



WEATHER MODIFICATION IN ND
DAN BROTHERS, METEOROLOGIST NDDWR

NORTH
Dakota
Be Legendary.™



OUTLINE

- Brief history
- Cloud seeding in ND
- Project evaluations & benefits
- Research & development
- Weather modification in North America

HISTORY

- Pioneering discoveries at GE Research Lab, 1946
 - Dr. Vincent Schaefer – Dry ice
 - Dr. Bernard Vonnegut – Silver Iodide
- Project Cirrus – collaborative research project began in 1947



Credit: GE News Bureau



Pl.259 Two lines cut through a deck of supercooled clouds, using dry ice fragments dispensed at rate of about 1 kg/km. Thin veils of ice crystals remain in seeded area but most have fallen.

Pl.260 An extensive hole cut through cloud deck shown above. This opening developed in about 40 minutes and remained open for several hours. New clouds are starting to form in cleared area.



Pl.261 A solid deck of supercooled clouds seeded with burning pellets of charcoal containing silver iodide. The nuclei in the smoke converted mile-wide strips of cloud to ice crystals.

Pl.262 The same area as shown on Plate 261, from the other end of the seeded field about 10 minutes later as the ice crystals settled out of the cloud to produce lines of virga below cloud base.





WHY SEED CLOUDS?

- Rain/Snow enhancement
- Hail suppression
- Fog dispersal
- Sponsors include:
counties, cities, states,
irrigation districts, ski
resorts, public utilities,
water distributors, etc.



Cloud Seeding in North Dakota



CLOUD SEEDING IN NORTH DAKOTA

- First seeding attempts in 1948
- Project areas established, ground-based seeding in 1951
- Aircraft become preferred seeding delivery method in 1960
- In 1975, the Legislature created the ND Weather Modification Board to provide regulatory functions, operational support, conduct research and evaluations and provide State cost-share funding

NORTH DAKOTA PILOT PROJECT

- NDPP conducted from 1969-72
 - Randomized (3:1) proof of concept cloud seeding project in McKenzie County. Mountrail and Ward included in 1972
 - 67 rain gauges, radar observations
- Findings:
 - Statistically significant increases in (1) the number of rain events, (2) average rainfall per event, and (3) total rainfall in the target area (~10%). Published in AMS Journal of Applied Meteorology by Dennis *et. al*, 1975

NORTH DAKOTA PILOT PROJECT

- Findings:
 - Analysis of cloud seeding on hail indicated the ratio of average rainfall to hail energy was greater on seeded days and crop-hail insurance losses lower. Due to smaller sample size, results weren't statistically significant. Published in AMS JAM by Miller *et. al*, 1975



PROGRAM CREATION

- County participation through 51% petition or public vote
 - Creates 10-year authority
- Temporary (up to 4 year) authority created through public hearing and resolution of the county commission



PROGRAM CREATION

- Co. Comm. appoints 5 members to “Weather Modification Authority”, which oversees project
 - DWR staff communicates with Authority members during the project to solicit feedback and adjust operations

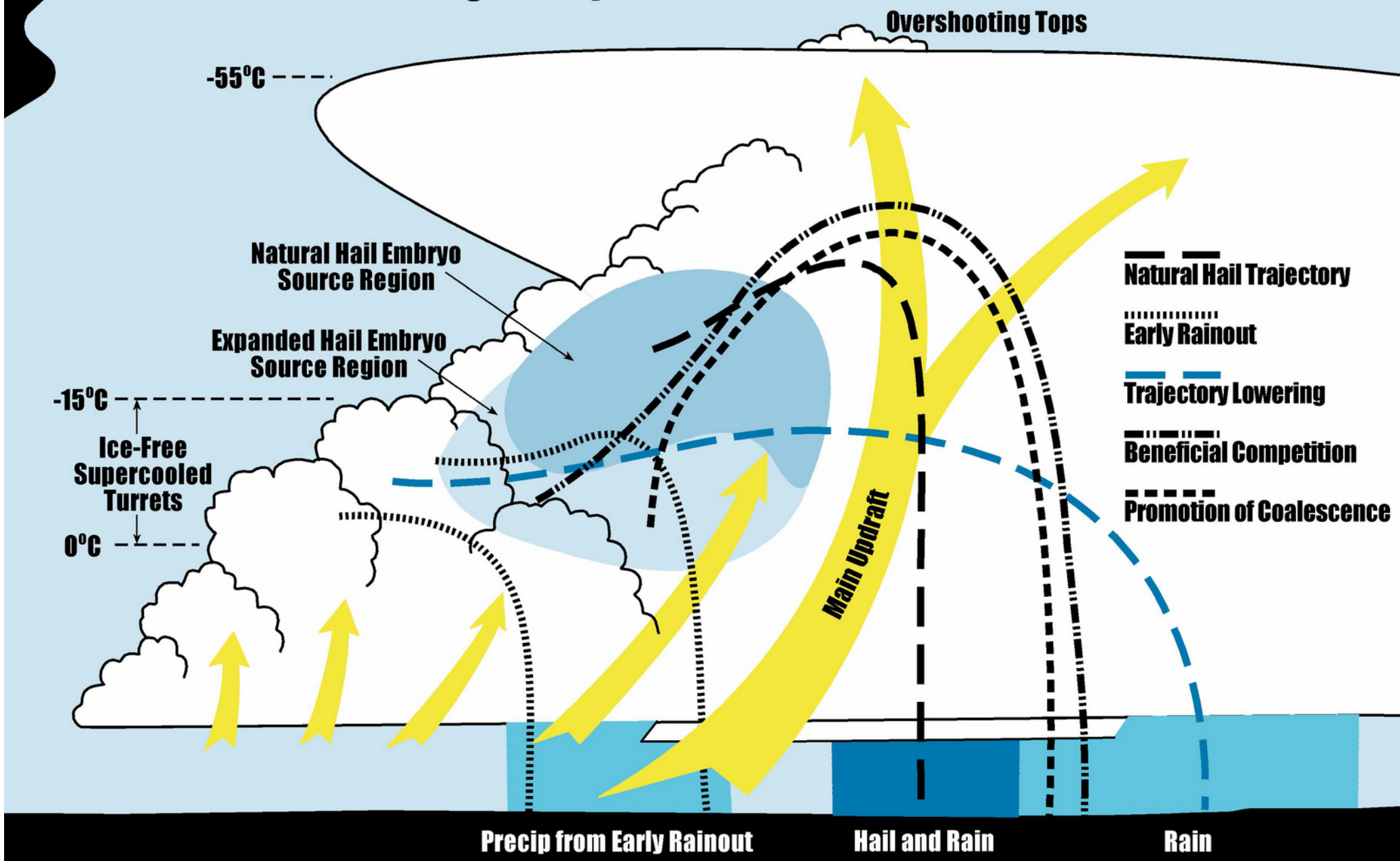
NDCMP 2026



ND CLOUD MODIFICATION PROJECT

- NDCMP goals are hail suppression and rain enhancement
- Convective clouds (e.g. thunderstorms) are seeded by aircraft in the updraft below cloud base.
- Silver iodide acts as a nucleus for droplets to form and then freeze earlier than what occurs naturally
- Earlier ice formation induces competition and distributes the water in the cloud over more particles
- These particles don't grow as large and have greater ability to melt as they fall from the cloud

Cloud Seeding Conceptual Model

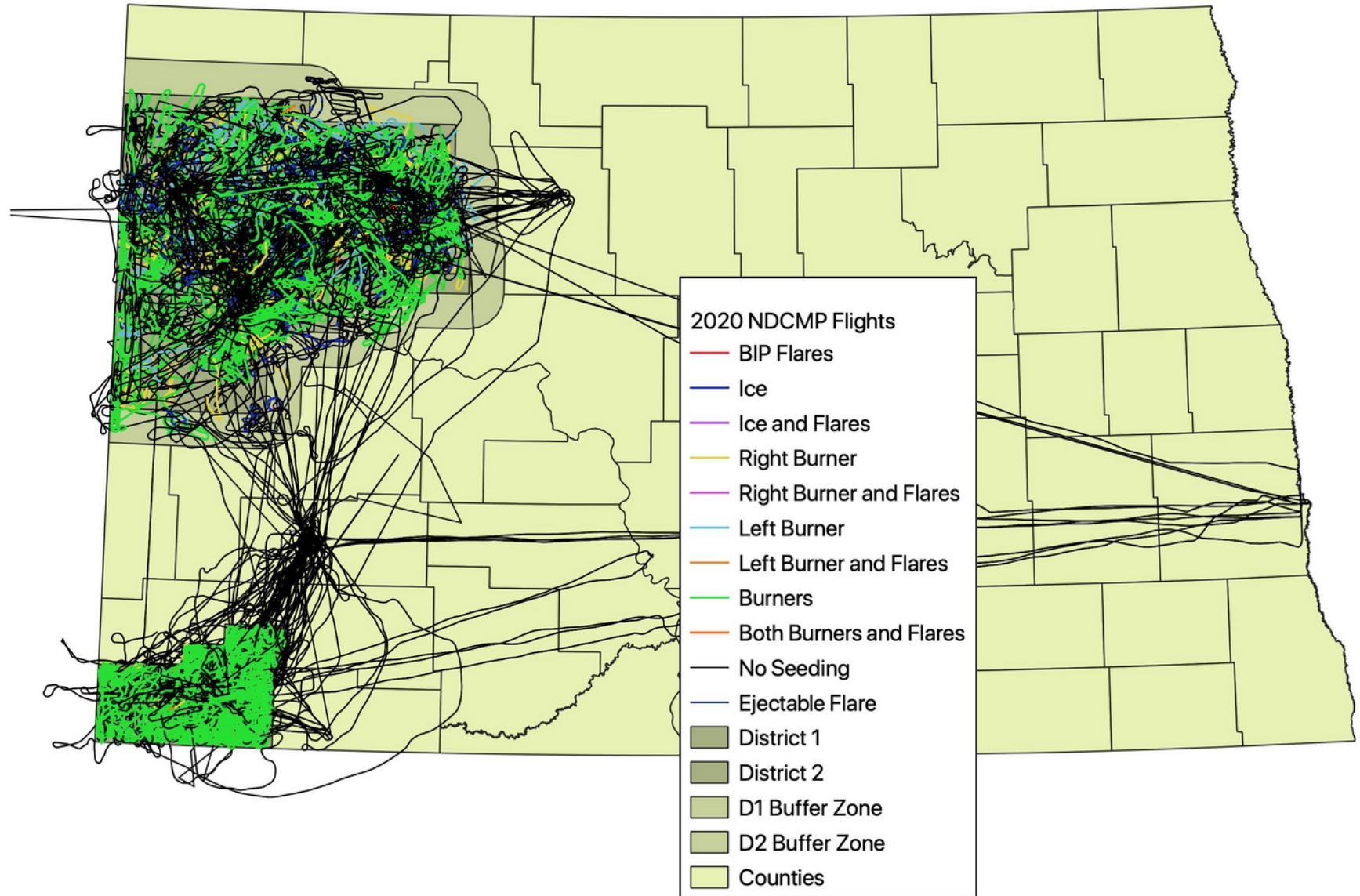


NDCMP AIRCRAFT

- Piper Seneca II
 - Base seeding



2020 NDCMP Flight Tracks





INTERN PROGRAMS

- DWR & UND have had an MOU to provide Intern Pilot training since 1975
 - Since then, 414 pilot interns have participated
- DWR's meteorology intern program began in 1996 and has provided training for 76 students

INDEPENDENT EVALUATIONS

- Crop insurance analysis over a 13-year period found 45% lower crop-hail losses in seeded counties vs. upwind control (JAM, Smith *et al.*, 1997)
 - Prior study of crop insurance in 1987 found 43.5% reduction
 - Nodak Insurance study found 43% lower incidence of hail claims in seeded counties versus the rest of N.D. (K. Pifer, personal comm., 1995)
- Several rainfall studies using varied datasets have indicated percentage increases from the low single digits to the low teens, with typical results in the 5-10% range (Eddy & Cooter, 1979, Johnson, 1985, Smith *et al.*, 2004, Wise, 2005, Tuftedal, 2020)

