SnT2017 T3.5-P21

Disclaimer
The views expressed on this poster are those of the author and do not necessarily reflect the view of the CTBTO

International Data Centre Re-engineering Phase 2: Analysis Interface Improvements

D. Brown[1], J. Burns[2], D. Carr[2], J. Coram[2], J. Harris[2], R. Le Bras[1], P. Mialle[1], E. Peiszer[1], E. Tomuta[1], and C. Young[2]

[1]CTBTO, [2]Sandia National Laboratories

The IDC RP2 Requirements Definition Process and the Role of Storyboards

During Phase 2 of the IDC Re-engineering Process, the CTBTO and Sandia National Laboratories worked together on designing the re-engineered system that will be implemented in Phase 3. The CTBTO began the process by defining a set of 340 requirements that define at a moderate level of detail what the combined seismic, hydroacoustic, and infrasonic System must do to perform the CTBTO monitoring mission. The combined CTBTO-SNL team then expanded these requirements into a much more detailed set of 1238 specifications. From these we then developed 94 Use Cases that describe the functionality that the system must provide. Of these, 70 involve a direct interaction with a user and hence a User Interface (UI) is involved. Neither requirements nor use cases can fully capture what is required for a UI, so we developed UI Storyboards for all the uses cases that involve a UI. A Storyboard is a mockup of what the interface could look like, and captures only the level of detail needed to give a designer a good sense of what will be needed to code the UI. Thus a Storyboard needs to show the types of displays involved (waveforms, maps, tables, etc.), but does not need to capture more detailed information such as the exact number or position of buttons, or the layout of menus.

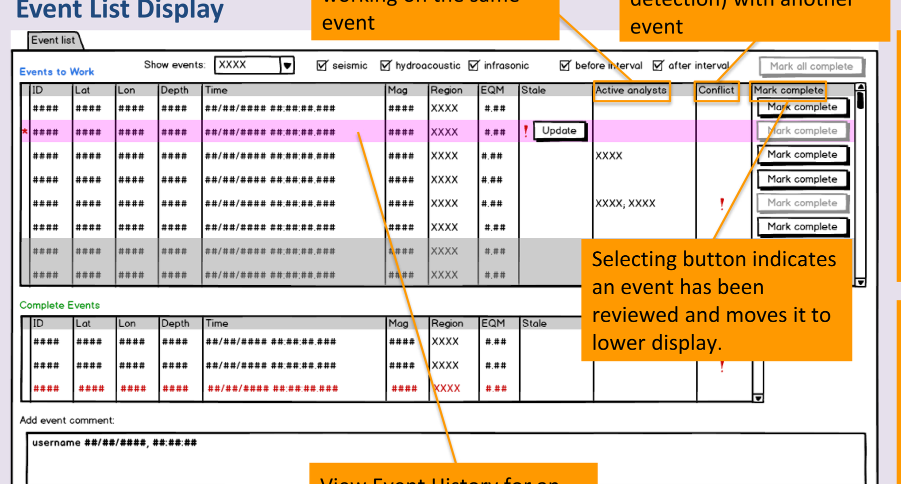
The process of developing the Storyboards was an iterative process between the Storyboard development team and the would-be users of the new UIs. The Storyboard development team came up with first drafts, showed these to the IDC experts to get feedback, made appropriate changes and generated new versions, showed these to the experts, etc. until both the development team and the experts were satisfied that the Storyboards captured the necessary information for a UI designer to have a sufficient understanding of what is needed to implement the UI described by a Storyboard.

The richest set of UIs in the IDC System are the Analysis Interfaces, and in this presentation, we show samples from some of the many Storyboards that cover this area. In the course of creating the Storyboards, we also identified several "common components" that show up in many of the Storyboards, and we include some of those here as well.

Event List, Event History, & Event Comparison

The primary job of an analyst is to review an existing set of events (either produced automatically by the System or manually by another analyst) and correct any errors or omissions: e.g. add missing detections, refine picks, relocate, etc. The **Event List Display** is a new component designed to make the event review process more efficient. Sometimes an analyst may be curious to understand the processing history of an event in the list. This can be viewed with the **Event History Display**. Viewing the history often can lead to questions about how the event differed at different processing stages. The **Event Comparison Display** allows the analyst to quickly and easily examine the differences.

Event List Display



Indicates other analysts working on the same event

Indicates conflict (shared detection) with another event

The Event List display has two sections:
- The Events to Work section contains events that the Analyst has not yet worked or that are in progress
- The Complete Events section contains events that the Analyst has already reviewed and that do not need more work

An event is moved from one list to another when the Analyst marks it as complete.

