

ARM

CLIMATE RESEARCH FACILITY

The ARM Aerial Facility in TCAP



Beat Schmid, Technical Director
Pacific Northwest National Laboratory
Richland, WA



U.S. DEPARTMENT OF
ENERGY

Office of
Science

Components of the ARM Aerial Facility



Virtual Hangar

- CLASIC, Oklahoma; 6/2007
- ISDAC, Alaska; 4/2008
- RACORO, Oklahoma; 1 – 6/2009
- SPARTICUS, Oklahoma; 1 – 6/2010
- ARM Airborne Carbon Measurement Experiment, Oklahoma, 2008 - 2011
- So far worked with 13 aircraft:
 - ER-2, Lear 25, P-3 (2), B-200, CV-580, J-31, G-1, Twin Otters (3), C206, Bell 206



+ Instrumentation

- Legacy (AVP, ASP)
- Recovery Act
- PI's
- Maturation Program



+ G-1

- PNNL since 1989
- ARM since 2010
- CARES, Sacramento, 6/2010
- CALWATER, Sacramento, 2-3/2011

Planned

- India 1-3/2012
- Cape Cod 7/2012 & 2/2013
- Brazil 2x in 2014

ARM Aerial Facility Staff

- Beat Schmid, AAF Technical Director
- Jennifer Comstock, AAF Science/Data Liaison
- John Hubbe, G-1 Payload Director
- Jason Tomlinson, G-1 Payload Scientist
- Celine Kluzek, G-1 Payload Engineer
- Mike Hubbell, G-1 Director of Operations & Chief Pilot
- Bill Svancara, G-1 Director of Maintenance, Pilot, AI
- Dick Hone, G-1 Pilot
- Gene Dukes, G-1 Crew Chief/A&P Mechanic
- Cole Blessinger, A&P Mechanic (contract)
- Bob Hannigan, PNNL Aviation Safety POC

G-1 (BMI owned, ARM base funded, PNNL based and managed, for the science community)



Aircraft Technical Information

Length: 63.75 feet (19.44 m)

Wingspan: 78.33 feet (23.88 m)

Height: 23.33 feet (7.11 m)

Cabin space: 165 square feet

External probes (PMS cans, etc.): 8

Maximum gross weight: 36,000 pounds
(16,330 kg)

Endurance with maximum fuel: 8 hours

Endurance with typical payload/fuel: 5 hours

Crew capacity: 7 max, 2 pilots + 3-5 scientists

Cabin payload: 4,200 pounds

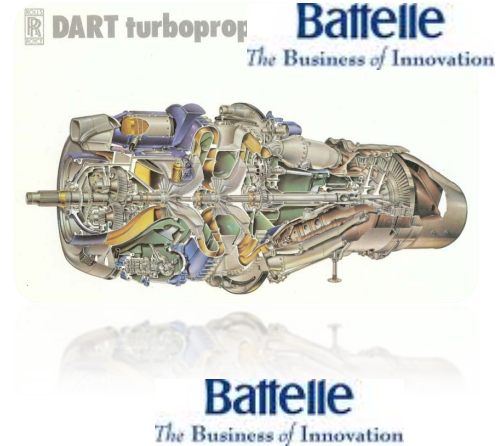
Research Power: 700A @ 28 VDC (incl. 85A
@ 115 VAC, 60 Hz)

