ISDAC Applications

Greg McFarquhar

ISDAC Breakout Session
ARM Science Team Meeting
10-13 March 2008, Norfolk, Virginia.

ISDAC Applications

- Described in Appendix of flight overview document
  - Description of needed profiles
  - Description of probes needed to make measurements to meet applications
  - Applications listed separately for clouds and aerosols

Cloud water closure

- **Science Motivation**: Compare measured bulk cloud water with that calculated by integrating measured size distribution—important check on measurements & investigates shattering on probe inlets.
- **Measurement Objective**: Sample cloud in stratified layers known to be warm, ice, or mixed phase. Critical measurements: Total water content, particle size distribution 0.5-5000 μm, particle shapes 20-5000 μm. Perform separate closure for warm, ice, & mixed phase conditions.
- **General Aircraft Flight Profiles**: Horizontal tracks thru multiple cloud levels for 5-10 minutes each (~30 km).
- **Weather Conditions**: stratiform cloud preferred
- **Synergy with other Flight Objectives**: Cloud modelling, ice nucleation, cloud extinction closure, aircraft intercomparison studies
- **Critical Instrumentation**: CAPS-CAS, CDP, FSSPs, CAPS-CIP, 2DS, 2DC,2DP, CPI, CVI, Nevzorov LWC/TWC, PMS King

Cloud Extinction Closure

- **Science Motivation**: Compare bulk cloud extinction with that calculated from Mie or other theories using measured cloud size/shape distributions. Tests theories for warm, ice, and mixed-phase conditions and impacts of crystal shattering. **Measurement Objective**: Sample cloud in stratified layers known to be warm, ice, or mixed phase. Critical measurements: cloud extinction, particle size distribution 0.5-5000 μm, particle shape 20-5000 μm.
- **General Aircraft Flight Profiles**: Spirals, constant altitude legs or ramped legs. Horizontal track or spirals through multiple levels of cloud for 5-10 minutes each (~30 km).
- **Weather Conditions**: Stratiform cloud preferred
- **Synergy with other Flight Objectives**: Cloud modeling, ice nucleation, cloud water closure, shattering investigations & intercomparisons with other aircraft
- **Critical Instrumentation**: CAPS-CAS, CDP, FSSPs, CAPS-CIP, 2DS, 2DC, CPI, 2DP, Korolev extinction meter

Small Particles in Ice/Mixed Clouds

Science Motivation/Hypothesis: Concentrations of crystals with D < 100 μm & their contributions to mass and extinction in mixed- & ice- clouds are poorly known. Large crystals may shatter on probe tips artificially amplifying small crystal concentrations?
Measurement Objective: Measure size distributions using probes with and without tips and with coincident bulk mass and extinction, ground-based and satellite remote sensing retrievals
General Aircraft Flight Profiles: Level legs, porpoises or spirals
Repetitions Necessary: Several samples (10 to 20) should be made under a variety of conditions in cloud and radiation physics.
Weather Conditions: Measurements in stratiform clouds in mixed-, ice- and liquid-conditions
Synergy with other missions: Ground-based and A-train evaluation, in-situ probe comparison, mass & extinction closure
Critical Instrumentation: CAPS-CAS, CDP, FSSPs, CAPS-CIP, 2DS, 2DC, 2DP CVI, CPI, Korolev Extinction meter

Relation of IN/Ice Crystal Concentration

- **Science Motivation**: During M-PACE, ice crystal numbers far exceeded IN numbers. However, IN numbers were near detection limit of CFDC. If IN numbers are higher during ISDAC, relations can be examined with more confidence. Secondary production of ice crystals is expected to be less important for ISDAC, so might be better agreement between IN and Ni; we also hope to have better Ni measures by taking account of shattering.
- **Measurement Objective**: Measurements of T, Si, IN(T,Si) below and above ice cloud, crystal number within stratified ice cloud.
- **General Aircraft Flight Profiles**: Horizontal legs of 15 minutes below, above, and within ice clouds to get sampling statistics.
- **Repetitions Necessary**: 10
- **Weather Conditions**: Stratiform ice clouds
- **Critical Instrumentation**: Rosemont, CFDC, SPEC CPI, CDP, CAPS-CAS, CAPS-CIP, 2DS, 2DP

Other Science Objectives/Profiles

1. Thermodynamic conditions for maintaining mixed-phase clouds
2. Statistical characterization of microphysics & thermodynamics of mixed-phase clouds
3. Remote sensing evaluation (ground-based, CloudSat, CALIPSO)
4. Spatial scale of mixed-phase cloud variability
5. Scale dependence of ice crystal number concentration
6. Cloud cover parameterizations

Other Science Objectives/Profiles

7. Ice fog microphysics & extinction
8. Use of airborne remote sensing data for cloud microphysics studies
9. Aerodynamic effects of in-flight icing

a) CCN closure
b) Droplet number closure
c) Cloud modeling objectives
d) Semi-direct effect
e) Ice crystal nucleation
f) Aerosol extinction closure
g) Aerosol optical closuure in arctic troposphere
h) Long-range transport of Arctic pollutants in troposphere

ISDAC Flight Planning Document: Overview

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Locations of Flights

- Vicinity of Barrow
  - # of detailed flight scenarios proposed
- Satellite overpasses
  - Primarily in vicinity of Barrow
- Coordinated flying with other aircraft
  - NASA P-3, DC8, B200 & NOAA P-3
- Transits between Barrow/Fairbanks
  - Science would slow down transit so not a high priority to do science during these legs
  - No science from Fairbanks to Barrow
  - Science from Barrow to Fairbanks ONLY when conditions over Barrow not conducive to meeting science goals

Spiral Flights over Barrow

- Cloud altitudes determined from on-board radar, ARM NSA remote sensors or visual observations
  - From 100 m below to 100 m above the highest layer of horizontally extensive cloud
  - Fly at 2 to 4 m/s to last 5 to 10 minutes
  - Eulerian fashion
  - Radius of curvature as tight as possible
  - If can't get over NSA site, ideally fly spiral downwind of the NSA site
  - Need as many as possible in wide range of meteorological conditions

