# Attachment 2

# Capability Development Document (CDD)

# Rescue Operations Support
# Unmanned Aircraft System (ROS UAS)
# Development Program

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The University of Texas at Austin
Department of Aerospace Engineering and Engineering Mechanics
Boeing Aircraft System Integration Laboratory (BASIL)

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# 1 Introduction

This Capability Development Document (CDD) identifies desired operational performance attributes of the ROS UAS operational capabilities.

This CDD is system specific and applies to the initial increment of capability in an evolutionary acquisition program. It defines measurable and testable capabilities to guide development leading to the Engineering and Manufacturing Development (EMD) acquisition phase.

The CDD provides development performance attributes (KPPs, Key System Attributes (KSAs), and Additional Performance Attributes (APAs), to guide the development of the system. Measures of Effectiveness (MOEs) are provided to evaluate effectiveness of the system for use in design optimization.

Affordability Metrics are provided as a means of assessing components of the Life Cycle Cost (LCC). During the current development phase, the cost metrics are focused on Unit Flyaway Cost and Operational Cost.

Other System Attributes define desired capabilities, including weather support, air dropped payload, and transportability.

Technology Readiness objectives are addressed as a means of containing developmental risk.

# 2 Operational Context

## 2.1 Vision Statement

Provide continuous 24 hours per day, seven days per week (24/7), unmanned aircraft system capabilities for search, surveillance, and precision airborne drop package delivery in support of Austin Fire Department rescue operations with minimal basing requirements.

## 2.2 Mission Description

The ROS UAS supports Austin Fire Department (AFD) rescue operations by locating and identifying people that need assistance and rescue after natural disasters. By surveilling an area of interest, it locates stranded people, identifies distressed persons, and delivers a medical supplies kit by precision aerial drop. The location of the homes where people are stranded, an assessment of distress, and any other intelligence that is gathered, is transmitted to AFD to assist planning of rescue team activities.

## 2.3 Mission Scenario

There has been flooding around the Austin metropolitan area. AFD has received reports of water rapidly rising above the level of homes in some areas. Wanting to know if they need to deploy their rescue teams and where to deploy them, AFD sends several ROS UAS to search for people in need of assistance.

In the Area of Interest (AOI), houses are surrounded by water. Unable to escape the rapidly rising water, people have moved to the roofs of their houses.

Some people are uninjured and content to wait for the water to subside. The ROS UAS identifies and maps their locations and transmits the data to the AFD command center.

A few people are in distress and may be unconscious or injured, needing immediate medical assistance. In addition to transmitting the location data to the AFD command center, the ROS UAS performs a precision aerial drop payload (ADP) delivery containing a medical supply kit.

## 2.4 System Architecture

The system shall consist of four elements as shown in Table 2.4.

**Table 2.4** – System Architecture

| Element | Description |
|---|---|
| 1 | Mission Systems (retained and expendable payloads) including, sensors, sensor installation, sensor comms equipment (radios and antennae), sensor comms installation, internal and external suspension and release equipment, air dropped payload (ADP) |
| 2 | Air vehicle with on-board subsystems not included in Element 1 |
| 3 | Mission control including ground-based computers, displays and communications required for mission simulation and execution |
| 4 | Mission support and logistics including maintenance, spares and logistics |

# 3 Capability Development Background

The University of Texas at Austin, through the Boeing Aircraft System Integration Lab (BASIL), has conducted an Analysis of Alternatives (AoA) to satisfy Austin Fire Department (AFD) Rescue Operations Support (ROS) needs.

The AoA assessed a multitude of system concepts using performance and affordability metrics. Potential system concepts considered were manned fixed wing aircraft, manned helicopters, unmanned fixed wing aircraft, unmanned helicopters, unmanned quad-copters, and space-based surveillance assets. Based on a balance of system performance and affordability, a system based on unmanned fixed wing aircraft was identified as the best alternative to close the capability gap. This selection reduces the ROS UAS development and acquisition cost by keeping the system simple and aircraft size small.