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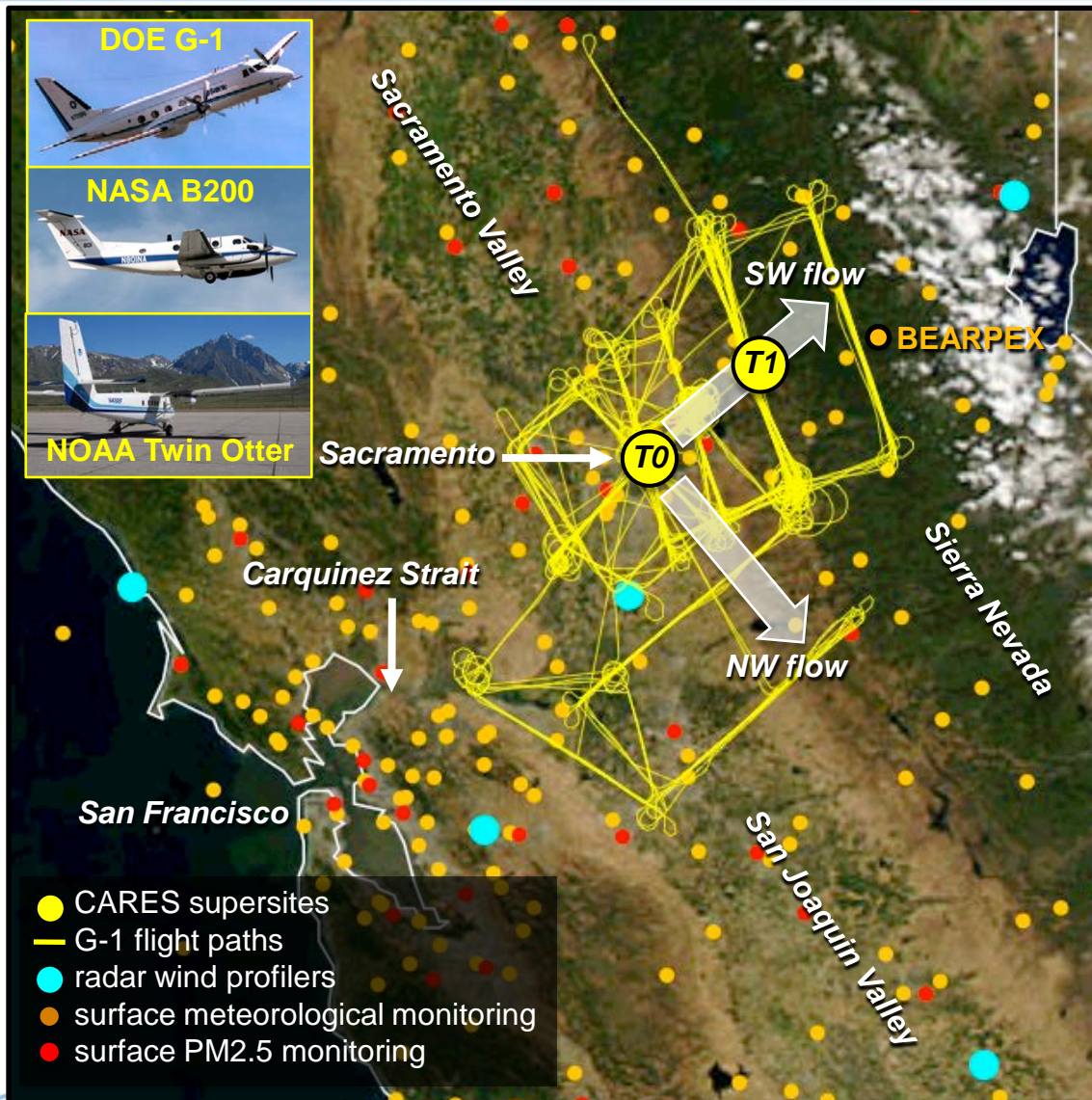
CLIMATE RESEARCH FACILITY

Recent Upgrades to G-1 Aircraft

- Rolls Royce DART1860 Engines
 - Noticeably quieter
 - More power (~10%)
 - Greater fuel efficiency (~20%)
 - Higher operating ceiling (25kft)
- Power distribution and inverter upgrade
 - 40% increase in available payload power
- New Floor Cover
- New Wing Pylons → 8+ external probes
- New CVI and isokinetic inlet
- 18 new ARRA instruments
- Base of installed PI instruments is growing (ATOFMS, CFDC, 4STAR...)
- New Traffic and Collision Avoidance System (planned)
- Extended Range Fuel Tanks (planned)



G-1 Flight Tracks in CARES



DOE G-1 (June 2 – 28)

- Research Flights: 22
- Flight Time: 67.5 hours
- Flight Distance: ~24,000 km

NASA B-200 (June 3 – 28)

- Research Flights: 23
- Flight Time: ~68 hours

Coordination with CalNex

In Sacramento Area

- R/V Atlantis (June 3 – 4)
- NOAA Twin Otter (June 15 – 28)

