

1.3 A PDA-BASED RECORD KEEPING SYSTEM FOR CLOUD SEEDING OPERATIONS

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1. INTRODUCTION

An important aspect of cloud seeding operations is the accurate documentation of seeding activities. The North Dakota Atmospheric Resource Board (NDARB) has collected detailed information on North Dakota seeding activities since its creation in 1975. Until 2004, ND Cloud Modification Project (NDCMP) pilots logged seeding activities on paper forms. In 2003, after a recommendation from an independent review panel (Orville et al., 2003), NDARB undertook the development of a system incorporating a personal digital assistant (PDA) and a wireless GPS to collect seeding operations data electronically. The system records GPS information at prescribed intervals and allows the user to key in additional information through a graphic user interface specifically developed for the PDA. Recorded information can be uploaded directly into the NDARB database through telephone land line. In addition to the spatial data collected from the GPS, pilots input seeding events (acetone generators, flares and dry ice), updraft velocities, temperature, cloud base height, and remarks. The system also assists project pilot's logistics and navigation with an aircraft location map display. The electronic data format will greatly improve the utility of the information, improving our ability to perform evaluation, research, and analysis activities.

2. HARDWARE

The primary data collection tools for the NDCMP recordkeeping system include a Palm Tungsten T2 PDA, and a Socket Bluetooth GPS. The T2 connects to the GPS via Bluetooth wireless technology, removing the need and hassle of wired communications in the cockpit. The GPS transmits data continuously using National Marine Electronics Association (NMEA) (<http://www.nmea.org/>) 0183 sentences. The NMEA sentences are parsed to obtain latitude, longitude, altitude, date, time, and GPS accuracy. This information is transmitted every second and saved at prescribed intervals by the software. Additional hardware includes a modem for data upload and an external battery pack, allowing for hours of uninterrupted use.

3. SOFTWARE

There are five applications (Figure 1) used by

the pilots to record and send data. These applications were created in-house using Appforge® MobileVB and

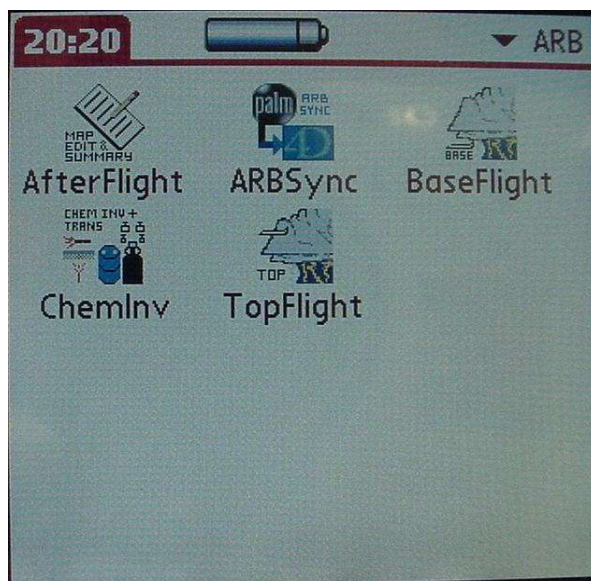


Figure 1. Palm screen showing NDARB programs.

MS Visual Studio® 6 and are fully customizable. The two main data collection applications, one for cloud-top seeding and one for cloud-base seeding, are TopFlight (Figure 2) and BaseFlight (Figure 3). These applications run during the entire flight and provide the

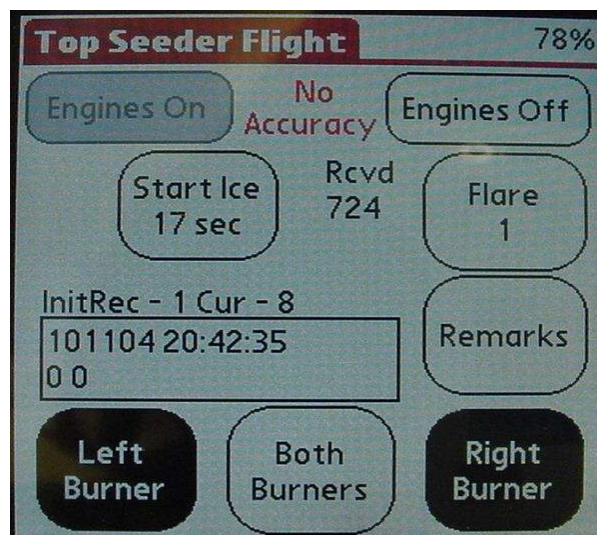


Figure 2. Main page of TopFlight program.

