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IDC RE-ENGINEERING REPORT

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IDC Re-Engineering Phase 2 Iteration E2 Use Case Realizations

Version 1.2

J. Mark Harris, John F. Burns, Benjamin R. Hamlet, Randall R. Lober, James W. Vickers

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Abstract

This document contains 4 use case realizations generated from the model contained in Rational Software Architect. These use case realizations are the current versions of the realizations originally delivered in Elaboration Iteration 2.

REVISIONS

Version	Date	Author/Team	Revision Description	Authorized by
1.0	06/01/2016	SNL IDC Re-Engineering Team	Initial Release for E2	M. Harris
1.1	06/30/2016	SNL IDC Re-Engineering Team	Release for E2	M. Harris
1.2	12/16/2016	SNL IDC Re-Engineering Team	Release for the end of the Elaboration Phase	M. Harris

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IDC Use Case Realization Report

UCR-01.04 System Acquires Meteorological Data

Use Case Description

This architecturally significant use case describes how the System acquires meteorological data to build atmospheric models used in automatic and interactive processing of infrasound data. The System requests the latest available high-resolution global meteorological data from external data centers and puts them into the correct formats for generation of infrasound propagation models. The System forwards the meteorological data to other Data Acquisition Partitions in the System or stores the data for access and processing by the Data Processing Partition. The System builds a new atmospheric model based on the meteorological data.

This use case is architecturally significant because it describes acquiring meteorological data from various sources and creating dynamic atmospheric transmission models to support the prediction of infrasonic signal detections.

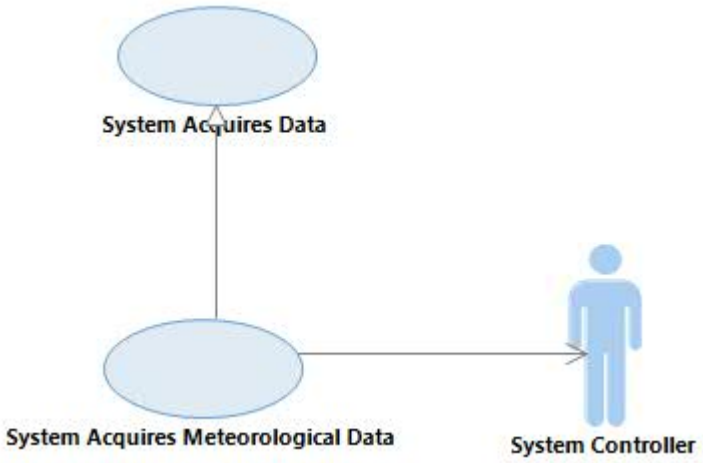
Architecture Description

The Meteorological Data Acquisition Control is the control class that coordinates the acquisition of meteorological data into the system. The Meteorological Data Acquisition Control reads an instance of Meteorological Data Acquisition Control Configuration from the OSD and requests new meteorological data at the configured time intervals. If configured, Meteorological Data Acquisition Control saves the data received from External Data Centers to the OSD before conversion to System Format Meteorological Data objects. The Meteorological Data Acquisition Control passes the data replies received from the External Data Centers to the Meteorological Data Format Converter utility class, which merges the raw data sets and creates an instance of the System Format Meteorological Data entity class.

Meteorological Data Acquisition Control then stores the System Format Meteorological Data in the OSD. Based on configuration for its partition, Meteorological Data Acquisition Control registers for OSD callbacks about newly stored System Format Meteorological Data objects. When it receives this callback, Meteorological Data Acquisition Control passes the System Format Meteorological Data to the Atmospheric Model Plugin through the Meteorological Data Update Plugin IF Interface. The Atmospheric Model Plugin uses the System Format Meteorological Data it receives to build an atmospheric model with possible additional processing such as gravity wave corrections. The Atmospheric Model Plugin provides access to its model, which can be used for infrasound signal propagation predictions (see 'System Predicts Signal Features' UCR), through the Earth Model Plugin interface.

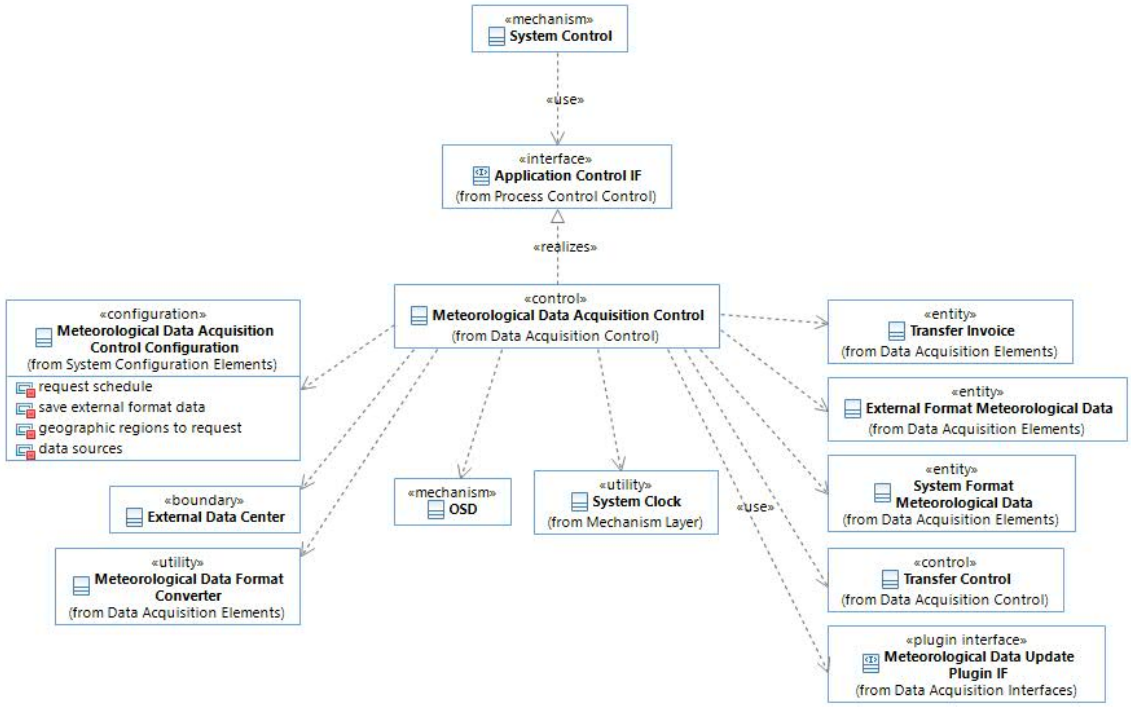
Based on configuration, a System Clock callback periodically stimulates Transfer Control to upload the System Format Meteorological Data to other Data Acquisition Partitions.

Use Case Diagram



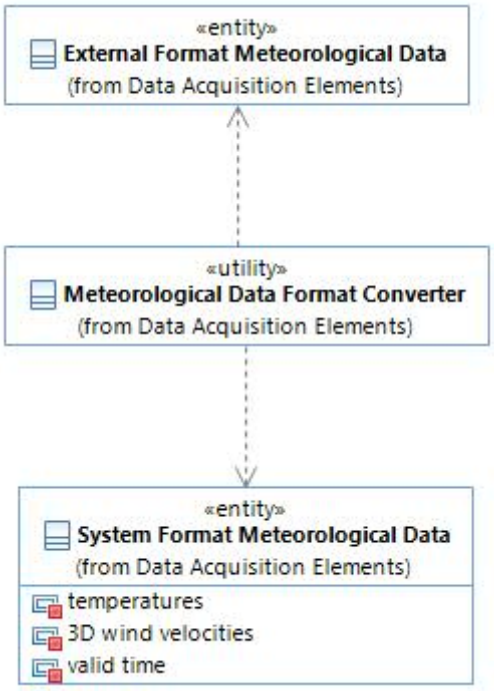
Class Diagrams

Classes - Meteorological Data Acquisition Control



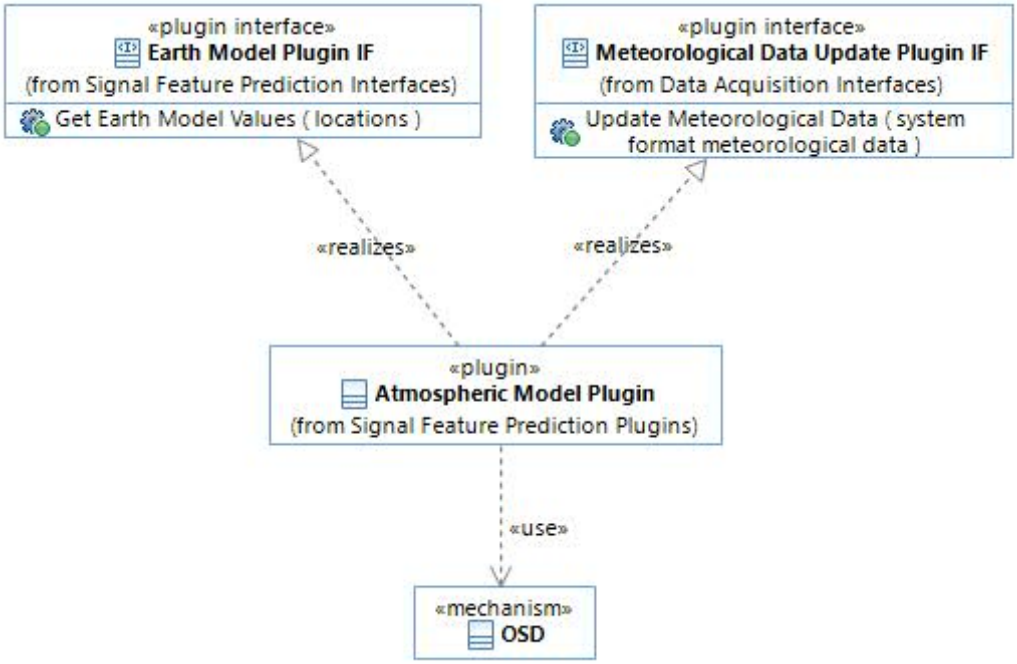
This class diagram depicts the Meteorological Data Acquisition Control class and classes it interacts with to request, acquire, and process External Format Meteorological Data from an External Data Center. Meteorological Data Acquisition Control requests updated data from an External Data Center when stimulated by the System Clock, uses Meteorological Data Format Converter to convert the received data into a System Format Meteorological Data, and then uses Transfer Control to forward the System Format Meteorological Data to other Data Acquisition Partitions.

Classes - Meteorological Data Formats and Format Conversion



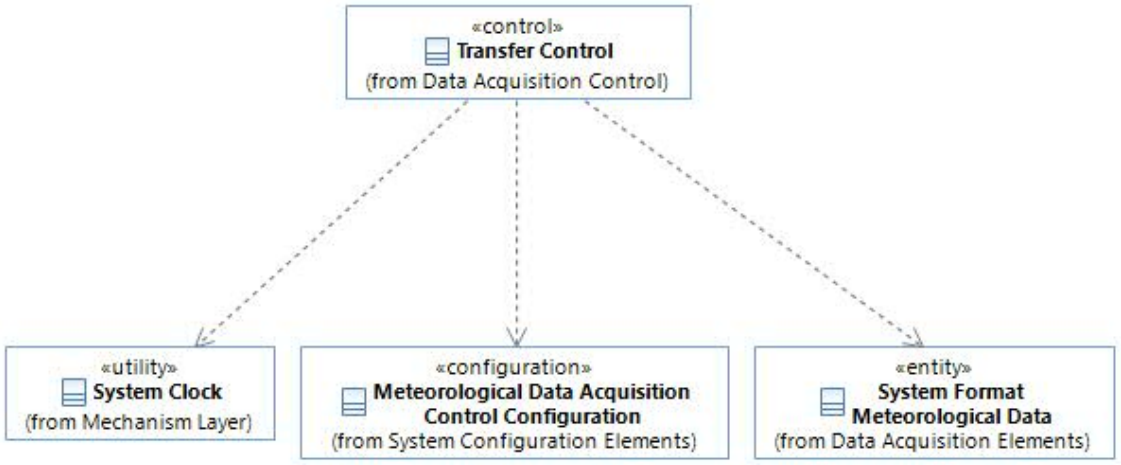
This diagram shows the classes that represent meteorological data in differing external and internal System formats and the Meteorological Data Format Converter utility that converts from the External Meteorological Data format to the System Format Meteorological Data. There are two different formats of Meteorological Data because the format the System receives from an External Data Center may differ from the internal representation. Meteorological Data Acquisition Control uses this utility to convert formats when it acquires data in the External Meteorological Data format.

Classes - Atmospheric Model Plugin



This diagram shows the Atmospheric Model Plugin and the two plugin interfaces it realizes. Atmospheric Model Plugin provides a kind of earth model by realizing the Earth Model Plugin IF interface and updates that model via the Meteorological Data Update Plugin IF interface.

Classes - Transfer Control



This diagram shows the Transfer Control class and other classes it uses when transferring System Format Meteorological Data between Data Acquisition Partitions. System Clock periodically stimulates Transfer Control via a callback to requests a data transfer. Transfer Control uses the Meteorological Data Acquisition Configuration to determine which System Format Meteorological Data to transfer to which other Data Acquisition Partitions.

See ‘System Receives Station Data’ UCR for further details about how transfers occur, how

transfers are verified to complete successfully, and how failed transfers are retried either automatically or interactively.

Class Descriptions

<<boundary>> External Data Center
Represents an external data center.

<<configuration>> Meteorological Data Acquisition Control Configuration
Represents configuration information such as whether to save external format data, meteorological data sources to request from, how often to request data, what data to request (geographic regions).

<<control>> Meteorological Data Acquisition Control
Responsible for coordinating the acquisition and storage (via the OSD) of meteorological data in the System, and for updating an atmospheric model via the Meteorological Data Update Plugin IF Interface.

<<control>> Transfer Control
Responsible for transfer of data (e.g. Raw Station Data Frames, meteorological data, bulletins, etc.) between Data Acquisition Partitions. A separate instance runs on both partitions to coordinate the transfer.

<<entity>> External Format Meteorological Data
Represents meteorological data in the original format provided by an External Data Center (e.g. GRIB2 format). This data includes temperatures, 3D wind velocities, metadata about format, and a time for which the data is considered valid. Meteorological Data Format Converter converts this data into a System Format Meteorological Data object.

<<entity>> System Format Meteorological Data
Represents meteorological data in the internal format stored on the System and used by Meteorological Data Update Plugin IF to update an Atmospheric Model Plugin.

<<entity>> Transfer Invoice
A list of transferred data (e.g. Raw Station Data Frames, System Format Meteorological Data) between Data Acquisition Partitions, and information about previous transfers.

<<interface>> Application Control IF
Defines the interface implemented by all <<control>> classes in the system that are controlled by System Control.

<<mechanism>> OSD
Represents the Object Storage and Distribution mechanism for storing and distributing data objects internally within the system.

<<plugin interface>> Earth Model Plugin IF
Standard interface for all Earth Model plugins. All Earth Model plugins in the system realize

this interface.

<<plugin interface>> Meteorological Data Update Plugin IF
This interface allows a class to take an update to the meteorological data it uses. If necessary, the plugin is responsible for storing updated information (e.g. an updated atmospheric model) in the OSD.

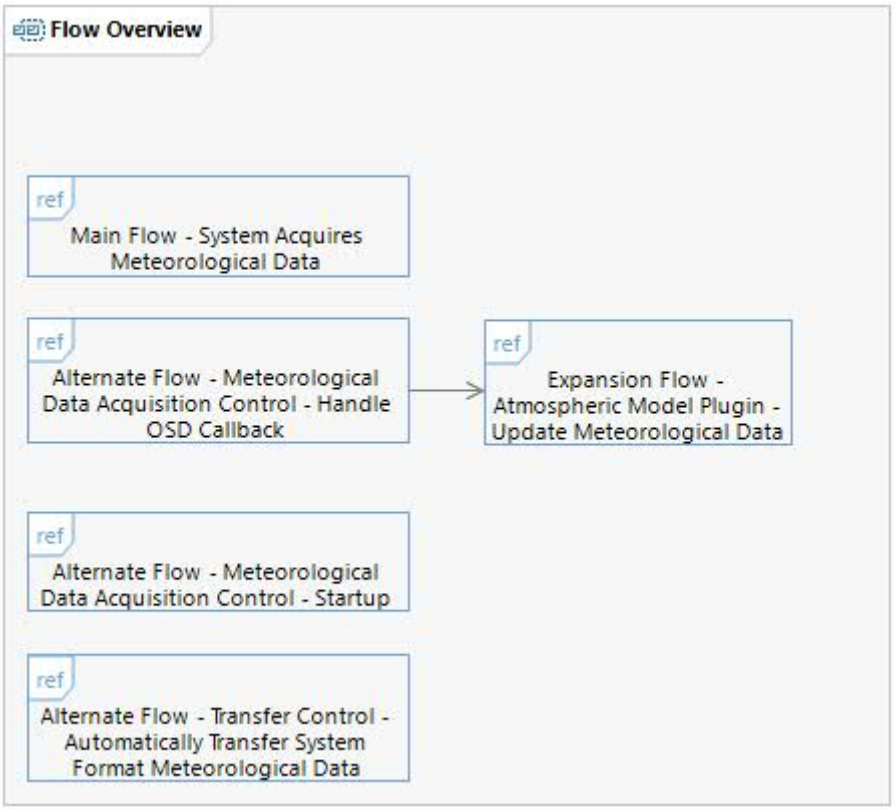
<<plugin>> Atmospheric Model Plugin
Provides atmospheric data by implementing the Earth Model Plugin interface. This atmospheric data includes, but is not limited to 3D wind velocity and temperature at varying altitudes ranging from 0km to 140 km above sea level. The model this plugin provides may also contain gravity wave corrections made to temperature predictions and wind velocities. The Atmospheric Model Plugin may periodically update its atmospheric model when it receives new meteorological data via the Meteorological Data Update Plugin IF interface. Atmospheric Model Plugin is responsible for storing the updated model in the OSD.

<<utility>> Meteorological Data Format Converter
Responsible for converting data received from External Data Centers in the External Meteorological Data format into the System Meteorological Data Format. May merge meteorological data from multiple data centers (e.g. data for different altitude ranges; data for different geographic regions) when creating the System Meteorological Data Format object. The format conversion includes a coordinate system to translate to (e.g. altitude-coordinate).

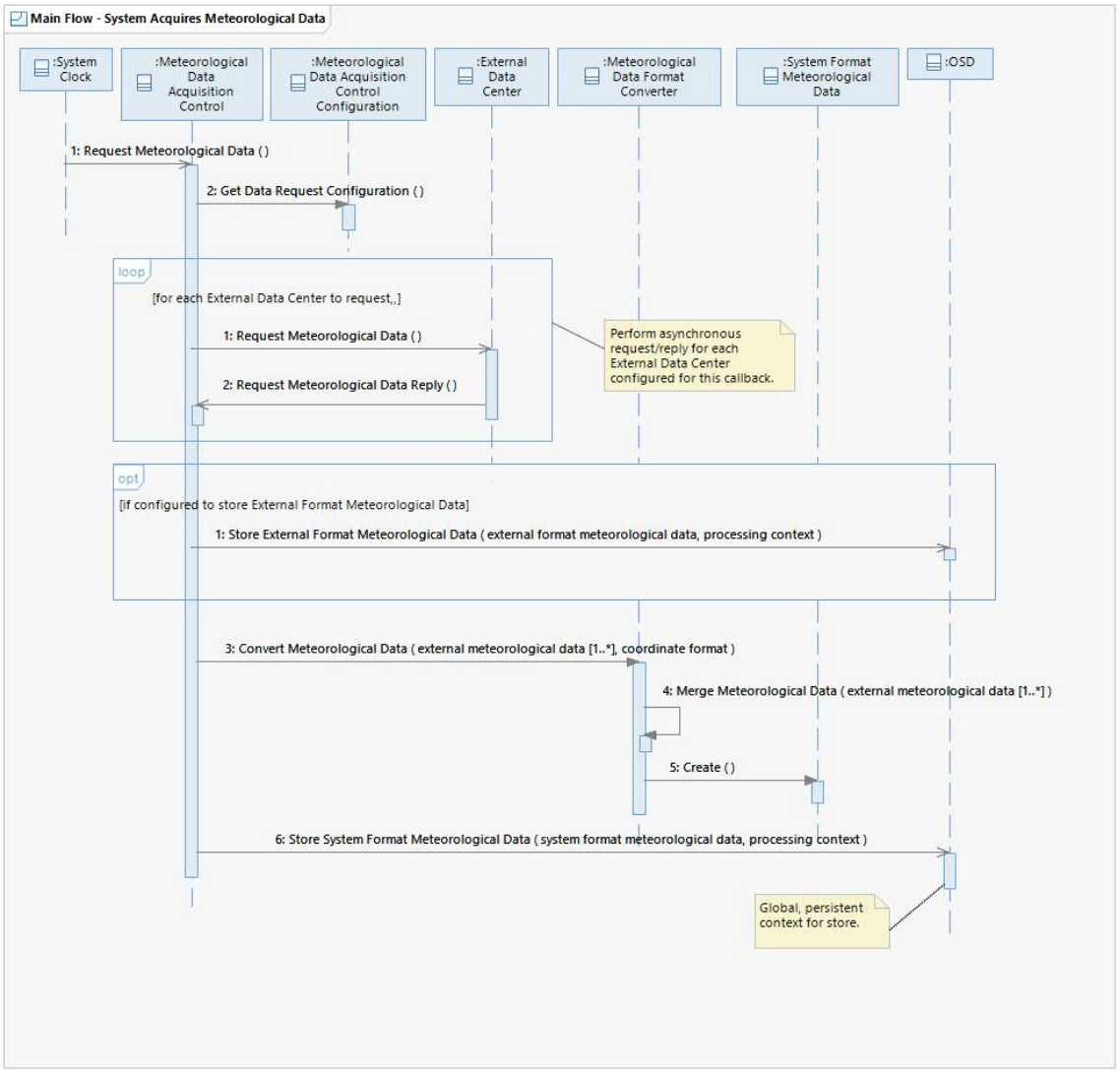
<<utility>> System Clock
Represents the mechanism to schedule, reschedule, and cancel callbacks.

Sequence Diagrams

Flow Overview



Main Flow

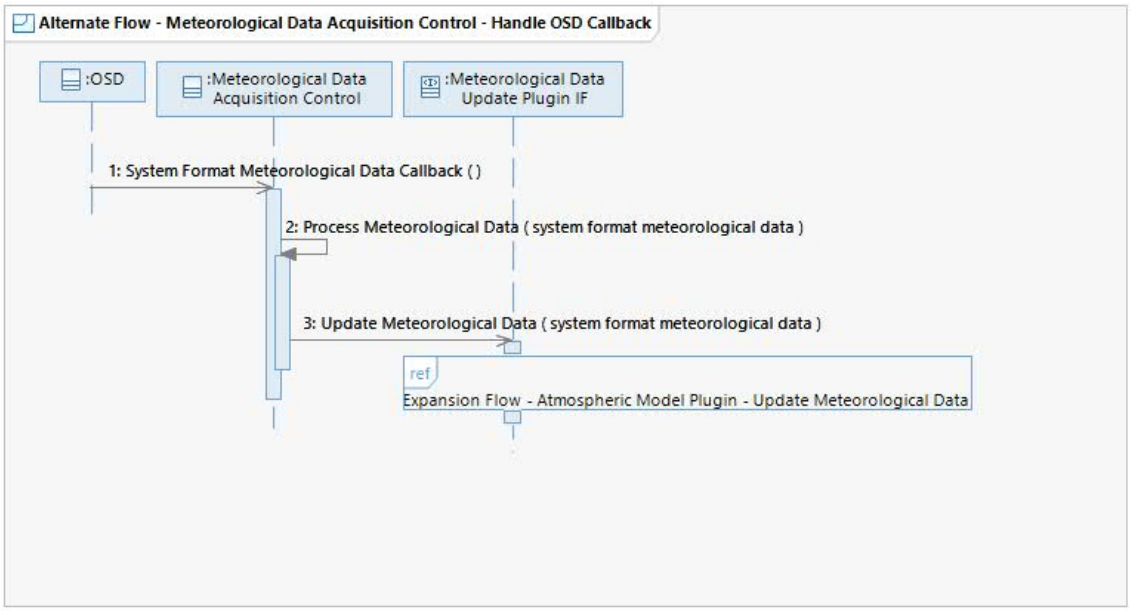


This flow shows how the Meteorological Data Acquisition Control responds to a callback from the System Clock to acquire External Format Meteorological Data from External Data Centers in order to convert, merge, and store the acquired data as a System Format Meteorological Data object. Once stored, the System Format Meteorological Data object is available for upload to other partitions (see "Alternate Flow - Transfer Control - Automatically Transfer System Format Meteorological Data"), further processing to update an Atmospheric Model (see "Alternate Flow - Meteorological Data Acquisition Control - Handle OSD Callback"), or distribution to other Subsystems, External Data Centers, and Authorized External Users (see 'System Automatically Distributes Data' UCR).

Operation Descriptions

None

Alternate Flow - Meteorological Data Acquisition Control - Handle OSD Callback

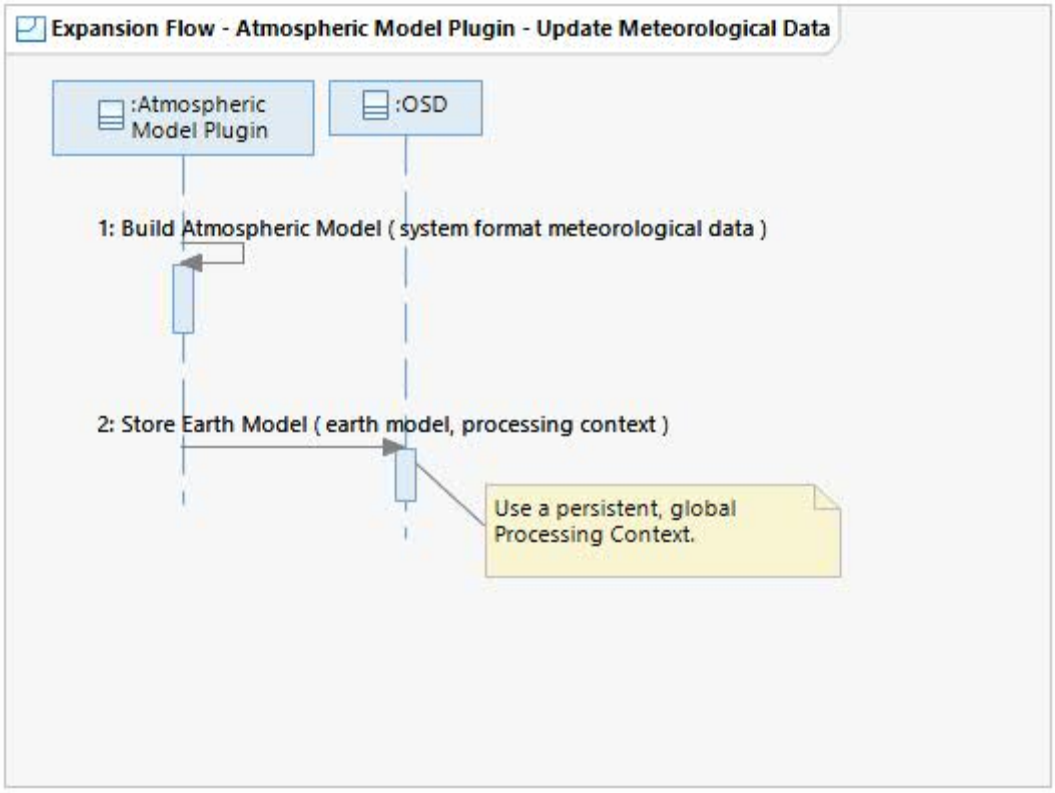


This flow depicts how the Meteorological Data Acquisition Control handles a callback from the OSD to process System Format Meteorological Data. Meteorological Data Acquisition Control updates an Atmospheric Model Plugin with the System Format Meteorological Data via the Meteorological Data Update Plugin IF.

