

## WHITE PAPER

### Drone/sUAS Safe and Secure Drone Flight System (S<sup>2</sup>DFS)

#### **BACKGROUND:**

The prolific growth in applications of drone and small Unmanned Air Systems (sUAS), performing asset repositioning and surveillance tasks, has the potential to provide a significant stimulus to the economy, and improve productivity and quality of life.

To take advantage of this potential, systems must be put in place to ensure drone operations can occur in a safe and secure manner. Specifically there are two main hazards:

- (1) Drone operations should be **limited to safe areas of operation and not enter secure/unsafe zones** (e.g. prisons, government campuses and buildings, areas where other vehicles are operating).
- (2) Drone operations must **accommodate the trajectories of other vehicles in the safe zones** (e.g. medical helicopters servicing an accident site.)

Current regulatory rules limit the operations of drones to below 400' and in Class G airspace. A certified pilot with knowledge of the airspace rules and regulations is also required. The drone must be operated in line-of-sight.

The costs of pilot licensing all drone operators would be prohibitive (and eliminate the low cost benefits of drones). Further enforcement of these rules is not possible given the ubiquitous availability and operation of these vehicles.

#### **STATEMENT OF OPPORTUNITY:**

Develop the concept-of-operations for the safe and secure operations of drone/sUAS in such a way that eliminates the requirements for a licensed pilot but enables the low cost operations of these vehicles. This may be accomplished using new low-power GPS, transponder (and collision avoidance) equipment.

#### **THE SAFE AND SECURE DRONE FLIGHT SYSTEM (S<sup>2</sup>DFS)**

##### **Concept-of-Operations:**

The proposed concept-of-operations leverages the economies-of-scale in the large volume of drone sales to manufacture a low-cost, low power geo-fencing/transponder system for small drones.

Regulations shall require that the manufacturers install the S<sup>2</sup>DFS equipment on all drones manufactured and/or sold in the U.S.

The S<sup>2</sup>DFS shall be stand-alone unit, certified by the regulatory authorities, installed on each drone/sUAS manufactured and/or sold in the U.S.

The S<sup>2</sup>DFS shall be based on a flight control over-ride that will decouple the drone flight control system from the flight-plan/trajectory instructions from the operators controller (see Figure below).

The S<sup>2</sup>DFS shall utilize stand-alone GPS/INS to determine vehicle position.

The S<sup>2</sup>DFS shall perform two functions: (1) Geo-fencing, (2) Traffic Collision Avoidance

- (1) Geo-Fencing: The vehicle position shall be compared with an approved Navigation Data-base (NDB) to determine with the vehicle is approaching or has penetrated a NoFlyZone (e.g. NOFlyZone.org). The NDB can be updated and refreshed using broad-band internet connection. A drone operating in a static NoFlyZone shall result in a S<sup>2</sup>DFS trajectory over-ride.
- (2) Traffic Collision Avoidance: The vehicle position shall also be compared with traffic in the vicinity of the vehicle using the Automatic Dependent Surveillance link. A drone operating in dynamic NoFlyZone in the vicinity of vehicle shall result in a S<sup>2</sup>DFS trajectory over-ride.

The S<sup>2</sup>DFS shall perform a Trajectory Over-ride: when the over-ride is in effect the flight control system can take one of the following options:

- (1) Hover the vehicle in the current position
- (2) Return the vehicle to it's launch site either by shortest path or using the same route that brought it to that location
- (3) Descend the vehicle to controlled landing in current position or in a nearby designated safe landing zone.

