G1000 Search Patterns
National Emergency Services Academy
Mission Aircrew School
(June 2013 Rev D)

Standardized Visual Search Pattern method

Visual search pattern techniques include:

- Minimum # of user waypoints
- GPS nav data displays - Track (TRK), Bearing to Waypoint (BRG), Distance to Waypoint (DIS), Cross Track Error (XTK) and Ground Speed (GS)
- GPS OBS course line selection
- Setting Magnetic Variation to true North

Five primary visual search patterns - Parallel Line, Creeping Line, Sector Search , Expanding Square and Route Search

Two less common search patterns – Parallelogram and Random Polygonal shapes

G1000 Initial setup

Many user options can be changed

Assume previous crew made changes

Restore to factory settings, delete all flight plans and user waypoints

Avoid the "what's it doing?" & "why does it look like that?" syndrome

G1000 Initial setup

All flights

- ## Map display setup

On base map page - Menu – Map Setup – Menu – Restore All Defaults

Map Group – Auto Zoom – Off, turn all other selections - ON

- ## Delete all Flight Plans

FPL – Flight Plan Catalog (page 2) – Menu – Delete All - ENT

- ## Delete all user waypoints

WPT – User Waypoint (page 5) – Menu – Delete All User Waypoints - ENT

- ## System setup

AUX – AUX System Setup (page 4) – DFLTS - Time Format UTC - ENT

Search Patterns

- ## Map display setup

On base map page - Menu – Map Setup – Menu – select Land group – set LAT/LON Text – medium, set RNG to 10NM

- ## System setup

AUX – AUX System Setup (page 4) – Set NAV ANGLE – True
set POSITION – HDDD MM'SS.S"
MFD DATA BAR
Field 1 – GS
Field 2 – XTK
Field 3 – TRK
Field 4 – BRG
GPS CDI
SELECTED – 0.30NM

G1000 Initial setup cont....

MAP – NAVIGATION MAP

| NAV1 | 108.00 | ↔ | 117.95 |
| NAV2 | 108.00 | | 117.95 |

GS 0KT   DIS __.__NM   XTK _.__NM   BRG ____°T

| 122.800 | ↔ | 136.975 | COM1 |
| 136.975 | | 118.000 | COM2 |

MAP SETUP

GROUP
Map

ORIENTATION	North up
AUTO ZOOM	◄ Off ►
LAND DATA	◄ On ►
TRACK VECTOR	◄ On ►
WIND VECTOR	◄ On ►
NAV RANGE RING	◄ On ►
TOPO DATA	◄ On ► 1500NM
TOPO SCALE	Off ►
TERRAIN DATA	◄ On ► 2000NM
OBSTACLE DATA	◄ On ► 20NM
FUEL RNG (RSV)	◄ On ► 01:30

Preferred Setup

Press the FMS CRSR knob to return to base page

MAN IN 27.3
RPM 2060
FFLOW GPH
OIL PRES
OIL TEMP
CHT
EGT
FUEL QTY GAL
ELECTRICAL
M	BUS	E
36.5	VOLTS	0.0
M	BATT	S
0.0	AMPS	0.0

TA OFF SCALE

G1000 Initial setup cont....

G1000 Initial setup cont....

Preferred Setup

Flying the Patterns

All patterns can be
flown by ref to these
data fields
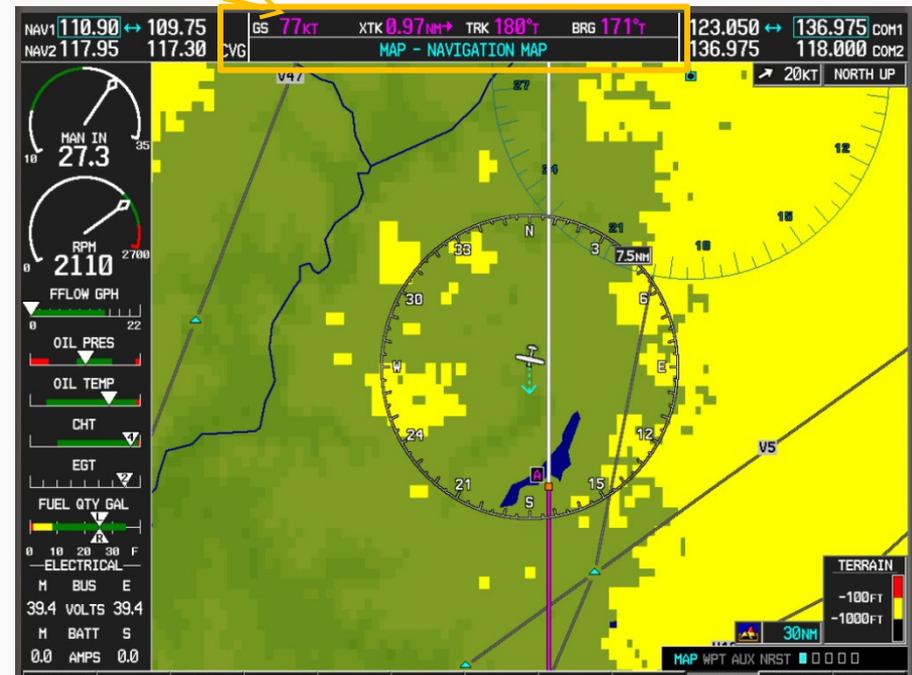
All Methods – G1000 Core Skills