Cloud legs flown at constant altitude

- Need legs both in cloud and out of cloud, with out of cloud layers desired first
- Legs should be flown along wind and cross wind during project
- Also want legs along coast & cross coast to characterize effects of land versus ocean (and leads)
- Ideally part of leg always over the ARM site
- Legs should be 10 to 15 km (2 to 3 minutes) long
- Start 100 m above cloud top and then step down 50 to 150 m each leg, last leg conducted near level of ice sublimation as identified from on board radar OR no lower than 300 to 600 m below cloud base
- Transition between altitudes should be conducted along enroute descent at speed of 3 to 5 m/s
- Cross coast legs (later in project when ice may have moved away from coast) should be 50 km long & at multiple levels

Aerosol legs at constant altitude

- Described in last slide, length 60 to 75 km or 10 to 15 minutes long
- Do first to avoid icing on inlets
- Legs also needed perpendicular to coastline as for clouds (especially later in project)

Missed approach at Barrow

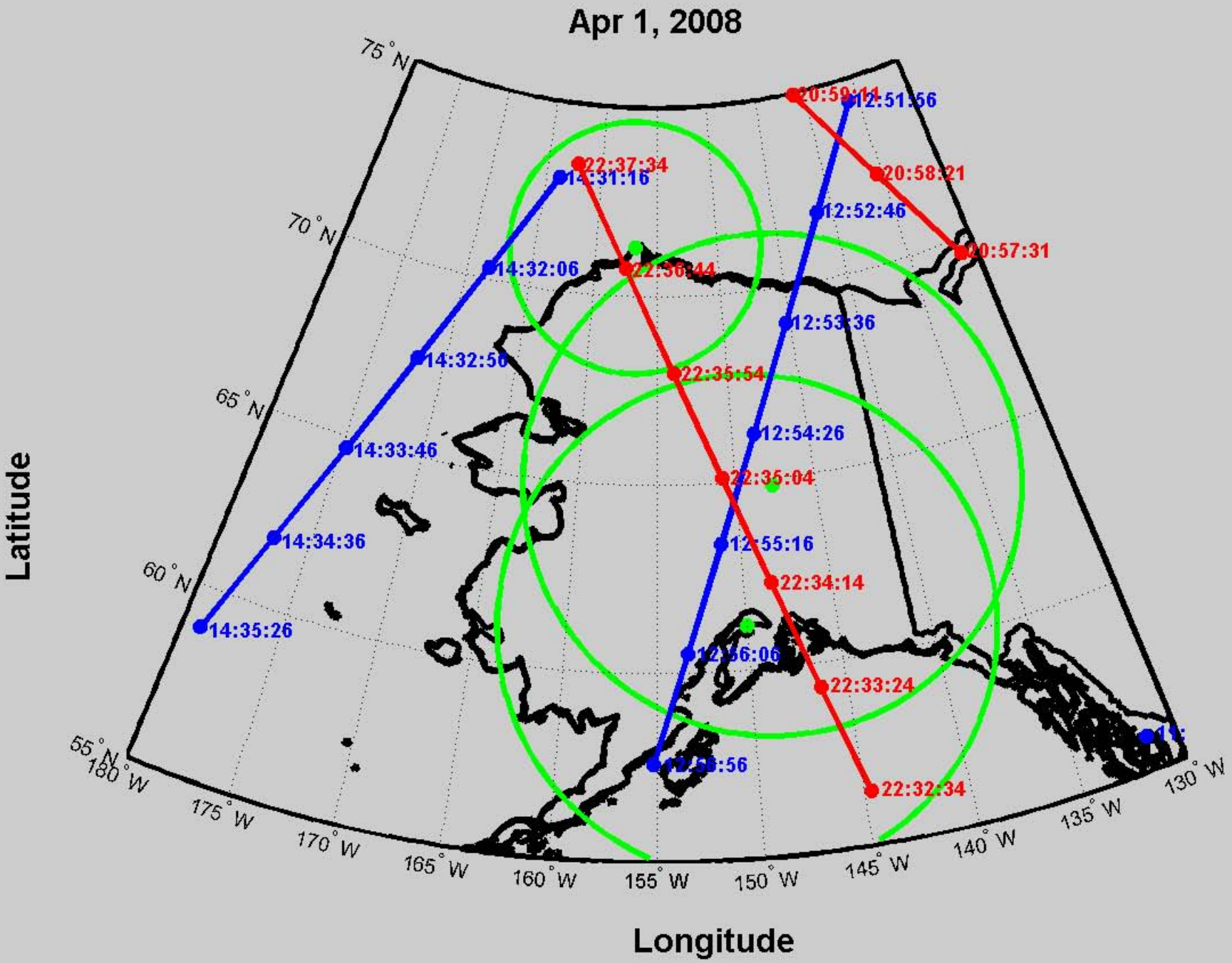
- When spirals below cloud not possible because of cloud altitudes
- Start at lowest altitude sampled and go as low as possible

Porpoising Manuever

- One ramped ascent/descent through cloud during one leg

Barrow Vicinity Flights

- **Ordering of legs important because of potential icing of inlets**
  - Spiral profiles over the ARM site at Barrow
  - Legs flown at constant horizontal altitude in cloud
  - Legs flown at constant horizontal altitude outside of cloud
  - Missed approaches at the Barrow airport
  - Porpoising maneuvers (i.e., ramped ascents and descents)


Apr 1, 2008
Latitude
Longitude
75 ° N
70 ° N
65 ° N
60 ° N
55 ° N
180 ° W
175 ° W
170 ° W
165 ° W
160 ° W
155 ° W
150 ° W
145 ° W
140 ° W
135 ° W
130 ° W
14:35:26
14:34:36
14:33:46
14:32:56
14:32:06
14:31:16
12:56:56
12:56:06
12:55:16
12:54:26
12:53:36
12:52:46
12:51:56
22:32:34
22:33:24
22:34:14
22:35:04
22:35:54
22:36:44
22:37:34
20:57:31
20:58:21
20:59:11

Coordinated Flights

- A-train evaluation legs
  - Convair: straight line above, within or below cloud or spiral descent through cloud
  - Other aircraft no doubt will target same overpass
- Cloud/aerosol comparison with NOAA P-3
  - In vicinity of Barrow, Beaufort Sea or Fairbanks
  - 2 way points selected & aircraft fly same legs but with altitude separated by ATC (i.e., they each step up in altitude)
- Cloud comparison with NASA DC8
  - Similar sampling strategy as for NOAA P-3, more emphasis on cloud data

Coordinated Flights cont.

