Instrumentation for Unmanned Aircraft Systems (UAS)

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Objective

- Discuss how instruments are used for conducting airborne measurement in atmospheric research programs.
- What specific application are going on at the University of North Dakota.
- What are the prospects for UAS measurements?

Cloud Deck from Citation Research Aircraft
August 30, 2012

Right Wing of Citation Research Aircraft
September 2, 2012

Impact of Measurements on Research Progress

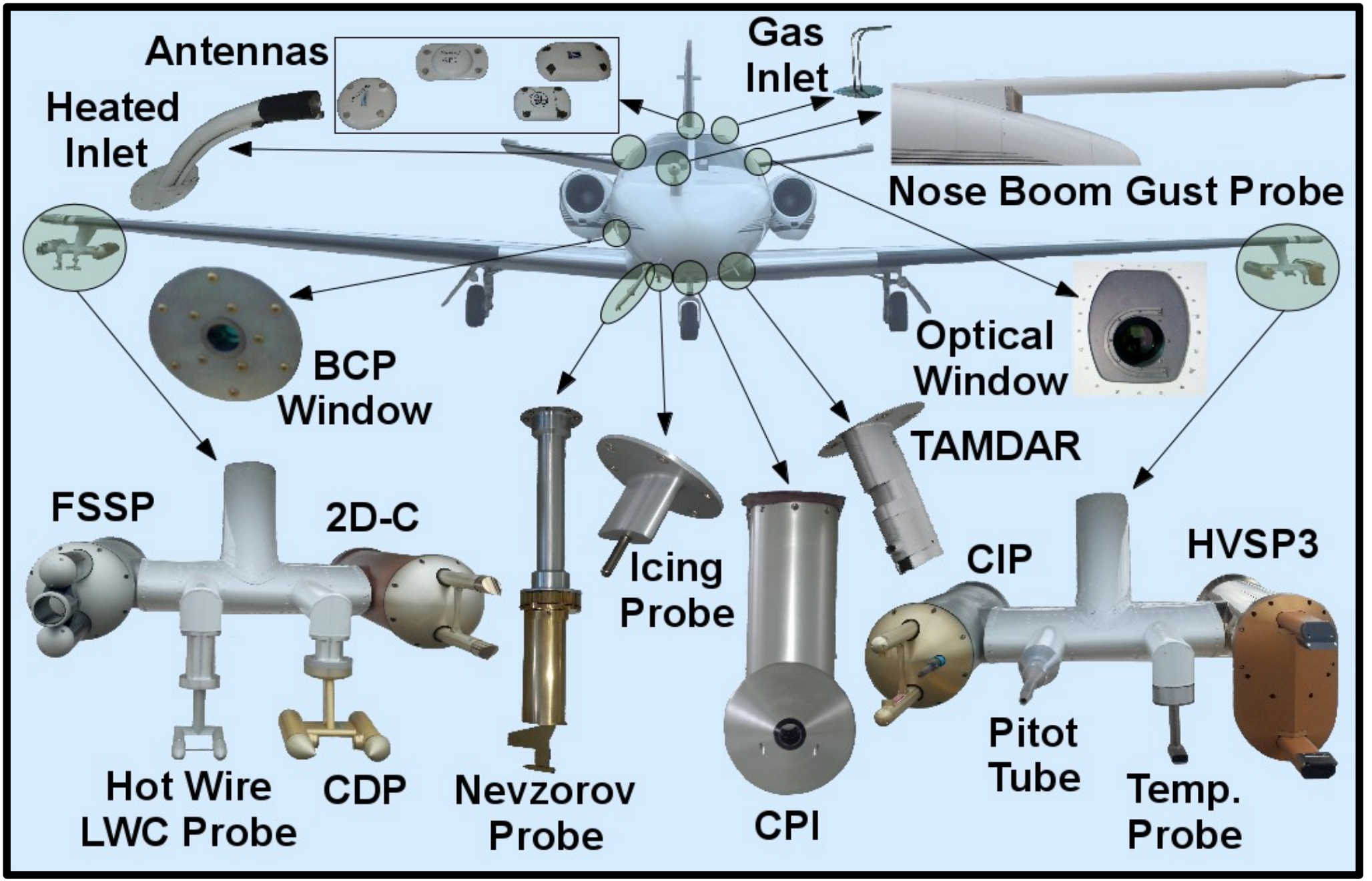
The scientific method consists of **the collection of data through observation** and experimentation, and the formulation and testing of hypotheses - *Merriam-Webster Dictionary*.

"The returns [of science] are so large that it is hardly necessary to justify or evaluate the investment" National Science Foundation. 1957, Basic Research: A National Resource, page 61

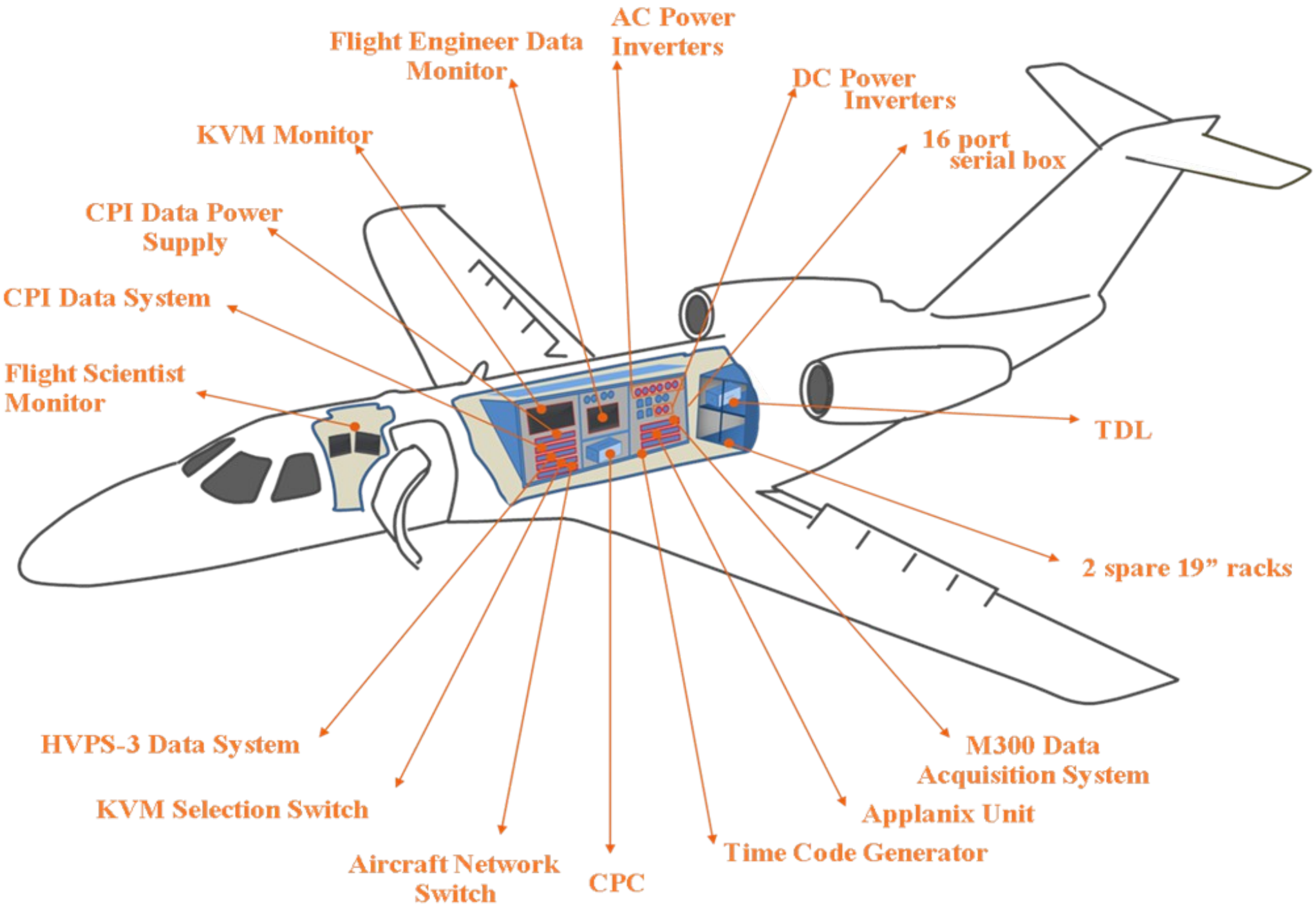
"A $3.8 billion investment drove $796 billion in economic impact, create 310,000 jobs and launched the genomic revolution." Economic Impact of the Human Genome Project.

National Academies (US) Committee on Measuring Economic and Other Returns on Federal Research Investments. Measuring the Impacts of Federal Investments in Research: A Workshop Summary. Washington (DC): National Academies Press (US); 2011. 8, EMERGING METRICS AND MODELS. Available from: https://www.ncbi.nlm.nih.gov/books/NBK83139/

Advanced Instrument on Airborne Platforms for Field Projects

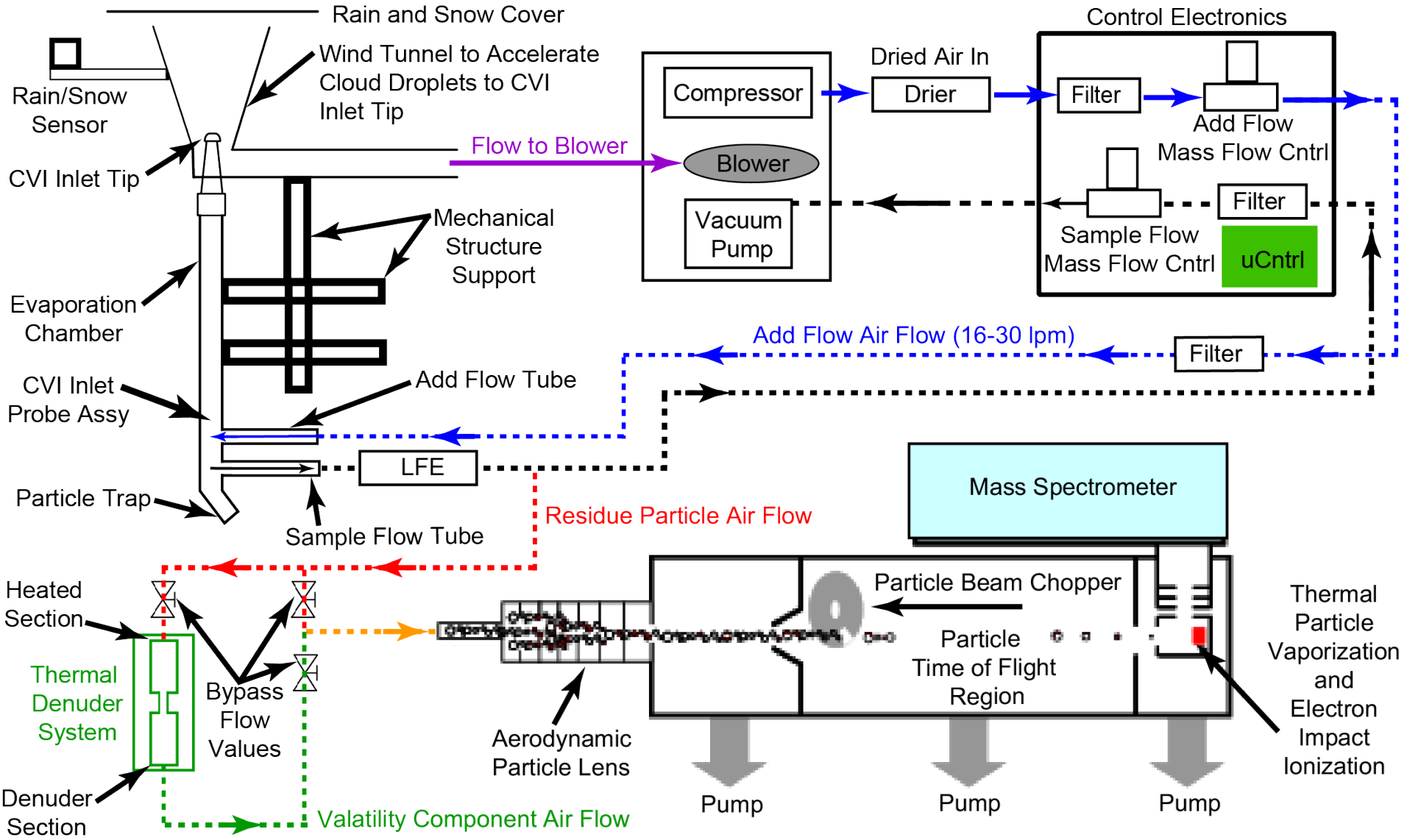


Scientist Will Fill Any Platform



Are some Instrument just to complex for UAS operations?