Operation Descriptions

Operation: Meteorological Data Update Plugin IF::Update Meteorological Data()
Provides new meteorological data to an Atmospheric Model Plugin. The plugin applies gravity corrections if required to the model at this time. The plugin is responsible for storing the updated atmospheric model in the OSD.

Expansion Flow - Atmospheric Model Plugin - Update Meteorological Data

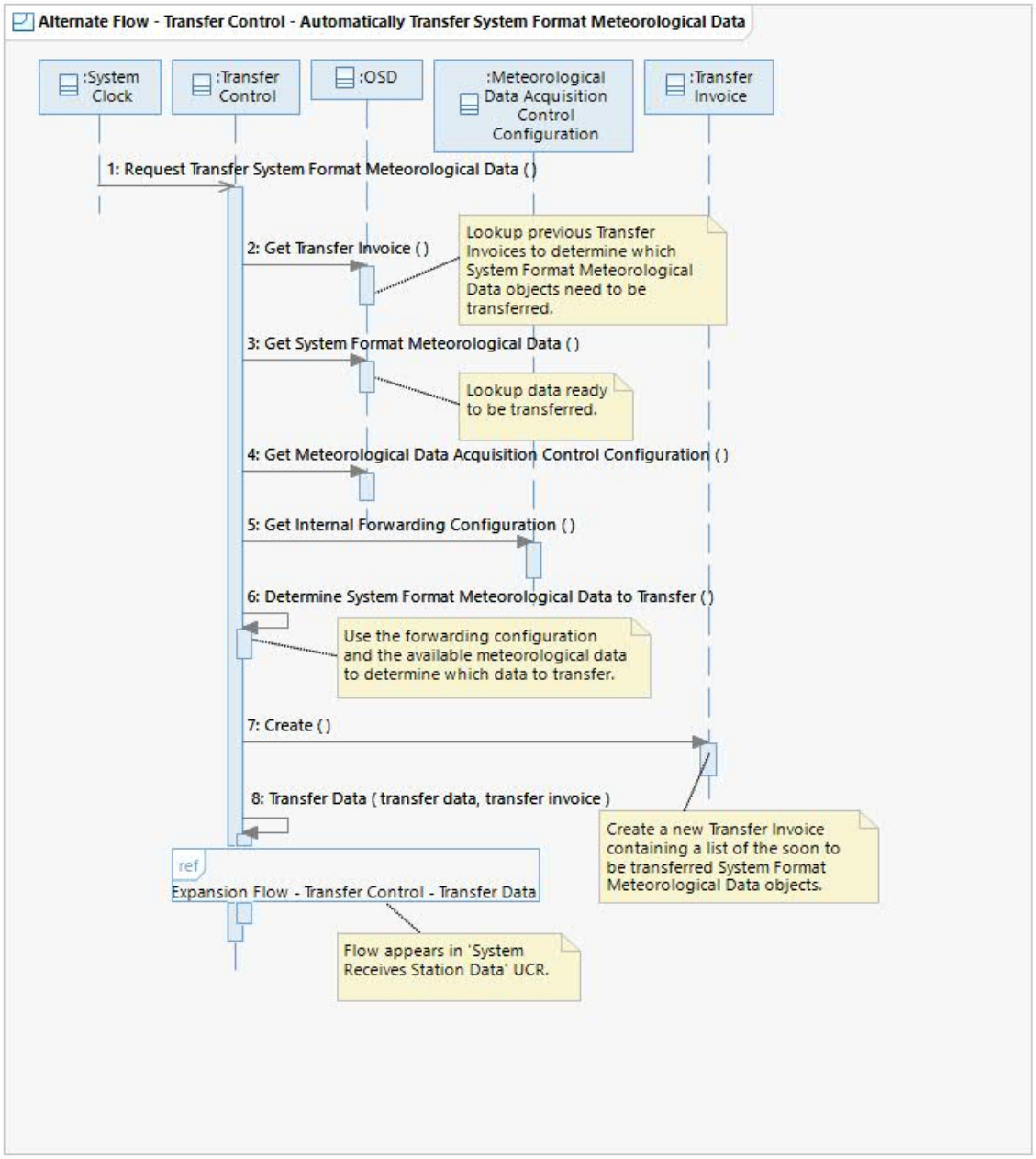


This is a notional flow showing an Atmospheric Model Plugin implementation is responsible for updating its atmospheric model (which it exposes as a realization of the Earth Model Plugin IF interface) with new meteorological data and storing the updated model in the OSD.

Operation Descriptions

None

Alternate Flow - Transfer Control - Automatically Transfer System Format Meteorological Data

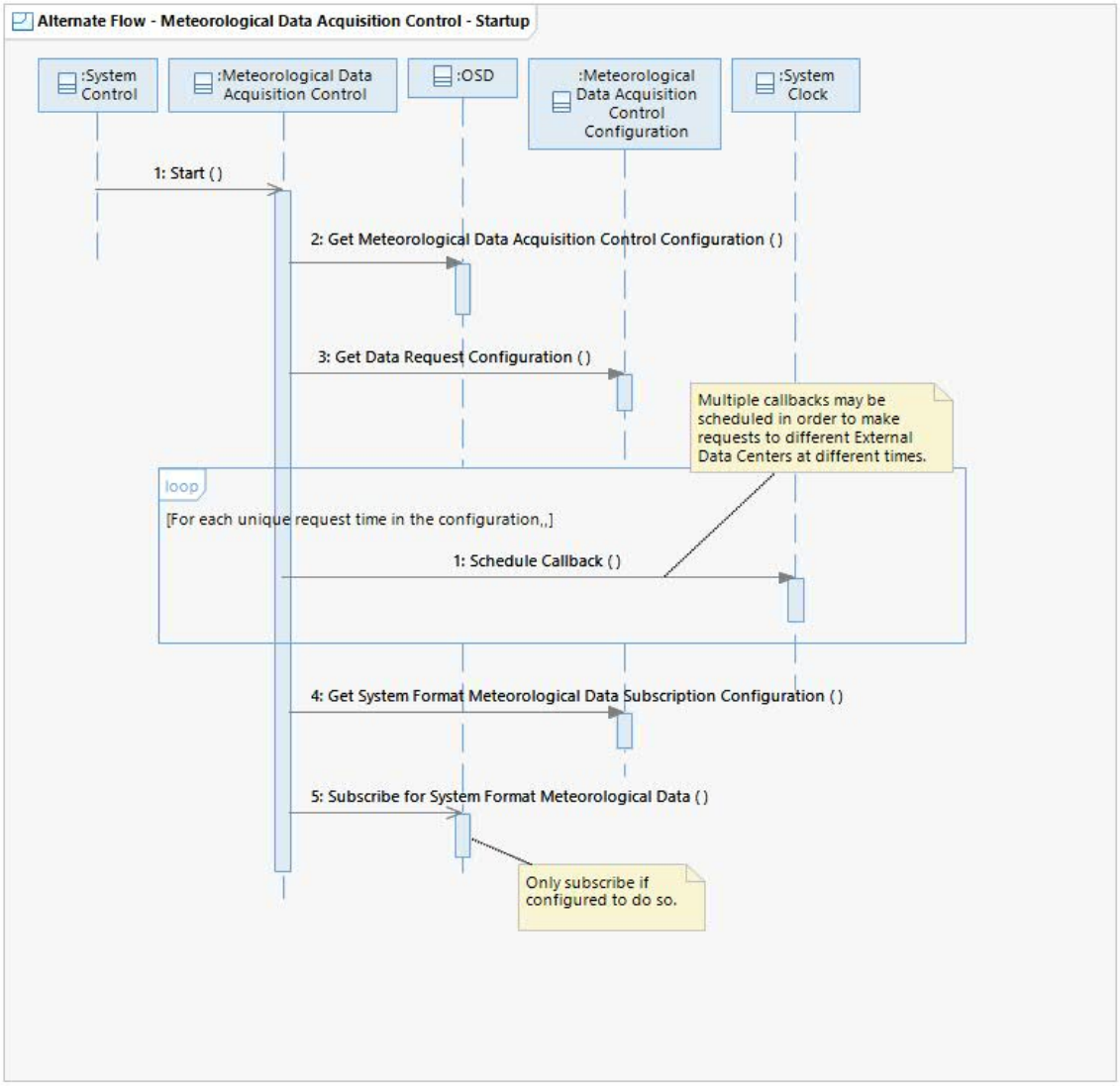


This flow is only performed on the sending Data Acquisition Partition. The Transfer Control class periodically transfers System Format Meteorological Data from the sending Data Acquisition Partition to the receiving Data Acquisition Partition.

Operation Descriptions

None

Alternate Flow - Meteorological Data Acquisition Control - Startup



This flow shows how Meteorological Data Acquisition Control starts when requested by System Control. Meteorological Data Acquisition Control uses the OSD to get configuration describing from which External Data Centers it will request meteorological data and how often to make those requests. Meteorological Data Acquisition Control registers for System Clock callbacks at the time intervals it will request data. Depending on configuration, Meteorological Data Acquisition Control subscribes for OSD callbacks when System Format Meteorological Data is stored in the OSD so it can further process the meteorological data (e.g., by updating an earth model, see "Alternate Flow - Meteorological Data Acquisition Control - Handle OSD Callback").

Operation Descriptions

None

State Machine Diagrams

None

SSD Mappings

General:

S-5623: [*Threshold*] The system shall request global meteorological data (3D wind, temperature and uncertainties) from specified sources spanning the altitude range of 0 km (sea level) to 140 km above sea level.

S-5624: [*Threshold*] The system shall convert global meteorological data received in pressure coordinate format into altitude coordinate format.

S-5652: [*Extensibility*] The System shall compute corrections to wind velocity predictions based on a model for atmospheric gravity waves.

S-5653: [*Extensibility*] The System shall compute corrections to atmospheric temperature predictions based on a model for atmospheric gravity waves.

S-5654: [*Threshold*] The system shall compute an infrasound propagation model using gravity wave corrected wind velocity and atmospheric temperature predictions.

S-5656: [*Objective / Priority 1*] The system shall compute an infrasound propagation model that incorporates high resolution meteorological data.

S-5714: [*Threshold*] The System shall store global meteorological data.

S-5717: [*Extensibility*] The System shall store gravity wave corrections to temperature predictions.

S-5759: [*Objective / Priority 1*] The System shall request global meteorological data from specified sources within 10 minutes of its availability.

Notes

General:
1. One example of a meteorological format that the External Meteorological Data class could represent is GRIB2. GRIB2 is a file format used for storage and transport of gridded meteorological data. For more information about GRIB2 see: https://weather.gc.ca/grib/what_is_GRIB_e.html.

2. This UCR stores different meteorological data items on different System partitions. Based on configuration, the Data Acquisition Partition may store External Format Meteorological Data

received by the System from External Data Centers. Each Data Acquisition Partition stores the System Format Meteorological Data. The Atmospheric Model is stored by the Atmospheric Model Plugin which runs on the Data Processing Partition.

3. UCR 01.06 "System Synchronizes Processing Results" handles the synchronization of the Atmospheric Model and System Format Meteorological Data between the Primary and Backup Subsystems.

4. Depending on Transfer Control Configuration, Transfer Control will either automatically retransmit missing meteorological data from the sending Data Acquisition Partition to the receiving Data Acquisition Partition or notify the System Controller of the missing data so the System Controller can manually request a retransfer using “Alternate Flow - System Controller Requests Transfer of Missing Data" in System Receives Station Data UCR.

5. This Use Case Realization uses some common behavior and flows from “System Receives Station Data” UCR for handling the transfer of data between Data Acquisition Partitions.

6. Current meteorological models extend to 80km; to get to 140km will require merging data sets and possibly additional requests.

IDC Specific:
1. The IDC requests meteorological data from External Data Centers with frequency on the order of hours. The IDC converts the data to the System Format Meteorological Data and then provides it to subscribers (see 'System Automatically Distributes Data' UCR).

2. External Data Center is currently the ATM system. In the future, the External Data Center's may be actual meteorological data centers.

IDC Use Case Realization Report

UCR-02.06 System Builds Events using Signal Detections

Use Case Description

This architecturally significant use case describes how the System uses signal detections and features measured from those signal detections to build single station event hypotheses, build network event hypotheses, and associate previously unassociated signal detections to existing event hypotheses.

To build an event hypothesis, the System associates signal detections from one or more seismic, hydroacoustic, or infrasound stations. The System builds event hypotheses meeting predefined event formation criteria and associates previously unassociated signal detections to existing event hypotheses using signal detections, feature measurements based on those signal detections (see 'System Measures Signal Features' UC), and single station signal detection groups. The System references empirical knowledge from past events and geophysical models when forming event hypotheses and when associating previously unassociated signal detections to existing event hypotheses. The System makes signal detection phase assignments using information available when considering signal detections in the context of event hypotheses. The System validates event hypotheses and phase assignments using empirical and geophysical model based parameters. The System computes quality metrics for all event hypotheses.

The System Maintainer configures the phase assignment parameters, signal detection association parameters, and event hypothesis quality metric parameters (see 'Configures Processing Components' UC). The Analyst has the option to select values for these parameters during interactive review (see 'Builds Event' UC).

This use case may initiate reprocessing of earlier analysis steps such as signal enhancement (see 'System Enhances Signals' UC), signal detection (see 'System Detects Signals' UC) and signal feature measurement (see 'System Measures Signal Features' UC) if an iterative, feedback-based processing sequence is implemented.

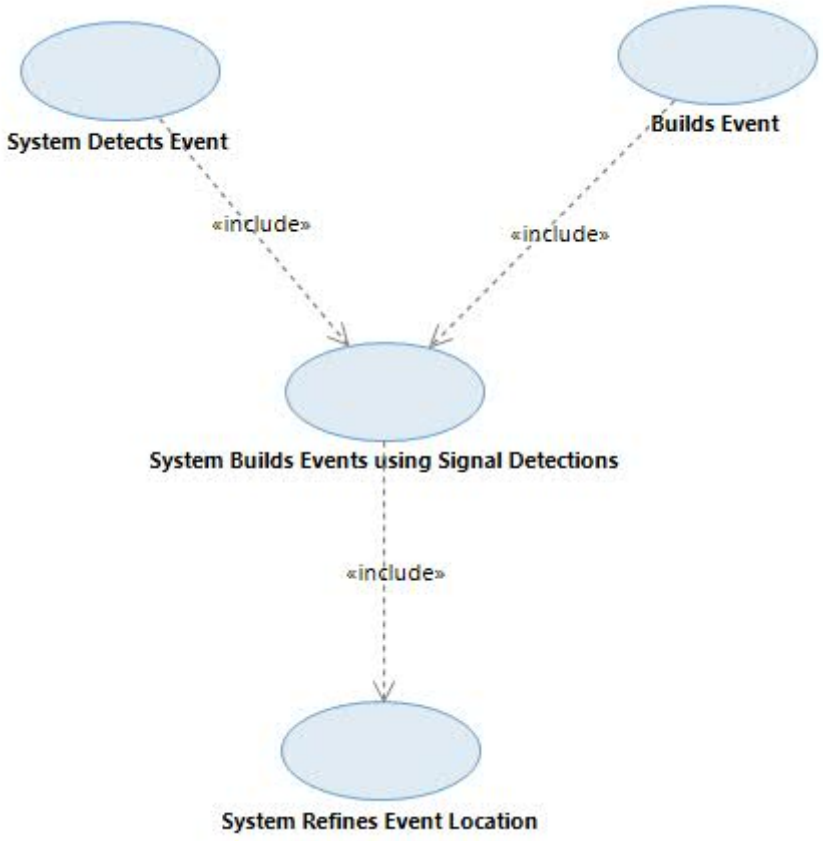
This use case is architecturally significant because it involves complex algorithms for automatically building and modifying events.

Architecture Description

The Signal Detection Association Control class is responsible for controlling computations that associate signal detections to build new event hypotheses or update existing event hypotheses. Signal Detection Association Control may be invoked by Processing Sequence Control as part of executing a step in a Processing Sequence (see 'System Detects Event' UCR) or be manually invoked by an Analyst as part of building an event (see 'Builds Events' UCR). Signal Detection Association Control uses a Signal Detection Associator Plugin to perform the association

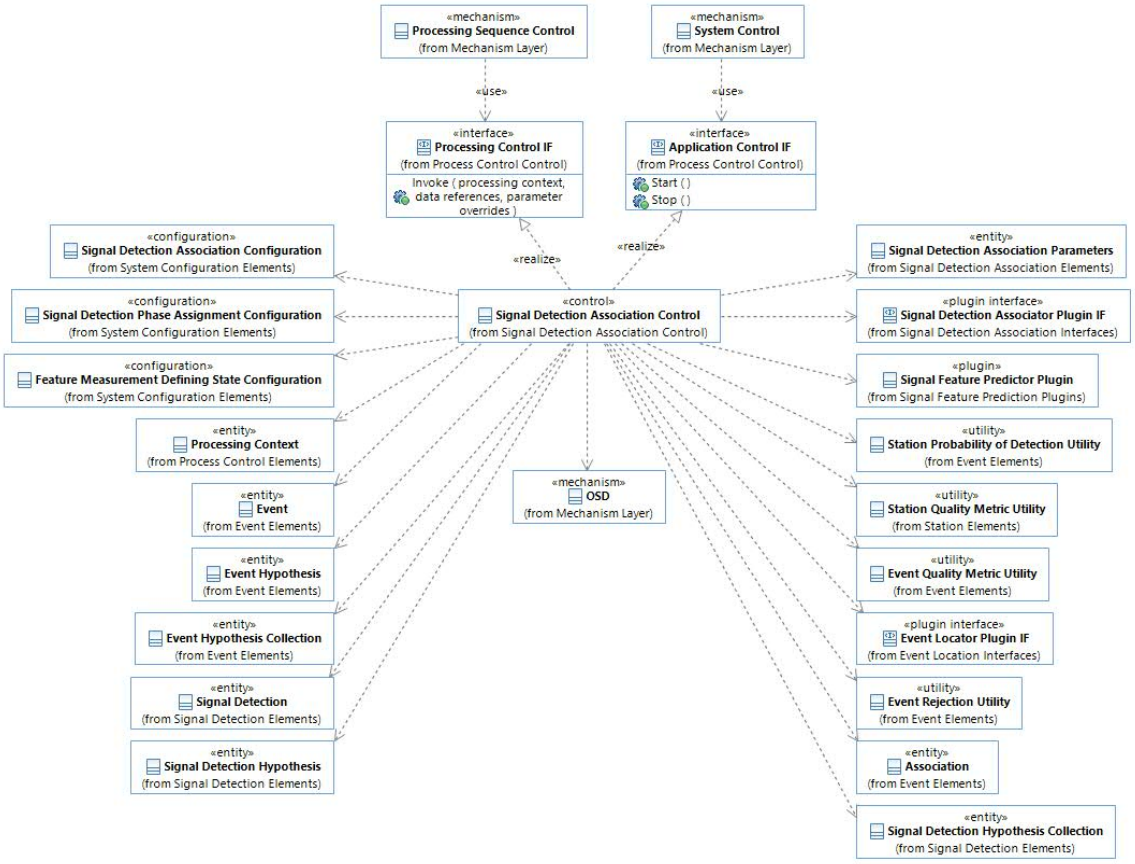
calculations. Multiple Signal Detection Associator Plugins exist in the system and each of them realizes a common plugin interface. The specific Signal Detection Associator Plugin varies dynamically at runtime based on the Signal Detection Association Parameters. When invoked from Processing Sequence Control, Signal Detection Association Control uses the Signal Detection Association Configuration to build the Signal Detection Association Parameters to pass to the Signal Detection Associator Plugin, selects and invokes the appropriate Signal Detection Associator Plugin based on those parameters, and stores the new or modified Events and Event Hypotheses via the OSD mechanism.

Use Case Diagram



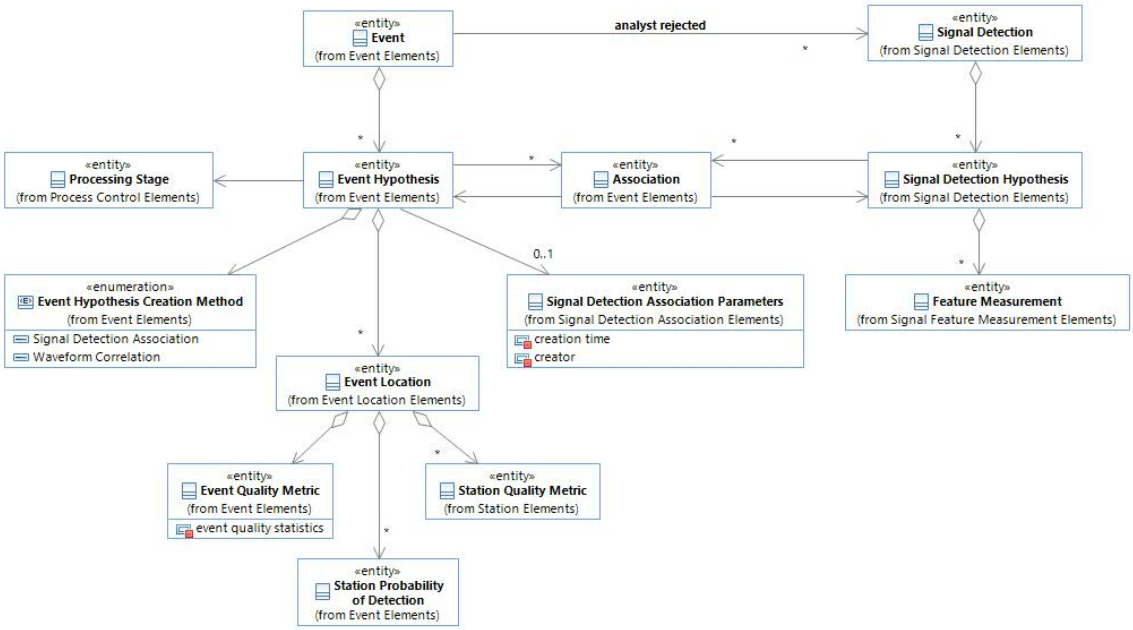
Class Diagrams

Classes - Signal Detection Association Control



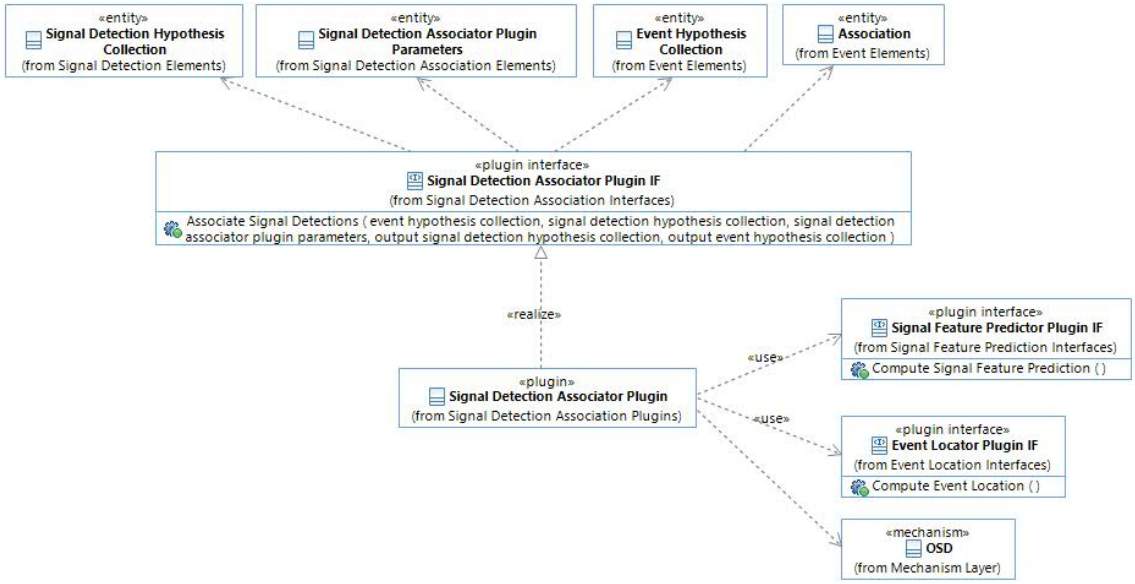
This diagram shows Signal Detection Association Control and related classes.

Classes - Event Hypothesis



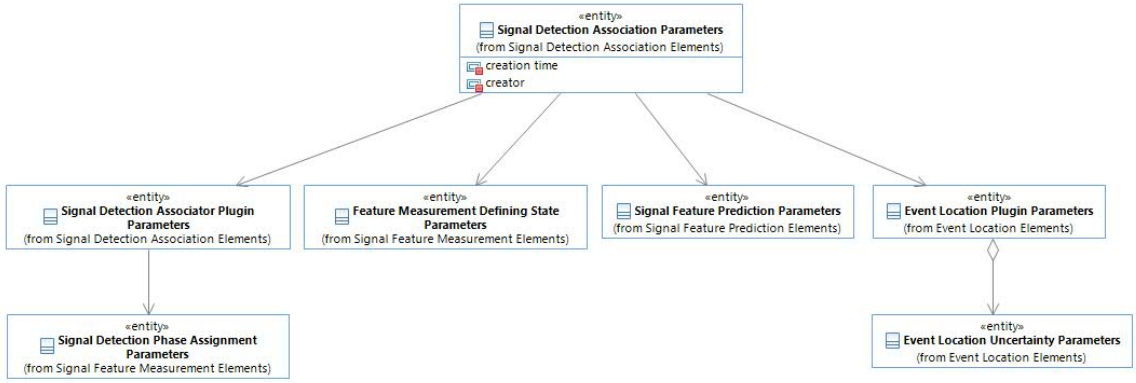
This diagram shows the Event Hypothesis class and related classes as used in this realization. Each Event Hypothesis has a creation method, location, related quality metrics, and an association to the Signal Detection Association Parameters used by the Signal Detection Association Plugin that built the Event Hypothesis. These parameters track the Event Hypothesis' provenance. Signal Detection Hypothesis aggregates Feature Measurements, which Signal Detection Associator Plugins may use during association computations. Signal Detection Association Control uses the association between Event and Signal Detection to keep from reassociating a Signal Detection to an Event when an Analyst has previously unassociated the two.

