

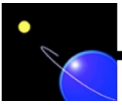
Towards managing the radiation environment effects on aviation

NBAA November 19, 2015

Emerging Aviation Weather Research

W. Kent Tobiska

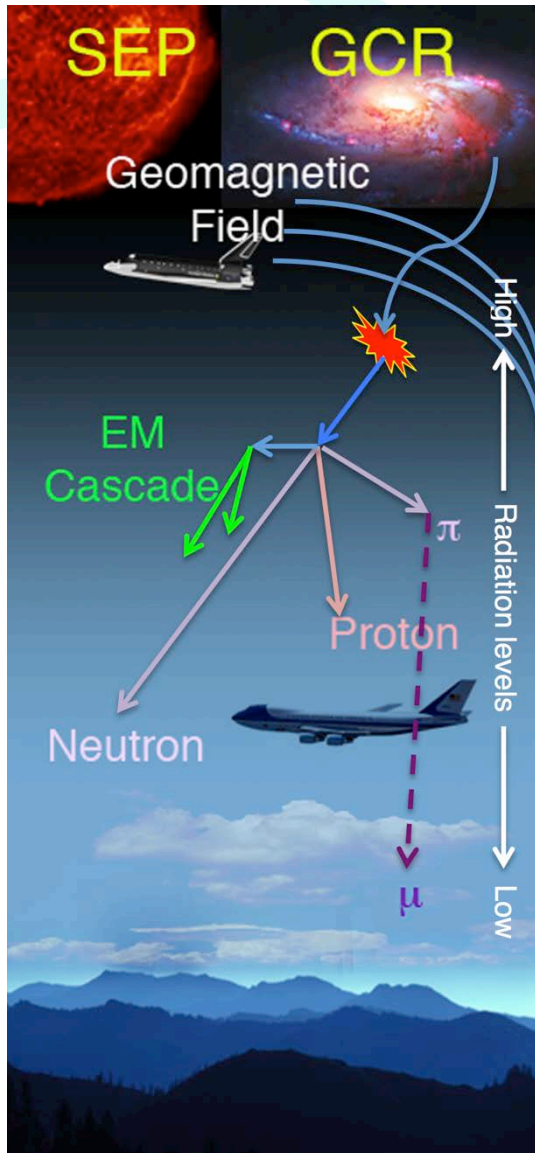
President and Chief Scientist
Space Environment Technologies
<http://spacewx.com>

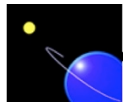


Space weather creates the aviation radiation environment

Aviation radiation exposure comes from

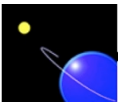
- GCR background dose (career health)
- SEP event dose (fleet operations and aircrew/passenger safety)





ARMAS Objective:

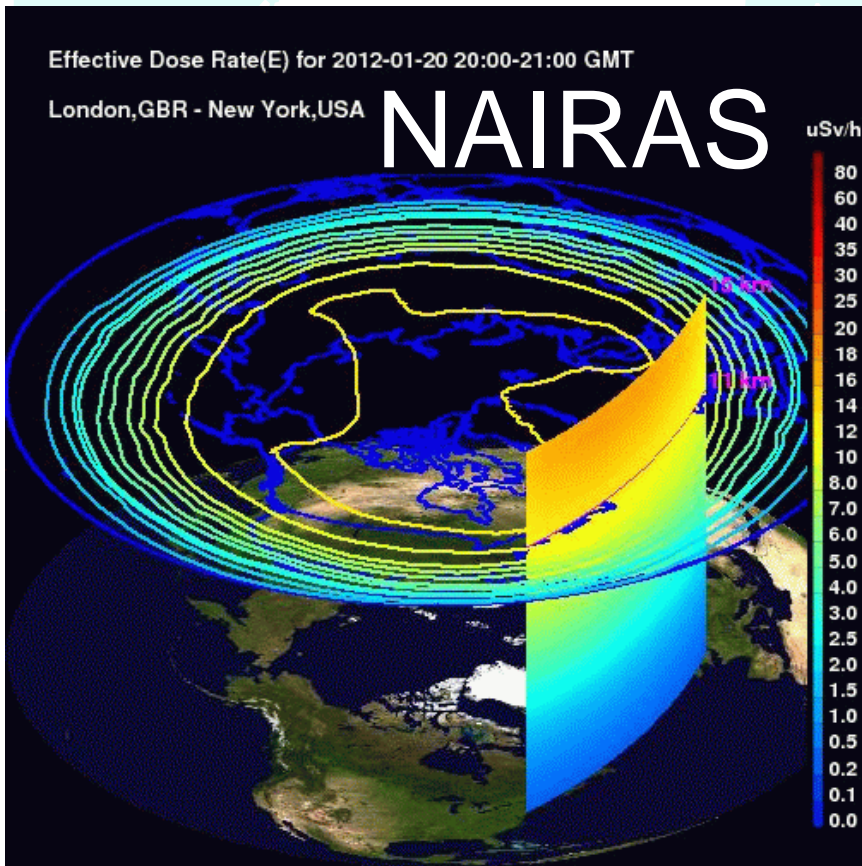
Build a **real-time, operational system** to measure and report aviation radiation for use by pilots, operators, and air traffic management