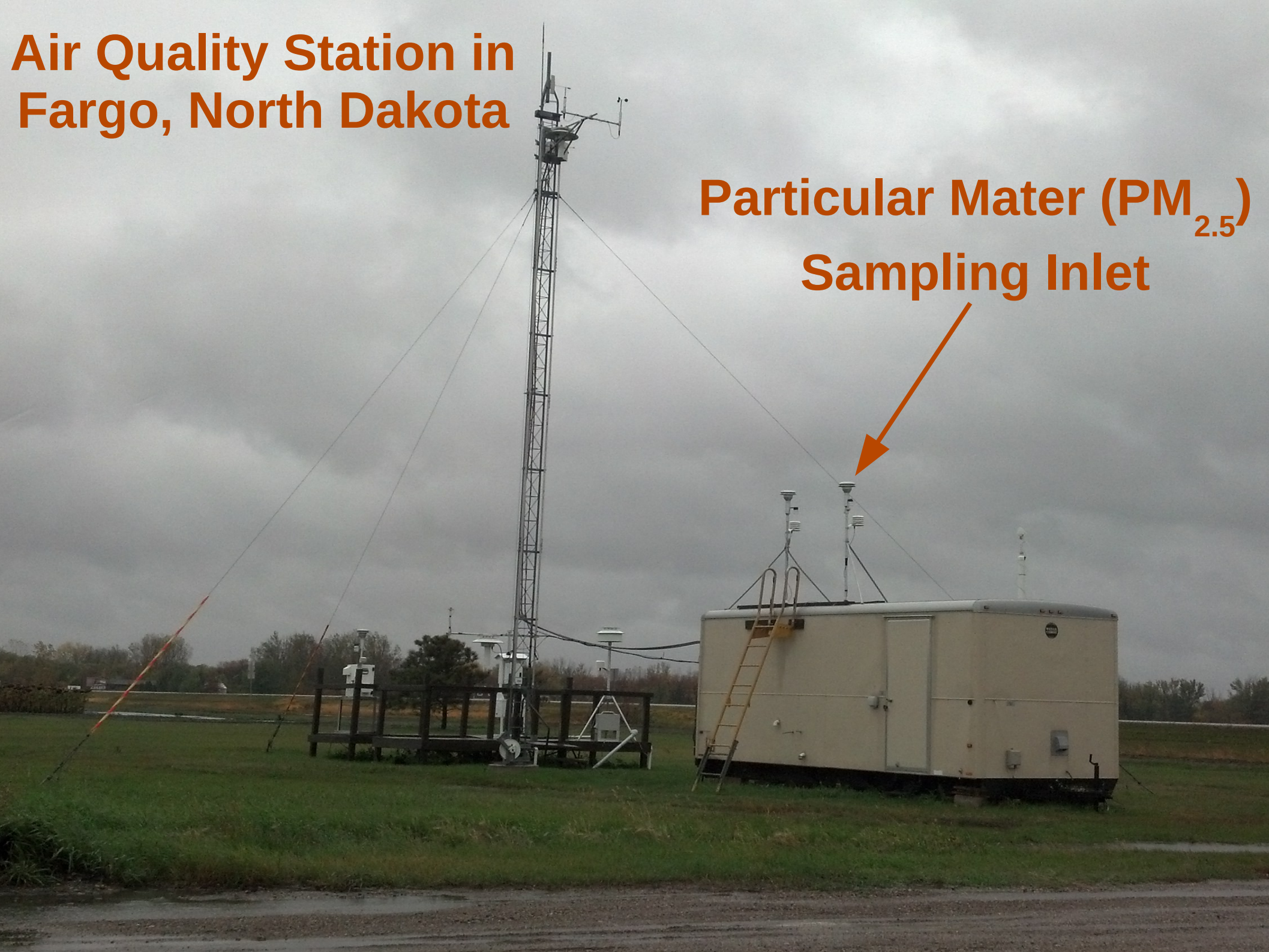
Counterflow Virtual Impactor, Thermal Denuder, High Resolution, Time-of-Flight, Aerosol Mass Spectrometer (CVI-TD-HR-ToF-AMS)



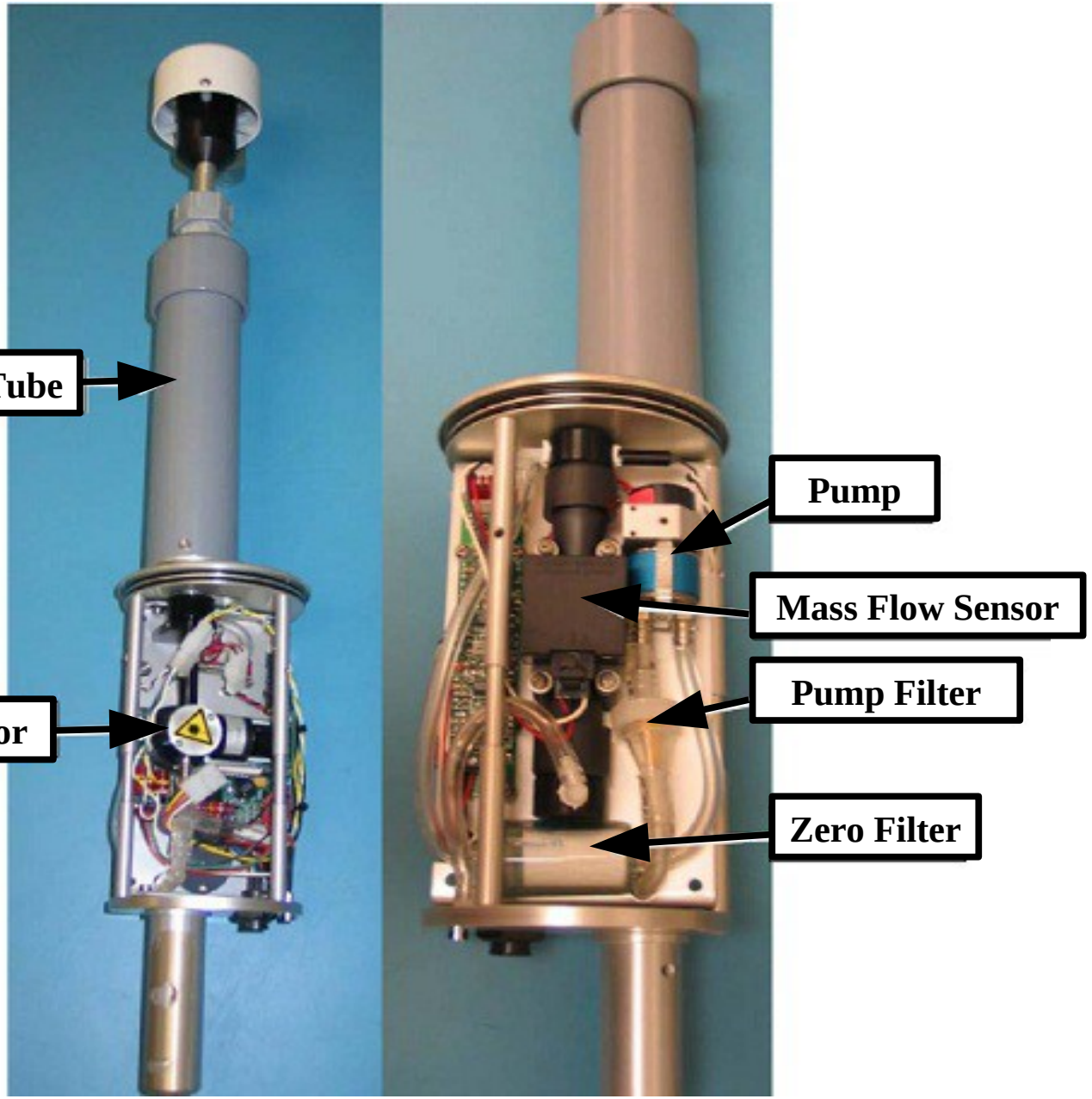
NSF Proposal: Major Research Instrumentation: Acquisition of an Aerosol Mass Spectrometer

Airborne Aerosol Mass Spectrometer Instrument

Top Left Image from Aerodyne Research Web page, http://www.aerodyne.com/products/aerosol-mass-spectrometers

