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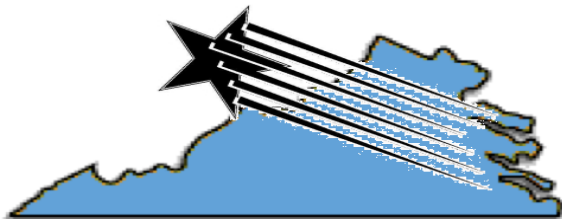
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2010 STUDENT UAS COMPETITION

WEBSTER FIELD, ST INIGOES, MD

June 16 -20, 2010



ZENITH CHALLENGE

SCIENCE ★ TECHNOLOGY ★ ENGINEERING ★ MATH

2010 STUDENT UAS COMPETITION TEAM JOURNAL/GUIDEBOOK

EDITORS

Justin McMahon, Sophomore, Kempsville HS
Wesley Cross, Junior, Smithfield HS

CONTRIBUTORS

Challenge Team Members

NOTE TO JUDGES:

Sections 2 thru 5 provided for
judges consideration

ZENITH CHALLENGE PROJECT

A HAMPTON ROADS VIRGINIA STEM INITIATIVE

JUNE 2010

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ZENITH CHALLENGE PROJECT

TEAM JOURNAL/GUIDEBOOK

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CONTRIBUTORS

Challenge Team Members



Join our efforts to enhance tomorrow's leaders in technology.

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ZENITH CHALLENGE PROJECT

Introduction

This team journal/guidebook provides information used by Zenith Challenge Project team members involved in designing planning, coordinating, synchronizing or executing actions that support the effective employment of unmanned aircraft systems (UAS) for competition. The focus is on engaging students in real-world Science, Technology, Engineering and Math (STEM) applicability. Students are engaged in engineering a total solution to a challenging mission, requiring the design, fabrication and demonstration of a system capable of completing a specific autonomous aerial operation.

Our ultimate mission is to raise awareness, and improve the pipeline and workforce development of our future leaders across diverse social, ethnic, cultural, gender, age, economic backgrounds and skill levels. Students are challenged to improve their critical thinking and technical skills, teamwork, leadership and confidence. The first year for the Zenith Challenge Project consists of fifteen (15) students independently participating from seven (7) Hampton Roads high schools (*First Colonial, Aviation Academy DHS (Denbigh HS), Landstown, Menchville, Kempsville, Smithfield, and Heritage*), across four (4) congressional districts.



Our sincere appreciation is extended to the Hampton Roads community for supporting this first year effort and allowing us to continue developing students beyond the competition.

MISSION REQUIREMENTS

2

Mission Objective

In accordance with the competition scenario, a company of US Marines is conducting a patrol. Our unmanned aerial system (UAS) will provide supporting with intelligence, surveillance and reconnaissance (ISR). In order to support these troops, our UAS must comply with Air Tasking Order (ATO) Special Instructions (SPINS) for departure and arrival procedures, and remain within the assigned airspace. We are assigned to search an area for typical targets, and expected to be ready to conduct an immediate route reconnaissance for convoy support or a point reconnaissance if requested. Immediate ISR tasking may be requested outside currently assigned airspace, causing our UAS operators to request deviations.

Concept of Operations

Types of UAS for Command and Control integration include Man-portable, tactical, and theater systems. Tactical and theater UAVs are larger systems than that used by the Zenith Challengers. The Zenith Challenge UAS demonstration aircraft is a small, self-contained and portable UAS. This is similar to systems that support small ground forces and may be controlled by a single individual who also views the sensor images on a laptop. The Line of Sight (LOS) is limited.



Figure 1 - Zenith Team's Concept of Operations

ZENITH CHALLENGE PROJECT

The Zenith Challenge UAS may be used to perform multiple support roles. The following missions may be assigned:

- *Search and Rescue* – emergency rescue operations
- *Reconnaissance* – Near real-time information received
- *Surveillance* – Area surveillance
- *Situational Awareness and Situational Understanding*: Provide commanders with understanding of area
- *Security* – Reaction time and maneuver space for main body and area security
- *Targeting* – Target detection and recognition, target designation and illumination, and damage assessments
- *Communication Support* – Voice and data com's retransmission
- *Movement Support* – Convoy security, and mine/IED detection

Mission Conduct

Phase I - Preflight Planning

1. Pre-Flight Planning shall be conducted in accordance with the Mission Planning Checklist.
2. Critical information needed to support unit commander:
 - Start point, release point, designated route time of mission, and start to finish
 - Critical points identified
 - Intelligence gathering
 - Any constraints or restrictions
 - Weather over target area
 - Type of units or vehicles expected to use the route
3. Tasking Assignments

Immediate – Requests are submitted outside Air Tasking Order (ATO) cycle and may be relayed through the quickest means available - internet chat, email, phone or radio.