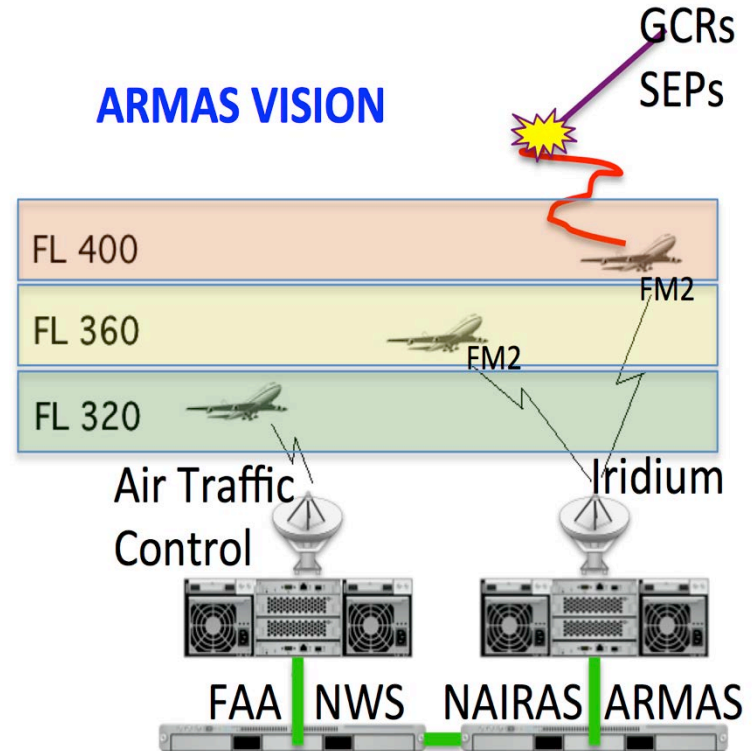
NAIRAS and ARMAS

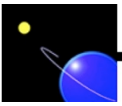
Real-time global aviation radiation climatology