The MP and MO should master the following core skills in order to fly the search patterns:

Entering user waypoints by lat/long, by using reference waypoints (radial and distance) and by using panning feature

Autopilot flying in NAV & HDG mode and seamless transitions in and out of autopilot (KAP140) and CWS operations (GFC700)

Using the OBS & course selector

Flying with the KAP140 & GFC700 autopilots

KAP140 A/P is operationally limited to 80 - 160 KIAS, the GFC700 is limited to 70 - 165 KIAS

Monitor airspeed as power changes are made

> The autopilot will command pitch to maintain the set altitude regardless of airspeed impact, it will fly the aircraft into a stall if power is not managed accordingly

Autopilot turns are made at standard rate, turns may need to be made manually:

> KAP140 - disengage then reengage the A/P when re-established on the next segment of the search pattern

> GFC700 - the CWS button can be used to make the turns

The blue track vector arrow can be used to assist in turns, the end of the arrow is your predicted position in 60 seconds, a 90 degree turn at std. rate takes 30 seconds

Flying with the KAP140 autopilot

Care must be taken when disengaging and re-engaging the autopilot since altitude will not automatically ARM and capture

The KAP140 A/P captures the VS at the moment the A/P is turned on

The altitude must be ARMed, use VS mode to maneuver the aircraft back to the search pattern altitude from above or below as appropriate

Flying with the KAP140 & GFC700 autopilots

The general sequence for autopilot operations for faster than standard rate turns is as follows. It is assumed that the A/P is in HDG mode tracking a GPS course line or XTK to course line in OBS mode:

KAP140 autopilot

1) Press OBS soft key

2) Change course using CRS knob to direction of next leg

3) Disconnect the A/P

4) Turn to intercept the next leg of the pattern

5) Engage A/P and press ALT to capture current altitude

6) Adjust ALT (UP or DN as reqd to reach search altitude – 20 feet increments per button push)

Flying with the KAP140 & GFC700 autopilots

GFC700 autopilot

1. **Activate next leg of flight plan (OBS mode is automatically cancelled)**
2. **Press OBS soft key**
3. **Change course using CRS knob to direction of next leg**
4. **Hold CWS button and make the turn to intercept the next course line and maneuver the aircraft to the desired search altitude, then release CWS button**
5. **Synchronize the HDG bug**
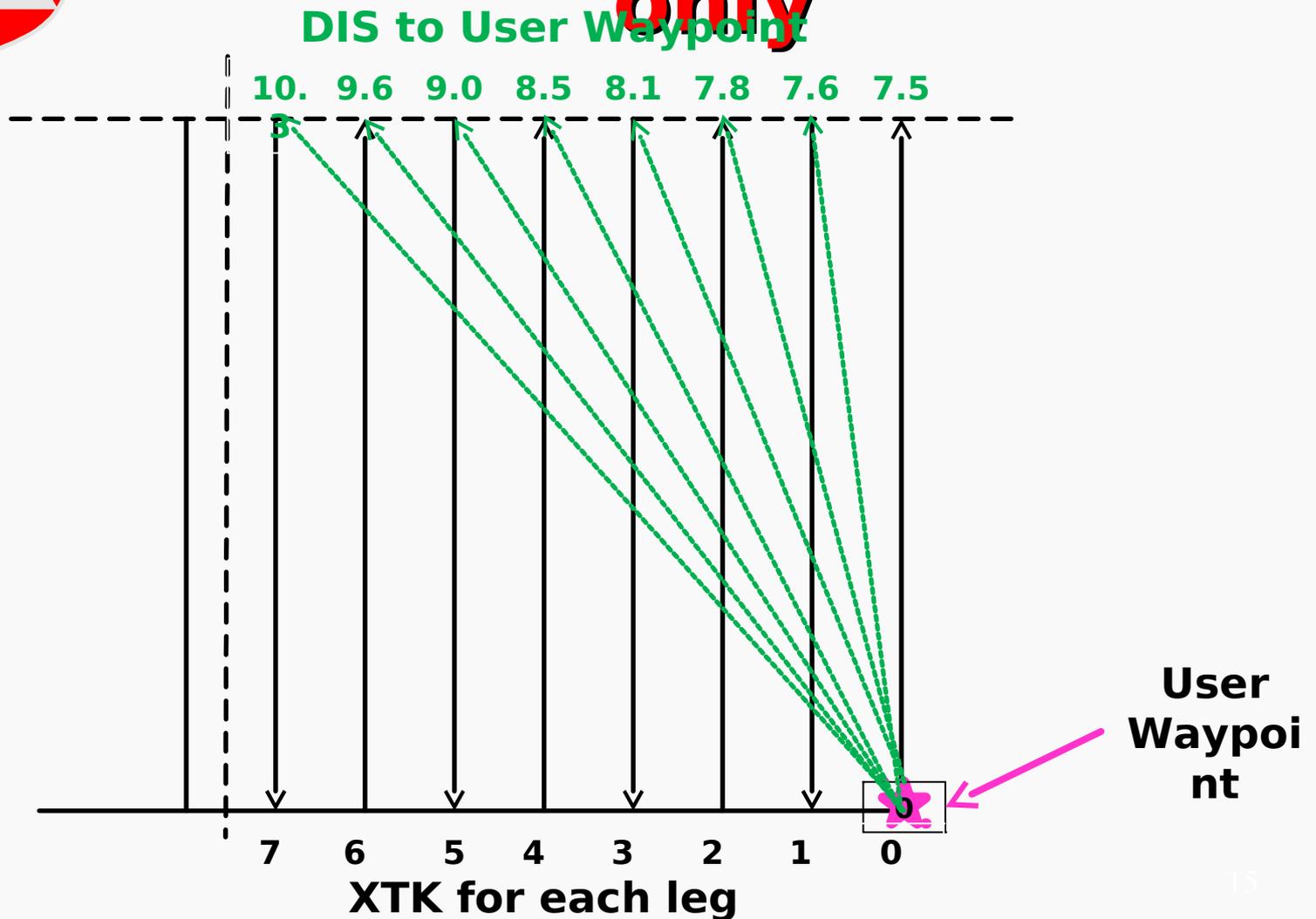6. **Release CWS button**