- Coordinated flights with B200
  - During A-train legs
  - Fly same way point legs, B200 at 28,000 ft & Convair below, either within, above or below cloud layer
  - If Convair spiraling, b200 can fly figure 8 patterns centered at location of spiral
- Coordinated flights with NASA P-3
  - Flight patterns as above with NASA P-3 well above cloud measuring radiation
  - In-situ intercomparison (clouds/aerosols) as above
  - Legs where NASA P-3 just above cloud top and Convair within cloud (aerosol optical depth leg) and then both planes fly legs at lower heights through cloud

Transit Flights, unlikely

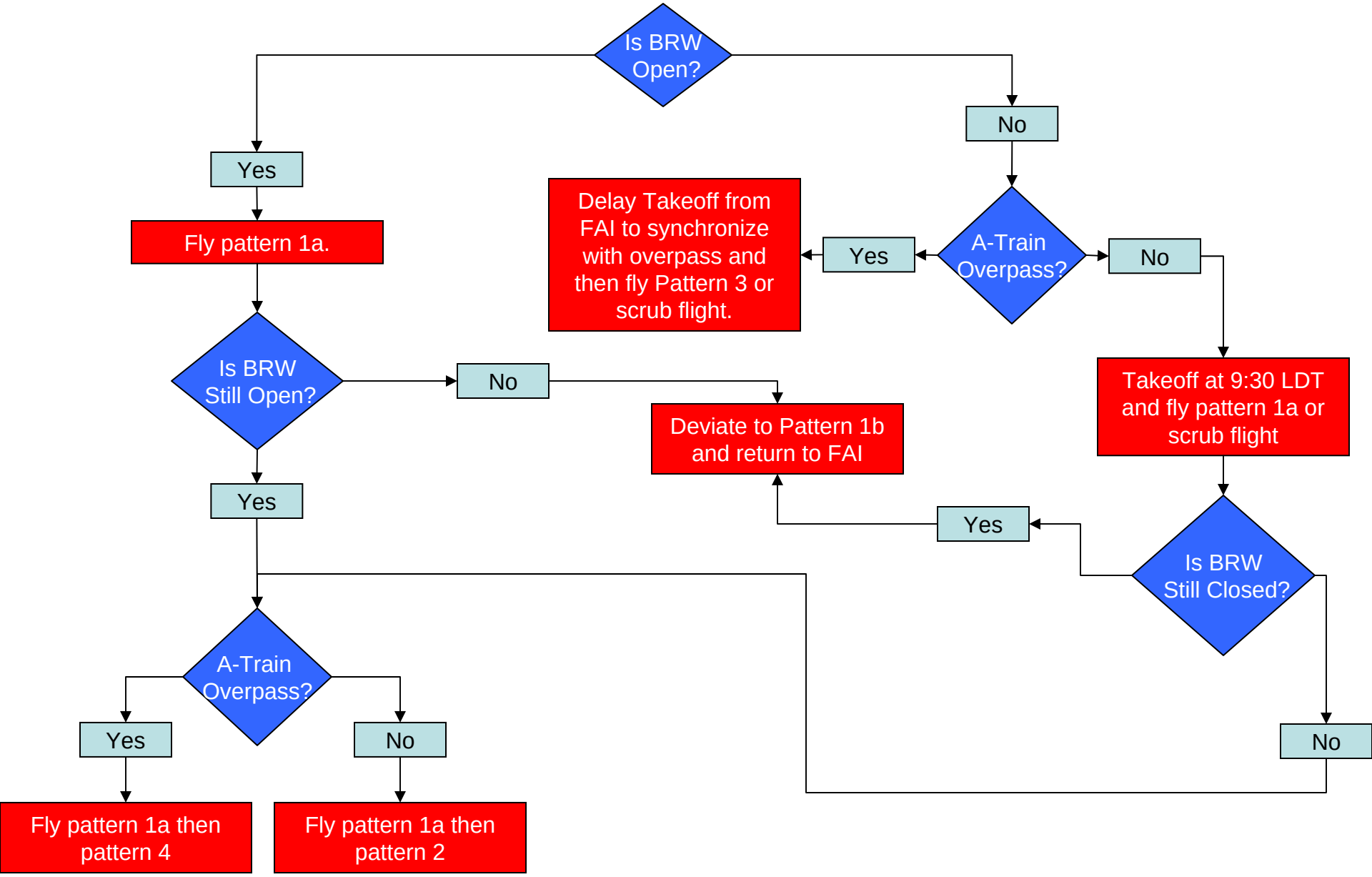
- Legs flown at constant horizontal altitude in cloud
- Legs flown at constant horizontal altitude outside of cloud
- Porpoising maneuvers (i.e., ramped ascents and descents)

Science Objectives

- Many different aerosol/cloud objectives that take advantage of these flight profiles are described in the Flight Overview Document
- Everyone should have a copy—email me if you do not (mcfarq@atmos.uiuc.edu)

Flight Planning Group

- Flight planning will be an open/transparent process during ISDAC
- Recommended flight profiles will be facilitated by small group of individuals:
  - Greg McFarquhar, AVP Chief Scientist, co-PI of ISDAC
  - Beat Schmid, AVP Technical Director
  - Steve Ghan (ISDAC PI) and/or Dan Dziczo
  - Hans Verlinde, NSA Site Scientist (weather liaison)
  - John Hubbe or Jason Tomlinson (PNNL)
  - Walter Strapp and/or Alexei Korolev (EC)
  - Mengistu Wolde and/or Dave Marcotte (NRC)


