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UAVs and Relief Operations – a role for Sky Hopper

Recent events in the Caribbean have involved widespread devastation not only to private homes, but to public infrastructures. This latter effect brings additional burdens to any recovery operations; it is difficult to organise, schedule and administer a relief effort without good field communications, logistics re-supply points and feedback about progress being made.

What role could advanced UAVs with load carrying capacity offer in these circumstances? The Sky Hopper Project team analysts and engineers, engaged in the development of a mid-mass UAV with a target cargo capacity of 100Kg over 100km at 100knots, decided to analyse this prospect. [1]

Total destruction overwhelms the ability to assess the needs of the population or for infrastructure repairs.

Our conjectural mission was to provide relief to the islands of Barbuda and Anguila; two of the most badly affected in the region hit by hurricane Irma. These islands provide two usefully different examples for this exercise; Barbuda is small in area with a sparse population of less than two thousand, Anguila is larger and more densely populated with eighty thousand residents. As we shall see, this difference in density has a bearing on how relief operations might be done.

It took the Royal Navy some days to arrive at these islands, to discover that access to numerous areas was impossible, with power, transport and communications infrastructures wrecked. In addition, getting to grips with the disparate needs of a disorientated human population found in a state of anxiety and confusion taxed even the well trained service personnel of the British armed forces. They pride themselves in being well organised to influence those they come into contact with. Lack of information and therefore an ability to be seen to act coherently puts military personnel at risk in these circumstances; small incidents can develop rapidly into situations where violence erupts and a forceful response can become necessary. Such events are highly counter-productive to effective relief of human misery; they taint relations for a long time after a flare up.

Analysing the need

The first step therefore for any UAV capability is to survey the locality and assess needs. As we know, using drones for surveys is a burgeoning industry, but the larger Sky Hopper vehicle offers a capability that extends the scope for a productive rapid and early response.

Our team assumed that a single vehicle was available at an early stage to provide a full island survey from around 2500 feet, performing repeated single vector passes collecting imaging, thermal and other processed data along 500 metre wide tracks across the islands. At 100 knots each track would take around 13 minutes to cross Antigua, and 8 minutes on Barbuda.

[1] This paper may be circulated freely. Please site the source as www.skyhopper.co.uk and retain branding.

This tracked survey would cover the land area of Antigua in approximately six and a half hours, and Barbuda in three and a half. However, Sky Hopper is an electrically powered vehicle, so we also needed to add in some ground operations time for data equipment re-loading and battery changes.

Our calculations suggested that a comprehensive survey with collection of advanced digital data might take ten hours in total for Anguila and five hours for Barbuda. During this time, and while later data is still being collected, we believe that early survey results could be analysed to plan for an initial, and early, logistics response.

A Sky Hopper UAV carrying high resolution cameras, thermal imaging and image analysis equipment could rapidly assess and collect data on wide area damage.

Our project associates at The Geodata Institute in Southampton are experts in the handling of large amounts of geographical data, and we have access with them to analysis packages through which layered Geographical Information System information can be presented for logistics management. This processing could be done on site within hours of data being downloaded.

A logistical response

As information about the status on the ground across the islands became available, specialist despatchers would use a triage system to deal with urgent needs in a logical cascade of relief missions. Such skills exist within the UN, NGOs and the military.

We therefore made the assumption that stratifying relief missions would not be the concern of the Sky Hopper team. Our role would be to provide as much load carrying ability per hour as possible. We therefore posited that ten Sky Hopper vehicles were made available, departing either from an offshore merchant ship platform or from an onshore facility where stores had been pre-landed. The former is clearly more efficient, and Sky Hopper, despite having a vehicle planform area of 4 metres square could easily be landed on a small cargo ship deck space where obstacles have been removed or covered.

Typical short sea or feeder vessel. Vessels of this class operate worldwide. The freight containers offer a flexible solution for an at-sea Sky Hopper aero park.

The merchant marine industry globally uses what are known as “short sea” or “feeder” ships that have arrays of containers arranged longitudinally. A typical stacked array for a short sea vessel is five abeam, eight longitudinally and around three to five high. Such a stacked array cannot however be made accessible for sea based extraction of their contents for logistical provisions.

We therefore made the conservative assumption that it would be possible using a short sea vessel to arrange containers such that ten Sky Hopper vehicles were brought on task in five containers and relief cargo in twenty others containers arranged in an array that allowed protected access to loading personnel while operations were underway.

A final assumption is needed – the average mass of the materiel to be carried. Clearly, relief replenishment involves multiple items of varying density. For the sake of simplicity we assumed that an average mass density of that of water would be carried. That is, within our cargo space of 2000mm x 600mm x 500mm each of five 400mm x 600mm planform crates would weigh on average 20 kilos. This is an important figure, because carry loads above 20Kg demand special handling, both for safety and a duty of care to cargo-handling personnel, and so slow down loading operations.

This assumption is in fact probably over-conservative; water is much heavier than, say, blankets, but if for example we were delivering electrical switching equipment or water pumps, the volumetric weights would be higher than water. [2]

Delivering the goods

With this scenario in mind, we then calculated the potential rate of delivery of relief materiel across both Barbuda or Anguila. The former could be serviced through relief flights lasting on average approximately 15 minutes, the latter approximately 35 minutes. These figures include an assumption of an average ground re-load and vehicle service period of approximately ten minutes per flight. Standardised palletisation of specific relief supplies makes this perfectly feasible.