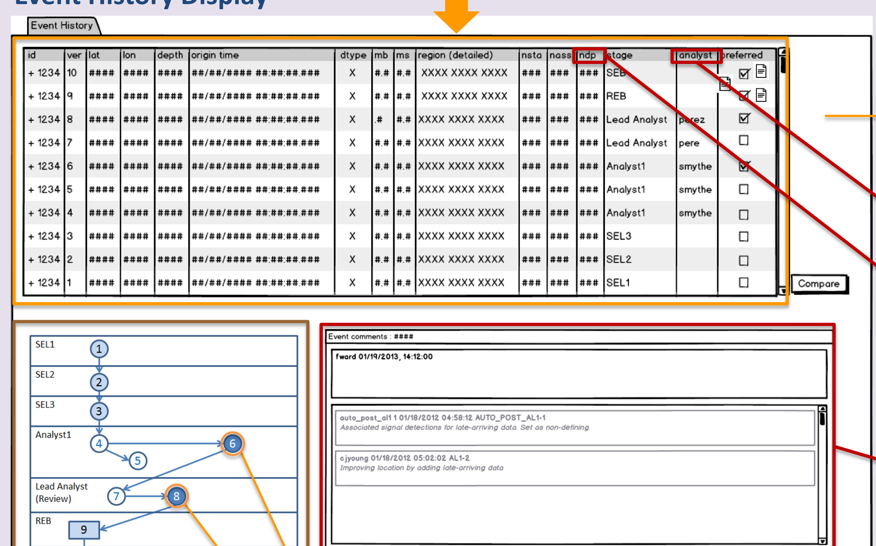
Selecting button indicates an event has been reviewed and moves it to lower display.

The Analyst double-clicks on an event in the list to open it for refinement. That event is then highlighted in the "open for refinement" color (pink here).

If displays are configured to synchronize, then opening an event for refinement causes other open displays (Waveforms, Map, etc.) to update and show information about the selected event.

View Event History for an event selected in Event List

Event History Display



In the event history display, a list shows all of the event solutions saved during processing. Click on the expansion ("+" to the left of each row in the list) to see all location solutions for a specific event solution.

Indicates which solution is preferred for a given processing stage

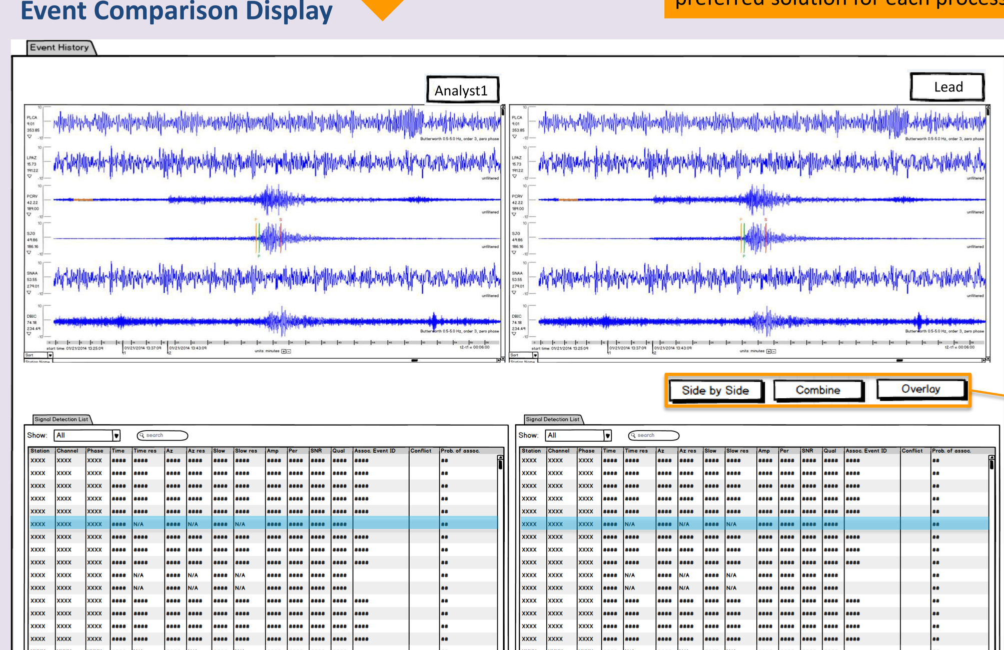
Indicates processing stage event was created in.

The event comment section shows the comments made during event processing. Comments are timestamped and attributed to a particular user. They are also tied to a specific event solution. Selecting a comment in the display will highlight the solution it applies to in the list above.

The event solutions are also shown in a "tree" to show how the event progressed through all processing stages. Note that there can be multiple versions and even branches within each processing stage. The dark shading indicates the preferred solution for each processing stage.

Select event versions for Event Comparison

Event Comparison Display



Waveforms and the signal detection list for the two different hypotheses come up side by side (default) and kept in sync. Selecting a detection on one side will automatically select the corresponding detection on the other side.

The correct filters, beams, etc. that were used for each version are shown.