Parallel Line (Grid) Search

Single User waypoint XTK, TRK, BRG, DIST and OBS

1. Input user waypoint at grid entry point by Lat/Long
2. Load a "direct to" user waypoint flight plan
3. Rotate the course line (OBS) to the direction of the first track then fly the track. This first track will establish the "base line" for subsequent parallel tracks
4. At the end of the first track and at least 0.5NM outside the grid turn to establish a new track in the opposite direction at a distance XTK= track spacing (e.g. 1 nm for the second track and 2 nm for the third track etc.)
5. For NS tracks end of grid can be established by DIS from User Waypoint (see next slide)
6. Fly each track adjusting heading to achieve the desired TRK while maintaining desired XTK from the base line
7. The entry edge of the grid can be established by BRG to WPT, in the example given on next slide BRG, 000 on entry edge of grid

Parallel Line DIS to Wpt – for N-S Tracks only

DIS to User Waypoint

10. 9.6 9.0 8.5 8.1 7.8 7.6 7.5

User Waypoint

7   6   5   4   3   2   1   0

XTK for each leg
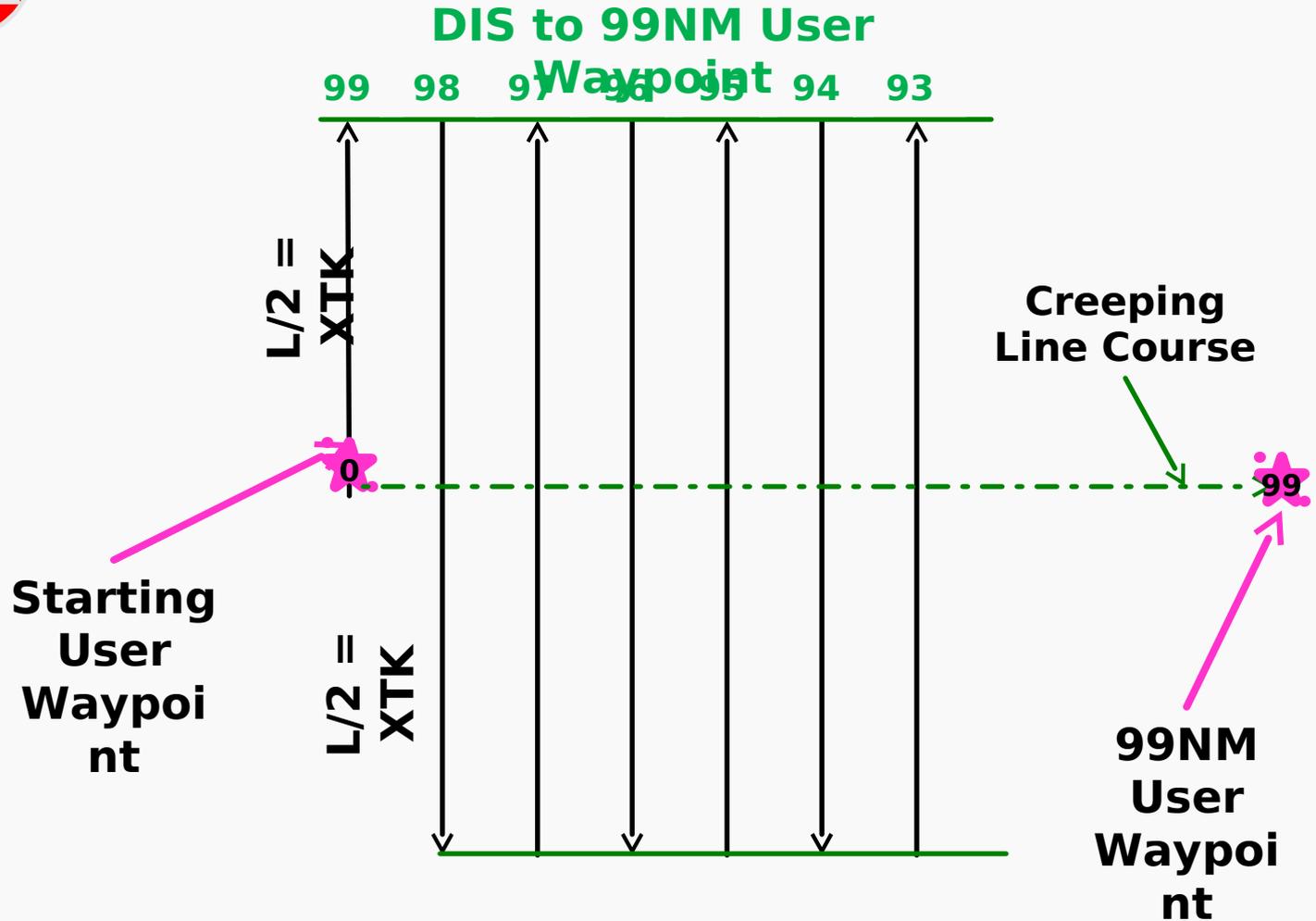
Creeping Line Search (GPS arc method)

