



Final Report ASSURE A28: Disaster Preparedness and Response Using UAS Appendix C – MBSE Communications & Interactions of Disaster Case Studies

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ATC	Air Traffic Control
COA	Certificate of Waiver or Authorization
EM	Emergency Management
EOC	Emergency Operation Center
FAA	Federal Aviation Administration
ICS	Incident Command Structure
MBSE	Model-Based Systems Engineering
MEMA	Mississippi Emergency Management Agency
NCDOT	North Carolina Department of Transportation
NTXPSURT	North Texas Public Safety Unmanned Response Team
OSHA	Occupational Safety and Health Administration
RPIC	Remote Pilot in Command
SAL	Spatial Analysis Lab
SGI	Special Government Interest
SOSC	System Operations Support Center
TFR	Temporary Flight Restriction
UAS	Unmanned Aircraft System

1 MBSE COMMUNICATIONS & INTERACTIONS OF DISASTER CASE STUDIES

1.1 Pearl River Flooding – February 2019

1.1.1 Target Entity Relationships

The entities that are involved in the disaster and their high-level relationships are depicted using the Model-Based Systems Engineering (MBSE) Block Definition Diagram. The data collection subject is the Unmanned Aircraft System (UAS) Program Coordinator who works for the Mississippi Emergency Management Agency (MEMA). The Air Boss and Remote Pilot in Command (RPIC) work for MEMA and are tasked by the UAS Program Coordinator. For the 2019 Pearl River Flooding, the UAS Program Coordinator interacted with the Federal Aviation Administration (FAA) System Operations Support Center (SOSC), local Air Traffic Control (ATC), county EMA, and local responders. The FAA SOSC also interacts with the local ATC while interacting with the MEMA. Figure 1 provides direct information about which entities are involved and which entities are interacting directly. However, it provides no information about the kind of interactions happening between the various entities. This information is presented using a use case diagram that follows in the next section.



Figure 1. Pearl River Flooding Block Definition Diagram.

1.1.3 Target Entity Use Case

The Use Case diagram depicts the high-level interactions among the entities that take place during the disaster. The entities are identified in this diagram as actors and are placed outside of the dashed rectangular box. The interactions are identified as use cases and are place inside the dashed rectangular box. Information exchange can happen in either direction. Figure 2 shows the Pearl River Flooding Use Case Diagram.



Figure 2. Pearl River Flooding Use Case Diagram.

The diagram in Figure 2 can be read as follows:

- The county EMA requests UAS assessment from the UAS program coordinator.
- The UAS program coordinator conducts a mission feasibility. The mission feasibility may also involve the need for a Special Government Interest (SGI) Certificate of Waiver or Authorization (COA). If an SGI COA is needed, the UAS program coordinator works with the FAA SOSC and local ATC. The FAA SOSC interacts with the local ATC on the SGI COA. Note that the FAA SOSC or the local ATC does not interact with the UAS program coordinator regarding other mission feasibility interactions except the SGI COA.
- The UAS program coordinator may direct the Air Boss to request a Temporary Flight Restriction (TFR) with the FAA SOSC. The local ATC is also included in this process, and they interact both with the air boss and the FAA SOSC office.
- The flight missions are supervised by the UAS program coordinator but conducted by the RPIC. Before beginning any flights (pre-mission), the RPIC coordinates with the local ATC office to coordinate airspace and inform flight activity. They also work with the local responders to share mission profiles and understand specific needs.
- The RPIC performs the mission and is coordinating with the local responders on the ground and providing them what they need (live stream, etc.).
- After the mission is complete (post-mission), the RPIC reports the local ATC about end of flight activity. They coordinate with the local responders to ensure they have received all the needed data. Finally, mission summary is generated by the UAS program coordinator and shared with the county EMA.

1.1.4 Target Entity Mission Activity Diagram

The Activity Diagrams depict the flow of activities from start of the disaster to the finish. Figure 3 shows the Pearl River Flooding Mission Activity Diagram.



