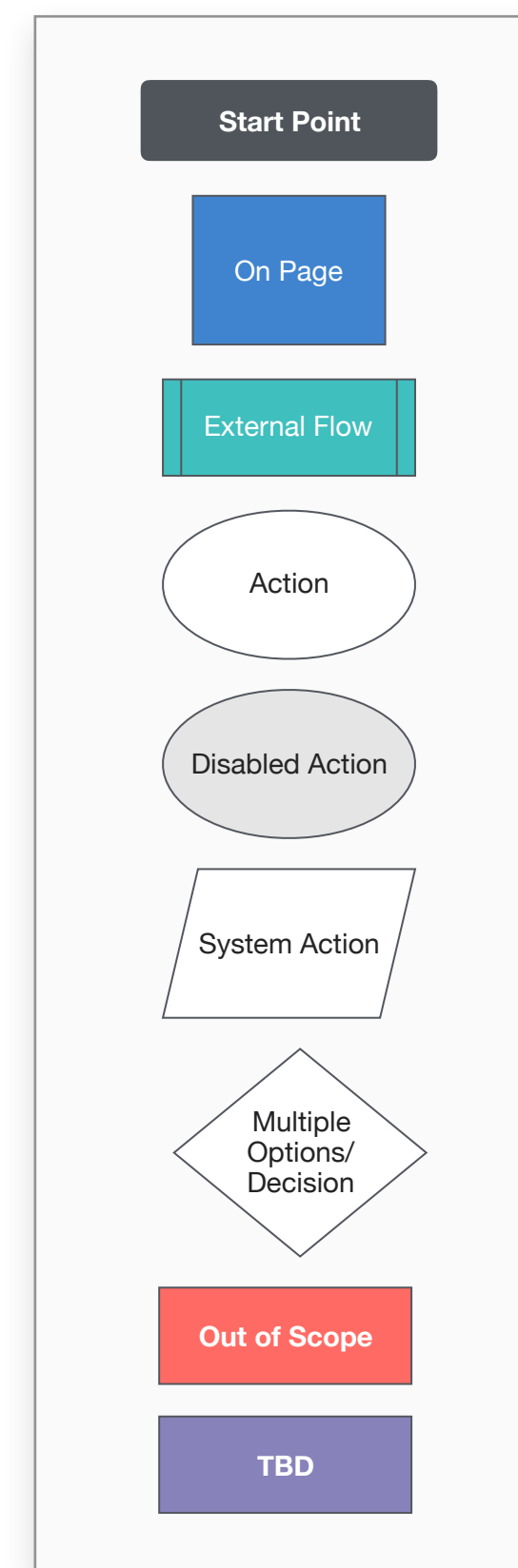


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# Command – Pass Plan Mnemonic Verification



Key





# Command – Command Line

## Functionality

The Command Line component allows for a user to access commands needed to maintain the overall health of the pass, as well as retrieve a database of commands needed for anomaly resolution and/or other operational needs.

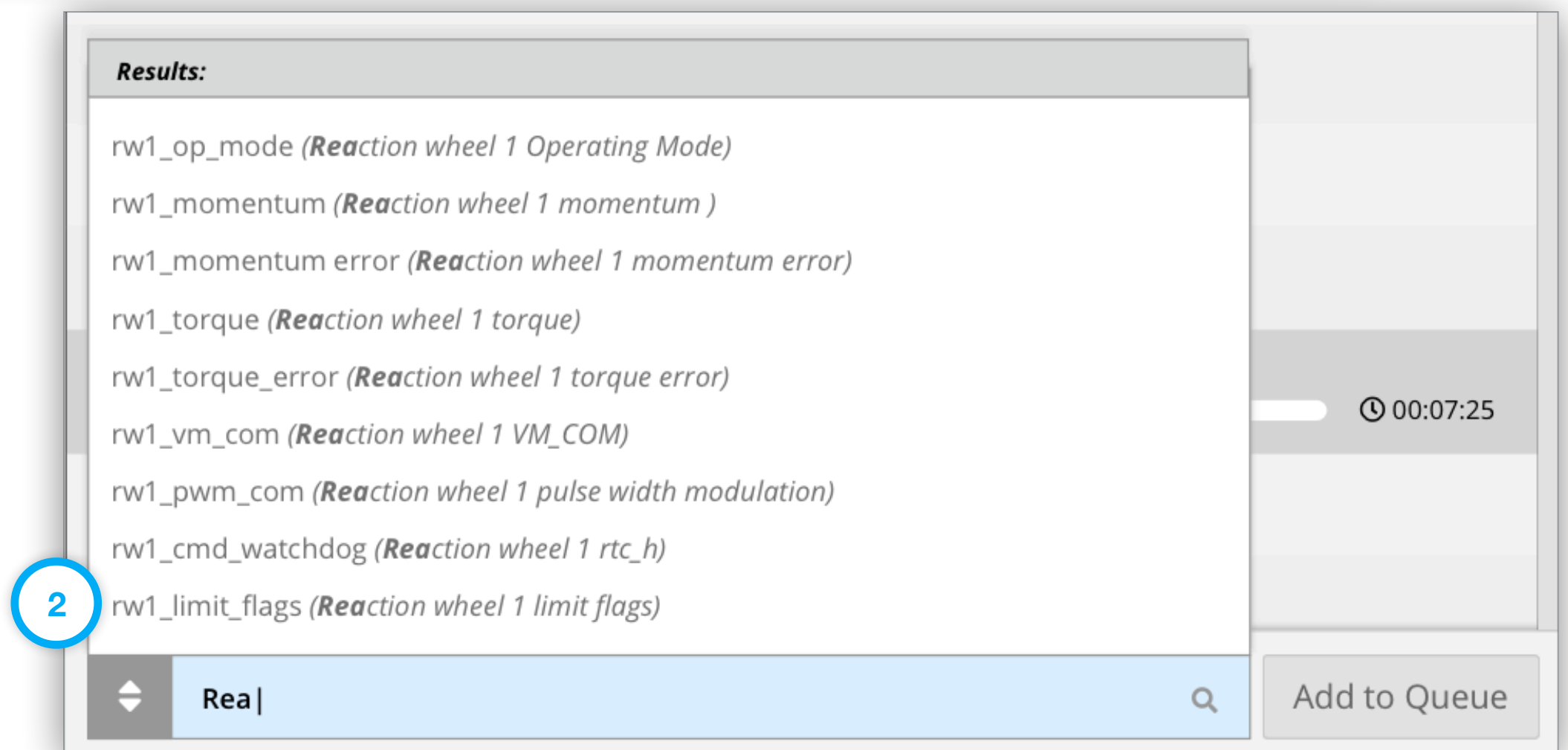
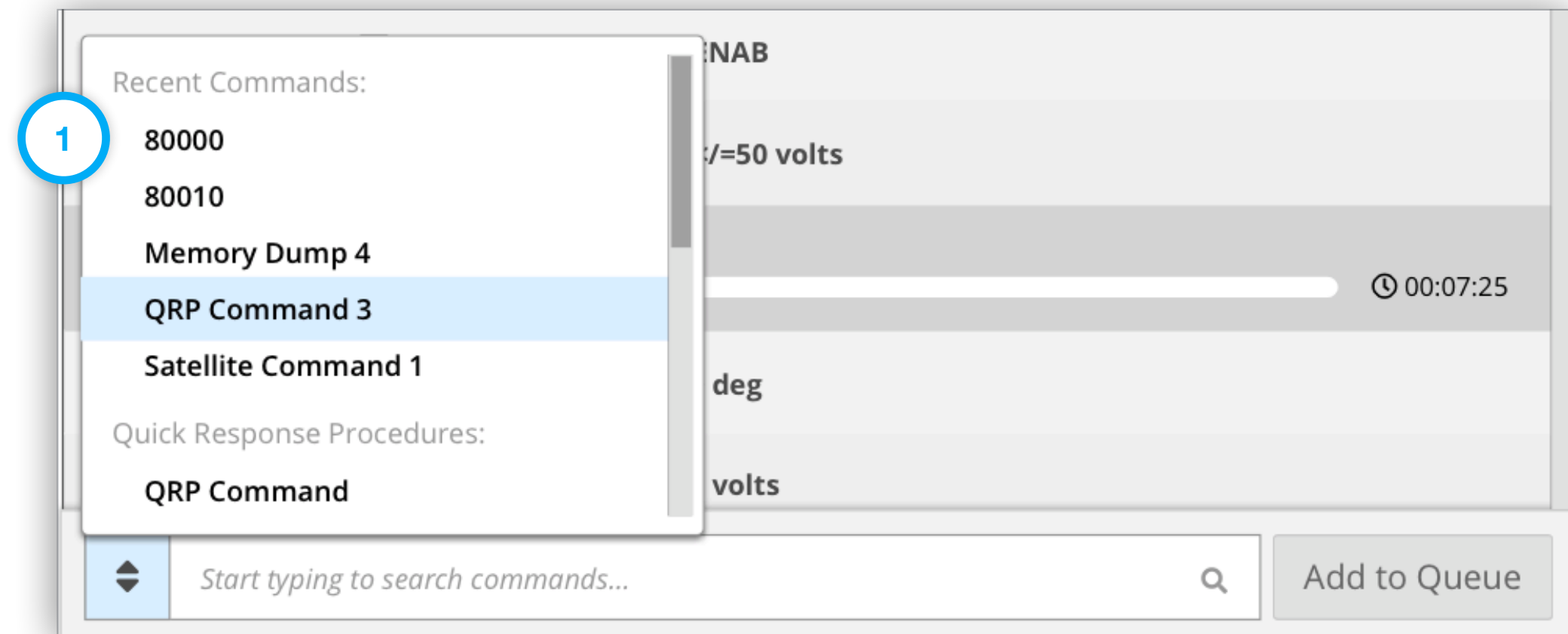
## Features & Interactions

