

# ARGOS

**A Revolutionary High-Altitude, Long Duration Flight Platform for Long-Term Monitoring of the Radiation Environment in the Stratosphere**

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**Space Environment Technologies**

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# A Revolutionary High-Altitude, Long Duration Flight Platform for Long-Term Monitoring of the Radiation Environment in the Stratosphere

*“Later, I realized...the real barrier wasn't in the sky but in our knowledge and experience.”*

--Chuck Yeager

## I. Executive Summary

### a. Company mission statement

Space Environment Technologies (SET) is a global leader providing space weather instrumentation and cloud-based data applications. Our customers are the U.S. government, academia, and the international commercial aerospace industry. SET has built an ecosystem of complementary products and services, including support from our partners, that combines leading-edge space physics models, innovative instruments, and unique operational data feeds found nowhere else in the world. Together, these capabilities reduce adverse effects of space weather upon our planet, upon humans, and upon our technology. Our Vision of building new capabilities for living, working, and thriving in space guides our development of fundamental scientific knowledge, space weather hazard mitigation tools, satellite protection processes, radiation decision aids, navigation accuracy methods, and communication solutions.

### b. Synopsis of need and proposed solution

i. **Problem We Solve:** Radiation exposure is a natural hazard faced by aircrew, high-altitude pilots, frequent flyers, and space travelers. Multiple sources of ionizing radiation contribute dose exposure in the aerospace environment reaching from Earth's surface into space. During every flight mission, the warfighters (pilots and aircrew) as well as the high-value assets that they control receive a non-negligible dose exposure of radiation in the aerospace environment. Though needed, global, operational, real-time radiation weather monitoring and forecasting does not currently exist for safe operation in all theaters of operations. We have developed a capability for providing accurate flight path radiation specification as shown in Figure 1 for aerospace domain awareness.

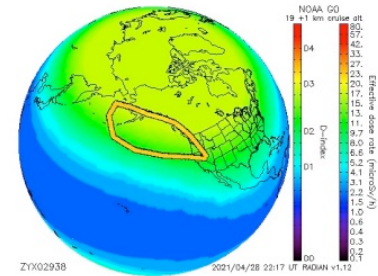


Fig. 1. RADIATION 19 km flight path in a regional radiation context.

ii. **Problem Alignment:** The radiation environment from the Earth's surface, through the atmosphere and suborbital regimes into Low Earth Orbit (LEO) space is sparsely sampled and is primarily measured for research purposes only. Modeling typically provides only climatological solutions. The system we are designing fills a missing link in global, operational, real-time radiation weather **monitoring** at high altitudes. It sets the basis for **forecasting** radiation weather by using commercial assets for the benefit the U.S. warfighter in the air and space. Results from our measurement constrained radiation environment models can be easily integrated into existing Air Force, Space Force, and other organizations' weather mission support.

iii. **Proposed Solution:** SET is developing the Aeronautical Regional Geospatial Observer System (ARGOS), which is an unmanned aerial vehicle (UAV) capable of sustained flight for up to 1 year at 20 km (70,000 feet). This low cost, mass producible vehicle will contain space weather and atmospheric radiation monitors as its primary payload and there will be excess payload capacity for payloads of opportunity. A fleet of ARGOS vehicles will serve as a system for continuous space weather measurements and monitoring at high altitudes with the goal of closing the measurement gap. Data will flow in real-time to the SET server system using state-of-the-art models as the basis for the data assimilation to create the global weather of the radiation environment. The data cube produced by this cloud-based server system will reduce exposure hazards for the warfighter as well as civilian travelers.

## II. Background and Motivation

### a. Radiation environment in the stratosphere and the RadWeather system

i. **Atmospheric radiation environment:** A complex and fluctuating spectrum of galactic cosmic and solar energetic particle radiation continually penetrate the Earth's upper atmosphere and interact to produce showers of secondary radiation. The levels of ionizing radiation produced by cosmic ray air showers are most intense at altitudes between 20-30 km, i.e., above 70,000 ft, and is called the Regener-Pfotzer Maximum as seen in Figure 2. Additionally, leakage of high energy particles from the Van Allen radiation belts causes an increment of radiation above the GCR background.

Below and in the Regener-Pfotzer maximum is where high altitude aircraft operated by the USAF, particularly reconnaissance aircraft like the U-2s and Unmanned Aerial Vehicles (UAVs) such as the RQ-4 and MQ-4C routinely operate. Flying at high altitudes subjects pilots and radiation sensitive electronics to absorbed dose rates as high or higher than those encountered aboard any other flight platform in the atmosphere or Low Earth Orbit (LEO). Quantitative details regarding radiation exposures at these altitudes are still sparse. An example of an ARMAS balloon flight to these altitudes is shown in Figure 3. The ARGOS platform

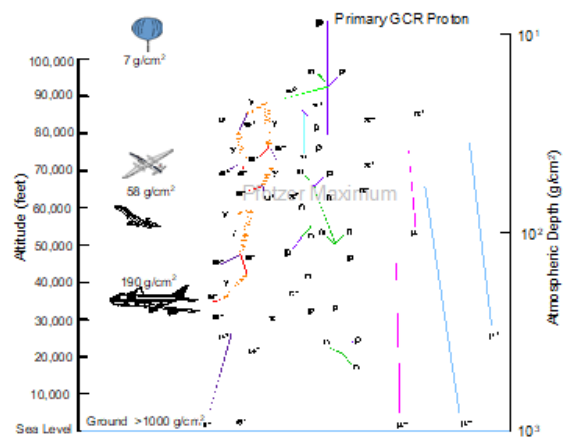


Fig 2. The primary and subsequent interaction of a Galactic Cosmic Ray (GCR) as well as the radiation produced in the atmosphere. Also shown are representative flight platforms at their average cruising altitude.

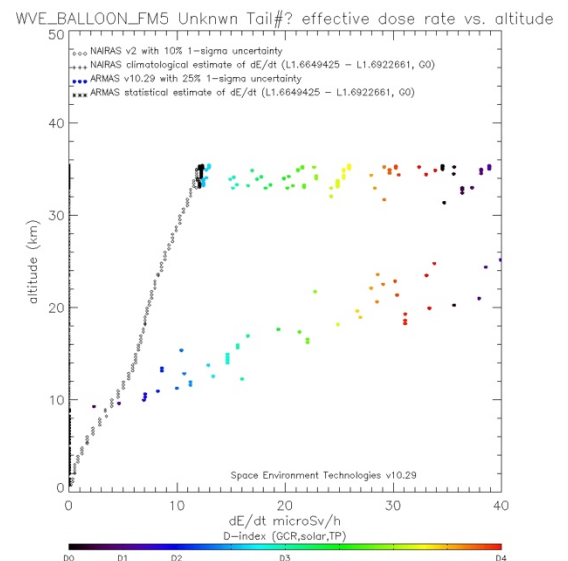


Fig 3. The ARMAS balloon flight through the Pfotzer-Regener Maximum in 2018.

will carry instruments to fill this knowledge gap as well as provide valuable information to SET’s modeling systems for applications related to radiation exposures at other altitudes. The ARGOS measurements will enable SET to deliver a robust, systematic aircrew radiation monitoring and modeling system to the aviation community that serves as the basis for an aircrew radiation safety program.

ii. **Global, real-time radiation weather system from ground to space (RadWeather):** Radiation exposure is a hazard for aircrew, high-altitude pilots, frequent flyers, and space travelers from the Earth's surface up to altitudes beyond Low Earth Orbit (LEO). A global, operationally real-time radiation weather monitoring and forecasting system is crucially needed since multiple ionizing radiation sources can cause adverse health effects, including cancer. The RadWeather system provides a decision-aid tool for warfighter mission planning of options that reduce radiation exposure hazards. It will provide Technology Readiness Level 9 information from measurements and data assimilative models, along with cloud-based server systems, addressing mission requirements for ionizing radiation mitigation (Figure 4).

**b. The ARGOS platform provides radiation measurements in the stratosphere**

The ARGOS system will be fleet of aircraft deployed in the stratosphere. With a global reach enabled by continuous solar array power on each aircraft, an ability to deploy anywhere with vertical take-off and landing without a runway, using global satellite communications, and a network of vehicles creating a 24/7/365 data stream from multiple locations around the world, ARGOS is a unique technology that will fill the stratospheric information gap with continuous radiation monitoring that has never been achieved before. The high-level CAD design of ARGOS is shown in Figure 5 and is designed to provide continuous and autonomous high-efficacy radiation measurements for up to a year at altitudes just below the Regener-Pfotzer maximum of 20 km. To accomplish these goals, the ARGOS has a host of unique design characteristics and specifications. These unique design features include:

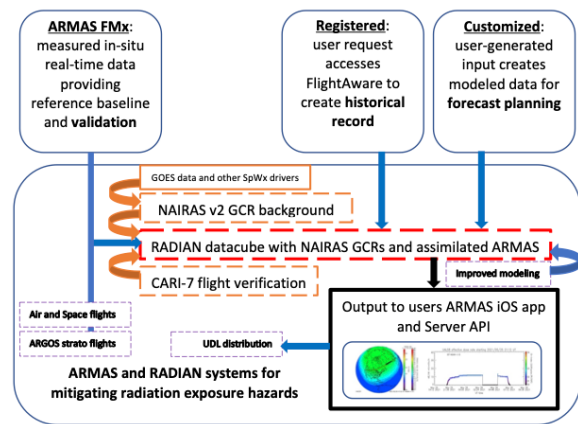


Fig 4. The SET RadWeather System concept.

