

DESIGNING FUTURE UNMANNED COMBAT AIR SYSTEMS FROM THE EFFECTOR POINT OF VIEW

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ABSTRACT

In the future more and more combat missions will be executed by weaponized UAVs or UCASs (unmanned combat air systems). A coordinated development of all UCAS subsystems is necessary in order to get a harmonised product - this also includes the effectors. A three-step procedure is proposed for designing an UCAS. It reduces the large number of theoretical possible designs to only one or very few optimum UCAS concepts by consecutive sieving steps.

1. DEFINITION OF TERMS

The evolution of unmanned or better uninhabited aerial vehicles (UAVs) is an ongoing process which still seems to gain impetus. More than 500 different platforms are in development or production worldwide. Almost every week new designs and companies are introduced to a growing market. All concepts share the common characteristic that there is no pilot on board the aerial platform. Contrary to missiles UAVs are designed to be recovered and reused several times.

Recently, the term unmanned aerial system (UAS) is used to clarify that it is not only the aerial platform but a whole system of systems necessary to achieve success. It consists of unmanned aircrafts, suitable sensors and control stations, dedicated communications systems and links, as well as mission planning equipment. In 2002, the US armed forces operated 127 UASs of five major types, which together amassed a combined total of approximately 26000 vehicle flight hours. In 2006, 520 US UASs of 16 different types amassed over 160000 flight hours - and these numbers do not include additional small battlefield UASs [1].

Right from the beginning there were numerous attempts to deliver weapons from an UAV. Chinese writings of a thousand years ago discuss the use of large kites to bomb defenders of a walled city. Whether fact or fantasy, it emphasized for the first time that unmanned systems were capable of attacking an enemy without placing ones' own soldiers at risk [2]. In more recent times (1818) Charles Rogier used unmanned balloons and time-fuses to launch rockets above his enemies.

During the last years there have been numerous efforts to add weapon systems to UAVs which have been originally designed for ISR (Intelligence, Surveillance and Reconnaissance) missions. The most prominent one is the Predator (see below). The US Air Force has provisional plans to acquire 220 or more weaponized UASs by around 2012. At present, the service plans to retire a comparable number of F-16s over the same period [3].

On the other hand, there are also increasingly efforts over the last years to develop an UCAV (unmanned/uninhabited combat air vehicle) which is designed to attack targets and deliver effectors. Similar to the rationale explained before the term UCAV names the aerial platform itself, whereas the term UCAS (unmanned/ uninhabited combat air system) comprises the whole system of systems (cf. FIG 1).

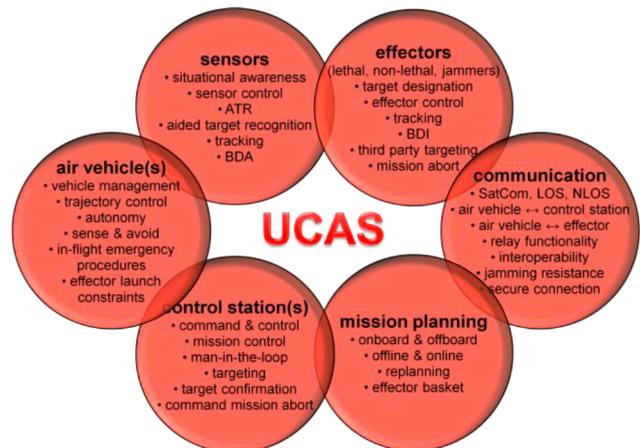


FIG 1. UCAS subsystems and some of their main tasks.

In designing an UCAS, all subsystems have to be carefully balanced to achieve the best result possible. At the moment however, there is nothing like a specialized UCAS manufacturer who provides all systems necessary. This means, quite a lot of companies have to coordinate their efforts in order to start a coevolution of all UCAS subsystems. Solo attempts or retarded development of single pieces of equipment will produce suboptimal results.

2. DESIGNING AN OPTIMUM UCAS

From a naïve point of view there exist almost innumerable possible designs for an UCAS. There are literally thousands of permutations of different realisations of the necessary subsystems (mission planning, control station, communication, air vehicle, sensors, and effectors). The demanding task is to find out which are the combinations that fulfil all requirements best.

