AD Cloud | Command and control

White paper

Autonomous UAV operations

AD Cloud provides a dedicated command and control module with plug and play capabilities for autonomous drone operations.

The module is designed to work alongside AD's mission control infrastructure which utilizes a range of technologies and hardware.

Cloud controlling UAV operations has significant advantages over manual flight. In this white paper, we'll illustrate the salient features that give AD Cloud an edge in executing complex, autonomous UAV missions.

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1 Advantages of autonomous UAVs

Autonomous UAVs are poised to bring in a new era of for society where services are provided at a large scale for organizations and individuals. Going past manual operations, autonomous frameworks can deliver entirely new business models and lead to a transformation in how we all work and live. Autonomous UAVs promise nothing less than a fundamental change in aviation.

Limitations of manual UAV operations

Perhaps the most significant restriction in manual UAV operations is the lack of beyond visual line-of-sight operations (BVLOS). Although in certain geographies, manual BVLOS flight is possible, for the most part it is not feasible and thus greatly curtails the range of operations.

Another limitation is the cost of scaling up manual UAV operations. With at least a 1:1 drone to person ratio, it quickly becomes expensive for organizations to train and employ a cadre of pilots for their UAVs.

And even if costs were not a consideration, manual UAV operations do not scale up smoothly due to variations in capabilities of the human pilots.

As such, more complex flight scenarios fall out of range of possibility – for example, close formation flights.

Finally, manual flight is not very efficient. Valuable flight time and fuel is often expended in path correction.

For example, surveying a large farm and its vegetation using thermal and spectroscopic sensors becomes an arduous and haphazard task using manual flight. Similarly, crop dusting may needlessly deposit too much pesticide over a patch of vegetation if a less than efficient flight path is utilized.

All these inefficiencies are abound in the absence of a controlling framework.

Replacing the human pilot

Cloud connectivity, artificial intelligence (AI) and edge computing converge in a real-time framework, enabling autonomous drone operations.

Basically, the cloud provides real-time connectivity to the hardware via LTE communications or other means. Algorithms on the cloud prescribe flight paths for a given mission and the mission itself is launched manually or based on a pre-determined schedule via the cloud.

Of course UAVs are mobile pieces of hardware and not limited to a controlled environment. As such, additional mission control infrastructure is needed on the ground in order to conduct autonomous operations.

For example, mobile edge computing data centers may be deployed in an area of operations to facilitate data analysis and storage in real time.

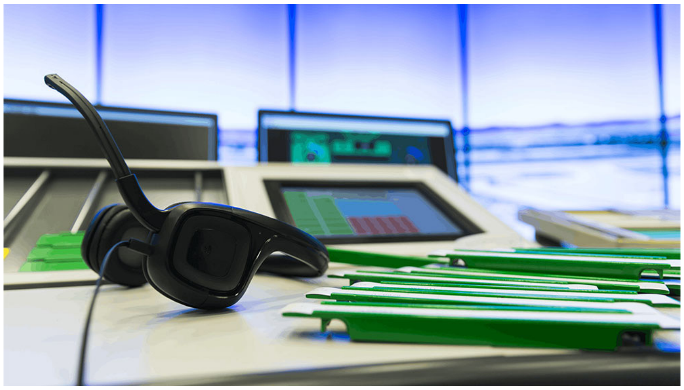
In this manner, the human pilot is replaced by human flight controllers or field operations experts that manage a collection of UAVs through cloud connected hardware. The drone to person ratio becomes greater than one, with expected economies of scale as operations get larger.

A specialized cloud

Cloud services that provide mission planning, flight path verification and mission execution need to be deployed on the cloud and paired up with the UAV hardware and mobile edge data centers before autonomous missions can be conducted. Once in place, operations can be scaled up, almost at will.

2 Mission planning

A command and control module for autonomous UAV operations should allow users to select hardware, specify a flight plan to set up a mission, launch the mission and monitor the mission till it has ended. The module must take into account any and all restrictions, environmental conditions and other authorizations as it generates mission options for the operator.



Setting up a mission

A mission planning module must allow an operator to select UAV hardware and specify a flight plan based on detailed map data.

With additional considerations taken into account, the module will generate a mission plan.

Scheduling the mission is next. Additional restrictions may come into play depending on the timing. Once verified, a periodic schedule of missions may be set up.

Past missions could also be cloned, so the entire planning process doesn't have to be repeated in its entirety. Thus the module must also maintain historical data.

If the mission relies on a mobile command center performing edge computing and providing communications to the cloud, that needs to be incorporated as well. Additionally, mission collaboration may be needed whereby a group of operators may want to define a mission.

Flight restrictions

In addition to the well defined restrictions on commercial UAV airspace, there are a variety of channels that may end up imposing constraints on a particular mission.

