Determining Safe Access with a Best-Equipped, Best-Served Model for Small Unmanned Aircraft Systems

This paper describes Amazon's proposed approach for determining airspace access for low-altitude small unmanned aircraft systems. Amazon anticipates this model will be refined over time, and will work in close collaboration with public and private industry on the development of the safest system of access for a wide range of applications, not limited to package delivery.

Best-Equipped, Best-Served

Best-Equipped, Best-Served means that the vehicle equipment, often referred to as equipage, network functionality and concept of operations (ConOps) determine whether or not the required level of safety—as determined by the relevant performance standards and rules—is achieved, and therefore, whether access to the airspace is granted.

Amazon envisions the safe operation of small unmanned aircraft systems (sUAS) as a combination of real-time planning and on-board vehicle automation. With this approach, required degrees of planning and automation vary based on vehicle capabilities, web-service-based command and control, and ConOps. These capabilities are expected to be online, with the network able to adapt in real time to varying situations, such as changes in weather and emergency access needs.

When looking at equipage, there are a number of critical technologies currently being explored in areas like vehicle-to-vehicle communications (V2V), command and control networks, and sense-and-avoid (SAA) technology. It is important to note the two distinct types of SAA in relation to vehicle equipage: collaborative and non-collaborative. V2V capabilities enable collaborative SAA, providing vehicles with a way to communicate directly with each other to create awareness and maintain separation. Sensor-based SAA capabilities, however, enable non-collaborative separation between vehicles and non-equipped entities, which can range from birds to balloons.

A Formula for Access

Airspace access for manned aircraft is determined by capabilities. For example, communication and navigation equipage is required for transit through controlled airspace and to gain access to certain airports. Amazon believes a similar model of determining access—one focused on segregated blocks of airspace below 500 feet and away from most manned aviation operations—is the best pathway for safe and scalable sUAS operations.

Evaluating the vehicle's equipage and network capability in order to determine performance is the first step. Once performance levels have been established, the operator's ConOps requirements will determine whether or not the operator is granted airspace access and can safely perform the designated mission.

The variety of ConOps and vehicle capabilities means there is no one-size-fits-all model. For example, an operator with a lesser-equipped vehicle may be able to achieve the required level of safety if they are flying in a remote area. On the other hand, an operator seeking to fly in an urban environment would have to meet a highly sophisticated equipage standard, with both robust communications and the ability to avoid other airborne entities and people on the ground.

Four Classes for Safe Operations

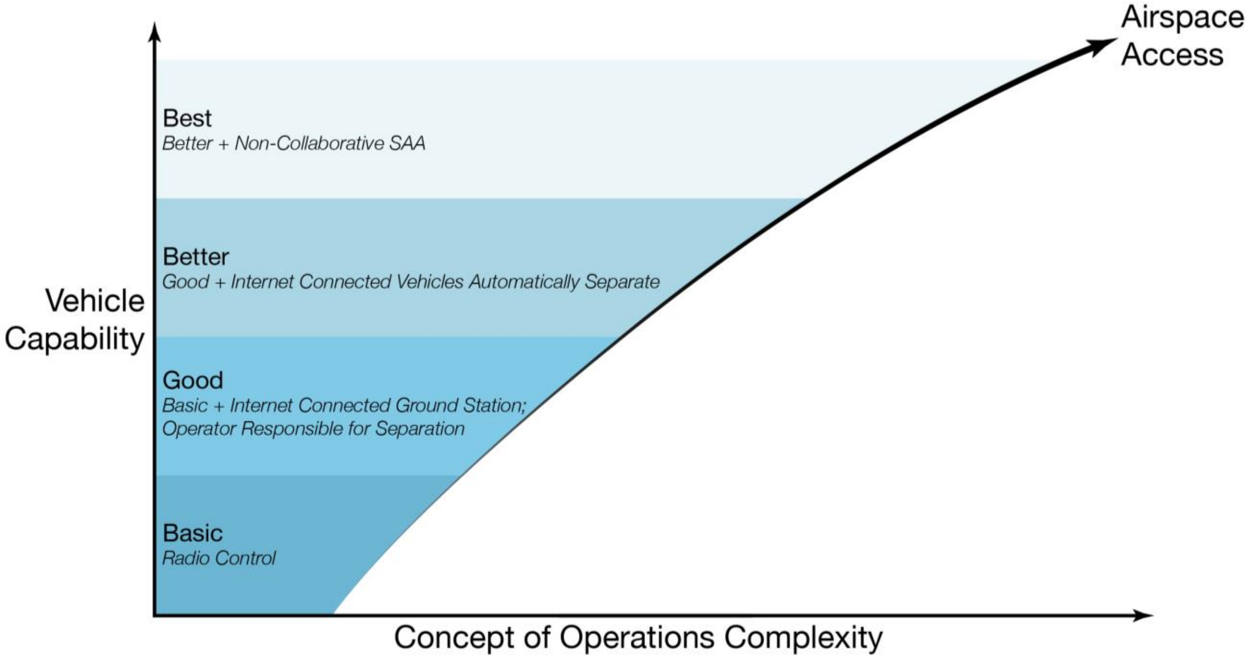
Operators seeking broad airspace access in multiple environments will need to have highly-equipped vehicles. They will also need to minimize interaction with lesser-equipped small unmanned aerial vehicles, as well as the occasional manned aircraft flying at low altitude. To ensure the safety and integrity of the overall system, it is paramount that all sUAS operators understand where they can and cannot safely operate.