INDEPENDENT EVALUATIONS

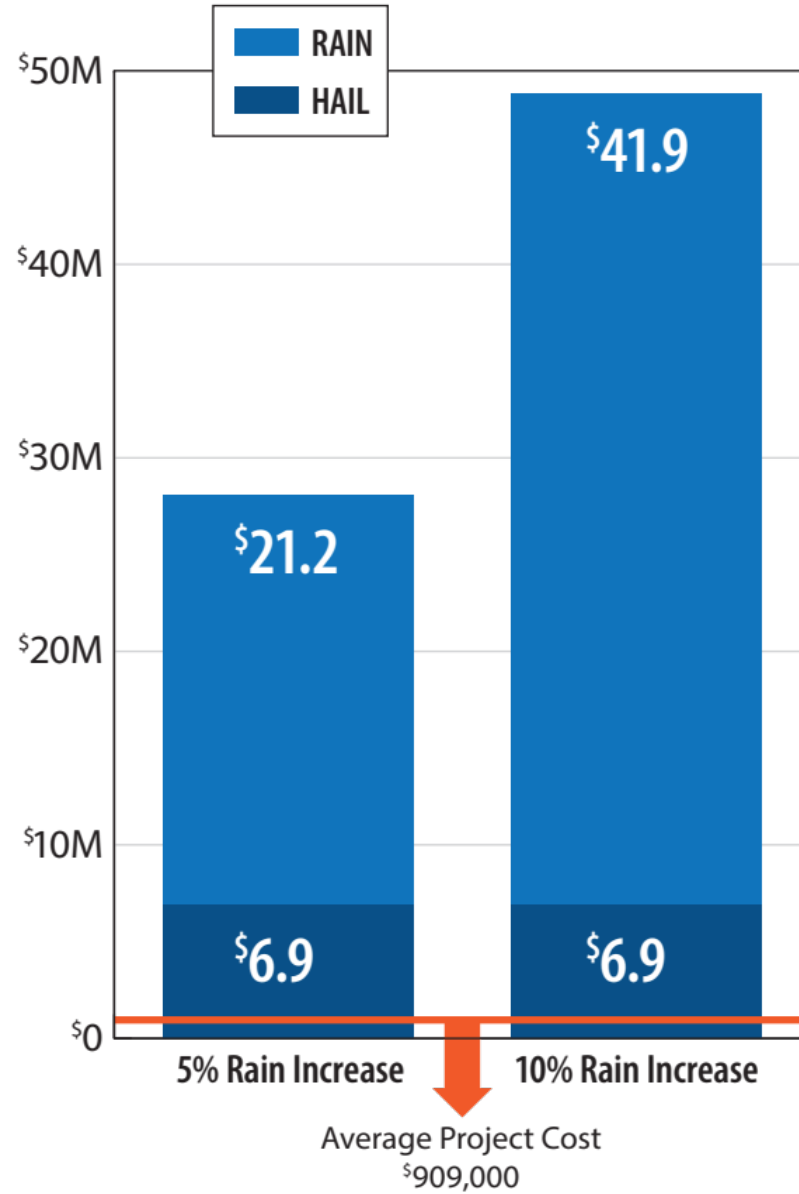
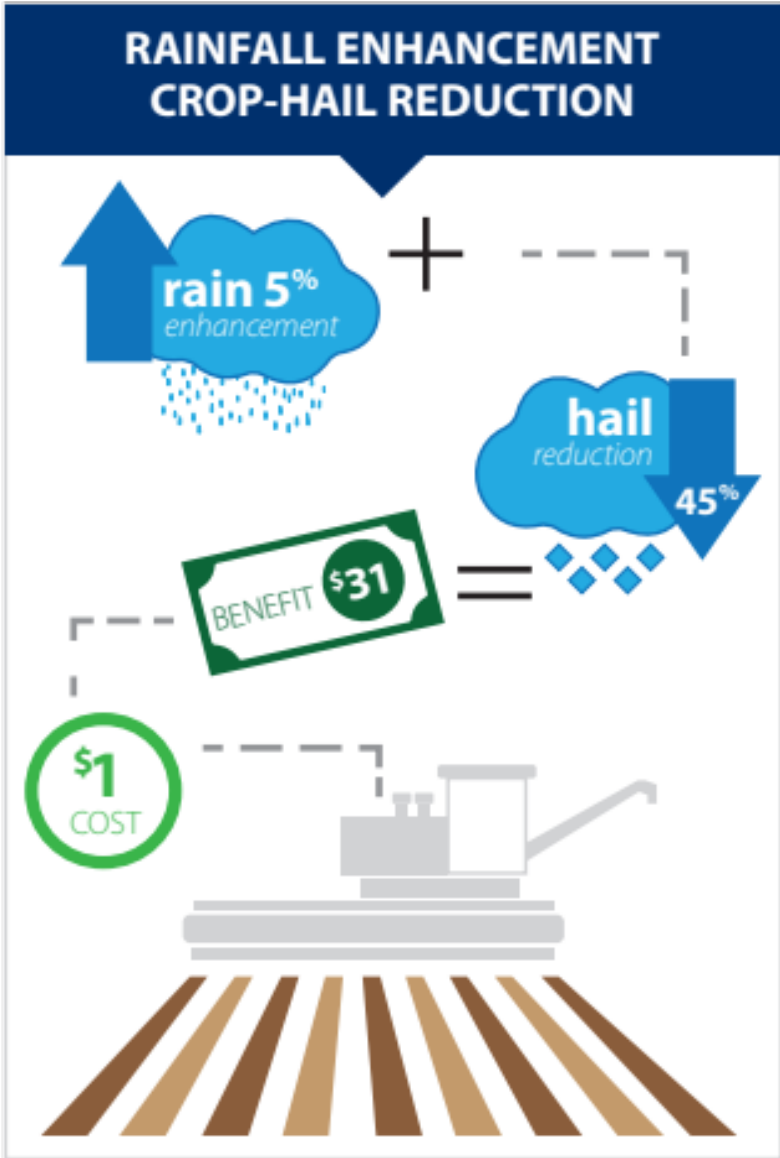
- Wheat yields were found to be 5.9% higher on average in the seeded counties versus an adjacent control area (JAM, Smith *et al.*, 1992)
- Downwind effects show a slight **increase** in rainfall (Wise, 2005), which is consistent with findings from other programs in the U.S. and around the world (DeFelice *et al.*, 2014)

ECONOMIC EVALUATIONS

- Several economic studies have been done, the most recent by NDSU this year (Bangsund and Hodur, 2019)
 - Economics were evaluated for rainfall increases of 5 and 10%, and crop-hail damage reductions of 45%
- Analysis included the top 8 crops by planted acreage plus alfalfa
 - In the 5% rainfall scenario, direct benefits through additional ag production are \$21.22 million annually, or \$9.12 per planted acre
 - Under the 10% scenario, benefits are estimated to be \$41.9 million annually, or \$18.15 per planted acre
 - Estimated crop savable due to hail suppression was estimated at \$6.9 million per year

ECONOMIC EFFECTS

- Total combined benefits at 5% rainfall enhancement is estimated at \$28.2 million. B/C ratio: 30:1
- Total combined benefits at 10% rainfall enhancement is estimated at \$48.8 million. B/C ratio: 53:1
- State and local government revenues from enhanced ag production are estimated to range from \$576,000-\$999,000
- Other potential benefits that may be attributed to cars, homes, businesses and other infrastructure are not included



ONGOING RESEARCH & EVALUATIONS

- UND Graduate Thesis on NDCMP rainfall evaluation (Tuftedal)
 - Results show statistically significant increases in rainfall in McKenzie County versus upwind control areas
- Knowles and Skidmore found statistically sig. results of increased wheat production (3.87 bu./acre) and lower insurance indemnities in seeded vs. unseeded counties
- NCAR/DWR analysis of radar estimated hail development
 - UND Graduate project set up an analysis scheme for seeded and unseeded storms
 - Showed very positive results over a 3-year period. (92.1% Significance)
 - PhD work to expand analysis and number of cases.

CONCLUSIONS

- Weather modification has a long, successful history in North Dakota
- Benefits to agriculture far outweigh the costs
- More than 3 dozen operational programs in the western U.S. with continuing expansion

COMMON MISCONCEPTIONS

- Fiction: Few studies have been done and they're all old
- Fact: Several independent studies have been conducted to evaluate the effectiveness of cloud seeding
- Fiction: Seeding "kills storms" or reduces rain downwind
- Fact: Studies show that ***seeding enhances downwind precipitation*** as effects persist for a time after seeding
- Fiction: Silver iodide is dangerous to people and the environment
- Fact: Dozens of studies and thousands of field samples have proven that ***AgI poses no human or environmental danger***

QUESTIONS



Pilot Aircraft Recordkeeping System (PARS)

Daniel Brothers



General Information

- ⊗ Paperwork is required by law.
- ⊗ From June 1 through the end of project a flight form and map are required for every flight the plane makes.
- ⊗ Keep it professional. All records are open to the public.
- ⊗ If/when PARS doesn't work, paper flight forms and maps will be expected, so be prepared. It will happen to someone over the course of the summer.
 - ⊗ Paper forms are provided in the packets given to pilots when they pick up their iPads.

Paperwork

- ⊗ Mission Summary
 - ⊗ Required for every flight
 - ⊗ Should be a synopsis of the mission. What happened. What was seen.
 - ⊗ If “Other” than what was the reason for the flight?
 - ⊗ Most commonly a reposition flight
 - ⊗ What kind of “Maintenance”? Burner check or something else?
 - ⊗ If “Recon” than why no seeding?
 - ⊗ Common Abbreviations are ok, but avoid less common ones.
 - ⊗ BIS for Bismarck is fine, 08D for Stanley is not.

Paperwork

- ⊗ There are 5 possible purposes on project
- ⊗ Recon – An operational mission where no seeding occurred.
- ⊗ Rain – Rain enhancement, typically characterized by only using one burner and no BIPs.
- ⊗ Hail – Hail suppression, typically uses two burners and possibly BIPs.
- ⊗ Other – Miscellaneous DWR flights, usually reposition flights after missions.
- ⊗ Maintenance – WMI flights, usually burner checks and test flights after repairs.

Paperwork



FLIGHT REPORT - CLOUD BASE AIRCRAFT
NORTH DAKOTA ATMOSPHERIC RESOURCE BOARD
 SFN 11816 (6/2000)

PAGE # 1 OF 1

ENGINES OFF 21:29
 ENGINES ON 20:24
 TOTAL TIME 1:05

FOR OFFICE USE ONLY

HOURS	
1 GEN	2 GEN
EJCTBL	BIP

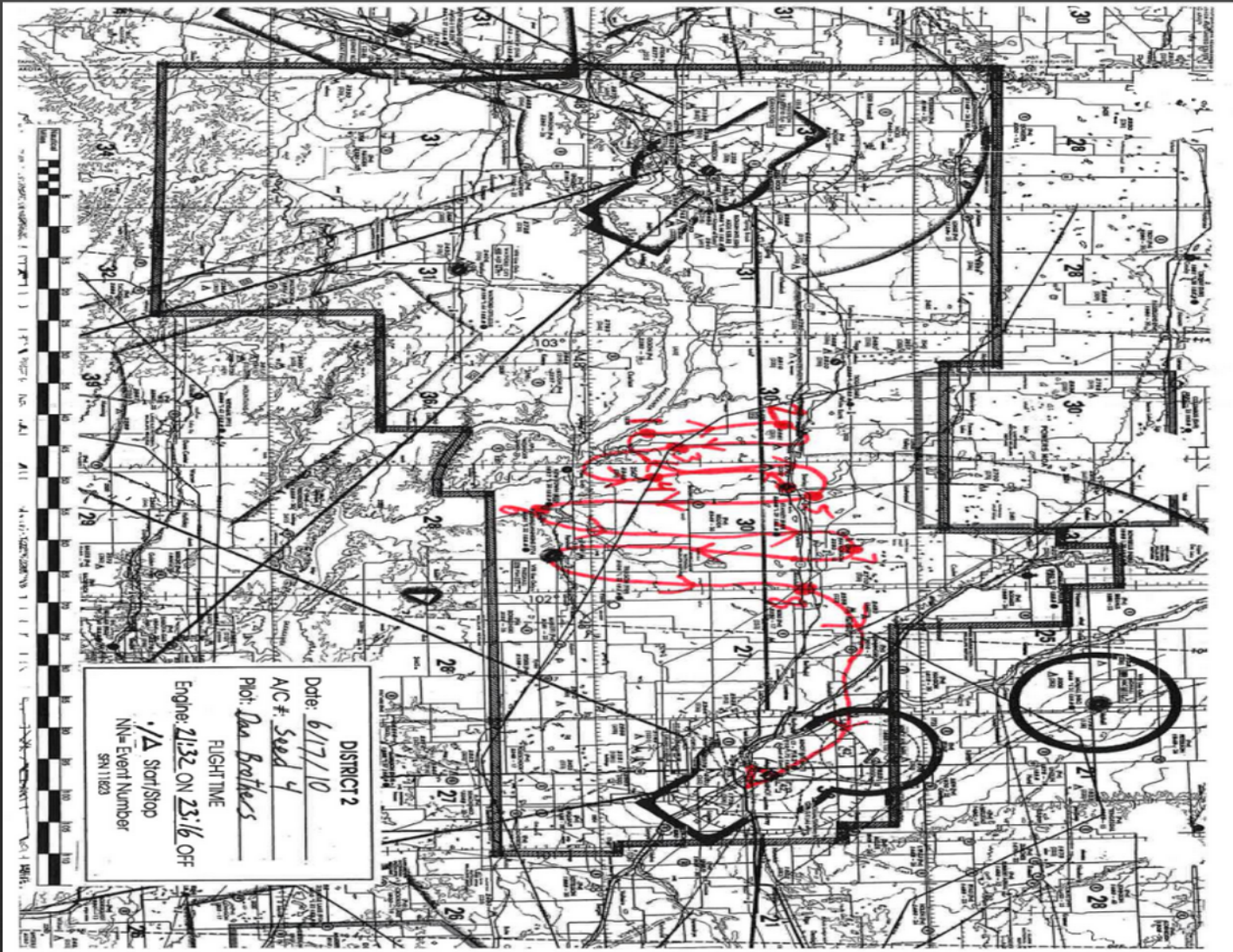
DATE (YY/MM/DD)		DISTRICT		SEED #	PILOT				COPILOT				PURPOSE	R - Rain	C - Reconnaissance
11/05/25		2		4	Daniel Brothers				Mark Schneider				H	H - Hall	M - Maintenance
A	B	C	D	E	F	G	H	I	J	K	L	M	N		
TIME (HH:MM)	EVENT #	VORTAC CODE*	VOR (deg)	DME (nm)	CLD BASE (kft)	ALTITUDE (kft)	UPDRAFT (ft/min)	TEMP (°C)	WINGTIP GEN (#)	PRECIP CODE**	# BIP FLARES	BIP FLARE YIELD (g)	REMARKS		
20:24		8	078	54	.	.		28	0				Engines On Stanley		
20:30		8	078	54	.	.		28	0				Takeoff, Burners 100%		
20:38	1	8	042	29	8.5	8.0	500	12	1	2			Bagged Bases, Right Burner On		
20:46	2	8	035	22	9.0	8.0	100	10	0	2			Lost inflow, Reposition, Burner Off		
20:55	3	8	164	2	8.0	7.0	700	11	2	3			Shelf Cloud, Both Burners On		
21:03	4	8	166	5	8.0	7.5	700	9	2	4	1	75	Steady Inflow, Green Tint, Flare		
21:12	5	8	115	11	8.5	7.5	0	9	0	2			Lost inflow, burners off, RTB		
21:25		8	173	53	.	.		25	0				Land Watford City		
21:29		8	173	53	.	.		25					Engines Off		
:					.	.									
:					.	.									
:					.	.									
:					.	.									
:					.	.									
:					.	.									

***VORTAC CODES**
 1. Bismarck 5. Stanley
 2. Devils Lake 6. Jamestown
 3. Dickinson 7. Minot
 4. Bowman 8. Williston

****PRECIPITATION INTENSITY**
 0 - no precipitation observed
 1 - virga only, precip not to ground
 2 - rain shaft to surface, light
 3 - rain shaft well established, but can be seen through
 4 - heavy rain shaft, cannot be seen through

MISSION SUMMARY
 Launched to development NE of Williston. Initially seeded for rain using one burner. Inflow was quickly lost, and we repositioned to a storm over Williston. The storm developed a nice shelf and green tint so one BIP was used. As the storm died we RTBed to Watford City.