Foremost are FAA Push Notifications, which provide safety-critical information to operators on airspace restrictions and other mission-relevant information.

Temporary Flight Restrictions (TFR) restrict a volume of airspace for air travel. A variety of reasons could trigger a TRF and these notifications are taken into account when a mission plan is autonomously generated by the command and control module.

There may be other mission-specific restrictions that come into play as well. UAS Volume Reservation (UVR) Push Notifications are needed for close formation flights. This forms the basis of a UAV traffic management system and is needed to ensure the safety of autonomous missions, when nearby UAV missions are also taking place.

Weather

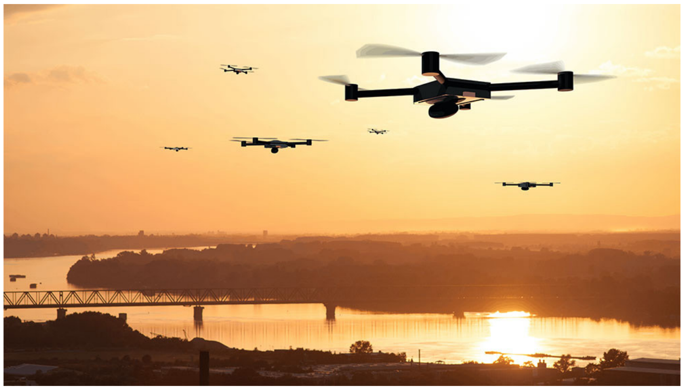
Like air-traffic data, weather data is essential for mission planning. Real-time weather data is taken into account not only at the planning stage but also while executing the mission.

UAVs are especially sensitive to weather conditions and rarely fall in the category of all-weather operations. The command and control module needs to judge the vulnerabilities based on the selected UAV hardware and external weather data while determining mission options at the planning stage.

During execution, this analysis continues and missions may have their flight paths and schedules altered or canceled altogether depending on relevant weather data.

3 Flight control

Full autonomous flight control for drones is a necessary component of a command and control module. Secure, aviation compliant auto-pilot and air-traffic control needs to be in place from take-off to landing. This should be able to run in both data center and 'edge' mode. The framework should be designed with redundancy and safety in mind.



Take-off and landing

A standardized set of APIs should be available for controlling UAVs. Compatible hardware would then be available for autonomous flights. Take-off and landing should be automated based on either a pre-determined schedule or a manual push.

Cloud integration ensures this capability is available from the dashboard or app via any connected device – which includes computers, tablets, mobile phones and car consoles.

In case a serious issue is encountered during flight, automated protocols must safely land the UAV in a safe or designated area. A mission abort procedure must also be present so that any in-flight hardware can be called back to base at any time with a manual override.

For high-density operations, take-off and landing needs to be especially precise both in terms of timing and Geo-position.

Point-to-point and other types of flight paths

Autonomous flight paths are generated by the mission planning module on the cloud. Depending on the application, a wide variety of flight path geometries are possible.

The simplest case is the point-to-point flight, where a UAV has to traverse the distance between the take-off and landing position, in a straight line. For multi-rotors and VTOL capable hardware, the elevation profile of such a pattern is an inverted 'U' shape.

Grid coverage and infrastructure inspection requires different types of flight paths that allow for monitoring large areas such as in land surveying, agriculture, asset inspection and security.

A UAV may take a zig-zag route while spraying an agri-cultural plot, while one that is inspecting a cell tower may take a vertical spiral route in order to generate a high resolution map of the tower.

Swarm missions

Close formation flights or 'swarm' missions are designed specifically for customer requirements on a case by case basis. In every case, they require a very detailed and accurate map of the elevation to navigate within – usually pre-generated using LIDAR or existing data.

Flight paths for such missions will require additional restrictions to be taken into account. Moreover, IFTTT (if this, then that) type of rules and even AI based algorithms that dynamically adjust flight paths depending on real-time data may be employed to manage the flights successfully.

Aerial refueling

As autonomous operations get more complex, there may be applications where a specialized UAV provides aerial refueling for other UAVs so landings are avoided. For example, providing wi-fi service in a disaster area. These require precision flight paths for the close maneuvers.

4 Fleet management

As operations get larger for both enterprises and individuals, specialized capabilities are needed to manage the UAV fleet.

Easy to access views of active, operating and in-maintenance hardware needs to be provided so operators can get detailed information and insights on the health of their UAV fleet, which can improve ROI and minimize downtime.

An enterprise asset management system (EAM)

Full life cycle operational data needs to be available to provide a comprehensive view of a UAV fleet, allowing customers to drill down to a specific piece of equipment as needed.

