ASX Use Case To Ontology

Prepared for the C2SIM ASX Product Development Group

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[1 Overview 6](#_Toc208936308)

[1.1 References 6](#_Toc208936309)

[1.1.1 IEEE Standards 6](#_Toc208936310)

[1.1.2 ASX Group Working Papers 6](#_Toc208936311)

[1.1.3 External Media 6](#_Toc208936312)

[2 Use Case Description 7](#_Toc208936313)

[2.1 Use Case Overview 7](#_Toc208936314)

[2.1.1 Large Urban Area Hit By Earthquake 7](#_Toc208936315)

[2.1.2 Deploy Surveillance Swarm 7](#_Toc208936316)

[2.1.3 Report Observed Swarm 7](#_Toc208936317)

[2.1.4 Deploy Fertilizer via Drone 8](#_Toc208936318)

[2.1.5 Protect Troops / Population 8](#_Toc208936319)

[2.1.6 Detecting and Disrupting EW Signals 8](#_Toc208936320)

[2.1.7 Disrupt Law Enforcement 8](#_Toc208936321)

[2.2 Earthquake Aftermath: General Search via UAV 8](#_Toc208936322)

[2.2.1 Scenario Description 8](#_Toc208936323)

[2.2.2 Scenario Entities 8](#_Toc208936324)

[2.2.3 Scenario Initialization Messages 9](#_Toc208936325)

[2.2.4 Scenario Messages 9](#_Toc208936326)

[2.3 Earthquake Aftermath: Request & Deliver Resource 10](#_Toc208936327)

[2.3.1 Scenario Description 10](#_Toc208936328)

[2.3.2 Scenario Entities 10](#_Toc208936329)

[2.3.3 Scenario Initialization Messages 10](#_Toc208936330)

[2.3.4 Scenario Messages 10](#_Toc208936331)

[2.4 Earthquake Aftermath: Extract Survivor and Deliver to Hospital 11](#_Toc208936332)

[2.4.1 Scenario Description 11](#_Toc208936333)

[2.4.2 Scenario Entities 11](#_Toc208936334)

[2.4.3 Scenario Initialization Messages 11](#_Toc208936335)

[2.4.4 Scenario Messages 12](#_Toc208936336)

[2.5 Swarm Scenario: Deploy Swarm 12](#_Toc208936337)

[2.5.1 Scenario Description 12](#_Toc208936338)

[2.5.2 Scenario Entities 12](#_Toc208936339)

[2.5.3 Scenario Initialization Messages 13](#_Toc208936340)

[2.5.4 Scenario Messages 13](#_Toc208936341)

[2.6 Swarm Scenario: Swarm Leader goes silent 13](#_Toc208936342)

[2.6.1 Scenario Description 13](#_Toc208936343)

[2.6.2 Scenario Entities 14](#_Toc208936344)

[2.6.3 Scenario Initialization Messages 14](#_Toc208936345)

[2.6.4 Scenario Messages 15](#_Toc208936346)

[2.7 Protecting Troops and populations against hostile UAX in modern urban environment 15](#_Toc208936347)

[2.7.1 Mission Overview 15](#_Toc208936348)

[2.7.2 Actions to Model 15](#_Toc208936349)

[2.7.3 Scenario Entities 16](#_Toc208936350)

[2.7.4 Scenario Initialization Messages 16](#_Toc208936351)

[2.7.5 Scenario Messages 16](#_Toc208936352)

[2.8 UC-004 Patrol Group 17](#_Toc208936353)

[2.8.1 Mission Overview 17](#_Toc208936354)

[2.8.2 Actions to Model 17](#_Toc208936355)

[2.8.3 Scenario Entities 17](#_Toc208936356)

[2.8.4 Scenario Initialization Messages 17](#_Toc208936357)

[2.8.5 Scenario Messages 17](#_Toc208936358)

[2.9 UC-005 Deploy Resources – Fertilizer, Poison 17](#_Toc208936359)

[2.9.1 Mission Overview 17](#_Toc208936360)

[2.9.2 Actions to Model 17](#_Toc208936361)

[2.10 UC-006 Disrupting Law Enforcement Team 18](#_Toc208936362)

[2.10.1 Mission Overview 18](#_Toc208936363)

[2.10.2 Actions to Model 18](#_Toc208936364)

[2.11 Report Observed Swarm 18](#_Toc208936365)

[2.11.1 Mission Overview 18](#_Toc208936366)

[2.11.2 Actions to Model 18](#_Toc208936367)

[2.12 UC-008 Detecting and Disrupting EW Signals 18](#_Toc208936368)

[2.12.1 Mission Overview 18](#_Toc208936369)

[2.12.2 Actions to Model 18](#_Toc208936370)

[3 ASX Needs 20](#_Toc208936371)

[3.1 Initialization – UxV-Specific Attributes 20](#_Toc208936372)

