**Macintosh HD:Users:Dependable:Shared:Documents:Templates:DCi.logo.pdf**

Sponsor: AFRL

Project No.: 144

Contract: ASTRA IST

This document is for authorized use only. Any information contained herein should be considered proprietary unless otherwise specified.

© 2023 Dependable Computing. All Rights Reserved

Dependable Computing

1/10/2024

Top-Level Specification

Zone Alert Service

Abstract

This document provides the intended functionality of an OpenUxAS Zone Alert Service as a top-level solution specification. The specification is meant to only be as formal as is required to be reasonably accurate for all readers. The specification defines what functions/behaviors the solution provides and the model of how it provides then fitting within the OpenUxAS environment.

.

Contents

1 Introduction 1

1. Introduction

The Zone Alert Service is a stand-up service that can be activated as part of an OpenUxAS instance. Its purpose is to alert subscribers to when vehicles associated with the UxAS instance in one of two states:

1. Are in current violation of a zone boundary
2. Will imminently violate a zone boundary for which avoidance is not possible.
3. Are in danger of violating a zone boundary in the near future at a time for which vehicle reaction to avoid possible reaction is still possible.

These three cases are more carefully defined below.

1. Functions

## Function 1: Report Zone Boundary Violations

### Definitions:

* **Zone Boundary Violation Event**: A *zone boundary violation* at time t is defined as one or more point in a *defined geometric region around a particular vehicle position* at time t being within one or more *keep-out zones* and/or outside one or *more keep-in zones*.
* **Defined Geometric Region Around the Vehicle**: The defined geometric region around the vehicle is typically a sphere of defined radius Rv.
* **Violated Zone**: A keep-in or keep-out zone at time t that is subject of one or more zone boundary violation events.
* **Iterative Service**: An OpenUxAS service that computes and delivers its functional behavior at fixed, repeated soft real-time (best effort) intervals.
* **Function Interval**: An iteration of an OpenUxAS iterative service.

### Assumptions:

1. Vehicle position at time t is the point-position estimated for a vehicle at time t in OpenUxAS.
2. A vehicle position at time t may be an exact reported position from OpenUxAS or an estimated position based on a physics-based interpolation from last reported vehicle state.
3. Vehicle positions are exact, without noise, in the intended simulation environment.
4. There are a limited number of zones and vehicles, so that the number of simultaneous notifications to be sent and received will never burden OpenUxAS or services.

### Function Definition:

1. Subscribers shall be informed as soon as possible of all new zone boundary violation events detected for the present function interval.
2. A notification is sent to subscribers for each zone violation event.
3. Subscribers shall receive further alerts for the same zone boundary violation events either (a) never or (b) at fixed time intervals until the event ceases (with a minimum of service iteration rate) for as long as those events continue.

### Examples Cases:

## Function 2: Stretch Goal: Report Imminent Zone Violations

**This function may be cut for time.**

### Definitions:

* **Imminent Zone Violations**: An imminent *zone violation* that will occur at time t <= tx <=t +Tc is defined as the entire *potential future path cone of the vehicle at time t* being such that all future potential position points at time tx violate the same zone(s).
* **Potential Future Path Cone:** A probability field of potential future motion from the current time t to a future time **Tc** assume the vehicle remains intact, such that it includes all possible motion of the vehicle. (It might not be a cone. We just like the word cone. Cone.)

### Assumptions:

1. Vehicle position at time t is the point-position estimated for a vehicle at time t in OpenUxAS.
2. A vehicle position at time t may be an exact reported position from OpenUxAS or an estimated position based on a physics-based interpolation from last reported vehicle state.

### Function Definition:

1. Subscribers shall receive imminent zone boundary violation warning events.
2. Subscribers shall not receive false-positive imminent zone boundary violation events relative to the agreed upon model of Potential Future Path Cone.
3. Service users have access to an accurate, document-based model of the potential future path code defined for a vehicle.

### Example Cases:

## Function 3: Report Path-Aware, Potential Unintended Zone Violations

### Definitions

1. **Potential future zone violation**: A vehicle is in potential future violation with a specific zone at time t if the vehicle’s **linear trajectory at time t** is a future **zone violation event** at one or more times from t to a future lookahead time t+Tlook, where Tlook is a defined constant.
2. **Same potential future violation**: For a given vehicle and zone, two potential future zone violations at times t1 and t2 are the same future potential zone violation if the same potential future zone violation exists for all times from t1 to t2 based on the actual path of the vehicle from time t1 to t2.
3. **Current filed path**: For a given vehicle, a current filed path is a declared mission path to be followed by the vehicle that has not yet been completed. If a filed vehicle point has been completed.

### Assumptions:

1. The zone alert service is aware of any pre-defined path that the vehicle is currently following.
2. Pre-defined paths are defined so as not to violate defined keep-in and keep-out zones for the path’s vehicle.
3. A ‘completed’ filed path is easy to discern from an uncompleted filed path.

### Function Definition:

1. At the iterative rate of the service, subscribers shall be notified of potential future zone violations satisfying the rules of this function.
2. The iterative period of the service is no greater than Titerate.
3. Subscribers are only be notified of the **same potential future violation** once.
4. Subscribers are notified of a potential future violation at future time tx during service iteration at time t, as follows:
5. **tx <= t + Trp:** Subscribers shall be notified of any **potential future violation** at time tx <=t + Trp when the violation is not also imminent (see function 1).
6. **T+Trp < tx <= t + Tnp and Not On Flight Path**: Subscribers shall be notified of any **potential future violation** at time t+Trp < tx <= t+ Tnp when the vehicle does not have a **current filed path** or the vehicle is not following their current filede path within distance tolerace Epath\_tol.
7. **t+Trp < tx <= t+Tnp and On Flight Path**: Subscribers shall *not* be notified of any **potential future violation** at time tx, for t+Trp < tx <= t+Tnp when the vehicle has a **current filed path** and is following that path within distance tolerance Epath\_tol.

### Example Cases:

## Function 4: Initialize Service

### Definitions:

### Assumptions:

### Function Definition:

1. The service is initialized with values for the parameters The service accepts subscriptions during the intilization / setup phase of OpenUxAS.
2. The service subscribes to the messages required to monitor system state for the service:
   1. Entity Configurations
   2. Entity States
   3. Keep-In/Out Zones
   4. Operating Regions
   5. Routes or maybe UniqueAutomationResponse TBD
   6. AirVehicleState

### Example Cases:

## Function 5: Subscribe to Reports

### Definitions:

1. Interest subscription. A party subscribes to interest in a mission group, as defined by the message profile, during OpenUxAS initiation phase.

### Assumptions:

1. We can create a message for entities that want to subscribe to zone alerts.
2. For the current use case, Amase entities, Controller, and other services might be interested in this subscription.

### Function Definition:

1. The service accepts subscriptions during the initialization / setup phase of OpenUxAS

### Example Cases:

## Internal Function A: Internal State Awareness

### Definitions:

### Assumptions:

1. The service receives and processes all relevant messages during initialization, planning, and execution phases of OpenUxAS

### Function Definition:

1. During the initialization phase of OpenUxAS, the service listens for and processes relevant declarations:
   1. The service listens to all entity definitions from AMASE and catalogues the entities
   2. The service listens to operating region declarations and catalogues them
   3. The service listens to keep-in and keep-out zone declarations and catalogies them
2. During operation the service listens for and processes all relevant state updates:
   1. Waypoint plans from UniqueAutomationResponse messages during planning phase
   2. AirVehicleState messages from AMASE during execution phase.

### Example Cases: