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Progress Towards Real-Time Radiation Measurements on Aircraft

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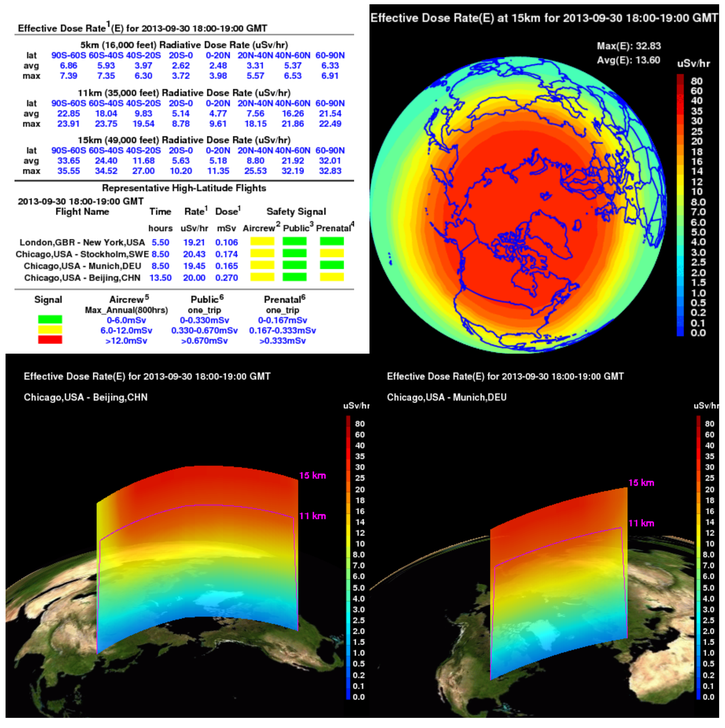
ARMAS builds on NAIRAS

- ARMAS (Automated Radiation Measurements for Aviation Safety) evolved from the highly successful NAIRAS (Nowcast of Atmospheric Ionizing Radiation System)

  - NAIRAS was a NASA LWS TRT funded Applied Sciences Program (2008-2011)
  - It developed an operational prototype for a global, real-time, data driven predictive system needed to assess biologically harmful radiation exposure levels for aviation.

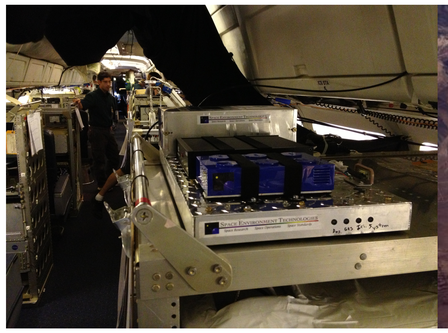


- **Objectives:**
  - Deploy and obtain real-time data from a dosimeter flown at commercial air traffic altitudes
  - Integrate real-time data into the NAIRAS modeled radiation environment
  - Improve the accuracy of radiation dose and dose rates along flight paths
  - Improve aviation safety by laying the groundwork for automated, reliable monitoring of the natural radiation environment at commercial aviation flight levels.

- **Team:**
  - Space Environment Technologies
  - Prairie View A&M University
  - Boeing
  - Utah State University Space Weather Center
  - FPS
  - Collaborators: NASA LaRC, Aerospace Corp., ASTRA, Teledyne, aviation pilots

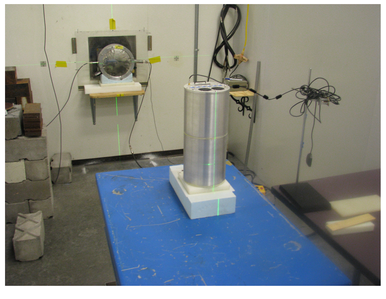
Flight Module

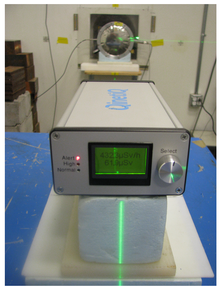
- NASA Dryden Flight Research Center provided 29 flights aboard DC-8
  - DC-8 flights occurred over a range of magnetic latitudes and longitudes, obtaining GCR dose measurements.

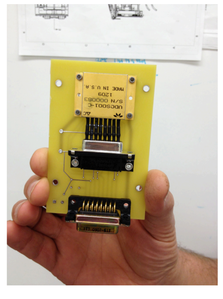


Calibrations with TEPC

- Tissue Equivalent Proportional Counter (TPEC)
  - TEPC is the community standard for tissue equivalent dosimetric measurements
  - TEPC collects data as a function of time
    - ✓ Measures the dose and estimates the dose equivalent by making spectral measurements of the lineal energy loss of the radiation as it passes through the detector volume
    - ✓ Omni-directional detector is surrounded by tissue equivalent plastic and internal propane gas to provide an energy deposition response similar to human tissue
    - ✓ Detector gas is at very low pressure (mass of gas is similar to a human cell)
  - TEPC HAWK instrument is maintained and operated by Prairie View A&M University







- ARMAS micro dosimeter (Sunset) – TEPC Calibration
  - First-time exposure of Teledyne dosimeter to neutrons
  - 1 hour of neutron beam time ~ 30,000 hours at 40,000 feet
  - Dose per neutron of a given energy measured (0.1-800 Mev)
  - 12 separate tests were done to determine Sunset susceptibility to neutrons
    - ✓ Background @ 777 ft. (237 m)
    - ✓ Background @ 7319 ft. (2231 m)
    - ✓ Without shielding
    - ✓ With thin Al cover 0.21 g/cm^2
    - ✓ With "airplane" Al 5.2 /cm^2 and HDPE 3 g/cm^2
    - ✓ With scattering 20^0 off-beam axis

Vision and Progress

- ARMAS will utilize airborne micro dosimeters, calibrated to TEPC, to make dose and dose rate measurements in real-time, transmit the data to the ground for data implementation into NAIRAS, and then distribute the updated information on to the end user

Data Integration and Test

- Preliminary Ground Test plan
  - Sunset flight experiment on DC-8 will measure real-time ambient dose rate with at least 1- minute time granularity and GPS position to within 200m (1s)
  - Use GPS on DC-8 and Iridium satellite link to transmit data in 5-minute packets
  - TEPC will fly simultaneously for cross comparison but will record data
  - CASES GPS will fly simultaneously for cross comparison of position
  - Pressure level flight logs will be used for NAIRAS post analysis
  - Sunset accumulated ambient dose and DC-8 GPS will be transited to the ground via Iridium satellite link
  - Ground data packet receipt will be verified by FPS and SET
  - Data will be assembled into ambient dose rate time series for each channel of data (nGy/ minute) and inserted into database as archival and most recent files
  - SET database will separately contain most recent NAIRAS global ambient dose equivalent rate data
  - USU SWC will extract most recent NAIRAS and files from SET database
  - Sunset flight data will be reported as a difference from 3D NAIRAS cells (1°x1°x1km) using a flight tracking radius filter
  - Small-sized difference files will be returned to database for NAIRAS extraction and conversion to effective dose rate
  - Goal is real-time update latency of less than 1⁄2 hour
  - Successfully accomplished all the above and successful real-time update latency of 15-minutes achieved