[3.1.2 UAV Descriptions 21](#_Toc208936373)

[3.2 Mission Execution – UxV-Specific Attributes 21](#_Toc208936374)

[3.2.1 Scenario Progress 22](#_Toc208936375)

[3.2.2 Swarm-Specific Messaging 23](#_Toc208936376)

[4 Ontology Elements 29](#_Toc208936377)

[4.1 C2SIM Concepts Used In Messages 29](#_Toc208936378)

[4.2 New / Modified Entities and Attributes 29](#_Toc208936379)

[4.3 Orders 29](#_Toc208936380)

[4.4 Reports 29](#_Toc208936381)

[5 Areas for Future Investigation 30](#_Toc208936382)

[5.1 Robotics Standard 30](#_Toc208936383)

[6 Robotics Standard Concepts 31](#_Toc208936384)

Tables

[Table 1 Scenario Entity Types 8](#_Toc208936385)

[Table 2 Initialization Messages 9](#_Toc208936386)

[Table 3 Scenario Messages 9](#_Toc208936387)

[Table 7 Scenario Entity Types 10](#_Toc208936388)

[Table 8 Initialization Messages 10](#_Toc208936389)

[Table 9 Scenario Messages 10](#_Toc208936390)

[Table 10 Scenario Entity Types 11](#_Toc208936391)

[Table 11 Initialization Messages 11](#_Toc208936392)

[Table 12 Scenario Messages 12](#_Toc208936393)

[Table 16 Scenario Entity Types 12](#_Toc208936394)

[Table 17 Initialization Messages 13](#_Toc208936395)

[Table 18 Scenario Messages 13](#_Toc208936396)

[Table 19 Scenario Entity Types 14](#_Toc208936397)

[Table 20 Initialization Messages 14](#_Toc208936398)

[Table 21 Scenario Messages 15](#_Toc208936399)

[Table 25 UxV Attributes 20](#_Toc208936400)

[Table 26 Search Drone Reports Survivor 23](#_Toc208936401)

[Table 27 UXV Description 23](#_Toc208936402)

[Table 28 Setting up Assignment table - General 24](#_Toc208936403)

[Table 29 Mission Description Data 24](#_Toc208936404)

[Table 30 Search Pattern Data 25](#_Toc208936405)

[Table 31 Target Library 26](#_Toc208936406)

[Table 32 Behaviour on Detection 26](#_Toc208936407)

[Table 33 Network Configuration 26](#_Toc208936408)

[Table 34 Order for Extraction or Deployment of Payload 27](#_Toc208936409)

[Table 35 Maintenance Behaviour 27](#_Toc208936410)

# Overview

The C2SIM standard captures concepts and message formats for use in military simulations. It was designed to be extendable, so that topics that were not part of the core ontology could be added as needed. One such extension is required to support the inclusion of Automated Vehicles (ASX) in simulations.

As part of developing the ASX extension, a number of use cases were identified that include unpiloted vehicles. This paper takes those use cases and defines messages that would be sent to and from any ASX. This is done to identify message elements that cannot be conveyed using the existing C2SIM standard. These elements are meant to serve as the basis of the ASX extension.

In addition, several IEEE standards for Robotics were reviewed to identify additional elements that are required to convey the capabilities of ASX.

## References

The high-level use cases were taken from the following sources.

### IEEE Standards

|  |  |
| --- | --- |
| Ref | Source |
| CORA | 1872-20 Standard Ontologies for Robotics and Automation (CORA) |
| AuR | 1872.2-2021 IEEE Autonomous Robotics (AuR) Ontology |
| SUMO | Suggested Upper Merged Ontology (SUMO) |

### ASX Group Working Papers

|  |  |
| --- | --- |
| Ref | Source |
| GPT4 | ASX PDG, GPT 4 generation pipeline Area to Objectives to Scenario |
| UC Overview | 2024-09 ASX Use Cases Overview |

### External Media

Some of the use cases came from reports in the media of how drones are being used, and proposals for how automated vehicles could be used in future.

|  |  |
| --- | --- |
| Ref | Source |
| Swarm | [Drone Swarms: The Good, The Bad, and The Terrifying Future (asisonline.org)](https://www.asisonline.org/security-management-magazine/latest-news/today-in-security/2023/september/drone-swarms-good-bad-and-terrifying/). Retrieved 12 September 2024 |
| MAD | 117672-152 CAE (2023), UxV National Security MAD CONOPS, Ottawa, Ontario. |
| SitAware | E. Hosang (2019), Representing Situational Awareness Data Using the C2SIM Standard, 2020 SISO Simulation Innovation Workshop (SIW), |

# Use Case Description

## Use Case Overview

This section lists the high-level use cases identified for ASX operation. They were derived from use cases identified in the early stages of the ASX work. For ease of analysis, they are broken into sub-use-cases that capture one function.

In some cases, the type of vehicle, or its function, may not currently exist, but they are included for the sake of ensuring the protocol extension accommodates them in future.

For the sake of time/effort, not every message that would be sent during a scenario has been defined, as it is assumed that existing messages are defined for core functions such as creating a vehicle, assigning it to its initial position, issuing movement orders, etc. are adequately defined in the core C2SIM ontology. Instead, the ASX-specific components are identified. They are broken out in each section. Proposals for how they can be brought together to form the basis of the ASX extension are described in the next chapter.

### Large Urban Area Hit By Earthquake

In this scenario, unpiloted vehicles are deployed as part of search and rescue after a large scale earthquake strikes an urban area. Survivors are located, extracted, and taken to medical facilities. Medical supplies are delivered to some survivors. The vehicles report low supplies and are ordered back to depot to restock.

Source Reference: GPT-4

This scenario is broken into the following sub-use-cases:

* Search for survivors via UAV.
* Request & deliver – Payload (medical supplies).
* Deliver resource – Vehicle with specific capability
* Extract survivors and deliver to hospital.

### Deploy Surveillance Swarm

In this scenario, a swarm of self-piloted airborne drones are deployed to perform surveillance of an area of interest. During the deployment the swarm coordinator goes silent, and the units must identify a new leader. The search pattern is changed and distributed to the remaining swarm members.

Source Reference: Swarm

* Deploy Swarm.
* Swarm Leader goes silent – new leader selected.

### Report Observed Swarm

In this scenario, a recce unit reports the presence of a swarm of drones entering an Area of Interest.

Source Reference: Swarm

* Patrol reports swarm of drones.

### Deploy Fertilizer via Drone

In this scenario, a self-piloting drone sprays fertilizer over a field.

Source Reference: Swarm

* Deploy fertilizer.

### Protect Troops / Population

In this scenario, multiple autonomous drones with weapons are deployed to the site of an armed confrontation. They provide cover fire to allow the friendly units to retreat.

Source Reference: GPT4

* Request support.

### Detecting and Disrupting EW Signals

This is for communications and jamming IED signals.

### Disrupt Law Enforcement

In this scenario, autonomous drones are deployed to prevent the effective operation of a Law Enforcement unit.

Source Reference: Swarm

## Earthquake Aftermath: General Search via UAV

### Scenario Description

UAVs are deployed to survey an urban area that has been hit by an earthquake.

For this scenario, the UAVs are fixed-wing, single engine. They carry video equipment and stream video back to the Command and Control (C2) unit.

The vehicle is autonomous, and navigates itself according to its programmed route.

When the unit’s on-board processing identifies a potential target (survivor, or severely damaged infrastructure, depending on the unit’s search parameters), it reports back to the C2 unit. It enters a holding pattern until the C2 unit confirms the sightings and directs it to resume its previous search pattern.

### Scenario Entities

The following table describes the types of entities deployed during the mission.

Table 1 Scenario Entity Types

|  |  |  |  |
| --- | --- | --- | --- |
| Label in Scenario | Unit Description | Role | ASX-related items |
| C2Unit | Headquarters Unit | Tasks Units, receives reports | N/A |
| UavSearch | UAV with visual | Scan for Survivors, Hazards, | Mobility: Jet Single Engine  VehicleType: FixedWing  Autonomy Type: Remote-Controlled, Self-Directed  Sensor Types:  Video Sensor  Mission-Related Equipment: On-Board Processing Capability,  Target identification algorithms,  Target database (can be hostile entities, hazards, etc.) |

### Scenario Initialization Messages

The messages in the following table capture the Initialization messages required to set up the exercise.

Table 2 Initialization Messages

|  |  |  |  |
| --- | --- | --- | --- |
| Receiver | Msg Reference | Msg Details | ASX-related items |
| UavSearch | InitializationConcept | SearchPattern |  |
|  |  | TargetDatabase – People |  |
|  |  | TargetDatabase – Hazards |  |
|  |  | TargetIdAlgorithm |  |
|  |  | SwarmNetworkParameters |  |
|  |  | SwarmNetworkRole |  |

### Scenario Messages

The following table lists the messages that would need to be generated during the mission to complete it successfully. The list is representative, not exhaustive, so the table does not represent conversations.

Table 3 Scenario Messages

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| From | To | Description | Msg Type | Details |
| C2Unit | UavSearch | Order  Move To Initial Location  Start Operation | Order | Operation types |
| UavSearch | C2Unit | Report arrival on scene | Report | Report Location |
| UavSearch | C2Unit | Report survivors | Report | Report  Observation  \*\* Include reference to media library where video can be viewed. |
| C2Unit | UavSearch | Order  Continue Operation | Order |  |

## Earthquake Aftermath: Request & Deliver Resource

### Scenario Description

UAV detects injured survivors, requests medical supplies.

