

Safeguard Interface Box

Overview

In order to provide Safeguard with the ability to interrupt power to the vehicle and ensure range containment, an interface system was designed and tested at NASA LaRC in support of the SAND competition. This document provides a description of the interface box, schematic, parts list, operational considerations, and power interrupt wire cutter.

Interface system overview and requirements

During development of the SAND competition it was realized that implementing Safeguard as an Independent Flight Termination System (IFTS) was a requirement. Being an “independent” FTS means that reliance on the vehicle’s autopilot or other subsystems can lead to lack of range containment due to failures of the autopilot or failure of the communication link between Safeguard and the autopilot. Proceeding in this manner would ensure that vehicles would not fly outside of the competition range and provide a comprehensive assessment of Safeguard’s use in this capacity. The system needs to be able to control the vehicle without reliance on potentially unreliable vehicle subsystems. The resulting system was conceived, designed, implemented and tested, features a simple, low-cost, highly-reliable interface box along with very light and reliable pyrotechnic wire cutter.

Safeguard interface system requirements

The overarching requirement was to design an interface box that would support operations with Safeguard configured as an IFTS. Things considered in the design was the ability to operate in non-engaged or disarmed mode for developmental testing and integration with new vehicles. There also was a need to enable clear and robust operations for when Safeguard were to be used as an IFTS.

1. Provide capability to know that Safeguard is ready to be armed with the vehicle on the flight line ready to launch.

This requirement means that when the vehicle is ready to actually takeoff the crew can determine the state of Safeguard and if it was clear to arm the system without the need of a computer. Arming the system when Safeguard was in terminate mode would lead to a false trigger of the wire cutter and would abort the flight on the ground.

2. Provide the capability to operate the Safeguard system in a test or bypass mode

This requirement is intended to provide a crawl-walk-run approach towards implementation of Safeguard as an IFTS. Providing a bypass mode with indicator light gives the flight crew feedback regarding Safeguard terminations without undue risk to the vehicle. This is very beneficial when implementing Safeguard into a new vehicle or when checking new flight paths or operations with a new and untested geofence with stayin boundary. It also gives this capability without need to actually integrate Safeguard digital data to the autopilot.

3. Keep cost of the box to be less than \$200, minimize complexity, and keep weight to less than 8 ounces.

In order to support the SAND competition the interface box needs to be relatively light, low-cost, and easily made.

4. Ensure reliability of Safeguard to keep the vehicle within the defined area

This requirement is intended to ensure that whatever design was selected for the interface system that it would reliably function and not cause any false terminations as well as to terminate the vehicle when needed.

Safeguard interface system design

During development of the Safeguard interface system the chosen path was to sever power to the vehicle's propulsion system when commanded by Safeguard. Several options were considered in this design cycle that included high-power relays and electronically-triggered pyrotechnic wire cutters. Evaluation of the high-power relays indicated that they would tend to be large and heavy in order to accommodate the current required to fly the vehicle. Heat for these relays was also an issue potentially requiring large heat sinks. A single pyrotechnic wire cutter design was evaluated for this design which is



Figure 1 - Kirintec electronic wire cutter.

shown in Figure 1. The Kirintec electronic wire cutter is designed for explosive ordnance disposal (EOD) applications. The Kirintec K-cutter wire cutter has other applications wherever a wire needs to be cut from a remote location or autonomously. Each K-cutter cost \$150 each and weighs a few ounces. It can be fired by applying ~1 amp current at 5v within a few microseconds. K-cutters were procured and lab tested with representative power cables and yielded very good results.

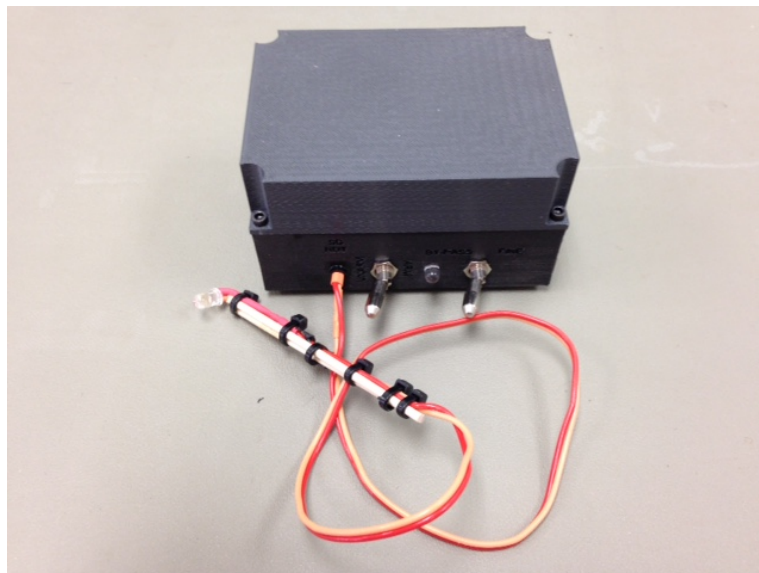


Figure 2 - Safeguard interface box.

A photograph of the Safeguard interface system box is shown in Figure 2. Two system control toggle switches and two status indicator lights are shown in Figure 2. The indicator light on the left is attached at the end of the power lead on the left of the box and illuminates when Safeguard is in operate mode and ready for arming. Providing a short extension for this light was performed to allow it to be placed in the field of view of an onboard camera for developmental testing. This light goes out when Safeguard trips into terminate mode. The toggle switch

on the left is used to arm or disarm the system. When in disarmed mode the electronic relay used to fire the K-cutter is disengaged. The status light on the right illuminates when Safeguard has fired and the system is in bypass mode. The toggle switch on the right controls whether current from the relay will flow through the wire cutter or will go through an LED light. Operating the system in bypass mode is useful to test the Safeguard system without unduly risking the vehicle. If a flight is performed that triggers a Safeguard termination in bypass mode, the right status indicator light will be illuminated when the vehicle returns from flight. This has been very useful for integration and development testing of Safeguard as an IFTS. A voltage regulator is included in the interface box to support a wide range of voltages. Testing was performed with a 4-cell LiPO battery. Provisions have also been included to enable the K-cutter to be plugged into the interface box or unplugged. This enables new K-cutters to be installed should one be triggered accidentally. Figure 3 shows the complete Safeguard system installed on a NASA DJI S-1000. The two aft-mounted GPS antennas provide GPS inputs for Safeguard. The rest of the system (main Safeguard box and interface box are on the lower tray). A dummy wire with K-cutter is shown at the front of the tray. This vehicle was configured this way for developmental testing. The schematic of the Safeguard interface system is provided in Figure 4.



Figure 3 - Flight test vehicle configured with Safeguard as an IFTS.

