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PEGASUS TRANSFORMING UAV/UGV HYBRID VEHICLE

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ABSTRACT

In this paper, we present Pegasus Transforming UAV/UGV Hybrid Vehicle, a unique, transformable UAS/UGV that is particularly well-suited for missions. The combination of flight and ground modalities allows Pegasus to fly to location, automatically transform into a ground vehicle, reposition, and quietly approach a target; or, Pegasus can land and "perch" for long durations, allowing for the maintenance of the custody trail and long ISR missions or emplace sensors particular for a specific mission. The sequential use of aerial and ground capabilities in this platform provides the reach usually lacking in these missions.

The Pegasus platform was developed with DTRA/ARDEC funding in support of specialized missions where these functionalities are needed. Robotic Research, LLC has developed the system from the ground up, including: mechanical, electrical, and software designs (without using foreign-made parts). The current system is shown in Figure 2. The system already has obstacle avoidance payloads, and has demonstrated capabilities in GPS-denied environments and SubT, while mapping and traversing line-of-sight and NLOS areas.

Introduction

U.S. warfighters and coalition forces are currently fighting ISIS (and other terrorist groups) in cities and villages where the conventional use of force is usually curtailed due to the risk of collateral damage to infrastructure and civilian personnel. It is not simply that fights erupt sporadically at these locations; on the contrary, our enemies fully understand the consequences of civilian casualties and their corresponding media effect. Therefore, in many cases, they purposely select locations that play to their strengths, and capitalize on any casualties to their benefit. The conflict is not only the physical fight happening in the location; it is an informational battle that happens with news outlets and social media around the world. When physically taking over a town, strategic losses are risked as there are chances that the destruction of infrastructure or ancient archeological sites will occur. Accurate ISR in these cases is not only appreciated, but is actually a prerequisite for effective operations designed to surgically remove fighters embedded within the populous. Satellites and high-flying UAVs provide valuable information about layout of the urban area and general patterns of life, but do not provide sufficient information to track individuals. Moreover, even Special Operations personnel may not have sufficient upper echelon assets to provide real-time ISR, making it difficult to cover all simultaneous events. Opposition fighters are very cognizant of our need to maintain custody of targets and their vehicles, and purposely use tactics that force loss of tracks from high-flying aerial eyes.

A low flying UAS provides a squad-level capability that can provide real-time information gathering, increasing the distance to engagement and saving warfighter's lives. ISIS (and other terrorist groups) are already using small UASs to deliver kinetic charges at short ranges, leaving our warfighters vulnerable to an enemy that is cognizant of technology, and has time to prepare and entrench within the civilian population, where high-flying assets cannot track or differentiate the threat.

Pegasus™ is a unique, transformable UAS / UGV that is particularly well-suited for these missions. The combination of flight and ground modalities allows Pegasus to fly to location, automatically transform into a ground vehicle, reposition, and quietly approach a target; or, Pegasus can land and "perch" for long durations, allowing for the maintenance of the custody trail and long ISR missions or emplace sensors particular for a specific mission. The sequential use of aerial and ground capabilities in this platform provides the reach usually lacking in these missions.

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Current Capabilities

As shown in the Figure 1, the vehicle provides a level or versatility that cannot be easily accomplished with a single vehicle. In Figure 1a, the vehicle is traversing a 24-in. corrugated pipe full of mud. In Figure 1b, Pegasus, in its air modality, uses its tracks as blade protectors as it climbs staircases. Finally, by comparing Figure 1a and 1c, it is possible to see how Pegasus changes its center of gravity (CG) to provide sufficient ground clearance in its ground modality, and

Figure 1. Robotic Research hybrid UAV/UGV Pegasus.

lowers its CG in its flight modality to become a stable flyer, while protecting its propellers using its tracks. A video showing its capabilities can be viewed here:

https://pydio.roboticresearch.com/public/037d41

An obvious application of the transformation advantages can be seen in Figure 2, where Pegasus is flown to a roof that would be otherwise hard to reach from a ground standpoint. The vehicle lands on the corrugated roof, and then uses its tracks to reposition and train its sensors at a target.

Figure 2. Pegasus quietly drives to a location, flies to a roof, and repositions on top of the roof to point to the OP.

Why is this capability important to the warfighter?