Is BRW Open?
Yes
No
Fly pattern 1a.
A-Train Overpass?
Yes
Delay Takeoff from FAI to synchronize with overpass and then fly Pattern 3 or scrub flight.
No
Takeoff at 9:30 LDT and fly pattern 1a or scrub flight
Is BRW Still Open?
No
Deviate to Pattern 1b and return to FAI
Yes
Is BRW Still Closed?
Yes
No
A-Train Overpass?
Yes
No
Fly pattern 1a then pattern 4
Fly pattern 1a then pattern 2

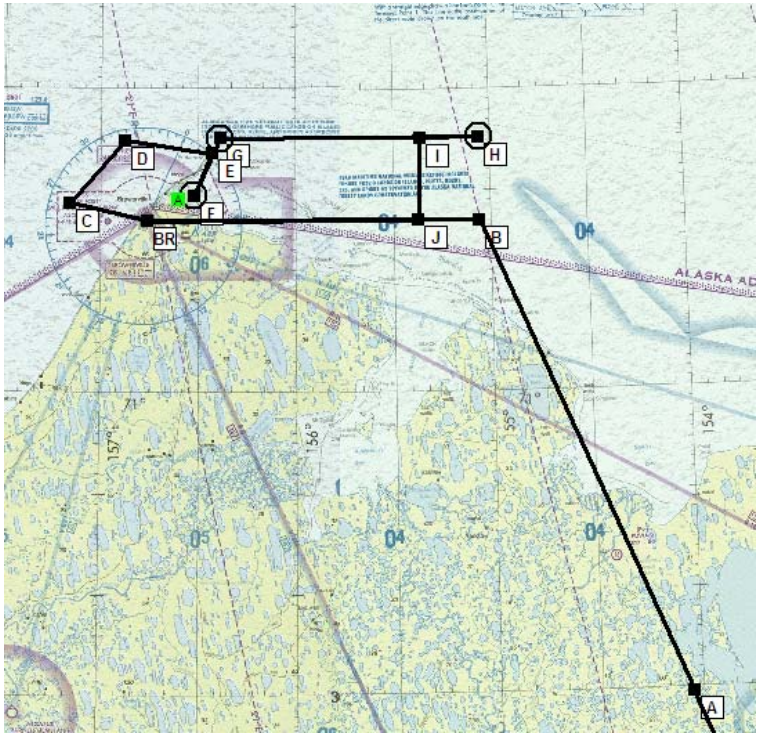
Day Before Flight Timetable

- **15:00** Meteorological briefing for all ISDAC participants (plane may be in air)
- **15:30** Meeting of flight decision-making group; if next day is suitable, preliminary flight plan produced.

Day of Flight Timetable

- **06:00** meteorological briefing for flight decision-making group; official flight plan produced;
- **07:00** alert flight crew and instrument support of possible flight; brief NRC pilots on expected mission profile; pull aircraft out of hangar
- **07:15** all crew and support on aircraft preparing for mission
- **09:00** doors closed, all non-crew members off the aircraft – final ‘go/no-go’ decision from flight decision-making group
- **09:30** takeoff Fairbanks
- **11:10** commence measurements over ARM site
- **12:30** landing Barrow after flight #1
- **12:45** NRC/EC flight director contacts flight decision-making group in Fairbanks for guidance on second flight
- **13:30** doors closed
- **14:00** takeoff Barrow for flight #2
- **14:18 -14:36** A-Train overpasses near Barrow (April 1, 3, 10, 12, 17, 19) or start measurements over ARM site without A-Train
- **16:50** start transit back to Fairbanks
- **18:30** land Fairbanks
- **19:00** Flight debrief and plans for next day announced/discussed

Pattern 1a



Total Distance (nm): 686.89 Total ETE (min): 182.9

WP	Time Elapsed	LAT	LON	ALT (ft)	SPD (kts)	HDG	Dist (nm)	ETE (min)
FA	00:00:00	64deg 49min	-147deg 51min	434				
FA1	00:25:00	66deg 06min	-149deg 09min	22000	200.0	316.2	83.35	25.0
A	01:26:06	70deg 30min	-154deg 00min	22000	280.0	316.8	285.10	61.1
B	01:37:07	71deg 17min	-155deg 03min	12000	280.0	315.4	51.42	11.0
BR	01:48:08	71deg 17min	-156deg 46min	500	180.0	249.1	33.04	11.0
C	01:50:43	71deg 19min	-157deg 10min	1500	180.0	262.0	7.79	2.6
D	01:53:28	71deg 25min	-156deg 53min	1500	180.0	20.5	8.21	2.7
E	01:56:21	71deg 24min	-156deg 26min	1500	180.0	77.5	8.64	2.9
F	01:57:51	71deg 20min	-156deg 31min	1500	180.0	181.8	4.53	1.5
F	02:04:51	71deg 20min	-156deg 31min	8000	180.0	spiral	21.00	7.0
G	02:06:56	71deg 25min	-156deg 23min	8000	180.0	3.8	6.24	2.1
G	02:13:56	71deg 25min	-156deg 23min	1500	180.0	spiral	21.00	7.0
H	02:22:26	71deg 25min	-155deg 03min	1500	180.0	69.0	25.53	8.5
H	02:28:26	71deg 25min	-155deg 03min	6000	180.0	spiral	18.00	6.0
G	02:36:57	71deg 25min	-156deg 23min	6000	180.0	249.0	25.53	8.5
G	02:40:57	71deg 25min	-156deg 23min	4000	180.0	spiral	12.00	4.0
H	02:49:27	71deg 25min	-155deg 03min	4000	180.0	69.0	25.53	8.5
H	02:52:27	71deg 25min	-155deg 03min	3000	180.0	spiral	9.00	3.0
I	02:54:24	71deg 25min	-155deg 21min	3000	180.0	248.6	5.85	1.9
J	02:57:06	71deg 17min	-155deg 22min	3000	180.0	159.7	8.11	2.7
BR	03:02:54	71deg 17min	-156deg 46min	44	280.0	249.1	27.04	5.8

