SAFTE-FAST
The Science of Performance at Work

Workload Calculator

Contents

SAFTE-FAST Workload Calculator

Overview

The release of SAFTE-FAST 4 introduced a user adjustable workload calculator. In SAFTE-FAST, specifically within the aviation industry settings; workload associated with a duty or a series of duties is conceived as a series of operational factors that impact the cognitive demands on the pilot. Operational factors may be any predictable condition that the model can derive from the input information. For the initial version of the workload calculator to be applied in aviation, we consulted airlines for the most common drivers of workload for a pilot. The basic operational factor for all pilots is the need to pilot the plane for takeoffs and landings. That initial version included the following four additional generic factors that could increase the workload of a takeoff or landing:

- Airport geography

- Time of day (related daily variations on traffic or weather conditions)

- Season of the year (related to factors such as snow and ice, winds, etc.)

- Language factors (ATC communication, for example)

The takeoff and landing factors were global and impacted all flight events. The additional factors were airport specific and were specified in an airport table. SAFTE-FAST 4 built on this basic logic to then generalize the calculator for both aviation and non-aviation environments and to allow much more flexibility in determining the workload triggers, the operational drivers, and weights:

- The triggers at the start and end of an event are no longer called "takeoff and landing" and have been generalized to "On Task" workload that corresponds to any added workload that can occur at the start and end of a work event or shift. In shiftwork, this may be the handoff that occurs at the start and end of a shift. In general, this trigger will capture the cumulative workload of multiple work events within a day or across days.

- Workload can also now trigger periodically to reflect the cumulative workload of any continuous activity, like serving passengers as a flight attendant or monitoring a control panel in an operations center.

- Customizable conditions define the circumstances and impact of a workload factor, such as aircraft type, crew position, crew complement, route, time of day, or events in the schedule, like a delicate maintenance procedure in a shiftwork setting.

Adjustable weights for each workload factor on a 7-point scale:

- o Very low   0.25
- o Low   1.0
- o Medium   3.0
- o High   5.0
- o Very High   7.0

Customizable Feature of the Workload Calculator

The user can simply use the default values and obtain a generic estimate of workload based on the density of sectors or shifts, generally defined as "On Task" workload events. The more advanced user can add specific factors listed above. Furthermore, additional custom factors can be added to capture known workload drivers in specific operations. For example, a particular airport may be notorious for crosswinds at particular times of the day, so a custom factor for "crosswinds" can be created and associated with airports that have that factor. And that factor can have a custom weight that reflects how much more difficult landings and takeoffs are at that airport. In shiftwork, a custom factor can be added for work at a specific site or situation because the nature of the work at that site is more demanding. An example might be work at the Emergency Command Center for a firefighter.

It is important to understand that all factors that match a set of conditions are additive. For example, the default workload weight of "On Task" is Medium (3), in aviation coinciding with Takeoff and Landings. Each of the airport specific factors adds an additional Low weight (1) to that value. An airport with the terrain factor would have a workload of 4 (3+1). If that airport had ALL the additional factors (geography, time of day, season, and language), each would add 1 for a total of 7 (3 + 1 +1 + 1 + 1) or Very High. But note that there is no limit on how extreme the workload of a single event could be. For example, that same airport with all four added factors could also have a Crosswind factor with a weight of Medium (3) giving a total of 10 (7 + 3), or extreme workload. It is left to the user to define the highest workload that might occur in their operation, relative to all other operational factors.