Two User waypoints XTK, DIS, DTK and OBS

1. Determine true course between beginning point and end point of search from sectional

2. Insert a waypoint 99 miles beyond the start point of the creeping line, enter a flight plan from start to waypoint 99 miles beyond start point (this must not be >99 miles since G1000 will not display 1/10th miles at 99 NM or more)

3. Desired track for left offset of creeping line is DTK – 90°, Right offset of creeping line is DTK + 90°.

4. Approach the beginning point from the right side of the search course so that aircraft is established on creeping line track (DTK – 90°) prior to crossing search course.

5. When the Cross Track Error (XTK) readout indicates that the aircraft is at the Offset plus at least + 0.5 NM from the course line, perform a turn to intercept the reciprocal track (DTK + 90°)

6. Adjust the turn as necessary so that the aircraft is closer to the course end point by distance equal to track spacing and on a ground track perpendicular to the course line

7. Continue this process until the search pattern is completed.

Creeping Line

DIS to 99NM User Waypoint

99   98   97   96   95   94   93

L/2 = XTK

Creeping Line Course

0

99

Starting User Waypoint

L/2 = XTK

99NM User Waypoint

Creeping Line Error

Example Creeping Line
(Leg Lengths, Track Spacing, & Example Headings Shown)
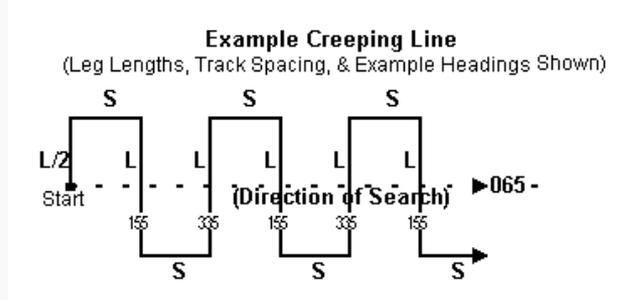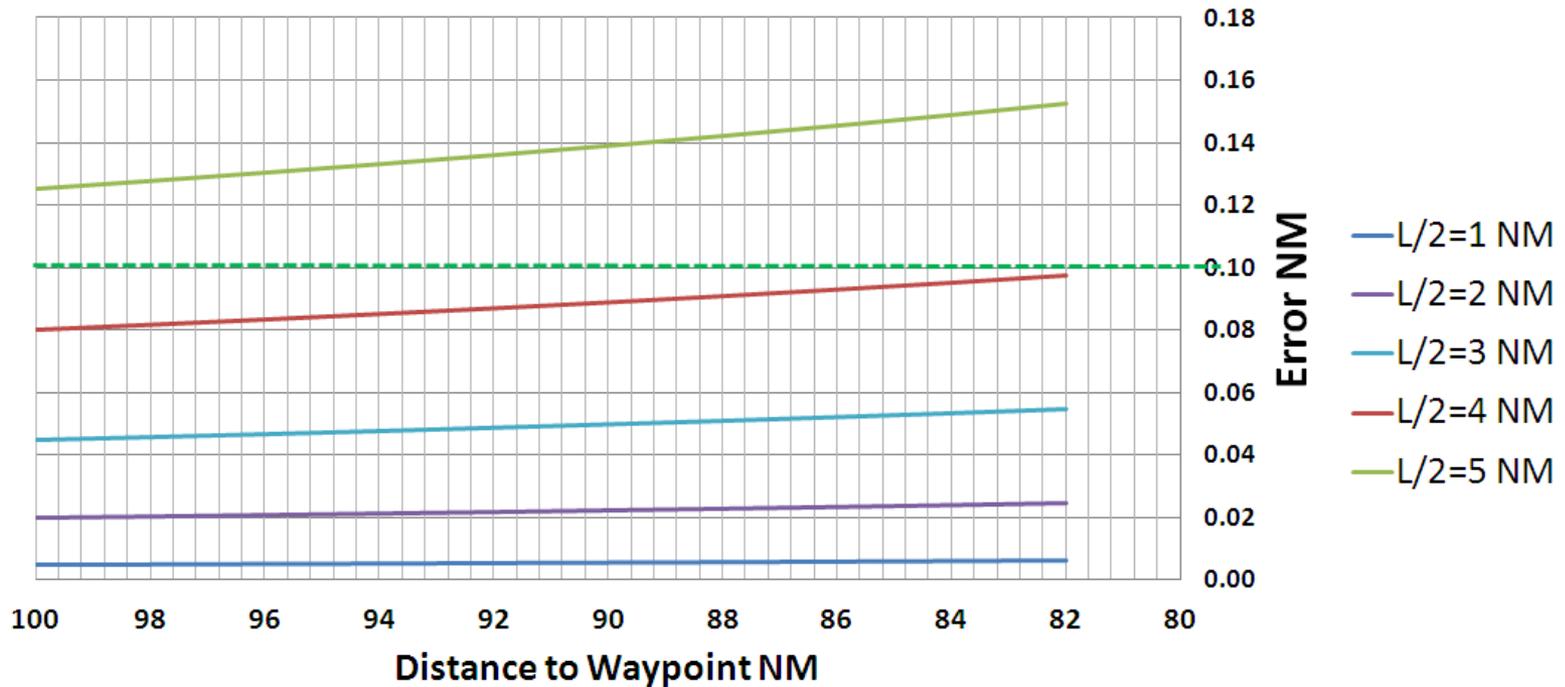
Sector Search

Single User waypoint DIS, TRK and OBS

Input user waypoint for center of sector search by Lat/Long.