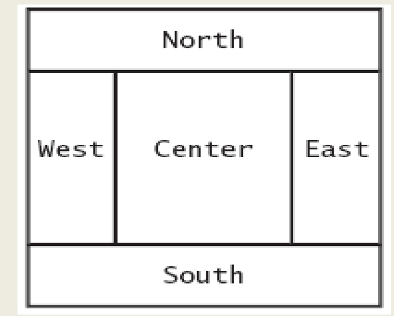
Other options for event comparison include Combine (interleaved waveforms) and Overlay (second event waveforms on top of first).

When a signal detection is selected in the waveform displays above, it also selected in the signal detection list, and vice versa.

Workspace Management (Common Component)

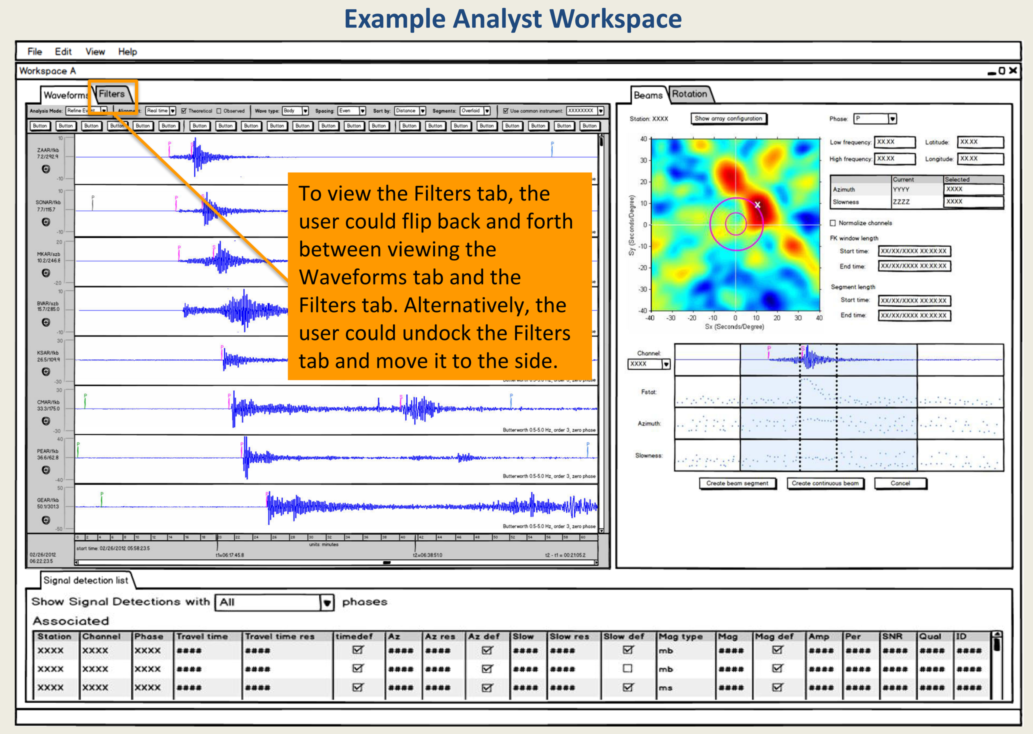
A workspace consists of one or more displays, each with a specific size and position on the screen.

- Each area can hold more than one display via a stacked tab approach (i.e., one display is visible at a time, switch tabs to see other displays).
- Each area can be resized to take up more or less of the overall display (e.g., by dragging edges vertically and/or horizontally).
- Not all areas need to be filled. Empty areas take no screen space.



Each area can hold more than one display via a stacked tab approach. The purpose of a workspace is to allow users to configure groups of displays into a preferred screen layout that helps them accomplish a specific goal. Users can configure multiple workspaces, where each workspace supports a different goal. For example, an Analyst might define one workspace to support building events, another for event location refinement. Display synchronization and undo/redo capabilities are managed within a workspace, but not across workspaces. Additional components can be added and managed, such as a map/GIS (for event display or PMCC pixel projection), a power spectral density (PSD) tool, or a spectrogram tool.

