ASX Use Case To Ontology

Prepared for the C2SIM ASX Product Development Group

Authors:

Elizabeth Hosang, CAE

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# 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.

### UC-01 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:

* UC-01-01 Deploy individual drones to search for survivors.
* UC-01-02 Request & Deliver Resource – Drone with Payload (medical supplies).
* UC-01-03 Extract survivors and deliver to hospital.

### UC-02 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, SitAware

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

* UC-02-01 Deploy Swarm.
* UC-02-02 Swarm Leader goes silent – new leader selected.
* UC-02-03 Change flight pattern
* UC-02-04 Report EW Intercept
* UC-02-05 Deploy Jammer

### UC-03 Protect Troops & Populations against Hostile UAX in an Urban Environment

In this scenario, a recce unit reports the presence of a swarm of drones entering an Area of Interest. The C2 Headquarters deploy armed UAVs to protect the troops and civilians.

This use case incorporates UC-004 Patrol Group from GPT-4.

Source Reference: GPT-4

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

* UC-03-01 Recce (Human) Patrol reports swarm of drones.
* UC-03-02 Artillery drones dispatched to provide covering fire.
* UC-03-03 Artillery drone reports damage – no longer functional
* UC-03-04 Artillery drone reports out of ammo

### UC-04 Patrol Group

In this scenario, \*\*\* Go back to source for actual activities.

Source Reference: GPT4

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

* Addressed under UC-03.

### UC-005 Deploy Resources via Drone Over a Large Area

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

Source Reference: Swarm

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

* UC-05-01 Deploy fertilizer.

### UC-006 Disrupt Law Enforcement

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

Source Reference: Swarm

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

* Detect activity of interest – See UC-01
* Jam Communications – See UC-01

## UC-01-01 Earthquake Aftermath: Deploy individual drones to search for survivors

### 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.

### Entities

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

Table 1 UC-01-01 Entities

|  |  |  |  |
| --- | --- | --- | --- |
| 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.) |

### Initialization Messages

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

Table 2 UC-01-01 Initialization Messages

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

### Operational Messages

The following table lists the messages that are exchanged during the mission. The list is representative, not exhaustive, so the table does not represent conversations.

Table 3 UC-01-01 Operational 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 |  |

## UC-01-02 Earthquake Aftermath: Request & Deliver Resource

### 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.

### Entities

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

Table 4 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, |

### Initialization Messages

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

Table 5 Initialization Messages

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

### Operational Messages

The following table lists the messages that are exchanged during the mission. The list is representative, not exhaustive, so the table does not represent conversations.

Table 6 Operational 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 |  |

## UC-01-03 Earthquake Aftermath: Extract Survivors and Deliver to Hospital

### 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.

### 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 | 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. |

### 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 |  |
| UgvExtractor | InitializationConcept | Initial Location |  |

### Operational Messages

The following table lists the messages that are exchanged during the mission. The list is representative, not exhaustive, so the table does not represent conversations.

Table 9 Operational 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 |  |  |

## UC-02-01 Surveillance Swarm: Deploy Swarm

### 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.

### 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 | 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.) |

### 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 |
| 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 |

### Operational Messages

The following table lists the messages that are exchanged during the mission. The list is representative, not exhaustive, so the table does not represent conversations.

Table 12 Operational 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 |  |

## UC-02-02 Surveillance Swarm: Swarm Leader goes silent

### 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.

### Entities

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

Table 13 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.) |

### Initialization Messages

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

Table 14 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 |

### Operational Messages

The following table lists the messages that are exchanged during the mission. The list is representative, not exhaustive, so the table does not represent conversations.

Table 15 Operational 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 | Report | Order | Confirm New Leader ID |
| UavSearch2 | UavSearch-all | Order  New Leader | Order | New Leader ID |
| UavSearch2 | C2Unit | Report  New Leader | Report | ID of new leader |

## UC-02-03 Surveillance Swarm: Change Flight Pattern

### 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 calculates a new flight pattern to compensate for a lost swarm member.

### 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.) |

### 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 (UavSearch-1) |

### Operational Messages

The following table lists the messages that are exchanged during the mission. The list is representative, not exhaustive, so the table does not represent conversations.