Assumptions:

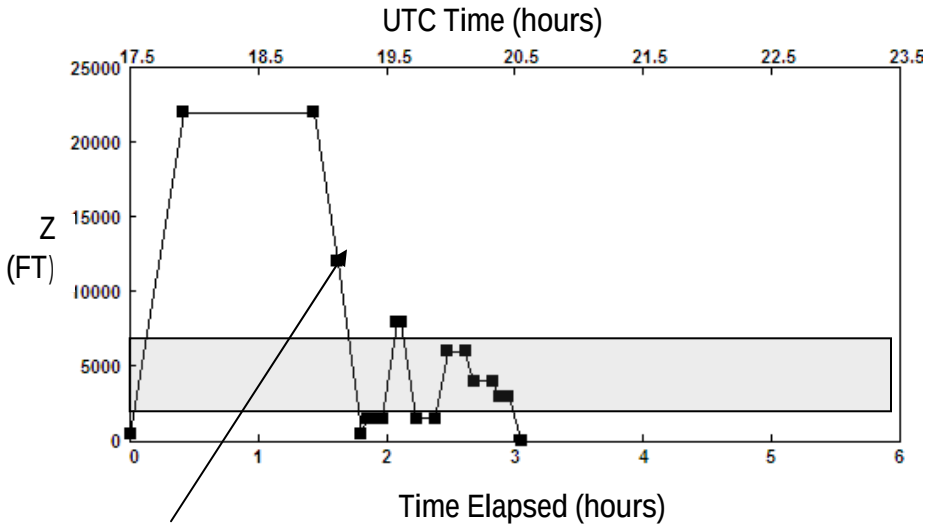
Take off from FAI

Clouds between 2000 and 7000 feet.

Cleared to land in Barrow.

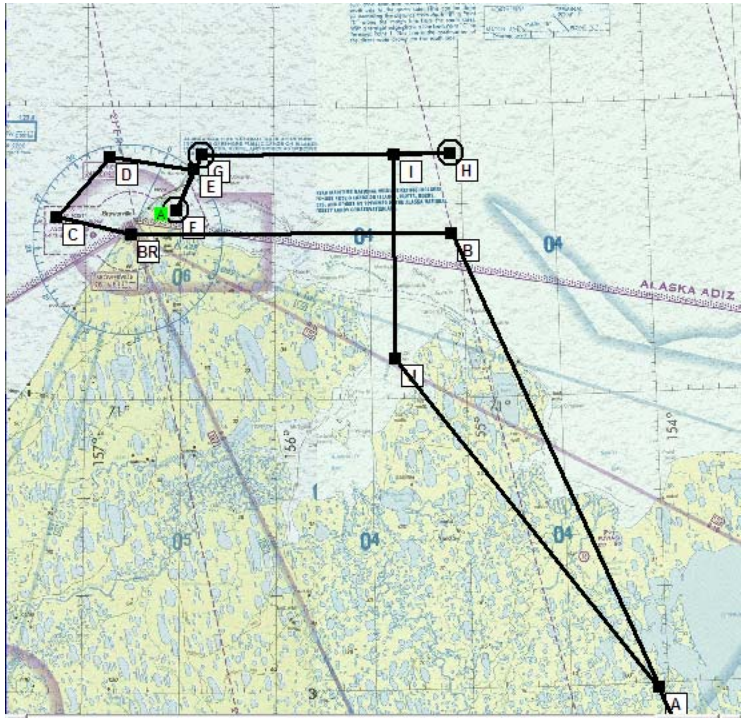
Further Information:

Pattern 1a and Pattern 1b (next page) are identical up to WP “I”. Here the aircraft with either turn to line up with the approach vector or return to FAI. This will depend on weather. The flight crew will have 45 minutes of flying between WP “G” and “H” before the final decision will need to be made.



Missed Approach between WP “B” and “BR”

Pattern 1b



Total Distance (nm): 1084.65 Total ETE (min): 269.7

WP	Time Elapsed	LAT	LON	ALT (ft)	SPD (kts)	HDG	Dist (nm)	ETE (min)
FA	00:00:00	64deg 49min	-147deg 51min	434				
					200.0	316.2	83.35	25.0
FA1	00:25:00	66deg 06min	-149deg 09min	22000				
					280.0	316.8	285.10	61.1
A	01:26:06	70deg 30min	-154deg 00min	22000				
					280.0	315.4	51.42	11.0
B	01:37:07	71deg 17min	-155deg 03min	12000				
					180.0	249.1	33.04	11.0
BR	01:48:08	71deg 17min	-156deg 46min	500				
					180.0	262.0	7.79	2.6
C	01:50:43	71deg 19min	-157deg 10min	1500				
					180.0	20.5	8.21	2.7
D	01:53:28	71deg 25min	-156deg 53min	1500				
					180.0	77.5	8.64	2.9
E	01:56:21	71deg 24min	-156deg 26min	1500				
					180.0	181.8	4.53	1.5
F	01:57:51	71deg 20min	-156deg 31min	1500				
					180.0	spiral	21.00	7.0
F	02:04:51	71deg 20min	-156deg 31min	8000				
					180.0	3.8	6.24	2.1
G	02:06:56	71deg 25min	-156deg 23min	8000				
					180.0	spiral	21.00	7.0
G	02:13:56	71deg 25min	-156deg 23min	1500				
					180.0	69.0	25.53	8.5
H	02:22:26	71deg 25min	-155deg 03min	1500				
					180.0	spiral	18.00	6.0
H	02:28:26	71deg 25min	-155deg 03min	6000				
					180.0	249.0	25.53	8.5
G	02:36:57	71deg 25min	-156deg 23min	6000				
					180.0	spiral	12.00	4.0
G	02:40:57	71deg 25min	-156deg 23min	4000				
					180.0	69.0	25.53	8.5
H	02:49:27	71deg 25min	-155deg 03min	4000				
					180.0	spiral	9.00	3.0
H	02:52:27	71deg 25min	-155deg 03min	3000				
					180.0	248.6	5.85	1.9
I	02:54:24	71deg 25min	-155deg 21min	3000				
					180.0	159.3	20.83	6.9
J	03:01:21	71deg 04min	-155deg 22min	10000				
					280.0	121.0	43.64	9.4
A	03:10:42	70deg 30min	-154deg 00min	22000				
					280.0	136.8	285.10	61.1
FA1	04:11:48	66deg 06min	-149deg 09min	22000				
					280.0	136.2	83.35	17.9
FA	04:29:39	64deg 49min	-147deg 51min	434				