### 1. Frequently Used Commands

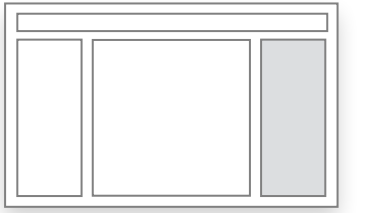
This drop down consists of frequently used commands by the user(s). As to what commands it contains, this may be configured by operation to operation. Through user testing, we suggest the following quick access commands: *Recent Commands*, *Quick Response Procedures*, *Ground*, *Satellite* and *Payload dump*.

### 2. Search Commands

Searching commands via the text input will retrieve a database of commands and match them by text string. Once an operator selects a command and adds it to the queue, the command will be inserted at the bottom of the pass plan.



# Command – Link Status



## Functionality

The Link Status lock up shows connection and critical health statuses that are vital to the mission. The attributes of what displays can differ from operation to operation.

## Features & Interactions

### 1. Lock and Signal Strength

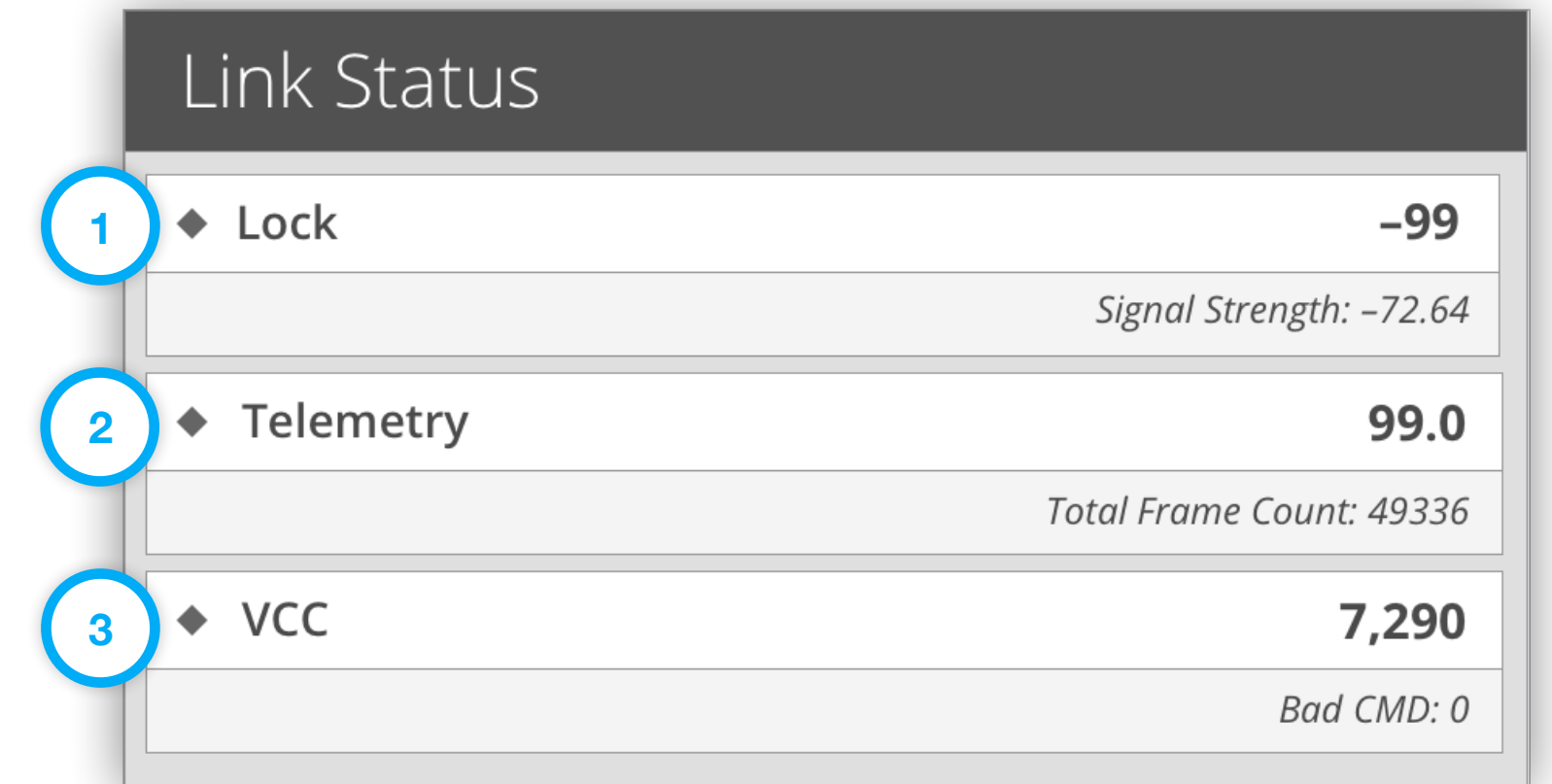
Displays the lock value and signal strength, as well as a status symbol indicating the quality of lock.

### 2. Telemetry and Total Frame Count

Displays telemetry value and a status symbol to determine, at-a-glance, the quality of telemetry, as well as the frame count.

### 3. VCC (Vehicle Command Count)

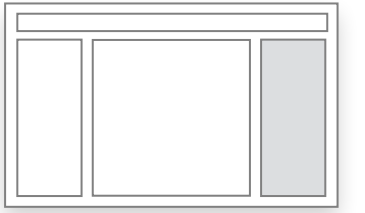
Displays the total command count of the commands being sent to the spacecraft as well as any bad commands sent or received.



Link Status	
1	<p>◆ Lock <span style="float: right;"><b>-99</b></span></p> <p style="text-align: right;"><i>Signal Strength: -72.64</i></p>
2	<p>◆ Telemetry <span style="float: right;"><b>99.0</b></span></p> <p style="text-align: right;"><i>Total Frame Count: 49336</i></p>
3	<p>◆ VCC <span style="float: right;"><b>7,290</b></span></p> <p style="text-align: right;"><i>Bad CMD: 0</i></p>

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# Command – Subsystems



## Functionality

The subsystems display shows a high level roll up status of a spacecraft's subsystems (indicated by status symbol). These systems vary from spacecraft to spacecraft.