Table 18 Operational Messages

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| From | To | Description | Msg Type | Details |
| UavSearch-1 | UavSearch-2 | Order  New Search Pattern  New Location | Order |  |
| UavSearch-1 | UavSearch-3 | Order  New Search Pattern  New Location | Order | Repeat for all active UavSearch units in swarm |
| UavSearch-1 | C2Unit | Order  New Search Patterns  New Locations | Order | May have to be Report at this point.  May have to send individual messages for each swarm member, including self (UavSearch-1) |

## UC-02-04 Surveillance Swarm: Report EW Intercept

### 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, a member of the swarm reports an intercepted transmission. The C2 unit dispatches a jammer drone to the area.

### 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: Self-Directed  Sensor Types:  Video Sensor  Mission-Related Equipment: On-Board Processing Capability,  Target identification algorithms,  Target database (can be hostile entities, hazards, etc.) |
| UavJammer | Jamming Equipment | Hover in AOI and send out jamming signal | Movility: HoverFan  Autonomy Type: Self-Directed  Mission-Related Equipment: Jamming Emitter |

### 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-all | 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 |
| UavJammer | InitializationConcept | Initial Location |  |

### Operational Messages

The following table lists the messages that are exchanged during the mission. The list is representative, not exhaustive, so the table does not represent conversations.

Table 21 Operational Messages

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| From | To | Description | Msg Type | Details |
| UavSearch-1 | C2Unit | Report  Action-Type – transmission  Network Parameters  Reference to Media library / repository | Report | Network Parameters are important, so that the Jammer emits the right frequency. |

## UC-02-05 Surveillance Swarm: Deploy Jammer

### 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, a member of the swarm reports an intercepted transmission. The C2 unit dispatches a jammer drone to the area.

### Entities

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

Table 22 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.) |
| UavJammer | UAV equipped with Jamming emitters. | Used to jam communications | Movility: HoverFan |

### Initialization Messages

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

Table 23 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 |
| UavJammer | InitializationConcept | Initial Location |  |

### Operational Messages

The following table lists the messages that are exchanged during the mission. The list is representative, not exhaustive, so the table does not represent conversations.

Table 24 Operational Messages

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| From | To | Description | Msg Type | Details |
| C2Unit | UavJammer | Order  Move to Location | Order |  |
| UavJammer | C2Unit | Report  Arrived at Location  Jammer active | Report |  |
|  |  |  |  |  |

## UC-03-01 Protect Troops: Recce Patrol Reports Swarm

### Description

A Reconnaissance (Recce) unit patrolling an area of unrest detects an incoming swarm of potentially hostile UAVs.

For this scenario, the UAVs have hover capability to allow them to provide sustained firing. The Recce patrol is equipped with sensors that detect the incoming drones and properly formats a report to send back to the C2Unit.

### Entities

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

Table 25 UC-03-01 Entities

|  |  |  |  |
| --- | --- | --- | --- |
| Label in Scenario | Unit Description | Role | Equipment, other notes |
| C2Unit | Headquarters Unit | Tasks UXVs and human units | N/A |
| Recce1 | Mobile Patrol vehicle | Patrols area of unrest and report back to C2Unit | N/A |
| UavHostile-1 to 8 | Hostile UAV with artillery | Attack Recce1 and other friendlies | Mobility: HoverFans  Mission Specific Equipment: Artillery, munitions |
| UavArtillery-1 to 4 | Friendly UAV with artillery | Attack UavHostiles | Movility: HoverFans  Mission Specific Equipment: Artillery, munitions  Swarm Network Info |

### Initialization Messages

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

Table 26 UC-03-01 Initialization Messages

|  |  |  |  |
| --- | --- | --- | --- |
| Receiver | Msg Reference | Msg Details | ASX-related items |
| UavRecce | InitializationConcept | SearchPattern, normal |  |
| UavHostile-1 to 8 | InitializationConcept | Location |  |
| UavArtillery-1-4 | InitializationConcept | Location  Artillery | Mobility Type |

### Operational Messages

The following table lists the messages that are exchanged during the mission. The list is representative, not exhaustive, so the table does not represent conversations.

Table 27 UC-03-01 Operational Messages

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| From | To | Description | Msg Type | Details |
| Recce1 | C2Unit | Report  Observed Units: Multiple  Locations of each reported unit  Observed Equipment Type  Media Reference – to photograph or video showing vehicles, plus any other sensor readings. | Report |  |
| Recce1 | C2Unit | Report  Observed Units Firing | Report |  |
| C2Unit | UavArtillery | Order  Go to location  Offer Support  Target Info | Order | Targetting info |

## UC-03-02 Protect Troops: Artillery drones dispatched

### Description

A group of Artillery UAVs are deployed to provide covering fire for a Recce patrol under attack by a hostile swarm of UAVs.