Enter a flight plan from the departure airport or present position to the center of the sector search, position aircraft to intercept and fly inbound to the search center on the radial closest to the direction of fight. Select this radial using the OBS function. Fly in A/P HDG or NAV mode.

After arrival at the search center continue to fly the same track out to the search radius on the other side of the center using DIS to verify position from the center and the OBS line for course guidance

When DIS > search radius, synch the HDG bug, engage the A/P in HDG mode select next radial using OBS, D/C A/P and turn right to intercept the next inbound radial track. The next radial bearing – 90 degrees is a good heading to fly to intercept the next radial inbound. Synch the HDG bug Re-engage the A/P in HDG then NAV mode.

Sector Search

Low High

High Low
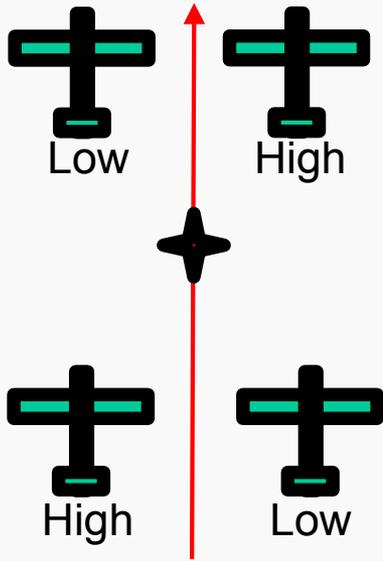
Bearing to wpt.

Example sector search
Bearing to wpt. in red
interim headings in black -
**use up to 3 NM from
centerpoint**

**use up to 6 NM from
centerpoint**

Sector Search

Sector Search

Expanding Square Search

Single User waypoint XTK, DIS, TRK and OBS

1. Input user waypoint for center of expanding square search by Lat/Long
2. Load a "direct to" user waypoint flight plan
3. Set OBS to 360, intercept course line and cross waypoint at designated ground speed and altitude
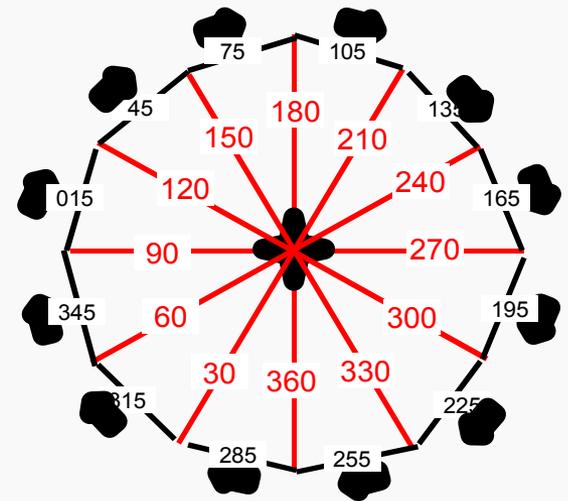4. At DIS=0.7, turn right using a 20 degree bank angle to a TRK of 090. when XTK=0.7 turn right to 180 using a 20 degree bank angle, roll out XTK=1.
5. Establish heading to stay on XTK = 1.0 and TRK=180, use ground track bug if able
6. When ground track stable, set OBS=270; at XTK=0.7 turn right using 20 degree bank angle, roll out to achieve TRK=270 and XTK=1.0
7. Establish heading to stay on XTK = 1.0, TRK=270
8. When ground track stable, set OBS=360; at XTK=0.7 turn right using 20 degree bank angle, roll out to achieve TRK= 360 and XTK=1.0
9. Establish heading to stay on XTK = 1.0, TRK=360
10. When ground track stable, set OBS=090; at XTK=1.7 turn right using 20 degree bank angle, roll out to achieve TRK= 090 and XTK=2.0
11. Continue this process until the search pattern is

Expanding Square

OBS = 360

OBS = 270

OBS = 090

OBS = 180
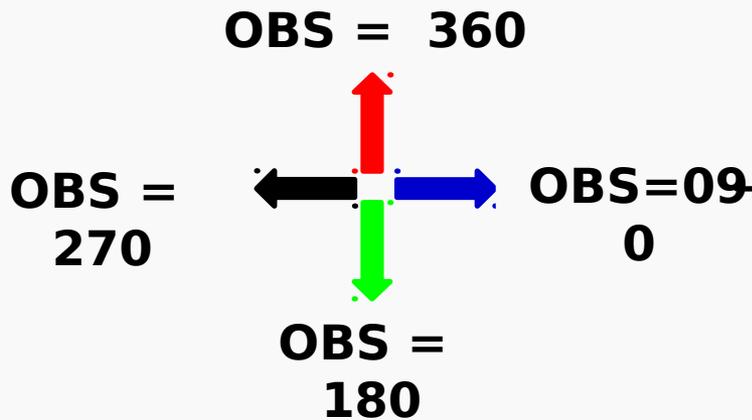
Approx. location
of OBS change
for next leg