Classes - Signal Detection Associator Plugin



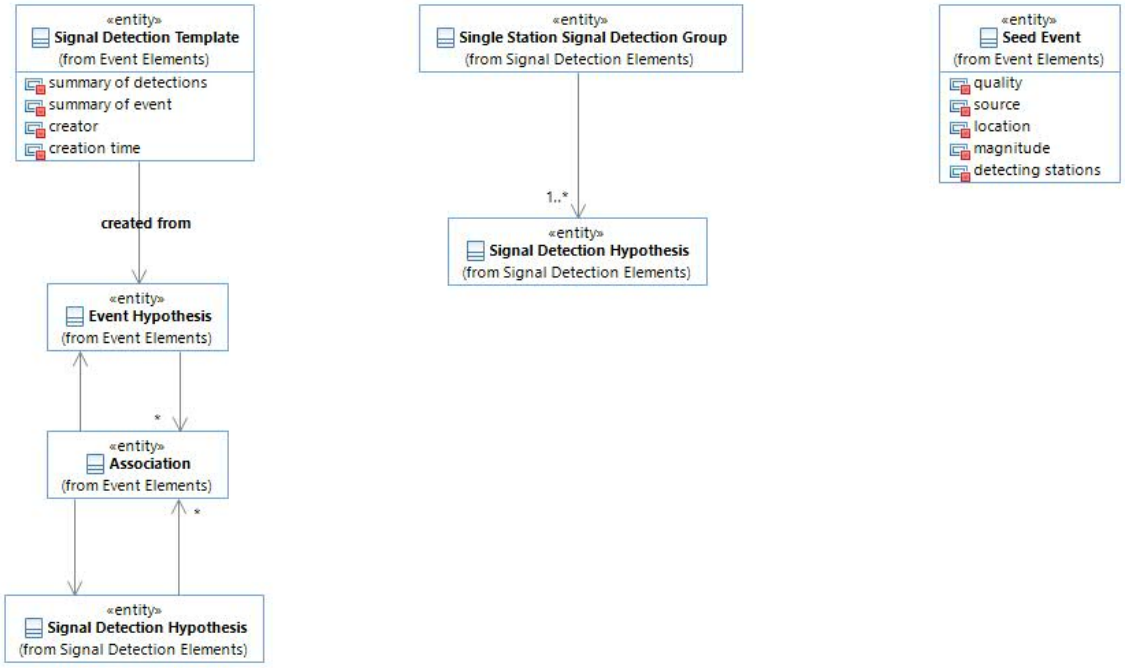
This diagram shows the Signal Detection Associator Plugin, related elements, and related plugins. The Signal Detection Associator Plugin class shown on this diagram is a general class representing any possible implementation of the Signal Detection Associator Plugin IF. Depending on the algorithm implementation a Signal Detection Associator Plugin may access the OSD, use Signal Feature Predictor Plugins, and use Event Locator Plugins.

Classes - Signal Detection Association Parameters



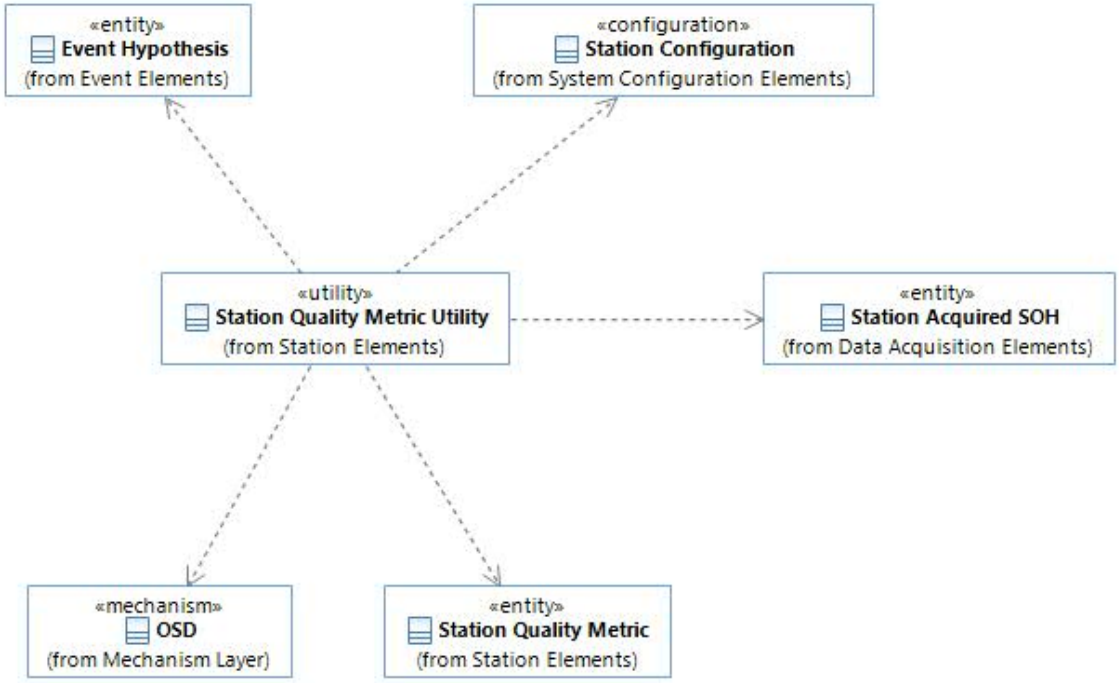
This diagram shows details of the Signal Detection Association Parameters class. Signal Detection Association Parameters includes the information Signal Detection Association Control uses to invoke a single Signal Detection Associator Plugin, to set feature measurement defining states, and to refine the locations of event hypotheses it creates and modifies. Signal Detection Associator Plugin Parameters collects the parameters used by plugins, including the plugin specific parameters and phase assignment parameters. Signal Detection Association Control also uses the phase assignment parameters to assign signal detection phase labels. Signal Detection Association Control creates these parameter classes based on the Signal Detection Association Configuration, Signal Detection Phase Assignment Configuration, and Feature Measurement Defining State Configuration classes.

Classes - Additional Signal Detection Associator Plugin Inputs



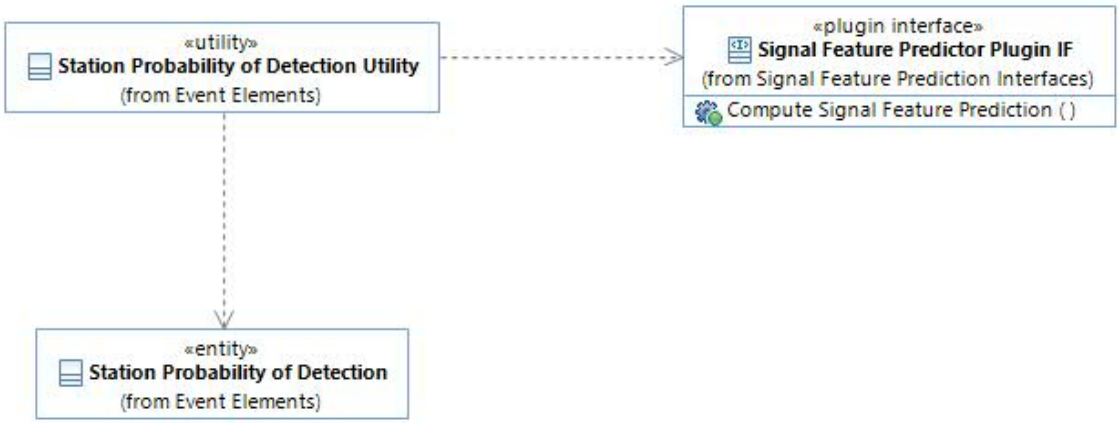
This diagram show details for additional classes that Signal Detection Associator Plugin implementations can use to build new Event Hypotheses. Plugin implementations may use Signal Detection Templates to build new event hypotheses and associate additional detections to existing event hypotheses by using lists of signal detections matching the pattern of signal detections associated to the Signal Detection Template's event hypothesis. Plugin implementations may use Single Station Signal Detection Groups which contain multiple Signal Detection Hypotheses detected by the same station which have features indicating they likely correspond to the same Event. Plugin implementations may build new event hypotheses using Seed Events as hints indicating the location, time, magnitude, etc. of potential event hypotheses.

Classes - Station Quality Metric Utility



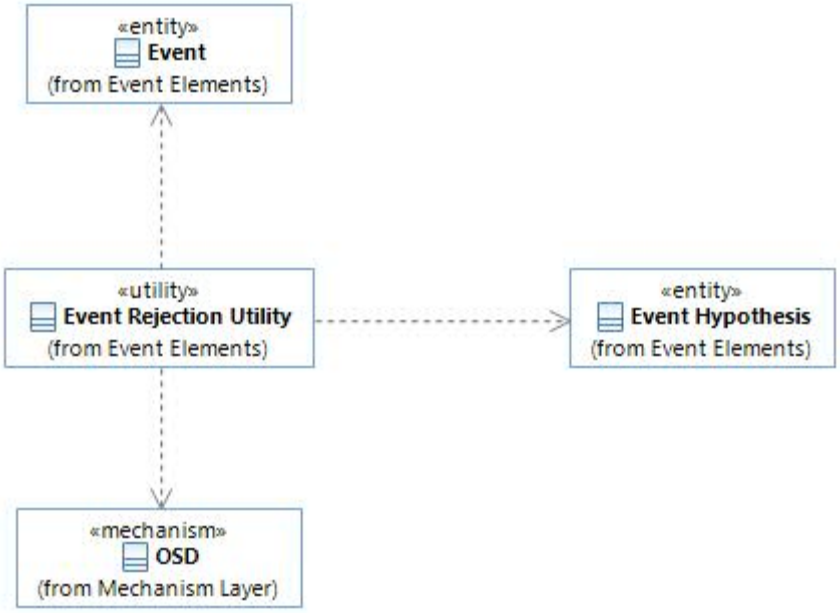
This diagram shows the Station Quality Metric Utility class and related classes it uses to compute Station Quality Metrics.

Classes - Station Probability of Detection Utility



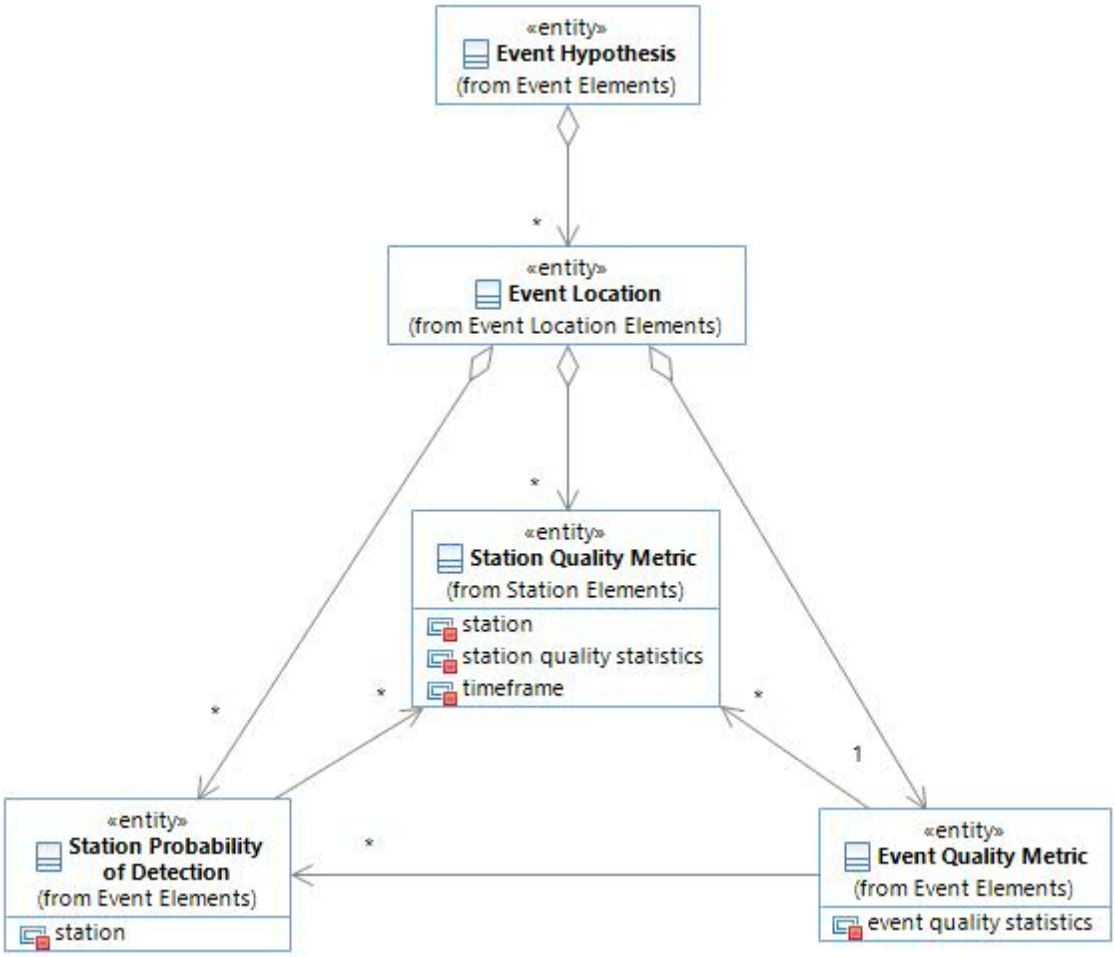
The diagram shows the Station Probability of Detection Utility and related classes. The utility uses a class realizing the Signal Feature Predictor Plugin IF interface to calculate a station's probability of detecting particular phases of an event. The utility uses these probabilities to determine the overall station probability of detecting an event, which is represented by the Station Probability of Detection class.

Classes - Event Rejection Utility



This diagram shows the Event Rejection Utility class and related classes it uses to reject invalid events.

Classes - Quality Metrics



This diagram shows the relationships between the Station Quality Metric, Station Probability of Detection, and Event Quality Metric classes. The Station Probability of Detection and Event Quality classes have associations to the Station Quality Metric class since it is an input to the calculations which create those classes. Similarly, Event Quality Metric is associated to Station Probability of Detection since that class is an input to event quality calculations. Since the quality metric calculations depend on event location each quality metric class has an association from Event Location rather than from Event Hypothesis.

Class Descriptions

<<configuration>> Feature Measurement Defining State Configuration
Represents all signal detection feature measurement defining state configuration in the system. This includes all configurations used to determine which signal detection feature measurements are by default defining and non-defining for various types of system calculations.

<<configuration>> Signal Detection Association Configuration
Represents all signal detection association configuration in the system. Includes event location configuration used to refine the locations of event hypotheses created or modified during signal

detection association. May also include associations to plugin-specific configurations for individual Signal Detection Associator Plugins (each Signal Detection Associator Plugin may define a plugin specific configuration class containing e.g. configuration for other plugins that plugin uses when it is invoked, single station event formation criteria configuration, network event formation criteria configuration, etc.)

<<configuration>> Signal Detection Phase Assignment Configuration
Represents all signal detection phase assignment configuration in the system. This includes all station, channel, frequency, and geographic region specific configurations used to determine signal detection phase assignments.

<<configuration>> Station Configuration
Represents the configurable aspects of a Station such as its name, location, the sites at the station, the channels from the sites, site instrumentation, instrument calibration, etc.

<<control>> Signal Detection Association Control
Control class responsible for controlling signal detection association calculations. Retrieves configuration from the OSD, invokes the appropriate Signal Detection Associator Plugin, computes quality metrics, and stores the new or modified events in the OSD.

<<entity>> Association
Represents an association between a Signal Detection Hypothesis and an Event Hypothesis.

<<entity>> Event
Represents information about an Event. Keeps track of all the Event Hypotheses for the Event, which Event Hypothesis is the preferred one for each processing stage, the active analysts for the Event (i.e. whether the Event is under "active review"), whether the Event is "complete" for each processing stage, and other Event-related information.

<<entity>> Event Hypothesis
Represents geophysical information about an Event as determined by an Analyst or through pipeline processing. There can be multiple Event Hypotheses for the same Event (e.g. different associated Signal Detection Hypotheses, different location solutions).

<<entity>> Event Location
Represents a computed location for an event.

<<entity>> Event Location Plugin Parameters
Represents all parameters passed to an Event Locator Plugin. This includes parameters describing default feature measurement defining states and the types of uncertainty bounds the plugin should compute. May also include parameters specific to the plugin being invoked.

<<entity>> Event Location Uncertainty Parameters
Represents the type of uncertainty bound (Confidence, Coverage or K-Weighted), confidence level and scaling factor for the locator to use when computing event location uncertainty.

<<entity>> Event Quality Metric
Represents the quality of a single event hypothesis. Event quality is based on a variety of event quality statistics, possibly including the Station Quality Metric and Station Probability of Detection for Stations with Signal Detections associated to the Event Hypothesis as well as for Stations that did not detect the Event Hypothesis, the algorithms used to detect the event, event location and event location uncertainty, etc.

<<entity>> Feature Measurement
Represents the value and uncertainty of a measured feature of a signal detection.

<<entity>> Feature Measurement Defining State Parameters
Represents defining state parameters for feature measurements. The parameters include the following for each feature measurement for each type of calculation (e.g. location, magnitude, etc.)
- Whether the feature measurement is initially defining or non-defining
- Whether an algorithm is free to toggle the defining state

The analyst can override the defining/non-defining state for these parameters, unless prohibited by the default defining/non-defining state:
- Time, azimuth, or slowness measurement of a signal detection for event hypothesis relocation
- Signal Detection measurements for event hypothesis relocation based on channel
- Signal Detection measurements for event hypothesis relocation based on signal detection phase assignment

<<entity>> Processing Context
Represents the context in which data is being stored and/or processed. This includes the Processing Stage (either automatic or interactive) and Interval performing the processing session (e.g. processed by Analyst vs. processed by System). For Analyst processing, may identify the Analyst work session. For System processing, may identify the Processing Sequence and/or Processing Step being executed (including a way to identify a particular Processing Sequence and Processing Step among the many possible instantiations), the visibility for the results (private vs. global), and the lifespan of the data (transient vs. persistent). This information is needed by the Processing Sequence Control to manage the execution of Processing Sequences, which may execute in the context of an Analyst refining an Event or in the context of the system initiating automatic processing. It is also needed by the Object Storage and Distribution (OSD) mechanism to determine how to store and distribute the data.

<<entity>> Processing Stage
Represents a named stage of data processing, which may be part of the System Maintainer-defined workflow or an Analyst-defined stage outside the workflow. All Processing Results are associated to a Processing Stage.

<<entity>> Seed Event
Contains information about an event hypothesis that a Signal Detection Associator Plugin should attempt to build. The Seed Event is based on information provided by a particular source (e.g. a bulletin from an External Data Center, an event location provided by a different system, an

algorithm running in a Research application, etc.) and has a quality metric based on the likelihood the Seed Event corresponds to an actual Event.

<<entity>> Signal Detection
Represents information about a Signal Detection and keeps track of all the Signal Detection Hypotheses for the Signal Detection. Represents information about a Signal Detection and keeps track of all the Signal Detection Hypotheses for the Signal Detection. For an unassociated Signal Detection the preferred Signal Detection Hypothesis is the most recently created Signal Detection Hypothesis. For an associated Signal Detection the preferred Signal Detection Hypothesis is the one associated to a preferred Event Hypothesis.

<<entity>> Signal Detection Association Parameters
Represents the parameters used by a particular invocation of Signal Detection Association Control. This includes parameters used to invoke a Signal Detection Associator Plugin to build events and parameters used to invoke a Event Locator Plugin to refine event locations as well as parameters controlling additional calculations performed in the control class.

<<entity>> Signal Detection Associator Plugin Parameters
Represents the parameters used by a call to a Signal Detection Associator Plugin. This includes parameters that apply to all Signal Detection Associator Plugins and may include plugin specific parameters.

<<entity>> Signal Detection Hypothesis
Represents geophysical information about a Signal Detection as determined by an Analyst or through pipeline processing. There can be multiple Signal Detection Hypotheses for the same Signal Detection (e.g. different onset times, different phase labels).

<<entity>> Signal Detection Template
A template that represents the pattern of Signal Detections for an Event (i.e. channels detected, relative positions for each detection, phases, etc.). An Analyst may apply the template to quickly build new Events that match the pattern of detections. Signal Detection Associator Plugins (see "System Builds Events using Signal Detections" UCR) may also use Signal Detection Templates to build new Event Hypotheses and associate additional detections to Event Hypotheses matching the template. Also includes summary information about the original Event from which the template was created (e.g. Event location, magnitude, etc.), as an aid to the Analyst in finding and applying a relevant template.

<<entity>> Single Station Signal Detection Group
Represents groups of Signal Detection Hypotheses detected by the same station for a single Event. Station processing creates Single Station Signal Detection Groups to help assign initial phase labels for the detections (see "System Measures Signal Features" UCR) and network processing uses the groups to help create Event Hypotheses (see "System Builds Events using Signal Detections" UCR).

<<entity>> Station Acquired SOH
Represents the state-of-health for a single Station. Includes state-of-health information acquired

from the Station (including whether the station has GPS locked) and digital signature authentication status.

<<entity>> Station Probability of Detection
Represents a Station's probability of detecting an Event Hypothesis.

<<entity>> Station Quality Metric
Represents a Station's quality for a particular time. Separate station quality metrics can be computed for a Station with each metric based on different selections of the Station's raw and derived waveforms (e.g. Station Quality Metric could be computed using Waveforms from a Station's raw Channels and a separate quality metric could be computed for a beam created from the Station's waveforms).

<<enumeration>> Event Hypothesis Creation Method
Indicates the type of algorithm used to create an event hypothesis.

<<interface>> Application Control IF
Defines the interface implemented by all <<control>> classes in the system that are controlled by System Control.

<<interface>> Processing Control IF
Defines the interface implemented by all <<control>> classes in the system that are controlled by the Processing Sequence Control <<mechanism>>. <<control>> classes realize this common interface to support configurable processing sequence definition and execution. Processing Sequence Control uses the Invoke() operation declared in Processing Control IF to call <<control>> classes while executing processing sequences. When called in this way the <<control>> classes operate on the provided data (e.g. event hypotheses, signal detections, etc.) using either default parameters configured by the System Maintainer and loaded by the <<control>> class on startup or override parameters provided to the Invoke() operation.

<<mechanism>> OSD
Represents the Object Storage and Distribution mechanism for storing and distributing data objects internally within the system.

<<mechanism>> Processing Sequence Control
Mechanism for executing and controlling processing sequences configured by the System Maintainer.

<<plugin interface>> Event Locator Plugin IF
Standard interface for all Event Locator plugins. All Event Locator plugins in the system realize this interface.

<<plugin interface>> Signal Detection Associator Plugin IF
Standard interface for all Signal Detection Associator plugins. All Signal Detection Associator plugins in the system realize this interface.

<<plugin interface>> Signal Feature Predictor Plugin IF
Standard interface for all Signal Feature Predictor plugins. All Signal Feature Predictor plugins in the system realize this interface. Plugins that implement Signal Feature Predictor IF may predict different types of signal features, such as travel time, azimuth, slowness, amplitude, and probability of detection.

<<plugin>> Signal Detection Associator Plugin
An abstract base class that realizes the Signal Detection Associator Plugin IF interface. Specializations of this class may define specific configurations and parameters used in their implementations, such as parameters for Signal Feature Predictor Plugins, single station event formation criteria parameters, or network event formation criteria parameters.

<<plugin>> Signal Feature Predictor Plugin
Abstract class that represents any/all of the Signal Feature Predictors that may be plugged in to the system behind the Signal Feature Predictor IF plugin interface. Signal Feature Predictors are responsible for calculating signal feature predictions.

<<utility>> Event Quality Metric Utility
Utility class that computes the event quality metric. The quality metric may be based on how well an event hypothesis meets the event definition criteria, the Event Hypothesis Creation Method, etc.

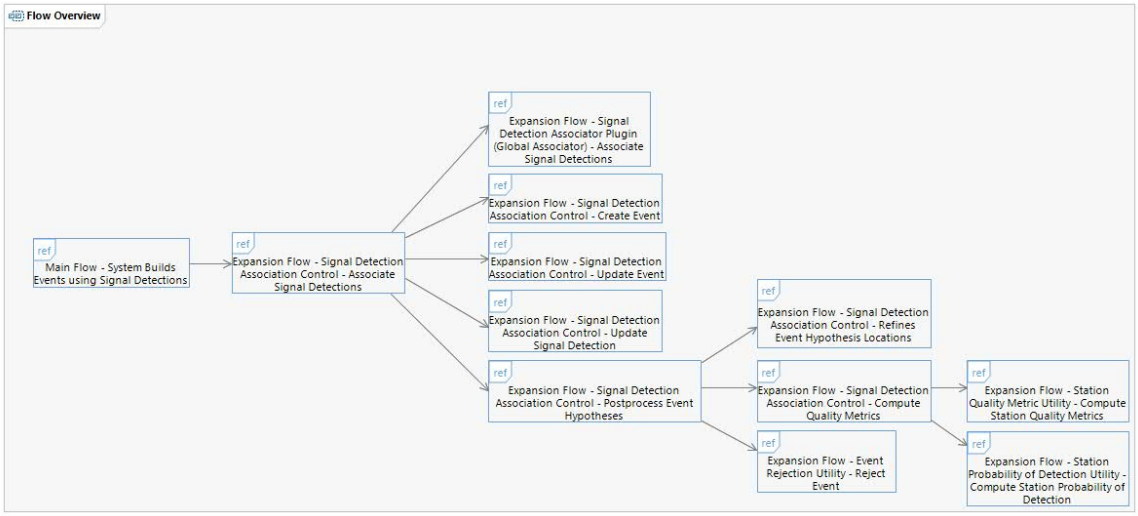
<<utility>> Event Rejection Utility
Utility class used to reject event hypotheses.

<<utility>> Station Probability of Detection Utility
Utility that computes station probability of detecting events. The utility may base this probability on either modeled noise or on actual noise recorded at a station.

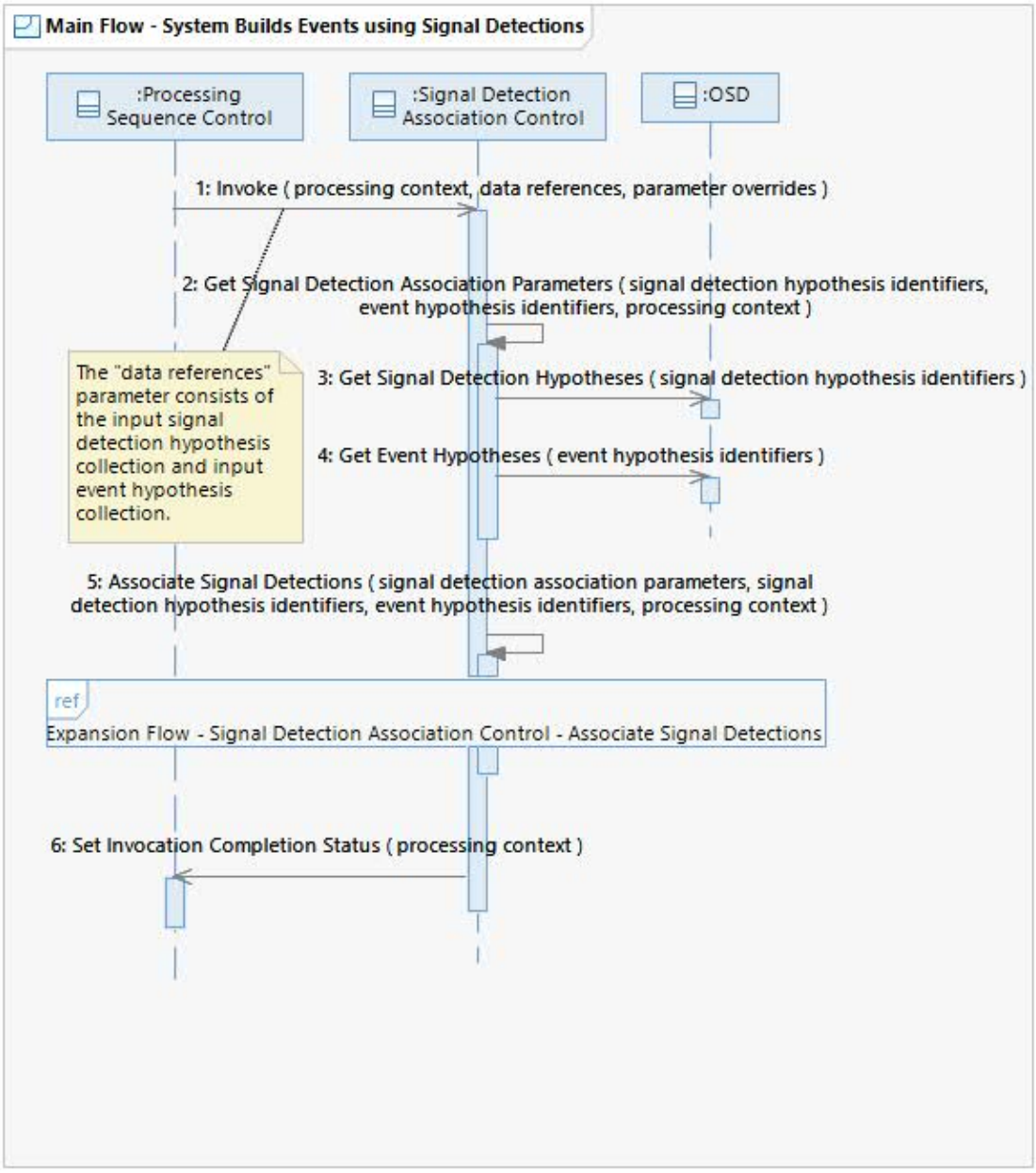
<<utility>> Station Quality Metric Utility
Utility class that computes the station quality metric. Computes the metric for stations using waveforms, SOH information, Waveform QC Masks, etc. and also computes the metric for configured derived channels (e.g. detection beams). Can compute a continuous station quality metric for use in performance monitoring and a different but related station quality metric based on an event hypothesis.