Figure 3. Pearl River Flooding Mission Activity Diagram.

After the pearl river flooding is declared a state of emergency, the county EMA requests the UAS program coordinator for UAS assessment (situational awareness). The UAS program coordinator performs a check of mission feasibility. If an SGI COA is required, the UAS program coordinator requests COA from the FAA SOSC office. The FAA SOSC office begins the COA process and reaches out to the local ATC. The COA is approved after the mission and scope are defined by all entities involved. If a TFR is required, the Air Boss requests the FAA SOSC, and, after assessment, the SOSC office issues the TFR. All previous activities comprise the mission feasibility check. The mission is now accepted and the RPIC begins pre-mission where he reviews the COA with the UAS program coordinator and coordinates airspace with local ATC. He also informs the local responders on the site about the flights and considers their requests. Next, he performs the mission and communicates with local responders and provides live streaming and other needed information. After mission completion, he verifies local responders have what's needed and then informs ATC of flights completed. A flight summary is generated, and the program coordinator sends it to the county EMA officials. If more data is needed, further flights are conducted. Otherwise, the UAS mission is complete.

1.2 Missing Persons - November 2020

1.2.1 Target Entity Relationships

The data collection subject is the UAS Lead at the Spatial Analysis Lab (SAL) of the University of Vermont. On November 10th, 2020, a person went missing. Figure 4 shows the Missing Persons Block Definition Diagram. The below diagram represents the entities involved in the UAS operation for Search and Rescue.



Figure 4. Missing Persons Block Definition Diagram.

The UAS lead interacts with the FAA SOSC, local ATC, and Burlington Police Department. The FAA SOSC also interacts with the local ATC while interacting with SAL.

1.2.2 Target Entity Use Case

Figure 5 shows the Missing Persons Use Case Diagram.



Figure 5. Missing Persons Use Case Diagram.

The diagram shown in Figure 5 can be read as follows:

- The Burlington police departments requests UAS support from the UAS Lead at SAL for Search and Rescue.
- The UAS lead needs an SGI COA and interacts with the FAA SOTC and Burlington ATC. The FAA and ATC also interact with each other.
- During the mission, SAL directly interacts with the Burlington Police Department. Additionally, airspace coordination takes place between SAL and local ATC.

1.2.3 Target Entity Activity Diagram

Figure 6 shows the Missing Persons Activity Diagram.



Figure 6. Missing Persons Activity Diagram.

After a person goes missing, the Burlington Police Department requests the SAL for aerial assistance with a missing person search and rescue. An SGI COA is needed since the last known

location of the missing person was near an airport. The UAS lead at SAL contacts the FAA SOSC for an SGI COA. The FAA SOSC contacts the Burlington ATC tower and exchanges information about the potential fight mission. The FAA SOSC approves an SGI COA waiver for SAL. Before the flight mission, SAL contacts the ATC tower for airspace coordination. During flight mission, SAL coordinates on the ground with Burlington Police Department officers. After the mission is complete, SAL informs the ATC tower of mission completion.

1.3 Hurricane Florence – September 2018

1.3.1 Target Entity Relationships

The data collection subject is the UAS Program Manager and the UAS Airspace Coordinator who work for the North Caroline Department of Transportation. In the summer of 2018, Hurricane Florence hit the Carolinas. Figure 7 represents the entities involved in the UAS operation for Hurricane Florence.



Figure 7. Hurricane Florence Block Definition Diagram.

The North Carolina Department of Transportation (NCDOT), North Carolina Department of Environmental Quality, and the North Carolina Emergency Management (EM) unit directly interact with the UAS Program Manager. The NCEM unit is part of the North Carolina Department of Public Safety. The UAS Airspace Coordinator works with the UAS Program Manager. Several RPICs directly work under the UAS Airspace Coordinator. The UAS Airspace Coordinator works with the FAA SOSC and local ATC. FAA SOSC interacts with the local ATC while interacting with the UAS Airspace Coordinator.