> *"The workload calculator was defined so that it could be validated with subjective rating tools like the NASA TLX scale."*

Each workload "driver" raises the current level of workload and the impact of that workload event has a persistence so it can accumulate across the course of a duty. As a result, a duty that contains multiple difficult airports will have an accumulated workload that is higher than a duty that contains only one high workload airport. In shiftwork, a duty that contains many high workload maintenance events (for example) would have higher workload than a similar shift with only one maintenance activity. But the impact of a workload event dissipates over time. The scientific literature on workload provides very little guidance on the "persistence" of workload effects. To be realistic, we created a decay function so that the workload function behaved in a reasonable way across a week of duties or shifts. We adopted an exponential decay function that is typical of many physiological processes. That function is well defined mathematically and behaves in a predictable way when multiple workload events add together over time. The rate of decay is adjustable but defaults to a rate so that any workload factor will decay to 1% of its starting value in 72 hours. In general terms, this means that subjective workload on Friday is impacted by how difficult duty was on Thursday and to a small extent by duty on Wednesday but not by what happened on Monday. This behavior is parallel to how workload effects dissipated in the prior versions of SAFTE-FAST but more predictable, adjustable, and physiologically reasonable.

The workload calculator was defined so that it could be validated with subjective rating tools like the NASA TLX scale. Within the general structure of the TLX, psychological workload factors are rated on a 7-point scale and summed to give a total workload score. We adopted a parallel

structure but peg the workload factors to known and predictable OPERATIONAL WORKLOAD FACTORS. Nevertheless, if we were to know the operational factors of a series of duties AND the TLX ratings, we could validate or calibrate the SAFTE-FAST workload calculator to provide scores on a scale that correlates with the TLX ratings.

Note, however, that the SAFTE-FAST workload calculator does not base its score on psychological factors as in the TLX, but on operational factors that can be derived from the input data. From a practical point of view, the SAFTE-FAST workload calculator does not require the user to know the psychological components of a workload event, only its total subjective workload based on the TOTAL score from the TLX or the total subjective impact based on fatigue reports or polling of experienced operators. NASA TLX Scale:

https://humansystems.arc.nasa.gov/groups/TLX/downloads/TLXScale.pdf

Scaling Workload

Since the weights applied to workload factors are user defined and since operations vary in the density of workload factors, SAFTE-FAST provides a way to scale workload for the user's context. Under the workload parameters, the user specifies a Scale Maximum for workload and all values will be divided by that maximum, so workload is effectively displayed on a scale from 0 to 100. Normally, the maximum value will be set to a value a bit above the highest observed value to provide "room" for unexpected increases. If the normal maximum value is 30, the user can set the maximum scale value to 40. In that case, a 30 will be scaled to a workload value of 75. In that context, the workload score of 75 would be considered high.

Workload Normalization

The enhancements introduced with SAFTE-FAST 4 provide the user a wide range of flexibility in defining workload factors and their weighting. Furthermore, those factors are additive over time, so there is no arbitrary limit to the range of workload scores. For purposes of visualization, we provide a way to place all workload values on a 100-point scale. This is done by setting a maximum value in the workload parameters and all "raw scores" are divided by that maximum, converting the scale to percentages of that maximum. There are several ways to use the workload scores. If the maximum is set to 100, then the values shown in the results table and the graphs will be the "raw scores" – whatever the scores are at any particular time. If any raw scores are greater than 100, then they will be off the graph. But if the user determines that no practical scores are greater than 100, then this method will simply report raw scores for comparison across schedules. But if a large operator has diverse operations with some experiencing high workload and others experiencing relatively low workload AND there is a desire to compare across operations, then the maximum can be set either higher or lower than 100 to reflect the overall maximum across operations. For example, short-haul operations generally have higher workload and might have raw scores over 100, while international single segment operations might not have raw workload scores greater than 20. To compare across these two cases, the user would set the maximum workload value for both operations based on the short haul experience, say 130. As a result, the short haul scores will approach 100 at maximum and the international will top at around 15. However, if there is no desire to compare across operations, then the maximum for short haul can be set to 130 and for international set to 20. Then both will scale from 0 to 100 but have vastly different raw scores.

We recommend a two-step process to scale workload. First, set the maximum to 100 and visualize the maximum raw scores across operations in the results table. Those scores could exceed 100. Based on the maximum raw score observed across operations, set the workload maximum in the parameters list to a value a bit above that observed maximum and standardize that across operations. That then becomes a standard reference scale for comparing workload within and across operations.