Sequence Diagrams

Flow Overview



Main Flow - System Builds Events using Signal Detections



This flow shows how the system builds events by associating signal detections. This flow is stimulated by the Processing Sequence Control mechanism as part of executing an automatic processing sequence. Processing Sequence Control populates the data references parameter with a signal detection hypothesis collection and an event hypothesis collection. The signal detection hypothesis collection contains the signal detection hypotheses that this UCR uses to build new event hypotheses and to update existing event hypotheses. Depending on the Processing Configuration that Processing Sequence Control used to invoke this UCR, this collection may contain any combination of unassociated signal detections that have never been reviewed by an Analyst, unassociated signal detections that have previously been reviewed by an Analyst, signal detections associated to events that have not been reviewed by an Analyst, or signal detections

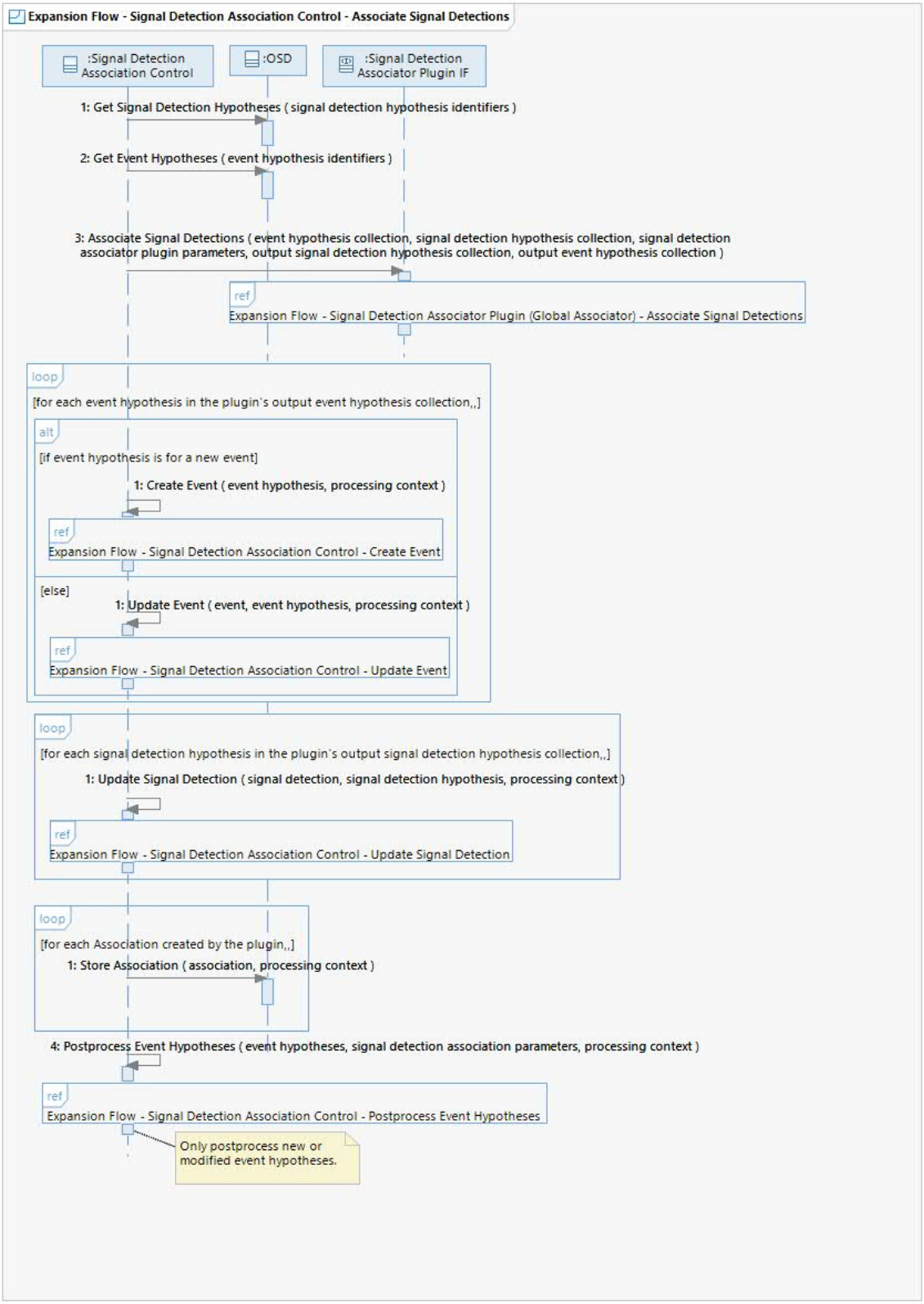
associated to Analyst reviewed events. The event hypothesis collection contains existing event hypotheses whose signal detection associations may be updated by this UCR. It is possible for this collection to contain event hypotheses previously reviewed by an Analyst.

The System Maintainer configures the conditions in which Processing Sequence Control executes these sequences (see 'Defines Processing Sequence' UCR). For more information about the Processing Sequence Control mechanism see 'System Detects Event' UCR.

Operation Descriptions

None

Expansion Flow - Signal Detection Association Control - Associate Signal Detections



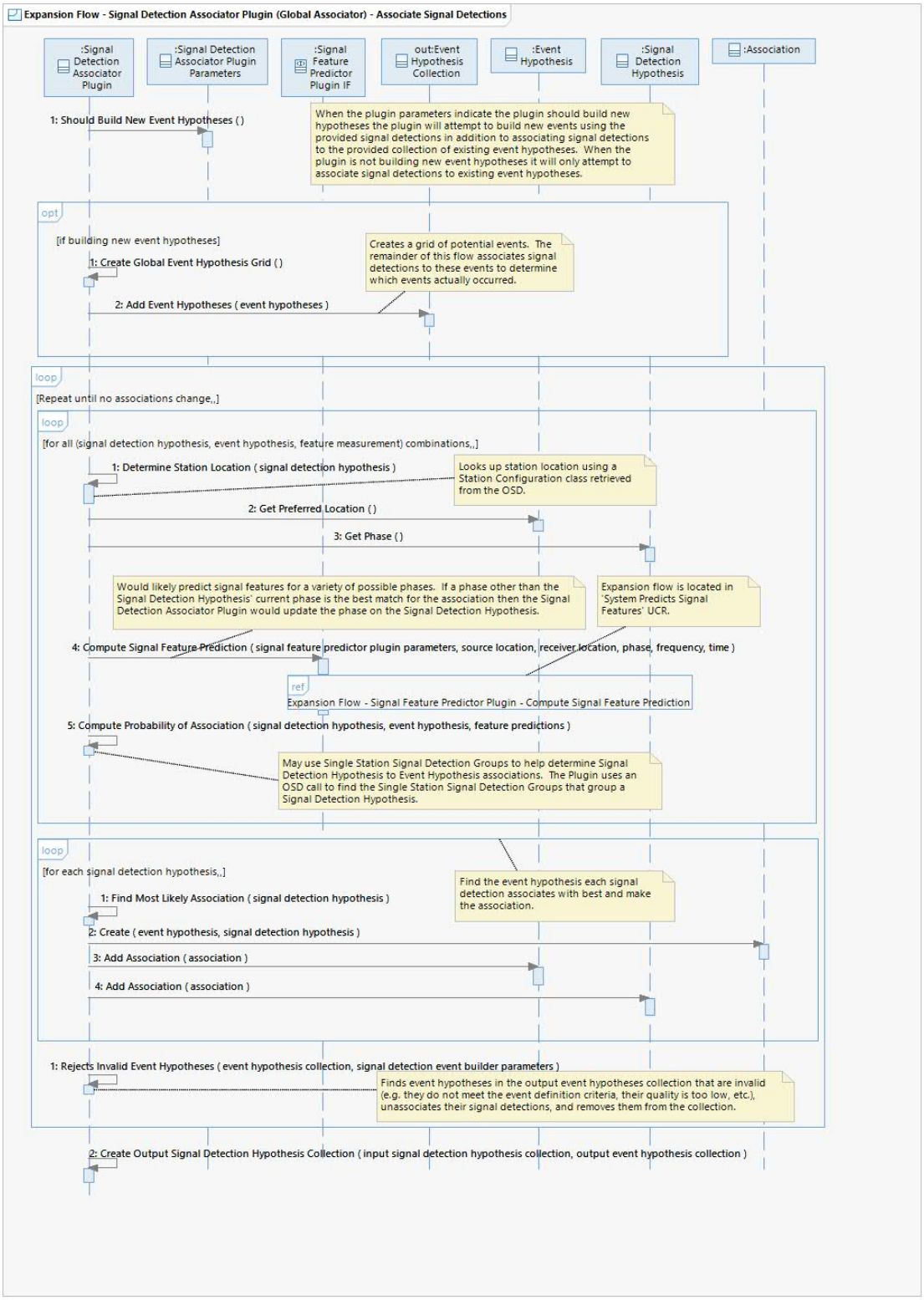
This flow shows how Signal Detection Association Control associates signal detections to build

new event hypotheses and to update existing event hypotheses. Signal Detection Association Control invokes a Signal Detection Associator Plugin to perform the association calculations. The control class uses Event Hypotheses output by the plugin to create new Events or to update existing Events and then postprocesses the event hypotheses to prepare for further processing by other UCRs. Signal Detection Association Control also stores any modified Signal Detection Hypotheses in the OSD.

Operation Descriptions

Operation: Signal Detection Associator Plugin IF::Associate Signal Detections()
Classes realizing the Signal Detection Associator Plugin IF interface implement this operation to build new event hypotheses, associate signal detection hypotheses to existing event hypotheses, or both. The input signal detection hypothesis collection contains all of the signal detection hypotheses the plugin may associate to events and the input event hypothesis collection contains all of the existing event hypotheses that may be associated to the input signal detections. The output signal detection hypothesis collection contains the signal detection hypotheses from the input collection that were updated by this operation (e.g. new phase assignment, associated to an event hypothesis) as a result of this operation. The output event hypothesis collection contains all of the event hypotheses that were modified or created by this operation.

Expansion Flow - Signal Detection Associator Plugin (Global Associator) - Associate Signal Detections



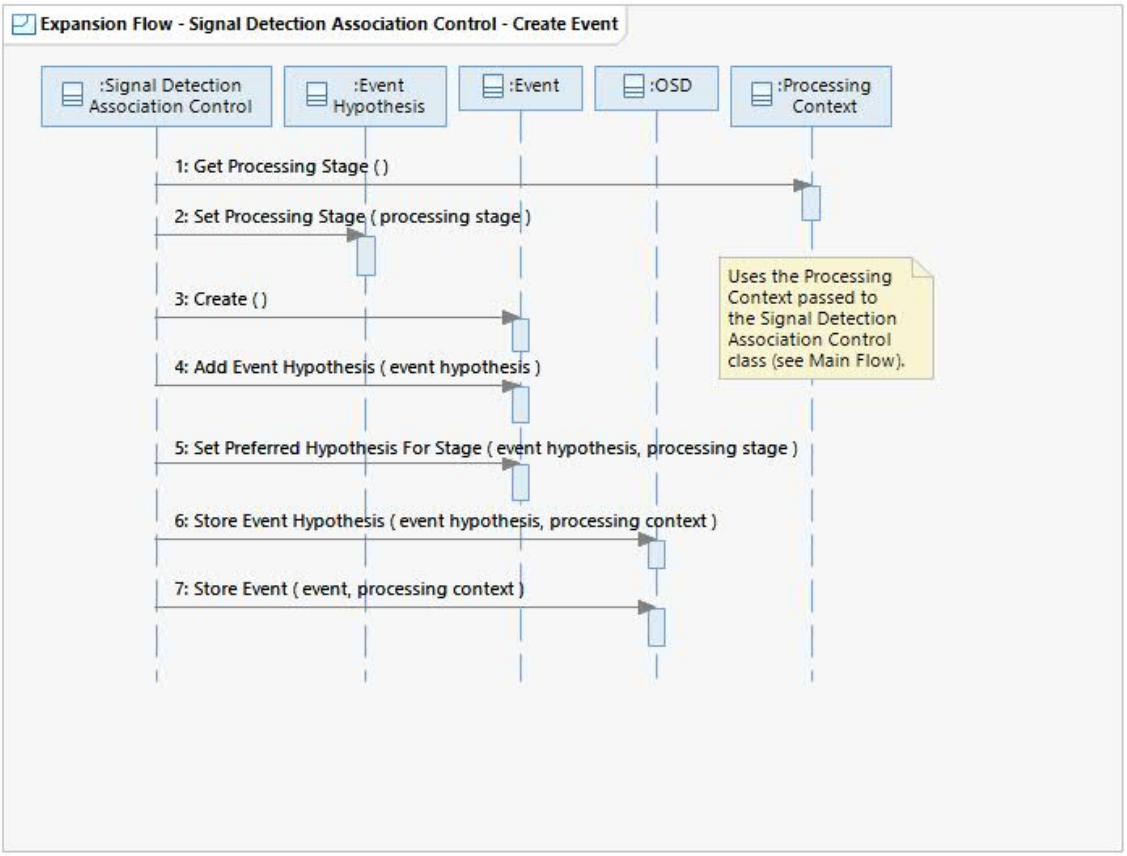
This flow is a notional flow showing how a Signal Detection Associator Plugin may associate

signal detections to build new event hypotheses and to update the associations to existing event hypotheses. Other plugins may exist which use different algorithms (e.g. associate signal detections by matching the signal detection pattern from a waveform correlation reference event, associate signal detection by matching a Signal Detection Template, etc.). The plugin creates an Event Hypothesis grid of potential events and associates Signal Detections to Events based on the probability of signal detection to event association. This is an iterative process that continues until no associations change. At the end of each iteration the plugin removes improbable events from the event hypothesis grid, freeing the associated signal detections for association to other events.

Operation Descriptions

None

Expansion Flow - Signal Detection Association Control - Create Event



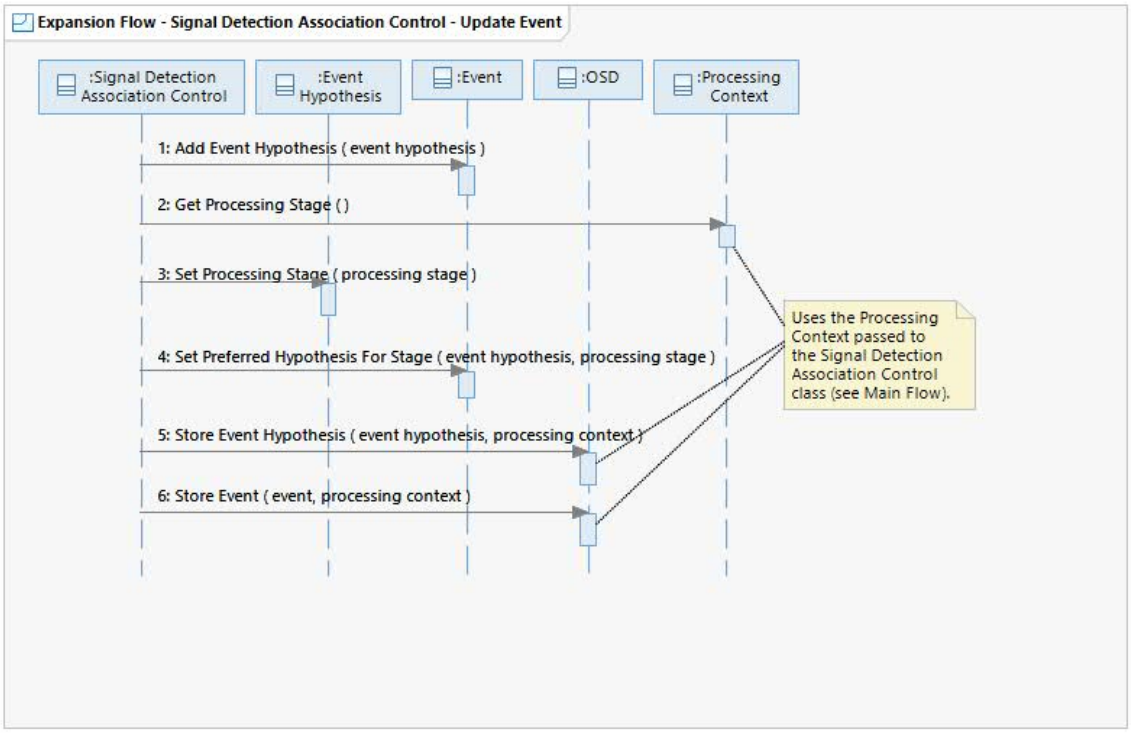
This flow shows Signal Detection Association Control creating a new Event, adding an Event Hypothesis as the preferred hypothesis of that event, and saving both in the OSD.

Operation Descriptions

Operation: OSD::Store Event Hypothesis()
Store the given Event Hypothesis with the given lifespan (persistent vs. transient) and visibility (private vs. global) as specified by the given Processing Context and notify relevant subscribers via callbacks.

Operation: OSD::Store Event()
Store the given Event with the given lifespan (persistent vs. transient) and visibility (private vs. global) as specified by the given Processing Context and notify relevant subscribers via callbacks.

Expansion Flow - Signal Detection Association Control - Update Event



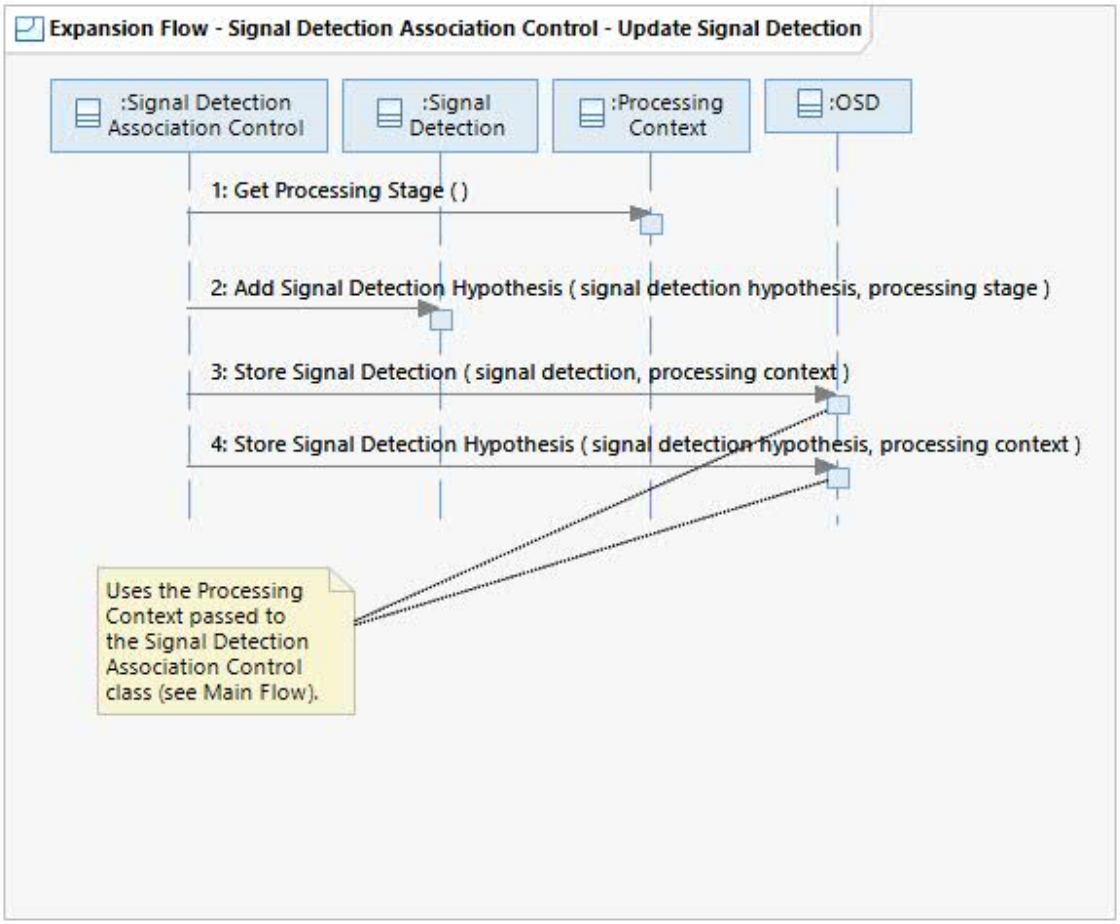
This flow shows Signal Detection Association Control adding a new Event Hypothesis to an Event, setting the hypothesis as the preferred hypothesis for that event, and saving both in the OSD.

Operation Descriptions

Operation: OSD::Store Event Hypothesis()
Store the given Event Hypothesis with the given lifespan (persistent vs. transient) and visibility (private vs. global) as specified by the given Processing Context and notify relevant subscribers via callbacks.

Operation: OSD::Store Event()
Store the given Event with the given lifespan (persistent vs. transient) and visibility (private vs. global) as specified by the given Processing Context and notify relevant subscribers via callbacks.

Expansion Flow - Signal Detection Association Control - Update Signal Detection

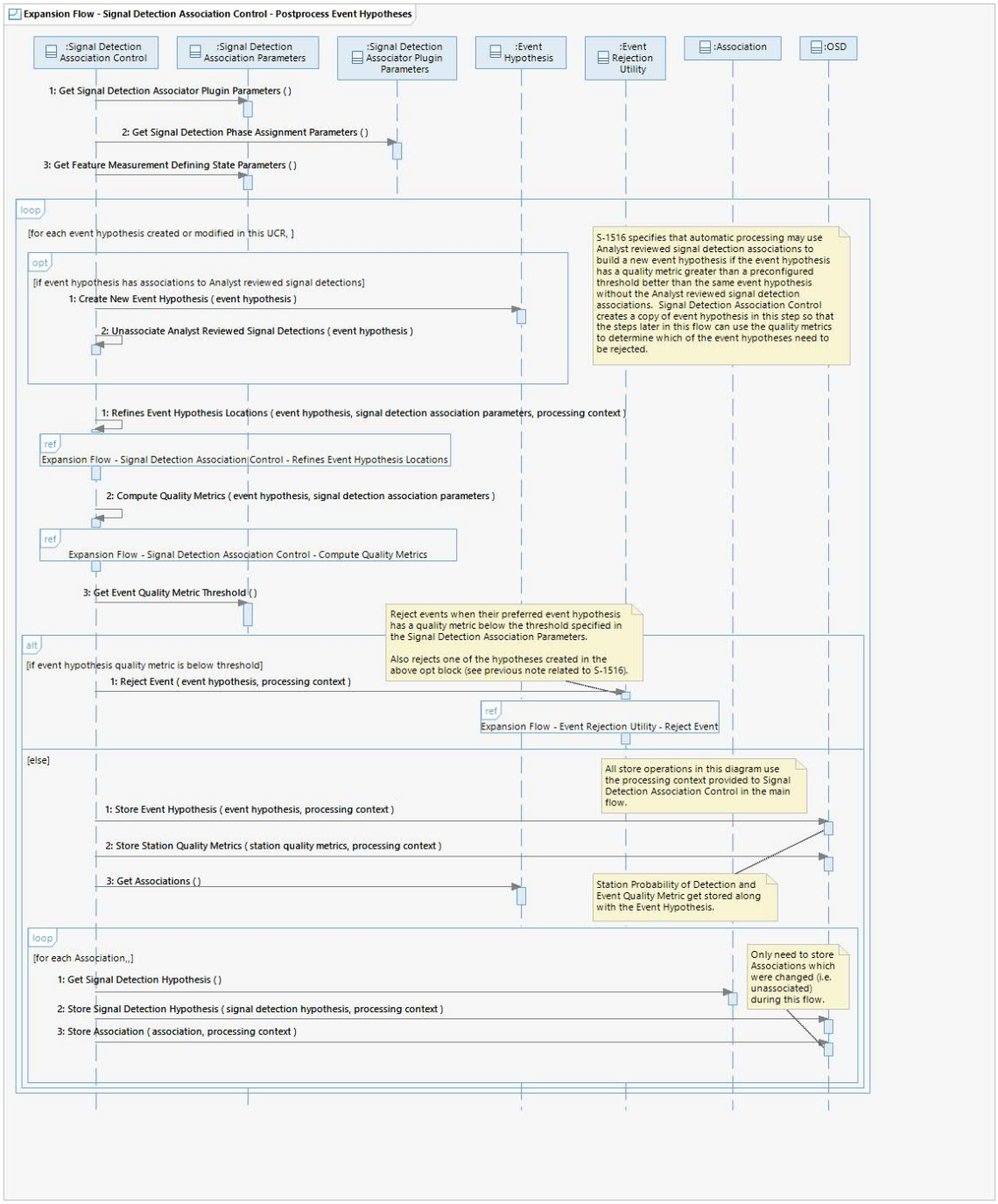


This flow shows Signal Detection Association Control adding a new Signal Detection Hypothesis to a Signal Detection and storing both of them in the OSD.

Operation Descriptions

Operation: OSD::Store Signal Detection()
Store the given Signal Detection with the given lifespan (persistent vs. transient) and visibility (private vs. global) as specified by the given Processing Context and notify relevant subscribers via callbacks.

Expansion Flow - Signal Detection Association Control - Postprocess Event Hypotheses



This flow shows Signal Detection Association Control refining the location of each event hypothesis created or modified in this UCR, computing quality metrics for those event hypotheses, and rejecting any hypotheses not meeting a preconfigured minimum quality metric.