Paperwork



Old PARS



Old PARS Equipment



palmOne

TUNGSTEN | E2

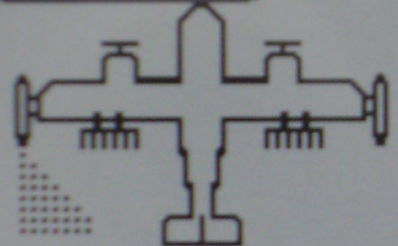
Base Seeder Flight

100%

Engines On
0.3 hours

3D
Accuracy

Engines Off



Rcvd
844

Flare
0

InitRec - 4 Cur - 14

041608 17:04:06
46.81689 -100.7783

Remarks
8 min

Left
Burner
9 min

Both
Burners

Right
Burner
0 min





FLIGHT REPORT
 NORTH DAKOTA ATMOSPHERIC RESOURCE BOARD
 SFN 50864(12/2014)

ENGINES OFF 02:42:15	HOURS 2.02		PAGE # 1	OF 2
ENGINES ON 00:41:00	DRY ICE RATE 0	1 GEN 0.00	2 GEN 0.87	
TOTAL TIME 02:01:15	DRY ICE (lbs) 0.00	EJCTBL (grams) 0	BIP (grams) 450	

DATE June 2, 2005		DISTRICT 1	SEED # 1	PILOT Jason Akina				COPILOT					PURPOSE H	R - Rain H - Hail O - Other M - Maintenance C - Reconnaissance
Time (HH:MM)	EVENT #	LATITUDE (deg)	LONGITUDE (deg)	CLD BASE (kft)	ALTITUDE (KFT)	UPDRAFT (FT/MIN)	TEMP (°C)	PRECIP CODE**	DRY ICE (sec)	FLARES		WINTIP GEN (#)	REMARKS	
										EJC	BIP			
00:41:00		46.18383	-103.4268		2.8					0	0	0	Engines on in Bowman.	
00:51:15		46.17180	-103.3990		3.3					0	0	0		
00:58:10		46.17375	-103.3086	8	7.2	0				0	0	0		
01:05:00	1	46.36952	-103.1195		8.8	500	10	1		0	0	2	Two burners on.	
01:13:13	2	46.39356	-103.0816		8.3	0				0	0	0	Two burners off.	
01:21:52		46.09642	-103.2415		8.0	0				0	0	0		
01:24:28	3	46.00716	-103.2847		8.1					0	0	2	Two burners on.	
01:26:07	4	45.96891	-103.3281		8.3	400		2		0	1	2	BIP lit.	
01:32:30	5	46.00535	-103.3277		8.9	200				0	1	2	BIP lit.	
01:40:46	6	46.03755	-103.2380	9	9.1	700				0	1	2	BIP lit.	
01:45:56	7	46.08233	-103.1682		9.5	0				0	1	2	BIP lit.	
01:54:26	8	46.01844	-103.0616		9.6	800	10			0	1	2	BIP lit.	
02:02:17	9	46.21321	-102.9349	8	8.8	600				0	1	2	BIP lit.	

**PRECIPITATION INTENSITY 0 - No Precipitation 1 - virga only, precip not to ground 2 - rain shaft to surface, light 3 - rain shaft well established, but can be seen through 4 - heavy rain shaft, cannot be seen through	MISSION SUMMARY launched to the S part of the district to seed a line of new development moving in from the SW. this new line started to developed and run up through the N part of the district. I approached the cell by seeding in the front part of the cell flying N and S tucked up against the shelf cloud. It was probably the biggest shelf I've seen since being with WMI. proceeded to seed in front of the cell till the end of the W buffer then RTB to the south around the storm.
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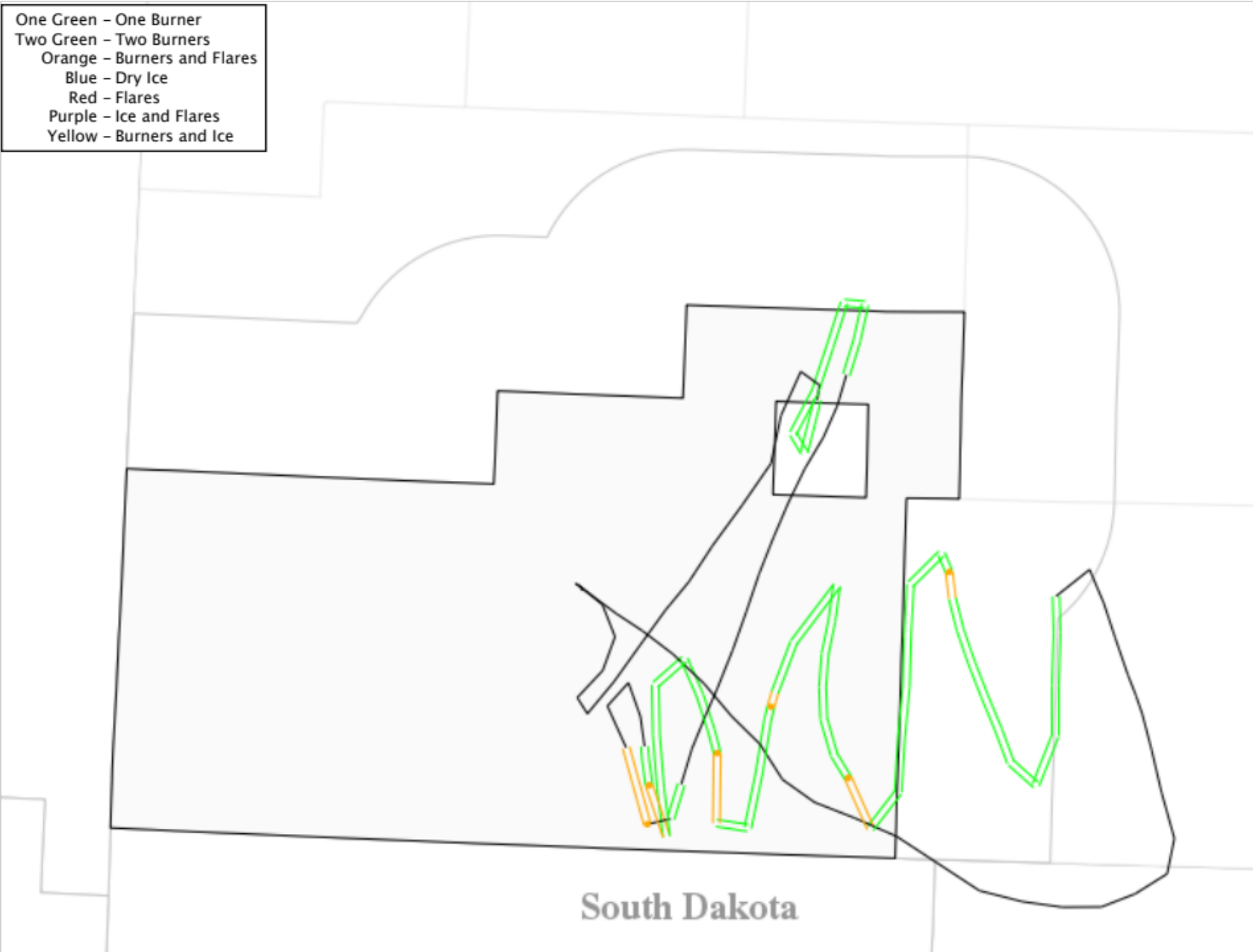
FLIGHT REPORT
 NORTH DAKOTA ATMOSPHERIC RESOURCE BOARD
 SFN 50864(12/2014)

ENGINES OFF 02:42:15	HOURS 2.02		PAGE # 2	OF 2
ENGINES ON 00:41:00	DRY ICE RATE 0	1 GEN 0.00	2 GEN 0.87	
TOTAL TIME 02:01:15	DRY ICE (lbs) 0.00	EJCTBL (grams) 0	BIP (grams) 450	

DATE June 2, 2005		DISTRICT 1	SEED # 1	PILOT Jason Akina				COPILOT					PURPOSE H	R - Rain H - Hail O - Other M - Maintenance C - Reconnaissance
Time (HH:MM)	EVENT #	LATITUDE (deg)	LONGITUDE (deg)	CLD BASE (kft)	ALTITUDE (KFT)	UPDRAFT (FT/MIN)	TEMP (°C)	PRECIP CODE**	DRY ICE (sec)	FLARES		WINTIP GEN (#)	REMARKS	
										EJC	BIP			
02:12:30	10	46.19355	-102.7903		9.3	0				0	0	0	Two burners off.	
02:16:38		46.12243	-102.6910		9.3	0				0	0	0		
02:17:29		46.09520	-102.6750		9.3	0				0	0	0		
02:28:17		45.96544	-102.9941		7.3					0	0	0		
02:38:58		46.18854	-103.4312		2.8					0	0	0		
02:42:15		46.18464	-103.4266		2.8					0	0	0	Engines off in Bowman.	

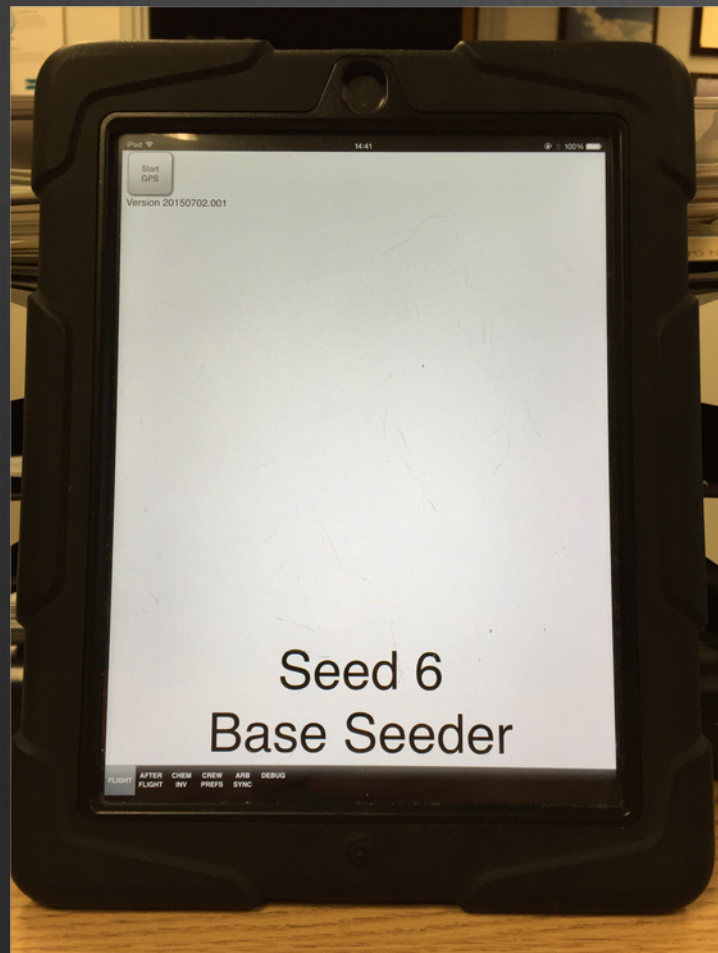
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Seed 1 on 6/2/05 at 00:41:00z

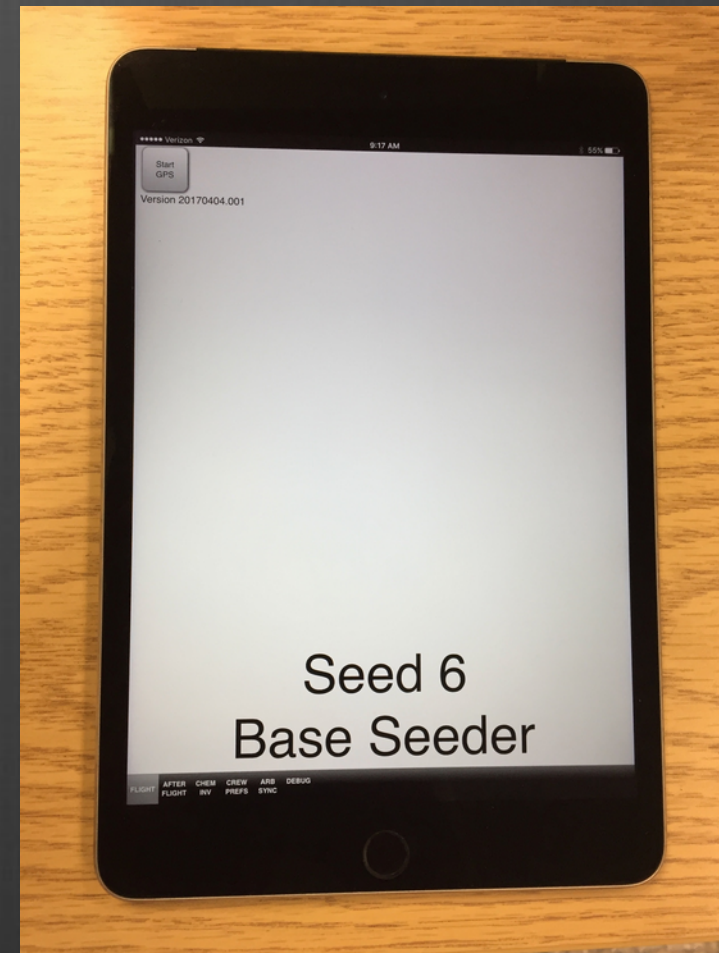


New PARS

iPad (3rd Gen)



iPad Mini (4th Gen)





FLIGHT REPORT
 NORTH DAKOTA ATMOSPHERIC RESOURCE BOARD
 SFN 50864(12/2014)

ENGINES OFF 00:54:35	HOURS 1.86		PAGE # 1	OF 2
ENGINES ON 23:03:01	DRY ICE RATE 0	1 GEN 0.00	2 GEN 1.19	
TOTAL TIME 01:51:34	DRY ICE (lbs) 0.00	EJCTBL (grams) 0	BIP (grams) 150	

DATE June 19, 2015		DISTRICT 1	SEED # 1	PILOT Vadim Alekseev				COPILOT Zach Santee				PURPOSE H	R - Rain H - Hail O - Other M - Maintenance C - Reconnaissance
Time (HH:MM)	EVENT #	LATITUDE (deg)	LONGITUDE (deg)	CLD BASE (kft)	ALTITUDE (KFT)	UPDRAFT (FT/MIN)	TEMP (°C)	PRECIP CODE**	DRY ICE (sec)	FLARES EJC BIP		WINTIP GEN (#)	REMARKS
23:04:23		46.16983	-103.3038		2.9					0	0	0	Engines on in Bowman.
23:14:28		46.12606	-103.5557		6.6					0	0	0	
23:23:26		46.13757	-104.0315	8	7.2	400	19	4		0	0	0	
23:25:29	1	46.22966	-104.0407	8	7.0	700	19	4		0	0	2	Two burners on.
23:26:16	2	46.26484	-104.0426	8	6.8	700	19	4		0	1	2	BIP lit.
23:36:18		46.16854	-103.9714		8.0					0	0	2	
23:37:13	3	46.20853	-103.9636	8.5	8.2	800	19	4		0	1	2	BIP lit.
23:47:36		46.10335	-103.9900	8.5	8.6	800	15	3		0	0	2	
00:08:48		46.04565	-103.7454		8.8					0	0	2	
00:18:54		46.02869	-103.5730		9.5					0	0	2	
00:23:37		46.03232	-103.4734	9.5	9.2	700	10	3		0	0	2	
00:33:42		46.03102	-103.4444		8.8					0	0	2	
00:36:51	4	46.01844	-103.3630	10	9.5		15	1		0	0	0	Two burners off.