### Entities

The entities for this use case are described under UC-03-01.

### Initialization Messages

The Initialization Messages for this use case are described under UC-03-01.

### Operational Messages

The following table lists the messages that are exchanged during the mission. The list is representative, not exhaustive, so the table does not represent conversations.

Table 28 UC-03-02 Operational Messages

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| From | To | Description | Msg Type | Details |
| C2Unit | Artillery | Order  Go to location  Offer Support  Target Info | Order | Targeting info |
| UavArtillery | C2Unit | Report  Arrived on site  Engage Hostiles | Report |  |

## UC-03-03 Protect Troops: Artillery Drone Reports Damage

### Description

A group of Artillery UAVs are deployed to provide covering fire for a Recce patrol under attack by a hostile swarm of UAVs. One of the Artillery UAVs reports it has been damaged.

### Entities

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

Table 29 UC-03-03 Entities

|  |  |  |  |
| --- | --- | --- | --- |
| Label in Scenario | Unit Description | Role | Equipment, other notes |
| C2Unit | Headquarters Unit | Tasks UXVs and human units | N/A |
| Recce1 | Mobile Patrol vehicle | Patrols area of unrest and report back to C2Unit | N/A |
| UavHostile-1 to 8 | Hostile UAV with artillery | Attack Recce1 and other friendlies | Mobility: HoverFans  Mission Specific Equipment: Artillery, munitions |
| UavArtillery-1 to 4 | Friendly UAV with artillery | Attack UavHostiles | Movility: HoverFans  Autonomy: Remote Control (?)  If not Remote Control, need guidelines for targeting drones.  Mission Specific Equipment: Artillery, munitions  Swarm Network Info |

### Initialization Messages

### Operational Messages

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Msg ID | From | To | Description | Notes / Details | Msg Ref |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

## UC-03-04 Protect Troops: Artillery Drone Reports Out of Ammo

### Description

One member of a group of Artillery UAVs deployed to provide covering fire to protect friendly assets is damaged and informs the C2Unit.

### Entities

The entities for this use case are described under UC-03-01.

### Initialization Messages

The Initialization Messages for this use case are described under UC-03-01.

### Operational Messages

The following table lists the messages that are exchanged during the mission. The list is representative, not exhaustive, so the table does not represent conversations.

Table 30 UC-03-04 Operational Messages

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| From | To | Description | Msg Type | Details |
| UavArtillery | C2Unit | Report  Damaged | Report |  |
| C2Unit | UavArtillery | Order  Return to Depot | Order |  |

## UC-05-01 Deploy Resources Over Large Area: Deploy Fertilizer

### Description

A single drone is dispatched to distribute fertilizer over a farm field.

This scenario also covers the case where a drone is dispatched to distribute poison over farmland, as described in ref. Swarm.

### Entities

The following table describes the entity involved in the mission.

Table 31 UC-05-01 Entities

|  |  |  |  |
| --- | --- | --- | --- |
| Label in Scenario | Unit Description | Role | Equipment, other notes |
| C2Unit | Farmer’s control station | Program vehicle’s distribution path | N/A |
| Drone1 | Hover drone with a liquid payload chamber | Deploy a liquid payload over field | Mobility: HoverFans  Mission Specific Equipment:  Liquid payload container  Distribution nozzle with control |

### Initialization Messages

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

Table 32 UC-05-01 Initialization Messages

|  |  |  |  |
| --- | --- | --- | --- |
| Receiver | Msg Reference | Msg Details | ASX-related items |
| Drone1 | InitializationConcept | SearchPattern, | Payload Type  Action / Capabilities  Payload capacity |

### Operational Messages

The following table lists the messages that are exchanged during the mission. The list is representative, not exhaustive, so the table does not represent conversations.