How to Use Workload for Hazard Identification

In SAFTE-FAST, Workload is a separate calculation from Effectiveness. Workload is a measure of "demands on the operator" and effectiveness is a measure of "capacity to react to demands". An operational hazard is created when there is a "mismatch" between these two factors, that is, high workload at the same time effectiveness is low. To state it another way, when alertness is low, a person is more vulnerable to making a mistake when workload is high because capacity is not sufficient to handle the load.

The SAFTE-FAST Reports Dashboard includes a default workload report which identifies all schedules with mismatches of high workload and low effectiveness:
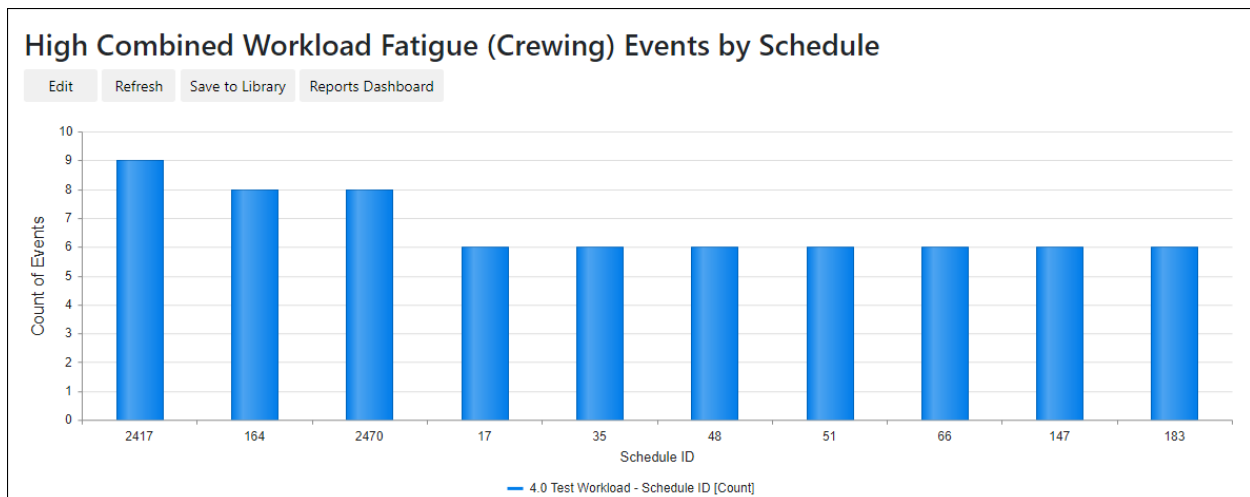
Examples of Workload Scores with SAFTE-FAST