Several alternatives for the UAS propulsion system concept were assessed in the AoA. Key considerations were system reliability, maintainability, and affordability. The AFD has limited aircraft maintenance capability, needs very high reliability to execute its rescue operations, and is funding constrained. Careful consideration of these constraints resulted in recommendation of a battery-electric propulsion system. This provides very high reliability, low maintenance, and low operating cost.

The AoA considered several system architectures. It was recommended that a Modular Open System Approach (MOSA) be used. This approach provides flexibility for evolution of capabilities to be added, removed, or replaced in future increments.

Finally, the AoA explored subsystem capabilities to be integrated into the MOSA architecture. The key considerations were technology readiness levels, reliability, maintainability, and affordability. It was recommended that Commercial Off the Shelf (COTS) subsystems be used to eliminate subsystem development time, cost, and risk and to reduce subsystem integration risk.

# 4 Program Summary

## 4.1 Acquisition Plan

A multi-phase acquisition plan is envisioned to implement the ROS UAS. Each successive step depends on the success of the previous step and funding availability for the next step.

The envisioned acquisition plan consists of the following phases:

- Phase 0 - Technology Demonstration
- Phase 1 - System Concept Definition
- Phase 2 - System Development and Demonstration
- Phase 3 - Engineering Manufacturing Development (EMD) and Initial Operational Test and Evaluation (IOT&E)
- Phase 4 - Production, Operational Test and Evaluation (OT&E), and System Deployment
- Phase 5 - System Operation and Maintenance
- Phase 6 - System Retirement

Phase 0 focuses on demonstration of wing structural technology, which will be used in subsequent development phases.

Phases 1 and 2 focus on demonstration of ConOps, systems integration, and subsystem technologies needed for the operational capability. A subscale Technology Demonstrator Vehicle (TDV) is used to mature the system concept at reduced cost. Most performance requirements are the same for both the Operational Vehicle (OV) and the TDV. Differences such as payload capacity and range capability are noted in the requirements below.

AFD desires to design the ROS UAS to be compliant with FAA Part 107 in order to bring the operational capability online quickly. However, waivers will be required due to operation over populated areas, Beyond Visual Line of Sight (BVLOS) operation, operations at night, and planned operational altitudes greater than 400 ft AGL. The path for obtaining appropriate FAA airworthiness approval required for the waivers includes several options. The first is type certification under FAA Part 21.17(b) for special classes of aircraft such as gliders, airships, and very light airplanes. A second approach uses the FAA “reliability-based airworthiness process”. A third option is to obtain an exception under Section 44807 of the FAA reauthorization legislation. The backup plan is to pursue certification under FAA Part 91 for small civil aircraft. The design and operation of the TDV shall be compliant with FAA Part 107 to avoid the need to complete these waiver and certification processes.

Initial Operational Capability (IOC) is needed within three years of the RFP release date. IOC is achieved when there is one squadron of 4 ROS-UAS operating at one base, which marks the end of Phase 3. Full Operational Capability (FOC) is needed two years after IOC, which marks the end of Phase 4. FOC is achieved with one squadron of 4 ROS-UAS operating at each of 4 bases.

It is anticipated that Phase 5 provides at least 10 years of operations before technology obsolescence, after which the system will be retired in Phase 6.

## 4.2 Basing Concept

The AFD has not yet finalized ROS UAS basing plans due to the envisioned multi-jurisdictional coverage area and the need to obtain base facilities. However, a notional basing concept, shown in Figure 4.2, has been developed to support design and performance analysis activities. It is envisioned that the Austin Metropolitan area will be covered by 4 bases. Each base covers a radius of approximately 6 nm. The envisioned basing arrangement provides overlapping coverage to improve coverage during times of high demand. This basing concept provides capability to deploy to AOIs located at the limits of the coverage area within 8-12 minutes at the objective or threshold deployment cruise speeds, respectively. Deployment to AOIs located within 3 nm of a base will nominally be achieved within 5 minutes.