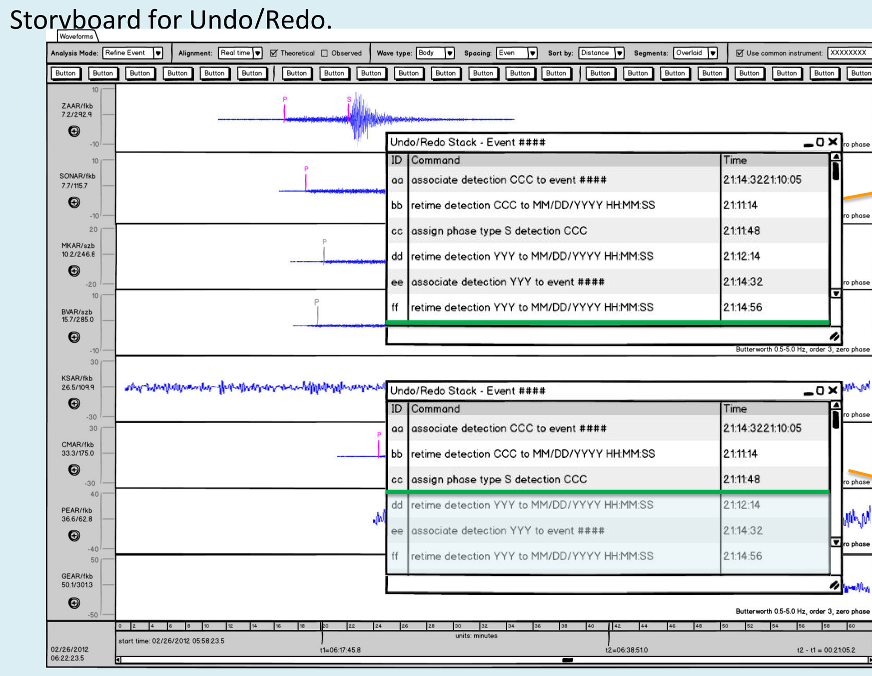
Example Analyst Workspace



To view the Filters tab, the user could flip back and forth between viewing the Waveforms tab and the Filters tab. Alternatively, the user could undock the Filters tab and move it to the side.

Undo/Redo (Common Component)

One of the most common requests from IDC analysts has been for an "undo/redo" capability, as is standard in most commercial software. This capability is conceptually simple, but in fact has significant implications for the System architecture due to the implied requirements for tracking commands as well as states. Shown below is part of our Storyboard for Undo/Redo.



The most recent action can be undone with a keystroke (e.g. Ctrl-z). This can be repeated to undo successive commands.

The analyst can also access a popup showing the Undo/Redo Stack Display. The current position is indicated with a green line.

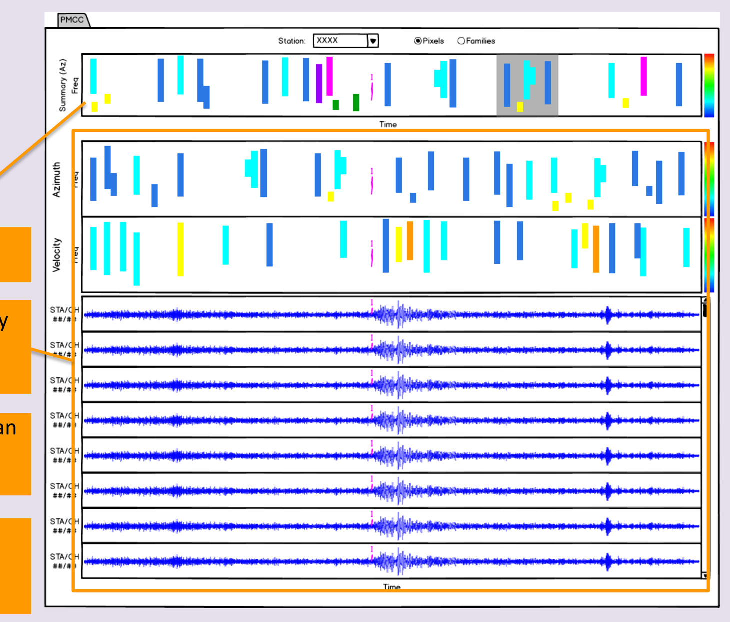
The analyst can jump all the way back to the state before a given command was applied by selecting that command. All of the displays will update accordingly (Waveforms, Map, Event List, etc.).

The green line will move back up to just below the last command that has not been undone. All the undone commands will be shaded to indicate they have not been applied, but can be by executing a "redo" to move forwards.

To limit the scope of information that must be tracked, the undo/redo stack is cleared when the analyst saves the event.

Progressive Multi-Channel Correlation (PMCC)

The IDC uses PMCC as its primary tool for detecting and characterizing infrasound signals. The IDC PMCC UIs are new and have gone through many iterations with analysts, so the content of our PMCC Storyboards is similar to the current tool, but with better integration into the analyst workspace.



Summary plot at top shows wave attribute (e.g. azimuth or velocity) over a configurable period of time vs frequency for a single selected station.

The analyst can select a smaller time window (gray shading) in the summary plot to see additional timeseries in the plots below: azimuth, velocity, and array channel waveforms.

Display can be configured show pixel families or individual pixels. Analyst can hover over a pixel in the plot to see additional information (e.g. azimuth value, frequency, etc.)