The resulting calculation suggests that the Sky Hopper system could deliver upwards of 30,000Kg of relief cargo per seven hour day across Barbuda, and 17,000Kg each day across Anguila.

It can quickly be seen that the 16Kg per person in Barbuda has a much higher immediate impact than that in the more highly populated Anguila; but that makes its own point; a small area location with a low density population is likely to have scattered needs and have less localised resilience; a more populated community is likely to have higher settlement density at particular locations where local resilience to the impact of a disaster will be higher.

Rapidly repeating sorties carrying targeted cargo to limited space landing sites is the key to the effective provision of widespread relief into localities with extensive damage.

UAV operations providing immediate food, water and shelter relief would therefore likely to be concentrated initially on wider area operations and work in tandem with other modal forms of transport in more densely populated areas; possibly moving to

[2] There is an interesting post-event exercise to be done here collecting real-life empirical data on the range of mass-carry loads for different relief operations. While this data is likely to exist for truck based relief, it can only be obtained from experience of aerial delivery systems over time.

specific infrastructure support at an earlier stage in the latter where water, sewerage and power re-instatement can become a critical need very rapidly.[3]

The lesson here is that the profiling of any cargo UAV based relief effort will benefit from the immediacy of flight operations and flexibility in their targeting. A triage approach, based on survey data, will be highly productive in delivering relief to the right location as early as possible and so minimising the suffering of the affected population.

It should be noted also that this productivity can be further enhanced by automated flight handling based on both the baseline survey data and, later, updated field reports. The prospect of autonomous vehicles self-defining their destinations on the basis of survey data in an integrated system is enticing. A system that automatically chooses both cargo and destination and then adjusts operations based on delivery histories and other feedback data from the ground could be revolutionary. Human input would be supervisory, examining the data from the field and making sure the cargo despatch systems responded coherently.

Re-instating normality

The above scenario concentrates on immediate relief. As such, this is human-centric, aimed at providing a support effort that stabilises the predicament of a community hit by an adverse event.

The visibility of Sky Hopper UAVs shuttling back and forth to deliver cargo would in our view provide additional benefits in morale and encouragement for those affected and make the work of the authorities in maintaining social control considerably easier. Being seen to be "on the job" and working to improve matters is a key factor in focussing the behaviour of a confused and needy populace on a better tomorrow rather than seeking blame and expressing anger. Allowing those affected to pull together and share the endeavour of re-building is important to the success of any relief effort.

But a Sky Hopper cargo system also offers a follow up capability that can enhance this positivity by allowing the repair and re-instatement of crucial infrastructure.

All communities, even those in the less developed nations, have a need for water and sewerage control, with electrical power an additional necessity for clinical facilities and the recovery of domestic light, heating or cooling/refrigeration.

Sub-assembly equipment for infrastructure repair up to 100Kg is a key deliverable for the Sky Hopper system. Such assemblies are relatively easy to source and replace if you know what legacy model is on site. UAV surveying is an

The parts required for these refurbishments are usually not in themselves massive; control systems, switches, pump parts, valves, pipe connectors, incubators, electric motor inverters, relays, insulators

[3] Again, there is a need for real-world experience to build and evidence base for the most productive approach to disaster relief triage in differing circumstances and areas.

and actuators are the sub-componentry of infrastructure equipment used worldwide. Additionally, identifying legacy part numbers and smaller sub-connector parts, as any system fitter will tell you, is part of the battle of re-instating function to damaged equipment. High resolution imagery from early Sky Hopper surveys, with follow up specific infrastructure surveys to identify specific needs are all valuable assets provided by the UAV system.

There is a role here for a rapid response, repeating, and smart delivery system; able to deliver the right part to the right place in a timely fashion – essentially the definition of what a cargo UAV capability is designed to supply.

Once again, within the wider context of a disaster relief operation, the ability to demonstrate deliberate and constant progress is of vital importance to community morale and understanding; building the resilience of the entire effort when it can be seen that a return to normality has begun across the community and not just for a few, often government controlled, facilities. Once again, the visibility of multiple UAV flight operations enhances the sense of progress.

Cost profile of enhanced operations

Bringing ship based supplies to a distribution location, either sea borne or ground based, is an unavoidable cost of any relief effort for remote territories. However, one of the advantages of a Sky Hopper cargo UAV system is that additional operational costs for rapid mission relief are well controlled.

Sky Hopper vehicles are planned not to be complex but workhorses of the sky. They use electrical power systems for reliability and low per mile flight costs. They also of course avoid the high cost of human aircrew in wages, accommodation and food. Their command and control systems are software-based and generic, requiring supervision which can be done from site or through communication links.

Ideally, operating a Sky Hopper relief effort would involve on site costs related only to the handling of cargoes and servicing of vehicles for repetitive operations. A machine based despatch system, acting robotically, and using reliable, flexible machines will always beat the cost burden of complex airborne systems – especially helicopters. In areas where road transport links have been disrupted they offer the only way of getting rapid relief to cut-off communities across a wide area.

Conclusion

Our calculations show that a mid-mass cargo UAV capability could have a dramatic role in enhancing the productivity of any relief effort. Properly organised with an initial survey triggering well controlled immediate needs relief, backed up by flexible automatic targeting, and then followed by small-step infrastructure reinstatement, a UAV based logistics effort could build up to large-scale relief from suffering very rapidly.

The key is the ability to target UAV operations, to integrate flexibility in response, and to allow repeated flight operations dedicated to well-defined productive goals that enhance community understanding and optimism about a return to normality.