Dynamic Re-Tasking – Our UAV may be re-tasked from the existing mission to a new target. Reasons for re-tasking include troops in contact or a high priority target opportunity. Typically, in a real-world scenario, minimum information required to begin dynamic re-tasking includes:

- Priority
- Call sign
- Routing
- Airspace control measures (ACM)
- Required altitude
- Payload considerations

Phase II - Takeoff

Launch & Recovery Element

The Launch & Recovery Element (LRE) handles all takeoff and landing functions of each UAV flight. (Current team ops will use manual mode). The LRE is only capable of conducting local line of site (LOS) missions.

Takeoff shall take place within one of two designated Takeoff/Landing areas, depending on wind direction. Area will be paved asphalt surface, roughly 100 ft wide, with no height obstacles. Systems utilizing launchers and/or not performing wheeled landing may utilize the grass immediately adjacent to the runway; however, grass area will not be prepared. After takeoff, the air vehicle shall maintain steady, controlled flight at altitudes above 100 feet and under 750 ft MSL (Note: airfield elevation is approximately 10 ft MSL). Takeoff under manual control with transition to autonomous flight is permitted.

Ground Control Station

During flight, the pilot controls the aircraft, while a payload operator directs the craft's sensor payload. This team is located in the Ground Control Station (GCS). At the end of the mission,

aircraft control is transferred back to the LRE for recovery, or landing.

Upon successful launch conduct airborne systems checks for navigation tracking, autonomous flight and video data collection.

Phase III - Waypoint Navigation

UAV shall overfly selected waypoints and remain inside assigned airspace, and avoid no-fly zones. Team must follow a predetermined course that includes changes in altitude and in heading, to and from the search area. GPS coordinates (ddd.mm.ssss) and altitudes will be announced the day prior to the flight competition. Expect that additional waypoint(s) and or search area adjustment(s) will be required.

Phase IV - Enroute Search

UAV will be required to fly specific altitudes while identifying several targets along the predefined entry/exit route. One of the targets will be directly along the route when the vehicle is required to be at 500 ft MSL (± 50 ft). Another target will be up to 250 ft from the center of the flight path while the vehicle is required to be at 200 ft MSL (± 50 ft). The team will be given the position of the off-center target. UAV shall not vary from the flight paths (± 100 ft tolerance) briefed during the mission planning in order to obtain an image of the target; flight path deviations shall not be permitted as to avoid being shot down by hostile or friendly forces.



Figure 2 Webster Field (Search Area)

Area Search - Once transitioning into the predefined search area via the entry/exit route, the UAV shall search for specific targets of interest. UAV may search the area at any altitude between 100 and 750 ft MSL. Targets will be distributed throughout the search area.

While executing the search mission, the team will be provided with a new search area (within the existing no fly zone boundaries) allowing you to locate “pop-up” targets. There will be a minimum of 200 ft margin between the search area and the no fly zone boundary. Teams choosing to look for these targets shall display the new search area to the operator and judges.

Terrain plays a key role in both sensor effectiveness and command and control.

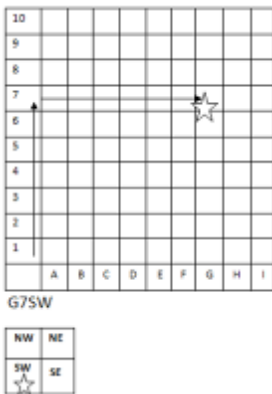
Manmade – Cities, airfields, bridges, railroads, ports, power, telecom lines, and towers

Natural – Flat or desert terrain provides optimal conditions for UAS sensors; mountainous and heavily vegetated terrain greatly reduces sensor effectiveness. Loss of signal is more likely in mountainous areas.

Phase V – Target Identification

Team shall record the characteristics (location, shape, color, orientation, alpha, alpha color) of all observed targets on a target data sheet and provide this sheet to the judges at completion of the mission.