For this scenario, the UAVs are propelled by fans, allowing the vehicle to hover over the site where it delivers its payload. The vehicle has a video sensor and can stream video back to the C2 unit. It is operated via a pilot in the C2 Headquarters.

When the C2 commander determines that supplies need to be delivered, they send the location to the vehicle pilot, who moves the vehicle to the target location. The vehicle delivers its payload, reports success, and then reports zero payloads. The pilot is ordered to return back to the depot to reload.

### Scenario Entities

The following table describes the types of entities deployed during the mission.

Table 7 Scenario Entity Types

|  |  |  |  |
| --- | --- | --- | --- |
| Label in Scenario | Unit Description | Role | ASX-related items |
| C2Unit | Headquarters Unit | Deploys UAV and controls its navigation | N/A |
| UavSupply | UAV with payload compartment and deployment equipment | Delivery: medical supplies, food, etc. | Mobility – HoverFan  Sensor Types:  Video Sensors  Autonomy Type: Remote-Controlled  Mission-Related: Deliverable Payload Type, Deliverable Payload Quantity, |

### Scenario Initialization Messages

The messages in the following table capture the Initialization messages required to set up the exercise.

Table 8 Initialization Messages

|  |  |  |  |
| --- | --- | --- | --- |
| Receiver | Msg Reference | Msg Details | ASX-related items |
| UavDelivery | InitializationConcept | Refill Depot Id |  |
|  |  | Payload Type |  |
|  |  | Payload Quantity |  |

### Scenario Messages

The following table lists the messages that would need to be generated during the mission to complete it successfully. The list is representative, not exhaustive, so the table does not represent conversations.

Table 9 Scenario Messages

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| From | To | Description | Msg Type | Details |
| C2Unit | UavDelivery | Order  Go To Location.  Deploy Payload | Order | Deploy, payload |
| UavDelivery | C2Unit | Report  Arrived on location  Payload deployed | Report |  |
| UavDelivery | C2Unit | Report  Payload Count 0 | Report | Payload count |
| C2Unit | UavDelivery | Order  Go To Depot  Reload | Order |  |
| UavDelivery | C2Unit | Report  Reload complete | Report |  |

## Earthquake Aftermath: Extract Survivor and Deliver to Hospital

### Scenario Description

After a report of survivors who need transport to a medical center, a pilot at C2 moves the vehicle to the site of the survivors, loads them, and transports them to a medical facility.

### Scenario Entities

The following table describes the types of entities deployed during the mission.

Table 10 Scenario Entity Types

|  |  |  |  |
| --- | --- | --- | --- |
| Label in Scenario | Unit Description | Role | ASX-related items |
| C2Unit | Headquarters Unit | Receives Reports, deploys units | N/A |
| UgvTransport | UGV transport | Transport that can be loaded with casualties and move them to evac centers | Passenger Capacity |
| UgvExtractor | UGV transport with grabber arm | Retrieve physical items and load them for transport. | On-Board capabilities: Arms, etc. (see Robotics standards)  Types of Activities it can perform. |

### Scenario Initialization Messages

The messages in the following table capture the Initialization messages required to set up the exercise.

Table 11 Initialization Messages

|  |  |  |  |
| --- | --- | --- | --- |
| Receiver | Msg Reference | Msg Details | ASX-related items |
| UavDelivery | InitializationConcept | Refill Depot Id |  |
|  |  | Payload Type |  |
|  |  | Payload Quantity |  |
| UgvExtractor | InitializationConcept | Initial Location |  |

### Scenario Messages

The following table lists the messages that would need to be generated during the mission to complete it successfully. The list is representative, not exhaustive, so the table does not represent conversations.

Table 12 Scenario Messages

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| From | To | Description | Msg Type | Details |
| C2Unit | UgvExtractor | Order  Go to location  Action: Extract survivor | Order | Action |
| C2Unit | UavTransport | Order  Go to location  Action: Transport Survivors |  |  |
| C2Unit | UavTransport | Report  Arrived at medical facility |  |  |

## Swarm Scenario: Deploy Swarm

### Scenario Description

A swarm of UAVs are deployed to survey an area of interest to a C2 unit. One of them acts as the swarm leader, which can change the search area and parameters as needed.

For this scenario, the UAVs are all the same model: fixed-wing, single engine. They carry video equipment and stream video back to the C2 unit.

The vehicles are autonomous and navigate according to their programmed search parameters. Their orders can be changed mid-operation.

### Scenario Entities

The following table describes the types of entities deployed during the mission.

Table 16 Scenario Entity Types

|  |  |  |  |
| --- | --- | --- | --- |
| Label in Scenario | Unit Description | Role | ASX-related items |
| C2Unit | Headquarters Unit | Tasks UXVs and human units | N/A |
| UavSearchX (where X = 1-5) | Search Drones | Search area of interest | Mobility: Jet Single Engine  VehicleType: FixedWing  Autonomy Type: Remote-Controlled, Self-Directed  Sensor Types:  Video Sensor  Mission-Related Equipment: On-Board Processing Capability,  Target identification algorithms,  Target database (can be hostile entities, hazards, etc.) |

### Scenario Initialization Messages

The messages in the following table capture the Initialization messages required to set up the exercise.

Table 17 Initialization Messages

|  |  |  |  |
| --- | --- | --- | --- |
| Receiver | Msg Reference | Msg Details | ASX-related items |
| UavSearch | InitializationConcept | SearchPattern |  |
|  |  | TargetDatabase – People |  |
|  |  | TargetDatabase – Hazards |  |
|  |  | TargetIdAlgorithm |  |
|  |  | SwarmNetworkParameters |  |
|  |  | SwarmNetworkRole | Only one of the units is assigned NetworkLeader. One or more may be assigned SecondaryLeader. |
|  |  | SwarmNetworkLeader | ID of current Swarm Leader / coordinator |

### Scenario Messages

The following table lists the messages that would need to be generated during the mission to complete it successfully. The list is representative, not exhaustive, so the table does not represent conversations.

Table 18 Scenario Messages

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| From | To | Description | Msg Type | Details |
| C2Unit | UavSearch1 | Order  Start Operation | Order | Operation types |
| UavSearch1 | UavSearch2, UavSearch3, UavSearch4, UavSearch5 | Order  Search Pattern | Order | Search Patterns |
| UavSearch1 | UavSearch-all | Order  Heartbeat send/receive | Order |  |

## Swarm Scenario: Swarm Leader goes silent

### Scenario Description

A swarm of UAVs are deployed to survey an area of interest to a C2 unit. One of them acts as the swarm leader, which can change the search area and parameters as needed.

For this scenario, the UAVs are all the same model: fixed-wing, single engine. They carry video equipment and stream video back to the C2 unit.

The vehicles are autonomous and navigate according to their programmed search parameters. Their orders can be changed mid-operation.

During the scenario, the leader of the swarm is disabled. The swarm selects a new leader, which alters the search pattern to make up for the missing drone.

### Scenario Entities

The following table describes the types of entities deployed during the mission.

Table 19 Scenario Entity Types

|  |  |  |  |
| --- | --- | --- | --- |
| Label in Scenario | Unit Description | Role | ASX-related items |
| C2Unit | Headquarters Unit | Tasks UXVs and human units | N/A |
| UavSearchX (where X = 1-5) | Search Drones | Search area of interest | Mobility: Jet Single Engine  VehicleType: FixedWing  Autonomy Type: Remote-Controlled, Self-Directed  Sensor Types:  Video Sensor  Mission-Related Equipment: On-Board Processing Capability,  Target identification algorithms,  Target database (can be hostile entities, hazards, etc.) |

### Scenario Initialization Messages

The messages in the following table capture the Initialization messages required to set up the exercise.

Table 20 Initialization Messages

|  |  |  |  |
| --- | --- | --- | --- |
| Receiver | Msg Reference | Msg Details | ASX-related items |
| UavSearch | InitializationConcept | SearchPattern |  |
|  |  | TargetDatabase – People |  |
|  |  | TargetDatabase – Hazards |  |
|  |  | TargetIdAlgorithm |  |
|  |  | SwarmNetworkParameters |  |
|  |  | SwarmNetworkRole | Only one of the units is assigned NetworkLeader. One or more may be assigned SecondaryLeader. |
|  |  | SwarmNetworkLeader | ID of current Swarm Leader / coordinator |

### Scenario Messages

The following table lists the messages that would need to be generated during the mission to complete it successfully. The list is representative, not exhaustive, so the table does not represent conversations.

Table 21 Scenario Messages

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| From | To | Description | Msg Type | Details |
| UavSearch2 | UavSearch1 | Request Heartbeat | Request | Generated when UavSearch1 fails to initiate Heartbeat request after a given time-frame. |
| UavSearch2 | UavSearch-all | Order  New Leader | Order |  |
| UavSearch-all | UavSearch2 | Order | Order | Confirm New Leader ID |

## Protecting Troops and populations against hostile UAX in modern urban environment

### Mission Overview

* Deployment
  + Assign missions, locations
  + Move to AOI.
  + Encounter Resistance – Engage hostile UAX (see Mission section)

### Actions to Model

* Perform Mission
  + Recce UAV reports incident
  + Recce UAV tasked to site of incident
  + Report observations – signal detection, visual item
  + Request support
  + Exchange fire – needs command/confirmation
  + Retreat
  + Recce UAV reports damage
* Maintenance
  + Refuel/reload
  + Report damage
* Mission Complete