Real-time local aviation radiation measurements



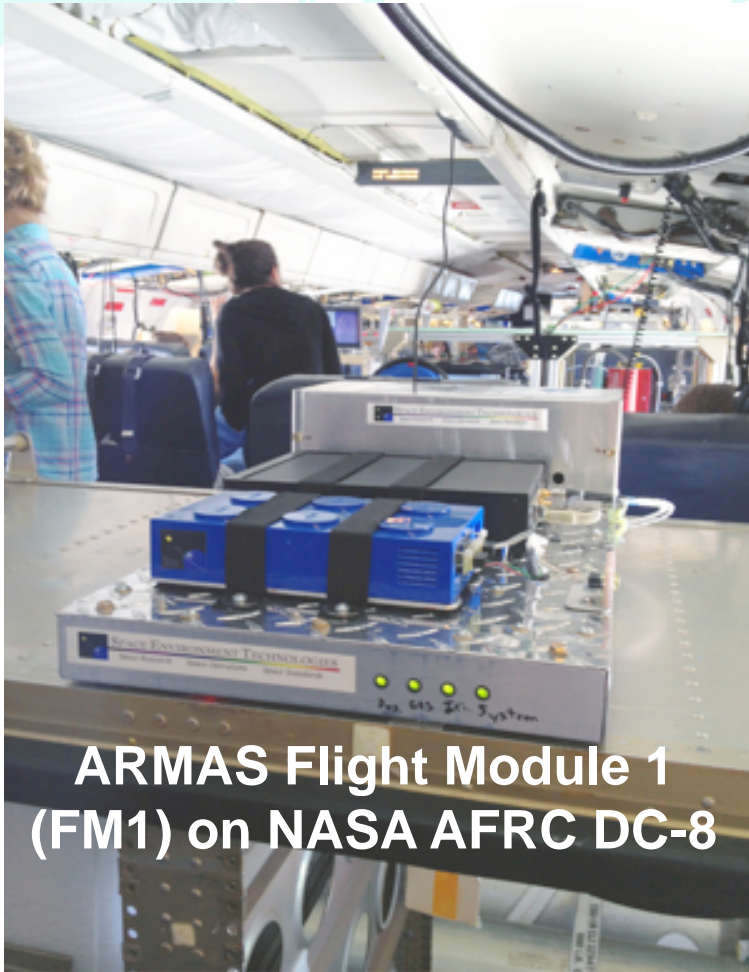
ARMAS VISION



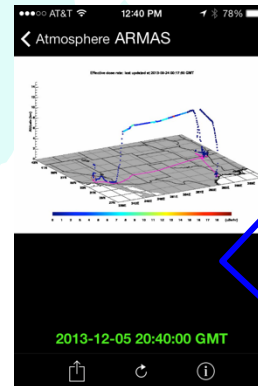


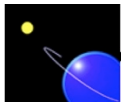
ARMAS real-time measurement demonstration

100 NASA DC-8, NOAA G-IV, NSF G-V flights 2013-2015



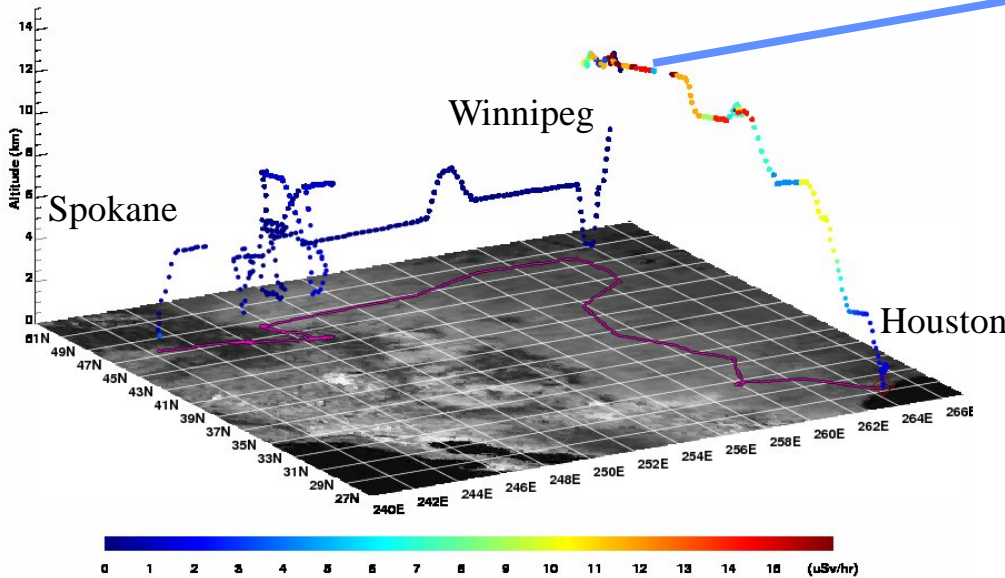
ARMAS Flight Module 1 (FM1) on NASA AFRC DC-8