Targets will be constructed of plywood of a given size, basic geometric shape, and color. Each target will be a different shape and a unique color; a different color alphanumeric will be painted on each target. There are an unknown number of targets in the area. The additional target will be more reflective of a realistic surveillance target.



Target location will be reported by the Zenith Reference grid superimposed over the search area.

In the example, the target is located in Southwest quadrant of G7 block.

Each major grid cell is approximately 435yds (Lat) by 345 yds (Lon)

Target 1 Posit – G7SW is translated into 38° 9'2.17"N / 76°25'46.72"W

Figure 3 Target Position Reference Grid

Phase VI - Landing

Landing shall be performed completely within the designated takeoff/landing area. Transition to manual control is permitted for landing. Control in landing will be graded. Mission completion is when the air vehicle motion ceases, engine is shutdown, and the mission data sheet and imagery have been provided to the judges.

Phase VII – Post Flight

NOTES:

1. Total Mission Time - Total mission time is the time from declaration of mission start from the judges and permission to turn on transmitters until the vehicle has landed, transmitters are shut off, and mission data sheet (or spread sheet) is handed to the judges.
2. Extra credit will be given for providing complete and accurate information (actionable intelligence) during flight: once that information is provided it cannot be modified later. Actionable intelligence is all six target characteristics (shape, background color, alphanumeric, alphanumeric color, orientation, and location) provided at that time and recorded on the target data sheet. This will not be considered to be actionable intelligence unless you designate it as such. Credit for actionable intelligence will only be given for one target.

UAS LEVEL OF OPERATIONS

The goal of the Zenith Challenge Project is to achieve autonomous flight and payload control for all phases of flight, including takeoff and landing. Levels of autonomy shall be determined by the following:

LEVEL 5 – Full Autonomy. Control and monitoring of UAS including launch and recovery.

LEVEL 4 – Autonomous control and monitoring of UAS (Manual take-off or recovery).

LEVEL 3 – Partial/full manual-control and monitoring of UAS payload (Video).

LEVEL 2 – Partial/full user control of UAS path and payload. Receipt of payload information through direct comms link.

LEVEL 1 – User control of UAV launch/recovery, flight path control, and payload control. Indirect receipt and transmission of UAS related data.

DESIGN RATIONAL

The Zenith Challenge Team UAS demonstrator is the Hangar 9 Brand, Ultra Stick Lite 120 ARF platform. This airframe was selected based on the highly stable flight performance and affordable airframe. The wide open body construction allows this newly assembled team to install the autonomous flight controls within the body of the airframe with relative ease. The miniature onboard equipment fits neatly inside and meets the objectives of the competition. As team progresses in skill levels, alternate airframe designs will be incorporated to take advantage of advanced aeronautical designs and flight characteristics.

UAS DEMONSTRATOR DESCRIPTION



Airframe: Ultra Stick Lite 120 ARF

Wingspan: 75 in (1924 mm)

Length: 56 in (1657mm)

Weight: 9–11 lb (4–5 kg)

Wing Area: 1,210 sq in (78.1 sq dm)

Engine (2-Stroke): G26 25.4cc 2 stroke engine

Fuel: Gas/oil mix

Sensors/Payload: B/W Camera(s)

FREQUENCY USAGE

Radio transmitter/receiver: 72mhz

Camera #1: 2.4ghz

Camera #2,3: 369-374 mhz and 1710-2850 mhz

Auto pilot and Ground modem: 900 Mhz

AUTONOMOUS CONTROL -

The APS-series autopilot platform consists of three boards: an SSA-series control board, an APX-series expansion board, and an APM-series modem board. The control board forms the programming and control center of the APS-series autopilot platform. While it is the same base board as used in the Servo Controller/Safety Switch, its microprocessor programming and hardware resources are dedicated to autopilot functionality. The expansion board includes the MIDG-series INS/GPS unit, as well

as providing additional I/O resources to the autopilot, and allowing for the use of an optional Secure Digital Flash memory card. The modem board physically mounts the RF wireless modem, as well as providing the power converter for the modem.