Assumptions:

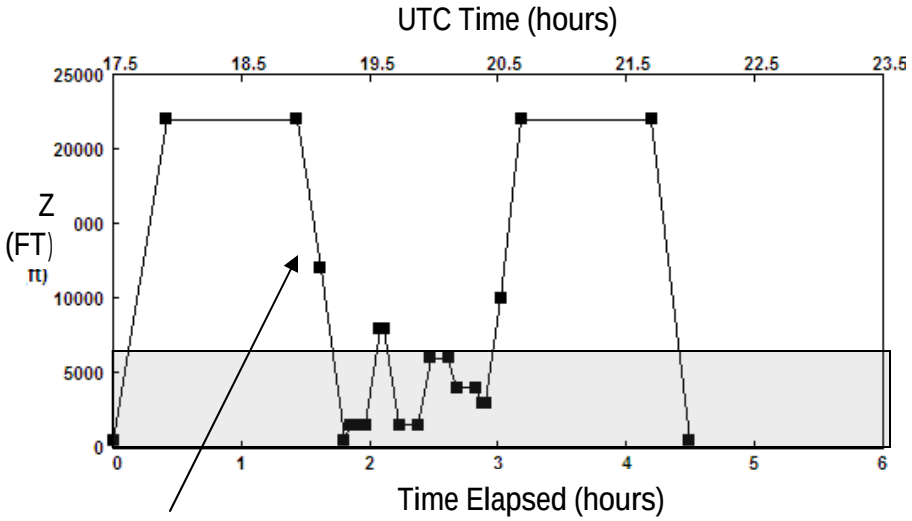
Take off from FAI

Clouds between 0 and 6000 feet.

Not cleared to land in Barrow.

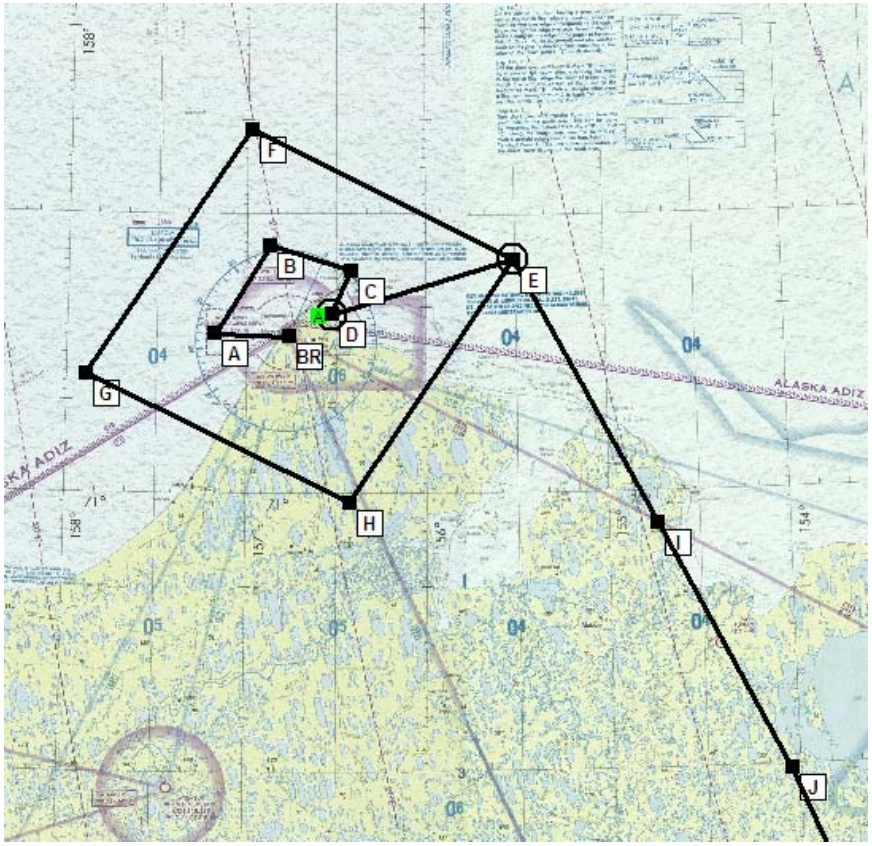
Further Information:

Pattern 1a (previous page) and Pattern 1b are identical up to WP “I”. Here the aircraft with either turn to line up with the approach vector or return to FAI. This will depend on weather. The flight crew will have 45 minutes of flying between WP “G” and “H” before the final decision will need to be made.