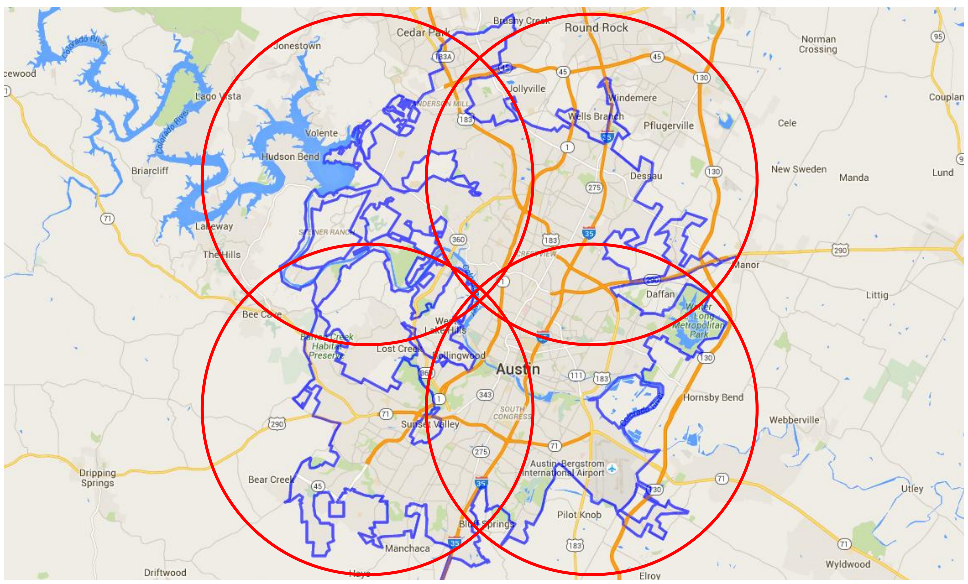


**Figure 4.2** – Notional Basing Concept

## 4.3 Key Operational System Capabilities

Table 4.3 describes key Operational System capabilities, which are not required for the TDV.

**Table 4.3** – Key Operational System Capabilities

| Capability Description | Capability | Notes |
|---|---|---|
| Target Size | 1600 sq ft | Medium size house rooftop |
| Search Area | 200 acres | Per each ROS UAS |
| Deployment Radius | 6 nm | Radius of base coverage area |
| ADP Internal Canister Payload Weight (each) | 1.25 lb | See Section 8.2 for geometry and additional details |
| Maximum Mission Cycle Time ($MCT_{Max}$) | 72 minutes | To maximum deployment radius (20 cycles per day) |
| Command and Control | BVLOS | |
| Operations | 24/7 | Includes night operations |
| Service Ceiling | 2500 ft AGL | |

The following sections of this CDD describe capabilities to be demonstrated by the TDV. Except for the capabilities described in Table 4.3, the remaining requirements for the Operational System and the TDV are identical.

# 5 System Performance Attributes

## 5.1 Key Performance Parameters (KPPs)

The ROS UAS shall provide operational capabilities defined by the KPPs listed in Table 5.1. Associated requirements and Technical Performance Measures (TPMs) are provided below.

**Table 5.1** – KPP Descriptions

| Key Performance Parameter | Description | Threshold | Objective |
|---|---|---|---|
| KPP1 | Deployment Responsiveness (Deployment & RTB speed) | 30 KTAS | 45 KTAS |
| KPP2 | Search & Surveillance Endurance Factor | 5 hours | 7.5 hours |
| KPP3 | Search Efficiency | 12 min | 4 min |
| KPP4 | Surveillance Efficiency | 6 min | 4 min |
| KPP5 | Payload Capability (First aid kits delivered per mission) | 2 | 4 |
| KPP6 | Mission Execution Efficiency | 45 min | 30 min |

Note: TPM = 1.0 at the objective value or better, 0 at the threshold value, and < 0 for values worse than threshold.