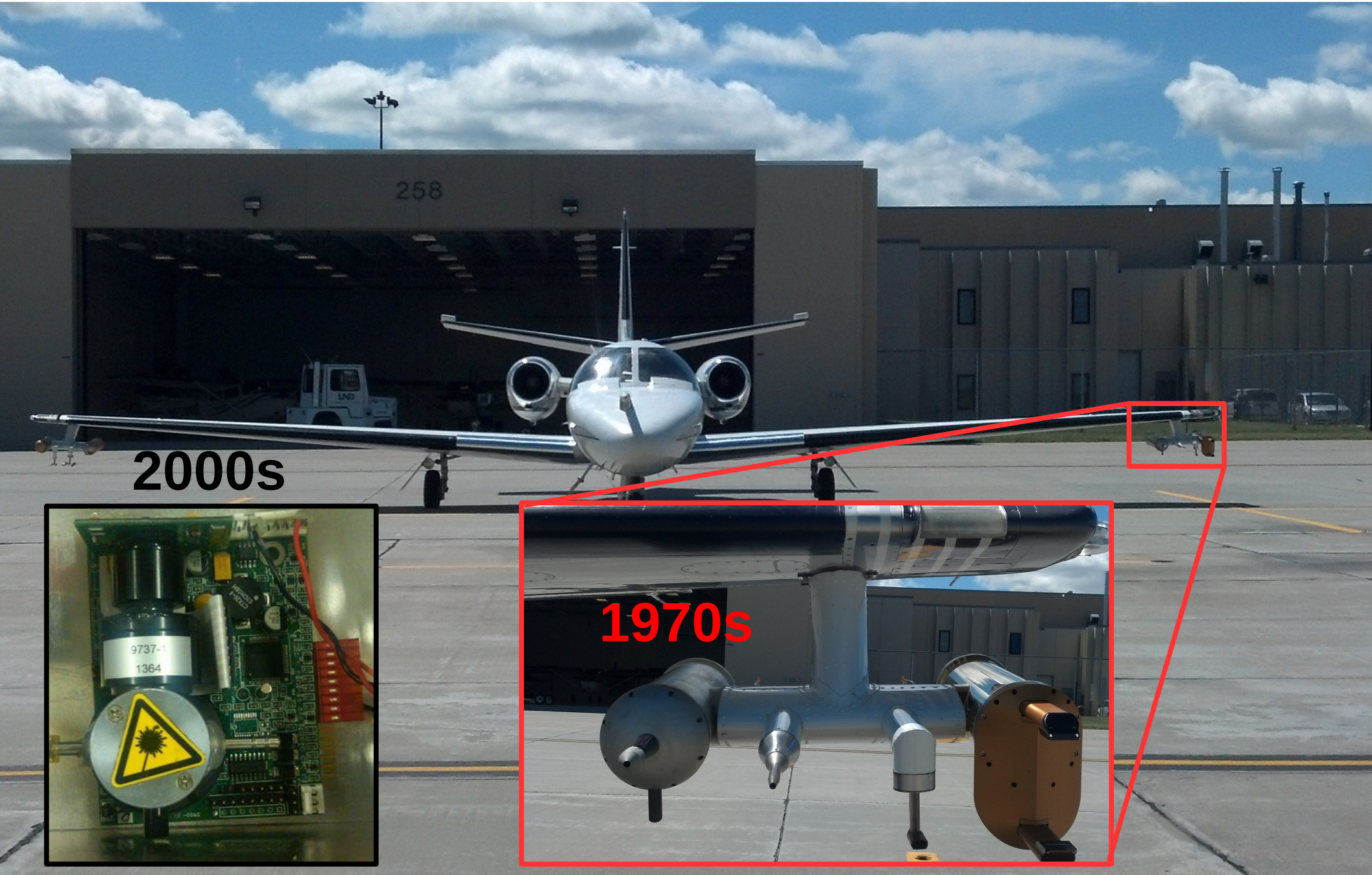

Air Quality Station in
Fargo, North Dakota
Particular Mater ($PM_{2.5}$)
Sampling Inlet

Met One 212-2 Eight Channel Particle Counter Particulate Profiler



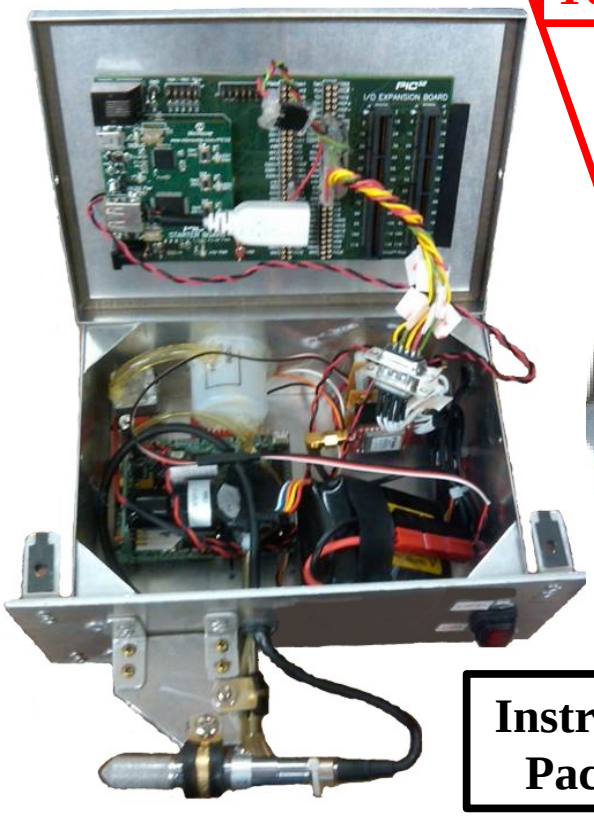
Images from Aitkencolon Web page, http://www.aikencolon.com/met-one-212-2-eight-channel-particle-counter

Passive Cavity Aerosol Spectrometer Probe on Citation Research Aircraft on July 31, 2013

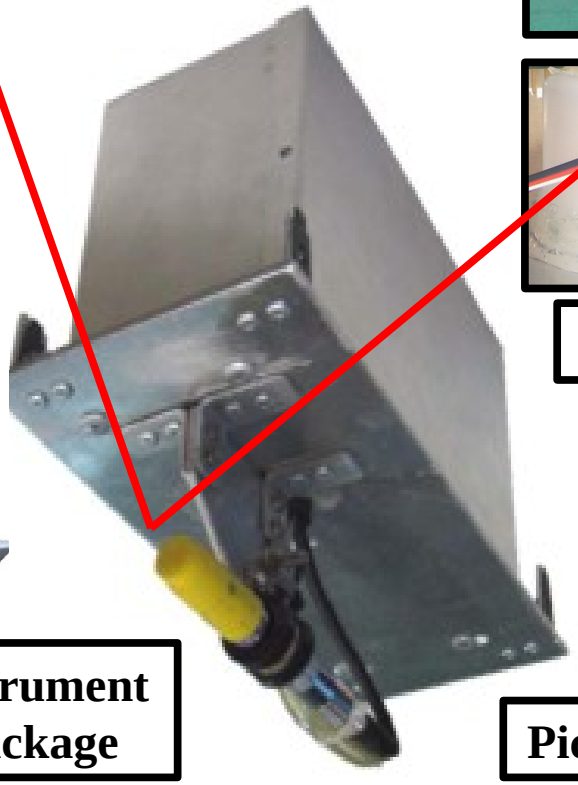


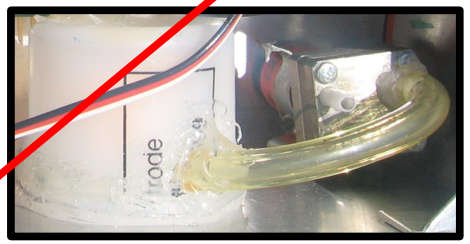
Sensor Telemaster Instrument Package

Vaisala HMP50
Temperature/RH Sensor



Instrument
Package



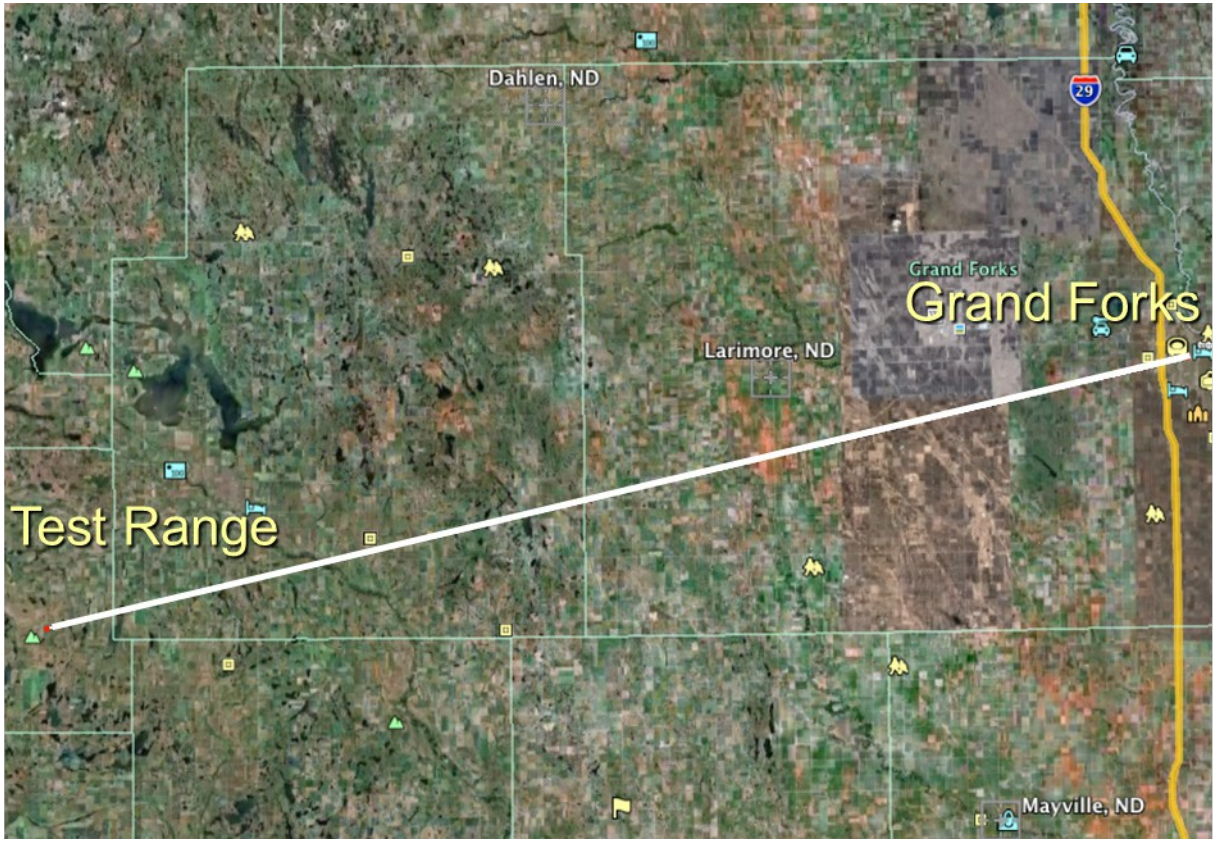


Counter Pump

Pic Microcontroller

Met One 9012
Optical Particle Counter

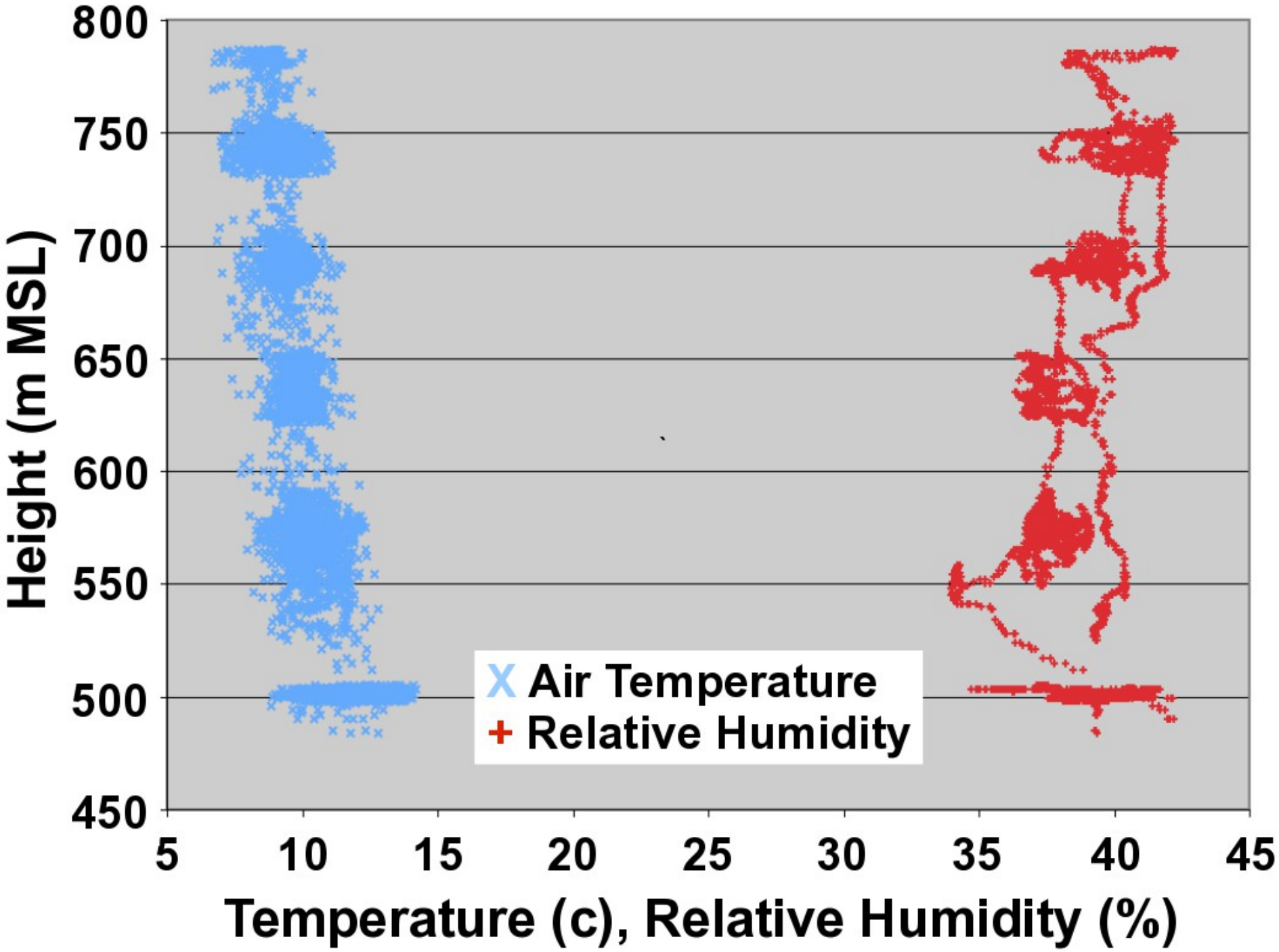
North Dakota National Guard's Camp Grafton South Facility



