# Cape19Ex Operations Plan

# North Dakota Citation Research Aircraft (N555DS)



Prepared by: The University of North Dakota and Naval Research Laboratory

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## **Project Objectives**

The main aircraft flight objective is to obtain in-situ measurements of hydrometers in the upper layer of convective storms over the Florida peninsula. The North Dakota Citation Research Aircraft (Delene et al. 2019) will obtain in-situ micro-physical measurements concurrent with Mid-Course Radar (MCR) observations. During aircraft flights, the MCR will be operated to either track the Citation Research Aircraft and obtain concurrent measurements, or to conduct vertical stares while the Citation Research Aircraft over flies the MCR. In both cases, the sampling objective is to measure hydrometers from the edge of the cloud anvil to near the convective core in the horizontal dimension, and from the bottom to the top of the anvil in the vertical dimension.

The cover image shows the instrumentation the aircraft frame. The on "CapeEx19\_AircraftConfiguration" document list all instruments on the aircraft and contains detailed information each instrument's configuration. The Airborne Data Processing and Analysis software ((Delene 2011). The critical measurement to obtain the field project objectives are the total water content probe (Nevzorov Probe) and the particle size distribution (PIP, CAPS, CIP/2DC, CIP).

## **Institutional Participants**

- Naval Surface Warfare Center Dahlgren Division
- Marine Meteorology Division, Naval Research laboratory (NRL)
- University of North Dakota (Aircraft)
  - Weather Modification International
  - University of Alabama Huntsville
- L3Com (Radar)
- Scripps Institution of Oceanography, University of California (Surface)
- AECOM (Robert D. Yates)

## **Project Coordination**

The success of a field project depends on close coordination of personnel involved at the different facilities (forecast office, radar facility, and aircraft facility). The key functions of personnel involved in the project are briefly described in this section.

#### **Citation Research Aircraft Team Members**

- David Delene, Flight Scientist (<u>delene@aero.und.edu</u>, Cell 507-533-5363)
- Shawn Wagner, Probes Flight Engineer Graduate Student (<u>shawn.wagner@und.edu</u>)
- Kendra Sand, M300 Flight Engineer Graduate Student (<u>kendra.sand@und.edu</u>)
- Matthew Tuftedal, Remote Data Processing Graduate Student (<u>matthew.tuftedal@und.edu</u>)
- Henno Havenga, Local Data Processing Visiting Researcher (<u>hhavenga92@gmail.com</u>)
- Harrison Rademacher, Inlet Sampling Undergraduate Student (<u>hprademacher@gmail.com</u>)
- Jody Fischer, Research Pilot (<u>jfischer@weathermodification.com</u>)
- Dennis Afseth, Aircraft Instrumentation (<u>dafseth@weathermod.com</u>, Cell 701-799-5461)
- Martin Schnaiter, PHIPS Probe (martin.schnaiter@kit.edu)

#### Non-Aircraft Team Members

- Nicholas Gapp, MCR Radar/Aircraft Graduate Student (nicholas.james.gapp@und.edu)
- Joshua Hoover, Project Manager (joshua.hoover@navy.mil)
- Mark Anderson, Project Manager (<u>mark.j.anderson1@navy.mil</u>) Cell 540-376-2155

- Jerry Schmidt, Science Manager (Jerome.Schmidt@nrlmry.navy.mil) Cell 831-242-0355
- Paul Harasti (Paul.Harasti@nrlmry.navy.mil) Cell: 831-917-5043
- Bob Yates (robertdyates@earthlink.net) Cell- 310-505-3849

#### Area of Study

The study area is centered on MCR radar at latitude of 28.7550265 and longitude of 80.7743669. The Citation Research Aircraft will be based at Space Coast Jet Center (7003 Changer Ave, Titusville, FL, 83780, phone 321-267-8355) at Space Coast Regional Airport (KTIX).

#### Schedule

An intensive operations period (IOP) is planned for two weeks between 21 July – 4 August 2019 (Table 1). Surface instrument setup at the MCR site is planned for the week of July 14. The science team is staying at the Quality Inn in Titusville/I-95 Kennedy Space Center, Florida (321-269-7110, 3655 Cheney Hwy, Titusville, FL 32780) to be close to both the MCR and airport. The

Table 1: A preliminary time line for the overall project in the form of a Gantt chart.



#### **Aircraft Communications**

A VHF radio is used at the MCR to communicate with the Citation Research Aircraft using the frequency 122.75 MHz. The MCR receives the real-time position of the aircraft using a data modem at a frequency of 465.00 MHz. An on-board Ipad displays the aircraft's position on the current radar image, along the position of other aircraft, to enable the flight scientist to make decisions on changing altitude and sampling line location.

#### **Flight Profiles**

Flights focus on measurements in the cirrus cloud region (29,000 – 40,000 ft) of the anvil of convective storms (Figure 1), with the MCR radar track the Citation Research Aircraft. The field project will conduct 20-30 hours of flights, which includes test flight(s) in North Dakota to ensure the cloud probes are working and to calibrate the hot wire probes, wind system, and field mill measurements. The Citation Research Aircraft instrument configuration will enable take-off with a full fuel load; hence, flight duration could be up to 4 hours. However, with frequent altitude changes, flights will typically last approximately 3 hr, with 2 hr being sampling cirrus anvils. Most days will consist of a single afternoon flight; however, we expect two flights on some days. Flight days are restricted for approximately 48 hours before rocket launches, which are planned as:

- Monday, July 22 7:30 am CRS-18, Falcon 9 Block 5, SpaceX, SLC-40, Cape Canaveral AFS
- Thursday, July 25 10:55 pm GPS III SV02 Delta IV Medium+, ULA SLC-37B,, Cape Canaveral AFS



Figure 1: Flight profile for sampling thin cloud layers 1-2 km above the main anvil or in high cirrus. The Citation Research Aircraft samples at 160 knots and does 500 ft/min ascents to provide good instrument measurement performance. Horizontal distance between legs is 1,000 ft with a total east to west width of 40 nmi. Sampling is to be conducted 20 nmi either east or west of the Mid-Course Radar (MCR).



Figure 2: Plan view of the flight profile for the North Dakota Citation Research Aircraft, where sampling is shown 20-60 nmi to the west of the Mid-Course Radar (MCR). Sampling is planned either west or east of the MRC, within a distance of between 20 and 60 nmi. Storms generally move from west to east so aircraft measurements will measure different conditions with each

horizontal leg. With 160 knots and 40 nmi legs, each leg will take approximately 15 minutes. The 40 nmi leg is the maximum leg distance, with legs planned between 25 and 40 nmi. Once the aircraft is out of cloud, the aircraft will turn to around. Turns will generally be simple 180 degree turns to the west. Each north-south leg will sample slightly different parts of the storm. The idea is to sample different conditions, instead of multiple sampling of the same storm condition/location. Additionally, during turns, altitude changes of 1,000 or 2,000 ft may be done be conducted. Hence, the north and south leg likely will not be at the same altitude.

# Reference

Delene, D. J., 2011: Airborne data processing and analysis software package. *Earth Sci. Inform.*, **4**, 29–44, https://doi.org/10.1007/s12145-010-0061-4.

—, K. Hibert, M. Poellot, and N. Brackin, 2019: The North Dakota Citation Research Aircraft Measurement Platform. *SAE Tech. Pap. 2019-01-1990*, https://doi.org/doi: 10.4271/2019-01-1990.