**PRECIPITATION INTENSITY 0 - No Precipitation 1 - virga only, precip not to ground 2 - rain shaft to surface, light 3 - rain shaft well established, but can be seen through 4 - heavy rain shaft, cannot be seen through	MISSION SUMMARY We launched to check out a storm on the MT border. It was a well defined supercell. We had good consistent inflow of 800 ft/min. We seeded for a little over an hour and then returned to base to refuel and rechem.
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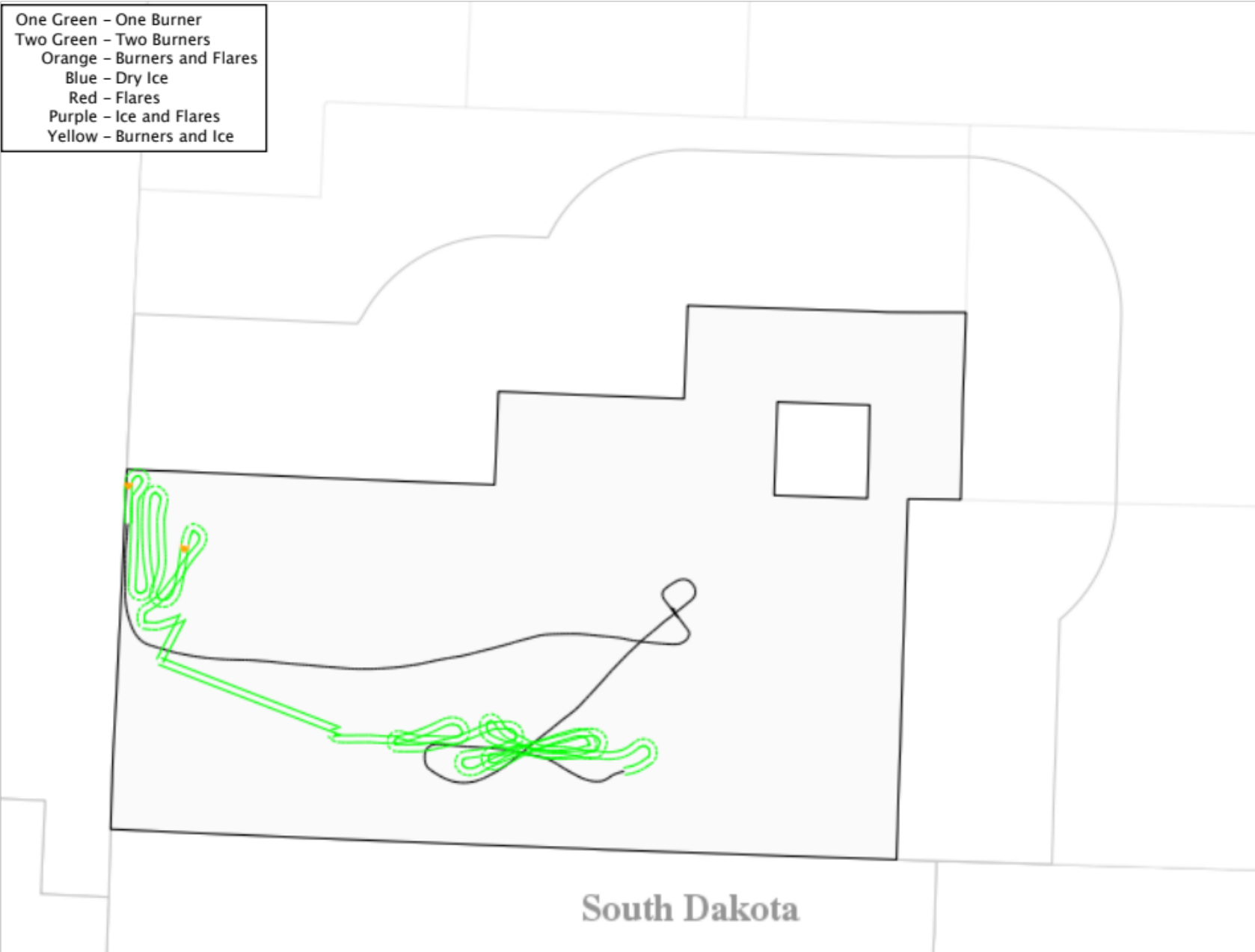
FLIGHT REPORT
 NORTH DAKOTA ATMOSPHERIC RESOURCE BOARD
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ENGINES OFF 00:54:35	HOURS 1.86		PAGE # 2	OF 2
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Time (HH:MM)	EVENT #	LATITUDE (deg)	LONGITUDE (deg)	CLD BASE (kft)	ALTITUDE (KFT)	UPDRAFT (FT/MIN)	TEMP (°C)	PRECIP CODE**	DRY ICE (sec)	FLARES		WINTIP GEN (#)	REMARKS
										EJC	BIP		
00:46:55		46.12352	-103.3694		4.8					0	0	0	
00:54:35		46.17124	-103.3038		2.9					0	0	0	Engines off in Bowman.

**PRECIPITATION INTENSITY 0 - No Precipitation 1 - virga only, precip not to ground 2 - rain shaft to surface, light 3 - rain shaft well established, but can be seen through 4 - heavy rain shaft, cannot be seen through	MISSION SUMMARY We launched to check out a storm on the MT border. It was a well defined supercell. We had good consistent inflow of 800 ft/min. We seeded for a little over an hour and then returned to base to refuel and rechem.
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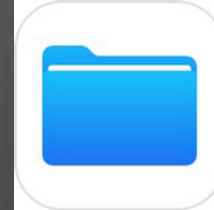
Seed 1 on 6/19/15 at 23:03:01z



Apps

- 🎬 Files App

- 🎬 NDCMP Documents



- 🎬 Foreflight

- 🎬 Available June 1

- 🎬 I'll send an email with log in info when setup



- 🎬 GoTo

- 🎬 Video Chat service for briefings



- 🎬 Other

PARS

- ⊗ iPad should always be charged and ready to go.
- ⊗ Bring the charging cord with you.
- ⊗ Battery lasts longer with lower screen brightness.
- ⊗ Location Services On for Safari
- ⊗ WiFi OFF when running PARS
- ⊗ Don't Overheat iPad. Don't leave on dash of car or plane

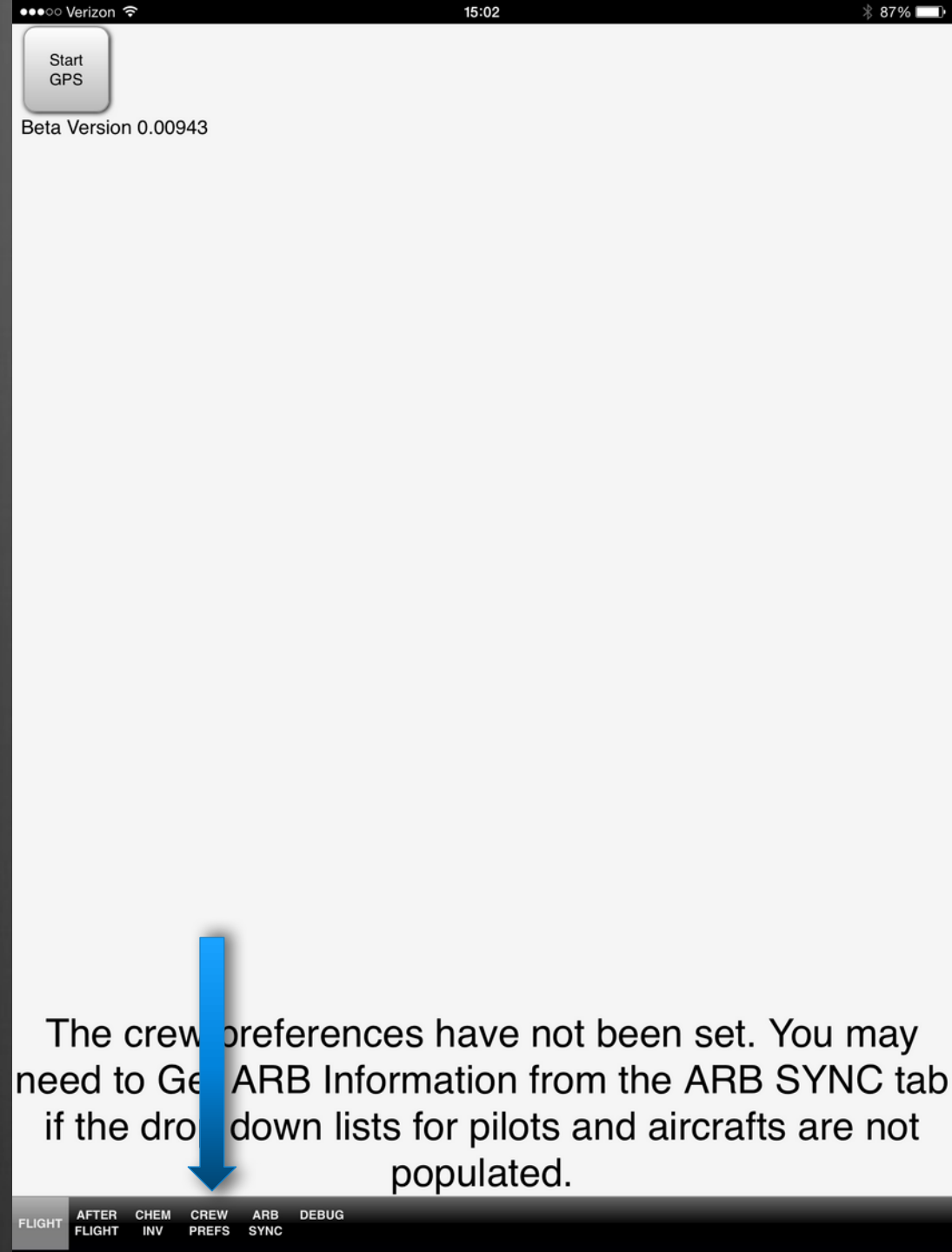
PARS

- ⊗ GPS Flight Tracking WILL NOT WORK if you are not in the PARS app with the screen on.
- ⊗ Select PARS!
- ⊗ Always allow PARS to use current location. That's the GPS!
 - ⊗ PARS is a web-based application, so you ALWAYS give Safari permission to use GPS as well, if asked.

PARS Homepage

Crew Preferences may not be set the first time you open PARS, or the preferences may not be accurate.

First Select Crew Prefs to set the Security Key



CREW PREFS

The Security Key is required to Download and Upload info to the Flight Database

Should already be set, but check to make sure.

If you need the Security Key, call Dan.

Next Select ARB SYNC to download the most up-to-date info from ARB. (Must be connected to Wi-Fi)

1:24 PM

Default Pilot: Jody Fischer

Default CoPilot: Daniel Brothers

Aircraft Type: Base

Seed Number: Seed 1

Default Airport: Bowman

District: D1

Security Key: 960-536-731-890

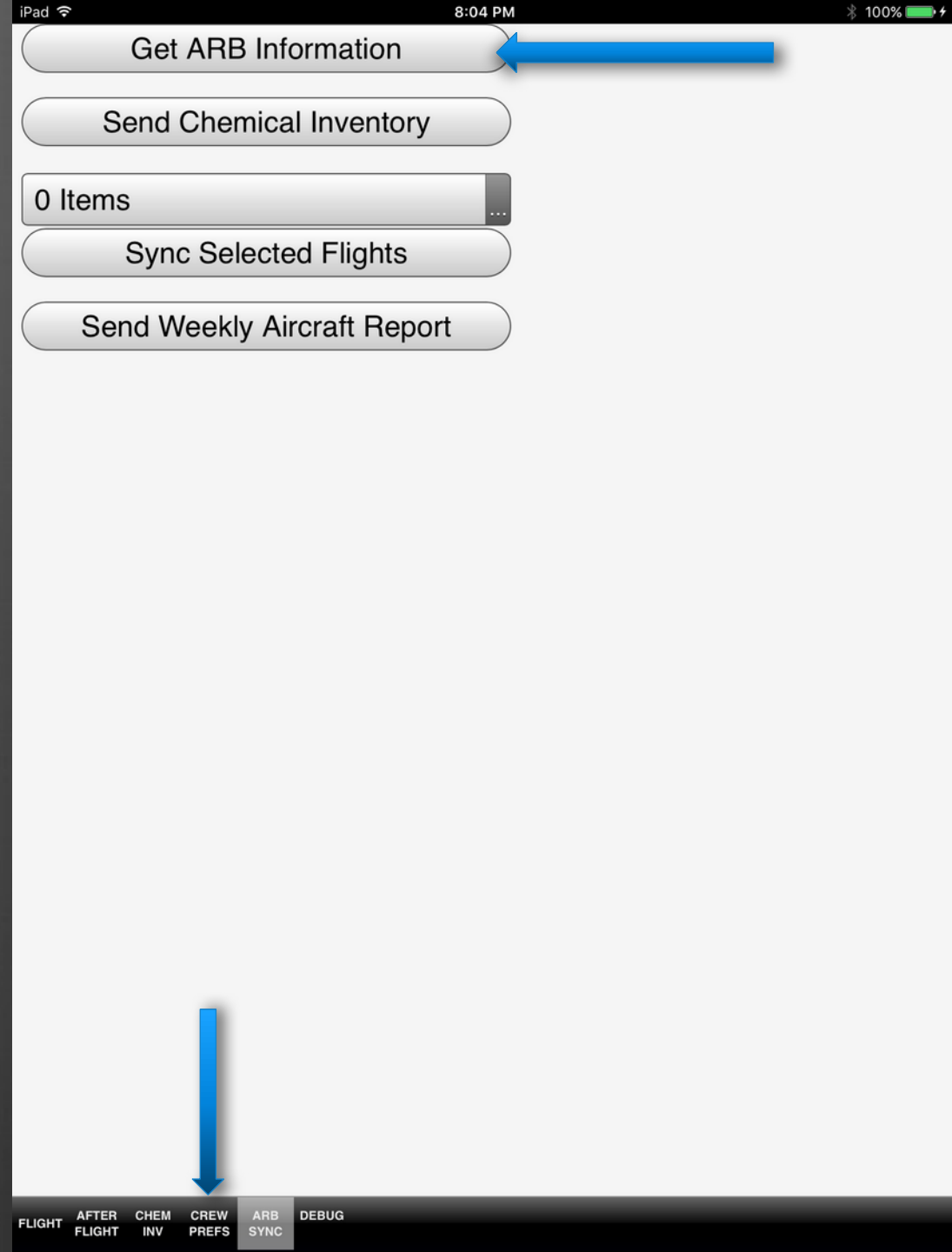


ARB SYNC

Get ARB Information

- Downloads info such as Pilot lists, Co-Pilot lists, and Airports.