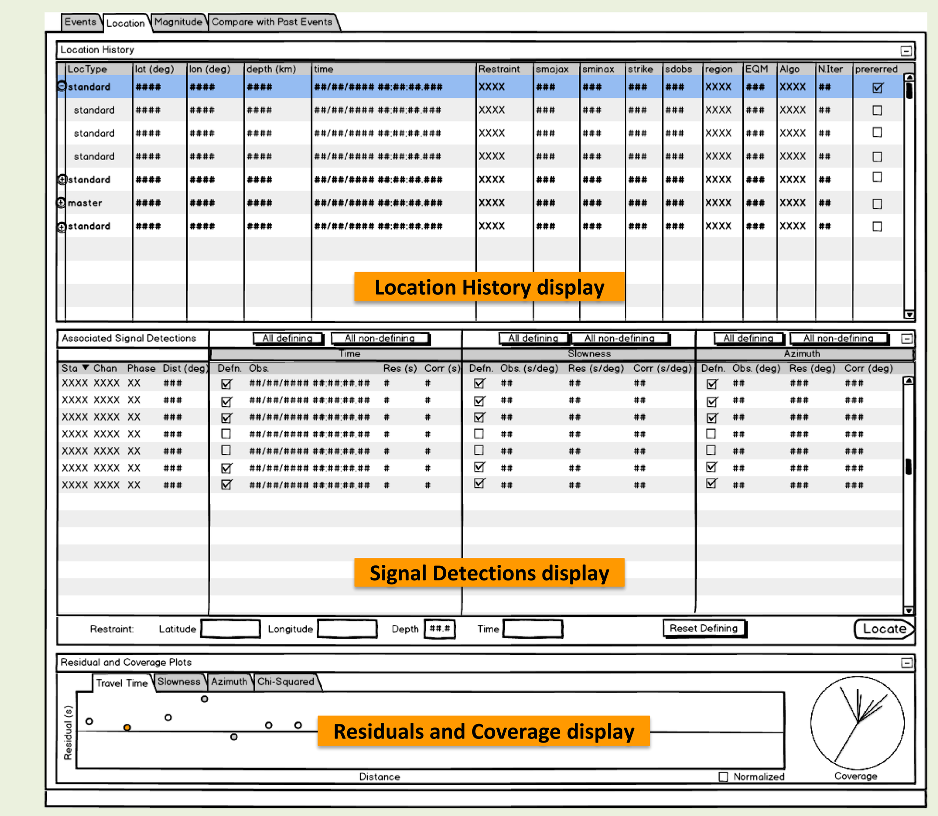
Analyst can also choose to display PMCC results on a polar plot (not shown here) to facilitate investigating azimuth/velocity ranges, e.g. identifying all detections coming from a known source..

Event Relocation

The process of refining an event often involves relocating the event multiple times as signal detections are added, deleted, and edited. Our Storyboard for the event relocation interface went through many iterations with IDC analysts to make sure all important functionality was captured and laid out in the most efficient manner.

The **Location History display** shows different location solutions for one event hypothesis. The columns in the table are configurable. The location solutions go back to the beginning of the Analyst session. When an event is saved the history is cleared out and a new event hypothesis row is added to the event history list. The preferred solution is visually indicated and is generally the top row in the table.

If a location solution is part of a depth constraint set (free, fixed to surface, etc.) a (+) button will be shown which the user can click on to expand to show the full set.



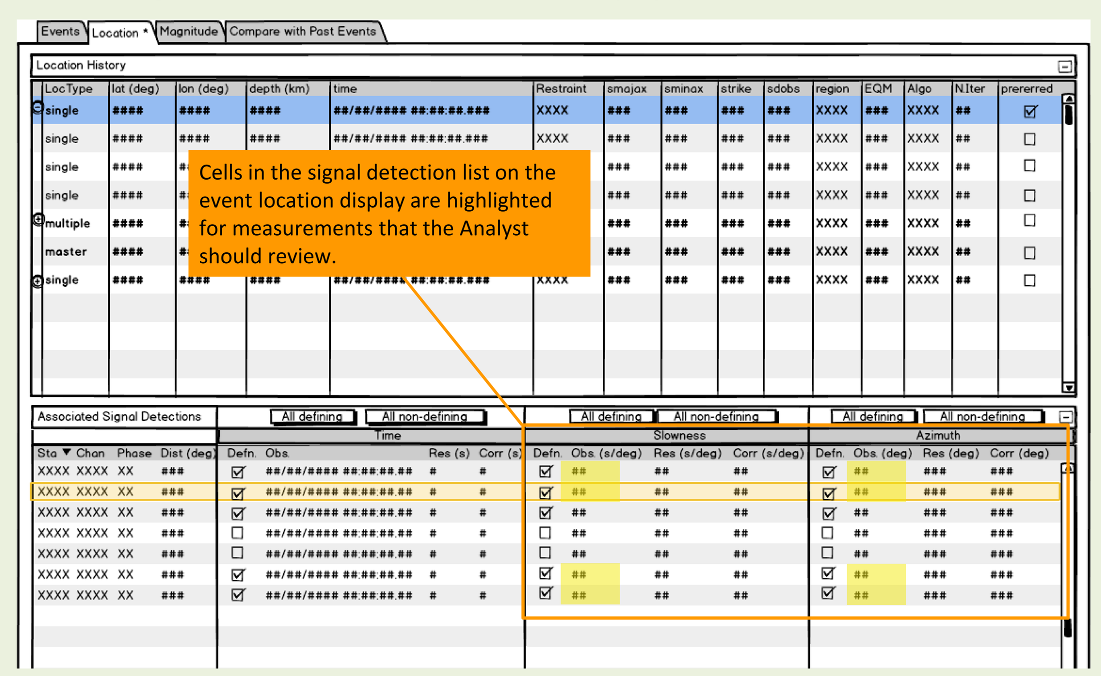
All signal detections associated to the event hypothesis are in the **Signal Detections display**:
- Listed by station, channel, phase, and distance from preferred event hypothesis
- Shows measurement values and residuals for time, azimuth, and slowness
- Provides selections for defining/non-defining state