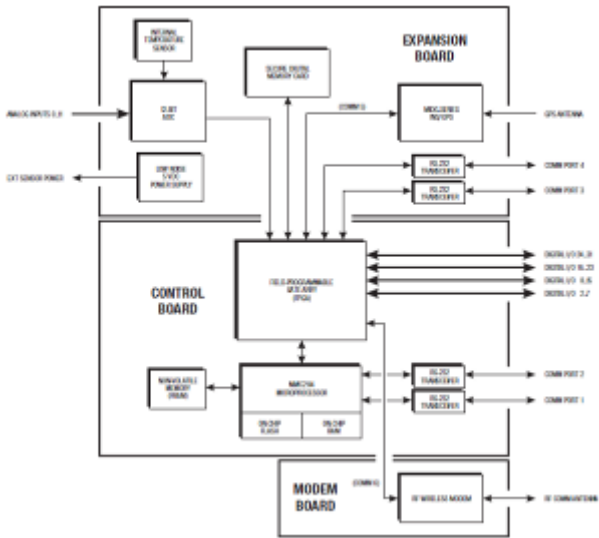


Figure 4 Autopilot Block Diagram



FLIGHT CONTROLS –



Figure 5 Servo Switch/Controller

The Servo Switch / Controller (SSC) is a highly configurable, multiplexing switch for servo command signals. The SSC can be used to control RC servo or other UAV servo devices. It allows the dynamic selection of servo command signals from several pulse signal sources. Pulse sources include asynchronous serial communication packets from a control computer, pulse signals from a conventional radio control receiver or other servo pulse generator, and user definable constant signals.

AUTOPILOT –



Figure 6 Microbot AP Autopilot

The Microbotics Autopilot Platform provides an optional [MIDG II INS/GPS](#), making a complete inertial solution for use in Unmanned Vehicle Autopilot applications. The Microbotics APS includes the ability to drive up to 30 servos, has 12 analog inputs for measurement application (fuel, battery power, altitude, airspeed, etc.), supports a memory card (SD card) for real-time data recording, and has a built-in wireless transceiver - all of this in a single integrated package.



Figure 7 Serial Controller

The Microbotics serial converters offer full duplex serial line level conversion that supports connections to RS232, RS422, and

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TTL devices. Use of these converters allows a device with an RS232 port to obtain higher data rates and longer cable lengths. In addition, the small size of the Microbotics RS232-RS422 converters allows them to be wired directly into a harness.

ALTITUDE/AIRSPEED -



Figure 8 Dual Barometer Board

The Dual Barometer Board provides altitude and airspeed sensing for air vehicles. A pair of temperature compensated pressure sensors allows absolute and differential pressure sensing.



Figure 9 Air Data System

The Microbotics SPA20422 Air Data System is a microprocessor controlled system meant to provide basic altitude and airspeed information for unmanned vehicles. It consists of an absolute barometer (for static pressure), a differential barometer (for pitot pressure), and temperature sensors (both on-board and external) to assist in the airspeed determinations. An on-board microprocessor reads the sensor values, calibrates the readings, and then calculates the target parameters (altitude, airspeed, etc.). A non-volatile EEPROM is available to maintain user settings during power-down.

NAVIGATION -



Figure 10 MIDG II INS/GPS

The MIDG II is an Inertial Navigation System (INS) with Global Positioning System (GPS) contained in an incredibly small package. The MIDG provides position and velocity updates during GPS outages for a period of about 30 seconds. After that, the MIDG reverts to a vertical gyro mode in which only the attitude, rates, and accelerations are provided.

EVALUATION: The MIDG continues to provide position and velocity updates during GPS outages for a period of about 30 seconds. After that, the MIDG reverts to a vertical gyro mode in which only the attitude, rates, and accelerations are provided.

COMMUNICATIONS -

Communication is one of the most important aspects of tactical employment of UAS. Communication provides both capability and limitation to the UAS operations for control of UAS, sensors operation and general information flow. Published Line of Sight (LOS) of UAS range may not account for other factors, such as frequency interference, environmental interference and other performance degraders.

Radio transmitter/receiver: 72mhz

Camera #1: 2.4ghz

Camera #2,3: 369-374 mhz and 1710-2850 mhz

Auto pilot and Ground modem: 900 Mhz

TEST & EVALUATION

HARDWARE & ALGORITHM TESTING

Test data inputs/outputs by walking and driving aircraft. Testing includes increased distance and tracking reliability.

FLIGHT TEST CONDITIONS

Outdoors open field. Minimum clearance area should be at least size of football field. Wind conditions up to 10kts for routine flight tests, and up to 15kts allowable upon approval of Flight/Technical Coordinator. Tests shall be conducted under conditions of no visible precipitation (Precipitation limits will be as determined by Mission Commander for competition only).