After you Get ARB Information, select CREW PREFS from the bottom menu.



CREW PREFS

These menus let you select the basic information for your plane.

DO NOT change info for one flight or for a rotating vacation intern. These adjustments can and should be made in the Flight Info for that flight.

Once Preferences are set, select Flight from the bottom menu.

1:24 PM

Default Pilot: Jody Fischer

Default CoPilot: Daniel Brothers

Aircraft Type: Base

Seed Number: Seed 1

Default Airport: Bowman

District: D1

Security Key: 960-536-731-890



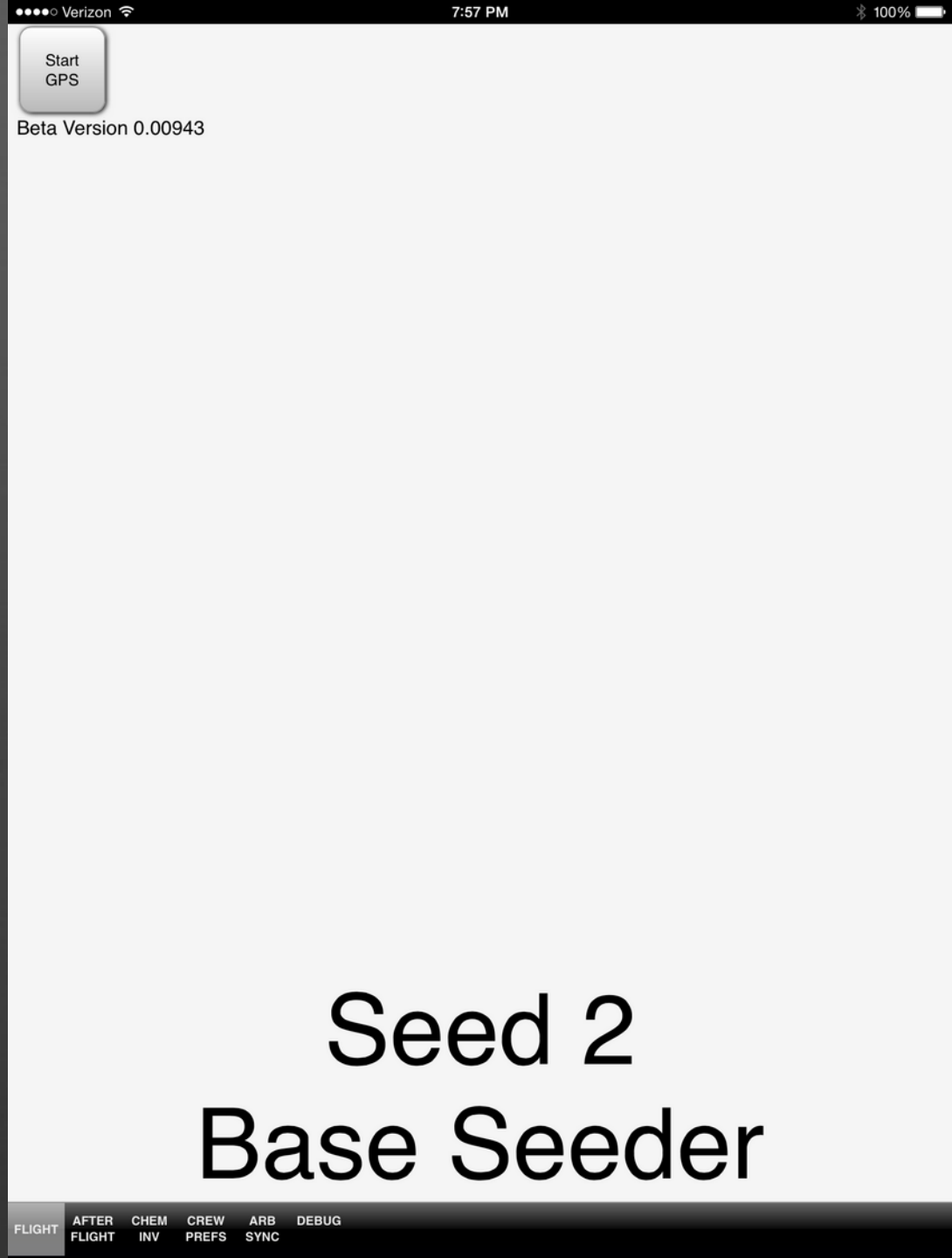
Flight

Anytime you are launched, Start GPS immediately.

- Before you even get to the plane.
- This gives the GPS a few minutes to get proper accuracy.

Many buttons require a double tap to work. The first tap darkens the button. The second tap confirms the button.

- Helps prevent mistakes in bumpy airplanes.



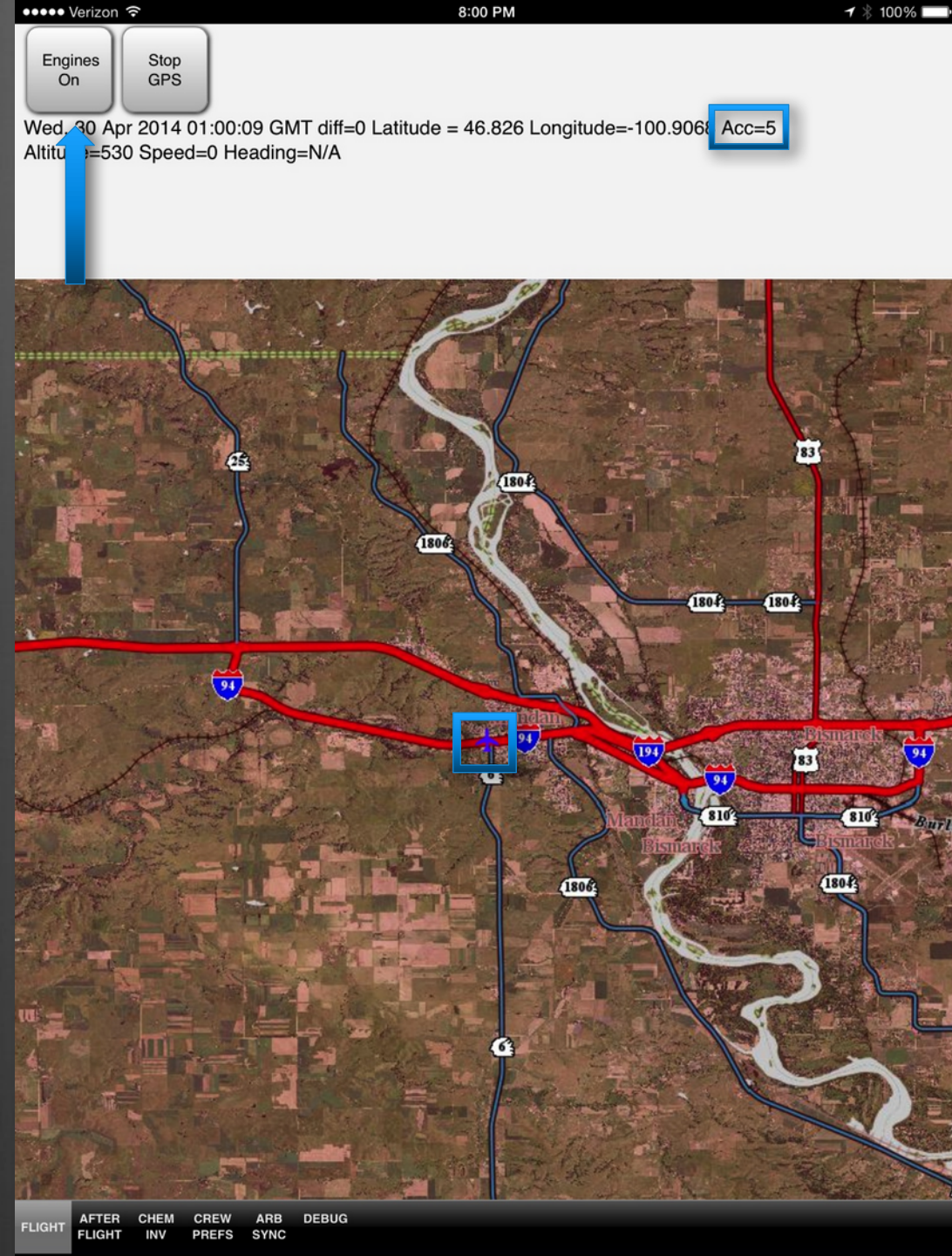
Seed 2
Base Seeder

Flight

Once GPS is turned on the map appears showing your current location.

GPS accuracy should be at least 10 before Engines On.

Press Engines On as close as possible to actual Engines On of the airplane.

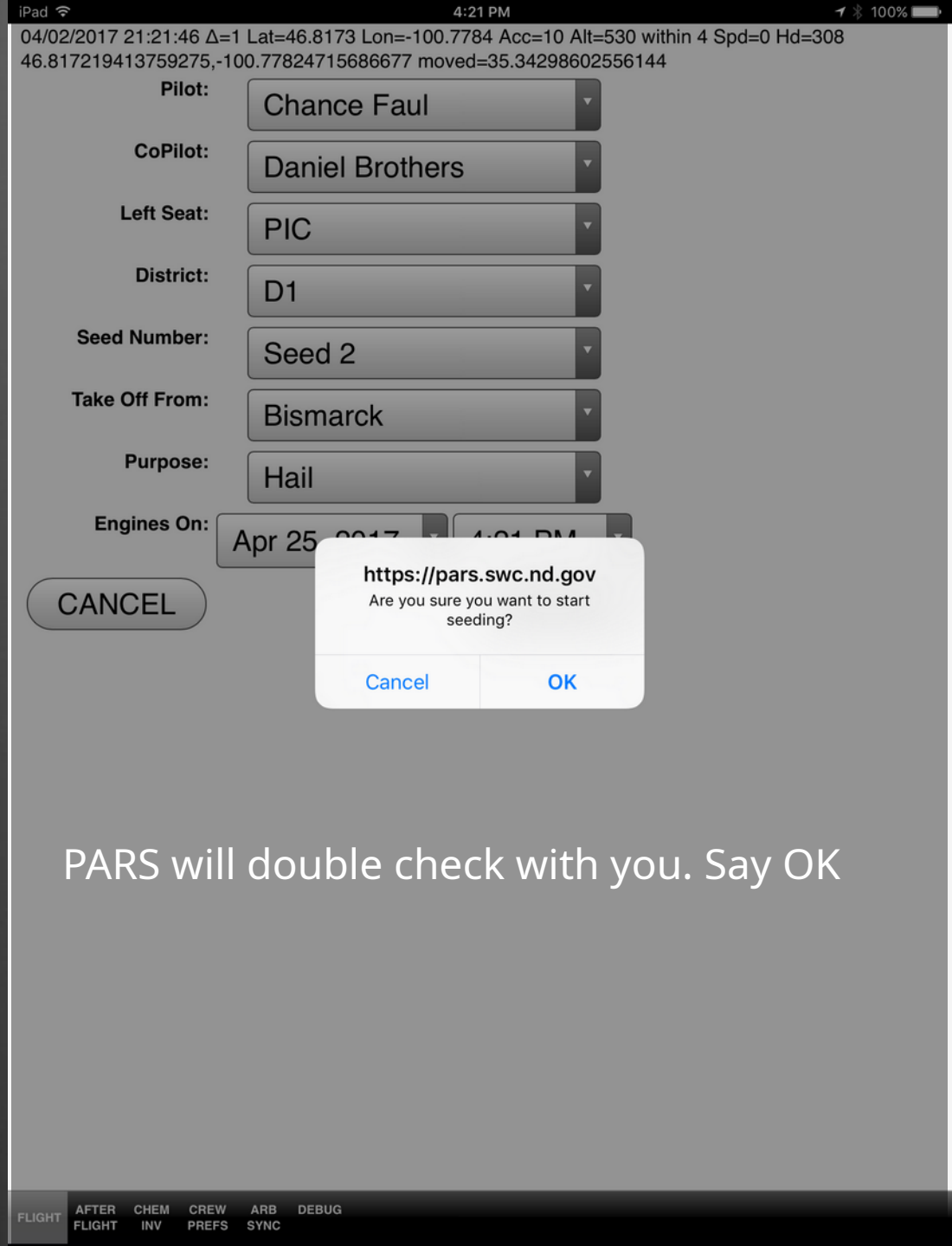


Flight

Select/Change the necessary fields.

- Left Seat must be selected as either PIC or Intern. Who is sitting in the left seat.
- Purpose must be selected. Use Recon if not sure. Can be changed during or after flight as well.
- Engines On Date and Time must be selected. If you pushed Engines On at the correct time minimal adjustment should be needed.