0

1 2

3

4

5 6

7

8
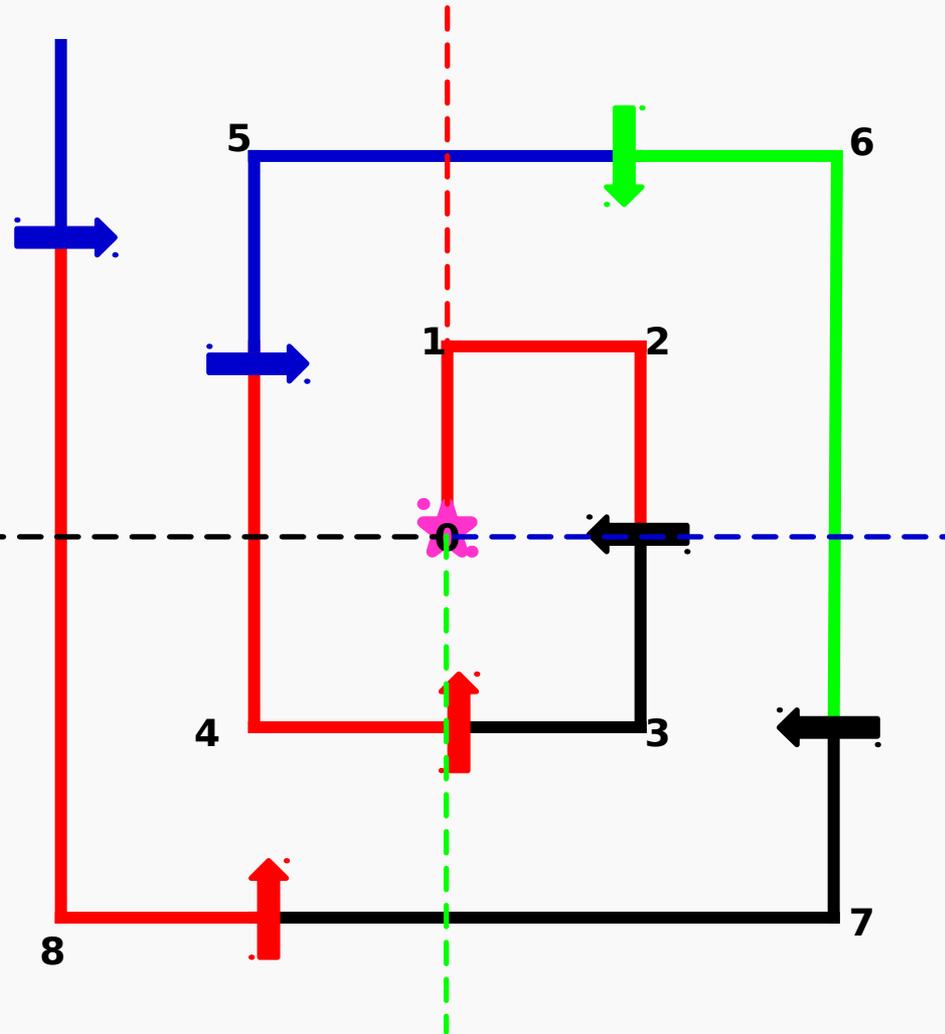
Route Search

Using flight plan and XTK

Enter and activate a flight plan for the route using a combination of Airports, VORs, NDBs and user waypoints as appropriate. Note the true course for each leg of the flight plan

Fly the required parallel track offset by using the MFD data bar for cross track information (XTK) relative to the flight plan route

Fly the parallel track in A/P HDG mode, use the current track bug on the PFD HSI to assist maintaining the parallel track

Parallelogram Grid Search

<u>Single User waypoint XTK, TRK, DIS, BRG and OBS</u>

1. Input user waypoint at grid entry point by Lat/Long
2. Establish angle α (360 – true track) and L (track length)
3. Load a "direct to" user waypoint flight plan
4. Rotate (OBS) the course line to the direction of the first track then fly the track. This first track will establish the "base line" for subsequent parallel tracks
5. End of the track can be established by DIS using tables given using your Track Length L and Angle α (see next slide).
6. At the end of the first track and at least 0.5NM outside the grid turn to establish a new track in the opposite direction at a distance XTK= track spacing (e.g. 1 nm for the second track and 2 nm for the third track etc.)
7. Fly each track adjusting heading to achieve the desired TRK while maintaining desired XTK from the base line
8. The entry edge of the grid can be established by BRG to WPT, in the example given BRG=090 on entry edge of grid
9. Repeat until the grid is complete