The **Residuals and Coverage display** visually displays azimuthal coverage and residuals between observations and predictions for each signal detection.
The residuals plot can be zoomed and panned and the y-axis can be scaled.
Selecting a point on the residuals plot will select the corresponding row in the Signal Detections display and vice-versa.

FK and Polarization Measurements

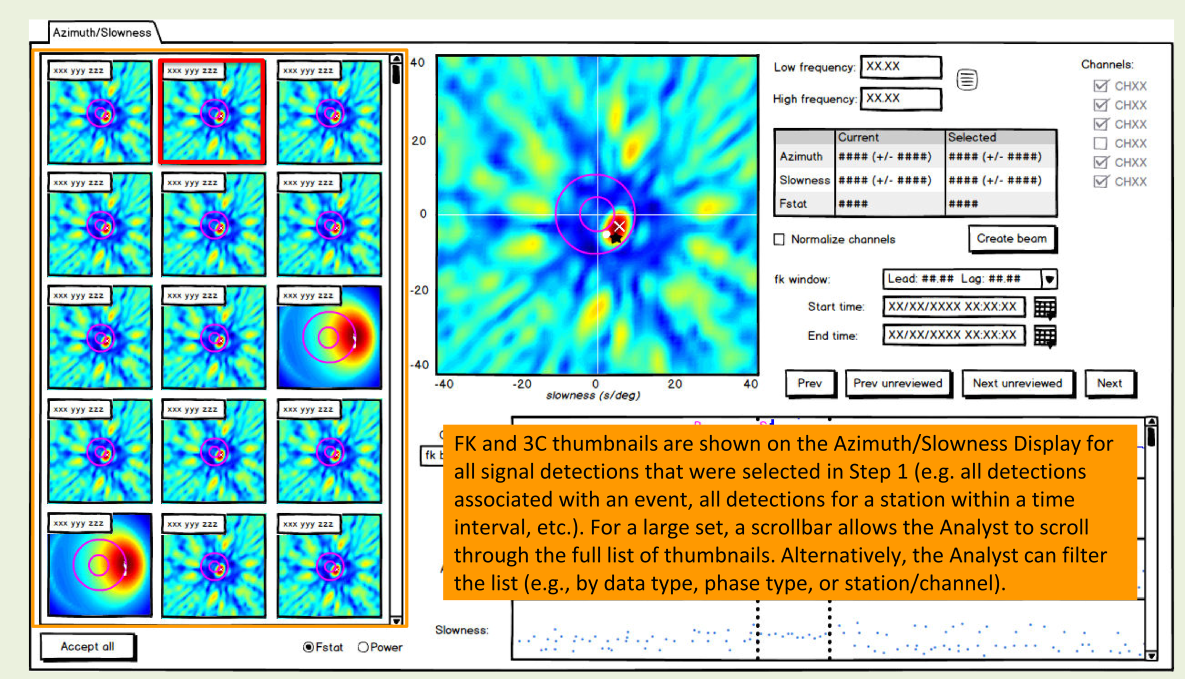
Analysts spend a lot of time using FK information for arrays and polarization information for 3-component (3C) stations to create and/or refine signal detections. Providing an interface that can make this process more efficient will have a significant impact on analyst productivity, so we worked extensively with analysts to come up with a new style of interface, which combines both types of information and allows an analyst to quickly and compare FK/3C information for a large set of detections.