MANUAL FLIGHT MODE TEST

Test ability of system to pass servo control information from transmitter to servos.

AUTOMODE ON

The Auto-mode switch is enabled to fly to three points.

NAVIGATION TEST

Auto-mode testing. Test GPS ability to navigate to 3 waypoints.

AUTOMODE FLIGHT TEST WITH CAMERA

Fly to 3 points and record video.

AUTONOMOUS LANDING

Approach

Test UAS ability to acquire and track the glide slope

Approach

Test UAS ability to acquire and track the glide slope

Deroll

Test UAS ability to level wings prior to touchdown

Decrab

Test UAS ability to align the nose with the runway axis

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Flare

Test UAS ability to transition from steep to moderate glide slope with gradual velocity reduction

Pitch up

Test UAS ability to ensure touchdown on the main landing gear with further velocity reduction

Touch Down

Test UAS ability to gradually release the pitch up command

Runway steering

Maintain the UAV on the runway center line

SAFETY

Safety First. Safety Always.

Flight operations of any type involve some level of risk to personnel and property. It's everyone's responsibility to identify, evaluate and mitigate risks to the maximum extent possible.

“**Shall**” indicates a requirement that is mandatory. Failure to meet this requirement will result in no points being awarded in this area.

“**Should**” indicates a requirement that will provide additional mission capability that is of value to the units, but the overall mission objectives can be achieved without meeting this requirement. Some bonus points will be awarded in achievement up to the objective.

“**May**” indicates a permissible implementation, but is not a requirement.

“**Will**” indicates actions to be taken by the competition judges or other information pertaining to the conduct of the competition.

The Fail-safe check

Team shall demonstrate flight termination on the ground by switching off the transmit radio for 30 seconds or 3 minutes (whichever applies) and observing activation of flight terminate commands.

Emergency Procedures

Loss of Signal - The air vehicle shall be capable of manual override by the safety pilot during any phase of flight. The air vehicle shall automatically return home or terminate flight after loss of transmit signal of more than 30 sec.

The air vehicle shall automatically terminate flight after loss of signal of more than 3 minutes. The return home system, if installed, shall be capable of activation by the safety pilot.

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The flight termination system shall be capable of activation by the safety pilot. Flight termination for fixed wing aircraft without an alternate recovery system (like a parachute) shall select:

Emergency Procedures for Flight Termination

1. Throttle closed
2. Full up elevator
3. Full right rudder
4. Full right (or left) aileron
5. Full Flaps down.

No Video

While watching video downlink, video drops out. Datalink control panel signal strength window is red, link quality window is green. Steps to resolve:

1. Confirm that cable connections are properly installed.
2. Confirm that the selected frequencies correspond to transmitted video signals.
3. The antenna is not properly setup or is not positioned properly.
4. The air vehicle could be out of range of the video receiver but not the UHF receiver.
5. Vehicles fly out of range (or directly overhead!).
6. Reset any scans and/or try —Scan for Video on the current aircraft Freq Range
7. Verify TX frequencies of the aircraft you are attempting to receive

MEET THE CHALLENGERS

Faculty Advisor-

Joe McMahon

Student Team Leaders:

Mission Commander – Deonte White

Pilot in Command – Zak Johns



Deonte White
Menchville HS
Senior

Career Goal(s): Aviation
Lawyer

Interests and Hobbies:
Debating Club, Rugby, RC
Helicopter. Flew Cessna 182
during his private pilots
training course. Completed
pilot's private license ground
school at the age of 16.
Member of Menchville High
School Rugby Team.



Zachary Johns
First Colonial HS
Junior

Career Goal(s): Pilot

Interests and Hobbies:

Flying, Competing, Rotary
and Fixed Wing RC Aircraft.
Virginia Aerospace Science
and Technology Scholar.
Competed in the annual world
competition, Extreme Flight
Championships (XFC)
(invitation only). Anticipates
obtaining private pilot's
license to fly full scale aircraft.

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Kiara Gwaltney
Menchville HS
Senior

Career Goal(s): Civil
Engineering

Interests and Hobbies:
Video Games, Hanging Out
With Friends, Drawing



Genei Ongcol
Aviation Academy DHS
Senior

Career Goal(s): Computer
Engineering

Interests and Hobbies:
Piano, Graphics Engineering



Bryce Caballero
Aviation Academy DHS
Senior

Career Goal(s): US Navy
Interests and Hobbies:
Aviation, Mechanical



Wesley Cross
Smithfield High School
Junior

Career Goal(s): Electronic
Engineering

Interests and Hobbies:
Electrical Engineering, Cross
Country, Web Designing,
Simulation, Physics, Guitar,
Technical Drawing.