KPP1: Deployment Responsiveness

- The air vehicle shall complete deployment to AOI of 3 nm after reaching cruise altitude
- The air vehicle shall complete Return to Base segment of 3 nm from last payload drop

$$TPM_{Dep} = \frac{1}{2} \times \left[ min\left\{1, \left(\frac{V_{Deployment} - V_t}{V_o - V_t}\right)\right\} + min\left\{1, \left(\frac{V_{RTB} - V_t}{V_o - V_t}\right)\right\}\right]$$

where:

$V_{Deployment}$ = Deployment segment average speed (KTAS)
$V_{RTB}$ = Return to Base segment average speed (KTAS)
$V_o$ = Deployment/RTB speed objective value (KPP1)
$V_t$ = Deployment/RTB speed threshold value (KPP1)

KPP2: Search and Surveillance Endurance Factor (EF)

- EF measures search and surveillance flight efficiency, which is defined as lift-to-drag (L/D) ratio divided by thrust specific fuel (battery power) consumption (TSFC).

$$TPM_{EF} = min\left\{1, \left(\frac{EF - EF_t}{EF_o - EF_t}\right)\right\}$$

where:

$EF$ = The average value for the Search and Surveillance segments, at maximum mission takeoff weight, with the design mission ADP loadout

$EF_o$ = Endurance Factor objective value (KPP2)

$EF_t$ = Endurance Factor threshold value (KPP2)

KPP3: Search Efficiency

- Measures efficiency of TOI search

$$TPM_{Src} = min\left\{1, \left(\frac{T_{Search} - T_t}{T_o - T_t}\right)\right\}$$

where:

$T_{Search}$ = Time to search AOI for all TOI

$T_o$ = Search time objective value (KPP3)

$T_t$ = Search time threshold value (KPP3)

KPP4: Surveillance Efficiency

- Measures efficiency of CAT surveillance, which includes time for one orbit of each CAT

$$TPM_{Sur} = min\left\{1, \left(\frac{T_{Surveillance} - T_t}{T_o - T_t}\right)\right\}$$

where:

$T_{Surveillance}$ = Time to perform surveillance of CATs to determine if CRT or NCRT

$T_o$ = Surveillance time objective value (KPP4)

$T_t$ = Surveillance time threshold value (KPP4)

KPP5: Payload Delivery Capability

$$TPM_{Pay} = min\left\{1, \left(\frac{N_{ADP} - N_t}{N_o - N_t}\right)\right\}$$

where:

$N_{ADP}$ = Number of ADPs delivered per mission

$N_o$ = Number of ADPs delivered per mission objective value (KPP5)

$N_t$ = Number of ADPs delivered per mission threshold value (KPP5)

KPP6: Mission Execution Efficiency

- Measures efficiency of mission execution

$$TPM_{Mission} = min\left\{1, \left(\frac{T_{Mission} - T_t}{T_o - T_t}\right)\right\}$$

where:

$T_{Mission}$ = Time to complete mission (start of takeoff roll to map delivery)
$T_o$ = Mission execution time objective value (KPP6)
$T_t$ = Mission execution time threshold value (KPP6)

## 5.2 Key System Attributes (KSAs)

The ROS UAS shall provide operational capabilities defined by the KSAs listed in Table 5.2. Calculation methodologies for TPMs associated with each KSA are provided below the table.

**Table 5.2** – KSA Descriptions

| Key System Attribute | Description | Threshold (ft) | Objective (ft) |
|---|---|---|---|
| KSA1 | Search Accuracy | 60 | 20 |
| KSA2 | Surveillance Accuracy | 40 | 10 |
| KSA3 | Delivery Accuracy | 40 | 10 |
| KSA4 | Mapping Accuracy | 40 | 15 |

Note: TPM = 1.0 at the objective value or better, 0 at the threshold value, and < 0 for values worse than threshold.

KSA1: Search Accuracy

TOI location accuracy during the Search phase is evaluated by matching TOI images with the TOI nearest the aircraft coordinates. Then each pair is scored using these equations:

$$TPM_{search} = \frac{1}{2 \times N_{images}} \sum_{\text{Targets}} \min\left\{1, \left(\frac{Error_{TOI} - Error_t}{Error_o - Error_t}\right)\right\}$$

$$Error_{TOI} = \|GPS_{TOI} - GPS_{actual}\|$$

where:

$GPS_{TOI}$ = GPS coordinates of TOI (calculated from aircraft GPS location & camera pixels)
$GPS_{actual}$ = GPS coordinates of TOI nearest the aircraft as measured by evaluators

$Error_o$ = Distance Error objective value for KSA1
$Error_t$ = Distance Error threshold value for KSA1
$N_{images}$ = The number of image and coordinate sets submitted