1. Select Signal Detections to Review (Various Displays)



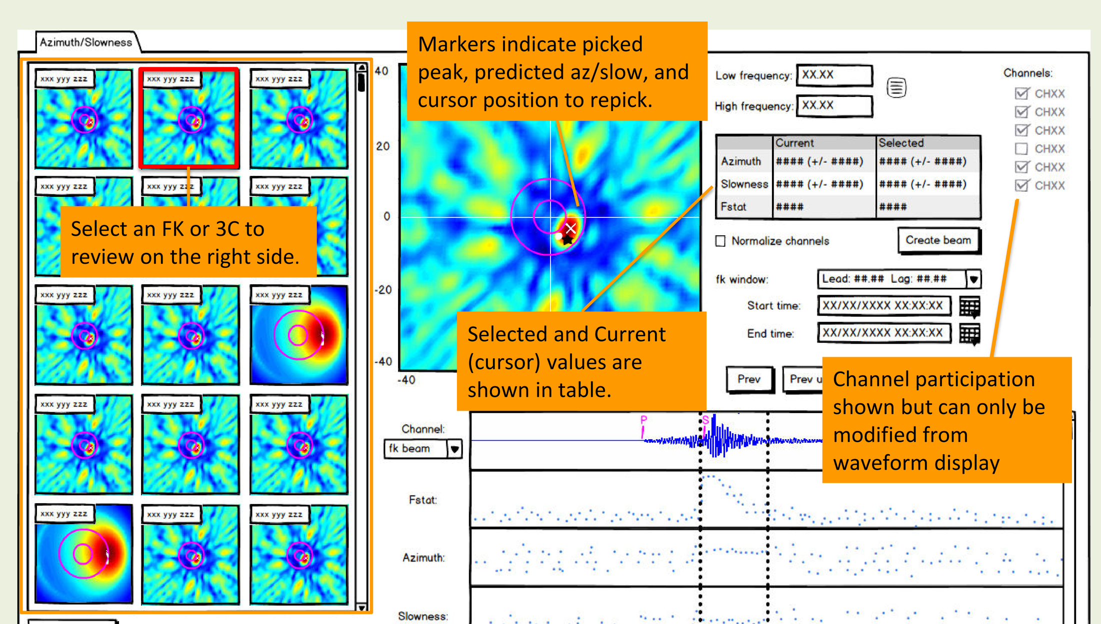
Cells in the signal detection list on the event location display are highlighted for measurements that the Analyst should review.

2. View Azimuth/Slowness Display (Both Arrays and 3C Stations)



FK and 3C thumbnails are shown on the Azimuth/Slowness Display for all signal detections that were selected in Step 1 (e.g. all detections associated with an event, all detections for a station within a time interval, etc.). For a large set, a scrollbar allows the Analyst to scroll through the full list of thumbnails. Alternatively, the Analyst can filter the list (e.g., by data type, phase type, or station/channel).

3. Select and Edit an FK or 3C



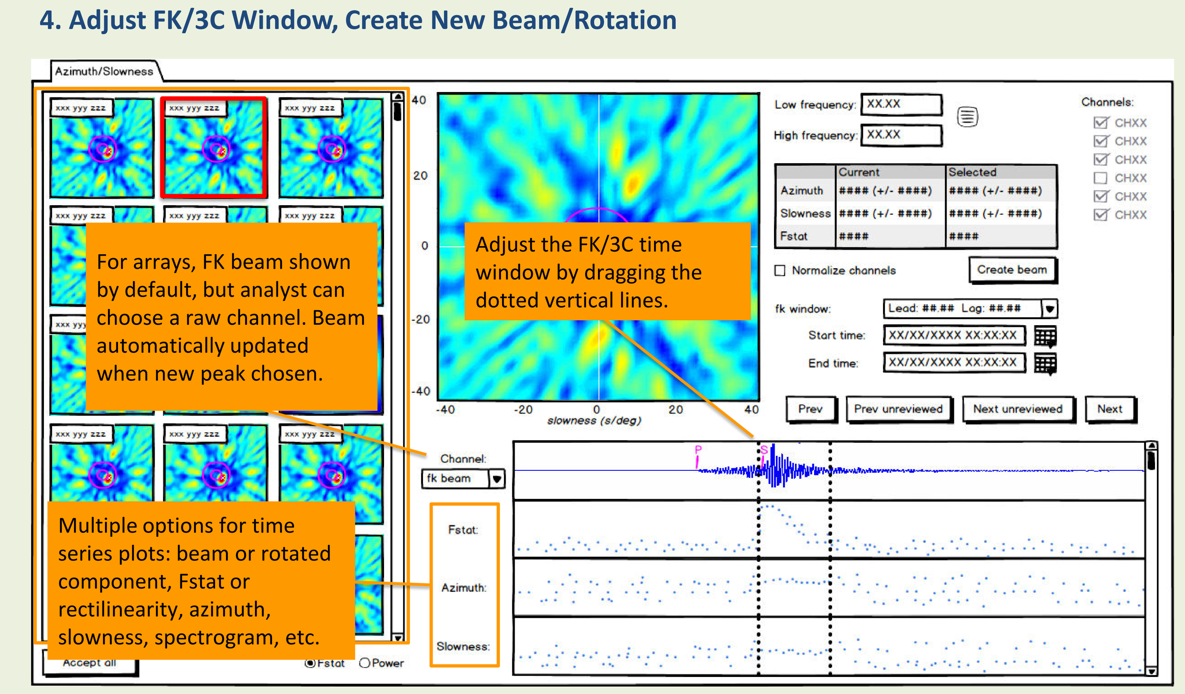
Markers indicate picked peak, predicted az/slow, and cursor position to repick.

Select an FK or 3C to review on the right side.

Selected and Current (cursor) values are shown in table.

Channel participation shown but can only be modified from waveform display

4. Adjust FK/3C Window, Create New Beam/Rotation



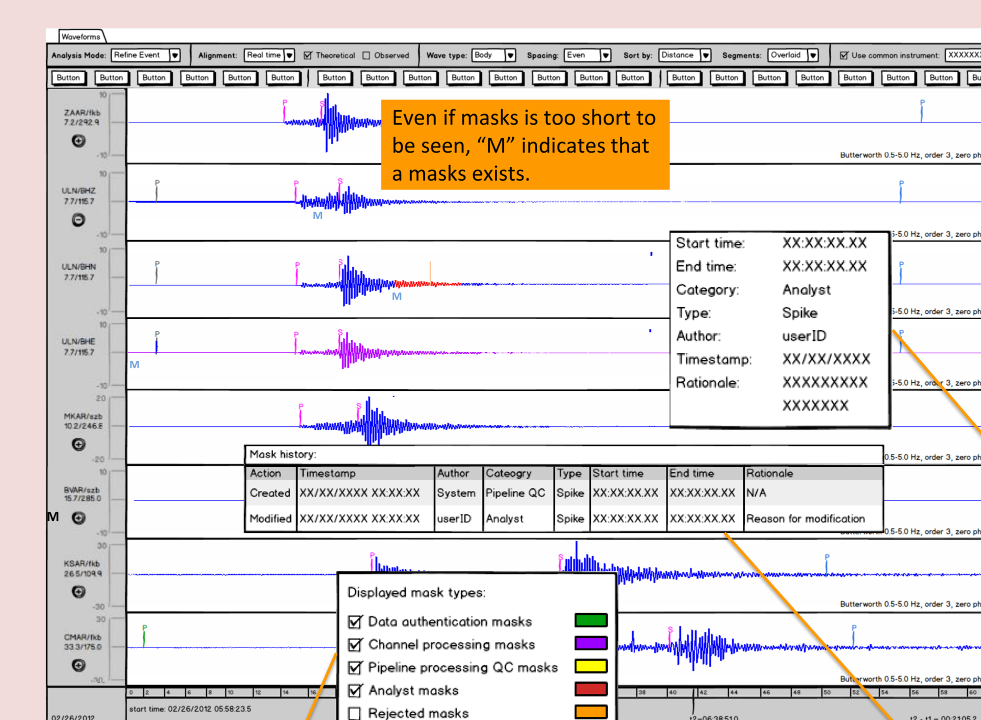
For arrays, FK beam shown by default, but analyst can choose a raw channel. Beam automatically updated when new peak chosen.

Adjust the FK/3C time window by dragging the dotted vertical lines.

Multiple options for time series plots: beam or rotated component, Fstat or rectilinearity, azimuth, slowness, spectrogram, etc.

Waveform Masking

Problems with waveforms (gaps, spikes, noisy channels, etc.) can corrupt data processing results and thus adversely effect the quality of the event catalog produced by the IDC. The System runs various algorithms to identify problematic data segments and creates masks that are available to the data processing algorithms to use. It is important for analysts to understand if masks are present in data they are reviewing and to be able to get details about why and when a mask was created. Below we show how analysts can view and interact with waveform masks.



Even if masks is too short to be seen, "M" indicates that a masks exists.

Masked portions of each waveform are highlighted on the main waveform display. Different categories of masks are displayed in different colors and a masked data badge appears underneath the waveform where the mask starts.

Hover or click on a mask to see a popup with more detailed information.

All types of masks are of interest to every analyst. Analysts can configure which categories of masks are shown on the waveform display, including masks that have been rejected.

Use a menu item or hotkey to view a history of modifications to that mask over time

What's Next: IDC Re-engineering Phase 3

During Phase 3 of the IDC Re-engineering Process, each of the UIs in our storyboards will be implemented by a software developer. Each storyboard will provide the developer with a good understanding of the information that the UI is supposed to present and of how the user will interact with that information to achieve a particular goal or set of goals. Having a clear sense of what the UI looks like and how it will work will make it possible for the developer to move much more quickly, without the risk of developing something that won't meet user needs. Because our storyboards were derived from use cases, which were in turn derived from IDC System specifications, we are confident the resulting UIs will meet the needs of the IDC. Further, because of the feedback we received by repeatedly reviewing storyboards with the potential users of the new UIs, we believe that the new interfaces will make IDC analysts more efficient than before, putting them in a better position to meet operational mission requirements when the CTBT enters into force.

CTBTO SnT2017 *The views expressed here do not necessarily reflect the views of the United States Government, the United States Department of Energy, the National Nuclear Security Administration, or Sandia National Laboratories. Sandia National Laboratories is a multi-mission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA-0003525.*