### Scenario Entities

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Label in Scenario | Unit Description | Role | Category | Equipment, other notes |
| Scenario Coordinator | N/A | Set up entities  Start scenario |  | Not modelled in scenario. |
| C2Unit | Headquarters Unit | Tasks UXVs and human units | HQ |  |
| UavRecce1 | UAV with visual/audio sensors | Provide video feedback to C2Unit | Recce | Visual/audio sensor |
| UavArtillery1, | UAV with artillery | Engage hostile forces | Artillery | Guns  Ammo  Target Recognition |
| UavArtillery2 | UAV with artillery | Report Status | Artillery | Guns  Ammo |
| UavEw1 | UAV with EW Sensors | Intercept audio signals, request Jammer | EW Sensor | EW Sensor(s) |
| UavEw2 | UAV with EW attack devices | Respond to request for Jammer | EW Attack | EW Jammer |

### Scenario Initialization Messages

|  |  |  |
| --- | --- | --- |
| Receiver | Msg Reference | Msg Details |
| C2Unit | InitializationConcept | Location.  List of resources. |
| UavArtillery1 | InitializationConcept | Location. |
| UavRecce1 | InitializationConcept | Patrol Route |

### Scenario Messages

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Msg ID | From | To | Description | Notes / Details | Msg Ref |
| UC03-01 | C2Unit | UavRecce1 | Order  Start Patrol |  |  |
| UC03-02 | UavRecce1 | C2Unit | Report Incident | Location, Entities Involved: Target, Entities to protect |  |
| UC03-02 | C2Unit | UavArtillery1 | Order  Move To Location  Fire on Target |  |  |
|  | UavArtillery1 | C2Unit | Arrived |  |  |
|  | UavAudio1 | C2Unit | Report  Audio signal  Reporting |  |  |
|  | C2Unit | UavEw1 | Order  Move to location  Jam signal |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

## UC-004 Patrol Group

### Mission Overview

* Deploy
  + Assign missions

### Actions to Model

* Perform Mission
  + Patrol

### Scenario Entities

### Scenario Initialization Messages

### Scenario Messages

## UC-005 Deploy Resources – Fertilizer, Poison

### Mission Overview

* Deploy
  + Fuel – instructions to depot?
  + Assign location and deployment pattern
  + Go to AOI.

### Actions to Model

* Perform Mission
  + Swarm deployed in patterns
  + Report problems – equipment failure?
* Mission Complete

## UC-006 Disrupting Law Enforcement Team

### Mission Overview

* Deploy
  + Assignments
  + Location
  + Behaviour patterns

### Actions to Model

* Perform Mission
  + Monitor law-enforcement frequencies.
  + Deploy jammers.
* Mission Complete.

## Report Observed Swarm

### Mission Overview

Forward unit observes arial drone swarm and reports back to HQ.

Entities:

* Observer
  + Visual observation?

### Actions to Model

Reporting Action-Events

* See swarm
* Report locations
* Report observed behaviour
* Report grouping – can this be done by existing grouping of vehicles? How do we report observation of a convoy?
  + Report multiple vehicles
  + Group them using context? Or report as organization with all associated entities.
  + How do we report engaging with an enemy force?

## UC-008 Detecting and Disrupting EW Signals

### Mission Overview

* Deployment
* Assign missions, locations
* Move to AOI.

### Actions to Model

* Perform Mission
  + Signal UAV reports incident
  + Report observations – signal detection
  + Signal detection – may be hostile or cry for help or ignorable transmission (yellow daisies)
  + Request support
  + Jam signals
* Maintenance
  + Refuel/reload
  + Report damage
* Mission Complete

# ASX Needs

This section captures the features of UXVs that need to be communicated to execute the missions defined in the previous section.

## Initialization – UxV-Specific Attributes

Table 25 UxV Attributes

|  |  |  |  |
| --- | --- | --- | --- |
| Attribute | New / Extisting | Range of Values | Parent (Class that Attribute belongs to) |
| Mobility | Enum Extension | HoverFan  Jet |  |
| VehicleType | Enum Extension | Drone – Fixed Wing  Drone - Hover |  |
| Payload |  | SensorType,  Armiture,  Supplies (Medical),  Supplies (Food),  Ammunition  Fuel | (see Robotics presentation for details) |
| Payload Quantity | Integer | Positive Integers | Platform type that takes Payload. |
| Passenger Capability | Integer (Count or Max. Load by weight) | Positive Integers |  |
| SensorType |  | Visual,  EW,  Counter EW (Jammer),  Audio | \*\*\*Check Robotics Standard for categories of sensor types |
| Control Function | New on Vehicle | Piloted,  Unpiloted – Autonomous  Swarm | See Robotics notes |
| Swarm Parameters | New entity | Leader – Boolean  Network – Network Parms (See Network entities in base standard; see EW Extension) |  |
| Autonomous Parameters | New entity | Algorithm/Type |  |
| Mission Function | New enum | Search General,  Search Targeted,  Retrieve Resource,  Deliver Resource |  |
| Mission Parameters | Construct from existing capabilities | Route,  Target Database,  Hostility Database,  Identification Parameters |  |