One of the possible procedures for designing such an optimum UCAS will be introduced in the following. It is based on the idea that the development of an optimum UCAS may be accomplished in consecutive evolutionary steps. Three filters (called sieves here) reduce the large number of possible permutations bit by bit to few meaningful designs.

2.1. Sieve 1: Design Drivers, System Requirements

The first reduction of all designs possible may be accomplished by reviewing the design drivers and system requirements (like endurance, stealth, speed, sensor coverage, airspace integration, autonomy, and network capability – to name just a few of them). Many designs do not comply with these basic requirements and are not worth to be considered any more.

To make things more complicated, these design drivers have changed over the last years. This may be outlined using the weaponized UAV Predator and its successor Reaper as an example. The latter was developed about six years after the first one. As a result, Reaper is bigger, heavier, and faster. It features upgraded computers, fuel-injected engines, different propellers, upgraded ground stations, and reliability enhancements (like triple avionics). Its service ceiling as well as the price is twice the one from Predator. In all, Reaper is comparable to an F-16, in that it flies at about the same altitude, has comparable sensors and designators, and carries a similar weapons load (e.g. 8 Hellfire, 2 JDAM, and 2 Sidewinder). However, it may remain on station considerably longer than a manned fighter and procurement costs are only about 20% of an F-16. On the other hand, it is slower and less agile than its manned counterpart [3].

The influence of a single requirement on several different subsystems may be demonstrated using the requested capability to command an effector mission abort. To make sure the operator is able to reach the missile at all times one may consider using satellite data links between the operator and the air vehicle and between the air vehicle and the missile. Unfortunately these links will impose considerably data delays on the systems. This, in turn, poses challenges for the sensor equipment and limits the speed of the effectors.

2.2. Sieve 2: Operational Concepts and Constraints

The number of remaining designs may be reduced further by looking at the operational concepts and constraints. Like before there are many of them: third party targeting, man-in-the-loop, no collateral damage, capability for both deep strike and close air support (CAS), Ultimately, only the customers are able to provide the designers with the necessary data.

An example which has great impact on the design is the favoured attack profile. Flying the common high-low-high profile (for ingress, attack, and egress) an unpowered bomb may be an adequate effector. However, widely proliferated manpads and SHORAD systems (short range air defence) pose an immense threat to every air vehicle flying such a trajectory. Using a high-high-high attack profile will reduce this threat considerably, but requires more sophisticated effectors like missiles.

2.3. Sieve 3: Evaluation Criteria

In a final step the remaining design concepts have to be evaluated. The evaluation criteria used for this step have to be defined by the customer. Very often they are not communicated, however. Possible evaluation criteria may be effectiveness, cost of procurement, life cycle costs, reliability, and so on, as well as combinations of these criteria.

As an example we will assume that cost-effectiveness is the ultimate evaluation criteria for the different concepts. UCASs have significant potential for life cycle cost savings compared to manned aircrafts [4]. However, the design and operational concept influences life cycle costs of UCASs considerably as may be shown for different attack profiles. As discussed before, a high-low-high attack profile will result in attrition and loss of a high number of expensive air vehicles with NLOS data links. Favouring a high-high-high profile on the other hand, will result in lower procurement costs for the air vehicles and data links, but higher costs for the sensor suites and effectors. Therefore, every decision has to be checked thoroughly.

Using the procedure outlined above and summarized in FIG 2 only one or very few optimum UCAS concepts should emerge in the end.

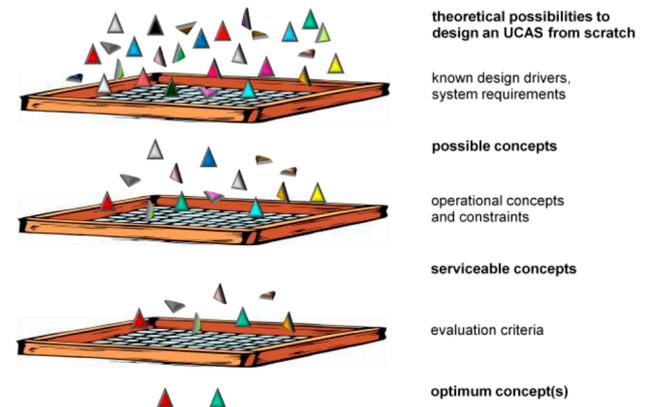


FIG 2. Possible procedure for designing an optimum UCAS concept.

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