There is always a wall blocking the way. Figure 3a, below, shows a typical compound in Afghanistan. As with many of the locations where warfighters operate, there is usually a wall protecting the area of interest. Pegasus can quickly fly over the wall, land at the center of the compound, and be used to look for IEDs in the area (i.e. doorways, etc). Finally, it can be flown again and perched on a roof, pointing to entry points where fighters could be hiding. In addition, when Pegasus flies to the building, it can inspect windows and land inside, or on the roof and employ sensors to pass vital information to the force. Pegasus can solve further problems in the field. Buildings as shown in Figure 3b traditionally present a problem for our warfighters: the structures may not be structurally safe, but they may also harbor enemies. Pegasus can safely survey by flying, and then – using its ground capabilities – drive inside the structure, further increasing the reach of the ISR capabilities.

Asset recovery is simplified. The DoD has created families of "throwable" systems designed to be tossed over the impeding wall. However, a robot that is throwable is not usually a competent ground vehicle. Moreover, there is nobody on the other side to "throw it back." Therefore, warfighters often need to enter dangerous areas in order to recover the asset when the systems get stuck. With Pegasus able to use its propellers if it gets stuck, it is capable of traversing terrains that are impassable by ground vehicles, and there is no need to put the warfighter at risk to recover the asset, as it can usually fly back on its own.

Access to areas that are inherently unreachable to robotic vehicles. Many indoor scenarios and underground facilities pose challenges to robotic systems (3D). For example, it easier to drive indoors in constrained areas, but it may be easier and faster to fly in larger areas. The platform allows for the sequential use of the modalities.

Noise. UAVs are loud, easily alerting enemies of their location. However, Pegasus, in its ground modality, is orders of magnitude quieter than when flying. This allows it to excel in missions where maintaining a low acoustic signature is important.

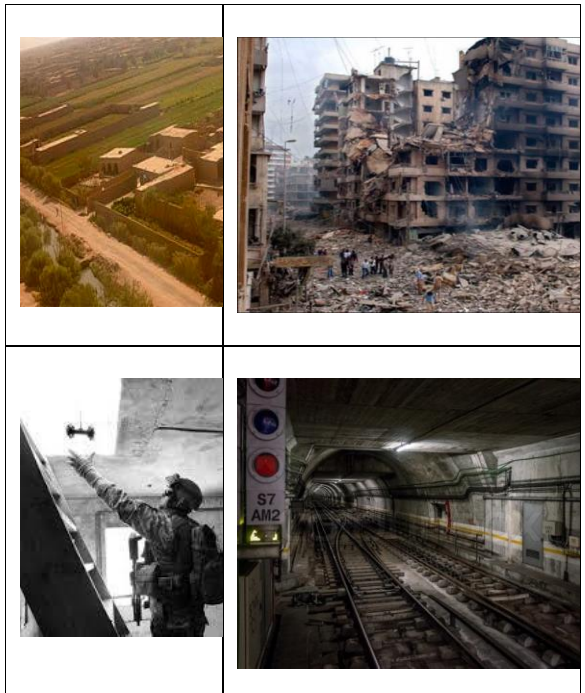

Figure 3. Missions that shown the importance of the transformable capabilities.

Ground endurance. Pegasus can drive for approximately 6 hours. Therefore, its mission durations can be significantly longer when the vehicle is mostly traversing in ground mode. This becomes important if the ISR mission has significant indoor components. UAVs are clumsy and noisy indoors, and because their battery life in flight mode is relatively short, mapping or searching a large indoor area is usually not possible. Pegasus, with its ground capabilities, can cover significant amount of indoor areas, and still conserve battery to fly back.

Emplaced sensor. Because Pegasus can perch in a location for long periods of time, it can provide the long-term sensor that is needed for many operations. Pegasus currently uses 9000mA/hour batteries at 24 v.

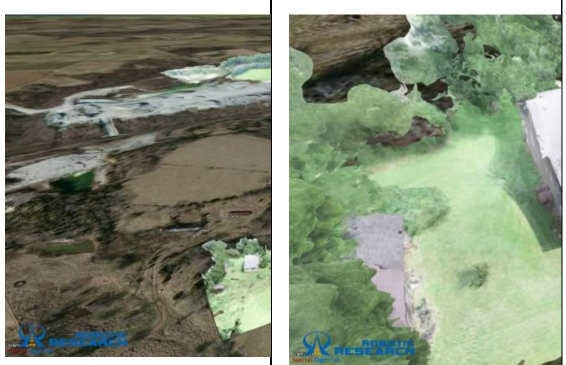

Figure 4. Maps from multiple Pegasus can be combined into a single display.