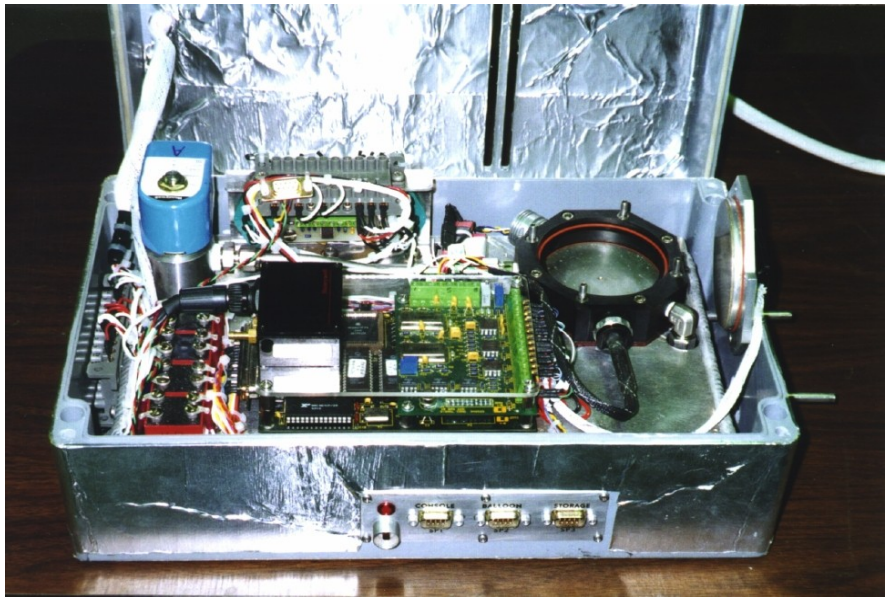
Location of the Test Range utilized for the November 5, 2010 Telemaster flights relative to Grand Forks, North Dakota. Image created using Google Earth.

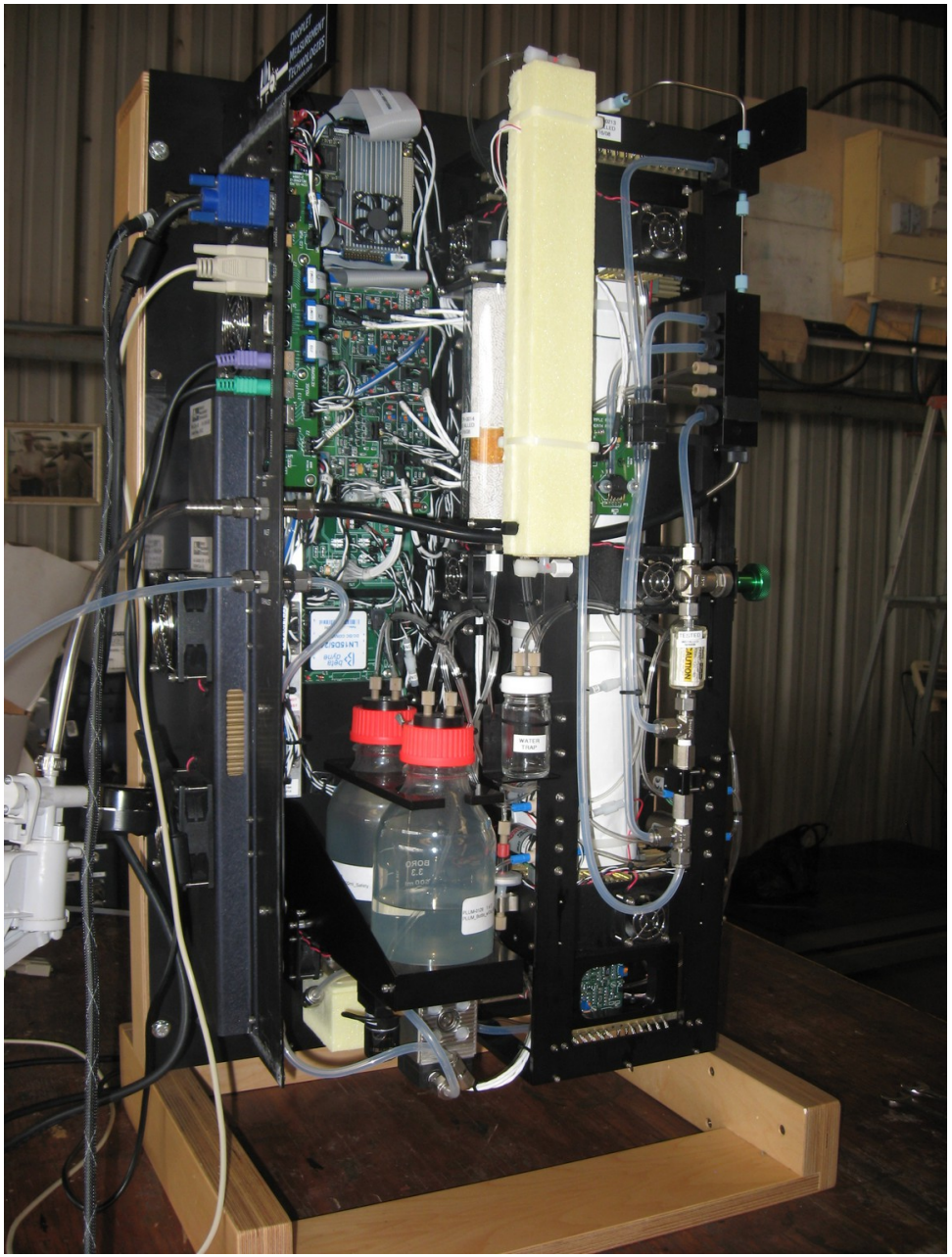
Image of the runway area at Camp Grafton. View is looking southeast from a ridge top overlooking the runway area.