1.3.2 Target Entity Use Case

Figure 8 shows the Use Case diagram for Hurricane Florence.



Figure 8. Hurricane Florence Use Case Diagram.

This diagram can be read as follows:

- NCDOT, NC Department of Environmental Quality, and NC EM unit request UAS assessment missions from the UAS Program Manager.
- The UAS program manager performs mission planning along with the UAS Program Manager. When SGI COA's are needed, they work with the RPIC to send a request to the FAA SOSC who works with the local ATC office as well. The Air operations unit of the NC EM is also informed of the SGI COA requests.
- The RPICs work with the local ATC for airspace coordination before and after flight missions.
- During the mission, the UAS Program Manager, UAS Airspace Coordinator, and RPIC work with the NC DOT, NC Department of Environmental Quality, NC EM. They receive mission requests and provide data to these entities.

1.3.3 Target Entity Activity Diagram

Figure 9 shows the Activity diagram for Hurricane Florence.



Figure 9. Hurricane Florence Activity Diagram.

A week before the hurricane, UAS assessments are requested internally by the NC DOT to the UAS Program Manager. The UAS Program Manager works with the UAS Airspace Coordinator and performs mission and resource planning. When SGI COA's are required, the UAS Airspace Coordinator generates COA request while working with the remote pilots. These requests are sent to the FAA SOSC who reviews them and coordinates airspace information with the local ATC. Once the COA is issued, the UAS Airspace Coordinator reviews the COA with the remote pilots. The remote pilots inform local ATC of all flights before and after all flight activity. As requests are received by the various entities, they are initially assessed by the UAS Program Manager who works with the UAS Airspace Coordinator and plans all flight activities with the RPIC and provides flight data to the entities that requested.

1.4 Dallas Crane Collapse – June 2019

1.4.1 Target Entity Relationships

On the afternoon of June 9th, 2019, a severe thunderstorm caused a crane to collapse on top of the Elan City Light Apartments in downtown Dallas. Figure 10 describes the entities and their relations in preparation of this disaster.



Figure 10. Dallas Crane Collapse Block Definition Diagram.

The data collection subject is the chair of the North Texas Public Safety Unmanned Response Team (NTXPSURT). The chair supervises a team of RPICs and an Unmanned Air Boss. The NTXPSURT is a working group under the North Central Texas Council of Government. The Emergency Preparedness Coordinator and the Dallas Urban Search and Rescue (USR) also work for the North Central Texas Council of Government and interact with the chair of NTXPSURT. The Incident Command Structure (ICS) comprised of Dallas fire and police departments, work with the chair of NTXPSURT. News helicopters interact with the Dallas police department. A freelance UAV pilot interacts with NTXPSURT. Occupational Safety and Health Administration (OSHA) interacts with NTXPSURT. The chair of NTXPSURT works with FAA SOSC office and Dallas Love field ATC. The FAA SOSC office also interacts with the Dallas Love field ATC.

1.4.2 Target Entity Use Case

Figure 11 shows the Dallas Crane Collapse Use Case Diagram.



Figure 11. Dallas Crane Collapse Use Case Diagram.

This diagram can be read as follows:

- The Emergency Preparedness Coordinator reaches out to the chair of NTXPSURT for aerial UAS mission support after the crane accident.
- The chair of NTXPSURT works with FAA SOSC and Dallas Love field ATC on SGI COA and TFR. The chair of NTXPSURT coordinates airspace with Dallas Love field ATC before and after flight missions. NTXPSURT engages with a freelance UAV pilot who is obstructing airspace. News helicopters are obstructing airspace, and the police department reaches out to them to clear the area.
- During the mission, the chair of NTXPSURT directs the Air Boss and remote pilots to work with the ICS on various mission requests. The live feed attained from the aerial missions are provided to the urban search and rescue. The recorded videos are provided to OSHA for reconnaissance.