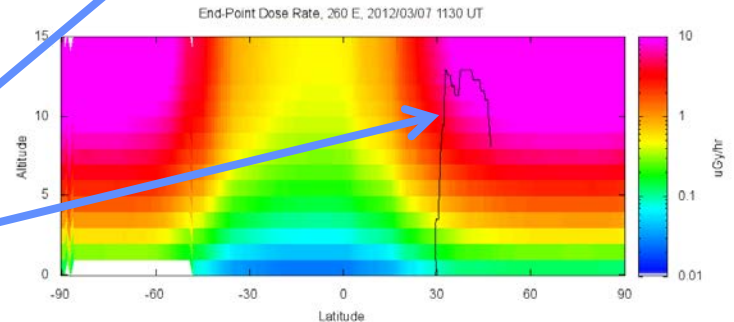
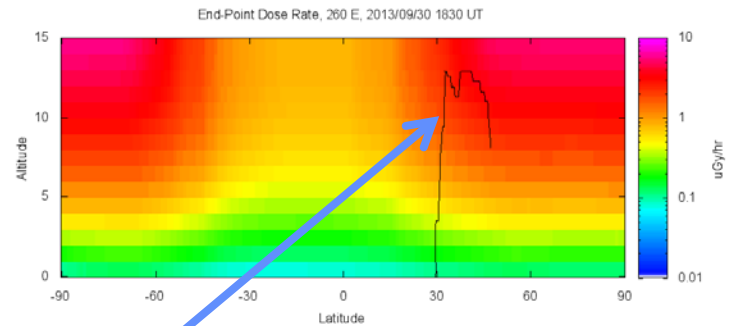
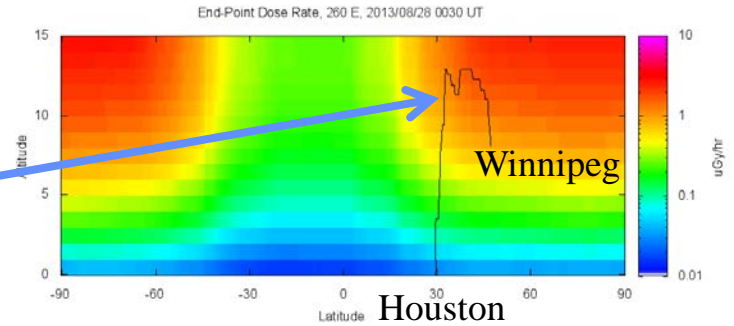


ARMAS FM1 (2013-2015) – flight 18 example

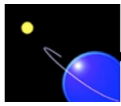
Effective dose rate: last updated at 2013-08-28 02:48:40 GMT



Emerging Aviation Weather Research

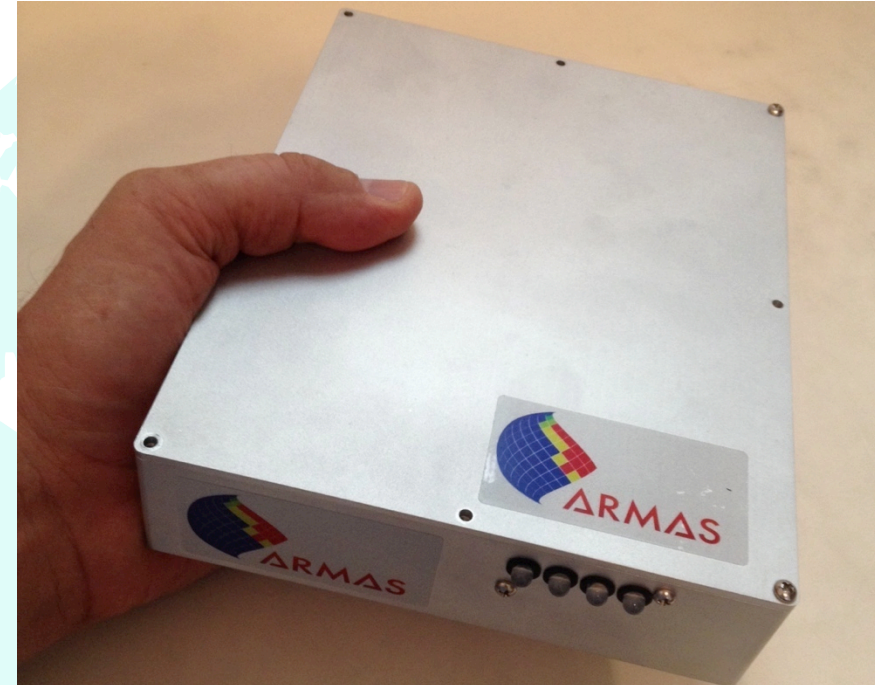


- **Top:** ARMAS flight 18 (August 28, 2013)
- **Middle:** S2 event (September 30, 2013)
- **Bottom:** S3 event (March 7, 2012)