These batteries can power the computer as sensors (cameras) for days. If low power modes are used (and the system is already capable of doing this), the batteries would last for weeks. For example, a "perch" behavior could be implemented where all motors, and even radios, are turned off; it would only transmit when the cameras see motion, or at certain designated times. These modalities are relatively simple to implement, and could further increase the capabilities of the platform.

Payloads. Robotic Research has already developed a number of system payloads for a number of customers related to SOCOM operations. Robotic Research is currently funded to develop a variety of sensors for CBRN applications that will be demonstrated in 2017.

Situational Awareness Tools & 3D Mapping

Pegasus has a developed, significant mapping capabilities. Mapping can be performed both with base platform sensors and with more advanced sensors in the autonomous mobility payload (LADAR). Figure 4 shows a map, generated with the sensors in the base platform. The figure shows not only the mapping capabilities of a single vehicle, but how they are integrated into a real-time multivehicle situational awareness tool. A group of Pegasus generated this map, and populated it with live video.

Figure 5. Pegasus 3D mapping from video (left) with "table clothing" of live video over the 3D map for change detection.

The base platform can also create what we call "table-clothing." In this case, a model is generated by one Pegasus (this takes a few minutes of processing time), and then the model is used to project the live stream video of other Pegasus.

Figure 5 shows one such example. Figure 5a shows the 3D model created by the first Pegasus platform. Figure 5b shows the live video stream provided by a second Pegasus, overlaid on the model generated by the first vehicle. This is important, as it significantly decreases the burden of the warfighter in understanding the position and pose of the video stream. Multiple video streams can be displayed this way.

The platform can also be used to create accurate short-range maps. Figure 6 shows different 3D models created by Pegasus for a variety of applications, from casualty evaluation to EOD reconnoitering.

Figure 6. Pegasus can create accurate 3d models of the surrounding areas.

If Pegasus is equipped with its autonomous mobility payload, it can also generate real-time 3D point clouds from LADAR. Figure 7 shows a 3D model generated by Pegasus at the Camp Pendleton ANTX experiment with the Marines. Figure 7a shows the complete model of the village, Figure 7b shows a close up of the model, and Figure 7c shows the raw LADAR point cloud. These 3D models can also be used to project the live videos.

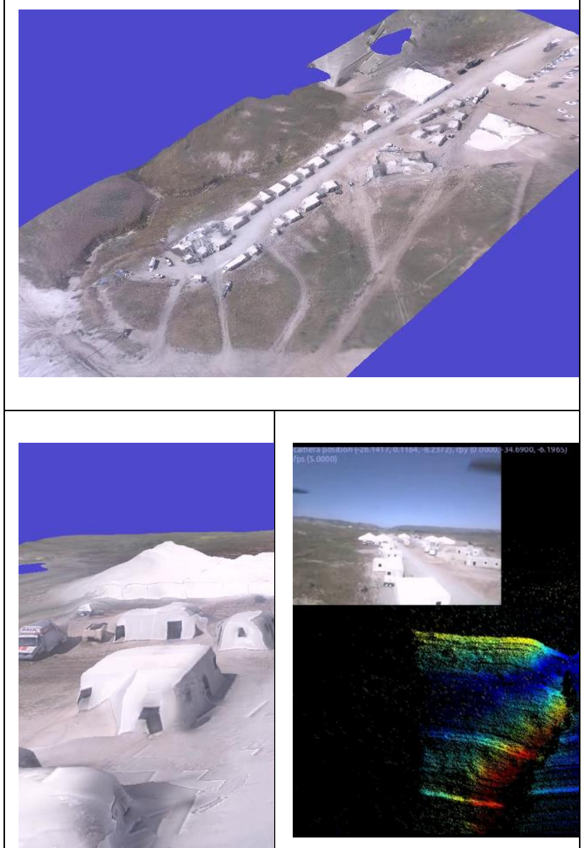

Figure 7. A 3D model created with Pegasus™. Top shows the complete map of the area. bottom shows a closeup, and c shows the raw/real time LADAR data point cloud.

Summary

We have presented an advanced hybrid air/ground vehicle for use for ISR missions. Traditionally the DoD has divided UAVs and UGVs as different vehicle classes with different communities of interest and different stakeholders. I have made the case that the advantages in mobility, endurance and capabilities provided by transformable platforms warrants a hard look at these divisions. Vehicles that straddle the air/ground functionality can make a difference in current and future missions, not only because they are two platforms in one, but because the sequential use of the two modalities allows for a level of "reachability" that cannot be accomplished with two separate platforms.