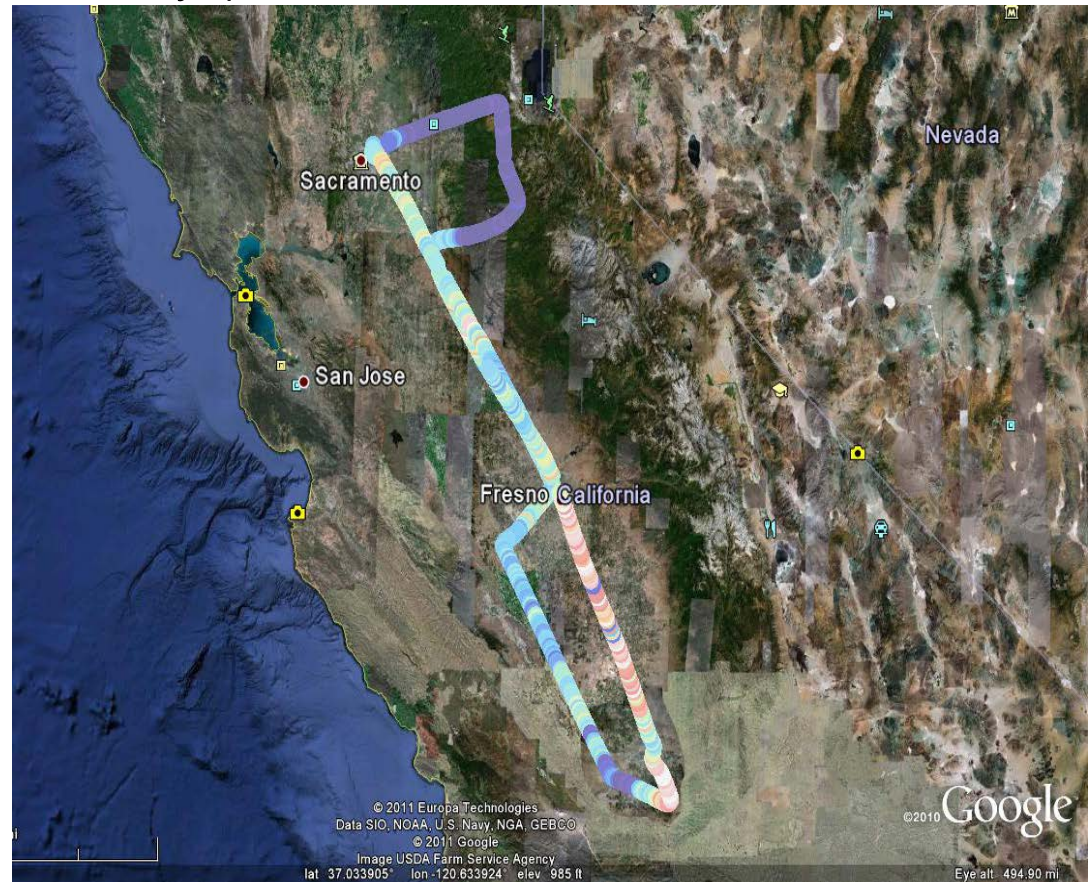
Intercomparison Flight From Fresno to Bakersfield, June 18

- DOE G-1
- NASA B-200
- NOAA P-3
- NOAA Twin Otter

G-1 in Calwater FY11



- Investigating the effects of anthropogenic emissions on winter precipitation in the California Central Valley and Sierra Nevada mountain range
- PI: K. Prather, UCSD
- Feb 1 to March 7, 2011 (incl. transit days)
- 28 flights, 70 hours on station
- 81 hours (incl. transit and test)
- Measurements
 - Atmospheric state
 - LWC/TWC
 - Cloud microphysics
 - Aerosols
 - Gases



G-1 TCAP Deployment

■ Location: Cape Cod, MA

- Barnstable Municipal Airport in Hyannis, MA. Airport ID is KHYA. Runway lengths are 5425'x150' and 5253'x150'.
- The FBO is <http://rectrix.aero/fbos/>
- It is a towered airport with 2 ILS approaches.

■ Mission Dates

- IOP1: 3 weeks in July , 2012
- IOP2: 3 weeks in February, 2013

■ Payload

- Aerosols, clouds, radiation and gases
- NASA B-200 not funded by DOE
- G-1 very full, 2 pilots + 4 crew



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G-1 TCAP Payload

(High Level Summary)

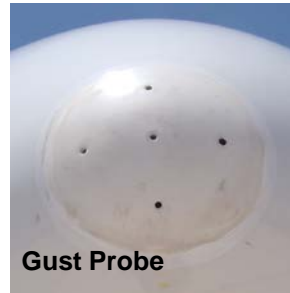
- Aircraft and Atmospheric State Parameters
- Trace Gases
 - H₂O (column and in-situ)
 - CO (in situ)
 - O₃ (column)
- Aerosol Properties
 - Total Concentration
 - Size Distribution (55 nm – 50 μm)
 - Cloud Condensation Nuclei Concentration
 - Hygroscopicity
 - Optical Properties (absorption, scattering, extinction, AOD)
 - Size resolved and single particle physico-chemical composition
- Cloud Properties
 - Liquid water, total water, ice water
 - Size Distribution (0.5 μm to 1.5 mm)
- Radiation
 - Upwelling hemispheric, spectral
 - Upwelling hemispheric, broadband
 - Direct beam irradiance and diffuse radiance angularly resolved

