CS 6600 Project Report: Unmanned Aircraft System

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Abstract—The abstract goes here.

1 Infrastructure

1.1 Infrastructure Description

In its simplest form, an unmanned aircraft system (UAS), is an aircraft system that operates without an onboard pilot. UAS are either controlled remotely through some form of wireless radio communication, semi-autonomously in conjunction with a remote pilot, or fully autonomously using some form of computational intelligence as navigation. These intelligent crewless vehicles have many potential uses in the defense sector, including surveillance, strategic mission execution, aerial sustainability support, and training systems, to name a few. These aircraft fall under the umbrella of cyber-physical systems (CPS), merging the intelligent navigation processes, system health monitoring, and communication with the physical mobile ariel vehicle.

We will design a proposed infrastructure security policy for the Boeing MQ-25 unmanned aircraft system, but it will also apply to similar mission support drones. The MQ-25 is an unmanned aircraft system designed for the U.S. Navy, and it provides autonomous refueling capability for the Boeing F/A-18 Super Hornet, Boeing EA-18G Growler, and Lockheed Martin F-35C fighters. This capability extends the combat range of the supported aircraft, seamlessly and semi-anonymously navigating to the plane, refueling, and returning to base. MQ-25 is the first unmanned aircraft to support aerial refueling another aircraft and is currently in the flight test phase of development [1], making it the perfect system to analyze security impacts for current and future unmanned aircraft systems.

1.1.1 Infrastructure Security Policy

Our infrastructure security policy breaks down the various actions a system user can perform using the following terms.

- *Subject*: Any entity that contains the proper rights can request the UAS perform operations, access objects, or grant rights to another subject.
- *Object*: An entity that is part of the UAS functionality or data that does not have control over another entity.
- *Rights*: A property assigned to a subject that defines its right to access an object or grant permissions to another subject.

Table 2 breaks down the subject roles involved in operating the UAS during a refueling mission. Table 1 describes the rights and their associated functionality. Table 3 contains the access control matrix (ACM) showing each subject's rights over the objects.

TABLE 1
Description of rights over objects in the UAS.

Right	Description
Owns (O)	The owner of the given object.
Read (R)	Can observe the given object.
Write (W)	Can modify the given object.
Execute (E)	Can execute the functionality of the given object.
Grant (G)	Can grant a given right to another subject.
Control (C)	Can control a given system object.
Delete (C)	Can delete a given .

1.2 Rights Leakages

The following basic HRU commands show how given our current ACM we can leak integrity right r into a subject that does not contain the right in our intial ACM. We create a simple command sqeuence that attempts to grant one right from subject p in object o to subject q in o if p has the given right.

1.2.1 Confidentiality

```
command grant_right_to_subject(r, o, p, q)
  if grant in A[p, o] and r in A[p, o]
  then
    enter r into A[q, o];
end
```

If we were to call this function with the subject *Pilot Commander (PC)* granting right *Read* to *Maintenance Crew (MC)* for object *Remote Navigation Control (RNC)*, this would cause a confidentiality right leakage.

```
grant_right_to_subject(Read, RNC, PC, MC)
```

1.2.2 Integrity

text

TABLE 2
Description of actor subject roles during a UAS refueling mission.

Subject	Description
Pilot Commander (PC)	The primary remote pilot of the UAS during the mission.
Mission Commander (MC)	Responsible for final planning and decision making during the UAS mission.
Instructor Pilot (IP)	Assists the Pilot Commander and can pilot the UAS if given permission from the PC or MC.
Quality Assurance Evaluators (QA)	Responsible for pre-flight operational checks, in-flight analysis, and post-flight evaluation.
Maintenance Crew (MC)	Handles work orders created by the QA and FDA, responsible for the maintenance of the UAS.
Flight Data Admin (FDA)	Handles and analyses all mission flight data.

TABLE 3
UAS Refueling Mission Access Control Matrix

	PC	*MC*	*IP*	*QA*	*MC*	*FDA*	**RNC**	**ANC**	**NP**	**RO**	**FED**	**RTD**
Pilot Commander (PC)	O,R,W	R,W	R,W	R,W	R,W	R,W	O,R,W,E,G,C	O,R,W,E,G,C	O,R,W,E,G,C	O,R,W,E,G,C	R,W,E,G,C	R,W,E,G,C
Mission Commander (MC)	R	O,R,W	R,W	R	R	R	R,W,E,G,C	R,W,E,G,C	R,W,E,G,C	R,W,E,G,C	R,W,E,G,C	R,W,E,G,C
Instructor Pilot (IP)	R	∅	O,R,W	∅	∅	∅	R,W,E,C	R,W,E,C	R,W,E,C	R,W,E,C	R,E	R,E
Quality Assurance Evaluators (QA)	∅	∅	∅	O,R,W	R	R	∅	∅	∅	∅	R,E	R,E
Maintenance Crew (MC)	∅	∅	∅	∅	O,R,W	R	∅	∅	∅	∅	R,E	R,E
Flight Data Admin (FDA)	∅	∅	∅	∅	R	O,R,W	∅	∅	∅	∅	O,R,W,E,G,C	O,R,W,E,G,C
Remote Navigation Control (RNC)	∅	∅	∅	∅	∅	∅	R,W,E,C	R	R	R	R	R
Autonomous Navigation Control (ANC)	∅	∅	∅	∅	∅	∅	R,W,E,C	R,W,E,C	R,W,E,C	R	R	R
Navigation Planning (NP)	∅	∅	∅	∅	∅	∅	R	R	R	R	R	R
Refueling Operation (RO)	∅	∅	∅	∅	∅	∅	∅	∅	R	R,W,E,C	R	R
Flight Engine Data (FED)	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	R,W,E,C	∅
Refueling Tank Data (RTD)	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	R,W,E,C

REFERENCES

[1] A. Erwin, and J. Gibson, Navy, Boeing Make Aviation History with MQ-25 Becoming the First Unmanned Aircraft to Refuel Another Aircraft, Accessed on: Sept. 1, 2021. [Online]. Available: https://www.boeing.com/defense/mq25/

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