Small UAS Detect and Avoid Requirements Necessary for Limited Beyond Visual Line of Sight (BVLOS) Operations

Encounter Timeline

Prepared for

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1 Encounter Timeline

In order to properly attribute hazards, an encounter timeline was developed. Previous work that was considered in the development of this timeline includes Coulter (2009) and Hottman et al. (2009).

The primary steps in this timeline are Detect, Track, Evaluate, and Execute Maneuver. In the detection step, some means (e.g., an instrument like a radar) is used to sense the presence of something that must be avoided. The highest priority intruder is manned aircraft, but this could include fixed objects like towers, houses, trees, etc.

In the second step, Track, the path of the intruder is estimated. In the case of fixed objects, this is elementary. However, for moving targets, this step can be complex, and the accuracy of the resulting track depends both upon the behavior of the intruder and upon the accuracy with which the position(s) of the intruder are determined in the Detect step.

The Evaluate step involves determining whether the identified intruder poses a threat. Herein, "threat" is taken to mean that some action is required to either avoid violating well clear, as defined for sUAS operating at low altitudes, or a collision, which, of course, takes higher precedence. Numerous considerations are contained within this step, including determining whether something is a threat, determining which threats are of greatest importance (e.g., an aircraft vs. a fixed object), etc.

The final step in the timeline is Execute Maneuver. In this self-explanatory step, one maneuvers ownship to avoid producing an unwanted state (e.g., violation of a well-clear boundary). Numerous factors must be considered in the determination of the maneuver that is executed. These include proximity (e.g., τ_{mod}), the type of intruder, whether multiple intruders are present, right-of-way rules, etc. The possibility of fixed objects constraining the path that one might take to resolve a conflict is captured by the "Constraints" oval in Fig xx.

For the primary steps in this timeline, some detail regarding "sub-steps" or "sub-functions" is provided. These provide some detail, but of course do not cover all of the sub-functions. The intent is to illustrate some of the essential sub-functions.

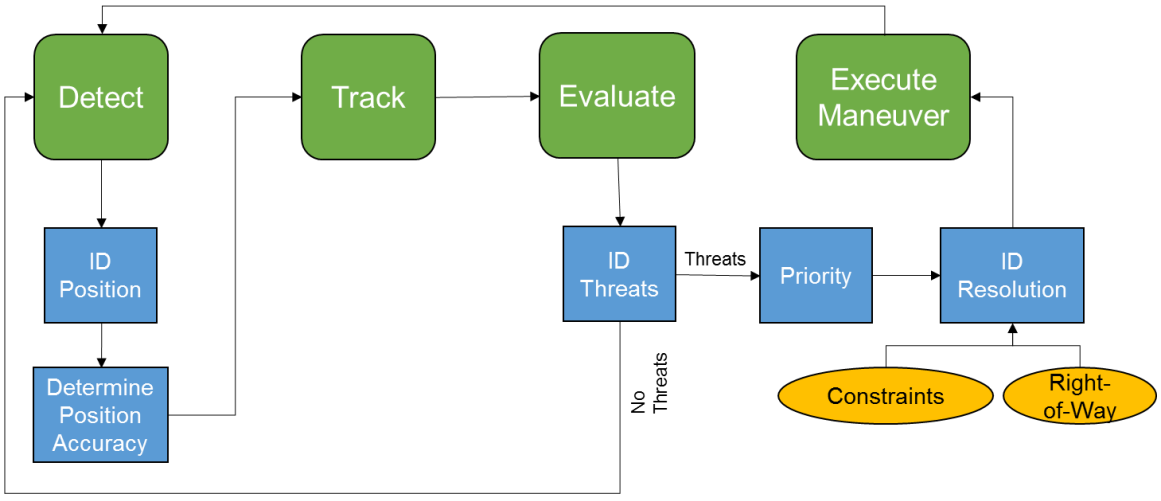

Figure xx. Illustration of the encounter timeline.

Bibliography

Coulter, D. M., 2009: UAS Integration into the National Airspace System: Modeling the Sense and Avoid Challenge. *AIAA 2009-1926, AIAA Infotech,* Seattle, WA, 10 pp.

Hottman, S. B., K. R. Hansen, and M. Berry: Literature review on detect, sense, and avoid technology for unmanned aircraft systems. DOT/FAA/AR-08/41, Air Traffic Organization Operations Planning Office of Aviation Research and Development, 88 pp.