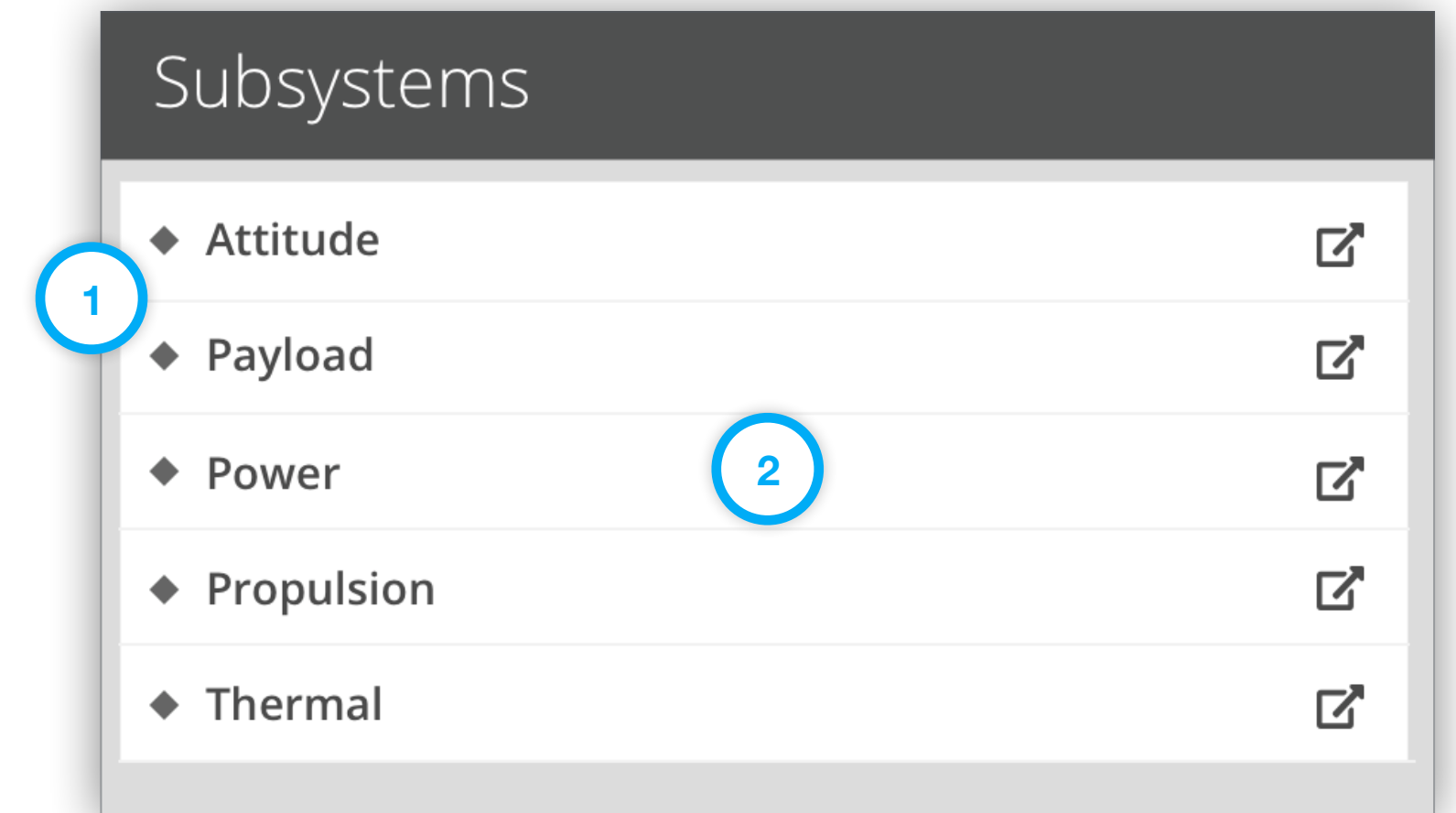
## Features & Interactions

### 1. Subsystem Status

The subsystem's health is identified by the accompanying status symbol. The order in which the subsystems display can be configured by the operation. It is suggested to not hide subsystems in a scrolling list, to avoid missing status symbols that require attention. If the list of subsystems is long enough that it does require a scroll, it is recommended that any subsystems that display statuses of anything less than nominal surface to the top of the list, in order of severity.

### 2. Investigate

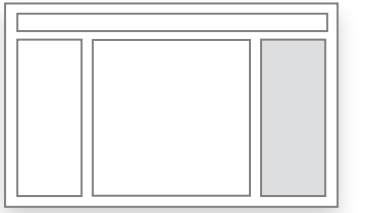
A status of anything less than nominal may require the user to investigate the issue and determine what the root cause of a status degradation is. By clicking any subsystem row, a user can open a hierarchal display of the subsystem, as well as its assembly, to gain a better understanding of what is causing the less than nominal status.



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# Command – Contextual Watcher



## Functionality

The Contextual Watcher exhibits the same behavior as the Monitor Watcher, with the exception that all items displayed are contextual to the satellite in pass. It does not display the full graph data, but that may be accessed via a “snapshot view” by clicking the mnemonic name.

## Features & Interactions

### 1. Mnemonic

Displays the mnemonic being watched and its status. Clicking on the mnemonic name brings up its attributes, as well as a snap shot graph (if applicable).

### 2. Unit

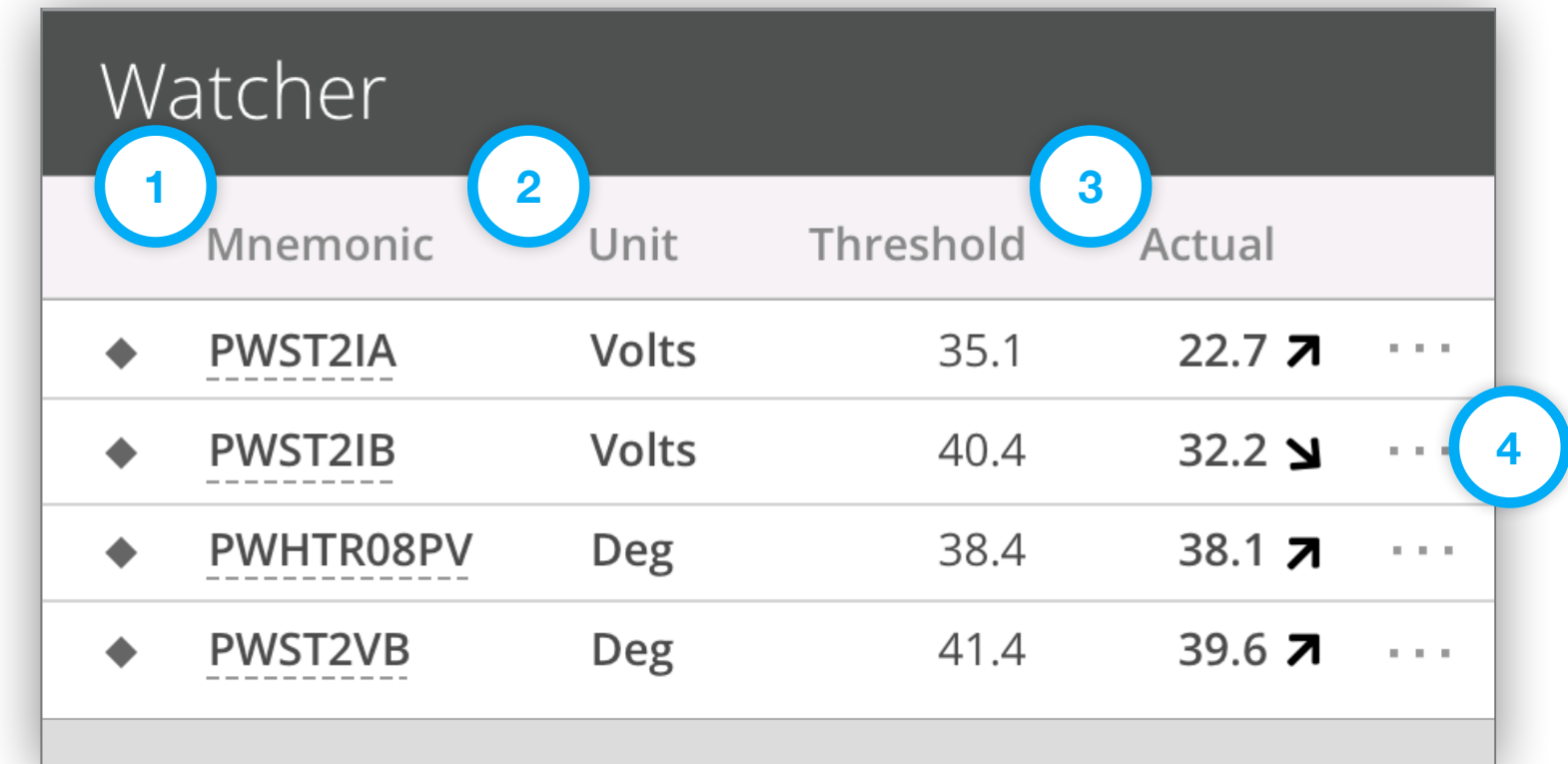
Displays the unit of measurement associated to the mnemonic. (Example: Volts, Degrees, Magnitude, Amps, etc.).