1.4.3 Target Entity Activity Diagram

Figure 12 shows the Dallas Crane Collapse Activity Diagram.



Figure 12. Dallas Crane Collapse Activity Diagram.

After the crane collapse on the City Light Apartments, the Emergency Preparedness Coordinator of the North Center Texas Council of Government reaches out to the chair of the NTXPSURT for UAS mission support. The NTXPSURT chair requests the FAA SOSC for an SGI COA approval. The FAA SOSC office coordinates with Dallas Love field ATC and issues the SGI COA to the NTXPSURT. NTXPSURT member communicates with a freelance UAV who is obstructing the airspace to land their UAV. Dallas police department reaches out to news helicopters who are also obstructing the airspace. The ICS and USR request aerial flights to cover certain areas to the NTXPSURT who then generates the necessary mission profiles. The NTXPSURT coordinates with the Air Boss who sections the area and divides the mission profiles among the remote pilots. The remote pilots coordinate with Love field ATC before and after flight missions. These flight missions generate a live video that is used by the ICS for disaster management and USR for search and rescue. The recorded video is later used by OSHA for reconnaissance and identifying how the crane failed.

1.5 Dallas Tornado Response – October 2019

1.5.1 Target Entity Relationships

The data collection subject is the chair of the NTXPSURT. In October 2019, a series of tornadoes hit the Dallas-Fort Worth area. Figure 13 shows the Dallas Tornado Response Block Definition Diagram.



Figure 13. Dallas Tornado Response Block Definition Diagram.

During the Tornado response, NTXPSURT helps the ICS setup at Marsh and Walnut Hill and directly interacts with the Fireman Division Chief. The Fireman Division Chief interacts with medic, fire department, and USR. The Dallas Emergency Operation Center (EOC) Emergency Operator is also in direct communication with the chair of NTXPSURT. The NTXPSURT also interacts with Secret Service and the Secret Service Coordinator. The chair of the NTXPSURT is

also in communication with FAA SOSC and Dallas Love field ATC. The FAA SOSC office also interacts with the Dallas Love field ATC.

1.5.2 Target Entity Use Case

Figure 14 shows the Dallas Tornado Response Use Case Diagram.



Figure 14. Dallas Tornado Response Use Case.

This diagram can be read as follows:

- The NTXPSURT uses a GCOA to fly over Richardson City (Class G Airspace) and does not need any permissions or coordination with FAA or ATC.
- NTXPSURT receives a mission request from ICS at Marsh and Walnut Hill and provides aerial situational awareness of downtown Dallas.
- The Fireman Division Chief coordinates with NTXPSURT for all downtown Dallas flight missions. As requests are made, NTXPSURT provides the necessary aerial data.
- Airspace Coordination for downtown Dallas involves the FAA SOSC and Dallas Love field ATC since an SGI COA is required. The NTXPSURT submits an SGI COA request.

• The Preston Hollow area came under the Presidential TFR. NTXPSURT chairperson, and the remote pilot works with the secret service, secret service coordinator and FAA SOSC to coordinate flights over this area.

1.5.3 Target Entity Activity Diagram

Figure 15 shows the Dallas Tornado Response Activity Diagram.



Figure 15. Dallas Tornado Response Activity Diagram.

On the night of October 20th, after the tornado hits, an internal mission request from within NTXPSURT is made to provide optical and thermal imagery of Richardson City. On October 21st, the Dallas EOC reaches out to NTXPSURT and discusses Dallas Downtown UAS missions. Following this, NTXPSURT chair works with ICS at Marsh and Walnut hill to provide them aerial surveillance of the tornado hit region. The Fireman Division Chief working in the ICS requests UAS flights of certain areas and the NTXPSURT chair coordinates with remote pilots to provide him livestream of the area. The recorded flight data is downloaded and saved after the mission and provided to ICS.