Operation Descriptions

Operation: OSD::Store Event Hypothesis()

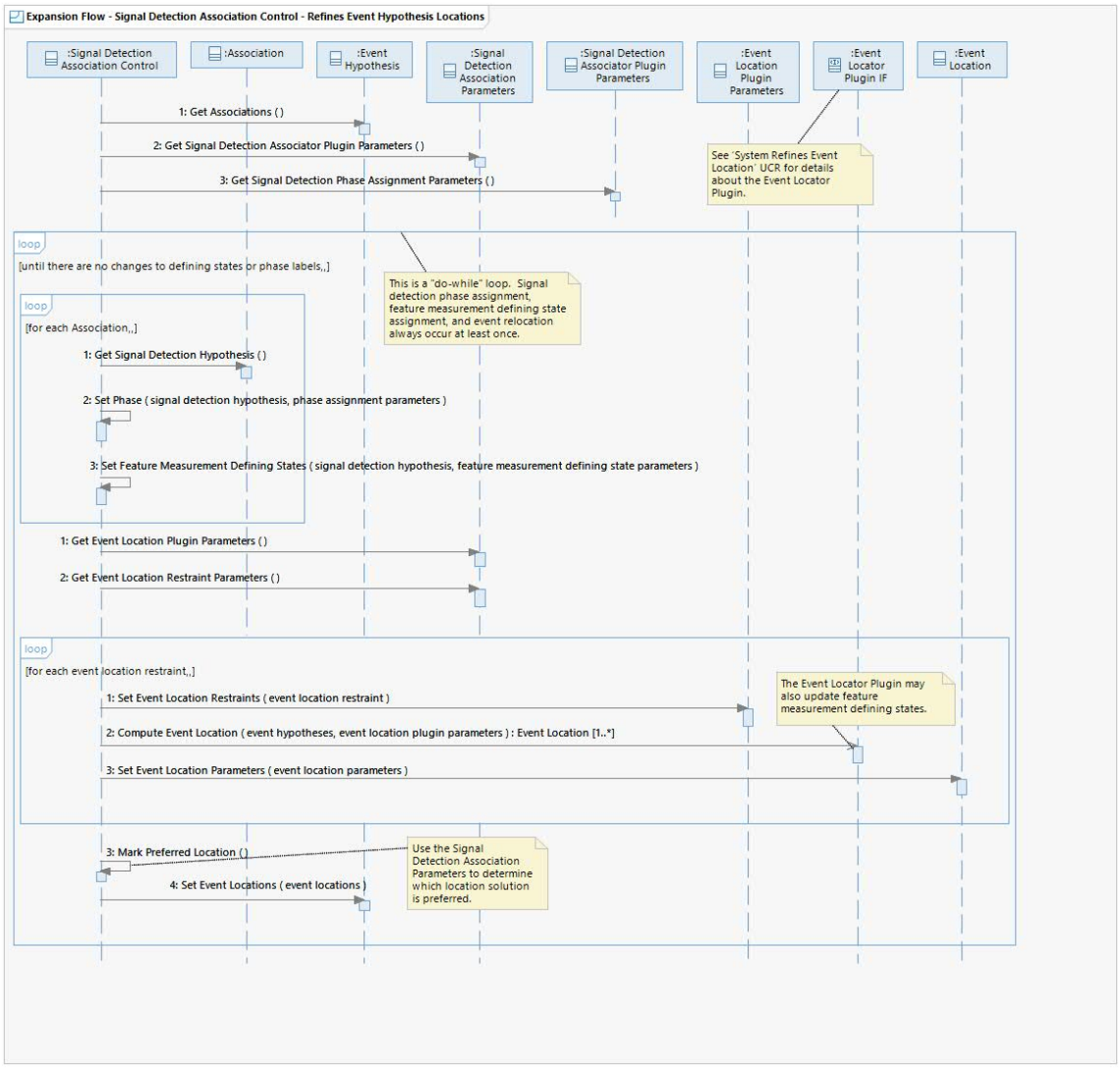
Store the given Event Hypothesis with the given lifespan (persistent vs. transient) and visibility

(private vs. global) as specified by the given Processing Context and notify relevant subscribers via callbacks.

Operation: Event Hypothesis::Create New Event Hypothesis()
Create a copy of the given Event Hypothesis. The copy has all of the same information as the original (e.g. same detections, location, etc.), with the following exceptions:

- The copy points to the original as its parent
- The copy starts out with an empty Analyst comment

Expansion Flow - Signal Detection Association Control - Refines Event Hypothesis Locations

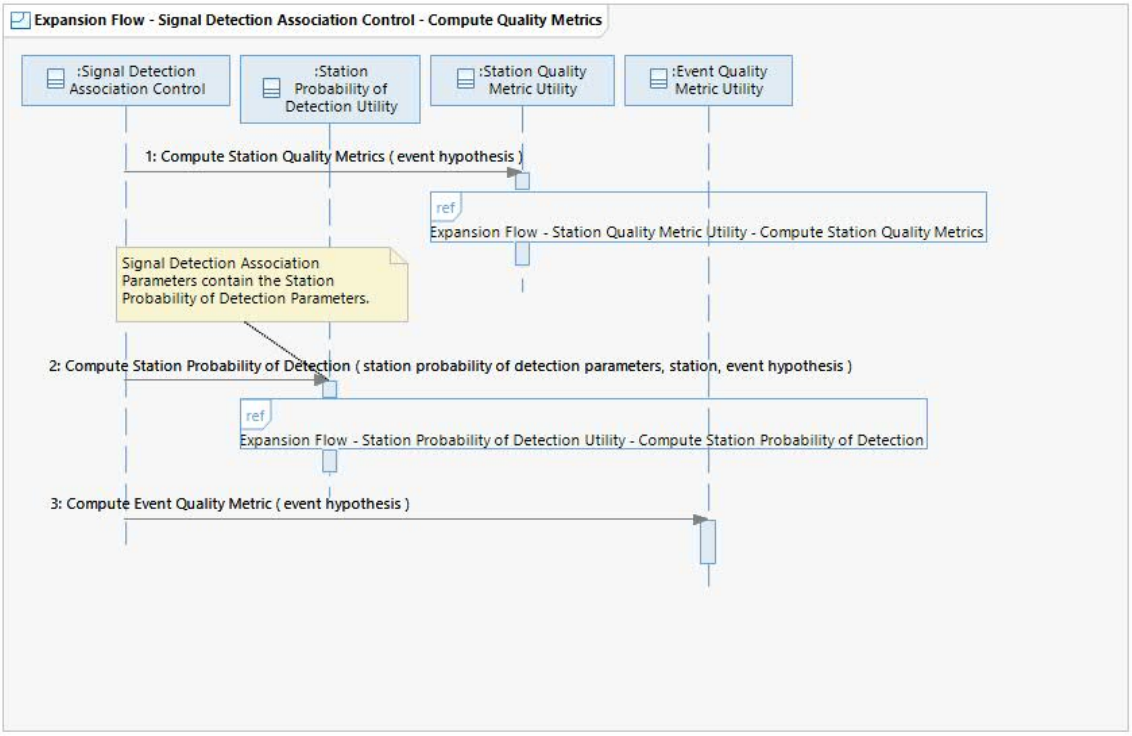


This flow shows Signal Detection Association Control iteratively setting signal detection phase labels and feature measurement defining states for all detections associated to an event hypothesis before refining the hypothesis' location. Iteration continues until relocating the hypothesis does not cause any changes to the phase labels or defining states.

Operation Descriptions

Operation: Event Locator Plugin IF::Compute Event Location()
The interface method for an Event Location Plugin to compute an event location. The plugin may compute the location using teleseismic and regional seismic signal detections.

Expansion Flow - Signal Detection Association Control - Compute Quality Metrics

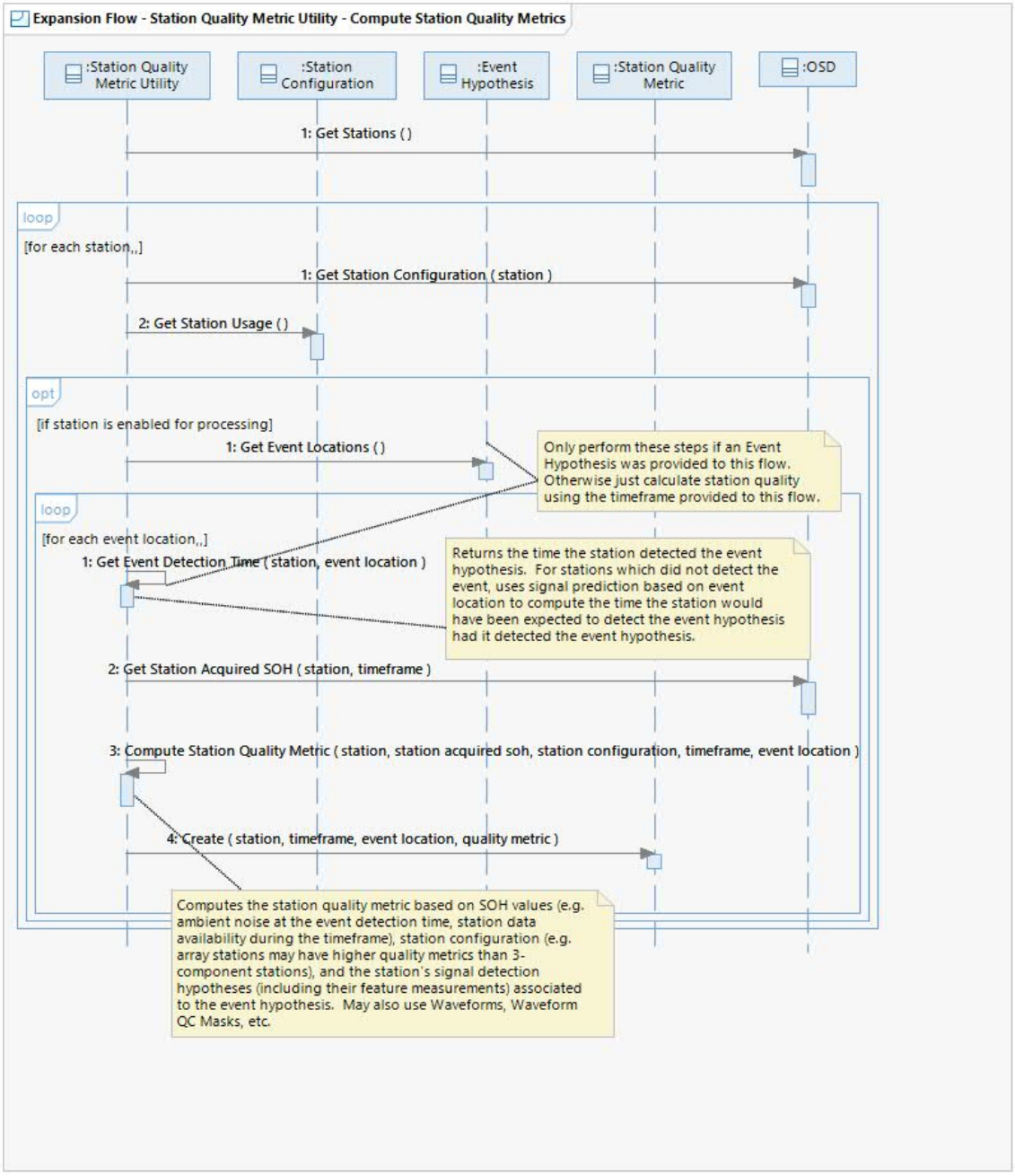


This flow shows Signal Detection Association Control computing station quality metrics, station probabilities of detection, and event quality metrics for the Event Locations of an event hypothesis.

Operation Descriptions

None

Expansion Flow - Station Quality Metric Utility - Compute Station Quality Metrics

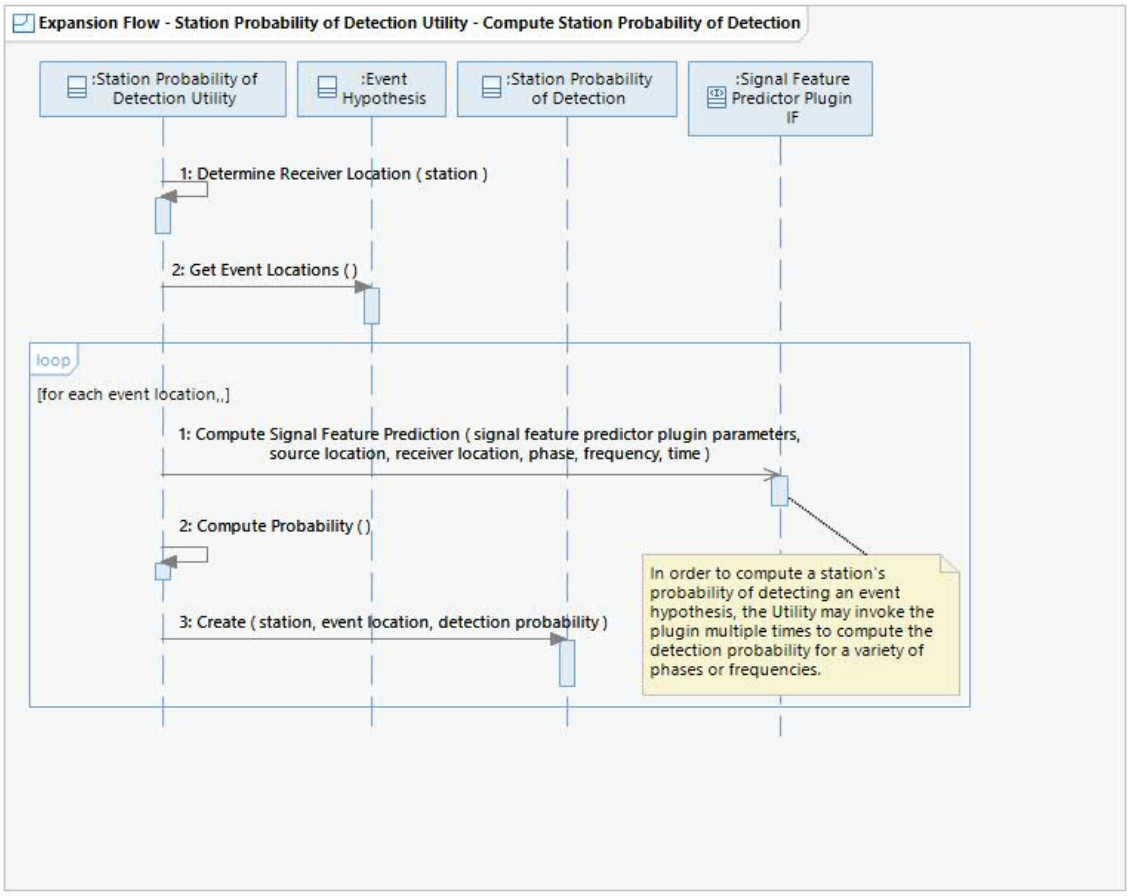


This flow shows Station Quality Metric Utility using information from Station Configuration, Station SOH, and Event Hypothesis to compute the station quality metric for each station. Station Quality Metric Utility computes a quality metric for each Event Location of an Event Hypothesis. The Utility computes quality metrics for the time each station detected the event hypothesis or for the station's predicted detection time based on Event Location solution. Station Quality Metric Utility potentially computes multiple Station Quality Metric values for each Station (e.g. based on raw waveforms from the Station, based on a detection beam created by System Enhances Signals Control using the Station's waveforms).

Operation Descriptions

None

Expansion Flow - Station Probability of Detection Utility - Compute Station Probability of Detection

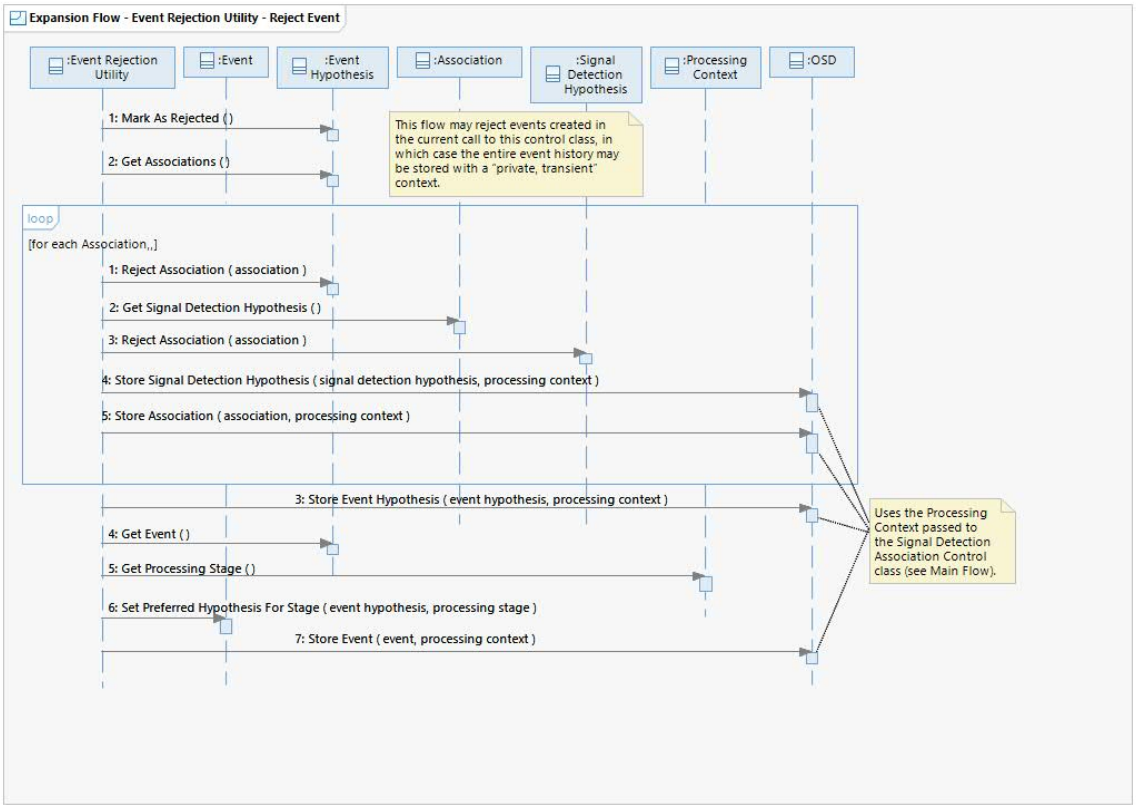


This flow shows the Station Probability of Detection Utility binding to and invoking a Signal Feature Predictor Plugin to calculate a Station's probability of detecting a provided Event Hypothesis. The utility calculates a probability of detection for each Event Location of the Event Hypothesis. The invoking Control class determines the parameters defining the specific Signal Feature Predictor Plugin IF used by the Station Probably of Detection Utility as well as the phases and frequencies it uses in calls to the plugin. Station Probability of Detection Utility creates a Station Probability of Detection object to hold the results of this calculation.

Operation Descriptions

None

Expansion Flow - Event Rejection Utility - Reject Event



This flow shows Event Rejection Utility rejecting an event. The utility marks the provided event hypothesis as rejected, unassociates all signal detections from the event hypothesis, and sets this hypothesis as the event's preferred hypothesis. The utility stores the event, the event hypothesis, and the unassociated signal detection hypotheses in the OSD using the provided Processing Context.

Operation Descriptions

Operation: OSD::Store Event Hypothesis()
Store the given Event Hypothesis with the given lifespan (persistent vs. transient) and visibility (private vs. global) as specified by the given Processing Context and notify relevant subscribers via callbacks.

Operation: OSD::Store Event()
Store the given Event with the given lifespan (persistent vs. transient) and visibility (private vs. global) as specified by the given Processing Context and notify relevant subscribers via callbacks.

State Machine Diagrams

None

SSD Mappings

General:

S-1504: [*Threshold*] The System shall use the seismic, hydroacoustic, and infrasound network signal association parameters to form event hypotheses from any combination of seismic, hydroacoustic, and infrasound signal detections meeting the signal association event hypothesis formation criteria.

S-1505: [*Threshold*] The System shall use empirical values of the network signal association parameters during event hypothesis formation.

S-1506: [*Threshold*] The System shall use historic probability of signal detection during event hypothesis formation.

S-1507: [*Threshold*] The System shall use seismic network signal association parameters to assign phases to seismic signal detections.

S-1508: [*Threshold*] The System shall use hydroacoustic network signal association parameters to assign H phases to hydroacoustic signal detections at hydrophone stations.

S-1509: [*Threshold*] The System shall use hydroacoustic network signal association parameters to assign T phases to hydroacoustic signal detections from T-phase stations.

S-1510: [*Threshold*] The System shall use infrasound network signal association parameters to assign phases to infrasound signal detections.

S-1511: [*Threshold*] The System shall support concurrent signal association event hypothesis formation criteria.

S-1513: [*Threshold*] The System shall associate unassociated signal detections created by any signal detection algorithm to event hypotheses formed by any event formation algorithm.

S-1514: [*Threshold*] The System shall compute the station probability of detecting an event hypothesis during event formation.

S-1515: [*Threshold*] The System shall use variable resolution representations of the Earth for signal association parameter predictions during signal association to account for the varying ability to resolve signals originating in different areas.

S-1516: [*Objective / Priority 2*] The System shall create new event hypotheses which modify existing user-reviewed event hypotheses only when the event quality metric for the automatic event hypothesis improves more than a configured threshold.

S-1517: [*Objective / Priority 2*] The System shall recreate previously rejected event hypotheses

as a result of the Analyst invoking automated processing algorithms only when the event quality metric for the automatic event hypothesis improves more than a configured threshold.

S-1518: [*Threshold*] The System shall use the configured earth model(s) during signal detection association.

S-1540: [*Threshold*] The System shall perform late network signal association using the seismic, hydroacoustic, and infrasound network signal association parameters to form event hypotheses from any combination of seismic, hydroacoustic, and infrasound signal detections meeting the signal association event hypothesis formation criteria.

S-1541: [*Threshold*] The System shall perform late network signal association for a time interval when one or more signal detections for that time interval become available that were not available during prior network signal association or late network signal associations for that time interval.

S-1542: [*Threshold*] The System shall not automatically perform network signal association affecting signal detections that the Analyst is actively reviewing.

S-1543: [*Threshold*] The System shall set signal detections to non-defining for event hypothesis location calculations when the System automatically associates them to Analyst reviewed event hypotheses.

S-1544: [*Threshold*] The System shall set station magnitudes to non-defining for event hypothesis magnitude calculations when the System automatically associates them to Analyst reviewed event hypotheses.

S-1547: [*Threshold*] The System shall recreate an event hypothesis during late association that was rejected in user review only when the event quality metric for the automatic event hypothesis improves more than a configured threshold or when the new event hypothesis definition differs from the original event hypothesis more than a configurable threshold.

S-1548: [*Threshold*] The System shall not automatically reassociate a signal detection to an event hypothesis if an Analyst has previously unassociated that signal detection from the event hypothesis.

S-1549: [*Threshold*] The System shall perform late network signal association during the operational processing time period.

S-1554: [*Threshold*] The System shall set to non-defining newly associated signal detections when the Analyst invokes automated processing algorithms to associate signal detections to existing event hypotheses.

S-1556: [*Threshold*] The System shall store all event hypotheses formed by the System.

S-1557: [*Threshold*] The System shall store all signal detection associations for each event

hypothesis stored by the System.

S-1560: [*Threshold*] The System shall associate signal detections to event hypotheses found with waveform correlation event processing by mapping signal detections on all network sensors to compatible signal detections on the historic waveforms.

S-1561: [*Threshold*] The System shall assign phase identifications to signal detections associated to event hypotheses found via waveform correlation to the same phases as the matching historic event hypotheses.

S-1572: [*Threshold*] The System shall compute the station quality metric for all events.

S-1576: [*Threshold*] The System shall store the station quality metrics for all stations for each event hypothesis.

S-1579: [*Threshold*] The System shall compute an event hypothesis quality metric using the event hypothesis quality statistics for each event hypothesis formed on the System.

S-1580: [*Threshold*] The System shall recompute the event hypothesis quality metric for an event hypothesis when any of the event hypothesis quality statistics used to calculate the event hypothesis quality metric are updated.

S-1581: [*Threshold*] The System shall not automatically form event hypotheses with event hypothesis quality metrics below the event hypothesis quality metric threshold.

S-1582: [*Threshold*] The System shall not screen any Analyst created event hypotheses by their event hypothesis quality metrics.

S-1588: [*Threshold*] The System shall store the event quality metric for each event hypothesis.

S-1597: [*Threshold*] The System shall compute new event hypothesis relocations when an automatic process associates a new location defining signal detection to that event hypothesis.

S-1598: [*Threshold*] The System shall compute new event hypothesis relocations when an automatic process unassociates a location defining signal detection from that event hypothesis.

S-2036: [*Threshold*] The System shall use configured default defining/non-defining state settings and precedence rules to determine the initial defining/non-defining state for each parameter.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-2342: [*Threshold*] The System shall mark as requiring Analyst review any event previously reviewed by an Analyst that has its signal detection associations subsequently modified by the

System.

S-3026: [*Threshold*] The System shall build new events using signal detection templates.

S-5596: [*Threshold*] The System shall use station-to-event distance when associating signal detections to events.

S-5597: [*Threshold*] The System shall use event magnitude when associating signal detections to events.

S-5598: [*Threshold*] The System shall use waveform data quality when associating signal detections to events.

S-5599: [*Threshold*] The System shall use station noise level when associating signal detections to events.

S-5600: [*Threshold*] The System shall use event location to assign phase identifications to signal detections based on predicted phase ID matching.

S-5601: [*Threshold*] The System shall use event location to assign phase identifications to signal detections based on available empirical phase ID matching.

S-5641: [*Objective / Priority 1*] The System shall identify microbarom signals.

S-5642: [*Objective / Priority 1*] The System shall prevent association of microbarom signals to events.

S-5968: [*Threshold*] The System shall associate signal detections to existing events using signal detection templates.

S-6513: [*Threshold*] The System shall build new events using seed events from third-party event bulletins.

S-6521: [*Threshold*] The System shall store seed events.

S-6522: [*Threshold*] The System shall store seed event quality.

Notes

General:
1. "Expansion Flow – Signal Detection Association Control - Associate Signal Detections" shows Signal Detection Association Control calling a single Signal Detection Associator Plugin. The System Maintainer may configure a Processing Sequence to call multiple Signal Detection Associator Plugins by configuring the Processing Sequence to invoke Signal Detection Association Control more than one time but with each call using parameters specifying a different plugin (see 'Defines Processing Sequence' UCR).

2. In “Expansion Flow – Signal Detection Association Control – Associate Signal Detections” Signal Detection Association Control creates a new Event for each new Event Hypothesis built by a Signal Detection Associator Plugin. Signal Detection Association Control may reject some of these Events if they have poor event quality metrics (see “Expansion Flow – Signal Detection Association Control – Postprocess Event Hypotheses”) and other Events may be modified or rejected during conflict resolution (see ‘System Resolves Event Conflicts’ UCR). As an optimization, the implementation may decide to not create Event objects for newly built Event Hypotheses until after conflict resolution.

3. 'System Resolves Event Conflicts' UCR describes how signal detection association conflicts are resolved, including conflict checking between event hypotheses built in this UCR and Analyst reviewed event hypotheses.

IDC Specific:
None.

IDC Use Case Realization Report

UCR-03.03 Scans Waveforms and Unassociated Detections

Use Case Description

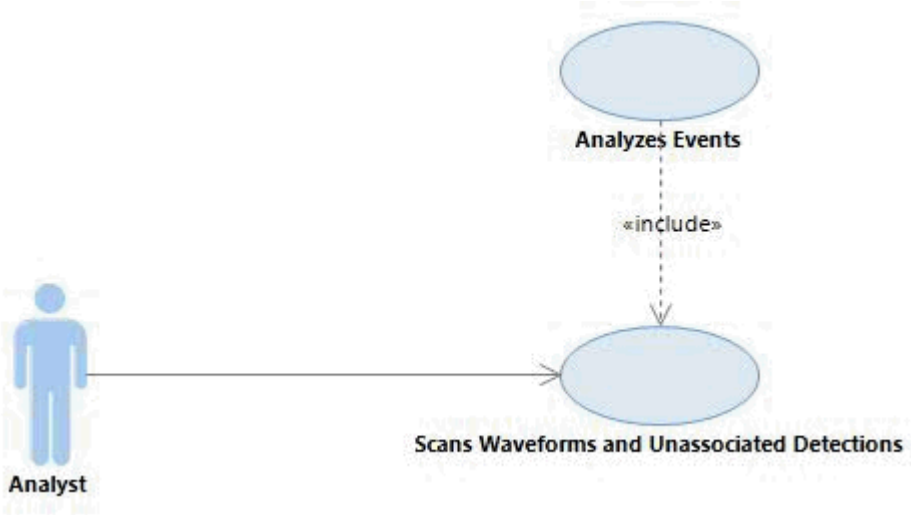
This architecturally significant use case describes how the Analyst scans waveforms and detection feature maps to find signal detections missed by prior processing. The Analyst scans unassociated signal detections to find signal detections that should be associated to existing event hypotheses (see 'Detects Signals' UC) and to build new events (see 'Builds Event' UC). The Analyst saves unassociated signal detections.