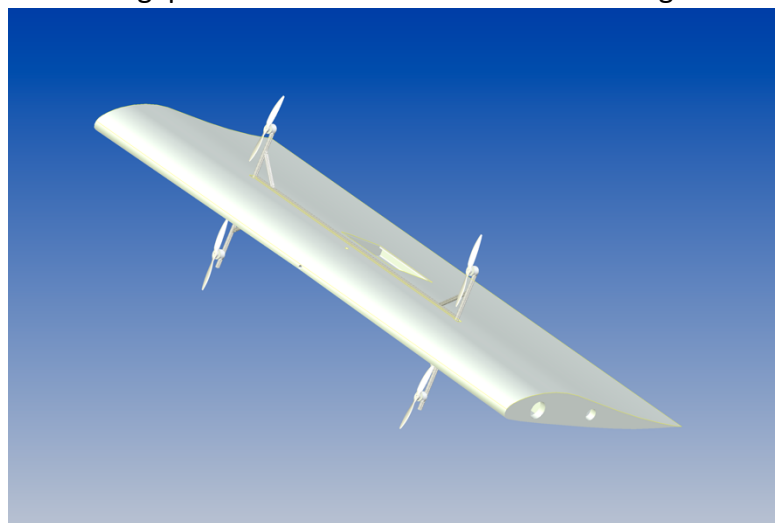


Fig 5. The ARGOS design for stratospheric flight without struts.

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- Solar array power: at 20 km sunlight is unobstructed and abundant. Collected energy will power flight during the day while storing excess for the night.
  - Vertical Take Off and Landing (VTOL): ARGOS can take off and land anywhere without a runway. From a single operations location there is a capability for global reach.
  - A flying-wing design measuring 5 m by 2 m. This flying wing design was chosen to maximize lift, minimize drag, minimize mass, and to maximize the surface area for solar arrays to power the craft.
  - 4 propellers mounted top and bottom of the wing, with landing struts protruding below them.
  - Autonomous control through an onboard computer system and software.
  - Payload capacity for a dozen payloads, including radiation monitoring, with a total mass of 5 kg.
  - Satellite link communications.

ARGOS Phase I design is proceeding with the computer aided design (CAD) for the first prototype (ARGOS 1) complete (Figure 5), the avionics purchased and going through configuration, and the first build underway. The first flight, scheduled for December 2021, will see the first VTOL tests with pitchover to horizontal flight in the troposphere anticipated within the first 10 flights. The goal in the first flights is to validate flight stability, ascend/descend/lateral control, and command authority.

There are challenges remaining and this white paper is offered to find additional resources to speed the development of ARGOS in high altitude testing, including first full flight demonstrations for duration at 20 km by June 2022.

### **III. ARGOS core attributes**

#### **a. Mission type assumptions**

- Mission duration: long-duration (months)
- Mission location: vertical take-off and landing (anyplace, anytime)
- Mission areas of interest: local monitoring with global reach (operate in a locale, transit to remote global locations from a single site if necessary)

#### **b. Size, weight, and power**

- 5 x 2 x 0.5 m wing dimensions
- 35 kg total vehicle mass with ~5 kg allocated for total payload
- 44 VDC power
- Satellite communications for data retrieval and commanding

#### **c. Flight altitudes**

- 20 km (nominal)
- <1 km (optional) with scaled-down vehicle (~1/2 size)
- Ascent and descent through entire troposphere into the lower stratosphere

#### **d. Payloads**

- ARMAS radiation detection, GPS, air velocity, temperature, pressure, magnetometer, camera

#### IV. Funding needed for ARGOS development

The following Table 1 shows the ARGOS development tasks, their success criteria, notional schedule, and funding needed for task completion.

Table 1. ARGOS vehicle development

ID	Task	Success criteria	Schedule	Funding
1	Avionics testbed	HITL complete	12/03/2021	\$5K SET
2	Power testbed	Motors calibrated	12/03/2021	\$5K SET
3	Structure manufacture	Delivery to SET	12/03/2021	\$5K SET
4	Structure integration	Rails attached to wing	12/03/2021	\$5K SET
5	ARGOS 1 integration	Avionics & power attached to structure	12/10/2021	\$5K SET
6	Test 1: VTOL demo	Stable take-off, hover, control, landing	12/11/2021	\$5K SET
7	Test 2: horizontal demo	Pitch-over, horizontal stability, control	01/15/2022	\$20K AFWERX
8	Test 3: ascent demo	Flight to 0.12 km (400 feet)	01/31/2022	\$20K AFWERX
9	Test 4: payload demo	Data receipt from payload	02/15/2022	\$10K AFWERX
10	Test 5: autonomous ops	Cruise control and RTH	02/28/2022	\$50K TBD
11	Solar power testbed	HITL complete	03/15/2022	\$50K TBD
12	Solar power upgrade	Retrofit ARGOS 1	03/31/2022	\$100K TBD
13	Test 6: altitude evolution	Flight to 5 km	04/15/2022	\$100K TBD
14	Communication testbed	Satellite link	04/30/2022	\$50K TBD
15	Communication upgrade	Retrofit ARGOS 1	05/15/2022	\$100K TBD
16	Test 7: altitude goal	Flight to 20 km	05/31/2022	\$100K TBD
17	Test 8: short flight	12-hour flight at area of interest	06/15/2022	\$100K TBD
18	Test 9: long flight	Multi-day flight at area of interest	06/30/2022	\$100K TBD
19	TRL 8 complete	All ops and payload retrieval complete	07/01/2022	