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graphical user interface to key in data, in addition to storing the spatial information from the GPS. Data collected by these applications include GPS location,

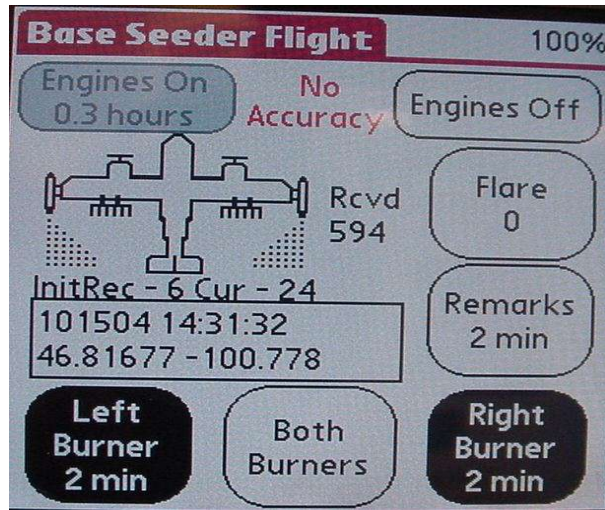


Figure 3. Main page of BaseFlight program.

altitude, time, seeding equipment operation, cloud base height, updraft velocity, temperature, precipitation code, and pilot remarks.

Both TopFlight and BaseFlight have components specifically tailored to the designed use of

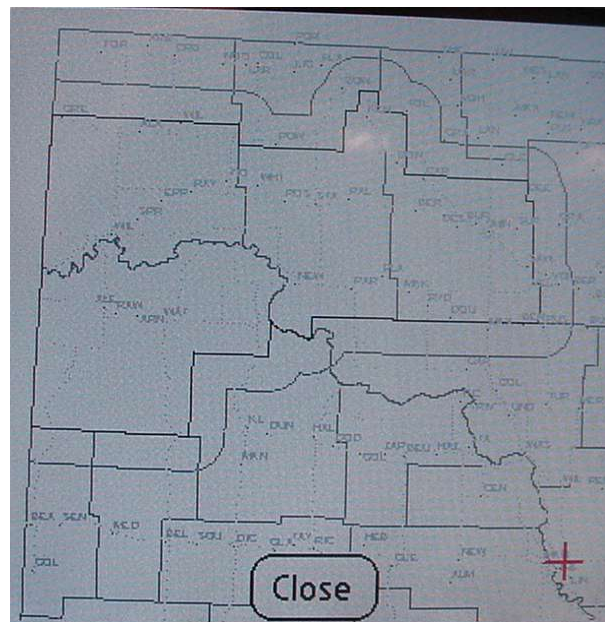


Figure 4. Map showing location at the crosshair.

the aircraft. TopFlight, for example, includes pellet-form dry ice, ejectable silver iodide flares, and wing-tip ice nucleus generators as seeding options, while BaseFlight tracks the use of wing-tip ice nucleus generators and burn-in-place flares. The programs also



Figure 5. Edit page of FlightSummary application.

track accumulated use of each of the seeding options available. Both programs allow the pilot to see the current position of the aircraft, (Figure 4) and the current chemical inventories of NDCMP field sites where they may land to refuel and reload chemical.

The AfterFlight (Figure 5) program allows the user to select and review flight data stored in the Palm database. Certain parameters, such as pilot remarks and flare use are editable, though the majority of the