November 5, 2010 Telemaster Flight



Cloud Condensation Nuclei Counters

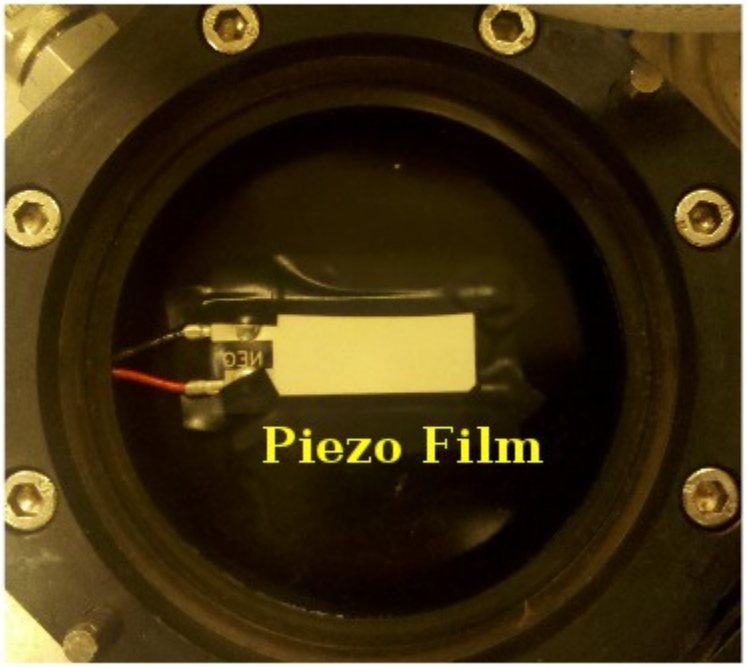


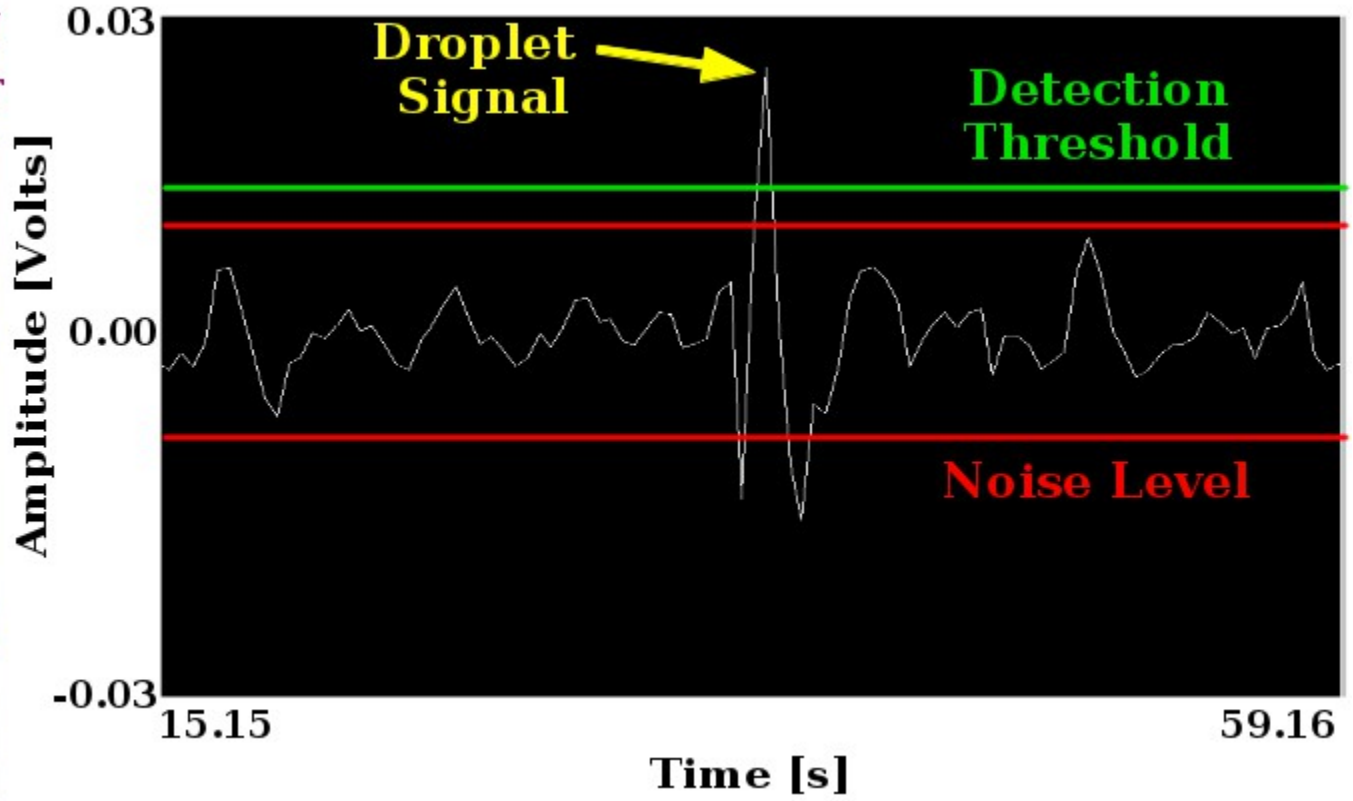


New Measurement Techniques

Miniaturized Cloud Condensation Nucleus Counter for UAS Platforms

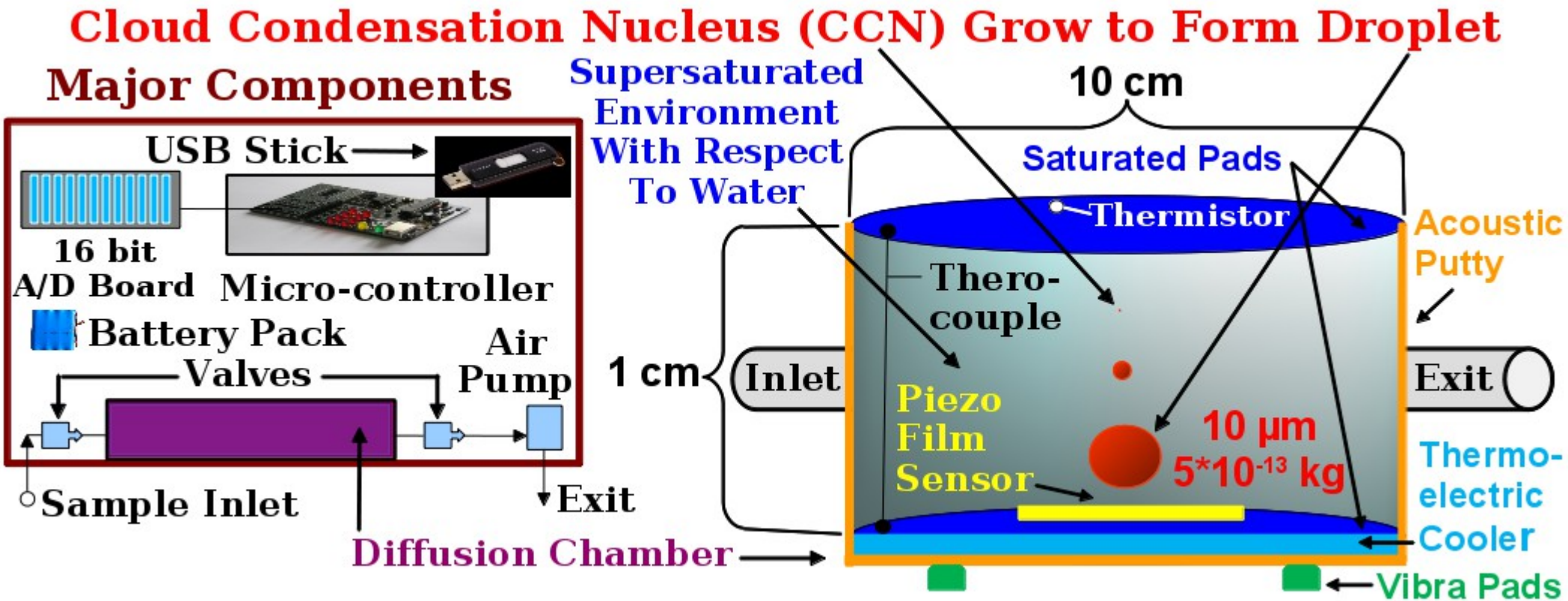
Top View of the UWYO CCN Counter Diffusion Chamber





New Measurement Techniques

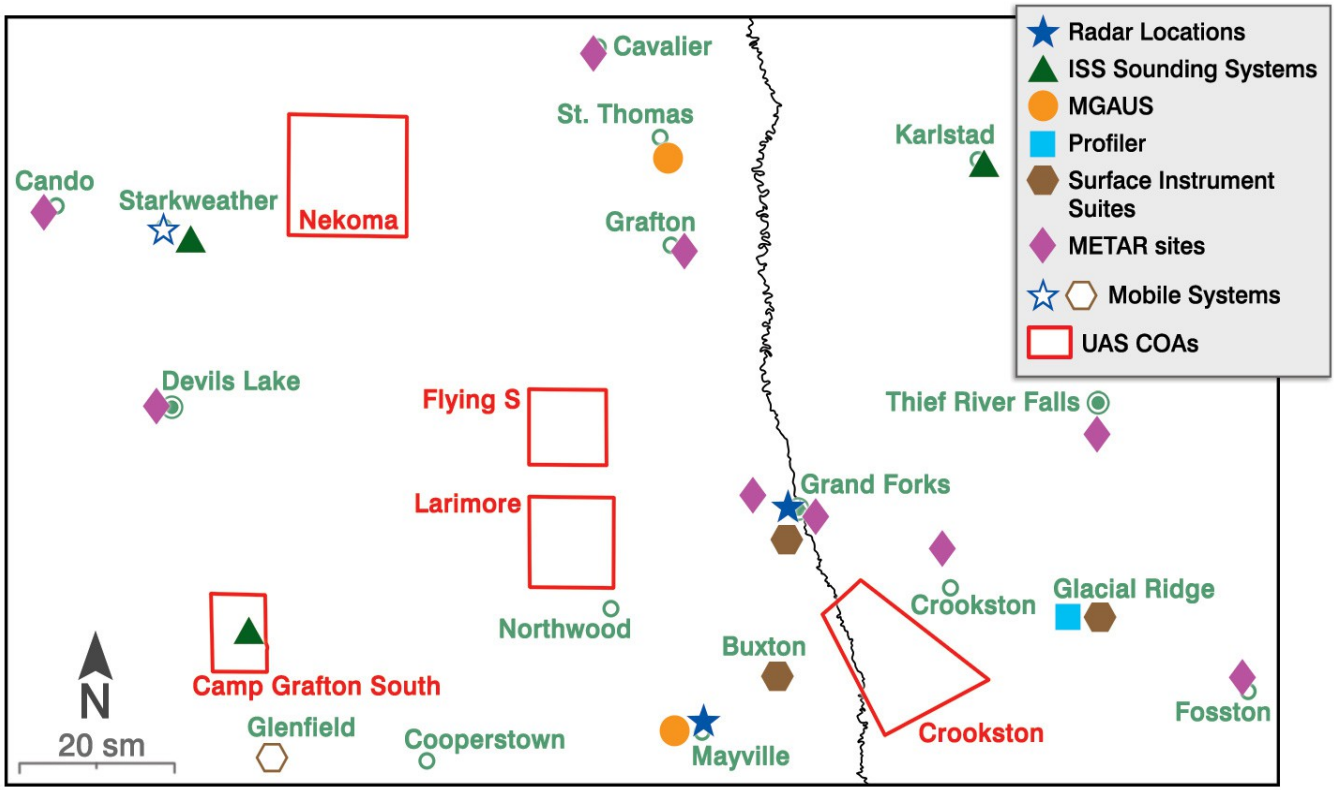
Miniaturized Cloud Condensation Nucleus Counter

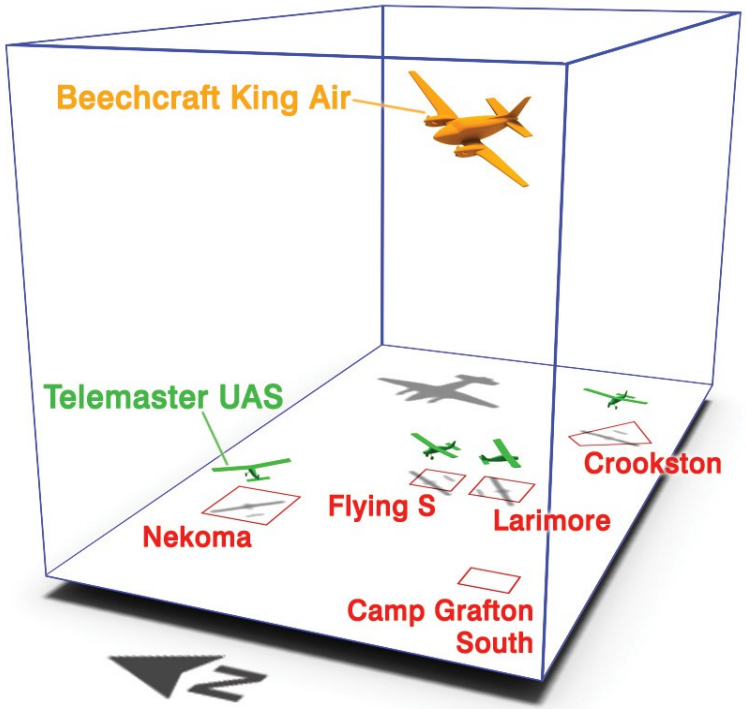


Collaborative Research Proposal to National Science Foundation

NORCIS - Northern Plains Convective Initiation Study

Field Projects using New Instrumentation
Northern Plains Convective Initiation Study