### 3. Threshold and Actual Value

Displays the defined threshold range of the mnemonic and its actual, current value. An arrow shows the user which direction the value is trending (may not be applicable to binary values).

### 4. Action Menu

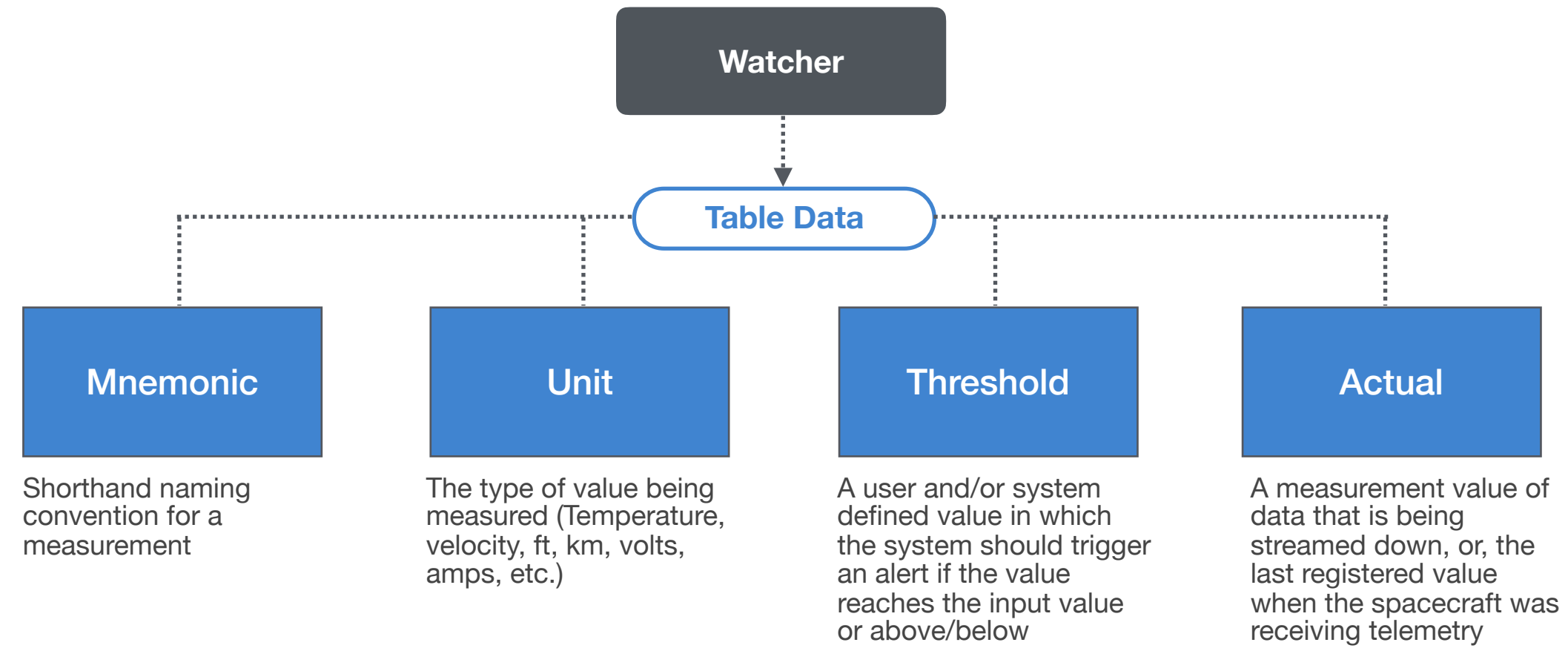
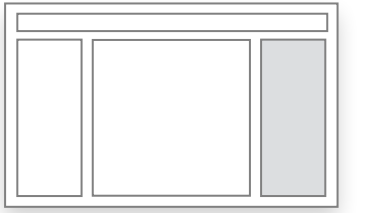
Allows users to remove the item from the watch list and/or further investigate the mnemonic’s subsystem.



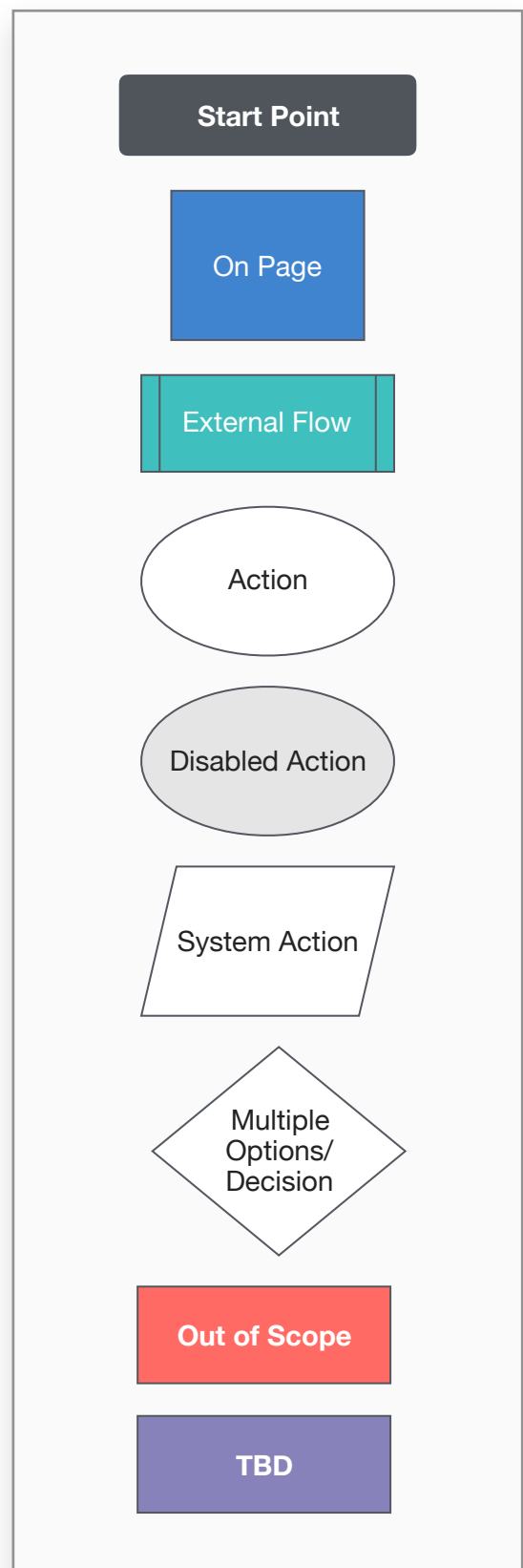
	1 Mnemonic	2 Unit	Threshold	3 Actual	
◆	PWST2IA	Volts	35.1	22.7 ↗	...
◆	PWST2IB	Volts	40.4	32.2 ↘	...
◆	PWHTR08PV	Deg	38.4	38.1 ↗	...
◆	PWST2VB	Deg	41.4	39.6 ↗	...