This use case is architecturally significant because it requires a platform for the Analyst to efficiently review large amounts of sensor data in order to evaluate, correct, and improve signal detection and event formation.

Architecture Description

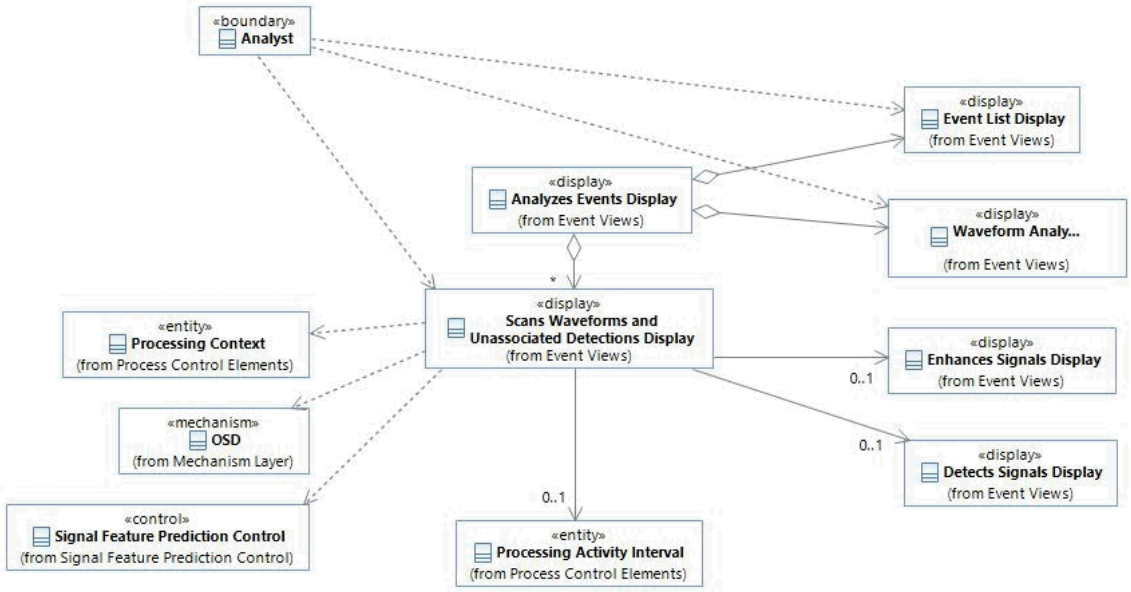
The Analyst begins scanning Waveforms, Detection Feature Maps, and unassociated signal detections by selecting a scanning activity from the Selects Data for Analysis Display. The Analyst uses the Scans Waveforms and Unassociated Detections Display to view and scan through the Waveforms, Detection Feature Maps, and unassociated signal detections. The Analyst uses the Enhances Signals Display to filter waveforms to emphasize signals. The Analyst uses the Detects Signals Display to create signal detections, refine signal detections, reject signal detections, associate signal detections to event hypotheses, and to modify existing signal detection associations to event hypotheses. These actions are depicted in those use case realizations. As the Analyst creates or modifies Signal Detections, Event Hypotheses, or Events the objects are stored transiently in a private context via the OSD mechanism to make them available to the Processing Sequence Control mechanism for further automatic processing (the Processing Sequence Control mechanism is described in 'System Detects Event' UCR). When the Analyst selects to save changes the Scans Waveforms and Unassociated Detections Display uses the OSD to store the Events, Event Hypotheses, unassociated Signal Detections, Waveforms, and Detection Feature Maps with a persistent, global context.

Use Case Diagram



Class Diagrams

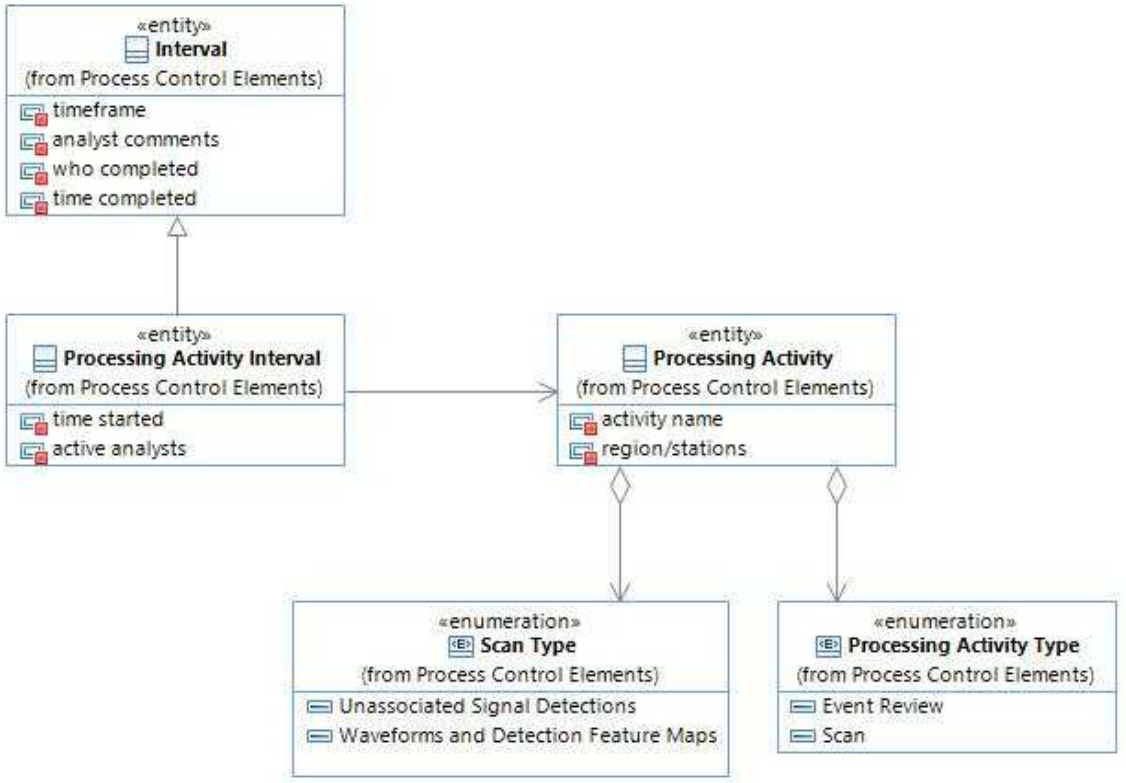
Classes - Scans Waveforms and Unassociated Detections Display



This diagram shows the Scans Waveforms and Unassociated Detections Display and its relationships to other classes as relevant to this use case. The display is created by the Analyzes Events Display when the Analyst selects to perform a scanning Processing Activity. The display uses the common Waveform Analysis Display to show Waveforms, Detection Feature Maps indexed to the Waveforms used to build them, and Signal Detections. The Waveform Analysis Display provides the Analyst with the capability to scan the Detection Feature Maps and to create, reject, and modify signal detections. The common Event List Display shows Events and allows the Analyst to scroll through the data. The Waveform Analysis Display uses the Enhances Signals Display to create derived waveforms and Detection Feature Maps, uses the

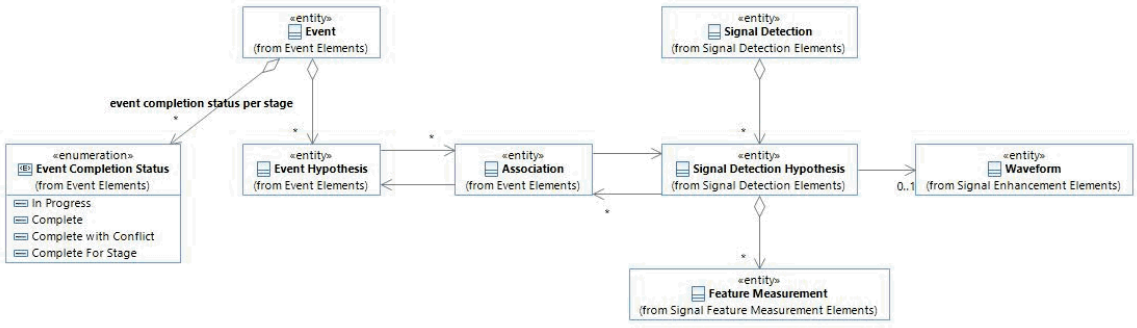
Detects Signals Display to create Signal Detections (and Signal Detection Hypotheses), and uses the Detects Signals Display to associate Signal Detection Hypotheses to Event Hypotheses. New or modified unassociated Signal Detections (and Signal Detection Hypotheses), and new or modified Events (and Event Hypotheses) are stored in the OSD. The OSD also provides data callbacks when other Analysts or the System update data related to the scan.

Classes - Processing Activity Interval



This diagram shows the Processing Activity Interval class and its relationships when used to define a scanning Processing Activity.

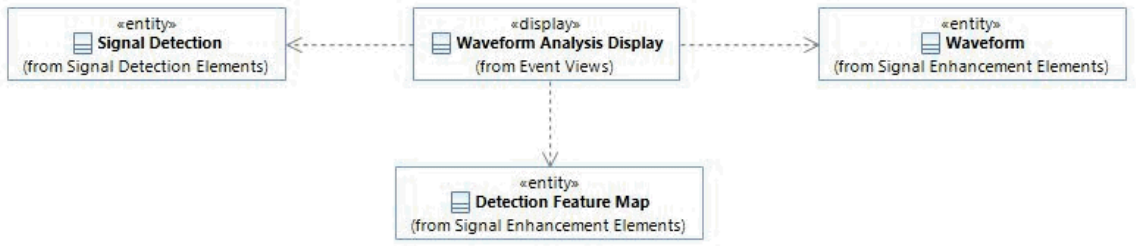
Classes - Event



This class diagram shows the Event class and its associated classes as used in 'Scans Waveforms and Unassociated Detections' UCR. While scanning waveforms and unassociated detections the Analyst creates new Signal Detections, modifies existing Signal Detection Hypotheses, rejects

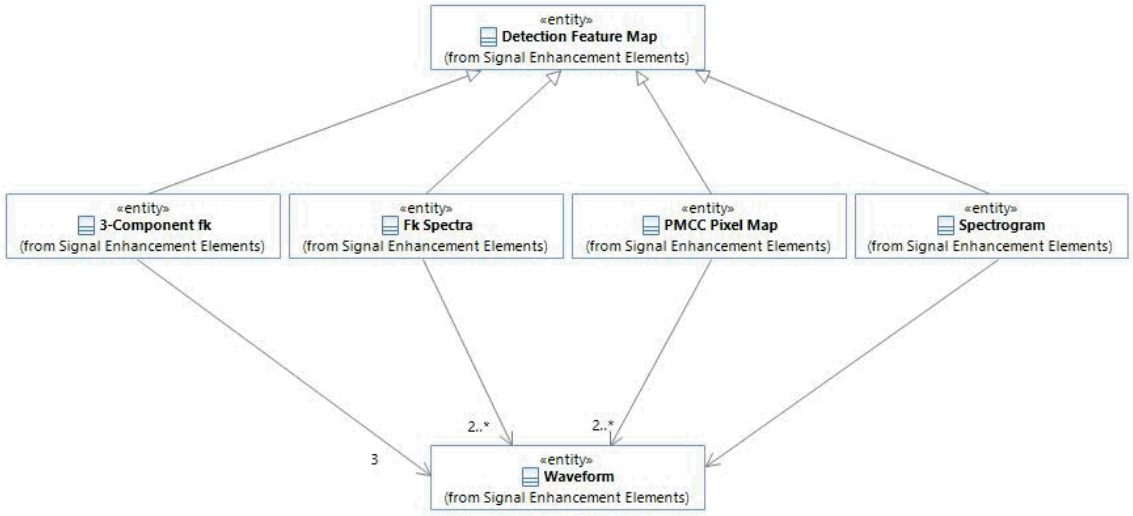
existing Signal Detections, builds new Event Hypotheses, and associates Signal Detection Hypotheses to Event Hypotheses. While creating Signal Detection Hypotheses the Analyst may create new Waveforms by enhancing existing Waveforms. These actions are depicted in 'Enhances Signals' UCR, 'Detects Signals' UCR, and 'Builds Event' UCR. All Events created or modified in this UCR are stored with an Event Completion Status of "In Progress". Further refinement and setting the Event Completion Status to other values is shown in 'Refines Event' UCR and 'Marks Processing Stage Complete' UCR.

Classes - Waveform Analysis Display



This diagram shows the relationship of the Waveform Analysis Display with the Detection Feature Maps, signal detections, and waveforms.

Classes - Detection Feature Map



This diagram shows the relationship of the Detection Feature Map with Waveform and the classes that specialize Detection Feature Map.

Class Descriptions

<<boundary>> Analyst
Represents the Analyst actor.

<<control>> Signal Feature Prediction Control
Responsible for controlling the signal feature prediction computations. Retrieves necessary data, invokes the appropriate Signal Feature Predictor Plugin to compute the desired signal feature prediction, and stores the result.

<<display>> Analyzes Events Display
Display that provides the Analyst with the ability to analyze data within a specified time interval in order to find or refine Events.

<<display>> Detects Signals Display
Provides the Analyst with the ability to rerun automatic signal detection with Analyst-specified parameters.

<<display>> Event List Display
The Event List Display provides a list of Events related to the current context of an Analyst's analysis activities. Primarily the Event List shows the Events within the selected Interval times. Alternately, the Event List shows the Events returned as result of a search or the list of Events selected by the Analyst. The Event List provides the interface to select an Event for further analysis.

<<display>> Scans Waveforms and Unassociated Detections Display
The Scans Waveforms and Unassociated Detections Display provides the interface for Analysts to create Signal Detections and associate/unassociate Signal Detections to Events. The Scans Waveforms and Unassociated Detections Display interacts with the Waveform Analysis Display to display Waveforms (this includes raw waveforms, filtered waveforms, origin beams, virtual origin beams, fk beams, and other derived channels), Detection Feature Maps, and Signal Detection Hypotheses.

<<display>> Waveform Analysis Display
Displays a set of waveforms and Detection Feature Maps and provides the Analyst with the ability to interact with them (e.g. create/modify/reject Signal Detections, associate/unassociate detections and Events).

<<entity>> 3-Component fk
Represents a 3-Component fk. This is an approximation of an fk spectra calculated for a 3-Component station by performing polarization analysis for the station's waveforms rotated to a variety of points in azimuth-slowness space.

<<entity>> Association
Represents an association between a Signal Detection Hypothesis and an Event Hypothesis.

<<entity>> Detection Feature Map
A Detection Feature Map is a base class representing multi-dimensional features computed from a Station's waveforms over time. Specializations of Detection Feature Map determine the measured feature (e.g. Spectrogram measures signal amplitude indexed by frequency).

<<entity>> Event
Represents information about an Event. Keeps track of all the Event Hypotheses for the Event, which Event Hypothesis is the preferred one for each processing stage, the active analysts for the Event (i.e. whether the Event is under "active review"), whether the Event is "complete" for each

processing stage, and other Event-related information.

<<entity>> Event Hypothesis
Represents geophysical information about an Event as determined by an Analyst or through pipeline processing. There can be multiple Event Hypotheses for the same Event (e.g. different associated Signal Detection Hypotheses, different location solutions).

<<entity>> Feature Measurement
Represents the value and uncertainty of a measured feature of a signal detection.

<<entity>> Fk Spectra
Represents the fk (frequency-wavenumber) power spectra and associated F-statistics for a set of waveforms. The fk power spectrum is a representation in the fk domain of coherent signal power in waveform data from multiple stations for a specified time interval. Calculation of fk power spectrum requires three Fourier transforms to convert time-sampling to frequency (designated by f), and longitude and latitude sampling to x and y wavenumbers (designated by k). Typically fk power spectra are represented as 2D plots (not 3D), by collapsing the frequency information to a single value for each x and y slowness by averaging values across the range of frequencies.

<<entity>> Interval
Class for tracking the status of interactive or automatic processing on a specific timeframe of data. Specialized intervals exist for Processing Stage, Processing Activity, and Processing Sequence.

<<entity>> PMCC Pixel Map
Represents a PMCC Pixel Map which contains pixels of coherent waveform segments from multiple sensors prior to grouping the pixels into families. Each pixel may contain measurements such as horizontal trace velocity and back azimuth.

<<entity>> Processing Activity
Defines an activity within a processing stage. Two types of Processing Activities exist: Event Review and Scan. The "region/stations" attribute may be set by the user to optionally limit the activity to the specified geographical region or set of stations.

<<entity>> Processing Context
Represents the context in which data is being stored and/or processed. This includes the Processing Stage (either automatic or interactive) and Interval performing the processing session (e.g. processed by Analyst vs. processed by System). For Analyst processing, may identify the Analyst work session. For System processing, may identify the Processing Sequence and/or Processing Step being executed (including a way to identify a particular Processing Sequence and Processing Step among the many possible instantiations), the visibility for the results (private vs. global), and the lifespan of the data (transient vs. persistent). This information is needed by the Processing Sequence Control to manage the execution of Processing Sequences, which may execute in the context of an Analyst refining an Event or in the context of the system initiating automatic processing. It is also needed by the Object Storage and Distribution (OSD)

mechanism to determine how to store and distribute the data.

<<entity>> Signal Detection
Represents information about a Signal Detection and keeps track of all the Signal Detection Hypotheses for the Signal Detection. Represents information about a Signal Detection and keeps track of all the Signal Detection Hypotheses for the Signal Detection. For an unassociated Signal Detection the preferred Signal Detection Hypothesis is the most recently created Signal Detection Hypothesis. For an associated Signal Detection the preferred Signal Detection Hypothesis is the one associated to a preferred Event Hypothesis.

<<entity>> Signal Detection Hypothesis
Represents geophysical information about a Signal Detection as determined by an Analyst or through pipeline processing. There can be multiple Signal Detection Hypotheses for the same Signal Detection (e.g. different onset times, different phase labels).

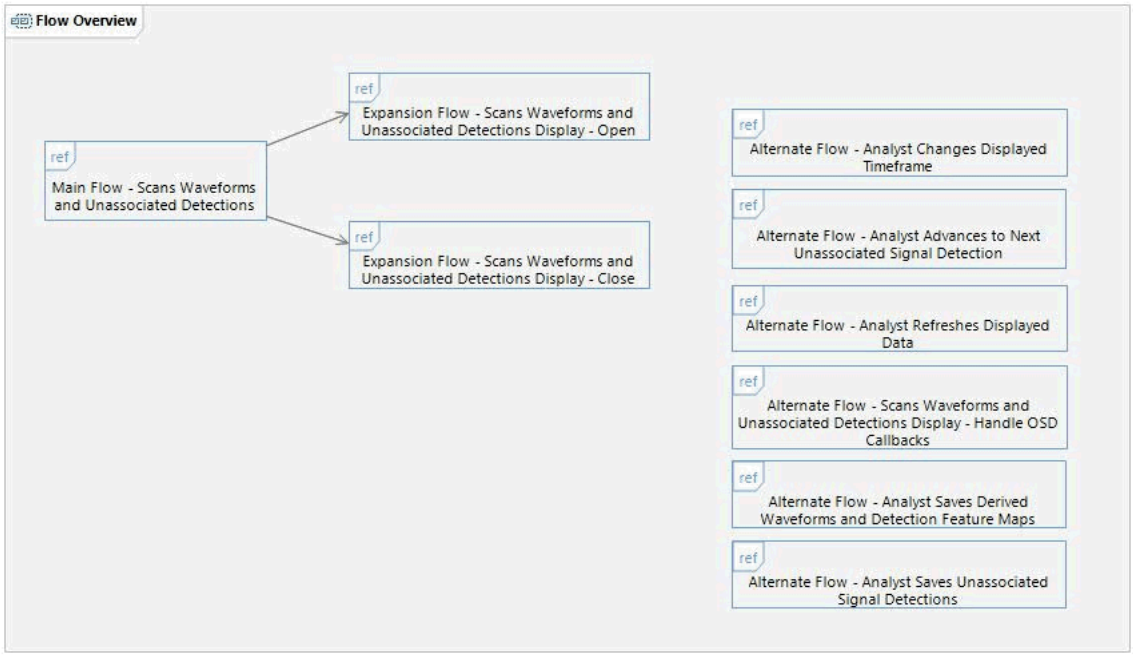
<<entity>> Spectrogram
Indicates how the frequency content of the associated Waveform varies over time.

<<entity>> Waveform
A Waveform represents a time-series of data from a Channel.

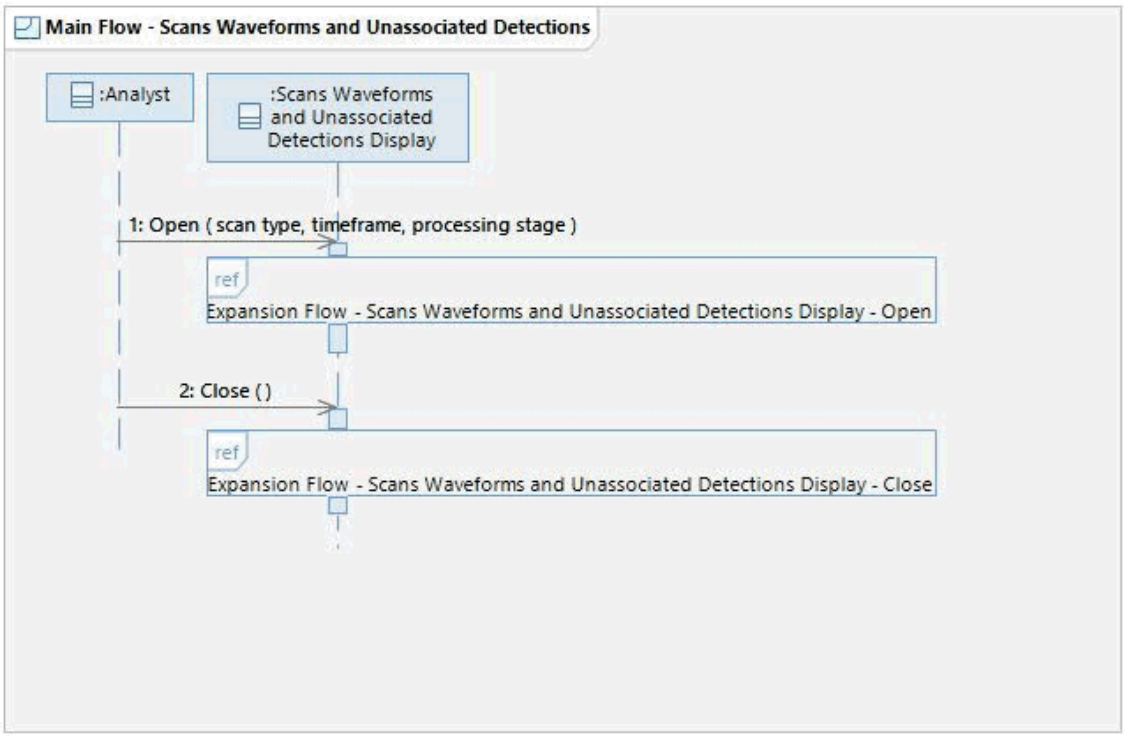
<<mechanism>> OSD
Represents the Object Storage and Distribution mechanism for storing and distributing data objects internally within the system.

Sequence Diagrams

Flow Overview



Main Flow - Scans Waveforms and Unassociated Detections



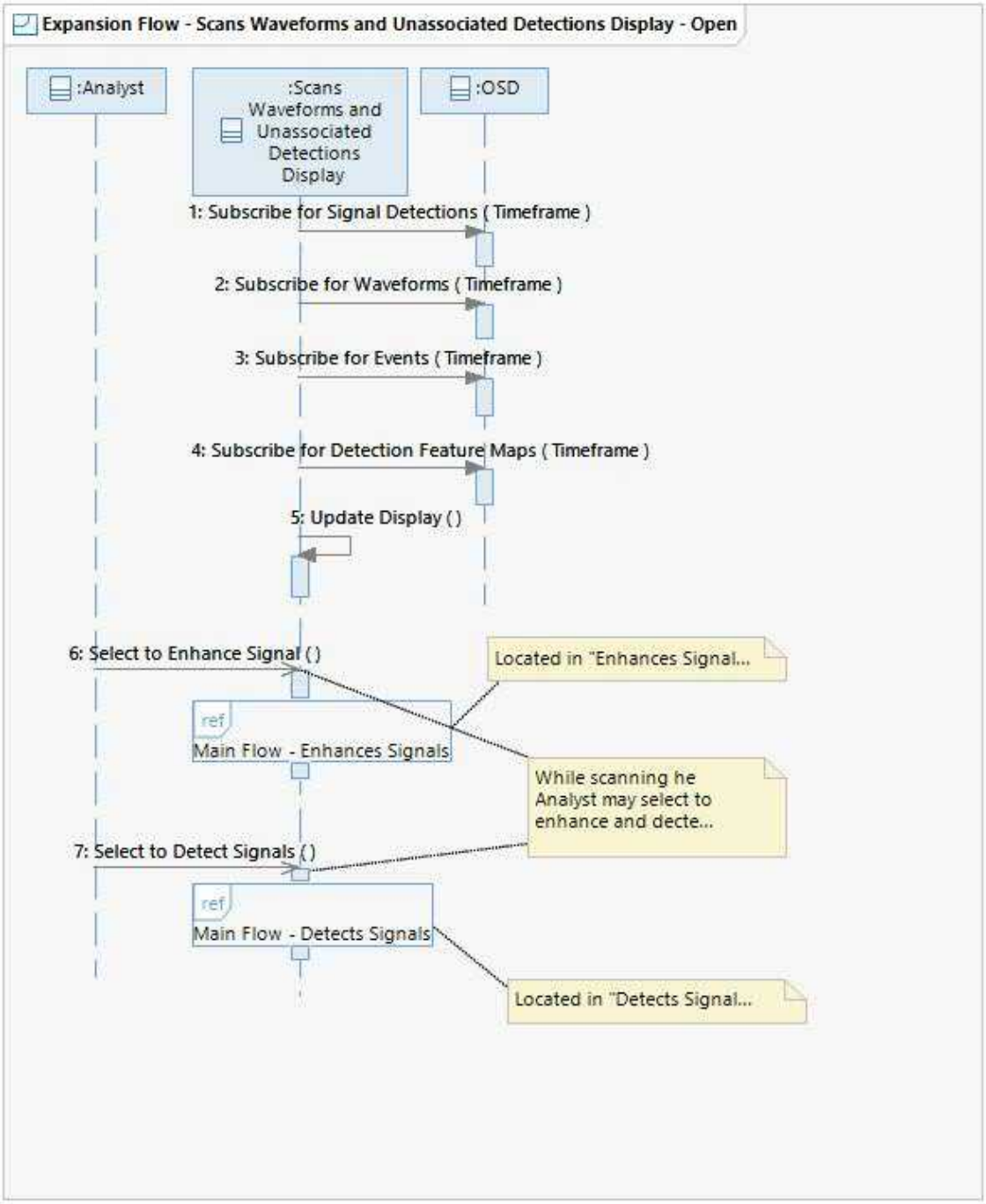
This flow shows the Analyst opening and closing Scans Waveforms and Unassociated

Detections Display. The Scans Waveforms and Unassociated Detections Display is primarily opened by the Analyzes Event Display when a Scan Processing Activity is selected.

