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# Overview

Have already defined:

* 6 Scenario-Level use cases
* Generic use cases

Next steps:

* Break Scenario-level use cases into sequence of generic use cases, plus any specialized use-cases.
* Identify entities involved in all use cases
* Map all entities from use cases to C2SIM entities.
* Model messaging between entities in use cases using C2SIM messages

Start by working through one scenario.

# Use Case Descriptions

## UC-001 Large Urban Area Hit By Earthquake

### Mission Overview

* Unit types involved
  + UAV
  + UGV
  + USV
* Mission Description:
  + Searching, locating – Locate missing persons or objects
  + Ensure immediate safety of survivors
  + Increase speed of response
  + Aid in property recovery
  + Collect valuable information: disaster site, environmental conditions, potential threats
  + Reduce risks for human rescuers
  + Help facilitate effective coordination among the rescue teams on the ground
  + Recover property where required
* Other entities:
  + Rescue Teams
  + Survivors
  + Objects

### Actions to model

* Start of scenario: calls for help received by Command Center.
* Deploy Units.
  + Units travel.
  + Units arrive on scene.
  + Units encounter obstacles as they travel.
* Perform mission:
  + Scan area using AI-based anomaly detection to analyze sensor data.
  + Search for survivors – search pattern.
  + Go directly to survivors – based on GPS from help request
  + Survivor(s) and/or Essential Property located:
    - Report location through network to all assets
    - Report survivor’s condition – mobile, needs assistance, un-responsive, deceased
    - Deliver medical supplies.
    - Extract survivor(s)
    - Report damage
    - Request additional units - Coordinating
  + Deliver medical equipment
    - Land/drop
    - Need to reload? If so, return to base for additional supplies.
      * Message back to HQ
      * Receive coordinates to reload.
  + Reload station
    - Get as close as possible to AOI
    - Report supply levels.
  + Extract survivor(s)
    - Self-driving or remote piloted large vehicle
  + Maintenance
    - Report maintenance needed – resupply deliverables, need refuel/new battery.

## UC-002 Surveillance and Information Gathering

### Mission Overview

* Deployment
  + Instructions – proceed to Area of Interest
  + Travel
  + Arrival at site.

### Actions to Model

* Perform mission
  + Report detections – signals.
  + Report events – on-site analyst? Or asset that can perform first-line analysis.
  + Stream information
  + Get assigned new locations.
  + Central node re-deploys local assets
* Maintenance
  + Request refuel
* Mission complete

## UC-003 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
  + Patrol
  + Report observations – signal detection, visual item
  + Signal detection – may be hostile or cry for help or ignorable transmission (yellow daisies)
  + Request support
  + Jam signals
  + Exchange fire – needs command/confirmation
  + Retreat
  + Detect loss of patrol unit
* Maintenance
  + Refuel/reload
  + Report damage
* Mission Complete

## UC-004 Patrol Group

### Mission Overview

* Deploy
  + Assign missions

### Actions to Model

* Perform Mission
  + Patrol

## 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.

## UC-007 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?

# Use Case Breakdowns

## UC-001 Large Urban Area Hit By Earthquake

### Scenario Entities

Table 9 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 |  |
| UavSearch1 | UAV with sensors | Scan for Survivors | Sensor | Video Sensors  AI Capability  Target identification algorithms  Programmable Target database |
| UavSearch2 | UAV with sensors | Scan for Hazards | Sensor | Video Sensors  Air Quality Sensors  Target identification algorithms  Programmable Target database |
| UavMedDelivery1 | UAV with payload | Deliver medical supplies; on call until given specific directive | Delivery | Refillable Payload  List of locations for delivery |
| UgvExtractor1 | UGV transport | Transport that can be loaded with casualties and move them to evac centers |  |  |
| UgvExtractor2 | UGV transport with grabber arm | Retrieve physical items and load them for transport. |  |  |
| UavTransport1 | UAV with payload capability | Deploy Med Kits |  |  |
| SwarmC2 | UAV | Automated Unit that coordinates all Automated units. |  | May be one of the other UXVs, or co-located with C2Unit |
| Survivor1 | Person | Call for help.  Get evacuated by air. |  | Injured |
| Survivor2 | Person | Call for help.  Get evacuated by ground. |  | Injured |
| Medical Facility | Building / Location |  |  |  |

### Scenario Initialization Messages

Set up the entities for the scenario. All of these messages are sent by Scenario Coordinator.