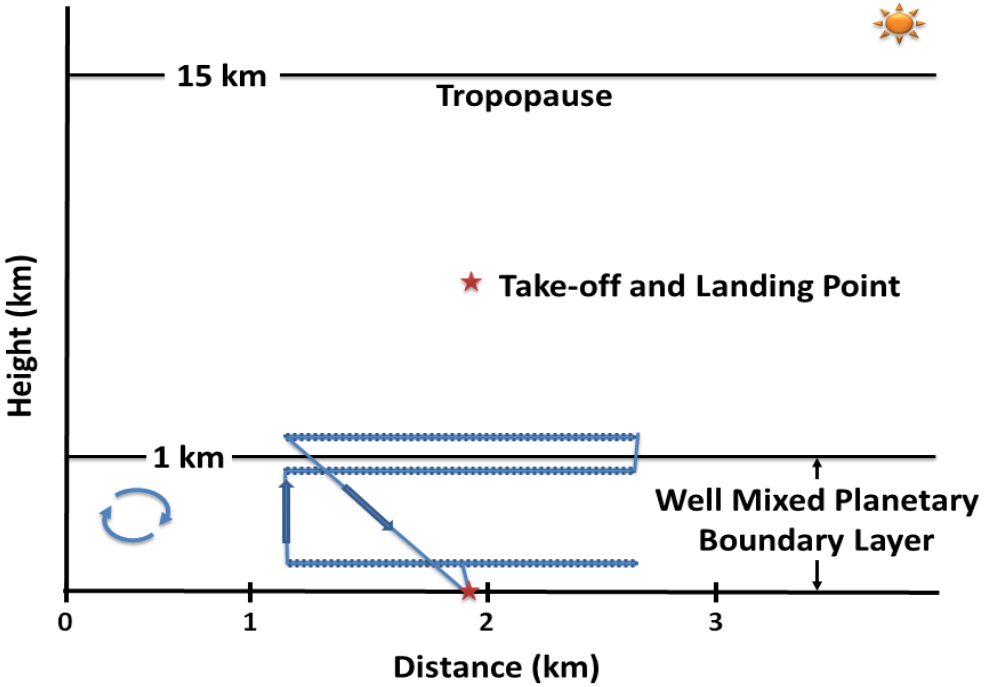


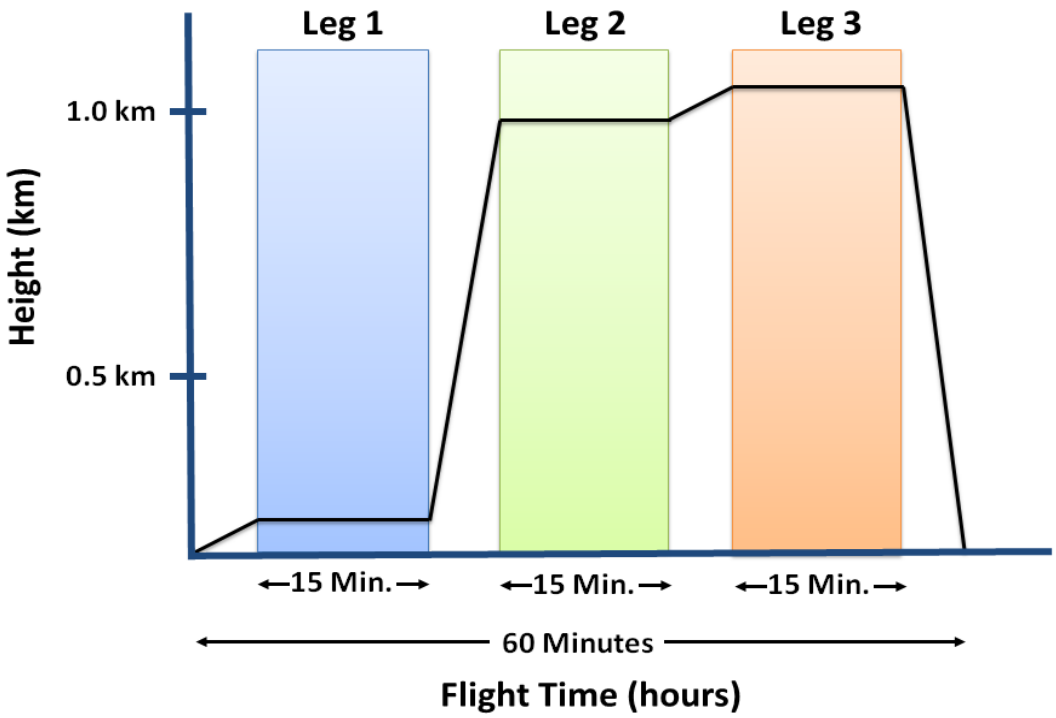


The open star represents the OU mobile X-band radar, at a possible deployment location; the open brown circle indicates the UMB MARS-1 system, which includes a profiling radiometer and a Doppler wind lidar. The green triangles are for the Integrated Sounding System (ISS) which is a self contained meteorological observing system at the Earth Observing Laboratory (EOL) of the National Center for Atmospheric Research (NCAR). The ISS consists of a wind profiler radar, radiosonde sounding system, a 10 m meteorological tower, solar radiation and other sensors. The orange circles is for the mobile GPS Advanced Upper-Air Sounding (MGAUS) systems from EOL.

NSF Proposal: Collaborative Research: NORCIS - Northern Plains Convective Initiation Study Proposal

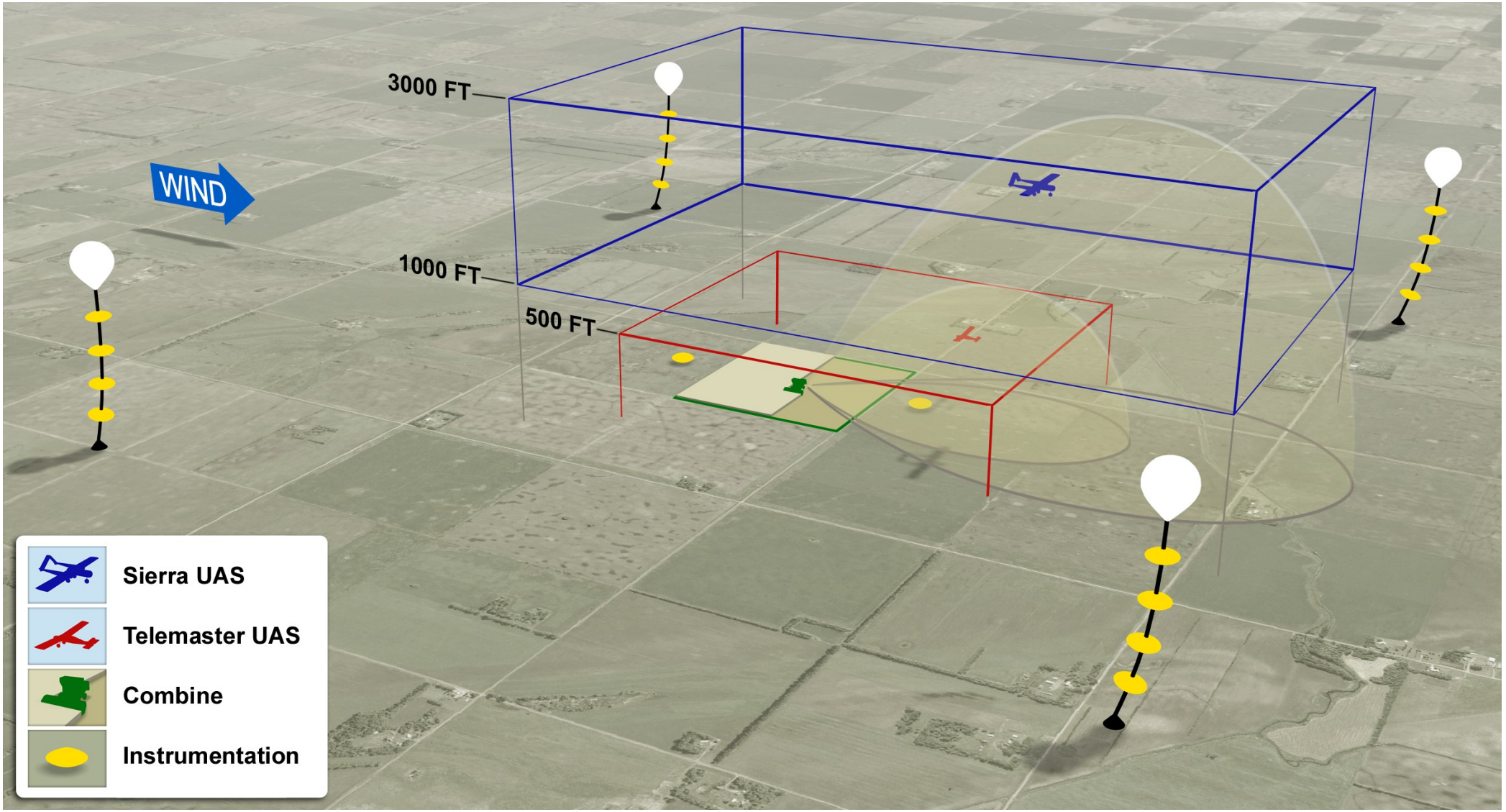
Research North Dakota Proposal
November 22, 2013





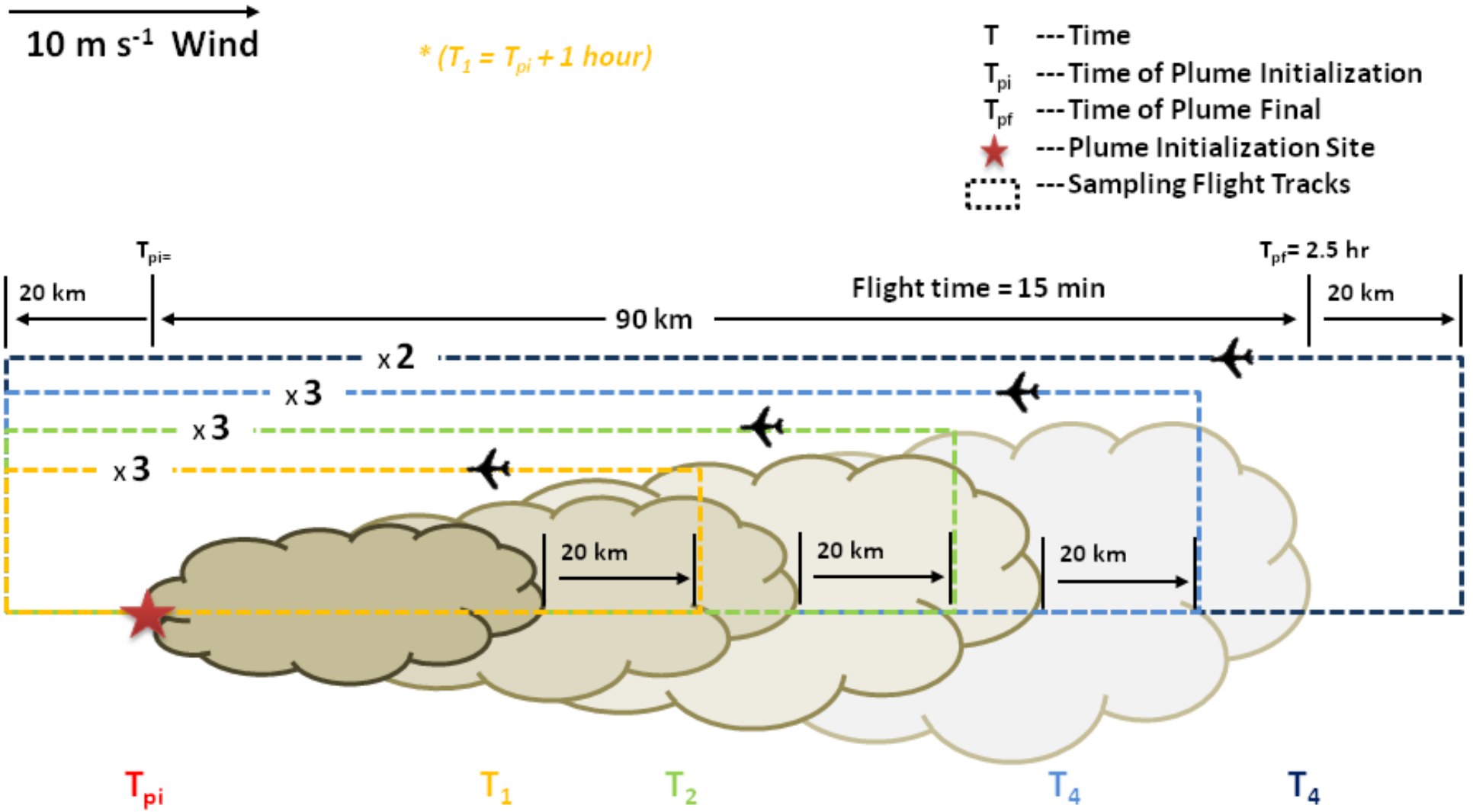
Left image is the cross-section view of the flight plan to test the developed instrument package on a manned aircraft and Unmanned Aircraft System (UAS). Right image is the time series illustration for the flight plan.