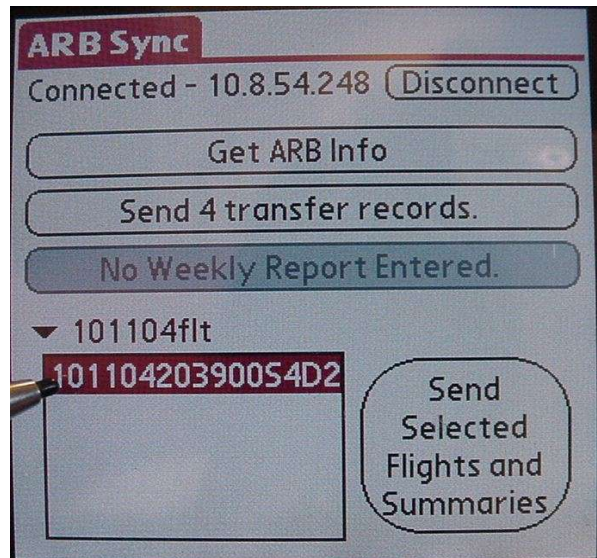


Figure 6. ARBSync application.

data can only be reviewed. AfterFlight also allows the pilot to create a written summary explaining the sequence of events associated with the flight.

After all of the information from a given flight is collected and reviewed it is uploaded into the NDARB database. The ARBSync (Figure 6) application performs the data upload function. During the syncing procedure, information is also sent to the T2 which includes NDCMP personnel contact information, chemical inventory, remarks, and airport information, which are used to populate the selections the pilots have available within the applications. In addition, software upgrades can easily be implemented remotely via the T2's Hotsync function.

The final application, ChemInv, assists NDCMP pilots and administrative personnel in tracking and reporting seeding chemical use and inventories at all of the NDCMP field sites.

4. DATABASE APPLICATIONS

The data collected are stored in PDB files on the Palm T2. A full season of flight data can easily be stored on the Palm. The data can be uploaded after the pilot completes the required flight summary and data review in the AfterFlight program. Data are sent over TCP/IP via web services that are hosted by a 4th Dimension® database. The data are then stored in the database along with all other aircraft information. Operations remarks, NDCMP personnel contact information, airport information, and data associated with the radar operation logs are also stored in this database.

The NDCMP Flight database, thus, has become the main repository for all information related to the cloud seeding project. The advantages of the database environment are many. 4th Dimension® provides robust tools for the management and manipulation of data stored in its system. This will allow user-prescribed data searches and downloads for future research, analysis, and evaluation of cloud seeding operations.

by the imagination and needs of the users. Currently, tools are in place to create paper copies of flight forms. The forms are generated with flight time, seeding time, and seeding agent use calculated from the data. 4th Dimension® also serves the data through web services to ArcGIS™ to create flight track mapping of each operational flight (Figure 7). Additional tools may be developed to create various statistical reports pertaining to flight hours, seeding agent usage, etc.

5. FUTURE PLANS

Incorporation of flight data into the NDCMP database opens the door to more robust analysis and evaluation activities down the road. NDARB plans to ingest TITAN radar data into the database in the near future allowing another realm of potential development tools and analysis. Custom tools and procedures could identify seeded from non-seeded radar echoes based on the comparison of the two datasets. These data, in addition to NDARB's Cooperative Observer Network data, which includes 28 years of high density statewide growing season rain and hail reports, offer a multitude of intriguing possibilities in the area of analysis and evaluation. At minimum, we intend to utilize these data in the development of an evaluation methodology for seeding operations.

6. REFERENCES

Orville, H.D., D. Banaszewski, J.A. Heimbach, Jr., L. Osborne, P.L. Smith, and W.L. Woodley, 2003: A Review of the North Dakota Cloud Modification Program. Report of a Review Panel to the NDARB, 29pp.

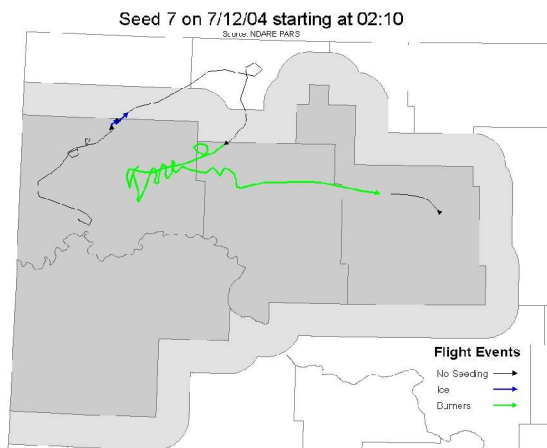


Figure 7. Flight map created from operations data.

The database provides standard tools and allows the development of additional tools limited only