

# Autolanding UAVs: Vision for the future

## Abstract

Landing is the most delicate and critical phase of an Unmanned Air Vehicle (UAV) flight. With the rapid growth of UAV deployment, the need to develop a reliable and automated landing procedure has never been greater. The need for fully autonomous flights from takeoff to landing presents a number of complex challenges to solve. This whitepaper looks at those challenges and appropriate technologies to address them.

## The role of UAVs in the future

It is clear that in the future UAVs will become increasingly prevalent in both military and civilian scenarios. It is anticipated that military use will lead the way, with civilian adoption of UAVs developing in light of this capability. In its Unmanned Air Systems Roadmap, the US army predicts a shift to mostly unmanned aircraft over the next 25 years. Extending the UAV's current role beyond surveillance and communications relay, the army foresees unmanned aircraft for cargo resupply missions, logistics, battalion-level missions, and eventually armed combat.

The UK MOD is predicting that future conflicts will occur in contested, congested, cluttered and constrained environments. UAVs will be used both on land and at sea, and will have to land accurately and reliably on moving platforms such as aircraft carriers and frigates. They may also be required to land on top of convoy vehicles or be used to re-supply disembarked troops.



Illustration showing Rotary Wing UAV landing on to a convoy

## The need for automated landing

Most large unmanned aircraft are remotely controlled by experienced pilots from a ground control station during landing. However, the current human interfaces for remote control present several problems for pilots. UAV pilots on the ground cannot hear the engine, they can't feel vibrations, acceleration or motion and they lose stereoscopic and peripheral vision. In short there is a lack of "realism". Too often it can feel as though the pilot is playing a computer game or simulation.

It should come as no surprise then that many remotely piloted aircraft are lost. The US Air Force has already lost one-third of its Predator unmanned aircraft, and just over a third of these losses were attributed to human error. The total cost of these losses is estimated at over \$250m.

Automated navigation and control systems offer increased accuracy in measuring aircraft position when compared to remote human operation. Automated solutions also offer the benefit that they do not suffer from fatigue, allowing 24/7 operation.

## Designing the right solution

The ideal landing system needs to offer a universal solution which caters for all of the different UAV systems in operation. These include fixed wing, rotary wing and future novel airframes. It will not be practical to have different landing zone requirements for each type of UAV, or to deploy different sets of equipment at the landing zone. Therefore, the system would need to be able to operate alongside manned systems, and allow several different UAV types to be used in one landing zone or even to have separate landing zones for manned and unmanned systems. The onboard flight control system for each aircraft will already be in place, and the ideal solution will be able to interact with any flight control system.

A landing system needs to provide the location of the aircraft in relation to the landing area. There are several solutions for sensing aircraft position, including laser guidance, d-GPS and radar.

However, these solutions have the sensor located on the ground, requiring equipment to be located at the landing zone. UAV landing solutions of the future could be totally self-contained within the aircraft, allowing operation at multiple sites and eliminating the need for several different complex systems to be installed at the landing zone.

A desirable solution would be to have a single centralised system on-board the aircraft that can measure everything necessary for automated landing, in the same way that a manned aircraft has a pilot on board. This removes the reliance on the communications link between the ground station and the aircraft, and means that the landing zone could be almost anywhere. A suitable landing zone could be set up in seconds – something that is likely to become a requirement for small UAVs of the future due to the changing nature of modern conflict.



## Autoland: Vision for the Future

An on board vision based system, such as "Autoland" from Roke, offers this functionality. Many UAVs already have a camera mounted on board the aircraft, for remote operation or as a mission payload system. A computer vision based system can use images from an onboard camera to measure the relative position and attitude of the airframe to the landing point far more accurately than a human operator, and it can provide updates faster than the human eye can respond. Roke has already demonstrated its vision based system autonomously landing a rotary wing UAV onto a moving ground vehicle – something that would be very difficult for a remote operator working with onboard video to do. Roke has over 25 years of image processing expertise, allowing us to offer this passive, self-contained auto-landing capability. It only requires a single off-the-shelf camera on the aircraft and a standard landing symbol to be laid out on the landing zone.

The system is able to accurately determine the position and attitude of the landing point in six degrees of freedom. It also determines the rate of change of these variables – providing all the information the onboard flight control system needs to land the aircraft safely and reliably.

The technology isn't limited to a well illuminated landing zone. Using IR landing beacons or LEDs to mark out the landing zone allows for covert and night-time operations should these be desired.

## Summary

This whitepaper has highlighted some of the future requirements for automated landing systems for UAVs. As smaller UAVs become more commonplace they will need to be capable of fully autonomous flight from takeoff to landing. An automated landing system that requires complex ground infrastructure will be impractical for deploying UAVs in a busy and congested environment. There is a clear benefit to keeping the automated landing system completely self-contained within the UAV, and Roke's vision based technology has already demonstrated this capability.

## Working with Roke

Roke develops 3D vision systems for a wide variety of advanced applications from transport to entertainment. Our work ranges from research into processing techniques through to the supply of bespoke operational systems. Building on more than 25 years of computer vision experience, Roke offers world class, real-time vision systems.

Roke's autoland solution for rotary wing UAVs

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