When all info is correct push
START

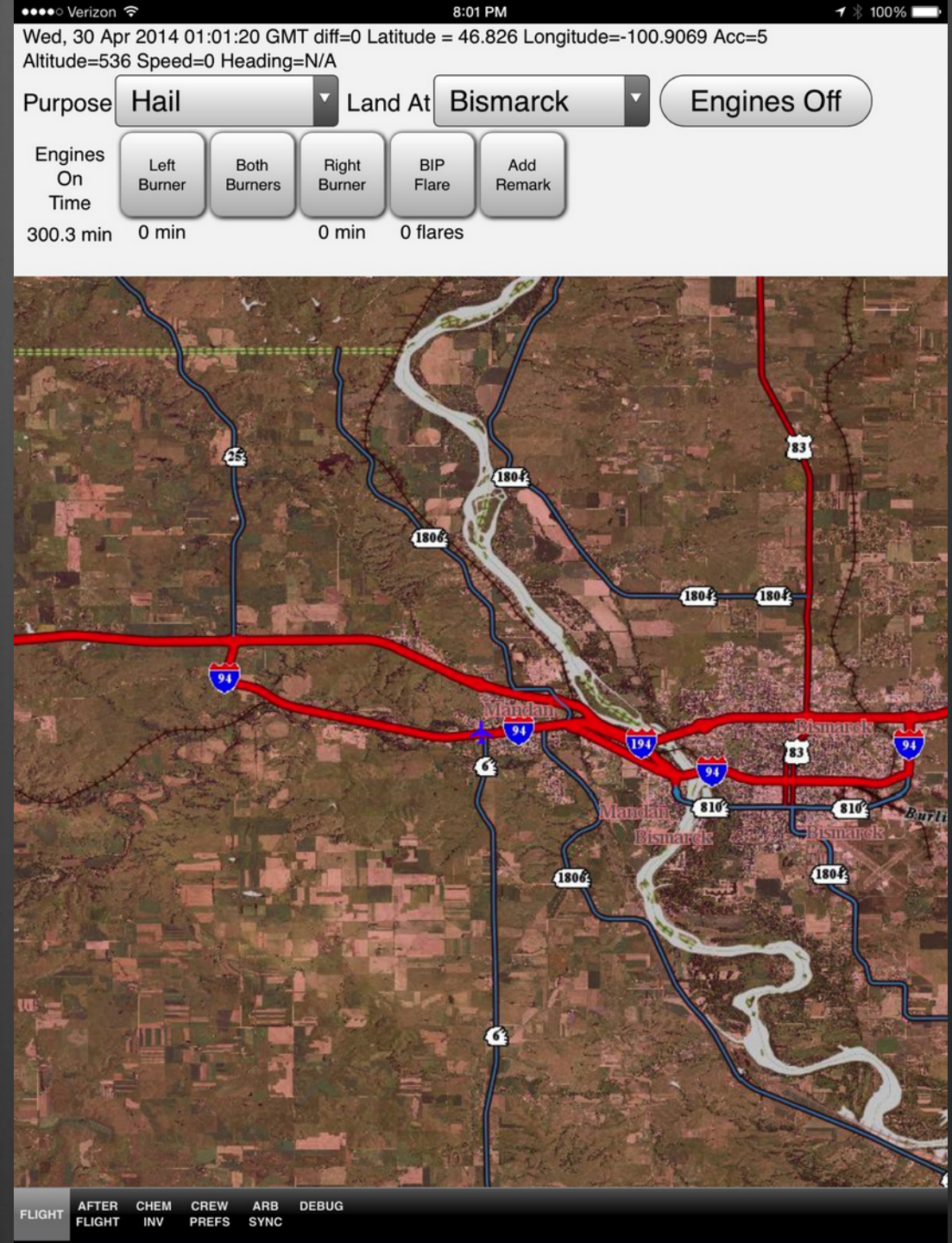


PARS will double check with you. Say OK

Base Seeder

Options for Left Burner, Right Burner, Both Burners, BIP Flares, and Add Remark.

- Push Buttons as actions actually occur in flight. This will give us the most accurate chem usage and physical position of events.
- Remarks should be entered at least once every 10 minutes, even if no event occurs.
- Any time an event occurs the iPad will automatically prompt you for Remarks.



Remarks

Remarks include Updraft, Temp, Cloud Base, and Precip Code.

- Updraft: Nearest 100 kft. Leave as N/A in clear skies.
- Temp: Must be entered. Air temp in degrees Celsius.
- Cloud Base: Leave as N/A if there are no clouds. Will automatically place the decimal point. (ex: Entering 65 produces a 6.5 kft cloud base height.)
- Precip Code: Use N/A for no clouds.
- **SAVE!**

Updraft (kft): 500 N/A Temp: 6 Cloud Base (kft): 5.5

100 200 300 7 8 9 7 8 9

400 500 600 4 5 6 4 5 6

700 800 900 1 2 3 1 2 3

1000 1500 2000 . 0 Back 0 Back

Down 0 Up +/-

Precip Code: 2

N/A 0 1

<http://pars.swc.nd.gov>
The Up or Down must be selected for the updraft.

Save

OK

FLIGHT AFTER CHEM CREW ARB DEBUG
FLIGHT INV PREFS SYNC

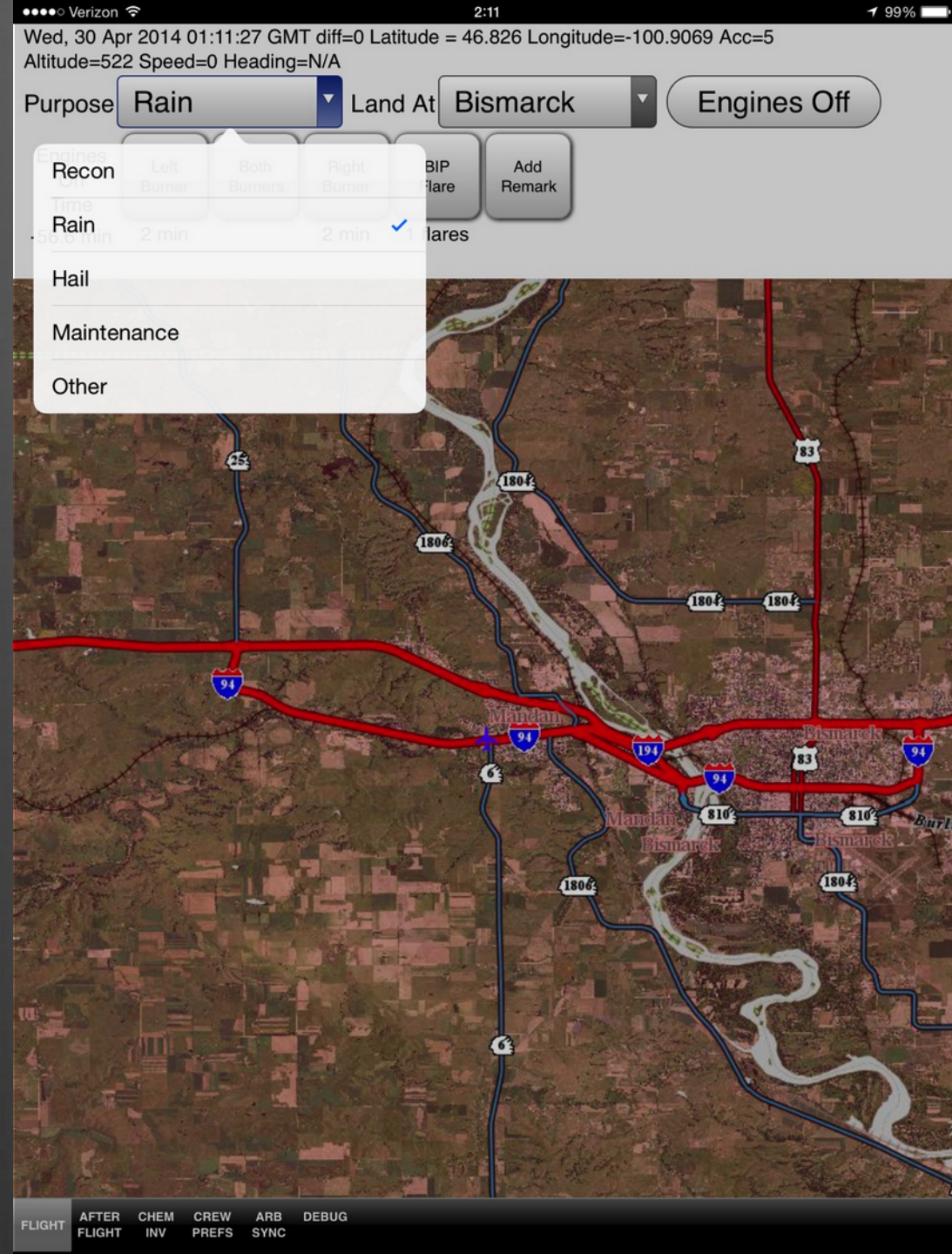
Base Flight

Counters keep track of chem usage

- Burners are tracked in minutes
- Flares are # of flares used

Flight time is also tracked in minutes.

If purpose changes, you can change it with a drop-down menu.



Base Flight

Make sure all seeding equipment is off before trying to turn off Engines

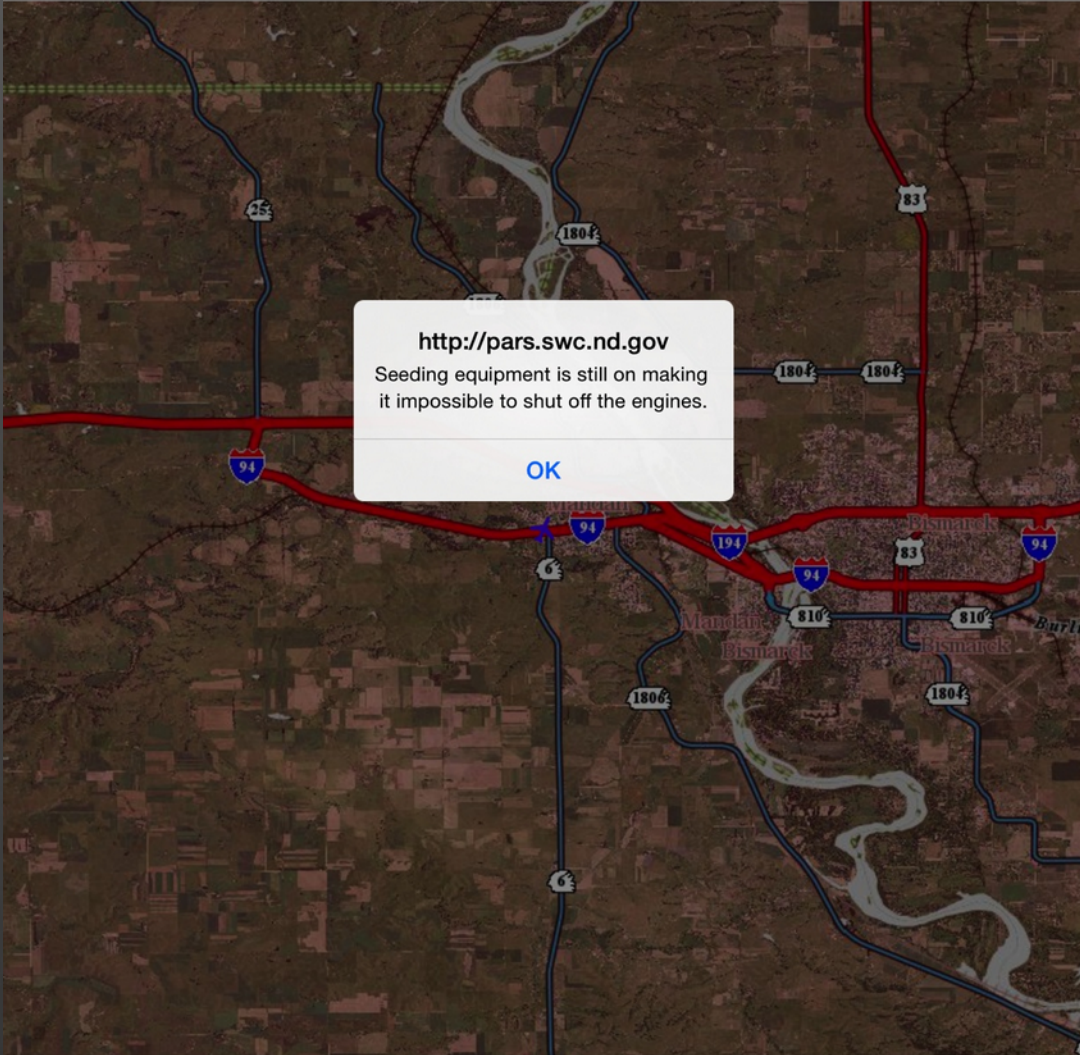
Hopefully, this isn't a problem since you are entering what happens in flight, and you wouldn't be landing with burners still on.

Verizon 2:11 99%

Wed, 30 Apr 2014 01:11:03 GMT diff=0 Latitude = 46.826 Longitude=-100.9069 Acc=5
Altitude=522 Speed=0 Heading=25

Purpose **Rain** Land At **Bismarck** Engines Off

Engines On Time	Left Burner 1.9min	Both Burners	Right Burner 1.9min	BIP Flare	Add Remark
-57 min	1.9 min		1.9 min	1 flares	



<http://pars.swc.nd.gov>
Seeding equipment is still on making it impossible to shut off the engines.