Missed Approach between WP “A” and “BR”

Pattern 2



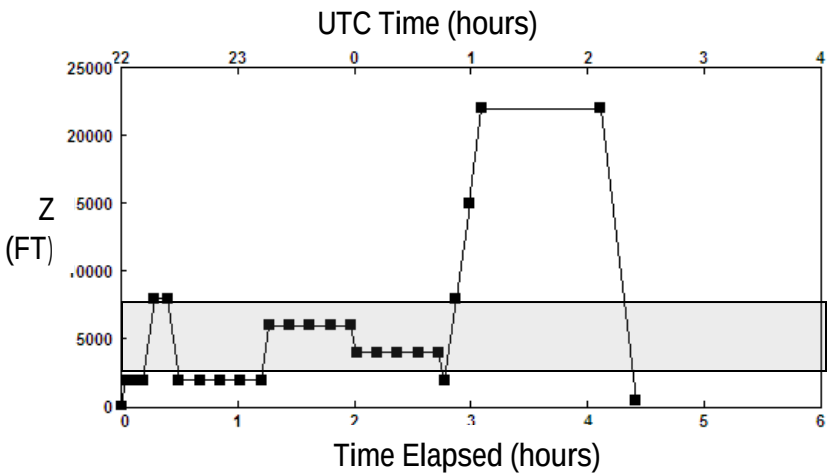
Total Distance (nm): 947.43 Total ETE (min): 264.5

WP	Time Elapsed	LAT	LON	ALT (ft)	SPD (kts)	HDG	Dist (nm)	ETE (min)
BR	00:00:00	71deg 17min	-156deg 46min	44				
A	00:02:40	71deg 17min	-157deg 11min	2000	180.0	251.2	8.02	2.7
B	00:06:23	71deg 27min	-156deg 53min	2000	180.0	10.9	11.14	3.7
C	00:09:25	71deg 24min	-156deg 25min	2000	180.0	86.5	9.09	3.0
D	00:11:07	71deg 19min	-156deg 32min	2000	180.0	182.6	5.09	1.7
D	00:17:07	71deg 19min	-156deg 32min	8000	180.0	spiral	18.00	6.0
E	00:23:54	71deg 25min	-155deg 30min	8000	180.0	52.5	20.39	6.8
E	00:29:54	71deg 25min	-155deg 30min	2000	180.0	spiral	18.00	6.0
F	00:40:20	71deg 39min	-156deg 59min	2000	180.0	275.5	31.28	10.4
G	00:50:51	71deg 13min	-157deg 55min	2000	180.0	193.2	31.56	10.5
H	01:01:28	70deg 59min	-156deg 26min	2000	180.0	94.7	31.85	10.6
E	01:11:59	71deg 25min	-155deg 30min	2000	180.0	13.5	31.51	10.5
E	01:15:59	71deg 25min	-155deg 30min	6000	180.0	spiral	12.00	4.0
F	01:26:24	71deg 39min	-156deg 59min	6000	180.0	275.5	31.28	10.4
G	01:36:55	71deg 13min	-157deg 55min	6000	180.0	193.2	31.56	10.5
H	01:47:32	70deg 59min	-156deg 26min	6000	180.0	94.7	31.85	10.6
E	01:58:03	71deg 25min	-155deg 30min	6000	180.0	13.5	31.51	10.5
E	02:01:03	71deg 25min	-155deg 30min	4000	180.0	spiral	9.00	3.0
F	02:11:28	71deg 39min	-156deg 59min	4000	180.0	275.5	31.28	10.4
G	02:21:59	71deg 13min	-157deg 55min	4000	180.0	193.2	31.56	10.5
H	02:32:36	70deg 59min	-156deg 26min	4000	180.0	94.7	31.85	10.6
E	02:43:07	71deg 25min	-155deg 30min	4000	180.0	13.5	31.51	10.5
E	02:46:07	71deg 25min	-155deg 30min	2000	180.0	spiral	9.00	3.0
E	02:52:07	71deg 25min	-155deg 30min	8000	180.0	spiral	18.00	6.0
I	02:59:03	70deg 57min	-154deg 43min	15000	280.0	130.6	32.41	6.9
J	03:05:32	70deg 30min	-154deg 00min	22000	280.0	131.3	30.24	6.5
FA1	04:06:38	66deg 06min	-149deg 09min	22000	280.0	136.8	285.10	61.1
FA	04:24:29	64deg 49min	-147deg 51min	434	280.0	136.2	83.34	17.9

Assumptions:

Take off from Barrow.

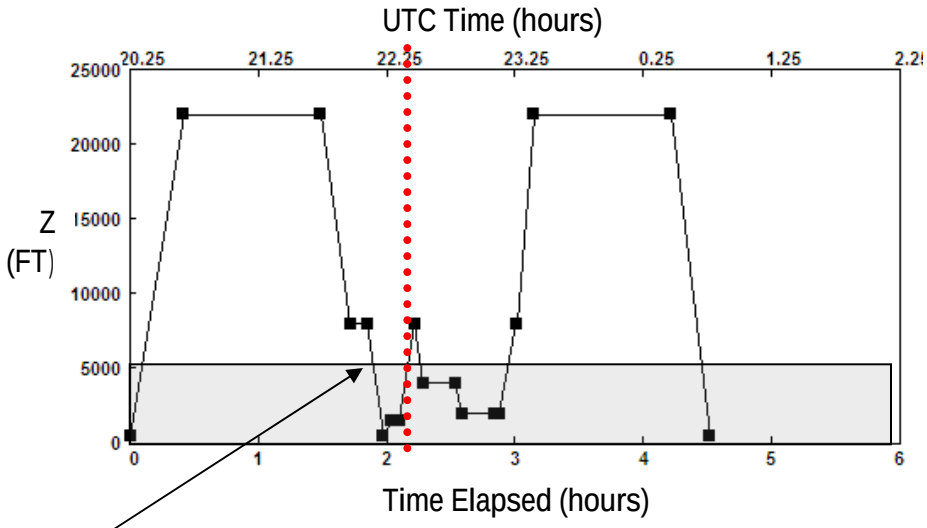
Clouds between 3000 and 7000 feet.