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# Contextual Watcher – Hierarchy\*



Key



\*Further functionality to be determined.

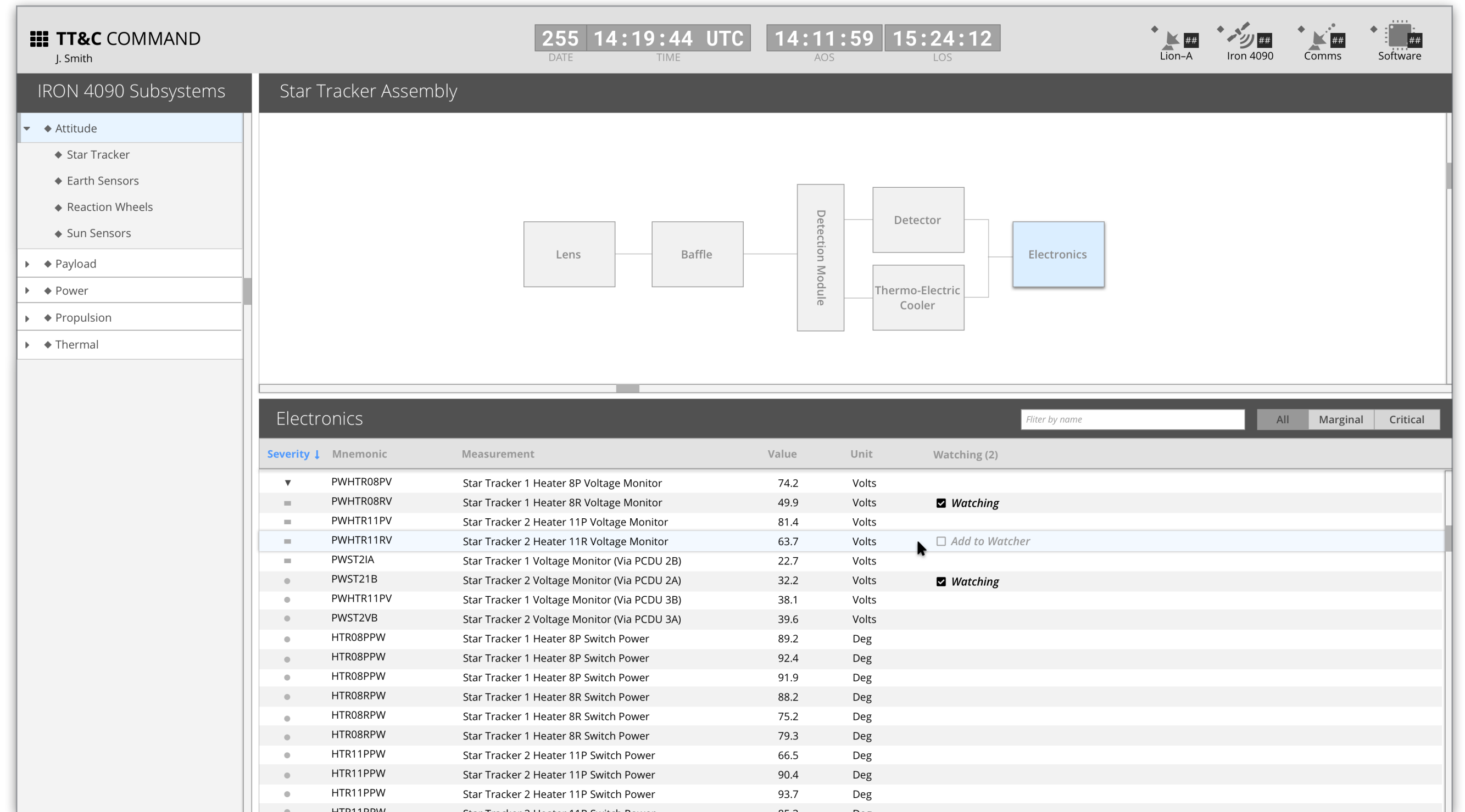
# Investigate

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# Investigate Overview\*

The Investigate Application houses all of the subsystems of a spacecraft. It's here that users can investigate anomalies and find useful information on subsystem assemblies such as assembly layouts, mnemonic data, and health and status.

*\*Further functionality of the Investigate Application to be determined.*



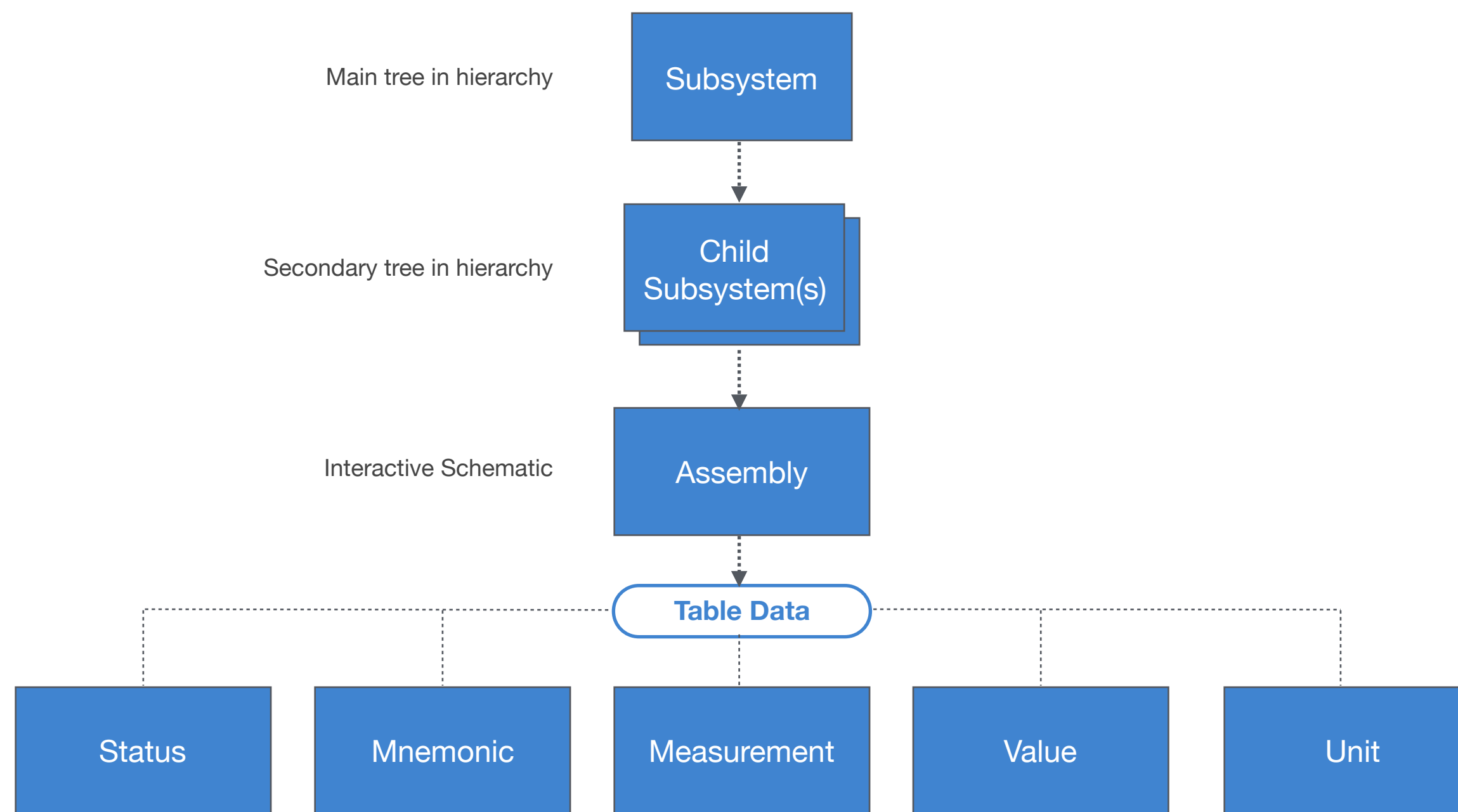
The screenshot displays the TT&C COMMAND interface. At the top, it shows the user 'J. Smith' and system status including '255' (DATE), '14:19:44 UTC' (TIME), '14:11:59' (AOS), and '15:24:12' (LOS). Navigation icons for 'Lion-A', 'Iron 4090', 'Comms', and 'Software' are visible.