It is with this in mind that Amazon envisions four separate sUAS equipage classes: Basic, Good, Better, and Best. These classes optimize for safe and efficient airspace operations by creating categories of access based on capability. For example, a vehicle with an equipage classification of 'Good' does not meet the vehicle capability requirements, such as automated collaborative deconfliction (via V2V) and non-collaborative SAA, that are needed to perform a complex mission in an urban environment. On the other end of the spectrum, operators requesting access to execute missions with high complexity must equip in the 'Best' class and possess five equipage elements: (1) geospatial data for safe separation from known hazards, (2) online flight planning and management, (3) reliable Internet connection, (4) collaborative V2V SAA, and (5) non-collaborative sensor-based SAA. It is Amazon's position that these five 'Best' equipage elements are essential for safe, highly-automated operations.

The following table identifies Amazon's proposed classes, equipage capability examples, and the resulting airspace access.

Class	Equipage *Examples*	Airspace Access
Basic	Radio control	Line of sight (LOS) flight in predefined low risk locations
Good	*Basic +* Ability to announce and log identity location and activity via V2V; ability to receive air traffic information, weather data, GPS and Wifi; Internet connected via ground control; proximity alerting to operator via collaborative V2V; basic geospatial data	*Basic +* Unrestricted daytime LOS flight less than 200 feet in rural operating areas; limited operations in suburban areas
Better	*Good +* Autopilot capable of auto-deconfliction via collaborative V2V; on-vehicle Internet connection; Automatic Dependent Surveillance-Broadcast (ADS-B) Out capability	*Good +* Daytime LOS flight less than 400 feet in suburban operating areas; limited operations in urban areas
Best	*Better +* Non-collaborative SAA and automated deconfliction; reliable on-vehicle Internet connection; 4D trajectory planning and performance management; geospatial data of all hazards to navigation over 200 feet; onboard vehicle condition monitoring system; alternate landing execution; long-range SAA able to detect and differentiate non-collaborative targets and safely deconflict; ADS-B In/Out	*Better +* Beyond line of sight flight less than 400 feet in all operating areas, including urban, with vehicle-to-operator ratios greater than 1:1, transiting between 200 feet and 400 feet; daytime and/or nighttime; good weather or all weather as determined by sensor-package performance capabilities

The proceeding graphic takes it ones step further and illustrates the relationship between vehicle capability, ConOps complexity and airspace access.



Creating Standards, Enabling Innovation

Aviation authorities, manufacturers and operators around the world have created high standards for equipment, operations, reliability, and safety. In order to maintain and enhance the level of safety achieved in aviation today for sUAS, aviation authorities should adopt performance-based equipage and operating standards. Such standards will allow for the safety of the system to improve as the technology improves, rather than locking into a specific set of technologies that quickly become outdated.

It is Amazon's position that a Best-Equipped, Best-Served model for determining airspace access, alongside the creation of four separate sUAS equipage classes, is the safest way to usher in this new era of aviation in scalable and sustainable way. Amazon is committed to collaborating with industry to help define standards in a way that will provide operators, manufacturers and policymakers with a clear understanding of what is needed to operate safely in the shared global airspace.