KSA2: Surveillance Accuracy

Candidate target location accuracy during the Surveillance phase is evaluated using the following equations:

$$TPM_{surv} = \frac{1}{2 \times N_{CAT}} \sum_{\substack{\text{Candidate} \\ \text{targets}}} \frac{t_{obs}}{t_{max}} + \min\left\{1, \left(\frac{Error_{GPS} - Error_t}{Error_o - Error_t}\right)\right\}$$

$$Error_{GPS} = \|GPS_{centroid} - GPS_{actual}\|$$

where:

$t_{obs}$ = The time that the CAT is in view during one orbit of surveillance segment
$t_{max}$ = The scored surveillance segment time (one orbit)
$GPS_{centroid}$ = GPS coordinates of the centroid of the observed CAT locations
$GPS_{actual}$ = GPS coordinates of the surveilled CAT as measured by the evaluators
$Error_o$ = Distance Error objective value for KSA2
$Error_t$ = Distance Error threshold value for KSA2
$N_{CAT}$ = The number of candidate targets

KSA3: Delivery Accuracy

ADP Delivery Accuracy is evaluated by measuring the average CRT miss distance:

$$TPM_{delivery} = \frac{1}{N_{drop}} \sum_{N_{drop}} \min\left\{1, \left(\frac{Error_{Miss} - Error_t}{Error_o - Error_t}\right)\right\}$$

$$Error_{Miss} = \left\|X_{impact} - X_{CRT}\right\|$$

where:

$Error_{Miss}$ = Actual Distance (ft) from CRT center to ADP impact point using tape measure
$Error_o$ = Distance Error objective value for KSA3
$Error_t$ = Distance Error threshold value for KSA3
$N_{ADP}$ = Number of ADPs dropped

KSA4: Mapping Accuracy

Mapping Accuracy for the TOI is evaluated by matching the nearest actual target location with targets identified on the map and then using the following equations:

$$TPM_{map} = \frac{1}{N_{map\ targets}} \sum_{\text{Targets}} \min\left\{1, \left(\frac{Error_{Map} - Error_t}{Error_o - Error_t}\right)\right\}$$

$$Error_{Map} = \|GPS_{indicated} - GPS_{actual}\|$$

where:

$GPS_{indicated}$ = Estimated GPS coordinates of the TOI
$GPS_{actual}$ = Actual GPS coordinates of the TOI (nearest the indicated coordinates)
$Error_o$ = Distance Error objective value for KSA4
$Error_t$ = Distance Error threshold value for KSA4
$N_{map\ targets}$ = Number of TOI identified on the map

## 5.3 Additional Performance Attributes (APAs)

The ROS UAS shall provide the operational capabilities defined by the APAs summarized in Table 5.3.1. TPM definitions are provided below the table.

**Table 5.3.1** – APA Descriptions

| Additional Performance Attribute | Description | Threshold | Objective |
|---|---|---|---|
| APA1 | Takeoff Control | Manual | Auto |
| APA2 | Landing Control | Manual | Auto |
| APA3 | Camera Control (ft) | 10 | 5 |

Note: TPM = 1.0 at the objective value or better, 0 at the threshold value, and < 0 for values worse than threshold.

APA1: Takeoff Control

Takeoff Control evaluates the capability to perform autonomous takeoffs:

$$TPM_{ATO} = Q_{control}$$

where: $Q_{control}$ = Evaluator’s autonomous control rating (see Table 5.3.2)

APA2: Landing Control

Landing Control evaluates the capability to perform autonomous landings:

$$TPM_{AL} = Q_{control}$$

where: $Q_{control}$ = Evaluator's autonomous control qualitative rating (see Table 5.3.2)

**Table 5.3.2** – Autonomous Takeoff and Landing Control Descriptions

| Type | Control Rating Description | $Q_{control}$ |
|---|---|---|
| Autonomous | Smooth and stable - fully autonomous operation | 1.0 |
| Autonomous | Somewhat unstable - no safety pilot intervention required | 0.5 |
| Autonomous | Unstable – successful safety pilot intervention | 0 |
| Autonomous | Crash - minor damage (unsuccessful safety pilot intervention) | -0.5 |
| Autonomous | Crash - major damage (unsuccessful safety pilot intervention) | -1.0 |
| Manual | Manual Takeoff and Landing | 0 |