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Anthony Harris
Heritage HS
Junior

Career Goal(s): Engineer
Interests and Hobbies:
Computers, Science,
Basketball



John Neff-Warren
Aviation academy
Junior

Career Goal(s): Aerospace
Engineer
Interests and Hobbies:
Camping, Video Games,
Hanging Out With Friends



Lana Rogers
Menchville HS
Junior

Career Goal(s): Entrepreneur
Interests and Hobbies:
Talking, Learning New
Things, Hands-On Activities



Justin McMahon
Kempsville HS
Sophomore

Career Goal(s): Mechanical
Engineering
Interests and Hobbies:
Mechanical/Electrical
Engineering, Building Models
And Machines, Architecture,
Drawing, Baseball, Track And
Field, Wrestling, Photography,
Game Design

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Josh Godby
Smithfield High School
Sophomore

Career Goal(s): Military Pilot
Interests and Hobbies:
Cross country, Track,
Swimming, Saxophone,
Guitar, Civil Air Patrol, Flying,
ATV/motorcycle riding



Breon Day
Landstown HS
Sophomore

Career Goal(s): Systems
Engineer
Interests and Hobbies:
Computers, Gaming



Renee Rogers
Menchville HS
Sophomore

Career Goal(s):
Entrepreneur, pilot, president
Interests and Hobbies:
Talking, Texting, Traveling,
Drawing, Going places with
friends, and trying new
activities



Felicia Fitzhugh
Menchville HS
Sophomore

Career Goal(s): air force
Interests and Hobbies:
fishing, hanging out with
friends

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Twymun Safford
Aviation Academy DHS
Sophomore
Career Goal(s): astronaut
Interests and Hobbies:
football, track, wrestling



Chris Perry
(BS –Mech Eng '09)
Old Dominion University
Graduate Studies
Career Goal(s): Mechanical
Engineer
Interests and Hobbies:
*Graduate Assistant



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ACTIVE SUPPORTERS



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Coordinator**
**Wayne Cross – Mission
Planning Coordinator**

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Al Riopel
Aviation Academy DHS
AVID LLC
BOSH Global Services, Inc
CrossWorks, LLC
Duron Goggins
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UAV Pro, LLC

US Navy

Virginia Air & Space Center

Waldy Wisnewski



ANNEX A - MISSION PLANNING CHECKLIST



Mission planning Checklist:

- Sensor selection (Video Only Available)
- Map of mission area
- Identify terrain that will interfere with LOS data link
- Grids defining search area
- Heading and distance to search area from launch point
- Heading and distance between search area
- Identify/mark natural and manmade hazards to flight
- Local hazards
- Alternate route (ingress and egress)
- Threat plotted along route
- Weather
 - Clouds
 - Precipitation
 - Wind
 - Visibility
 - Temperature
- Flight route outside search area
- Route time
- Loiter time
- Verify grids
- Check all altitudes, azimuths, and distances
- Waypoint card printed
- Times cards for judges
- Air control points plotted on map
- Primary/alternate routes plotted on map

Fuel planning

- Availability and on-hand
- Estimated fuel burn rate
- Estimated battery usage rate
- Minimum fuel at departure

Communication plan:

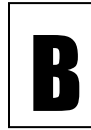
- Flight operations
- ROZ/ROA
- LOS characteristics of terrain (UA limits of operation based on LOS data link)

Contingency actions:

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- Frequency compromise
- Video Datalink compromise
- Emergency procedures for loss of signal
- Packet/card/map preparation
- Flight routes
- Crew card
- Time flow
- Mission sequence
- Waypoint card
- Rehearsal setup

ANNEX B – PREFLIGHT CHECKLIST



PRE-FLIGHT CHECKS

Weather (Mission Commander)

- Clouds
- Precipitation
- Wind
- Visibility
- Temperature

Aircraft (Pilot in Command)

- Fuselage
- Wings
- Wheels
- Wires Properly Connected
- Remote
- Ground Station (Op check)
- Laptop (Op Check)
- Navigation (Op Check)
- Battery (Recharged)
- Fuel (Safely stored)