The main content area is titled 'Star Tracker Assembly' and contains a block diagram with the following components: Lens, Baffle, Detection Module, Detector, Thermo-Electric Cooler, and Electronics.

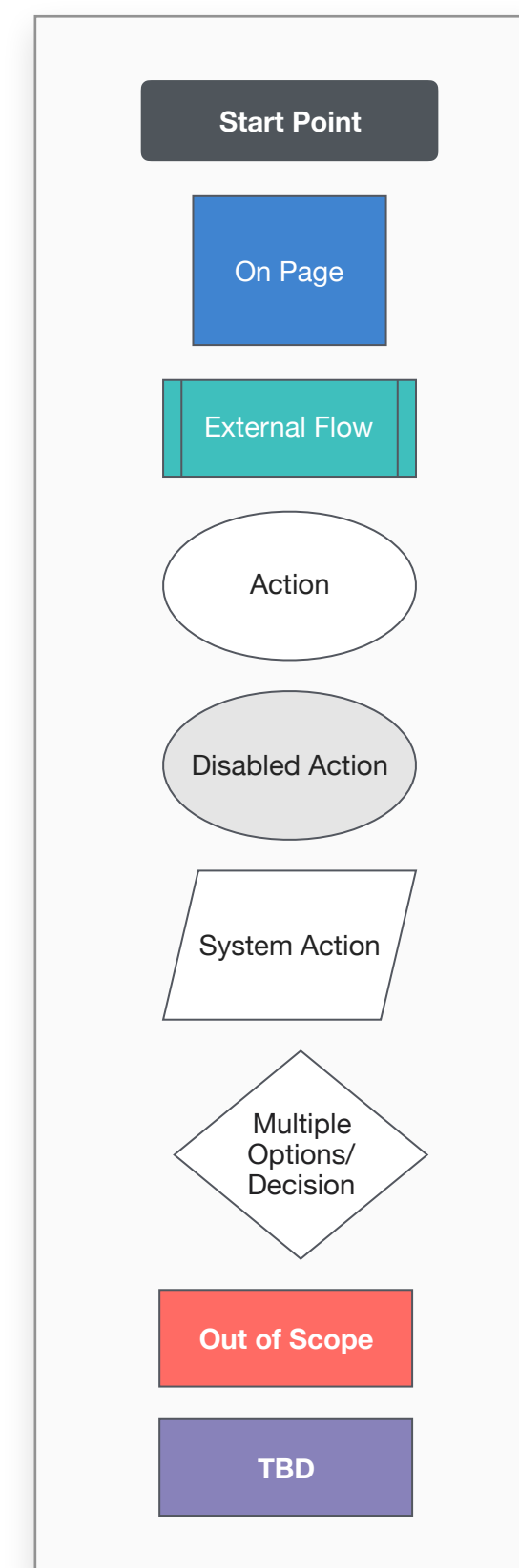
Below the diagram is a table titled 'Electronics' with columns for Severity, Mnemonic, Measurement, Value, Unit, and Watching (2). The table lists various voltage and temperature monitors for the Star Tracker assembly.

Severity	Mnemonic	Measurement	Value	Unit	Watching (2)
▼	PWHTR08PV	Star Tracker 1 Heater 8P Voltage Monitor	74.2	Volts	
■	PWHTR08RV	Star Tracker 1 Heater 8R Voltage Monitor	49.9	Volts	<input checked="" type="checkbox"/> Watching
■	PWHTR11PV	Star Tracker 2 Heater 11P Voltage Monitor	81.4	Volts	
■	PWHTR11RV	Star Tracker 2 Heater 11R Voltage Monitor	63.7	Volts	<input type="checkbox"/> Add to Watcher
■	PWST2IA	Star Tracker 1 Voltage Monitor (Via PCDU 2B)	22.7	Volts	
●	PWST2IB	Star Tracker 2 Voltage Monitor (Via PCDU 2A)	32.2	Volts	<input checked="" type="checkbox"/> Watching
●	PWHTR11PV	Star Tracker 1 Voltage Monitor (Via PCDU 3B)	38.1	Volts	
●	PWST2VB	Star Tracker 2 Voltage Monitor (Via PCDU 3A)	39.6	Volts	
●	HTR08PPW	Star Tracker 1 Heater 8P Switch Power	89.2	Deg	
●	HTR08PPW	Star Tracker 1 Heater 8P Switch Power	92.4	Deg	
●	HTR08PPW	Star Tracker 1 Heater 8P Switch Power	91.9	Deg	
●	HTR08RPW	Star Tracker 1 Heater 8R Switch Power	88.2	Deg	
●	HTR08RPW	Star Tracker 1 Heater 8R Switch Power	75.2	Deg	
●	HTR08RPW	Star Tracker 1 Heater 8R Switch Power	79.3	Deg	
●	HTR11PPW	Star Tracker 2 Heater 11P Switch Power	66.5	Deg	
●	HTR11PPW	Star Tracker 2 Heater 11P Switch Power	90.4	Deg	
●	HTR11PPW	Star Tracker 2 Heater 11P Switch Power	93.7	Deg	
●	HTR11PPW	Star Tracker 2 Heater 11P Switch Power	85.2	Deg	