Operation Descriptions

None

Expansion Flow - Scans Waveforms and Unassociated Detections Display - Open



This flow shows the Analyst's primary actions when scanning waveforms and unassociated

detections. The flow shows opening the Scans Waveforms and Unassociated Detections Display for a timeframe and scan type. The Scans Waveforms and Unassociated Detections Display registers with the OSD for data updates. The subscription Timeframes correspond to the timeframe parameter passed to this flow, which spans the entire timeframe of data to be scanned. The Analyst scans waveforms, Detection Feature Maps and unassociated detections by enhancing signals (see 'Enhances Signals' UCR) and creating, updating, and/or rejecting Signal Detections (see 'Detects Signals' UCR). The GUI in the Scans Waveforms and Unassociated Detections Display is opened with a different visual layout that is based on the scan type. The Analyst may build a new event during a scan by returning to Analyzes Events Display to access the Builds Event Display.

Operation Descriptions

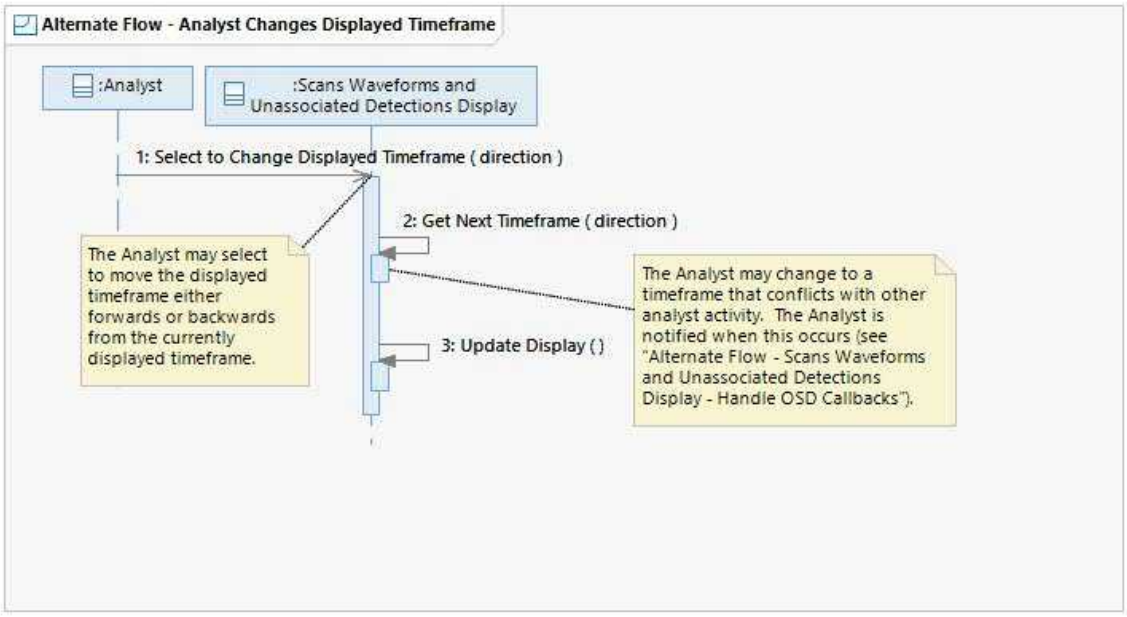
Operation: OSD::Subscribe for Signal Detections()
Subscribe for updates regarding Signal Detection creations, modifications, and associations occurring within the specified timeframe. This includes updates for new or modified unassociated Signal Detections.

Operation: OSD::Subscribe for Waveforms()
Subscribe for updates regarding raw and derived waveforms occurring within a specified timeframe. This includes information about what waveforms have been acquired by the System as well as what derived waveforms have been formed, but does not include the actual waveform data.

Operation: OSD::Subscribe for Events()
Subscribe for changes to Event objects within the given timeframe. Callbacks are invoked on subscribers any time an Event within the timeframe is added or modified.

Operation: OSD::Subscribe for Detection Feature Maps()
Subscribe for updates regarding Detection Feature Map creations and modifications within the specified timeframe.

Alternate Flow - Analyst Changes Displayed Timeframe

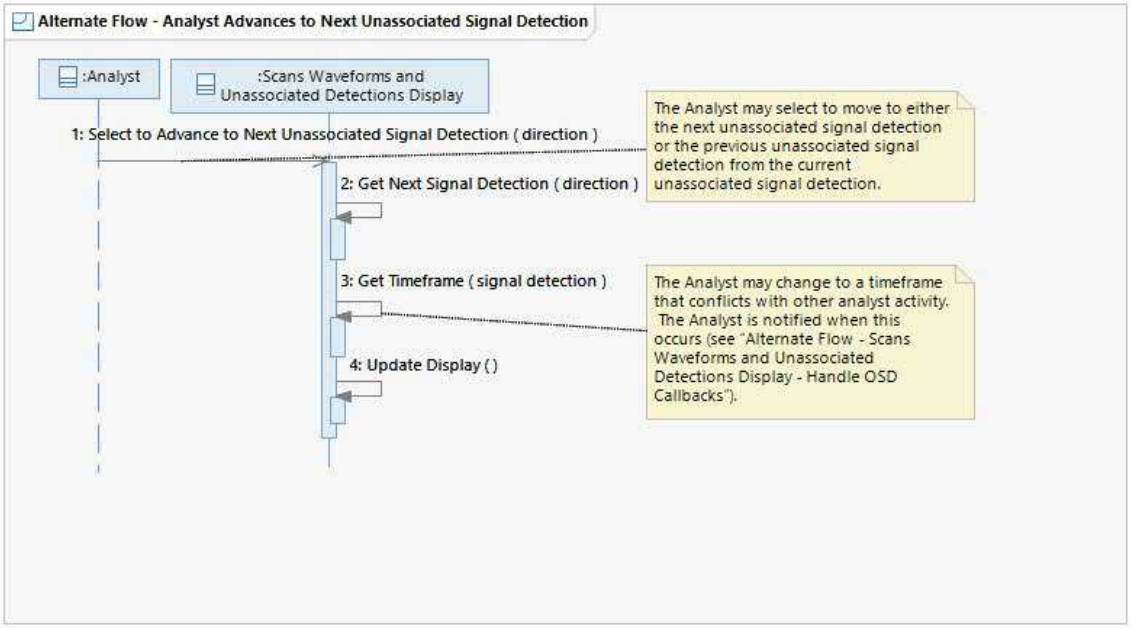


This flow shows how the Analyst changes the timeframe of waveforms and Detection Feature Maps visible in the Scans Waveforms and Unassociated Detections Display. The Analyst selects to scroll the timeframe to show waveforms either before or after the currently displayed waveforms.

Operation Descriptions

None

Alternate Flow - Analyst Advances to Next Unassociated Signal Detection



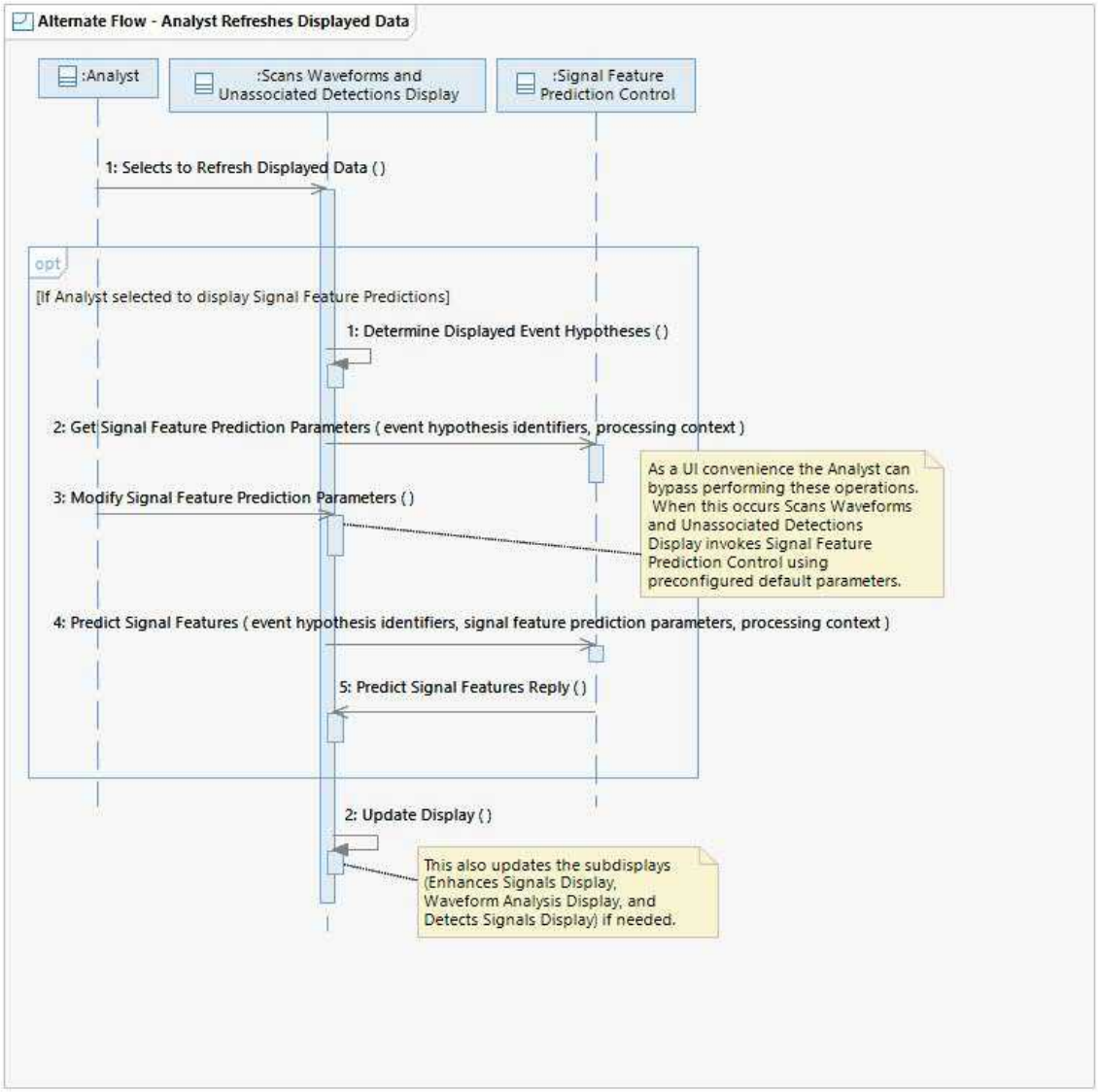
This flow shows how the Analyst changes the selected unassociated Signal Detection on the Scans Waveforms and Unassociated Detections Display. The Analyst selects to change to either the previous or the next unassociated signal detection. The Scans Waveforms and Unassociated Detections Display determines the new active timeframe as a timeframe centered on the selected Signal Detection Hypothesis.

Operation Descriptions

Operation: Scans Waveforms and Unassociated Detections Display::Get Timeframe()
Computes an active timeframe that is centered on the provided signal detection.

Operation: Scans Waveforms and Unassociated Detections Display::Select to Advance to Next Unassociated Signal Detection()
Based on the direction parameter, the Scans Waveforms and Unassociated Detections Display advances the selected Signal Detection to either the previous or the next unassociated Signal Detection.

Alternate Flow - Analyst Refreshes Displayed Data

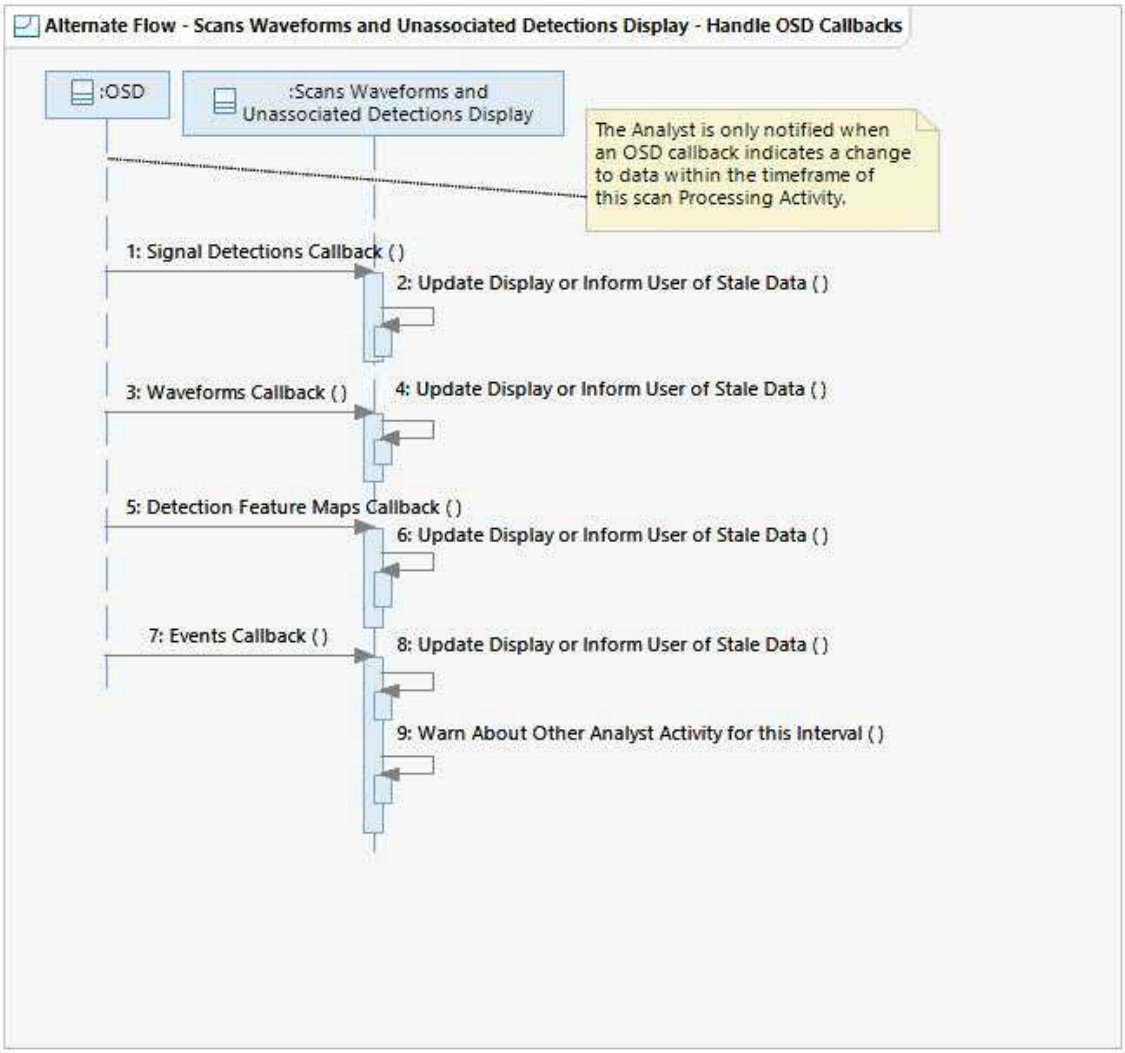


This flow shows how the Analyst refreshes the Scans Waveforms and Unassociated Detections Display to show the latest Waveforms, Detection Feature Maps, Predicted Signal Features, and Signal Detections. The Analyst needs this capability since newly acquired Waveforms, Detection Feature Maps, new or modified Signal Detections from other Processing Stages are only updated when requested by the Analyst. The Analyst may also select to display predicted signal features such as predicted signal detection arrival times for the displayed event hypotheses. Scans Waveforms and Unassociated Detections Display notifies the Analyst when there is new data that is not shown on the display (see "Alternate Flow - Scans Waveforms and Unassociated Detections Display - Handle OSD Callbacks"). The Analyst may refresh the display to show that data at any time via this flow. Note that the display does not need to retrieve the new data from the OSD since it already has it due to subscriptions with the OSD (see "Expansion Flow - Scans Waveforms and Unassociated Detections Display – Open").

Operation Descriptions

None

Alternate Flow - Scans Waveforms and Unassociated Detections Display - Handle OSD Callbacks



This flow shows how the Scans Waveforms and Unassociated Detections Display handles callbacks from the OSD. The OSD invokes these callbacks as appropriate when data is stored in the OSD, which may be initiated by the current Analyst, other Analysts, or by the System as part of executing a Processing Sequence (executing Processing Sequences is shown in 'System Detects Event' UCR.) The Scans Waveforms and Unassociated Detections Display subscribes for Intervals and Events in order to notify the Analyst when other Analysts may be performing work that conflicts with, overlaps with, or otherwise affects the current Analyst's work. The Scans Waveforms and Unassociated Detections Display subscribes for Signal Detection, Waveform, Event, and Detection Feature Map callbacks to notify the Analyst of new or updated data. The Scans Waveforms and Unassociated Detections Display does not automatically update the display after notifying the Analyst of new or updated data. The Analyst may refresh the

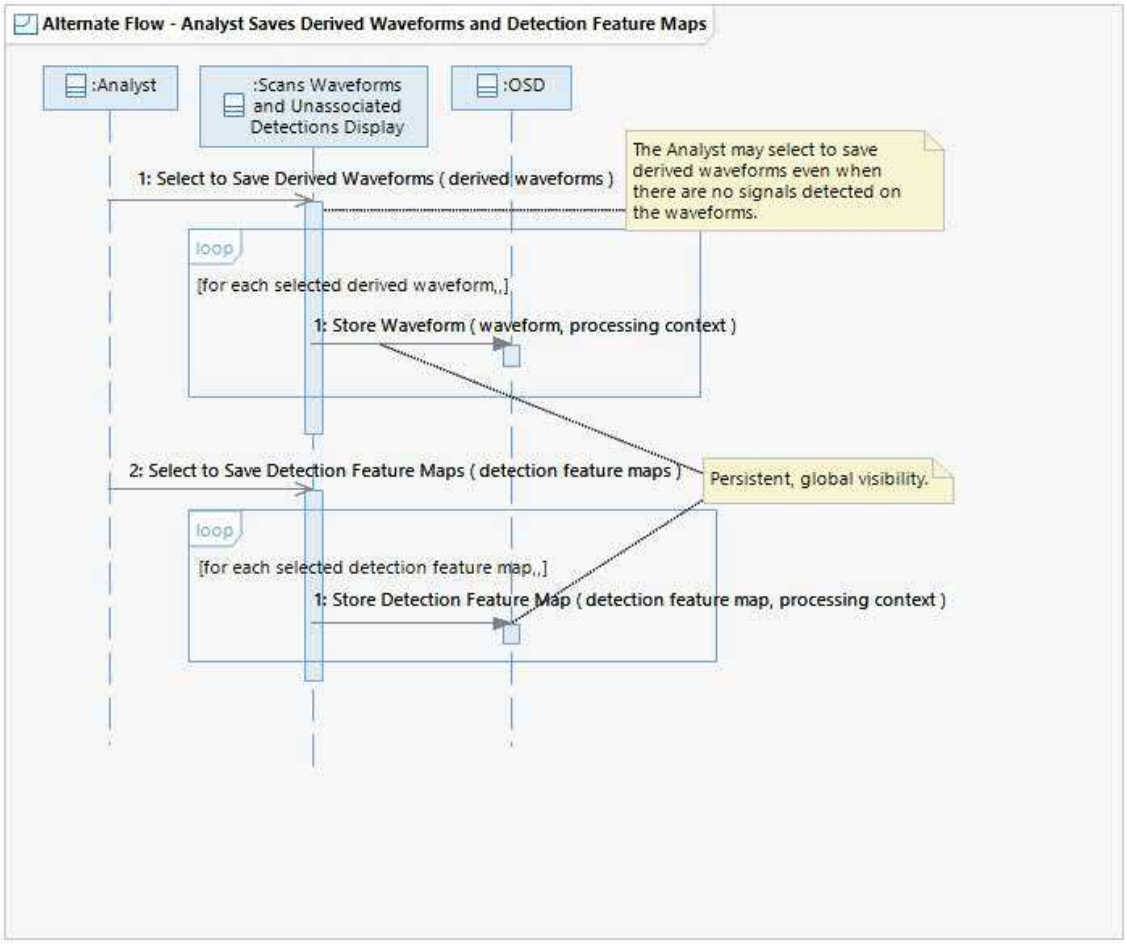
display to show the most recent data at any time (see “Alternate Flow – Analyst Refreshes Displayed Data”).

Operation Descriptions

Operation: Scans Waveforms and Unassociated Detections Display::Update Display or Inform User of Stale Data()

When the System receives late arriving data the System either immediately processes the data and updates the display or the System delays processing of the data until the Analyst processing stage is complete. The System Maintainer defines which alternative is performed by default (see 'Configures Processing Components" UCR). If the System delays processing the late data the System notifies the Analyst and the Analyst can choose to immediately process the data.

Alternate Flow - Analyst Saves Derived Waveforms and Detection Feature Maps



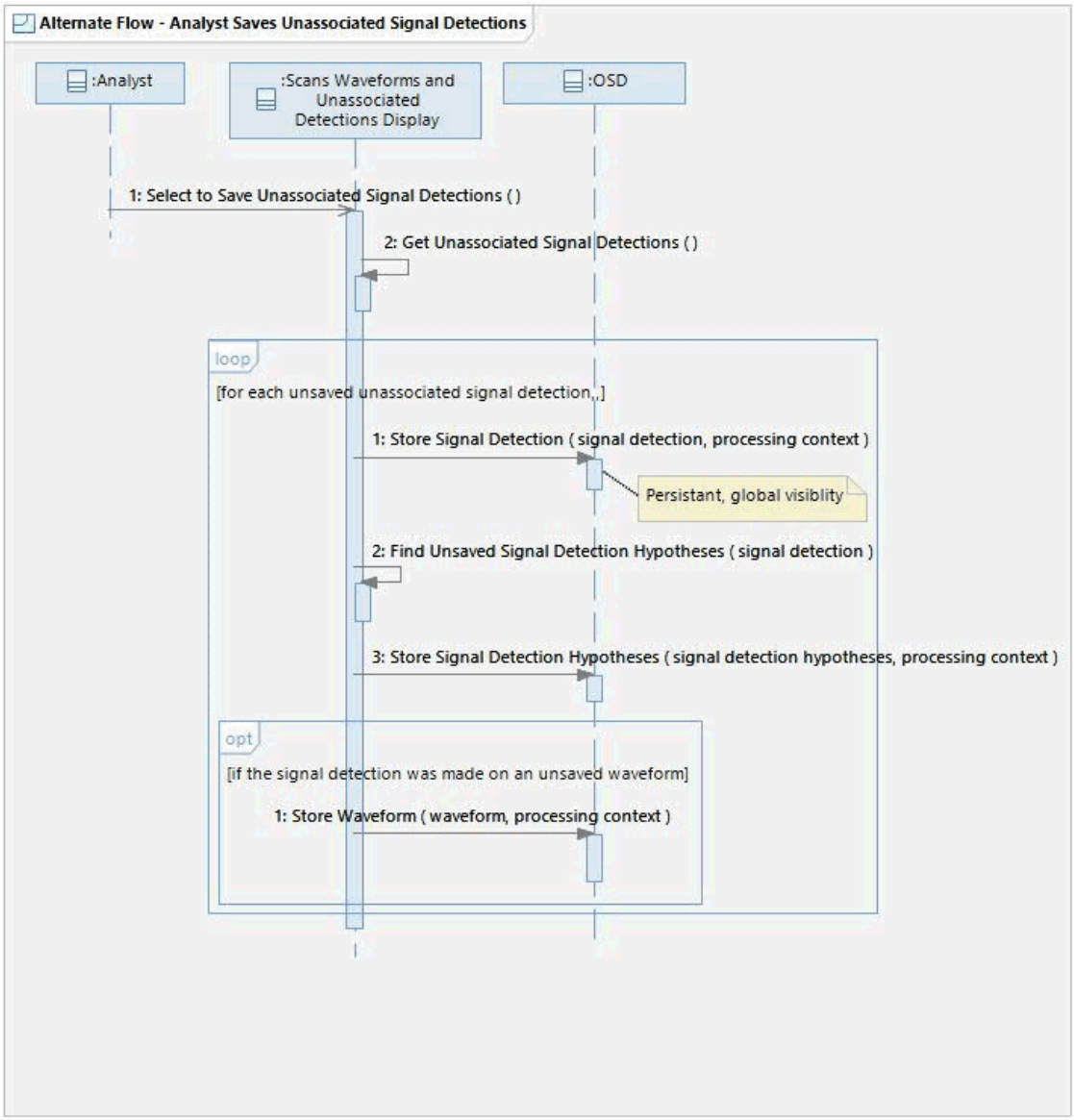
This flow shows the Scans Waveforms and Unassociated Detections Display using the OSD to derived waveforms and Detection Feature Maps.

Operation Descriptions

Operation: OSD::Store Waveform()
Store the given Waveform with the given lifespan (persistent vs. transient) and visibility (private vs. global) as specified by the given Processing Context and notify relevant subscribers via callbacks.

Operation: OSD::Store Detection Feature Map()
Store the given Detection Feature Map with the given lifespan (persistent vs. transient) and visibility (private vs. global) as specified by the given Processing Context and notify relevant subscribers via callbacks.

Alternate Flow - Analyst Saves Unassociated Signal Detections



This flow shows the Scans Waveforms and Unassociated Detections Display using the OSD to save unassociated Signal Detections. The display also stores to the OSD any previously unsaved

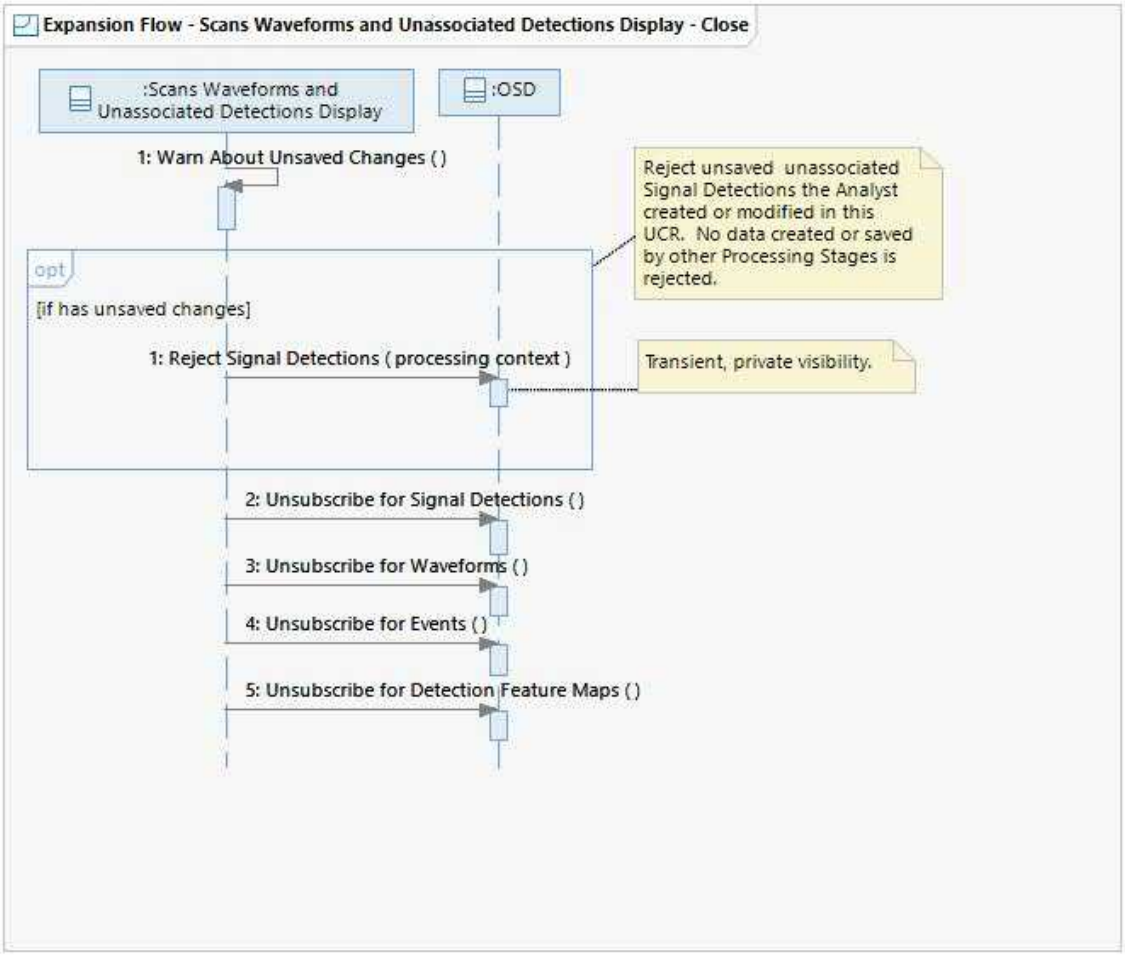
waveforms that contain saved signal detections.