Aircrew (Team)

- Googles
- Hearing Protection
- Flight routes
- Crew card
- Time flow
- Mission sequence
- Waypoint card
- Rehearse Walk Through

Go/No-go Criteria (Mission Commander)

- Weather
- Aircraft Integrity
- RF Interference
- Datalink
- Fuel/Battery
- Payload (Video)
- Computer
- Navigation

ANNEX C - SAFETY CHECKLIST



SAFETY CHECKS

SAFETY FIRST. SAFETY ALWAYS. Flight operations of any type involve some level of risk to personnel and property. It's everyone's responsibility to identify, evaluate and mitigate risks to the maximum extent possible.

Risks shall be handled in accordance with normal operating procedures. Unexpected events shall be brought to the immediate attention of Team Coordinators and Mission Commander.

- Upon start of Flight Preflight Check Phase, all evolutions shall be under the direction of the Mission Commander.
- Danger to persons or property shall be immediately brought to the attention of Team Coordinators and Judges.
- Aircraft shall be grounded during refueling.
- Preflight checks shall be conducted with Power-Off on aircraft.
- Upon Mission Commander's signal to ready aircraft for start, the following procedures shall be followed:

Danger Area Avoidance

- No more than one person may handle aircraft upon power-on
- No one shall be forward of the aircraft wing line upon power-on to aircraft

- Avoid Props and Rotors
- Personal Safety Equipment
 - Goggles
 - Ear Plugs
 - Other
- Flight Termination Test

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Team shall demonstrate flight termination on the ground by switching off the transmit radio for 30 seconds or 3 minutes (whichever applies) and observing activation of flight terminate commands.

Emergency Procedures for Flight Termination

- Throttle closed
- Full up elevator
- Full right rudder
- Full right (or left) aileron
- Full Flaps down.

System Degradation – See Section 5 (SAFETY)

- Abort
- Datalink Loss
- Flameout
- Flight Departure
- No-Fly Zone Penetration

Post-Flight

- Avoid aircraft danger zones ahead of wingline
- Secure engine/props/power-off
- Check aircraft integrity

Post-flight Debrief

- Report damage
- Lessons learned
- Reporting responsibilities

ANNEX D – COMPETITION CHECKLIST



UAS COMPETITION CHECKLIST

- Description of the systems engineering approach used for total systems design
- Descriptions of the UAS design
- Design rationale
- Test and evaluation results (including payload and navigation system performance)
- Safety considerations/approach
- Systems engineering includes mission/requirements analysis
- Expected performance
- Design descriptions are required for the air vehicle
- Ground control station
- Data link
- Payload
- Mission planning
- Data processing
- Method of autonomy
- Target types supported by autonomous cueing and recognition
- Safety criteria
- Photo of the UAS air vehicle.

ANNEX E – TEST & EVALUATION CHECKLIST



SYSTEMS CHECK

**HARDWARE &
ALGORITHM TESTING**

- X/Y/Z Axis
- Altitude
- Airspeed
- Video Datalink
- Simulation

NAVIGATION TEST

- Ground Navigation (Walk/Drive)
- Verified during Flight Tests

**MANUAL FLIGHT MODE
TEST**

- Acceptable Flight Controllability

VIDEO DATA LINK

- Capture
- Remote Operations
- Image Stitching

**AUTONOMOUS
OPERATIONS**

- Fail-Safe Test
- In-flight Autonomy
- Launch
- Recovery

AUTONOMOUS LEVELS OF OPERATIONS

- LEVEL 1** – User control of UAV launch/recovery, flight path control, and payload control. Indirect receipt and transmission of UAS related data.
- LEVEL 2** – Partial/full user control of UAS path and payload. Receipt of payload information through direct comms link.
- LEVEL 3** – Partial/full manual-control and monitoring of UAS payload (Video).
- LEVEL 4** – Autonomous control and monitoring of UAS (Manual take-off or recovery).
- LEVEL 5** – Full Autonomy. Control and monitoring of UAS including launch and recovery.

FLIGHT TEST CONDITIONS

Outdoors open field. Minimum clearance area should be at least size of football field. Wind conditions up to 10kts for routine flight tests, and up to 15kts allowable upon approval of Flight/Technical Coordinator. Tests shall be conducted under conditions of no visible precipitation.

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ANNEX F – NOTES PAGES

NOTES