Pattern 3

Total Distance (nm): 1078.12 Total ETE (min): 270.9

WP	Time Elapsed	LAT	LON	ALT (ft)	SPD (kts)	HDG	Dist (nm)	ETE (min)
FA	00:00:00	64deg 49min	-147deg 51min	434				
					200.0	316.2	83.35	25.0
FA1	00:25:00	66deg 06min	-149deg 09min	22000				
					280.0	307.8	300.01	64.3
A	01:29:18	70deg 23min	-156deg 09min	22000				
					180.0	327.4	41.04	13.7
B	01:42:58	71deg 03min	-156deg 34min	8000				
					180.0	33.1	23.62	7.9
C	01:50:51	71deg 17min	-155deg 35min	8000				
					180.0	250.5	22.87	7.6
BR	01:58:28	71deg 17min	-156deg 46min	500				
					180.0	250.2	10.73	3.6
D	02:02:03	71deg 18min	-157deg 19min	1500				
					180.0	33.2	12.09	4.0
E	02:06:05	71deg 25min	-156deg 49min	1500				
					180.0	spiral	21.00	7.0
E	02:13:05	71deg 25min	-156deg 49min	8000				
					180.0	spiral	12.00	4.0
E	02:17:05	71deg 25min	-156deg 49min	4000				
					180.0	328.5	44.95	15.0
F	02:32:04	72deg 09min	-157deg 15min	4000				
					180.0	spiral	9.00	3.0
F	02:35:04	72deg 09min	-157deg 15min	2000				
					180.0	148.5	44.95	15.0
E	02:50:03	71deg 25min	-156deg 49min	2000				
					180.0	77.3	7.48	2.5
F	02:52:32	71deg 24min	-156deg 25min	2000				
					180.0	163.1	24.87	8.3
G	03:00:50	70deg 59min	-156deg 31min	8000				
					280.0	147.5	36.80	7.9
A	03:08:43	70deg 23min	-156deg 09min	22000				
					280.0	127.8	300.01	64.3
FA1	04:13:00	66deg 06min	-149deg 09min	22000				
					280.0	136.2	83.35	17.9
FA	04:30:52	64deg 49min	-147deg 51min	434				



Missed Approach between WP “C” and “BR”

Assumptions:

A-Train (•••) passes over NSA at 14:30 LDT, which will be synchronized with the spiral at WP “E”.

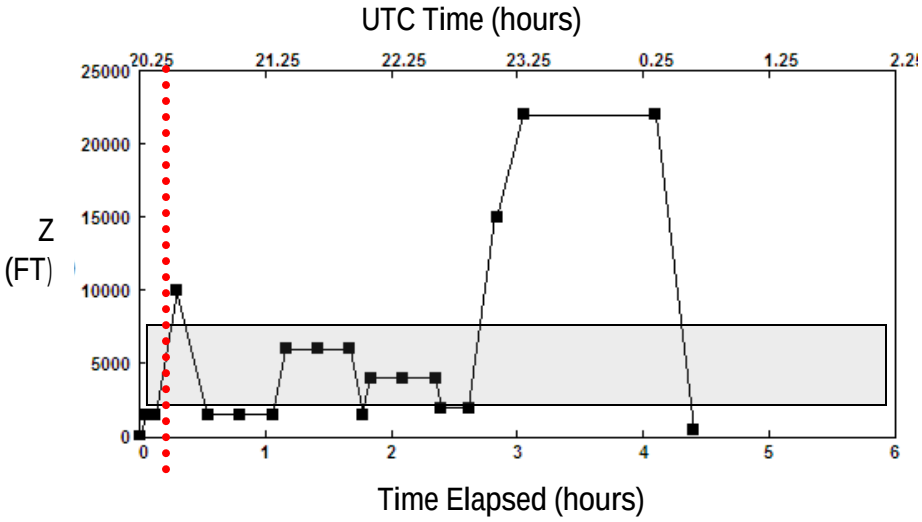
Clouds between 0 and 5000 feet

We know before take off in Fairbanks that we can not land in Barrow and therefore delay take off to 12:15 LDT.

Pattern 4

Total Distance (nm): 946.47 Total ETE (min): 263.5

WP	Time Elapsed	LAT	LON	ALT (ft)	SPD (kts)	HDG	Dist (nm)	ETE (min)
BR	00:00:00	71deg 17min	-156deg 46min	44				
A	00:03:35	71deg 18min	-157deg 19min	1500	180.0	250.2	10.73	3.6
B	00:07:37	71deg 25min	-156deg 49min	1500	180.0	33.2	12.09	4.0
B	00:17:37	71deg 25min	-156deg 49min	10000	180.0	spiral	29.99	10.0
C	00:32:53	72deg 09min	-157deg 19min	1500	180.0	327.0	45.80	15.3
B	00:48:09	71deg 25min	-156deg 49min	1500	180.0	147.0	45.80	15.3
D	01:03:33	71deg 15min	-154deg 28min	1500	180.0	81.7	46.20	15.4
D	01:09:33	71deg 15min	-154deg 28min	6000	180.0	spiral	18.00	6.0
B	01:24:57	71deg 25min	-156deg 49min	6000	180.0	261.7	46.20	15.4
C	01:40:13	72deg 09min	-157deg 19min	6000	180.0	327.0	45.80	15.3
C	01:46:13	72deg 09min	-157deg 19min	1500	180.0	spiral	18.00	6.0
C	01:50:13	72deg 09min	-157deg 19min	4000	180.0	spiral	12.00	4.0
B	02:05:29	71deg 25min	-156deg 49min	4000	180.0	147.0	45.80	15.3
D	02:20:53	71deg 15min	-154deg 28min	4000	180.0	81.7	46.20	15.4
D	02:23:53	71deg 15min	-154deg 28min	2000	180.0	spiral	9.00	3.0
E	02:37:00	71deg 21min	-156deg 29min	2000	180.0	258.9	39.37	13.1
E	02:50:00	71deg 21min	-156deg 29min	15000	180.0	spiral	39.00	13.0
G	03:03:02	70deg 30min	-154deg 49min	22000	280.0	126.5	60.82	13.0
FA1	04:05:40	66deg 06min	-149deg 09min	22000	280.0	133.6	292.30	62.6
FA	04:23:32	64deg 49min	-147deg 51min	434	280.0	136.2	83.35	17.9



Assumptions:

In this example the A-Train (···) passes over NSA at 14:30 LDT, which is synchronized with the spiral at WP “B”.

Clouds between 2000 and 7000 feet

We know before take off in Fairbanks that we can land in Barrow and therefore follow Pattern 1a before refueling.