Table 10 Initialization Messages

|  |  |  |
| --- | --- | --- |
| Receiver | Msg Reference | Msg Details |
| C2Unit | InitializationConcept | Location.  List of resources. |
| UavSearch1 | InitializationConcept | SearchPattern |
|  |  | TargetDatabase – People |
|  |  | TargetIdAlgorithm |
|  |  | SwarmNetworkParameters |
|  |  | SwarmNetworkRole |
| UavSearch2 | InitializationConcept | SearchPattern |
|  |  | TargetDatabase – Hazards |
|  |  | TargetIdAlgorithm |
| UavMedDelivery1 | InitializationConcept | Refill Depot Id |
|  |  | Payload Type |
| UgvExtractor1 | InitializationConcept | Initial Location |
| UgExtractor2 | InitializationConcept | Initial Location |
| ?? | Initialization Concept | SwarmNetworkParameters |
|  |  |  |

### Scenario Messages

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Msg ID | From | To | Description | Notes / Details | Msg Ref |
| UC01-01 | Survivor1, Survivor2 | C2Unit | Request for help | Location, Damage, Injury |  |
| UC01-02 | C2Unit | UavSearch1, UavSearch2, UavMedDelivery, etc.  Search Swarm | Order  Move To Location  Start Operation | Operation types |  |
| UC01-03 | Deployable units | C2Unit | Report arrival on scene | Report Location |  |
| UC01-04 | UavSearch1 | C2Unit | Search Drone reports survivor | Report  Observation |  |
| UC01-05 | UavSearch2 | C2Unit | Search Drone reports key asset located | Report Observation |  |
| UC01-06 | C2Unit | UavTransport1 | Order  Go To Location.  Deploy MedKit | Deploy, payload |  |
| UC01-07 | C2Unit | UgvExtractor1 | Order  Go to location  Action: Extract survivor, transport to Medical Facility | Action |  |
| UC01-08 | C2Unit | Medical Facility | Order  Prepare for incoming ambulance | Action |  |
| UC01-09 | UavSearch2 | C2Unit | Report Hazard | Report  Action |  |
| UC01-10 | C2Unit | UgvExtractor2 | Order  Go to Hazard  Monitor |  |  |
| UC01-11 | UavSearch2 | C2Unit | Report  Action Event  Gas main explosion |  |  |
| UC01-12 | Swarm Lead | Rest of Swarm | Heartbeat  Build map of search area. | Not a C2SIM message? |  |
| UC01-13 | Swarm Lead | C2Unit | Report  Swarm member lost  \*\* Results in change to search pattern. Do we need to report this back to C2Unit?  \*\* May depend on program of units. |  |  |
| UC01-14 | Swarm Lead | C2Unit | Report  Damaged  New Swarm Lead required  \*\* Next step depends on Swarm behaviour – negotiate, or designated 2nd in command |  |  |
| UC01-15 | New Swarm Lead | C2Unit | Report  New Swarm Lead selected. |  |  |
| UC01-16 | UavTransport1 | C2Unit | Report  Payload empty. |  |  |
| UC01-17 | C2Unit | UavTransport1 | Order  Directed to nearest reload depot. |  |  |
| UC01-18 | UavSearch2 | C2Unit | Report  Low fuel |  |  |
| UC01-19 | C2Unit | UavSearch2 | Order  Directed to nearest fuel depot. |  |  |
| UC01-20 | Swarm Member X | C2Unit | Report  Swarm Leader has gone silent.  New swarm leader ID is Member X. |  |  |

## UC-002 Surveillance and Information Gathering

### 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 |  |  |  |
| UavSwarm1,  UavSwarm2,  UavSwarm3,  UavSwarm4,  UavSwarm5,  UavSwarm6 | UAVs | Surveillance of Area of Interest |  |  |
| Emitter1, Emitter2 |  | Targets detected by sensors. |  | Locations,  Transmission Characteristics |