The Schedule Details graph view can be used to display workload in the right-axis for the purpose of identifying potential areas of increased risk. In the example below there is a high workload level at a time of lower alertness:
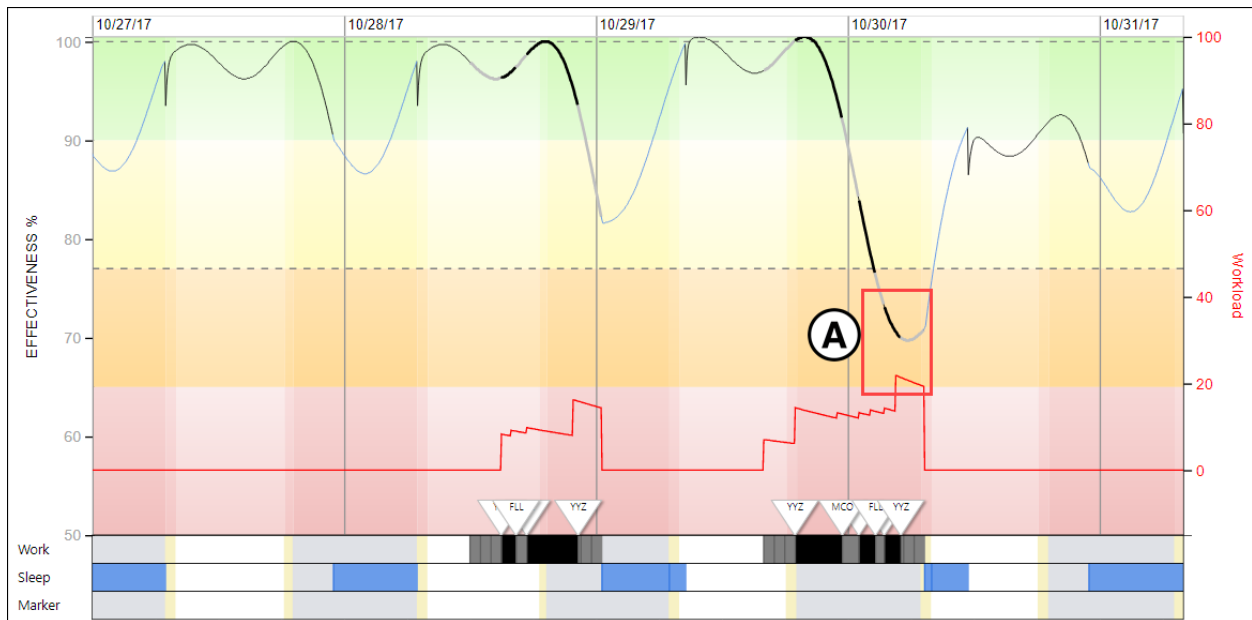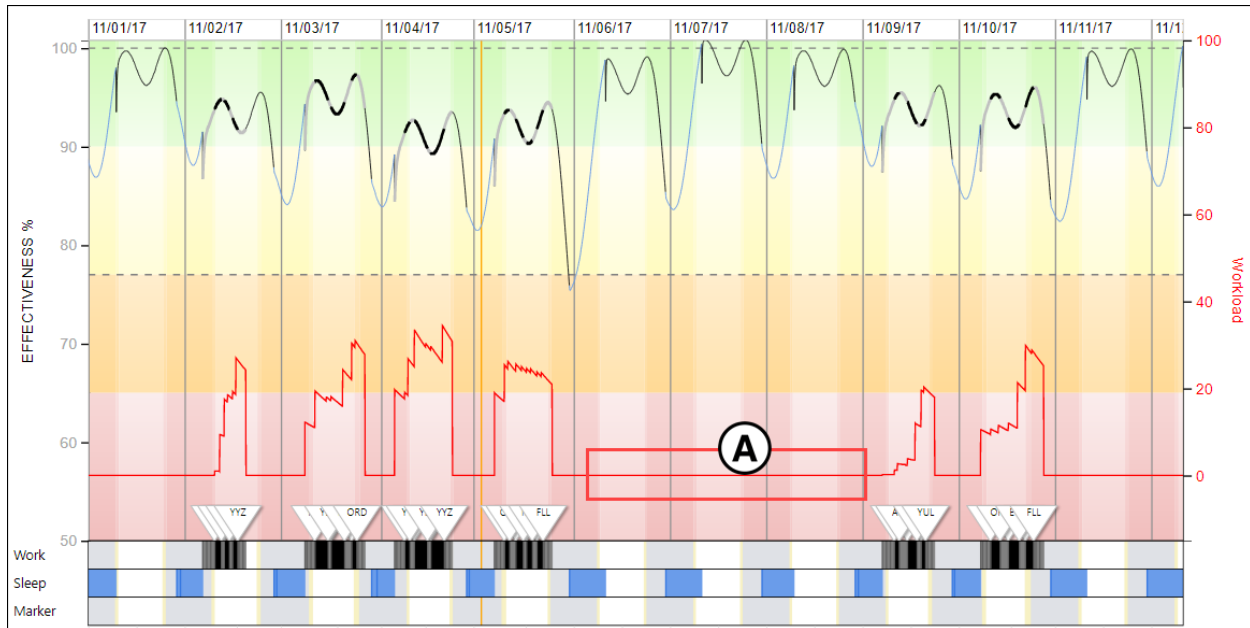

A. An increased risk due to a high workload and low alertness level is emphasized in the red box.

Workload Dissipation Example:

In the example below the use of a marker (indicated in purple) has been used to simulate the 72-hour decay rate over time. At the end of the 72 hours, the workload levels are at zero:
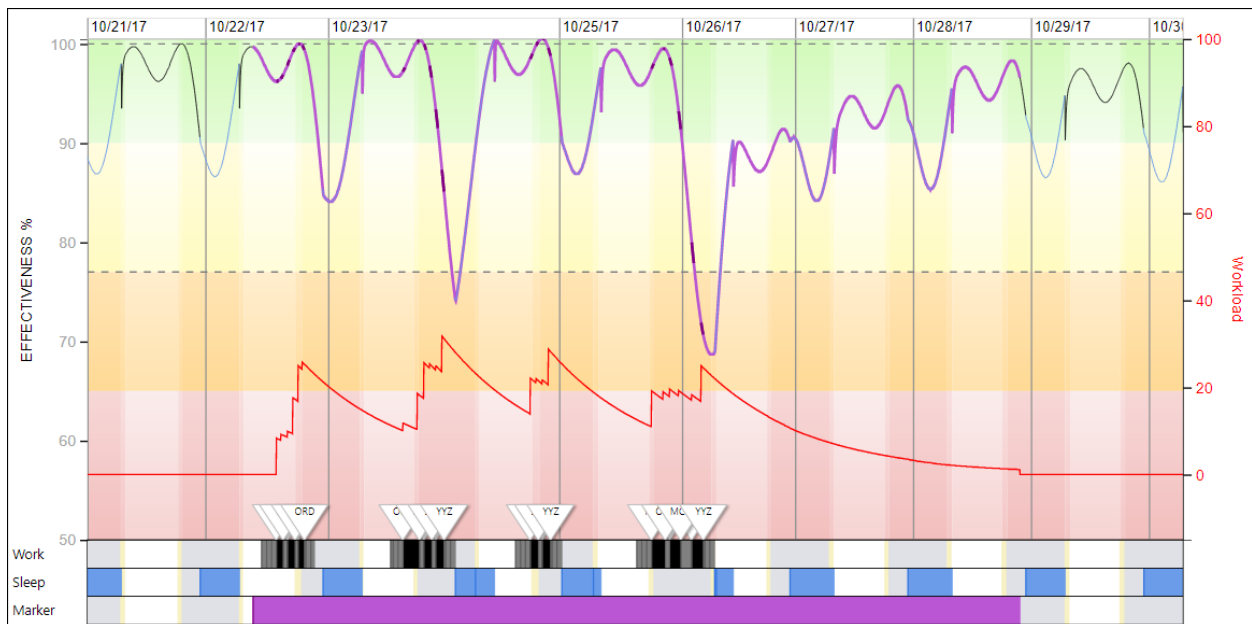
Normal Workload Example:

A. Per the example above the red box illustrates a section on the schedule where a 72-hour gap exists between two pairings. As a result of the days off, there are no work events and as such no workload levels are displayed. However, the decay rate does occur, so that at the start of the first duty in the second pairing, the workload level is minimal, compared to the starting workload where work events are less than 72 hours apart.
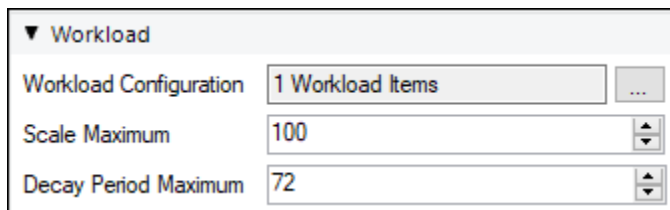
Guide to Using the Workload Calculator

Workload Parameters

Workload functionality is used to apply workload factors to events. You can apply workload factors to work and marker events. Specific events can be targeted with any combination of conditions set using the Event Rules Editor.

- Rules can be created for more than a single location. The rule builder has multiple optional conditions instead of a single location condition.

- Rules are additive. If an event is matched by more than one rule, the factors for each rule are applied to the event. In this way, complex workload rules can be layered on top of each other.