APA3: Camera Control

Camera Control is evaluated for the first two images of the image series taken during each ADP drop according to the following equations:

$$TPM_{CamCon} = \frac{1}{2 \times N_{drop}} \sum_{N_{drop},\ N_i} \max\left\{1, \left(\frac{Error_{CamConi} - Error_t}{Error_o - Error_t}\right)\right\}$$

$$Error_{CamConi} = \|Pixel_{crosshairs} - Pixel_{actual}\|$$

where:

$Pixel_{crosshairs}$ = Pixel coordinates of the camera crosshairs in the image
$Pixel_{actual}$ = Pixel coordinates of the critical target in the image
$Error_o$ = Distance Error objective value for APA3
$Error_t$ = Distance Error threshold value for APA3
$N_{ADP}$ = Number of ADPs dropped
$N_i$=2, to capture first 2 images

# 6 Measures of Effectiveness (MOEs)

The following MOEs are system level TPMs to be used for optimization of the system design and support of future program downselect decisions.

## 6.1 System Effectiveness (SE)

The SE MOE is intended to encourage development of superior performance electric powered unmanned aircraft systems for search, surveillance and payload delivery, which meet the system capabilities defined by the KPPs at minimum system cost. The SE MOE shall be used as an objective function for design optimization.

The SE MOE is based on the weighted sum of the KPP TPMs, defined in Section 5.1, divided by a system engineering cost estimating relationship (SE CER), defined in Section 7. The resulting MOE reflects achievement of the desired system capabilities per unit cost ($). Therefore, system solutions that meet or exceed KPP requirements and/or reduce cost are incentivized while those that do not are discouraged.

$$SE = \frac{\left(0.35 \times TPM_{Dep} + 0.35 \times TPM_{EF} + 0.1 \times TPM_{Src} + 0.1 \times TPM_{Sur} + 0.1 \times TPM_{Pay}\right)}{(System\ CER)/1000}$$

The maximum value of the SE MOE numerator is 1.0.

## 6.2 Mission Performance Effectiveness (MPE)

The MPE MOE measures the capability of the system design to achieve the capabilities defined by the KSAs. Essentially, it measures how well the system performs search, surveillance, package delivery, and mapping.

The MPE MOE is a weighted sum of the KSA TPMs:

$$MPE = {}^{1}/_{4}\left(TPM_{search} + TPM_{surv} + TPM_{delivery} + TPM_{map}\right)$$

The maximum value of the MPE MOE and each TPM is 1.0 for a perfect mission.

## 6.3 Control Effectiveness (CE)

The CE MOE measures the capability of the system design to achieve the operational capabilities defined by the APAs. It measures if and how well the system performs autonomous takeoffs and landings, and camera control during ADP drops.

The CE MOE is a weighted sum of the APA TPMs:

$$CE = {}^{1}/_{3}\left(TPM_{ATO} + TPM_{ATL} + TPM_{CamCon}\right)$$

The maximum value of the CE MOE and each TPM is 1.0 for a perfect mission.

# 7 Affordability Metrics

System affordability will be evaluated using a System Level Cost Estimating Relationship (CER). The System CER estimates the system acquisition cost as the sum of parametric acquisition costs of the airframe, motor, fuel (battery) and sensor, ADP Suspension and Release (SR&E) mechanism, plus notional personnel costs required to operate the system for a single mission:

$$Sys\ CER = \$AF + \$Motor + \$Fuel + \$Sensor + \$ADP\ SR\&E + \$Ballast + \$Ground\ Crew$$

For Phases 1 and 2, Sys CER will be calculated for the Technology Demonstrator Vehicles (TDVs). Vehicles used for ConOps development (CDVs) and backup will not be used for Sys CER evaluation.