* + 1. Initialize – Start Location

Hierarchy of base type:

* Owl:Thing
* InitializationConcept
  + InitializationDataFile
  + ObjectDefinitions
  + ScenarioSetting
  + SystemEntityList

Message:

|  |  |  |  |
| --- | --- | --- | --- |
| Type | Attribute | Value | Notes |
| InitializationConcept (sub-type of owl:Thing) | InitializationDataFile |  |  |
|  | ObjectDefinitions |  |  |
|  | ScenarioSetting |  |  |
|  |  |  |  |

### UAV Descriptions

\*\*\* Create full initialization for fixed-wing Drone, Hover Drone (Hover Fans)

## Mission Execution – UxV-Specific Attributes

During a mission, the following table contains UxV-specific information that needs to be included in the messaging.

|  |  |  |  |
| --- | --- | --- | --- |
| Attribute | New / Extisting | Range of Values | Parent (Class that Attribute belongs to) |
| Mobility | Enum Extension | HoverFans  Jet |  |
| VehicleType | Enum Extension | Drone – Fixed Wing  Drone - Hover |  |
| Payload |  | SensorType,  Armiture,  Supplies (Medical),  Supplies (Food),  Ammunition  Fuel | (see Robotics presentation for details) |
| Payload Quantity | Integer | Positive Integers | Platform type that takes Payload. |
| Passenger Capability | Integer (Count or Max. Load by weight) | Positive Integers |  |
| SensorType |  | Visual,  EW,  Counter EW (Jammer),  Audio | \*\*\*Check Robotics Standard for categories of sensor types |

### Scenario Progress

The following messages are broken out in this section.

1. Request for assistance. Includes Location, type of assistance required, own status (Damage / injury)
2. Order – Move to Location, start operation – operation type may already have been included in Initialize message.
3. Report – Arrived at scene of request for aid.
4. Report – Survivor detected.
5. Report – Hazard detected.
6. Order – Move to location and deploy resource – MedKit.
7. Report – Arrival at location and deployment of resource.
8. Report – Low on resource (fuel, deployable resource).
9. Order – Report to depot for refill.
10. Report – Arrived at depot. Successful refill. Ready for re-deployment.
11. Report – Action Event – Explosion of Gas Main.

### Swarm-Specific Messaging

1. Order – report current location and status.
2. Report – Location and status.
3. Order – Request for specific unit to report status.
4. Order – Change of search pattern / other change to orders.
5. Report – Swarm Lead damage report. Negotiate new Swarm Lead.
6. Order – ID of new swarm lead.

Table 26 Search Drone Reports Survivor

|  |  |  |  |
| --- | --- | --- | --- |
| Sender | Receiver | Msg Reference | Msg Details |
| UavSearch1 | SwarmC2 | MessageConcept | Location  Number of Persons  Request for Medical Personnel  Request for Medical Drone delivery  Request for Extraction |
| SwarmC2 | All units of role Extractor | MessageConcept | Report Location |
| UgvExtractor1 | C2Unit, SwarmC2 |  |  |
|  |  |  |  |

Table 27 UXV Description

|  |  |  |
| --- | --- | --- |
| Category | Description | Notes |
| Identifier | UAV |  |
| Network ID | Name string – electronic address | Set when unit is configured |
| Equipment Type | Drone / Rover / Submersible |  |
| Mobility | Airborne, Tracked, Surface |  |
| Sensors | Video / EW / CBRN / Gas | Sensor type is related to Role |
| Autonomy | Operational Role – Search, Extract, Delivery |  |
|  | Autonomy Level – Full, Partial | Modelling with Partial Autonomy requires messaging back and forth with controller – Orders and Reports. |
|  | Network Role: Coordinator – Assign roles  Function Performer – Execute Mission  Back-up Coordinator – If Coordinator reports damage or goes dark.  Relay – repeat signals |  |
| Network Connection | Network ID, Frequency, Call Sign | Connection for swarm communication |
| Network Connection | Network ID, Frequency, Call Sign | Connection for partially-autonomous units communication back to human to get Orders. |
| Mission Data | Search Pattern, Anomaly library, |  |

Message Contents

Descriptions of message parts that need to flow and the values that appear in them.