- Factors are not always triggered at the start and end of each matching event but can be configured to trigger optionally at the Start and/or End of an event, and/or Periodically through the course of an event.

- Factor weights are configurable. Weights ranging from Very Low to Very High can be selected for the standard factors and for custom factors.

- Custom factors can be created to account for any potential cases that go beyond the standard factors.

- The function that decays factor weights to a value of 0 after 72 hours is configurable. You can set the factors to decay faster or slower than the default 72 hours. See Decay Period Maximum.

Workload Configuration

This field shows you the number of Workload rules that you have in the system. This field is not editable.

Scale Maximum

Workload metric scores (as applied to Schedules and Events) are calculated as a percentage of this Scale Maximum parameter value.

Decay Period Maximum

Defines the duration in hours of how long it takes for a workload factor to decay from its full weight value to a value of zero. After this period, any workload factor is no longer relevant, and its score is not applied to subsequent events.

Workload Configuration Rules

Workload Rules need to be configured for the Workload Factor to be applied. You need to enter or import your rules in the Workload Event Rule dialog.

Clicking the (...) button beside the Workload Configuration field will launch the Workload Event Rule window (as per below). Any stored workload rules are displayed here.

Reset to Defaults

Click Reset to Defaults to return to the default system Workload rules (shown below). This cannot be undone. Export your current Workload settings before resetting to defaults to ensure that you don't lose any rules. You can import the .CSV to restore your rules. You can also reimport your Setup Package to restore Workload settings.

Add / Clone / Delete

Click Add to add a new workload rule, Click the first column beside the Conditions header by an existing rule to clone or delete the rule.

Move Up / Move Down

Click the first column by an existing rule to select it and then use the Move Up or Move Down to change the order of the rule. The order of the rules is not important as the system will continue to add rules until all have been applied.

Add Factor

Click Add Factor to add a new custom factor. Use the Custom Factor dialog to give the factor a name and weight. Options are Very Low, Low, Medium, High and Very High. Click OK to add the factor. The Custom Factor is shown on Workload dialog in the Custom Factors section. Click on the checkbox in the same row as the rule to apply it.
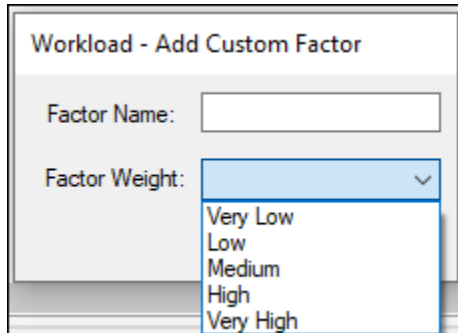

Delete Factor

Clicking on Delete Factor opens the Workload - Delete Custom Factor dialog. Click on the drop-down list to view a list of custom factors available for deletion. Select one from the list and click Ok to delete it. You can only delete Custom Factors. Terrain and Language are default factors.
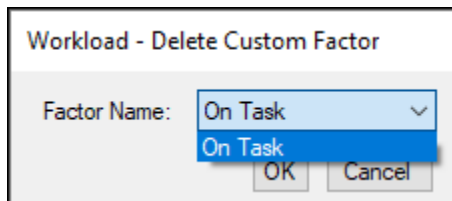
Edit Factor Weight

You can adjust the weight of any factor by clicking on its name. This opens the Workload - Edit Factor Weight Dialog. Use the drop-down to select a new weight. You cannot edit the name of a factor.
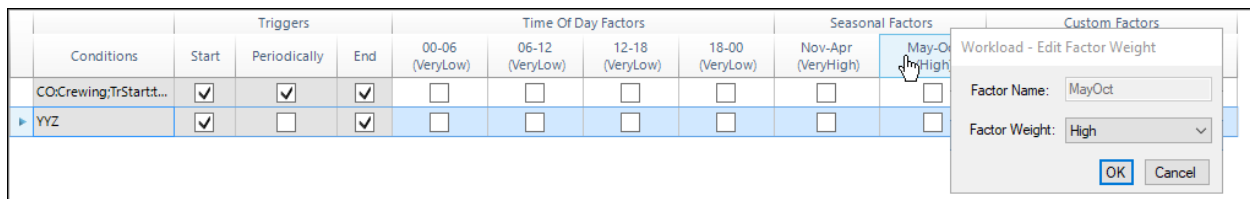
Import / Export

You can import an existing workload CSV file or export your current workload rules as a CSV file. Click Import or Export to open a standard Windows dialog to choose the file to import or location to export to complete the process.