## 7.1 Airframe CER

The Airframe CER is based on airframe weight at $150 per lbm:

$$\$AF = \left(150\left[\frac{\$}{lbm}\right]\right) n_{a/c} AFW$$

where $n_{a/c}$ is the total number of airplanes used to perform the mission using the ConOps. All aircraft utilized by the system are expected to be similar by design. However, due to variations in the fabrication of the airframes, the heaviest airframe weight of all airframes that fly during the competition will be used for the quantity $AFW$. That is, the airframe weight will be based on the heaviest weight vehicle used by the contractor at the Technology Demonstration as weighed by the customer evaluation team. The weight of the vehicle as weighed will be adjusted for non-airframe components using a documented contractor provided/customer validated weight statement.

## 7.2 Motor CER

The Motor CER is defined by the installed motor weight at $250 per lbm:

$$\$Motor = \left(250\left[\frac{\$}{lbm}\right]\right)\left[\sum_{i=1}^{n_{motors}} MW_i\right]$$

where $n_{motors}$ is the total number of motors in the system, and $MW_i$ is the installed weight associated with the $i^{th}$ motor including the motor mount and attachments but excluding structure added for installation drag reduction.

## 7.3 Fuel CER

The Fuel CER is based on uninstalled battery weight at $100 per lbm:

$$\$Fuel = \left(100\left[\frac{\$}{lbm}\right]\right)\left[\sum_{i=1}^{n_{batts}} FW_i\right]$$

where $n_{batts}$ is the total number of propulsion batteries, and $FW_i$ is the weight of the $i^{th}$ propulsion battery.

## 7.4 Sensor CER

The Sensor CER is based on uninstalled sensor weight plus associated component weights at $250 per lbm:

$$\$Sensor = \left(250\left[\frac{\$}{lbm}\right]\right)\left[\sum_{i=1}^{n_{sensors}} SW_i\right]$$

where $n_{sensors}$ is the total number of sensors plus sensor components in the system, and $SW_i$ are the uninstalled weights associated with each sensor or sensor component. Sensor component weights are defined as: (1) gimbal and associated servos (if used), and (2) sensor data transmitter and antenna. Batteries used to power the sensor and components are not included in the sensor cost.

## 7.5 ADP Suspension and Release Equipment (SR&E) CER

The ADP SR&E CER is based on uninstalled ADP and SR&E subsystem weights at $250 lbm:

$$\$ADP\ SR\&E = \left(250\left[\frac{\$}{lbm}\right]\right) PW$$

where PW is the total weight in lbm of the ADP SR&E subsystem(s) used in the system. SR&E component weights are defined as all SR&E mechanisms and associated servos. Batteries used to power the servo(s) are not included in the SR&E cost.

## 7.6 Ballast CER

The Ballast CER is based on ballast weight required at $1000 per lbm:

$$\$Ballast = \left(1000\left[\frac{\$}{lbm}\right]\right) BW$$

where $BW$ is the weight added above and beyond minimum aircraft operational weight for purposes of achieving a center of gravity location with an acceptable static margin as determined at the Flight Readiness Review.

## 7.7 Ground Crew CER

The Ground Crew CER is based on the number of personnel in the ground crew and the time that they spend to support mission execution at $200 per hour:

$$\$Ground\ Personnel = \left(200\ \left[\frac{\$}{hr}\right]\right) t_{mission} n_{operators}$$

where $n_{operators}$ is the total number of people required to operate the system (operators and other ground crew), and $t_{mission}$ is the total mission time, in hours. The total mission time is defined as the time elapsed between the start order and the delivery of mission data.

# 8 Other System Attributes

## 8.1 Weather Support

The TDV and Operational System shall provide full capabilities when operating in weather conditions for the Austin metropolitan area shown in Table 8.1. Note that these requirements are based on long term historical conditions observed at the Austin-Bergstrom International Airport (KAUS) and moderate turbulence levels.

**Table 8.1** – Austin Metropolitan Area Weather Design Requirements

| Weather Parameter | TDV | Operational |
|---|---|---|
| Maximum Temperature (deg C) | 40 | 40 |
| Minimum Temperature (deg C) | 7 | -3 |
| Barometric Pressure (in Hg) | 29.92 | 29.92 |
| Sustained Wind Speed (kts) | 16 | 16 |
| Lateral Gust (Variation) Speed (kts) | 12 | 24 |
| Vertical Gust Speed (fps) | 9 | 35 |

## 8.2 Air Dropped Payload

The Air Dropped Payload (ADP) shall consist of an aerodynamic pod, which houses a cylindrical internal canister (representative of a first aid kit), and a drag ribbon as shown in Figure 8.2.