Sampling of Aerosol Emissions from Harvesting Activities



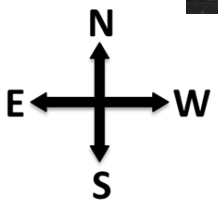
Deployment of Unmanned Aircraft Systems (UAS) and instrumentation during sampling of harvesting emissions. Proposal to NASA, March 22, 2011.

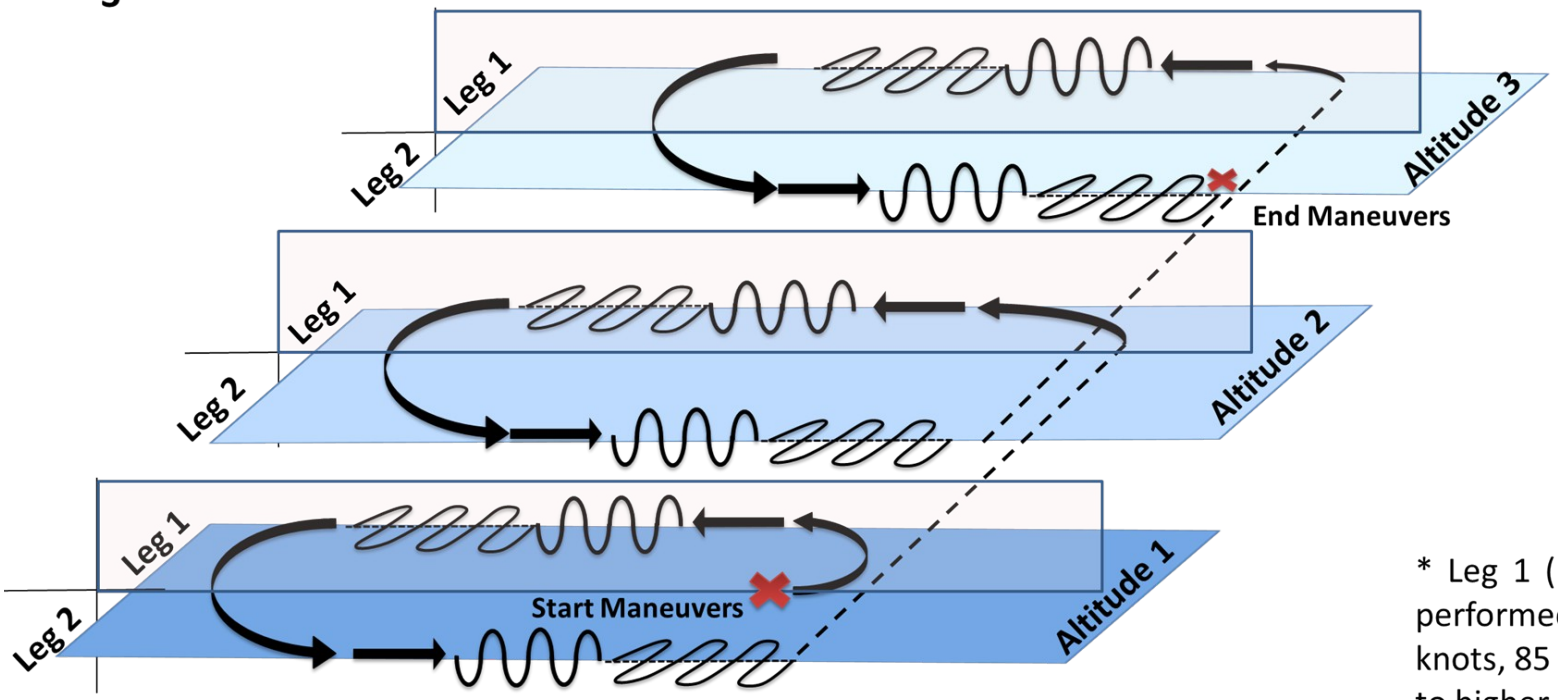
Flight Profile for Sampling of Emission Plume

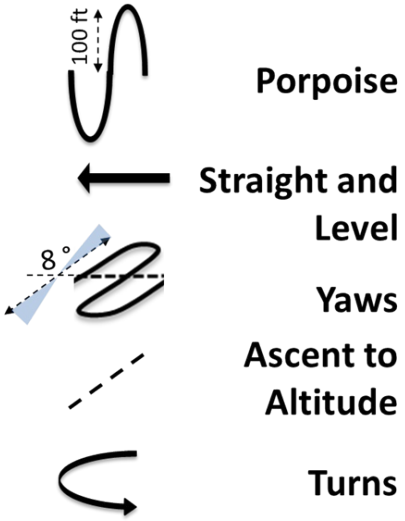


Wind Calibration Profile
November 19, 2013 Citation Flight

5 Port Gust Probe

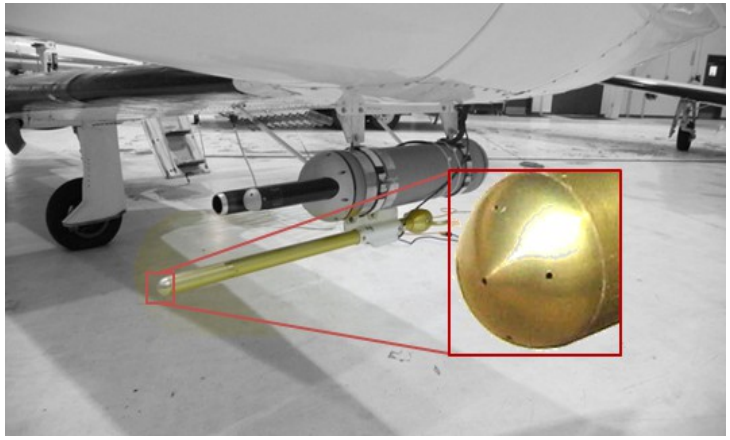


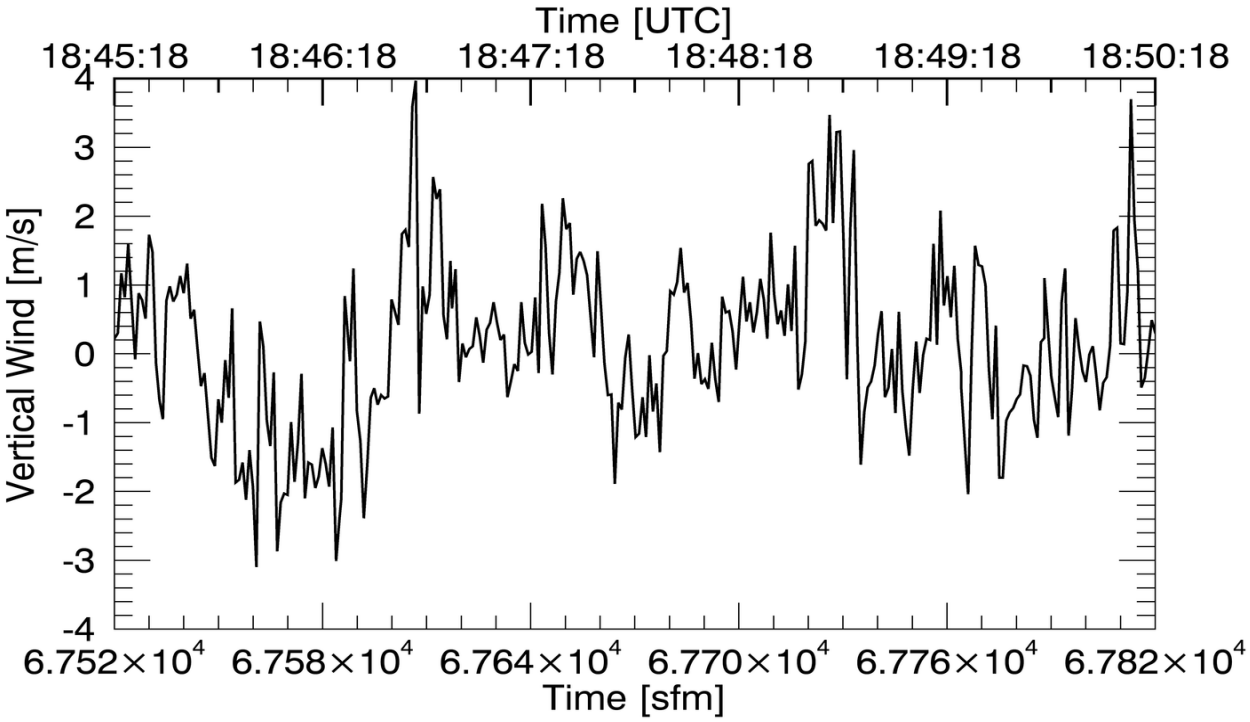


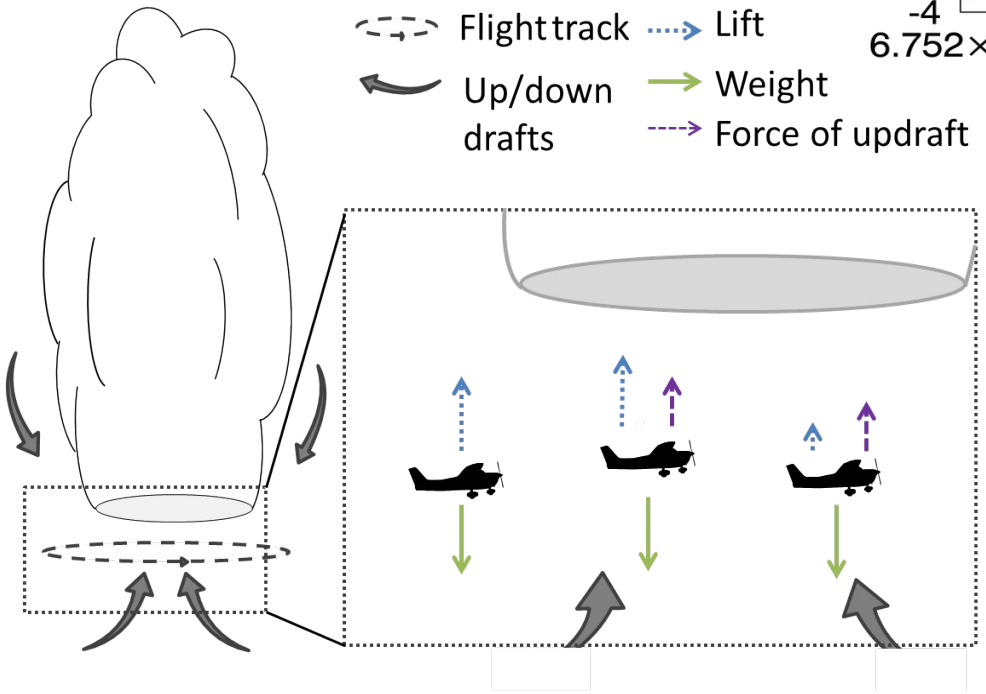


* Leg 1 (East) and Leg 2 (West) are each performed at three different speeds 75 knots, 85 knots and 95 knots before ascent to higher altitude.