Conditions

The Conditions column displays the name of the rule if a name is entered in the Name field Workload Event Rule dialog. If you don't give the rule a name a description of the rule is displayed (as displayed in the screenshot in Edit Factor Weight).

Triggers

The Triggers textboxes in the Workload dialog are display only. To add or edit Triggers use the Workload Event Rule dialog. The Workload Event Rule builder allows the configuration of how/when to apply factor weights. These "triggers" can be at the Start of an event, and/or the End of an event, and/or multiple times Periodically throughout the course of an event.

Workload Event Rule Editor

When a user elects to add a new workload rule, they will be presented with the Workload Event Rule (as per below).

Name: Enter a name for the rule. The name is displayed on Workload dialog. If you don't enter a

name a brief description of the conditions is displayed.

Crewing: Select if the event is Crewing (only crewing events), Non-Crewing (only non-crewing events), Marker (only non-critical markers), Critical Marker(only critical markers), Any Work (includes crewing and non-crewing work events), or Any Marker (includes critical and non-critical markers).

Duration: Enter the duration of flight for which the particular rule set will use to apply workload to.

Location: Enter the location for which the particular rule set will use to apply workload to. Multiple locations can be entered in the fields provided they are separated by a comma. The rule is applied if the location matches either the Start (From field) or End (To field) location.

Route: Enter an origin and destination for which the particular rule set will use to apply workload to. Origins and Destinations can be entered in either ICAO/IATA or by the City name in the Stations Table. Multiple origins and destinations can be entered in the fields provided they are separated by a comma.

Event(s): Enter specific Event names for which the particular rule set will use to apply workload to. Event names must match the Label in the Events Table.

Equipment Type(s): Enter specific Equipment Type names for which the particular rule set will use to apply workload to. As an example, a 767H might be a 767 aircraft used on domestic routes that does not require a new workload rule, whereas a 767Y might be a 767 used on international flights for which a new workload rule is needed. The Equipment Type code must match the equipment type in the data.

Crew Complement: Enter the crew complement aboard an aircraft for which the particular rule set will use to apply workload to. The Crew Complement workload event rule depends largely on the Crew Complement(s) being used.

- Example 1: One Workload Factor to apply for Crew Complements 3-5
- Crew Complement 3 to 5, Sleep Rule 1
- Example 2: Unique Workload Factor per Crew Complement
- Crew Complement 3 to 3, Workload Factor 1
- Crew Complement 4 to 4, Workload Factor 2
- Crew Complement 5 to 5, Workload Factor 3

Crew Position(s): Enter the specific crew position of a crewmember for which the particular rule set will use to apply workload to. An example of this would be where a crew position for a Relief Pilot is RP, or Relief Officer RO. The schedule data will need to include the Crew Position(s) for these changes to apply.

Time of Day: Enter the time of day for which the particular rule set will use to apply workload. A setting with a range from 02:00 to 05:00 applies workload to any event/marker that is within or overlaps this time range (provided all other criteria set in the rule has matched as well). You can also specify whether the time range used is in Local, Base or GMT.

Trigger at Start / Periodically / End: These checkboxes let you choose when to apply the workload rule. Trigger at Start applies the workload factor or factors at the start (first minute of the event). Periodic triggers cause each factor enabled for the rule to be added to the total workload score every X minutes after the start of an event. If the minute field is set to 0 (zero) no workload is applied. Trigger at End applies the workload factor or factors 30 minutes before the end of the event.