G-1 TCAP Payload (DRAFT)

(Detail)

Aircraft and Atmospheric State Parameters

Instrument	Measurement
Platform Pos/Vel/Attitude	
Trimble DSM 2285040C	position/velocity @ ~10Hz
Trimble TANS 10Hz 720 Receiver	pitch/roll/azimuth
Atmospheric State	
Rosemount 102	temperature
Rosemount 1201F1	static pressure
Rosemount 1221F2 (3x)	gust probe, differential pressure (dynamic, alpha, beta)
GE-1011B chilled-mirror hygrometer	dew-point temperature
AIMMS-20	5-port air motion sensing: true air speed, altitude, angle-of-attack, side-slip, T, RH
Inlet	
Aerosol Isokinetic Inlet	sample stream of dry aerosol, sizes < 2.5 microns



G-1 TCAP Payload (DRAFT)

(Detail)

Cloud Properties

Instrument	Measurement
Water Content	
WCM-2000	Liquid, total and ice water content
Cloud Spectrometer and Impactor (CSI)	Total water content
CAPS hot-wire	Liquid water content
Size Distribution	
CAS (part of CAPS)	Size Distribution 0.5 to 50 μm
CDP	Size Distribution 2 to 50 μm
CIP (part of CAPS)	Size Distribution 25 to 1,500 μm



CSI

G-1 TCAP Payload (DRAFT)

(Detail)

Aerosol Concentration and Size Distribution

Instrument	Measurement
Aerosol	
UCPC TSI 3025	total particle concentration (> 3 nm)
CPC TSI 3010	total particle concentration (> 10 nm)
UHSAS-A	aerosol size distribution (55-1000 nm)
CAS	aerosol size distribution (500-50,000 nm)



CPCs



UHSAS-A



CAS

G-1 TCAP Payload (DRAFT)

(Detail)

Aerosol Optical Properties

Instrument	Measurement
Aerosol	
Nephelometer (TSI 3563)	aerosol scattering, 3λ
Humidigraph	aerosol hygroscopicity, $f(\text{RH})$, 1λ
Particle/Soot Absorption Photometer (PSAP)	aerosol absorption, 3λ
DMT SP-2 Single Particle Soot Photometer	Soot mass, number and size distribution

Nephelometer



Humidigraph



G-1 TCAP Payload (DRAFT)

(Detail)

Aerosol Composition and Make-Up

Instrument	Measurement
Aerosol	
Mini SPLAT-II	Single particle aerosol composition
Particle Into Liquid Sampler-Ion Chromatography-Water Soluble Organic Carbon (PILS-IC-WSOC)	Aerosol chemical composition, anions, cations, and water soluble organic carbon
HR-ToF-AMS	Size-resolved aerosol composition
Cloud Condensation Nuclei (CCN) Counter	CCN concentration at 2 super-saturations



G-1 TCAP Payload (DRAFT)

(Detail)

Radiation

Instrument	Measurement
4STAR	Direct Solar Beam and Sky-Scanning: Aerosol OD, Size Distribution, Absorption, Extinction, Cloud OD, H ₂ O, O ₃
MFR	upwelling shortwave radiation global, 415, 500, 615, 673, 870, 940, 1625 nm spectral channels
SPN-1 unshaded	upwelling shortwave radiation global, broadband



G-1 TCAP Payload (DRAFT)

(Detail)

Gases and other

Instrument	Measurement
Radiation	
CO analyzer	Carbon Monoxide
Other	
Weather radar	cockpit display of precipitation returns
SEA Data System	Central Data System
Iridium Satellite Modem	Limited data link to ground station
Radar Altimeter	Altitude above surface
TCAS BF Goodrich SKY497	Traffic Collision and Avoidance System
TAWS Landmark TAWS8000	Terrain Awareness and Warning System



G-1 TCAP Draft Floor Plan

Power Budget OK, 100 lbs over on Zero-Fuel Gross Weight

Gulfstream 159 Cabin Floor Plan

2012 TCAP, "Payload v2", rev. 2011-3-25