Updraft Measurements to Determine Supersaturation





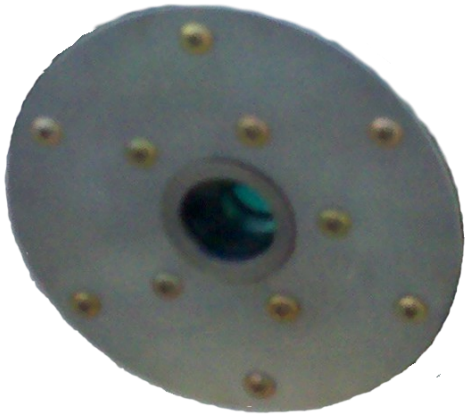


Vertical wind velocity measured at a frequency of 1.0 Hz by the Aircraft Integrated Meteorological Measurement System (AIMMS) during the first flight on 26 July 2012. Time period is the first five minutes (67,518-67,818 seconds from midnight (sfm) of sampling for target case 1.

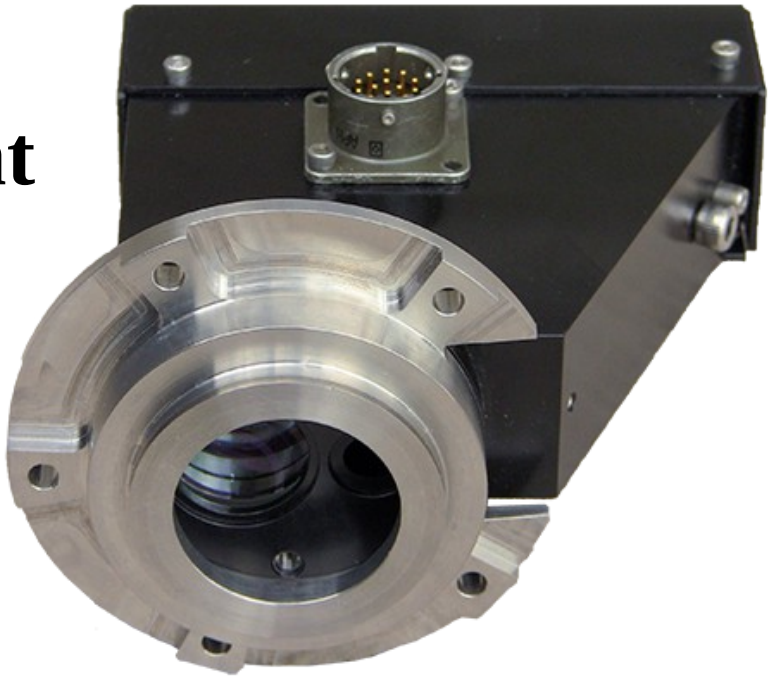
Simelane, P. S., D. J. Delene, H. Ahlness, and D. Langerud, Evaluation of Pilot Estimated Updrafts Using Aircraft Integrated Meteorological Measurment Systems (AIMMS) Measurements, Journal of Weather Modification, 45, in press, 2013.

Additional UAS Instruments

Aeroprobe Corporation
Micro Air Data Computer



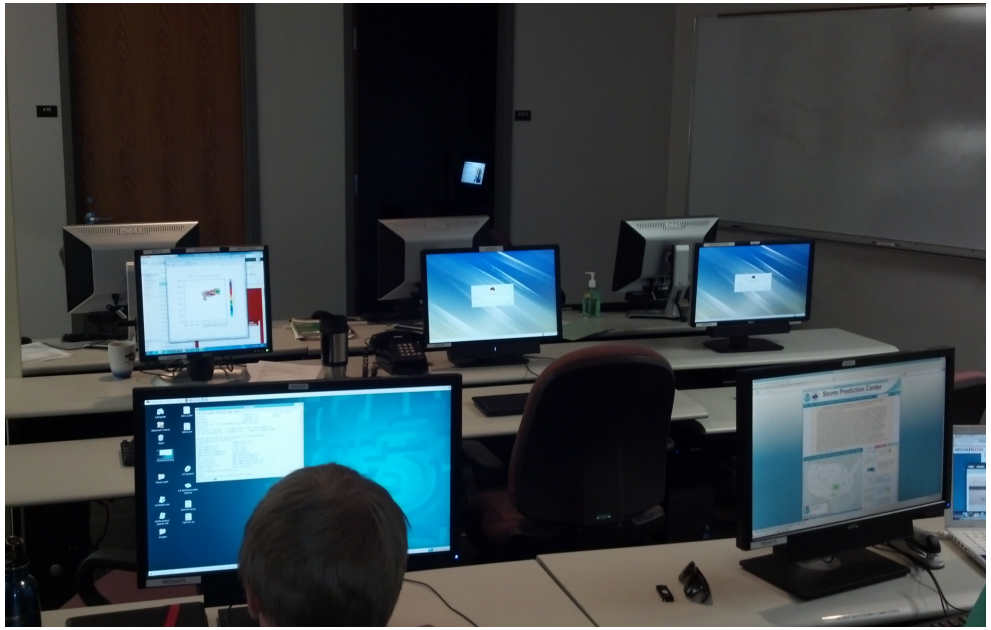
Droplet Measurement Technologies Back-Scatter Cloud Probe



QC/QA

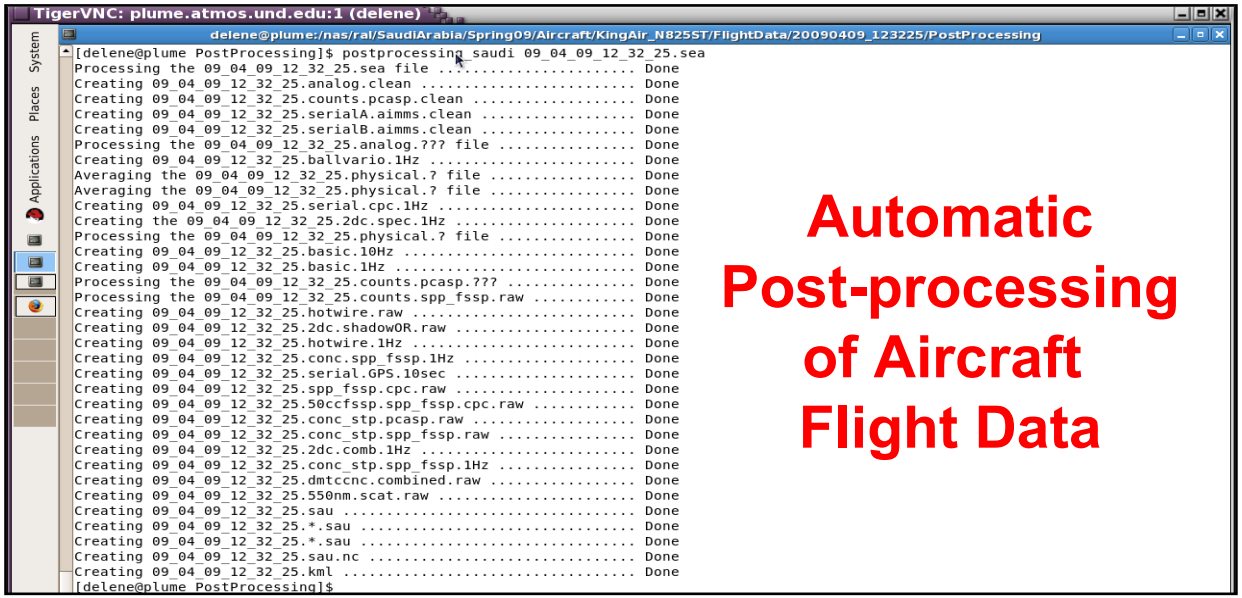
Quality Control (QC) - The process of conducting tests to check that measurements are being made correctly and accurately.

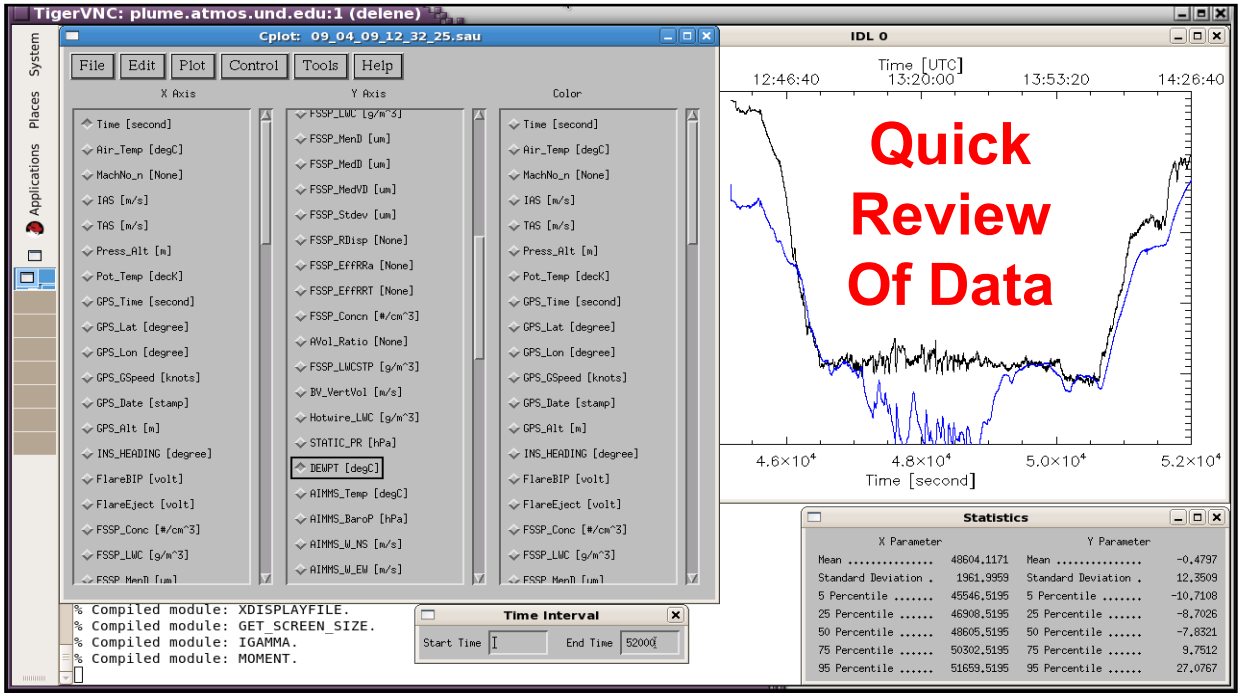
Quality Assurance (QA) The process of reviewing a data set to eliminate (replace with missing value codes) measurements that are invalid due to known problems.



Airborne Data Processing and Analysis (ADPAA) Software Package

- Combining measurement techniques requires robust software.
- Quality control (QC) and quality assurance (QA) of data sets requires a great deal of time.





Delene, D. J., Airborne Data Processing and Analysis Software Package, *Earth Science Informatics*, **4**(1), 29-44, 2011, URL: http://dx.doi.org/10.1007/s12145-010-0061-4, DOI: 10.1007/s12145-010-0061-4.

Conclusions

- Measurements are expensive.
  - **Unmanned Aircraft Systems can Help**
  - Requires Robust Hardware and Software
  - Need Quality Controlled and Quality Assured Data from Advanced Instruments.
- Measurements have a large impact on advancing scientific understanding.
  - Only measurements tell you what CCN concentration really are at cloud base.


If your in the Fog
Ask Questions

Hopefully things are a little clearer.

Thanks for listing.