Table 33 UC-05-01 Operational Messages

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| From | To | Description | Msg Type | Details |
| C2Unit | Drone1 | Order  Start Deployment | Order | May require specialized Action-Type for the Order |
| Drone1 | C2Unit | Report  Payload Depleted | Report | Indicates that the payload is empty |
| C2Unit | Drone1 | Order  Return to Depot  Reload | Order |  |
| Drone1 | C2Unit | Report  Resupply Complete | Report |  |
| C2Unit | Drone1 | Order  Resume Deployment | Order |  |
| Drone1 | C2Unit | Report  Deployment Complete | Report |  |
| C2Unit | Drone1 | Order  Return to Depot | Order |  |

# ASX Ontology Components

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 34 UxV Attributes

|  |  |  |  |
| --- | --- | --- | --- |
| Attribute | New / Extisting | Range of Values | Parent (Class that Attribute belongs to) |
| Mobility / Propulsion | Enum Extension | MultiRotor,  InternalCombustionEngine, |  |
| NavigationAutonomy | Enum | FPV (First-Person View), Autonomous,  RemoteControl (?), |  |
| VehicleType | Enum Extension | DroneFixedWing  DroneHover |  |
| Capability | Associated record – multiple | SensorVideo, SensorAudio, SensorEw, JammerEw, | Actual sensor is an associated Equipment type |
| PayloadCapability |  | None, Supplies, Fuel, Vehicles, Personnel | Associated Equipment type |
| Payload | Associated record – multiple equipment possible | 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 |  |

## C2SIM Concepts Used In Messages

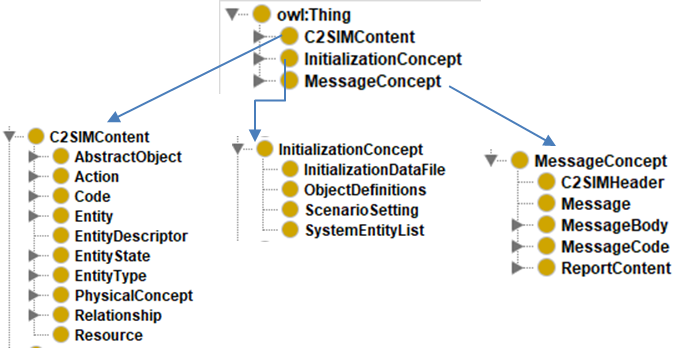


Figure 4‑1 C2SIM Standard Hierarchy

* + 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 35 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 36 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 37 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 38 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 39 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 40 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 41 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 42 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 43 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 44 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 |

# Sample Messages

## Initialization Messages

### Initialize Autonomous UAV with Video Search Capability

Description: Single-Engine drone

## Orders

Swarm-related Actions:

Action Events

## Reports

|  |  |  |  |
| --- | --- | --- | --- |
| Use Case ID | Description | Feature of Intereset | Report ID |
| UC-01-01 | Report Survivors | Video Image |  |
| UC-01-02 | Request Resources | Type of resource requested, quantity, location |  |
| UC-01-02, UC-02-01 | Report arrived on location;  payload deployed | Arrival |  |
| UC-02-01 | Report  Respond with heartbeat (swarm communication) | Response to swarm heartbeat. Must include swarm identifier. |  |
| UC-02-02 | Swarm Leader goes silent, new leader selected | ID of lost swarm leader, ID of new swarm leader |  |
| UC-02-04 | Report EW Intercept | Report includes reference to audio file repository. |  |
| UC-03-01 | Patrol reports swarm of drones | Location, size of swarm, type of propulsion, on-board equipment, e.g. munitions, weapons |  |
| UC-03-03 | Artillery drone reports damage – no longer functional |  |  |
| UC-03-03 | Artillery drone reports out of ammo |  |  |
| UC-05-01 | Report  Payload depleted (different from ammo) | Payload type, normal payload count (may be 1), current count = 0 |  |
| UC-05-01 | Report  Resupply Complete | Payload type, current count = payload count max. |  |
|  |  |  |  |

### Swarm Detection

Report from forward unit of swarm firing on civilians.

### Video Detection Report

UAV with video camera and on-board image processing detects looters. Sends back link to video and Action-Event of looting.

Key information that needs to be conveyed by the message:

|  |  |  |
| --- | --- | --- |
| Information | How Conveyed | Notes |
| Sender of message |  |  |
| Location at time of report |  |  |
| Link to video in appropriate repository |  |  |
| Time offset in video of image of interest. |  |  |
| Activity Observed |  |  |

# Areas for Future Investigation

## Robotics Standard

* Code for Attachments – arms, sensors, etc.

# Robotics Standard Concepts