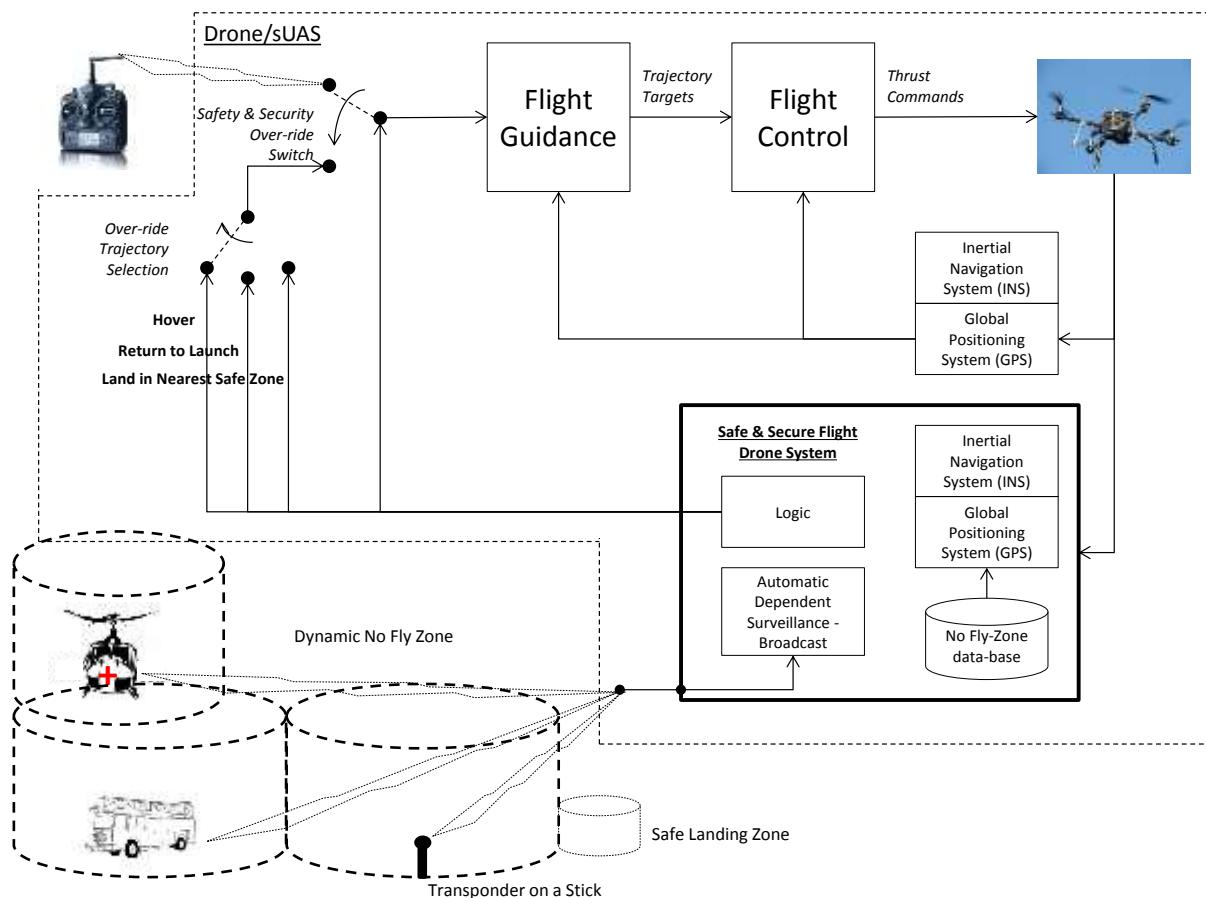


Figure: Functional Concept-of-Operations. S<sup>2</sup>DFS unit on drone allows over-ride of drone flight guidance system in presence of emergency system transponders

## **PROJECT PLAN**

### Concept-of-Operations:

- 1) Develop full concept-of-operations
- 2) Determine regulations and oversight of design and manufacture of mandated S<sup>2</sup>DFS
- 3) Develop economic feasibility model for S<sup>2</sup>DFS
- 4) Develop hazard model and safety analysis for static/dynamic NoFlyZones

### System Design and Development:

- 5) Develop standards for geo-fencing data-base NoFlyZone designations
- 6) Develop concept-of-operations for safe landing zones, return to launch flight-plans, hover
- 7) Develop logic for selection of alternate over-ride trajectories
- 8) Develop standards for ADS-B messaging
- 9) Determine best trajectory over-ride options (e.g. hover, return to launch, land in safe zone)
- 10) Develop standards for trajectory over-ride
- 11) Develop standards for S<sup>2</sup>DFS "logic" (i.e. decision-making)

### System Test and Demonstration

- 12) Develop Test Plan
- 13) Acquire and configure test equipment
- 14) Execute Test Plan
- 15) Analyze and Publish Results