The pod external OML shall be circular in cross-section. The overall pod shape shall be blunt. The pod shall open sufficiently to fully access the usable internal volume and shall lock closed so that the pod stays in one piece after impact.

The internal canister shape shall be cylindrical. Internal dimensions shall conform to Table 8.2. The canister is CFE and manufactured with dimensional tolerances of 0.05".

The ADP weight shall include the aerodynamic pod, internal canister, and ribbon. The weight of the internal canister shall conform to Table 8.2. The weight tolerance shall be +/- 5%. The value of the overall ADP weight is at Contractor discretion.

The drag ribbon is intended to slow the ADP descent and enhance visibility for recovery. The drag ribbon shall be attached to the ADP pod OML so that it does not come free during drop or impact. The ribbon shall be brightly colored and made of a soft, flexible material. The length and width of the drag ribbon shall be designed to ensure a threshold maximum descent speed of 35 ft/sec, with an objective of 25 ft/sec. The drag ribbon shall be at least 1.5 inches wide.

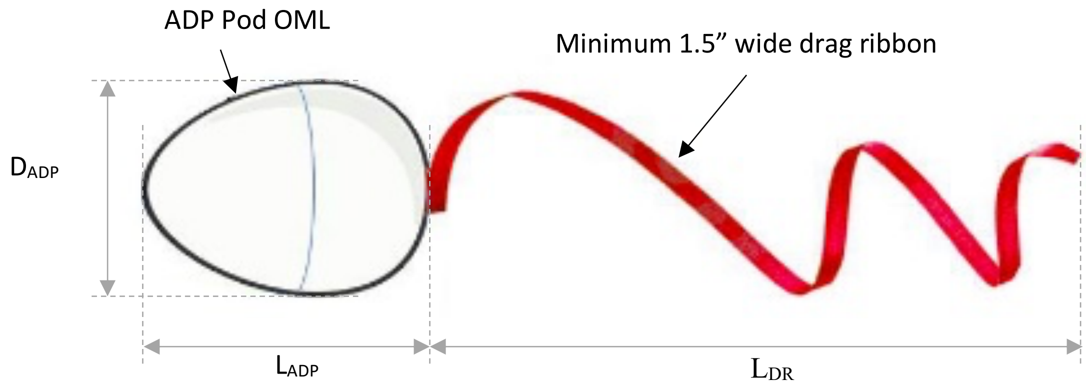


**Figure 8.2** – Nominal Air Dropped Payload

**Table 8.2** – ADP Design Parameters

| Parameter | TDV | OV |
|---|---|---|
| Internal Canister Diameter ($D_{canister}$) | 2.00” | 4.50” |
| Internal Canister Length ($L_{canister}$) | 3.00” | 6.75” |
| Internal Canister Volume | 9.4 cu in | 107.4 cu in |
| Internal Canister Payload Weight | 0.15 lb | 1.25 lb |

## 8.3 Transportability and Ground Handling

The ROS UAS TDV shall be transportable by pickup trucks or vans. Wings shall be removed or folded for transportation. The maximum length of the fuselage with wings removed or fuselage with folded wings shall be 6 feet. The maximum width of the fuselage, including horizontal tail and any folded wing shall be 3 ft. The maximum height of the air vehicle from ground to top of vertical tail while resting on landing gear shall be 3 ft. The maximum span of the wing when assembled on the fuselage shall be 10 ft.

# 9 Technology Readiness

The ROS-UAS acquisition program is targeting a near-term capability need, with low risk, in a funding constrained environment. Based on recommendations of the AoA, high Technology Readiness Levels (TRLs) are needed to meet these program constraints. Thus, the preferred approach is to use subsystems and components that are currently at TRL 9. Commercial Off the Shelf (COTS) subsystems and components generally meet this TRL. This approach ensures immediate subsystem and component availability at low risk and eliminates development cost. In rare instances, the Contractor may wish to consider components at TRL 6 if there are compelling performance and affordability advantages.