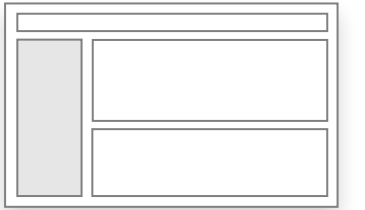
# Subsystem Drilldown Hierarchy



## Key



# Investigate - Subsystem Tree Menu



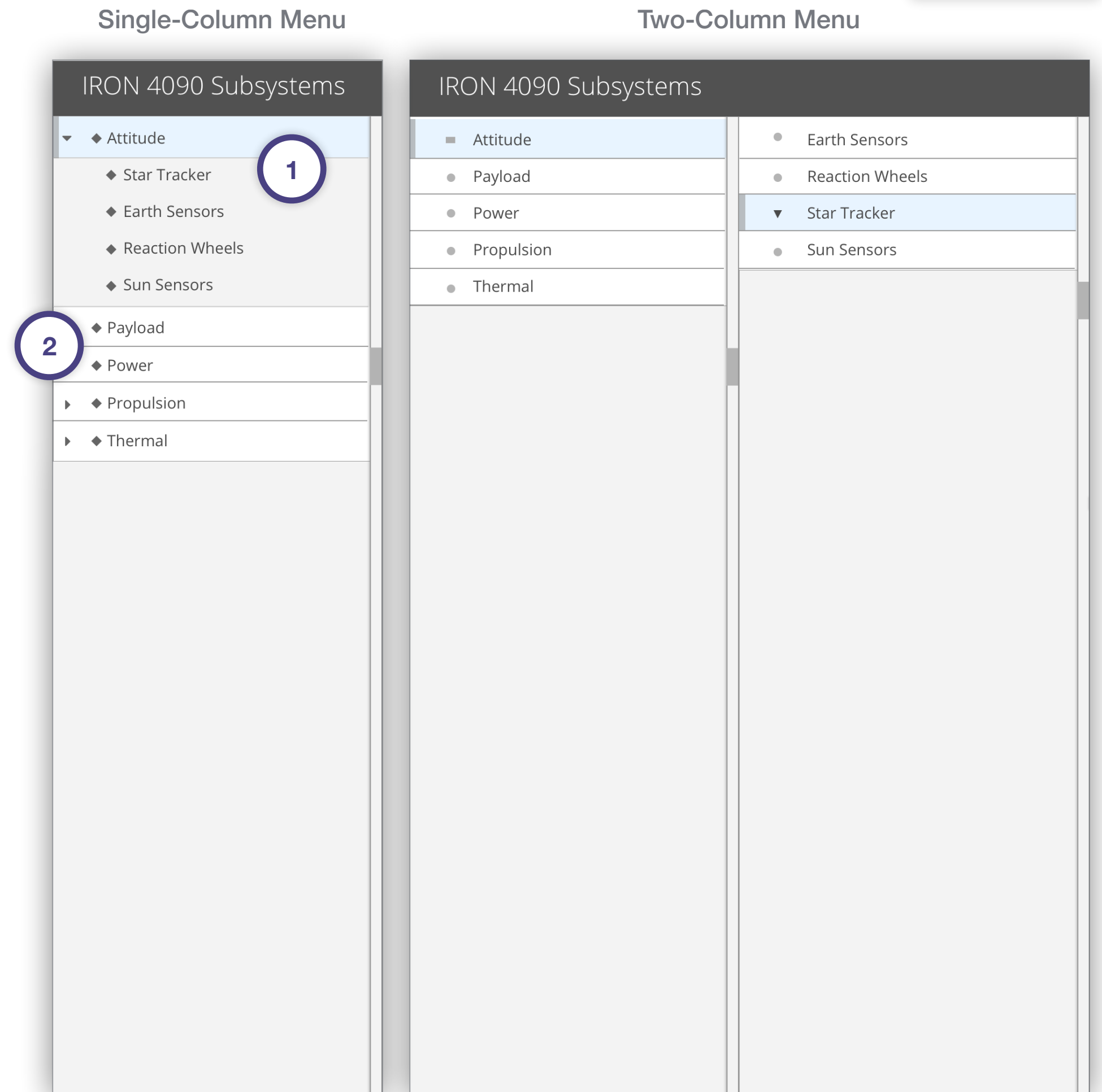
## Functionality

The Subsystem Tree Menu shows a hierarchical list of spacecraft's subsystems. When a subsystem is selected, the related subsystem assembly layout and mnemonic data table is shown in the content area to the right.

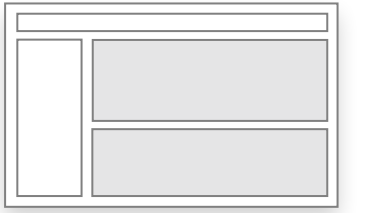
The subsystem tree can be modeled using a single-column or two-column format.

## Features & Interactions

1. **Expandable List Items**  
Subsystem menu items expand to show any related sub-subsystems.
2. **Status Symbols**  
Status symbols indicate current subsystem status and severity.



# Investigate - Subsystem Assembly Layout & Mnemonic Data Table



## Functionality

The Subsystem Assembly Layout and Mnemonic Data Table work in conjunction to show subsystem health, status and severity, as well as mnemonic data, such as measurements and values.

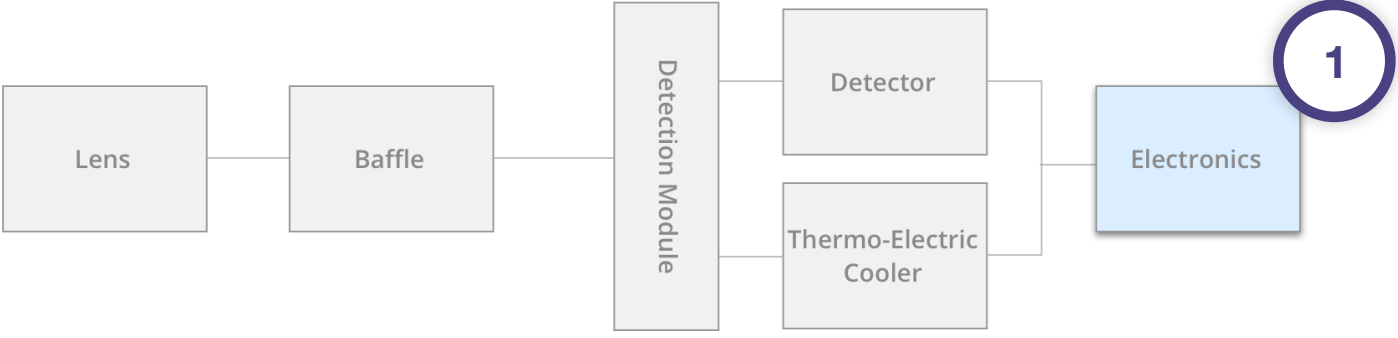
## Features & Interactions

### 1. Subsystem Assembly Layout

The subsystem assembly layout gives the operator an illustrative view of a subsystem assembly. The illustration is color-coded to show status and to help identify the root cause of an issue with the subsystem.

Clicking a component in the assembly layout shows its mnemonic data in the list below.

Star Tracker Assembly



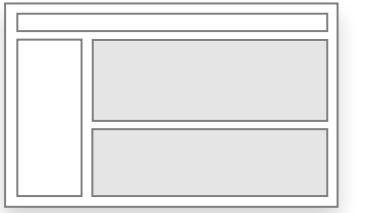
Electronics

All Marginal Critical

Severity ↓	Mnemonic	Measurement	Value	Unit	Watching (2)
▼	PWHTR08PV	Star Tracker 1 Heater 8P Voltage Monitor	74.2	Volts	
■	PWHTR08RV	Star Tracker 1 Heater 8R Voltage Monitor	49.9	Volts	<input checked="" type="checkbox"/> <i>Watching</i>
■	PWHTR11PV	Star Tracker 2 Heater 11P Voltage Monitor	81.4	Volts	
■	PWHTR11RV	Star Tracker 2 Heater 11R Voltage Monitor	63.7	Volts	<input type="checkbox"/> <i>Add to Watcher</i>
■	PWST2IA	Star Tracker 1 Voltage Monitor (Via PCDU 2B)	22.7	Volts	
●	PWST21B	Star Tracker 2 Voltage Monitor (Via PCDU 2A)	32.2	Volts	<input checked="" type="checkbox"/> <i>Watching</i>
●	PWHTR11PV	Star Tracker 1 Voltage Monitor (Via PCDU 3B)	38.1	Volts	
●	PWST2VB	Star Tracker 2 Voltage Monitor (Via PCDU 3A)	39.6	Volts	
●	HTR08PPW	Star Tracker 1 Heater 8P Switch Power	89.2	Deg	
●	HTR08PPW	Star Tracker 1 Heater 8P Switch Power	92.4	Deg	
●	HTR08PPW	Star Tracker 1 Heater 8P Switch Power	91.9	Deg	
●	HTR08RPW	Star Tracker 1 Heater 8R Switch Power	88.2	Deg	
●	HTR08RPW	Star Tracker 1 Heater 8R Switch Power	75.2	Deg	
●	HTR08RPW	Star Tracker 1 Heater 8R Switch Power	79.3	Deg	
●	HTR11PPW	Star Tracker 2 Heater 11P Switch Power	66.5	Deg	
●	HTR11PPW	Star Tracker 2 Heater 11P Switch Power	90.4	Deg	
●	HTR11PPW	Star Tracker 2 Heater 11P Switch Power	93.7	Deg	
●	HTR11PPW	Star Tracker 2 Heater 11P Switch Power	85.2	Deg	



# Investigate - Subsystem Assembly Layout & Mnemonic Data Table (Continued)



## Features & Interactions

### 2. Status Symbols

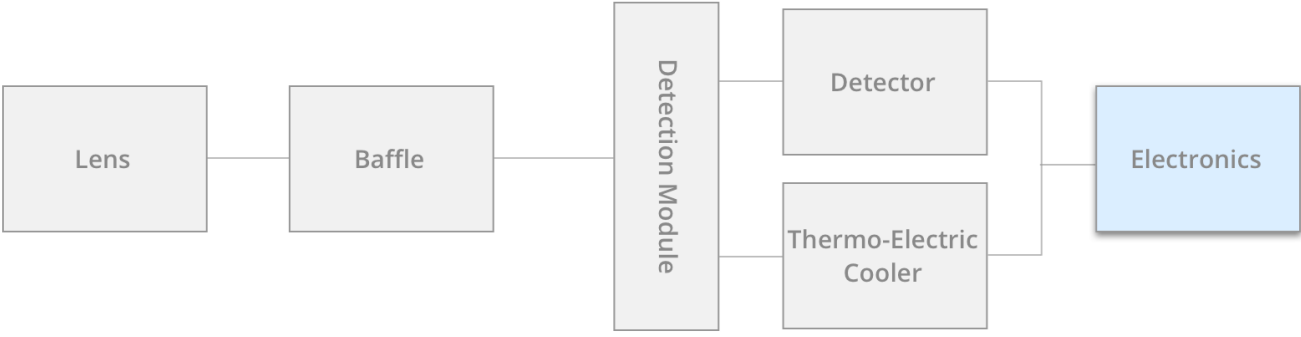
Status symbols indicate current mnemonic status and severity and can be sorted by severity as well.