ARMAS FM2 Deployments in 2015

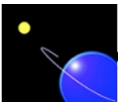
- Korea Space Weather Center purchased two FM2s as part of ARMAS Phase IIE commercialization
- FM2s were deployed to NOAA G4 and NSF G5 in Feb-Mar 2015
- Data became available to the community starting in June 2015 from the NOAA G4



NSF G5

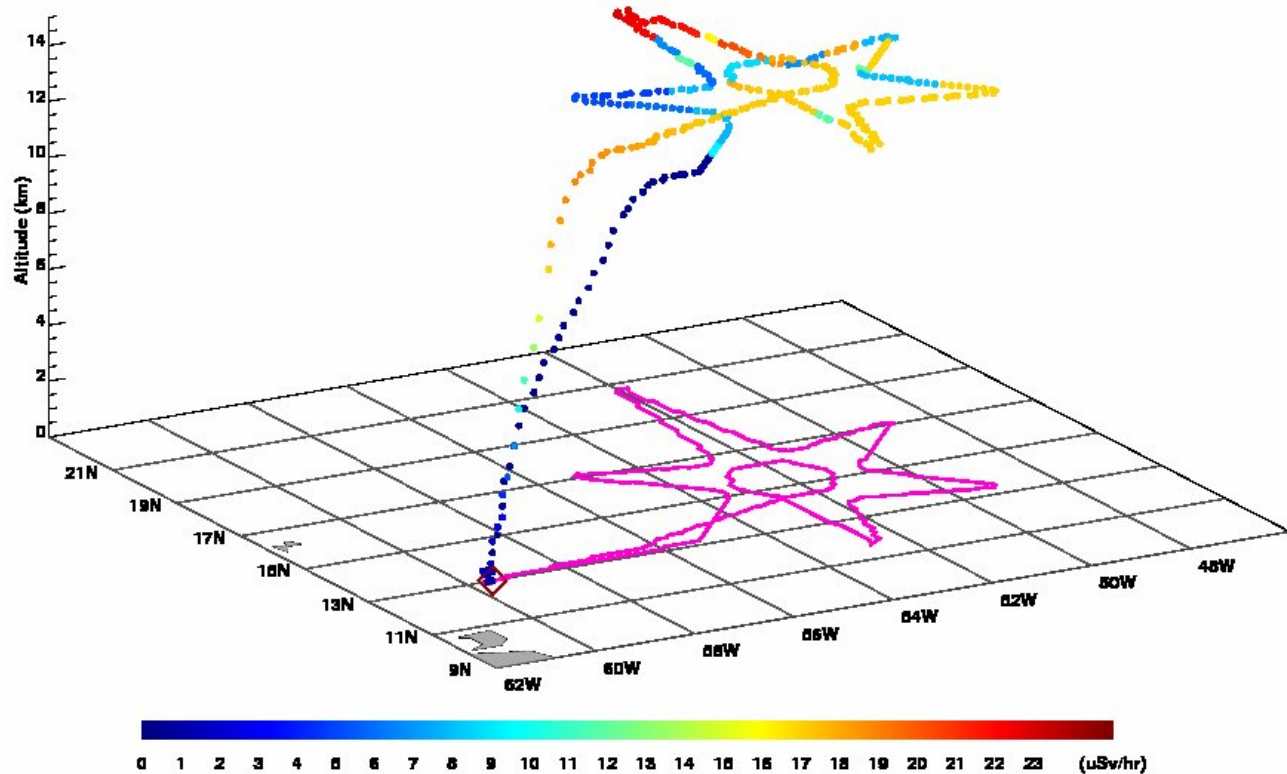


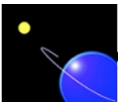
NOAA G4



NOAA G-IV flight profile (ARMAS FM2) for Hurricane Danny (August 2015)