Table 28 Setting up Assignment table - General

|  |  |  |
| --- | --- | --- |
| Sender | Receiver | Message Description |
| C2 Unit (human programmer) | UAV | Order: Mission Type (Search, Delivery, Extraction, etc.) |
|  |  | Configuration: Swarm Network Information (Freq, ID, Role) |
|  |  | Initial Location |
|  |  | Depot: ID of refuel / reload / maintenance unit / depot. (will query for location when needed) |

Table 29 Mission Description Data

|  |  |  |
| --- | --- | --- |
| Mission Type | Required Information | Notes |
| Search | Start Location |  |
|  | Search Path/Pattern Information | Route type info? |
|  | Target Library | Types of things to look for. See Table. |
|  | Behaviour on Detection | Enum: Report and continue, request support, etc. |
|  | Type of sensor |  |
|  | Anomaly Detection Parameters | Threshold for reporting detection?  May be integrated into sensor. |
| Extraction | Start Location | Where to wait for request for extraction. |
|  | Types of Extraction possible |  |
| Deliver | Type of payload |  |
|  | Count of payload options |  |
|  | Final Location | Where is payload delivered |
| Directed Deployment | Location or list of locations to search | In the case where a person has phoned in and GPS information is available, or need to examine a specific target, e.g. Gas Depot, Power infrastructure items such as electrical stations. Expected behaviour is sending back sensor data, e.g. visual data or atmospheric readings. |

Table 30 Search Pattern Data

|  |  |  |
| --- | --- | --- |
| Value | Description | Notes |
| Start Location | Geographical Point | Lat/Long |
| Elevation | Above Ground (UAV), Below Surface (UUV) | Not needed for Ground Vehicles. |
| Search Pattern | Start Location,  Pattern Type, | \*\*\* Needs Definition |
| Pattern Type | Enum,  Parameters – length of laps, distance between laps, etc. | \*\*\* Needs Definition |

Table 31 Target Library

|  |  |  |
| --- | --- | --- |
| Value | Description | Notes |
| Person |  | Status of human (as detectable by sensors) |
| Key Equipment | ?? Need more information for what would be key |  |
| Hazard | Gas leak, CBRN detection, Flood |  |

Table 32 Behaviour on Detection

|  |  |  |
| --- | --- | --- |
| Value | Description | Notes |
| Report Location | Geographical Point | Lat/Long |
|  | Elevation (if needed) | People in buildings, or in sink holes |
| Report Target | Human or Equipment |  |
| Report Environmental Anomaly |  |  |
| Report Hazard |  |  |
| Report condition of found human |  |  |
| Report search complete | May result in order to repeat search or start search at new location. |  |

Table 33 Network Configuration

|  |  |  |
| --- | --- | --- |
| Value | Description | Notes |
| Network Identifier | Unique ID string | In case of large deployments with multiple UXV Networks |
| Frequency / Network Characteristics | Depends on network type. | See EW C2SIM extension. |
| Callsign | Unique ID for specific node |  |
| Role | Participant,  Coordinator,  BackupCoordinator |  |
|  |  |  |

Message Sequences for Typical Operations

Table 34 Order for Extraction or Deployment of Payload

|  |  |  |
| --- | --- | --- |
| Value | Description | Notes |
| Move Order | New Location |  |
| Behaviour Order | Extract, Deploy |  |
| Additional Location | Location | Point to which extracted target must be delivered. May depend on location of target, if there are multiple locations, or treatment facilities move throughout scenario. |

Table 35 Maintenance Behaviour

|  |  |  |
| --- | --- | --- |
| Value | Description | Notes |
| Report | My Platform Status | Damage Value, fuel level, payload depleted |
|  | My location | Geolocation |
|  | Whether I can continue | Measured by level of damage |
| Order | Location | Location of nearest depot |
| Report | My Platform Status | Damage repaired, payload level, fuel level. |
|  | My Platform Status | Report from Depot – too damaged to resume mission |
| Order | Return to previous location, or deploy to new location |  |
| Order | Task another unit to take over damaged unit’s function | Remove from list of available Extraction or Deployment units. |
|  | Trigger new C2 unit | If damaged unit is a C2 unit |

# Ontology Elements

## C2SIM Concepts Used In Messages

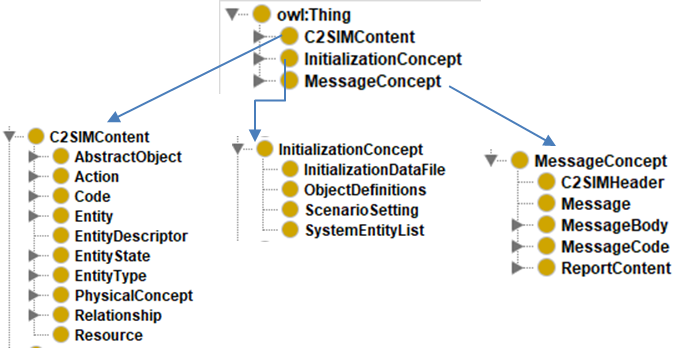


Figure 4‑1 C2SIM Standard Hierarchy

## New / Modified Entities and Attributes

* Roles

## Orders

* Swarm-related Actions:
* Action Events

## Reports

* Swarm-specific operations

# Areas for Future Investigation

## Robotics Standard

* Code for Attachments – arms, sensors, etc.

# Robotics Standard Concepts