### 3. Table Filters

The mnemonic data table can be filtered by name in order to narrow down high volumes of content and surface the most relevant results.

The table can also be filtered by severity using the segmented buttons (All/Marginal/Critical).

Star Tracker Assembly



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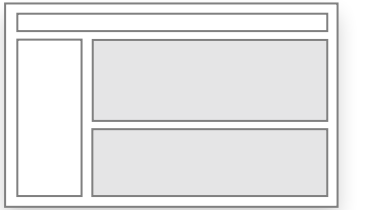
Electronics

All
Marginal
Critical

Severity ↓	Mnemonic	Measurement	Value	Unit	Watching (2)
▼	PWHTR08PV	Star Tracker 1 Heater 8P Voltage Monitor	74.2	Volts	
■	PWHTR08RV	Star Tracker 1 Heater 8R Voltage Monitor	49.9	Volts	<input checked="" type="checkbox"/> <i>Watching</i>
■	PWHTR11PV	Star Tracker 2 Heater 11P Voltage Monitor	81.4	Volts	
■	PWHTR11RV	Star Tracker 2 Heater 11R Voltage Monitor	63.7	Volts	<input type="checkbox"/> <i>Add to Watcher</i>
■	PWST2IA	Star Tracker 1 Voltage Monitor (Via PCDU 2B)	22.7	Volts	
●	PWST21B	Star Tracker 2 Voltage Monitor (Via PCDU 2A)	32.2	Volts	<input checked="" type="checkbox"/> <i>Watching</i>
●	PWHTR11PV	Star Tracker 1 Voltage Monitor (Via PCDU 3B)	38.1	Volts	
●	PWST2VB	Star Tracker 2 Voltage Monitor (Via PCDU 3A)	39.6	Volts	
●	HTR08PPW	Star Tracker 1 Heater 8P Switch Power	89.2	Deg	
●	HTR08PPW	Star Tracker 1 Heater 8P Switch Power	92.4	Deg	
●	HTR08PPW	Star Tracker 1 Heater 8P Switch Power	91.9	Deg	
●	HTR08RPW	Star Tracker 1 Heater 8R Switch Power	88.2	Deg	
●	HTR08RPW	Star Tracker 1 Heater 8R Switch Power	75.2	Deg	
●	HTR08RPW	Star Tracker 1 Heater 8R Switch Power	79.3	Deg	
●	HTR11PPW	Star Tracker 2 Heater 11P Switch Power	66.5	Deg	
●	HTR11PPW	Star Tracker 2 Heater 11P Switch Power	90.4	Deg	
●	HTR11PPW	Star Tracker 2 Heater 11P Switch Power	93.7	Deg	
●	HTR11PPW	Star Tracker 2 Heater 11P Switch Power	85.2	Deg	



# Investigate - Subsystem Assembly Layout & Mnemonic Data Table (Continued)



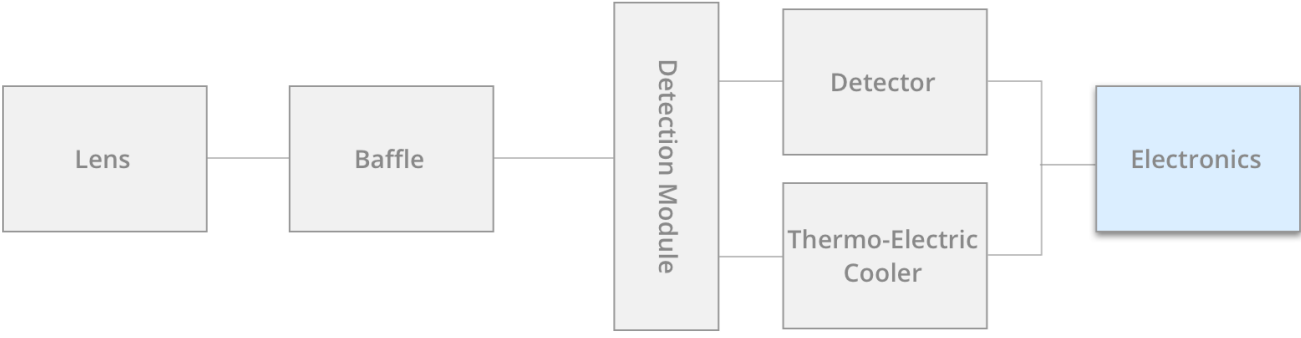
## Features & Interactions

### 4. Watcher Item Status Indicators

An Add to Watcher checkbox appears when hovering over a row. Clicking the checkbox adds that row item, or mnemonic, to the [Watcher component](#) in the Monitor Application.

Once an item has been added to the Watcher, from either here, the Monitor Application or the Command Application, a status indicator is shown in the Watching column to indicate the mnemonic is being watched.

Star Tracker Assembly



Electronics Filter by name

All
Marginal
Critical

Severity ↓	Mnemonic	Measurement	Value	Unit	Watching (2)
▼	PWHTR08PV	Star Tracker 1 Heater 8P Voltage Monitor	74.2	Volts	
■	PWHTR08RV	Star Tracker 1 Heater 8R Voltage Monitor	49.9	Volts	<input checked="" type="checkbox"/> <i>Watching</i>
■	PWHTR11PV	Star Tracker 2 Heater 11P Voltage Monitor	81.4	Volts	
■	PWHTR11RV	Star Tracker 2 Heater 11R Voltage Monitor	63.7	Volts	<input type="checkbox"/> Add to Watcher
■	PWST2IA	Star Tracker 1 Voltage Monitor (Via PCDU 2B)	22.7	V	
●	PWST21B	Star Tracker 2 Voltage Monitor (Via PCDU 2A)	32.2	Volts	<input checked="" type="checkbox"/> <i>Watching</i>
●	PWHTR11PV	Star Tracker 1 Voltage Monitor (Via PCDU 3B)	38.1	Volts	
●	PWST2VB	Star Tracker 2 Voltage Monitor (Via PCDU 3A)	39.6	Volts	
●	HTR08PPW	Star Tracker 1 Heater 8P Switch Power	89.2	Deg	
●	HTR08PPW	Star Tracker 1 Heater 8P Switch Power	92.4	Deg	
●	HTR08PPW	Star Tracker 1 Heater 8P Switch Power	91.9	Deg	
●	HTR08RPW	Star Tracker 1 Heater 8R Switch Power	88.2	Deg	
●	HTR08RPW	Star Tracker 1 Heater 8R Switch Power	75.2	Deg	
●	HTR08RPW	Star Tracker 1 Heater 8R Switch Power	79.3	Deg	
●	HTR11PPW	Star Tracker 2 Heater 11P Switch Power	66.5	Deg	
●	HTR11PPW	Star Tracker 2 Heater 11P Switch Power	90.4	Deg	
●	HTR11PPW	Star Tracker 2 Heater 11P Switch Power	93.7	Deg	
●	HTR11PPW	Star Tracker 2 Heater 11P Switch Power	85.2	Deg	