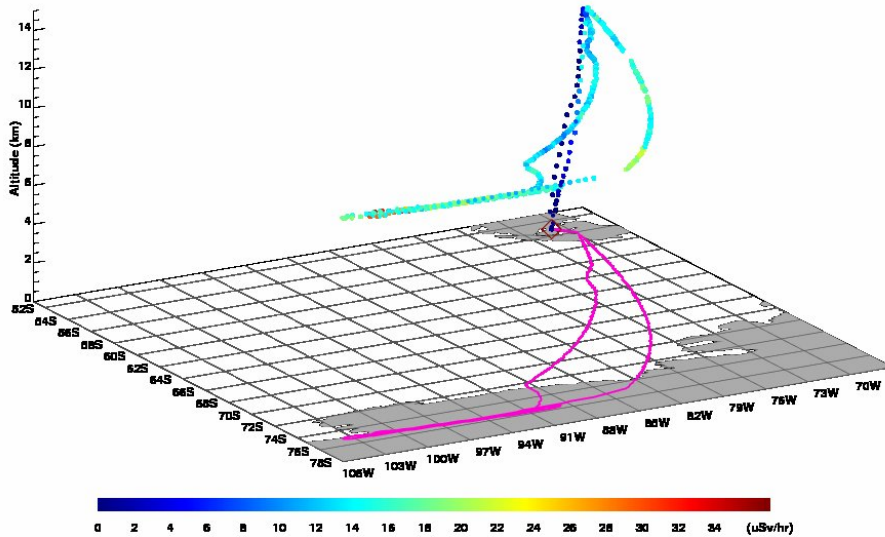
Effective dose rate: last updated at 2015-08-25 20:47:20 GMT



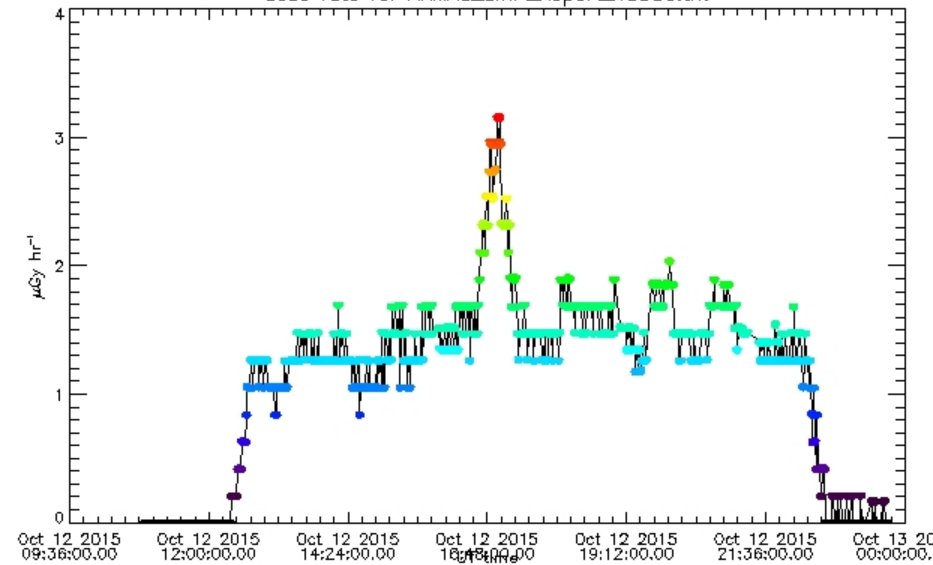


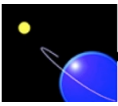
NSF G-V flight profile (ARMAS FM2) for Antarctica (October 2015)

Effective dose rate: last updated at 2015-10-12 23:41:00 GMT



dose rate for ARMAS_dirIP_Report_43550.txt





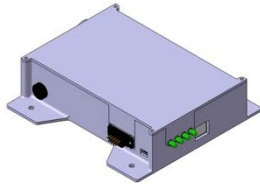
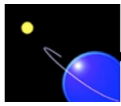
AFRC ER-2