Parallelogram Grid Search
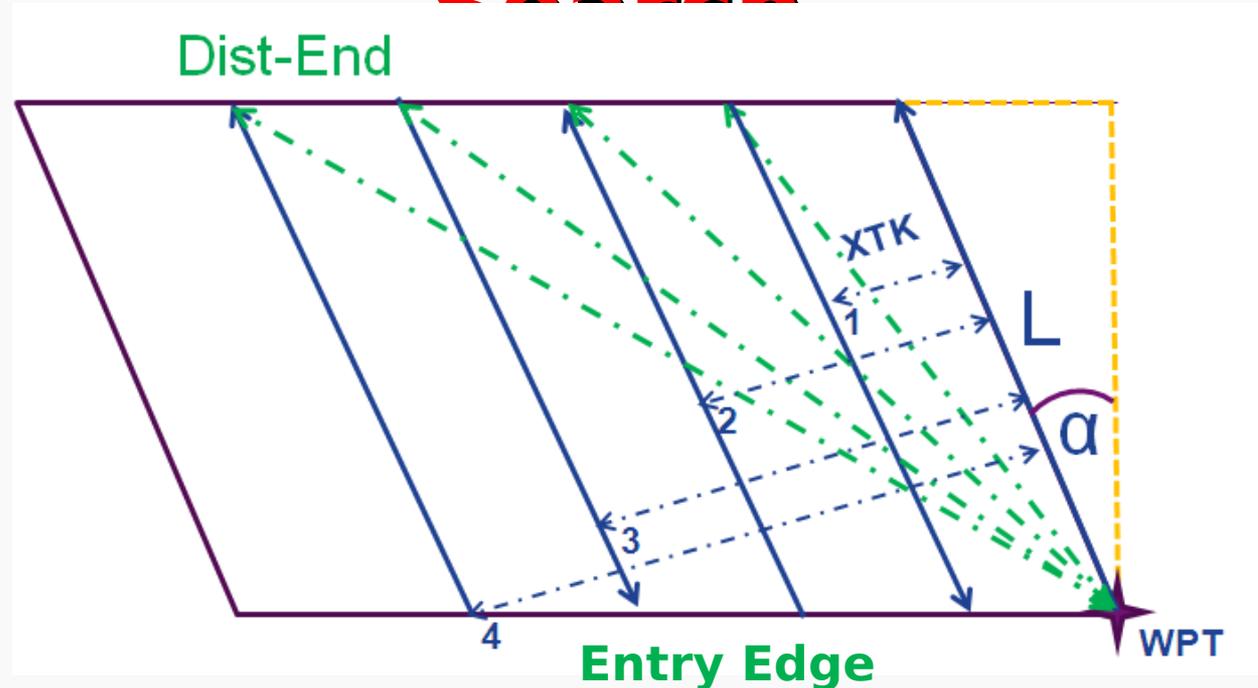
L= distance along track start- end of grid
XTK = Track Spacing (usually 1NM)
α = angle between track and entry edge (360-true track)

Dist-End = Distance from WPT to End of grid
Entry Edge of grid can be established from BRG to WPT in this example BRG= 090 along entry edge

Parallelogram Grid Search

L = 10

Angle Alpha	10	15	20	25	30	35	40	45
XTC	Dist - End	Dist - End	Dist - End	Dist - End	Dist - End	Dist - End	Dist - End	Dist - End
1	10.2	10.3	10.4	10.5	10.5	10.6	10.7	10.7
2	10.5	10.7	10.9	11.0	11.2	11.3	11.4	11.5
3	10.9	11.2	11.4	11.6	11.8	12.0	12.2	12.3
4	11.4	11.7	12.0	12.3	12.5	12.8	13.0	13.2
5	12.0	12.3	12.7	13.0	13.3	13.6	13.8	14.1
6	12.6	13.0	13.4	13.7	14.1	14.4	14.7	14.9
7	13.2	13.7	14.1	14.5	14.9	15.2	15.6	15.8
8	13.9	14.4	14.9	15.3	15.7	16.1	16.4	16.8
9	14.7	15.2	15.7	16.1	16.6	17.0	17.3	17.7
10	15.4	16.0	16.5	17.0	17.5	17.9	18.3	18.6
11	16.2	16.8	17.4	17.9	18.3	18.8	19.2	19.6
12	17.1	17.7	18.2	18.7	19.2	19.7	20.1	20.5
13	17.9	18.5	19.1	19.6	20.2	20.6	21.1	21.5
14	18.7	19.4	20.0	20.5	21.1	21.6	22.0	22.4
15	19.6	20.3	20.9	21.5	22.0	22.5	23.0	23.4

L = 8 (Angle Alpha: 10, 15, 20, 25, 30, 35, 40, 45 — partial)

25	30	35	40	45
8.5	8.6	8.6	8.7	8.7
9.0	9.2	9.3	9.4	9.5
9.7	9.9	10.1	10.2	10.4
10.4	10.6	10.9	11.1	11.2
11.1	11.4	11.7	11.9	12.1
11.9	12.2	12.5	12.8	13.0
12.8	13.1	13.4	13.7	14.0
13.6	14.0	14.3	14.6	14.9
14.5	14.9	15.2	15.5	15.8
15.4	15.8	16.1	16.5	16.8
16.3	16.7	17.1	17.4	17.8
17.2	17.6	18.0	18.4	18.7
18.1	18.5	19.0	19.3	19.7
19.0	19.5	19.9	20.3	20.7
20.0	20.4	20.9	21.3	21.6

L = 6 (Angle Alpha: 10, 15, 20, 25, 30, 35, 40, 45 — partial)