For fleet management, overall status and vital hardware statistics need to be communicated back to a unified dashboard – in real time.

A good EAM system will aggregate the data and perform analytics that allow customers to glean insights and make better decisions. Having the ability to scan historical data also provides potential guidance for future missions. These capabilities comprise an EAM type of functionality, served through the cloud.

Digital twin

A digital twin provides speed and agility across complex life cycles. Fleet management is a natural application. By utilizing digital twins of the entire fleet of UAVs, we can reduce downtime and increase fleet efficiency.

In essence, by providing an active view of operating and in-maintenance hardware, customers can get detailed information and insights on the health of their fleet, which can improve ROI.

A virtual interface can be provided in varying degrees of sophistication that can deliver a comprehensive view of the entire fleet in a digital environment. This includes virtual reality constructs (my drone landscape) and augmented reality interfaces that can superimpose real-time data on physical objects.

Maintenance, Repair, Overhaul (MRO)

Use asset performance management to gain insights into the health of your UAV fleet. This information can help predict equipment failure, prescribe remedial procedures and optimize maintenance schedules to minimize impact on overall equipment effectiveness.

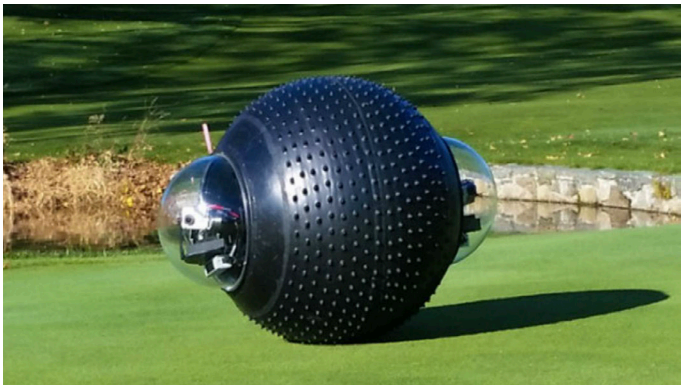
With the right mix of algorithms, a prescriptive model can be set up for all maintenance, resulting in minimal downtime and maximum fleet and worker efficiency.

Scalability

By combining historical mission data with real-time operational data, MRO data and other external data such as weather, a cloud-based fleet management system can perform deep analysis and provide predictive information that can become helpful for future missions, while also providing a recipe for jump-starting new areas of operations anywhere on the globe. Scalability becomes easier when your fleet is healthy and minimizing downtime.

5 Inventing new business models

Autonomous UAV operations are at a nascent stage at present. The confluence of technologies that are making it possible for the first time, will continue to rapidly evolve in the coming years. We'll start seeing UAVs operate without human intervention in the background and become ever-present over time. Safety, compliance and security standards will also have to keep pace with these fast evolving technologies.



Autonomous operations will be the foundation of planetary management and maintenance.

Infrastructure, cities, industry, agriculture, transportation and human lives will all depend on this machine activity, with varying degrees of dependence. UAVs and driverless cars will be at the forefront of this transformation, closely followed by commercial robots. So what kind of potential does all this technological convergence offer to us?

We can only imagine what wonders lie ahead. More complex applications are certainly in the cards and these have the potential to make dramatic changes in how both industry and society functions.

No doubt unique applications are beginning to appear as autonomous operations start to take off. Here are a few examples that shed light on what may be coming in the near future.

Life critical services

Autonomous UAVs can introduce great efficiencies in disaster response, emergency services and life critical deliveries. By automating both the dispatching of UAVs and the individual flights, valuable time can be gained when it matters.

One application is organ deliveries that use point-to-point UAV transport using pre-determined flight schedules.

Another application is getting critical supplies to needed recipients in a disaster zone – such as water, food, medicine and communications equipment.

Autonomous IoT

Cloud control of UAVs allow for autonomous operations. However, the same cloud can be extended to control a host of IoT sensors and devices that are mobile in physical environments.

In this manner, complex operations could be undertaken using a range of hardware to achieve full domain capability. An example would be using UAVs in the air in tandem with terrain and amphibious robots. Each type of hardware performs its prescribed function, with complementing and supplementing roles to deliver the mission milestone.

Fire prevention

A tantalizing use case that will soon come within the range of autonomous capabilities is fire prevention. By using a variety of mobile sensors including UAVs and ground robots, autonomous operations may be able to successfully detect fires starting and neutralize the incident in quick time before it becomes necessary to mobilize vast fire fighting resources.

Multiple types of UAVs (spotter, refueling, controller) may cruise over high risk areas like national forests with a range of sensor capabilities, being guided by ground robots that are roaming the forest floor. Extinguisher drones would then come in and put out the kindle before it becomes a serious conflagration.