ARMAS FM3 Deployment in 2015

- NASA Armstrong Flight Research Center has acquired one FM3 as part of ARMAS Phase III commercialization
- Deployment on the ER-2 in June 2015
- Data will be available to the community beginning Q3 2015



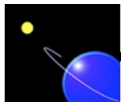


ARMAS FM4

Deployment

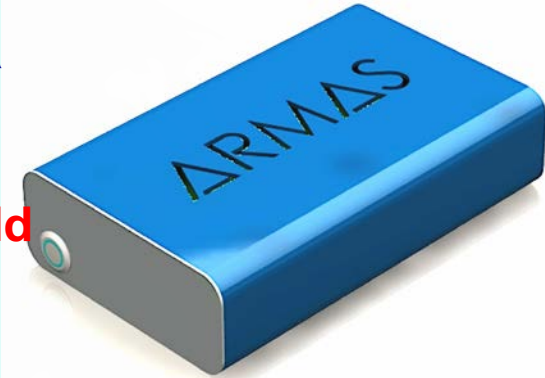
- Stratospheric balloon flights starting in 2016 under MOU between World View and SET
- Data will be extended to ~40 km as a World View pathfinder payload

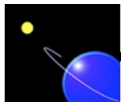




ARMAS FM5 on business jets in 2016

- FM5 has micro dosimeter, GPS, Iridium, and Bluetooth in a size similar to a smart phone
- All altitude ranges and all sources of radiation
- **Personal dose exposure reported anywhere in the world** providing situational awareness
- **Provides management options for rad flight events**
- FAA compliant (stand-alone unit with no attachment to plane)





Real-time Automated Radiation Measurements for Aerospace Safety (ARMAS) website

The screenshot shows the ARMAS website in a browser window. The browser address bar displays `sol.spacenvironment.net/~ARMAS/index.html`. The website header includes the ARMAS logo and the title "Automated Radiation Measurements for Aviation Safety". A navigation menu lists "About ARMAS", "Partners", "Gallery", "Current Dose Rates", and "News".

The main content area features a sidebar with a menu: Home, Overview, NAIRAS, Gallery, Movies, Instruments, Data, and Documents. The "Overview" section is active, displaying the following text:

ARMAS

The Automated Radiation Measurements for Aviation Safety (ARMAS) project uses an innovative approach with a low-cost dosimeter sensor to enhance Earth science research and improve aviation safety. The ARMAS team will deploy and obtain data from dosimeters to be flown on commercial aircraft. These data will be retrieved in real-time, downlinked to the ground, and used in the validated Nowcast of Atmospheric Ionizing Radiation for Aviation Safety (NAIRAS) modeled radiation environment. The result will be improved accuracy of radiation dose and dose rates along flight tracks. In doing so, the ARMAS project has made a significant contribution toward improving U.S. and international aviation safety by laying the groundwork for an automated, reliable operational system that can monitor the natural galactic and solar radiation environment at commercial aviation flight levels.

Accomplishments

The accumulated radiation doses from the flight tests were produced by an operational-grade integrated system that:

1. Acquires dose rate and GPS data on board.
2. Forms Iridium data packets that are sent in real-time.
3. Captures the real-time aircraft and NAIRAS most recent run data on servers at SET.
4. Pre-processes the data for differences from NAIRAS climatology at USU SWC.
5. Stores those results in an operational database.
6. Provides those results to NASA LaRC for generating accumulated dose rates over flight paths.
7. Delivery of dose rate jpegs to web sites and smart phones with ~15 minutes latency from original measurement.

Below the text is a section titled "Current Dose Rates (also see [Movies](#))" containing a 3D plot. The plot shows "Effective dose rate" on the vertical axis and "Time" on the horizontal axis. The data is represented by a series of colored lines (blue, green, yellow, red) that fluctuate over time. A color scale at the bottom of the plot ranges from 0 to 14, with a legend indicating units of $\mu\text{R/h}$.