OK

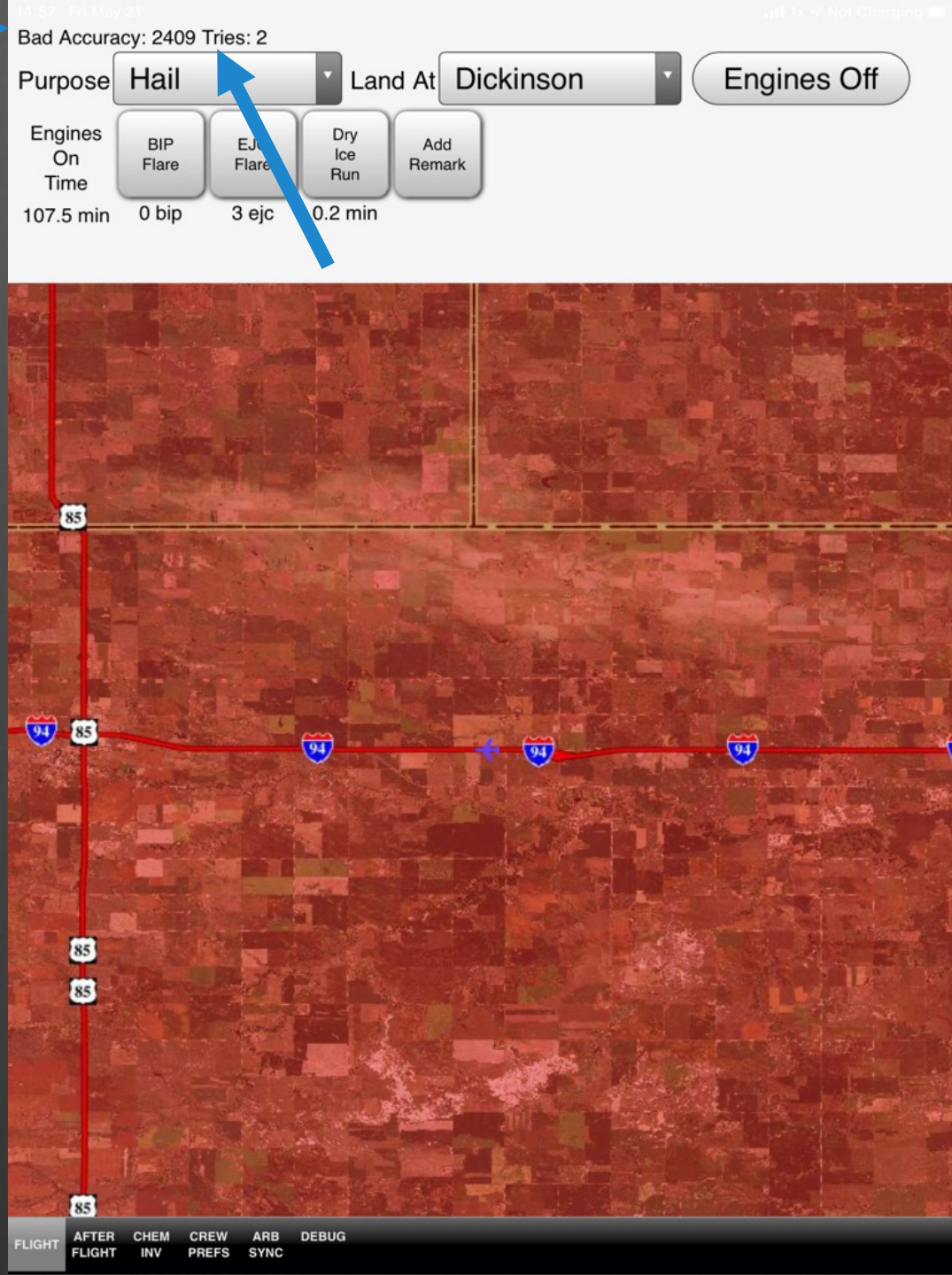
FLIGHT AFTER FLIGHT CHEM INV CREW Prefs ARB SYNC DEBUG

Bad GPS Issue

If GPS is working, you have a bunch of data at the top of the screen.

If GPS stops working, the data is replaced by a "Bad Accuracy" alert. (Or if $Acc > 10$)

The iPad will continue to reset the GPS until it regains a signal. Please let Dan know if there is a prolonged period with no GPS signal.



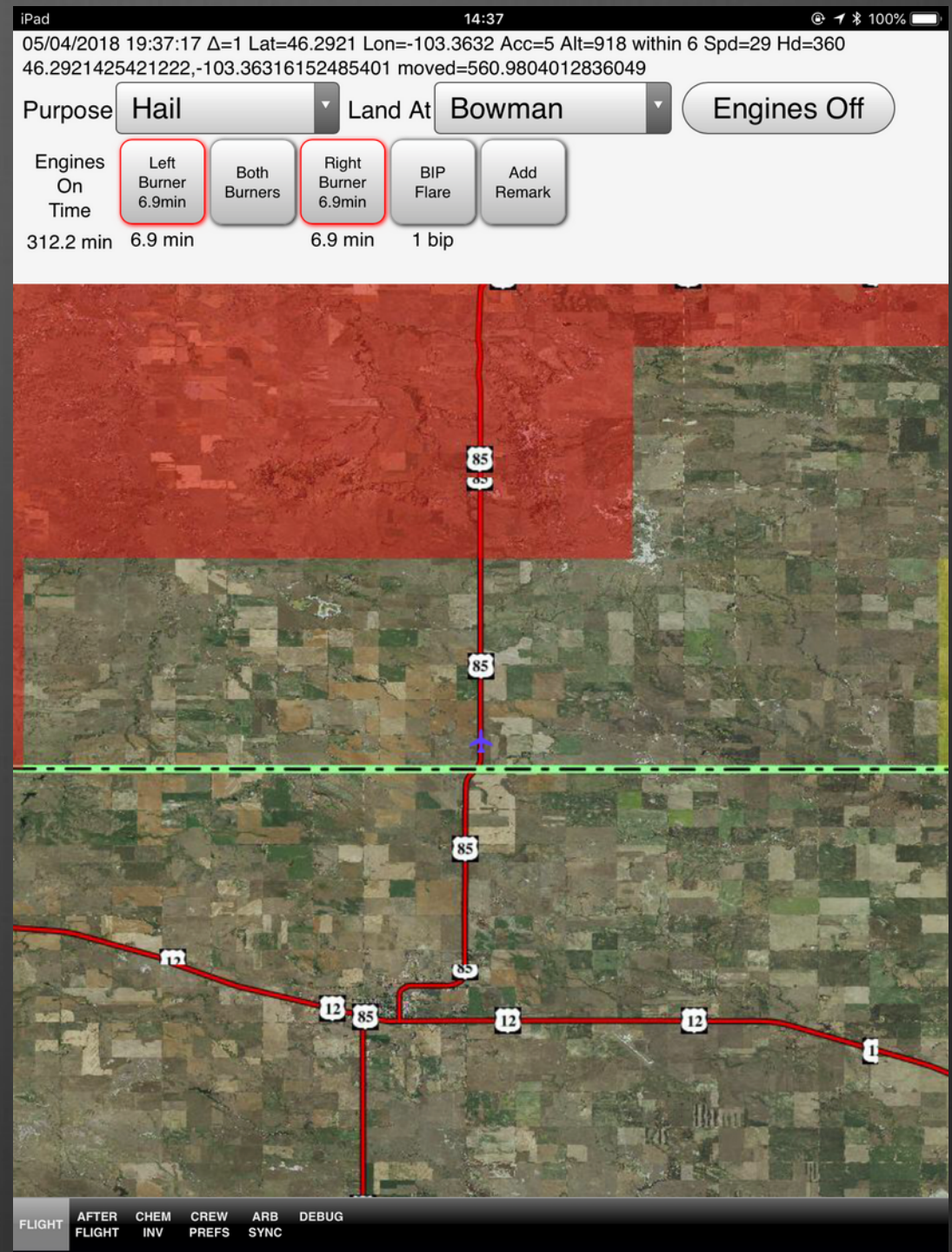
Map Shading

Target areas have no shading.

Buffer Zones have a light green shading (Not Shown).

Non-Operational areas have a red shading.

Red means No Seeding.

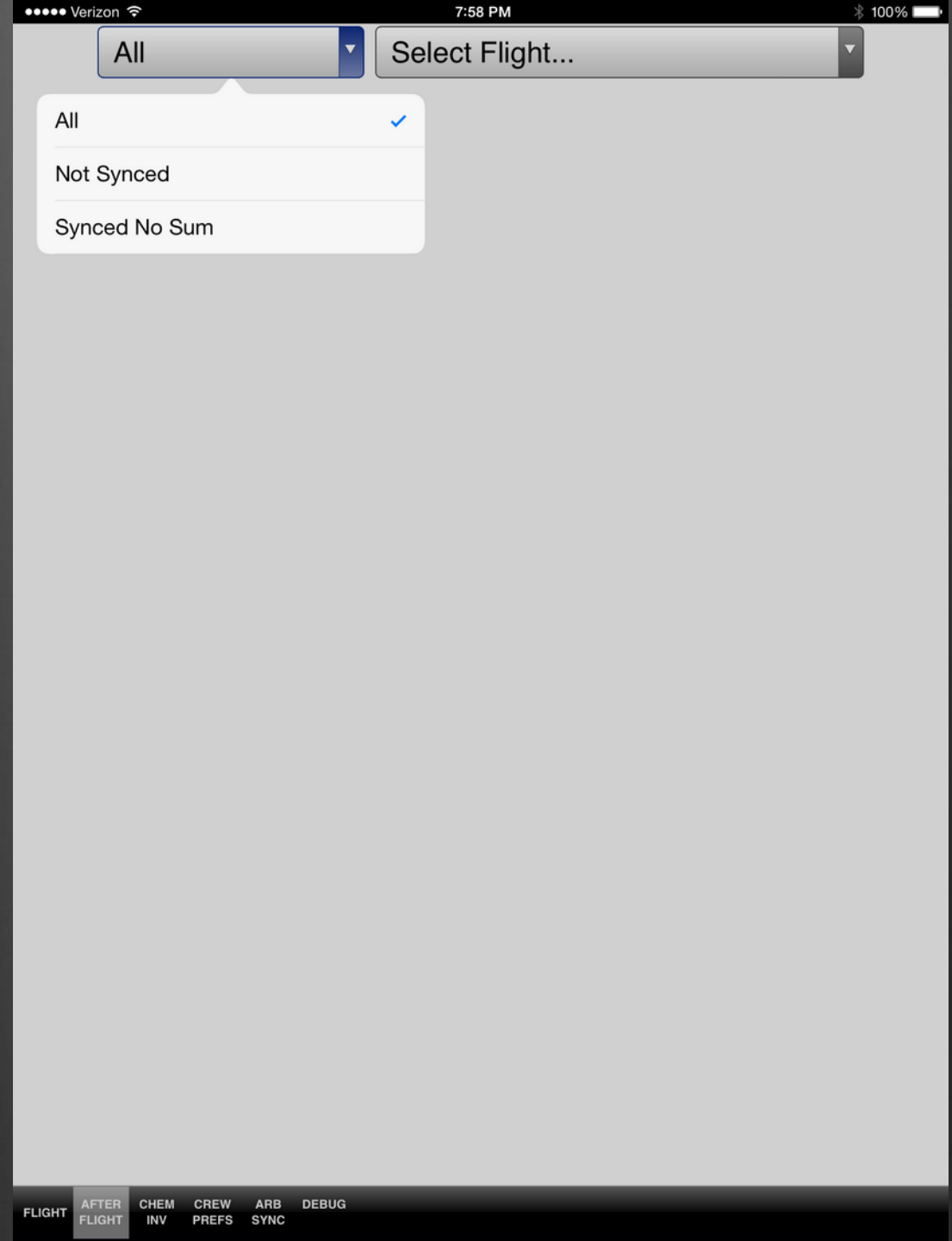


After Flight

Select AFTER FLIGHT from the bottom Menu.

Select the appropriate flight from the list.

You can also sort flights.



After Flight

The first time you select a flight you will be prompted for BIP and EJC usage.

- These should be based on a VISUAL count of the number of flares ACTUALLY used during flight.
- If you get it wrong, you don't get a second chance. Get it right the first time.
- Check the appropriate box if you had burner problems or if seeding was suspended due to flash flooding or tornado warnings.

The screenshot shows an iPad app interface for flight data entry. At the top, there is a status bar with 'iPad', signal strength, '18:34', and '61%' battery. Below the status bar, there are two dropdown menus: the first is set to 'All' and the second is set to 'Wed, 30 Apr 2014 13:25:00 GMT'. Below these are three input fields: 'BIP Flares:' with a text input field, 'EJC Flares:' with a text input field, 'Burner Problems:' with a checkbox, and 'Seeding Suspensions:' with a checkbox. A 'Done' button is located below the checkboxes. At the bottom of the screen, there is a keyboard with a 'Go' button and a microphone icon.

After Flight

If the number of flares used doesn't match the number of flares entered during flight the count turns red.

- You will need to fix this before syncing your flight.
- Various controls allow you to move between records.
- There are also menus for adjusting flight info if necessary.
- Enter a flight summary in the space provided.

iPad 3:22 PM 100%

On: 10:05:00 04/26/2017 Left Seat: PIC
Off: 15:10:33 04/26/2017

Takeoff: Bismarck Landing: Bismarck
Pilot: Chance Faul Co-Pilot: Daniel Brothers
Purpose: Hall District: D1

Seed 2 EON Record 1 of 65 at 15:15:35 04/26/2017 BIP Total = 3 1 too many

Aircraft Status				
Latitude	Longitude	Altitude	Heading	Speed
46.81737883020827	-100.77840152205972	535	8	1

Environment			
Cloud Base	Air Temperature	Updraft	Prncip Code
-999	-999	-999	-999

Seeding Status				
Dry Ice	Left Burner	Right Burner	EJC Flare	BIP Flare
0	0	0	0	0

First Record Prev Record Next Record Last Record All Save Summary

FLIGHT AFTER FLIGHT CHEM CREW ARB DEBUG
INV PREFS SYNC

After Flight

On: 15:20:00 05/23/2023 Left Seat: Intern
Off: 20:26:31 05/23/2023
Takeoff: Bismarck Landing: Bismarck
Pilot: Brooke Buccowich Co-Pilot: Daniel Brothers
Purpose: Rain & Hail District: D2

Seed 7 E 3/2023 BIP Total = 0

Aircraft Status				
Longitude	Altitude	Heading	Speed	
358197454294	512	113	15	

Environment		
Temperature	Updraft	Precip Code
	-999	-999

Seeding Status				
Dry Ice	Left Burner	Right Burner	EJC Flare	BIP Flare
0	0	0	0	0

First Record Prev Record Next Record Last Record All Save Summary

Test flight for iPad.

After Flight

Moving through Records

- You can sort records using the menu.
- Events include EON, EOF, BON, BOF, LON, LOF, RON, ROF, BIP, EJC, and ICE.
- You can Remove a Flare if you had an erroneous entry. (ex: A dud)
- You can add a flare if you forgot to hit the button during flight.
- Don't forget to Save Summary any time you make changes.