25	30	35	40	45
6.5	6.6	6.6	6.7	6.8
7.1	7.2	7.4	7.5	7.6
7.8	8.0	8.1	8.3	8.4
8.5	8.8	9.0	9.2	9.3
9.4	9.6	9.8	10.0	10.2
10.2	10.5	10.7	11.0	11.2
11.1	11.4	11.6	11.9	12.1
12.0	12.3	12.6	12.8	13.1
12.9	13.2	13.5	13.8	14.0
13.8	14.1	14.5	14.7	15.0
14.7	15.1	15.4	15.7	16.0
15.7	16.0	16.4	16.7	17.0
16.6	17.0	17.4	17.7	18.0
17.6	18.0	18.3	18.6	18.9
18.6	19.0	19.3	19.6	19.9

L = 4 (Angle Alpha: 10, 15, 20, 25, 30, 35, 40, 45 — partial)

10	15	20	25	30	35	40	45
4.3	4.4	4.5	4.5	4.6	4.7	4.7	4.8
4.8	4.9	5.1	5.2	5.3	5.4	5.5	5.6
					6.3	6.4	6.5
					7.2	7.3	7.4
					8.1	8.2	8.4
					9.0	9.2	9.4
					10.0	10.2	10.3
					10.9	11.1	11.3
					11.9	12.1	12.3
					12.9	13.1	13.3
					13.9	14.1	14.3
					14.8	15.1	15.3
					15.8	16.1	16.3
					16.8	17.1	17.3
					17.8	18.1	18.3

# Random Shapes Grid Search

Single User waypoint XTK, TRK, DIS, BRG and OBS

1. Draw shape on sectional , select longest edge for initial track, measure initial track direction and reciprocal track direction
2. Input user waypoint at grid entry point by Lat/Long
3. Load a "direct to" user waypoint flight plan
4. Rotate the course line (OBS) to the direction of the first track then fly the track. This first track will establish the "base line" for subsequent parallel tracks
5. End of the track can be established by measuring distance on sectional
6. At the end of the first track and at least 0.5NM outside the grid turn to establish a new track in the opposite direction at a distance XTK= track spacing (e.g. 1 nm for the second track and 2 nm for the third track etc.)
7. Fly each track adjusting heading to achieve the desired TRK while maintaining desired XTK from the base line
8. The ends of the track can be established by either BRG to WPT or by DIS from user waypoint whichever makes most sense
9. Repeat until the grid is complete

Random Shapes Grid Search
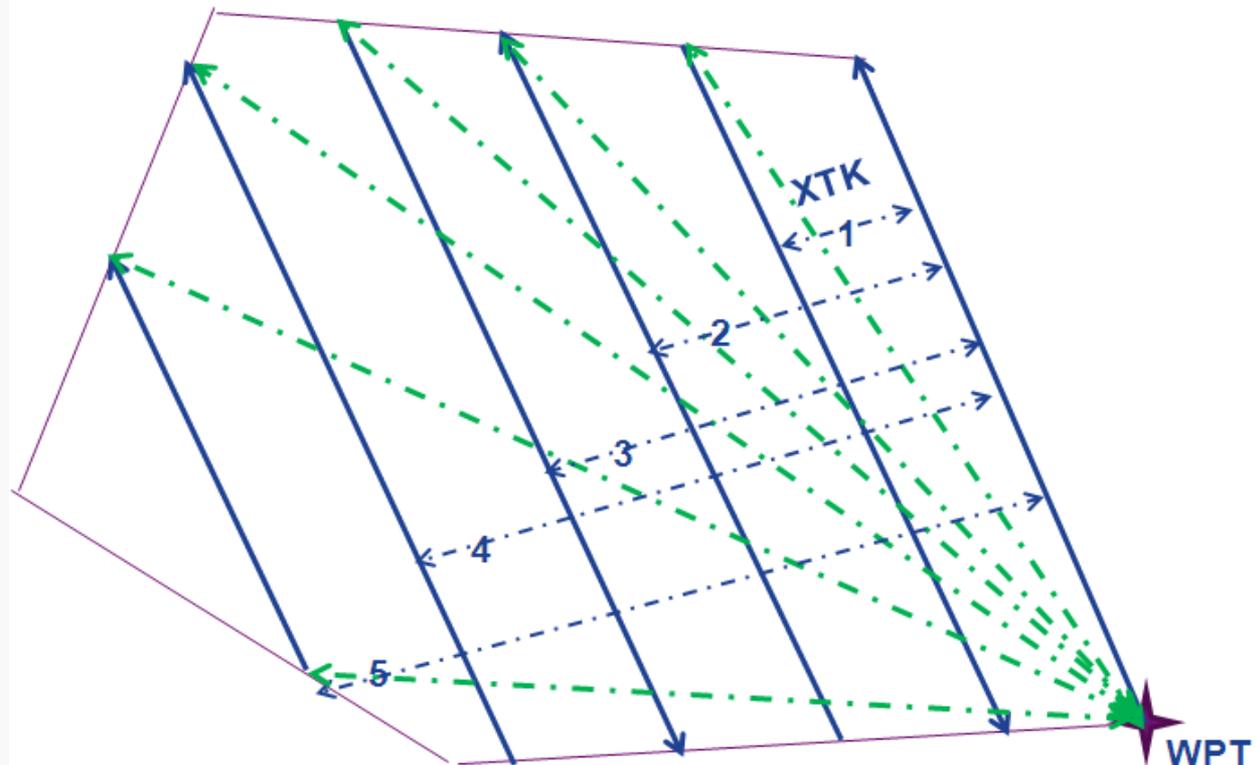
XTK = Track Spacing (usually 1NM)
End of tracks can be established by either distance from WPT to End of grid measured from sectional or by BRG to WPT

Questions?