

Preliminary Systems Evaluation for a Guidable Extended Range Tube Launched-UAV

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ABSTRACT

Tube Launched-Unmanned Air Vehicles (TL-UAV) are munitions that alter their trajectories during flight to enhance the capabilities by possibly extending range, increasing loiter time through gliding, and/or having guided targeting capabilities. Traditional munition systems, specifically the tube launched mortar rounds, are not guided. Performance of these “dumb” munitions could be enhanced by updating to TL-UAV and still utilize existing launch platforms with standard propellant detonation firing methods. The ability to actively control the flight path and extend range of a TL-UAV requires multiple onboard systems which need to be identified, integrated, assembled, and tested to meet cooperative function requirements. The main systems, for a mortar-based TL-UAV being developed at West Virginia University (WVU), are considered to be a central hub to process information, aerodynamic control devices, flight sensors, a video camera system, power management, and a wireless transceiver. A camera is used to provide video for a “man-in-the-loop” operator to steer the munition. A wireless transceiver relays flight information gathered by sensors such, as an IMU, to an operator and to receive operator control inputs. These systems do not naturally integrate with each other, therefore a central unit was used to handle and interpret signals from the systems. Each system has unique specifications for power and data requirements, which must be considered when selecting a central unit. Software running on the central unit handles processing of video, flight sensors, stability, control surface actuation, and course corrections received from an operator. Testing and assembly of the systems must meet stringent launch acceleration loading due to the $>2,000$ g's experienced during launch of the projectile. This paper describes the identification of appropriate systems, their interactions, and ruggedization methods for a TL-UAV that can glide to increase range and be video-relay guidable.

INTRODUCTION

The benefits of a traditional projectile, such as a minimal launch footprint, can be combined with the flight characteristics of a Unmanned Air Vehicle (UAV) to form a class of projectiles that transform mid-flight. These devices can be called Tube Launched-Unmanned Air Vehicles (TL-UAV) and are munitions that blossom from a traditional wingless projectile into a gliding controllable UAV. TL-UAVs can combine the benefits of a projectile, small launch platform and initial energy transfer, with the benefits of a UAV, flight and controllability. A TL-UAV may be used to gather reconnaissance of an area not visible from a launch position or be used to concentrate energetics on a specific target with greater accuracy than traditional munitions due to targeting capabilities. Researchers at the Mechanical and Aerospace Engineering department of West Virginia University have been developing a TL-UAV based on the US Army's 60 mm mortar and are currently in the stages where identification and integration of the flight systems are being examined to meet extended range and controllability goals.

Systems integration can be performed once a vehicle's external body has been designed. The majority of the flight systems were within the vehicle and, in this case, were limited by the amount of volume and weight that was available. Also important for a gliding vehicle, was sizing of an appropriate battery that provides enough power for the mission and fits within the volume and weight requirements. In some cases the specified battery may exceed a limitation, such as volume, and the systems will need to be revised in order to accommodate this. Several iterative design changes may be required, not only for the battery, but for other systems to meet requirements.

Munitions have been created by others that have similar characteristics of the round being developed, such as

extended range, controllability, imaging, and telemetry transmission but are launched and based on different munitions. A few of these TL-UAVs include the Navy 5 inch gun [1], the 120 mm mortar [2], and the M1 Abrams 120 mm smoothbore gun [3] and others [4,5,6]. Similar to existing TL-UAVs, the 60 mm TL-UAV is being designed with minimum external changes to the body of a standard 60 mm mortar so that the existing launch platform and launch pyrotechnics can be utilized to save on cost and development time.

The requirements of the TL-UAV currently being developed, based upon the US Army's 60 mm mortar are to extend the range and provide video targeting/surveillance. Once the munition has transformed by unfolding wings at its apogee, the TL-UAV can glide to increase range. Wing deployment after launch and before apogee was not the best case, due to the energy lost while the munition climbs to its apogee. The second requirement is to have a camera capturing video in the direction of flight, relay the images back to an operator, and accept flight control input from the operator. To achieve this, and properly unfold or deploy the wings, several electronic, aerodynamic, mechanical, and computer systems are necessary.

Overall, the research goals for the developed TL-UAV are:

1. Increase range of existing 60mm munition
2. Provide man-in-loop video surveillance/targeting ability

60 MM TL-UAV SYSTEMS

In order to meet the requirements of deploying a TL-UAV's wings at apogee and having video guidable targeting, a systems identification and selection process was followed [7,8]. First, the systems or electronics necessary were identified and prioritized. Second, a selection process was performed to properly select individual components. Next, identification of the system interactions or intercommunication was defined. Finally, for the systems selected an estimated battery load was developed.

Targeting and surveillance capabilities were designed by using a wireless transcieving system between the projectile, onboard camera, control surfaces, and an operator with a video display and input ability. It was envisioned that an operator would launch the projectile and then immediately begin using a tablet-like device to view where the projectile is headed and provide simple maneuvers to either view or direct toward and impact a target. The requirements for the systems are listed along with a description of each appears in [Table 1](#).

Specifically, the system requirements for the TL-UAV are:

1. Provide self-diagnostic preflight
2. Survive launch

3. Deploy wings at specific time or position in flight path correctly (right side up due to dihedral)
4. Maintain a stable flight profile
5. Send a video stream back to an operator wirelessly
6. Accept flight path corrections from an operator wirelessly
7. Self-guide to a pre-designated object optically
8. Allow for future control over energetics

Table 1. Systems Descriptions

System	Function Description
Microcontroller	Control actuators, control and compress camera images, transmit video and telemetry, receive control inputs, maintain stable flight, follow flight path, monitor other systems
Persistent storage	Contains main program(s), store telemetry and video imagery
Wireless transceiver	Handle wireless transmission and receiving over 3km and provide bandwidth for black & white video at 640x480 pixels and 5 frames per second
Camera	Provide imagery
IMU	Sensor for 6 or 9 degrees of freedom translated into body movements
GPS	Projectile position information
Accelerometer	Detect launch and apogee
Servos	Actuate control surfaces and deploy wings
Power management	Regulate to systems required voltages and monitor batteries

Typically, the electronics which handle power regulation, navigation/guidance, control surface actuation, and special function items do not come prepackaged or, most likely, were never designed to interface with each other. In order to instrument the developed transforming round, provide an estimated of battery usage, and meet project requirements, a systems identification and selection process was executed. Also, the electronics that would most likely be chosen for UAVs such as navigation may not be designed to survive a munition launch at 2,000 to 10,000 gs without modification. Systems that can survive a muntition launch have been developed, but these items can be specific to an application with limited availability and may be costly [9,10,11,12,13].

Fully functional auto-pilot systems that incorporate guidance, precise location tracking, and flight stability have been proven to work in the field [14], but lack a few essential requirements for a transforming projectile, such as launch ruggedization, footprint requirements, low power usage or modes, and computational processing power for compressing images and customized flight stability. All systems must meet a munition launch loading of 2,000 g. It is possible that