Problem Statement

Advancements in Unmanned Aerial Systems (UAS) are driving requirements for autonomous aerial refueling and recovery. UAS are expected to operate side-by-side with their manned counterparts; this includes the ability to land on carriers and refuel off of tankers or buddy stores. A technical solution is required that facilitates the refueling and recovery of these unmanned systems. The desired solution would be GPS-independent because denial/spoofing has to be assumed during future conflicts.

Electro Optical Grid Reference System (EOGRS)

Over the past few years GE Aviation Systems, LLC. (“GE”) has been developing Electro Optical Grid Reference System (EOGRS) to solve the need to refuel and recover UAS in a GPS-denied environment. EOGRS consists of three main components:

1) **EO Grid Transmitter** – A laser transmitter that is installed on the buddy store and/or tanker aircraft. This provides a tanker-relative navigation reference frame for the refueling drogue and receiver aircraft.

2) **EO Grid Detectors** – Sensors that are mounted on the refueling drogue and receiver aircraft. These sensors observe the navigation reference frame and report 3-D position and velocity.

3) **Data Link** – Mounted on the tanker, drogue, and receiver aircraft. The data link provides a short range wireless local access network (LAN) to ensure the continuity, integrity, accuracy, and availability of navigation solutions. In addition, the data link provides command and control (C2) and situational awareness.
EOGRS Concept of Operation
EOGRS calculates receiver aircraft and drogue position by measuring azimuth and elevation angles from the EO Grid transmitter to multiple EO Grid Detectors. Slant range is formed from the azimuth and elevation angle measurements to two or more detectors having known physical separations. A “Common Navigation Point” (CNP) location is computed in tanker body-relative spherical coordinates. The spherical CNP location can then be transformed to tanker body-relative Cartesian coordinates (X, Y, Z) that is shared with each receiver (aircraft and drogue) via the Data Link.

Other Benefits of EOGRS
EOGRS provides a GPS-independent relative-navigation system to address the challenge of recovering and refueling UAS in a GPS denied or challenged environment. EOGRS provides other benefits for situations that require relative navigation solutions:

1) **Controllable Drogue** – modifies an existing refueling drogue with an articulated wing and EO Grid Detectors. This enables the ability to control and position the drogue in 3-dimensional space, as well as stabilize it during turbulence and aircraft bow wave effect. This provides benefits to both unmanned and manned aerial refueling, primarily by making it easier to establish contact between the tanker and receiver.

2) **Landing System** – An EOGRS solution is appropriate for shipboard helicopter landing situations, unimproved landing sites, and augments the Joint Precision Approach and Landing System (JPALS).

3) **Helicopter Slung Load Positioning** – Utilize EOGRS to assist with helicopter slung load operations to help with the placement of loads and objects.

EOGRS Applications
GE is actively engaged with industry as EOGRS is being designed and developed. Its versatile design is helping to create a solution that will enable the refueling and recovery of UAS, as well as solving other unique problems. GE has worked on the following programs with EOGRS:

- NAVAIR Data Drogue Flight Test / Data Analysis (2010)