### Scenario Initialization Messages

|  |  |  |
| --- | --- | --- |
| Receiver | Msg Reference | Msg Details |
| C2Unit | InitializationConcept | Location.  List of resources. |
| UavSwarm Units | InitializationConcept | Location. (Co-located with C2Unit.)  List of resources.  ID of Coordinator unit.  Search pattern |
| UavSearch1 | InitializationConcept | SearchPattern |
| Emitter1 |  |  |

### Scenario Messages

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Msg ID | From | To | Description | Notes / Details | Msg Ref |
| UC01-01 | Survivor1, Survivor2 | C2Unit | Request for help | Location, Damage, Injury |  |
| UC01-02 | C2Unit | UavSearch1, UavSearch2, UavMedDelivery, etc.  Search Swarm | Order  Move To Location  Start Operation | Operation types |  |

## UC-03 Protecting Troops and Populations

### 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 |  |
| UavArtillery1,  UavArtillery2 | UAV with artillery | Engage hostile forces | Artillery | Guns  Ammo  Target Recognition |
| UavArtillery2 | UAV with artillery |  |  |  |

### Scenario Initialization Messages

|  |  |  |
| --- | --- | --- |
| Receiver | Msg Reference | Msg Details |
| C2Unit | InitializationConcept | Location.  List of resources. |
| UavArtillery1 | InitializationConcept | Location. |
| UavArtillery2 | InitializationConcept | Location. |
| PatrolUnit (Manned Patrol vehicle) | InitializationConcept | Patrol Route |

### Scenario Messages

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Msg ID | From | To | Description | Notes / Details | Msg Ref |
| UC03-01 | C2Unit | Patrol1 | Order  Start Patrol |  |  |
| UC03-02 | Patrol1 | C2Unit | Report Incident | Location, Entities Involved: Target, Entities to protect |  |
| UC03-02 | C2Unit | UavArtillery1 | Order  Move To Location  Fire on Target |  |  |
|  | UavAudio1 | C2Unit | Report  Audio signal  Reporting |  |  |
|  | C2Unit | UavEw1 | Order  Move to location  Jam signal |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
|  |  |  |  |  |  |

# Message Details

This section contains the details for messages for the scenarios. They are collected in one place as the same messages are expected to be used in multiple scenarios.

## Message Inventory

### Scenario Setup

The following messages are broken out in this section.

1. Initialize – Start Location
2. Initialize – Resources (or resource categories)
3. Initialize – Search Pattern
4. Initialize – Target Database – People.
5. Initialize – Target Database – Hazards
6. Initialize – Target ID Algorithm / Algorithm type
7. Initialize – Swarm Network Parameters
8. Initialize – Swarm Network Role
9. Initialize – Refill Depot Resources

### 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.

## Initialization

Initialization of a Scenario requires each system to send a

### 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 |  |  |
|  |  |  |  |

Table 11 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 1 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 2 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 3 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 4 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 5 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 6 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 7 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 7 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 8 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 |

# Findings

## C2SIM Concepts Used In Messages

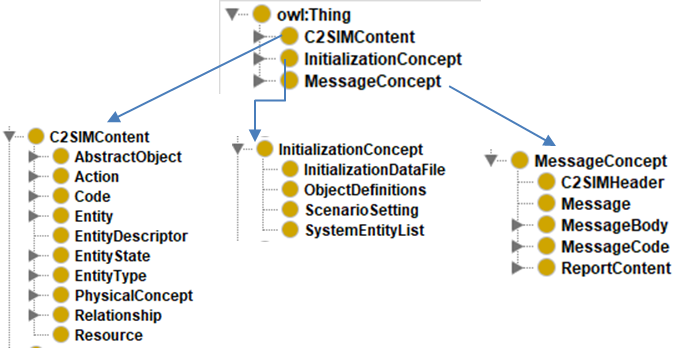


Figure 5‑1 C2SIM Standard Hierarchy

## Entities and Attributes

* Roles

## Orders

* Swarm-related Actions:
* Action Events

## Reports

* Swarm-specific operations

# Areas for Future Investigation