Operation Descriptions

Operation: OSD::Store Signal Detection()
Store the given Signal Detection with the given lifespan (persistent vs. transient) and visibility (private vs. global) as specified by the given Processing Context and notify relevant subscribers via callbacks.

Operation: OSD::Store Waveform()
Store the given Waveform with the given lifespan (persistent vs. transient) and visibility (private vs. global) as specified by the given Processing Context and notify relevant subscribers via callbacks.

Expansion Flow - Scans Waveforms and Unassociated Detections Display - Close



This flow shows closing the Scans Waveforms and Unassociated Detection Display. The Scans Waveforms and Unassociated Detection Display checks for and warns the Analyst if there are any unsaved changes to unassociated Signal Detections. The Scans Waveforms and Unassociated Detections display rejects the unsaved changes from the OSD. The Scans

Waveforms and Unassociated Detections display unsubscribes from OSD data updates.

Operation Descriptions

None

State Machine Diagrams

None

SSD Mappings

General:

S-1157: [*Objective / Priority 2*] The System shall provide the Analyst the capability to view newly acquired waveform data within 1 minute of acquisition.

S-1373: [*Threshold*] The System shall provide the Analyst the capability to view continuous beams for virtual event hypotheses for predefined geographic regions.

S-1393: [*Threshold*] The System shall store all derived channels related to one or more signal detections.

S-1877: [*Threshold*] The System shall notify Analysts working in a common processing stage if they are concurrently modifying signal detections in the same analysis time interval.

S-1878: [*Threshold*] The System shall provide the Analyst the capability to access and view all waveform data stored on the System.

S-1885: [*Threshold*] The System shall display 24 hours of continuous waveform data before the waveform displays flatline.

S-1888: [*Threshold*] The System shall provide the Analyst the capability to analyze continuous waveform data from within a selected time block.

S-1915: [*Threshold*] The System shall provide the Analyst the capability to process data without altering another Analyst's existing solution.

S-1929: [*Threshold*] The System shall provide the Analyst the capability to individually select signal detections as processing input during an analysis session.

S-1947: [*Threshold*] The System shall implement user interfaces according to the User Interface Guidelines.

S-2043: [*Threshold*] The System shall store automatic and interactive processing results.

S-2164: [*Threshold*] The System shall access requested waveform data within one (1) minute of

receipt by the Data Processing Partition.

S-2167: [*Threshold*] The System shall write a 6 hour or less time block of 40Hz waveform data within the Operational Processing Time Period with a maximum 5 second latency. (Goal: 1 second.)

S-2168: [*Threshold*] The System shall read a 6 hour or less time block of 40Hz waveform data outside the Operational Processing Time Period with a maximum 10 second latency. (Goal: 2 seconds.)

S-2169: [*Threshold*] The System shall read a 6 hour or less time block of 40Hz waveform data within the Operational Processing Time Period with a maximum 5 second latency. (Goal: 1 second.)

S-2170: [*Threshold*] The System shall write a 6 hour or less time block of 40Hz waveform data outside the Operational Processing Time Period with a maximum 10 second latency. (Goal: 2 seconds.)

S-2223: [*Threshold*] The System shall store all data and derived processing results to persistent storage as soon as the data and/or derived processing results are available.

S-2420: [*Threshold*] The System shall provide the Analyst the capability to store selected derived waveforms.

S-2603: [*Threshold*] The System shall provide the System User the capability to access requested waveform data.

S-2604: [*Threshold*] The System shall provide the Analyst the capability to access late-arriving waveform data within one (1) minute of receipt by the Data Processing Partition.

S-5708: [*Threshold*] The System shall read a 6 hour or less time block of processing results within the Operational Processing Time Period with a maximum 5 second latency. (Goal: 1 second.)

S-5709: [*Threshold*] The System shall write a 6 hour or less time block of processing results within the Operational Processing Time Period with a maximum 5 second latency. (Goal: 1 second.)

S-5712: [*Threshold*] The System shall read a 6 hour or less time block of processing results outside the Operational Processing Time Period with a maximum 10 second latency. (Goal: 2 seconds.)

S-5713: [*Threshold*] The System shall write a 6 hour or less time block of processing results from outside the Operational Processing Time Period with a maximum 10 second latency. (Goal: 2 seconds.)

S-6437: [*Threshold*] The System shall provide the Analyst the capability to time align detection feature maps based on signal detections.

S-6438: [*Threshold*] The System shall provide the Analyst the capability to time align detection feature maps with waveforms.

S-6439: [*Threshold*] The System shall provide the Analyst the capability to select signal detections on a detection feature map.

IDC Specific:

S-5612: [*Threshold*] The System shall provide the Analyst the capability to request auxiliary seismic waveform data from the Data Acquisition Partition.

Notes

General:
1. The Analyst refines Event Hypotheses created or modified by this UCR in 'Refines Event' UCR. When the Analyst creates or modifies an Event Hypothesis in this UCR, the System adds the Event to the list of Events requiring analysis (see 'Analyzes Events' UCR) with an Event Completion Status of "In Progress". The Analyst can then select to refine the Event from that list. See 'Marks Processing Stage Complete' UCR for a state machine diagram for Event Completion Status.

2. The Analyst may define a temporary, custom scan based on a location and time period.

IDC Use Case Realization Report

UCR-14.04 Performs Expert Technical Analysis

Use Case Description

This architecturally significant use case describes how the Fusion and Review Officer conducts an expert technical analysis upon request from a member state. A member state may request either more detailed analysis of a specific event using IMS data and software, or specific analysis using member state specified data and/or software. Both types of analysis may include but are not limited to geographic location, time, depth, magnitude, waveforms, the signal detection list, a map, phase and depth refinement, and focal mechanism.

If the request is for an Updated Event Bulletin (UEB), the Fusion and Review uses existing System tools and IMS data to improve an event solution or add measurements (see 'Analyzes Event' UC), storing the results in the UEB.

If the request is for a State Requested Methods Report (SRMR), the Fusion and Review Officer retrieves System data as needed for the analysis, performs analysis outside the System using the specified data and software (see 'Analyzes Research Event' UC), and creates an SRMR containing the results of this analysis.

The Fusion and Review Officer makes the UEB, SRMR, and member-state provided data and software available to all member states (see 'Views System Results' UC).

This use case is architecturally significant due to the inclusion of data and software provided by member states.

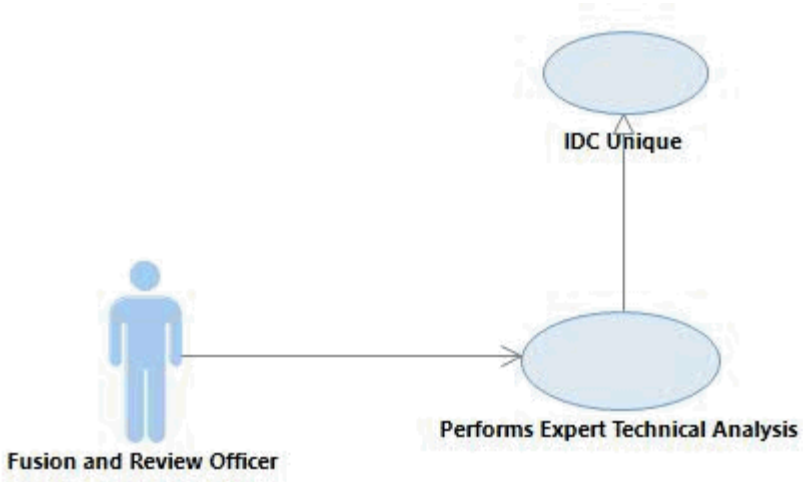
Architecture Description

The Fusion and Review Officer (FARO) performs expert technical analysis by invoking either the Analyzes Events UCR or the Analyzes Research Events UCR. When a member-state requests expert technical analysis using additional data or software, the FARO uses Analyzes Research Events UCR; otherwise, the FARO does the requested extra analysis via Analyzes Events UCR.

Once the FARO completes the requested analysis, the FARO opens the State Requested Methods Report (SRMR) Display to review and edit the SRMR. Using the SRMR Display, the FARO creates the SRMR, updates its contents with the results of the expert technical analysis and releases the SRMR.

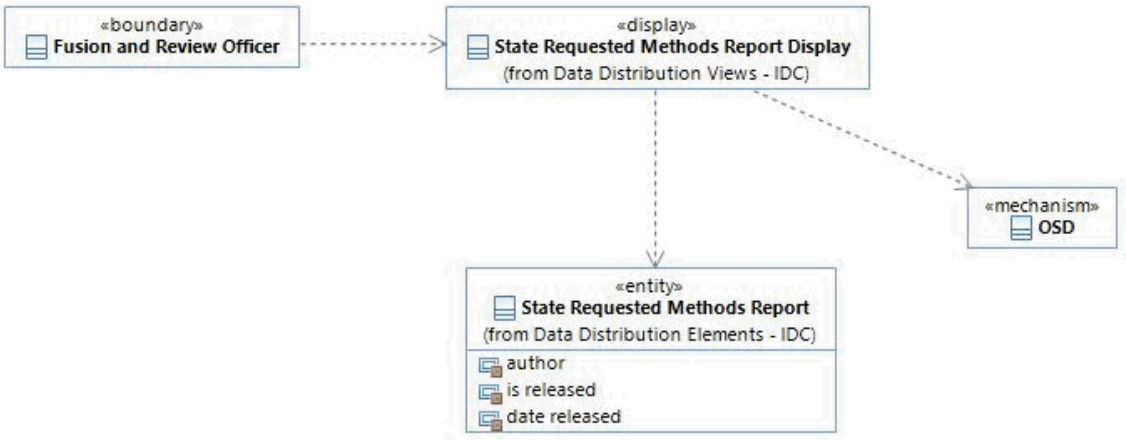
The FARO finds and views previously created States Requested Method Reports via the SRMR Display.

Use Case Diagram



Class Diagrams

Classes - State Requested Methods Report Display



This diagram depicts the State Requested Methods Report Display and related classes. The Fusion and Review Officer opens this display to make and view State Requested Methods Reports, which the display stores and retrieves via the OSD.

Class Descriptions

<<boundary>> Fusion and Review Officer
The Fusion and Review Officer actor is an Analyst who performs expert technical analysis.

<<display>> State Requested Methods Report Display
Display for creating, editing, and viewing State Requested Methods Reports.

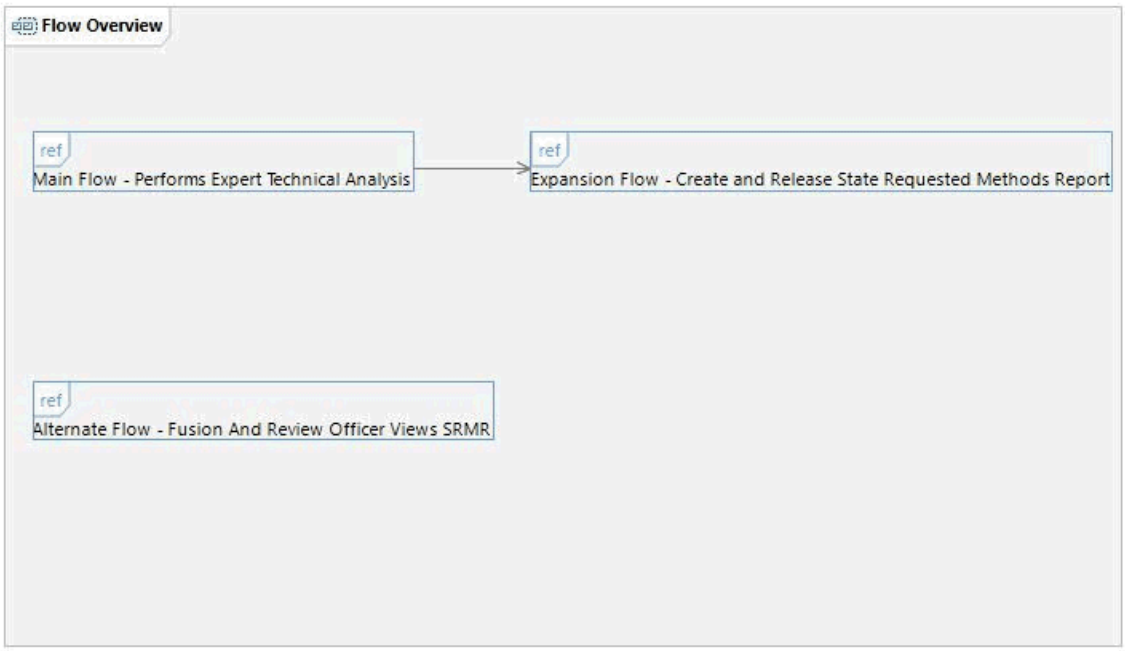
<<entity>> State Requested Methods Report
Entity representing a report of analysis undertaken by a Fusion and Review Officer per request

from a member-state, possibly using extra data and/or software provided by the member-state.

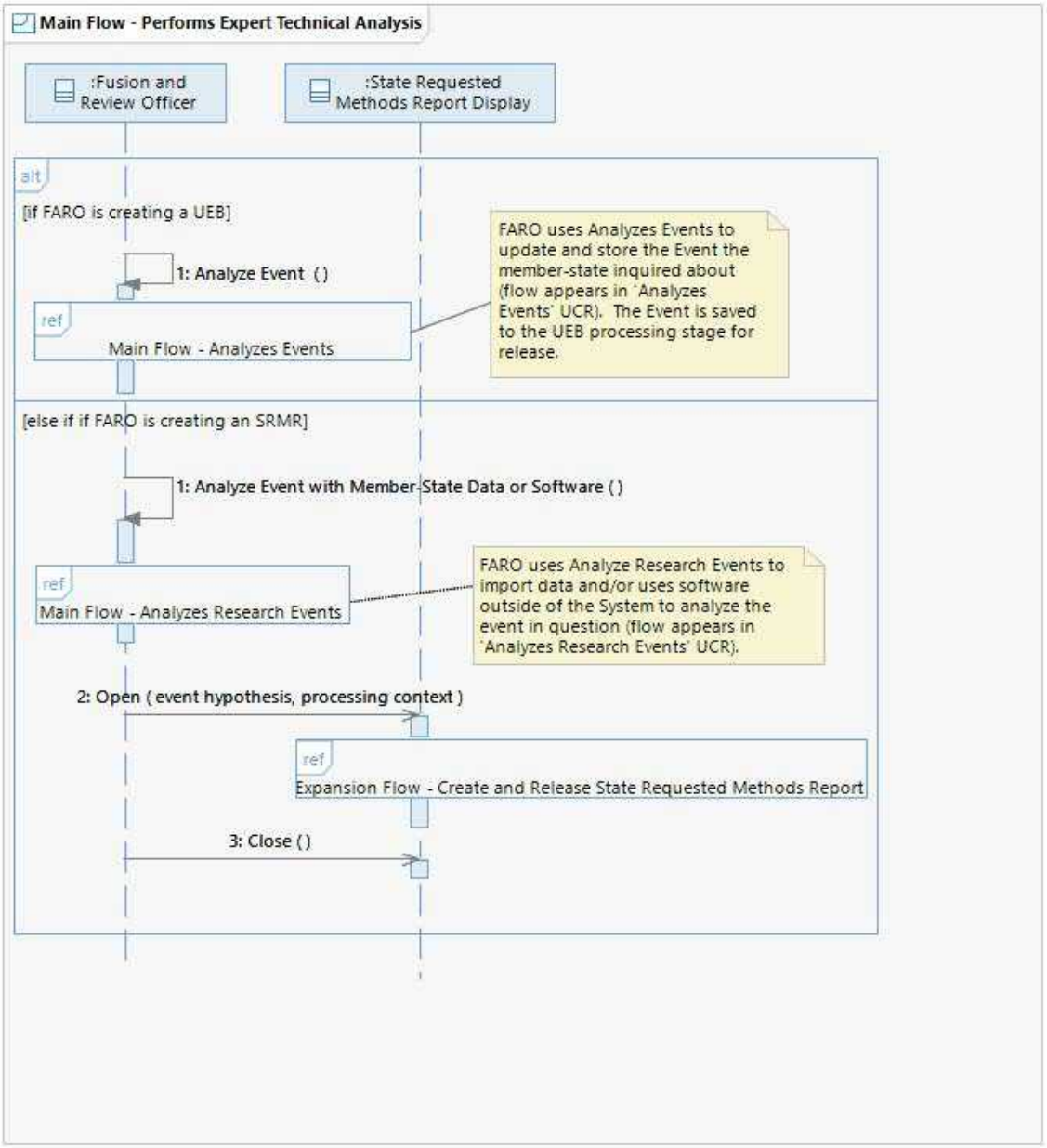
<<mechanism>> OSD
Represents the Object Storage and Distribution mechanism for storing and distributing data objects internally within the system.

Sequence Diagrams

Flow Overview



Main Flow - Performs Expert Technical Analysis



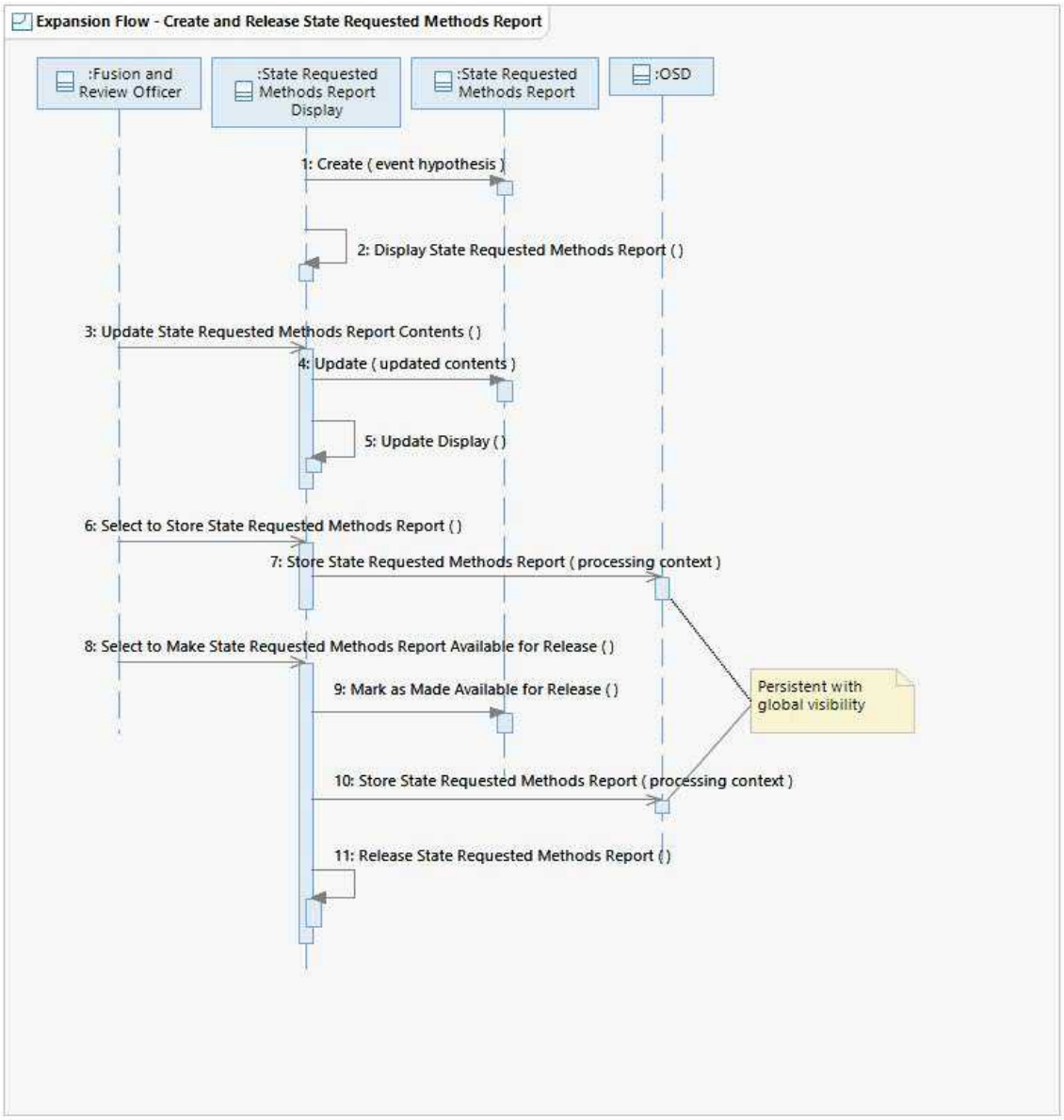
This flow illustrates how the Fusion and Review Officer (FARO) goes about performing the expert technical analysis of a particular event at the behest of a member-state. The FARO invokes either the Analyzes Event UC or Analyzes Research Events UC in order to refine the event; the Analyzes Research Events UC is used when the member-state requests that additional software or data be included in the analysis by the FARO. After performing the analysis on the event and saving it, the FARO opens the State Requested Methods Report Display, which creates the SRMR report and provides the FARO the capability to review, edit, and release the report.

Operation Descriptions

Operation: State Requested Methods Report Display::Open()

Opens the display. This display may be opened from a System display (e.g. Refines Event Display), or as a separate application.

Expansion Flow - Create and Release State Requested Methods Report



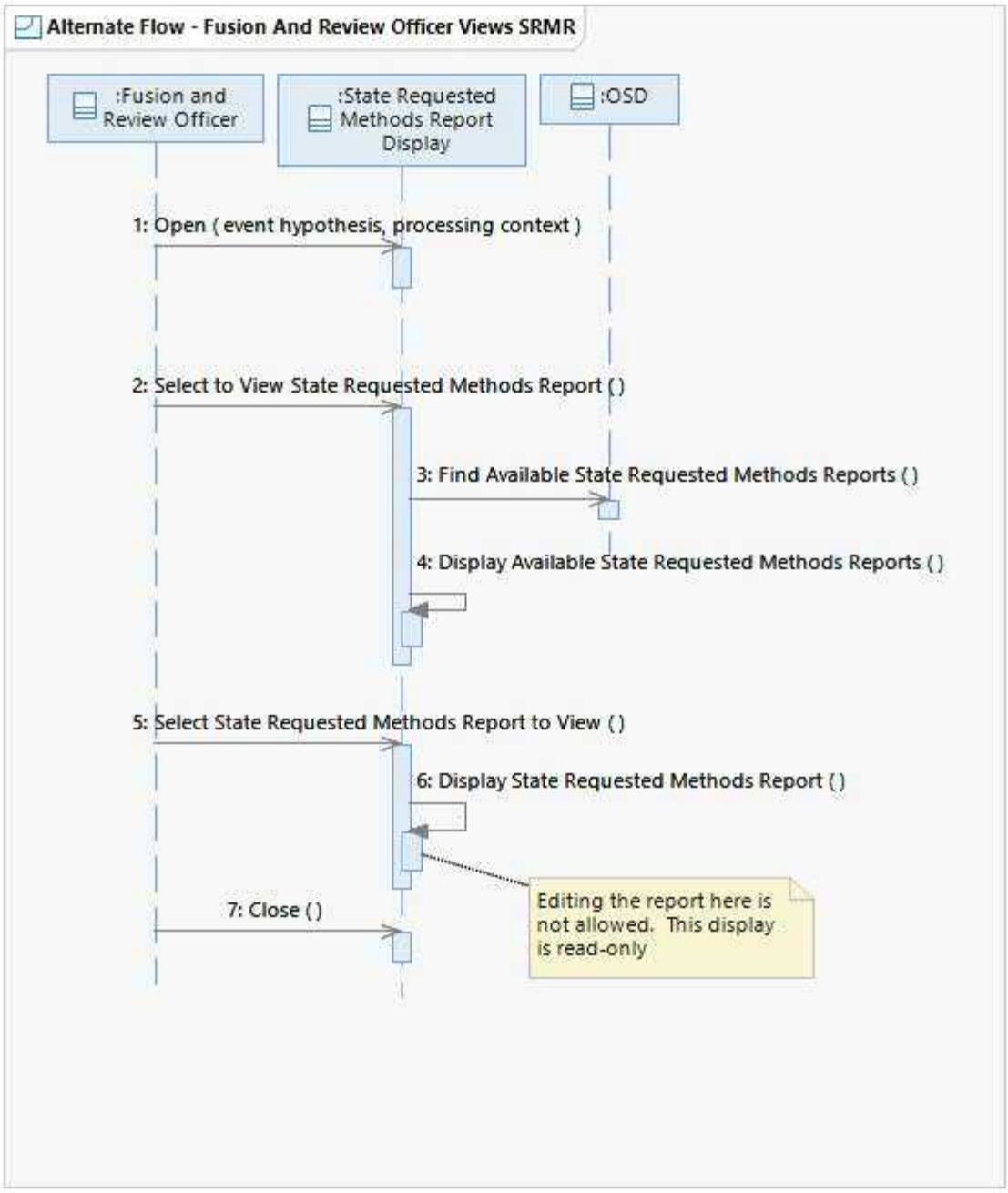
This flow shows how the Fusion and Review Officer interacts with the State Requested Methods Report Display to create, edit, store, and release a State Requested Methods Report.

Operation Descriptions

Operation: State Requested Methods Report Display::Update State Requested Methods Report Contents()

Add contents to the State Requested Methods Report, such as text and images that describe the results of the technical analysis of the event.

Alternate Flow - Fusion And Review Officer Views SRMR



This alternate flow shows how the Fusion and Review Officer can find and view State Requested Methods Reports through the State Requested Methods Reports Display.

Operation Descriptions

Operation: State Requested Methods Report Display::Open()
Opens the display. This display may be opened from a System display (e.g. Refines Event Display), or as a separate application.

State Machine Diagrams

None

SSD Mappings

General:

S-1947: [*Threshold*] The System shall implement user interfaces according to the User Interface Guidelines.

IDC Specific:

S-5763: [*Extensibility*] The System shall apply user-specified processing to existing data and products to create custom reports.

S-5764: [*Extensibility*] The System shall provide the Authorized External User the capability to select user-specified processing of data and products to create custom reports.

S-6457: [*Threshold*] The System shall provide the Fusion and Review Officer the capability to create an event report.

S-6458: [*Threshold*] The System shall provide the Fusion and Review Officer the capability to create a State Requested Methods Report.

S-6459: [*Threshold*] The System shall provide the Fusion and Review Officer the capability to save an event to the Updated Event Bulletin.

S-6460: [*Threshold*] The System shall provide the Fusion and Review Officer the capability to distribute a State Requested Methods Report.

Notes

General:
None.

IDC Specific:
1. The Updated Event Bulletin and State Requested Methods Report (SRMR) are processing results that are available for access by an Authorized External User (see 'Views System Results' UCR and 'Requests System Data' UCR).

2. The contents of a State Requested Methods Report have yet to be defined by IDC.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