Verizon 1:17 97%

All Sat, 10 Aug 2013 23:56:00 GMT

On: 23:56:00 08/10/2013
Off: 03:35:07 08/11/2013
Left Seat: PIC
Takeoff: Bowman
Landing: Bowman
Pilot: TJ Lehman
Co-Pilot: Brandon Renner
Purpose: Hail
District: D1

BIP Total = 7

Seed 2 POS Record 675 of 1930 at 01:03:31 08/11/2013

Aircraft Status				
Latitude	Longitude	Altitude	Heading	Speed
46.33736169435674	-103.47170499163072	2522	262	60

Environment			
Cloud Base	Air Temperature	Updraft	Precip Code
-999	-999	-999	-999

Seeding Status				
Dry Ice	Left Burner	Right Burner	EJC Flare	BIP Flare
0	1	1	0	0

First Record Prev Record Next Record Last Record Add BIP Add EJC All Save Summary

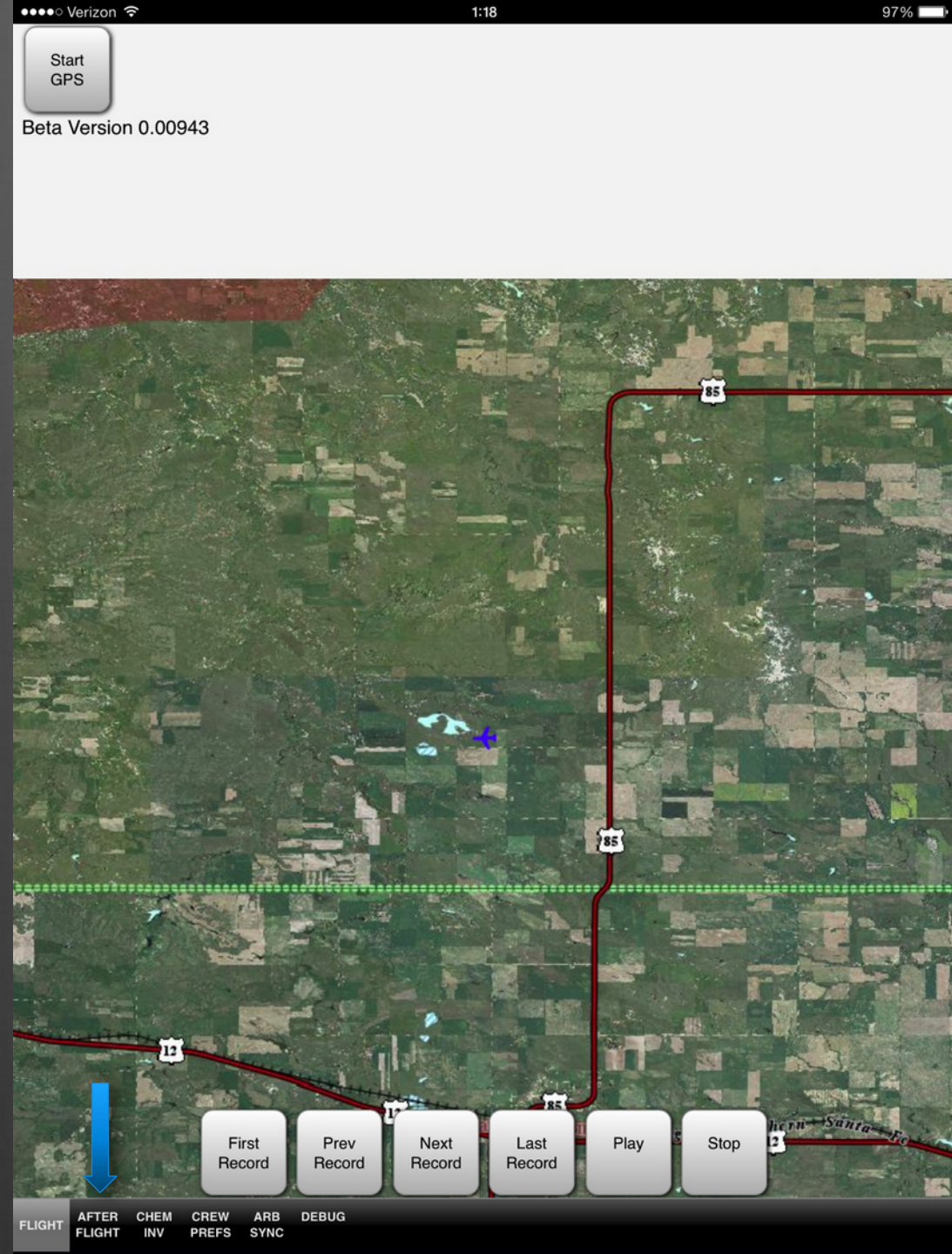
Correct engine off time is 2:58. Launched on line of storms moving in from the north. Began broadcast seeding as storm moved into buffer found good flow and lit flares as directed by radar. Seeded until area of inflow exited into sd. RTB Bowman.

FLIGHT AFTER FLIGHT CHEM INV CREW PREFS ARB SYNC DEBUG

After Flight

Finding where to add a flare.

- The map can be helpful in finding where to add a flare, if you know about where it should have been.
- While in the flight records, press the FLIGHT button at the bottom of the screen.
- The map shows the planes position at the time of that record. Use the controls to go through the flight.
- Go back to AFTER FLIGHT and you'll be on the new record for editing.



Weekly Report

Only for home site.

Weekly Chemical Inventories are completed every week before 17Z Monday morning.

Make sure Date and Time are entered and accurate.

SAVE

Weekly Report of Chemical in Bowman

Date and Time Measured:

Mix Reported			Flares	
Stick Reading	Carboy Type	Gallons	BIPs	
c1	34	One Hole	11	22
c2		One Hole		BIP Duds
c3		One Hole		EJCs
c4		One Hole		343
c5		One Hole		EJC Duds
				2

Total Mix

Acetone		Dry Chemical	
Acetone	<input type="text"/>	Sodium Perchlorate	4
		Ammonium Iodide	<input type="text"/>
		Silver Iodide	<input type="text"/>
		Paradichlorobenzene	<input type="text"/>

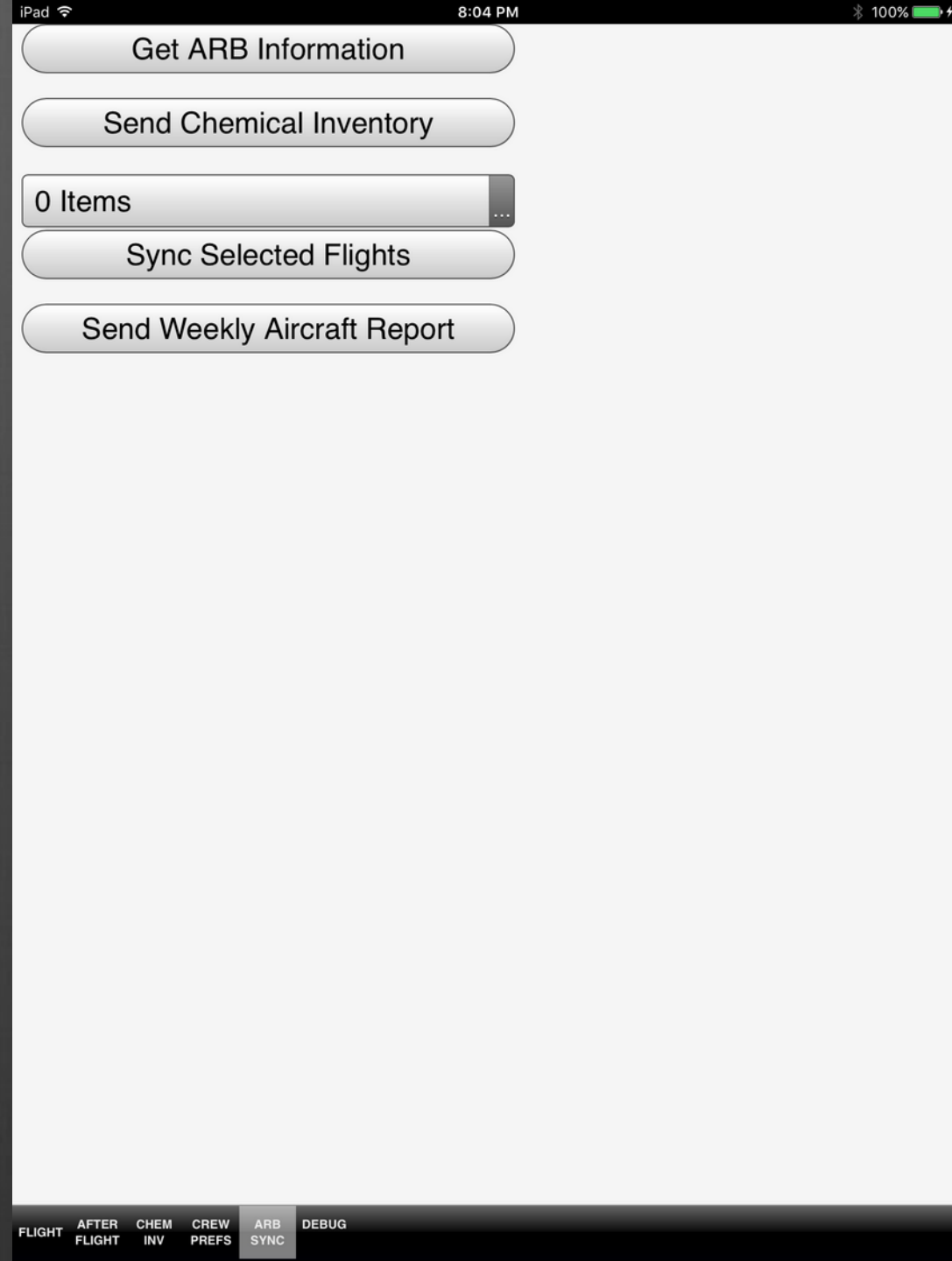
Cancel Save

<http://pars.swc.nd.gov>
Date and Time measured must be filled out.
OK

FLIGHT AFTER FLIGHT CHEM INV CREW PREFS ARB SYNC DEBUG

ARB Sync

Send Chemical Inventory will send your weekly chemical to Bismarck.



ARB Sync

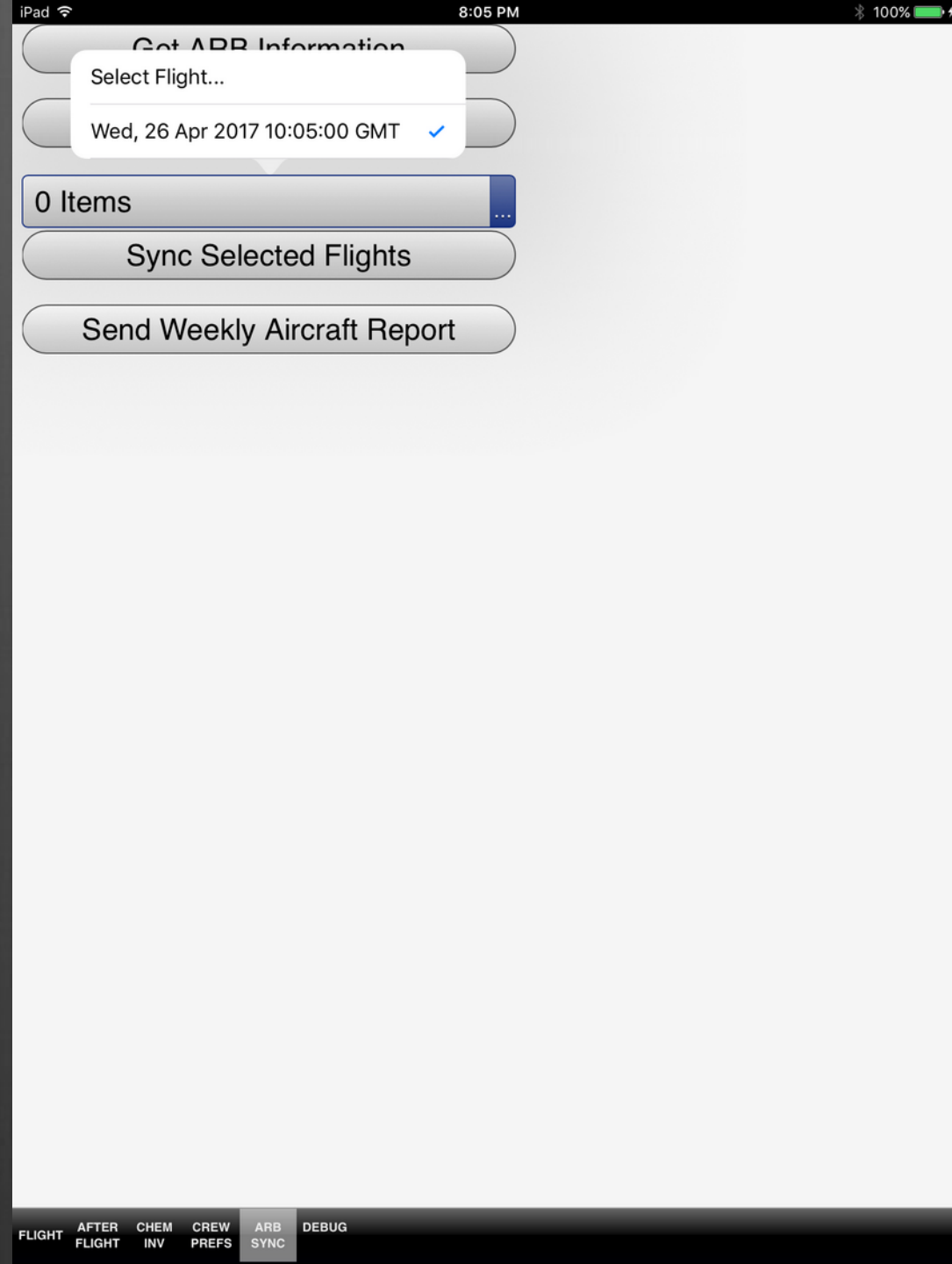
A menu shows any syncable flights.

Only select flights when you are ready to send them. (Summary is completed)

A flight is not syncable if you have not gone through After Flight yet.

A flight can not be resent unless a change is made. (Change Summary if needed)

Sync Selected Flights (May take a few minutes)



ARB Sync

SEND WEEKLY FLIGHT REPORT

-Used to report the number and type of flights during the week.

-Make sure the proper week is selected.

-Enter the total number of flights for each day, based on UTC, regardless of purpose.

-If flights occurred, list the EON, EOF, and purpose of each flight.

-List # and type of flares used, if applicable.

-Push Send. You will be automatically returned to the ARB Sync page.

iPad 8:08 PM 100%

4/24 - 4/30

Day	No. of Flights	Summary
Monday	<input type="text" value="0"/>	No flights
Tuesday	<input type="text" value="0"/>	No flights
Wednesday	<input type="text" value="0"/>	No flights
Thursday	<input type="text" value="1"/>	EON 1504 EOF 1735 Hail 2 2 BIPs
Friday	<input type="text" value="0"/>	No Flights
Saturday	<input type="text" value="0"/>	No Flights
Sunday	<input type="text" value="2"/>	EON 1832 EOF 1946 Recon EON 2103 EOF 2129 MX

Cancel Send

FLIGHT AFTER FLIGHT CHEM INV CREW PREFS ARB SYNC DEBUG

Questions?