

AVIGATION/RNAV

APPLICATION PAC PROPOSAL

for the

HP-41C/41CV

by: Robert A. Tims
P.O. Box 643
State University, AR 72467
Phone: 501-935-7586

AVIGATION/RNAV
PREFACE

For many years pilots have depended on a sliderule type of flight computer, plotter, and sectional maps for flight planning. Now there are available various calculators to replace the sliderule flight computer, and some at very reasonable prices such as the "Avstar". Some calculators even have numerous aviation programs built into them.

What has been offered is not enough and doesn't really meet the needs of the pilot. This problem was observed in the March 1981 issue of Commuter Air, "Most of the...programs built into these calculators are of relatively little practical use to the commercial operator..." And a pilot writing in the Professional Pilot, April 1981 stated, "At this time I can only recommend three units for Rnav use; Texas Instruments' TI59 and Hewlett Packard's HP67 and HP41C models. Unfortunately, off the shelf Rnav programs that truly meet the requirements of the "real world" Rnav have not been developed by these manufacturers. ... Hopefully this will change as the use of programmable calculators for Rnav grows."

The average professional pilot, flying in the present sophisticated ATC system needs and is willing to use a good navigation computer. When the flight department can afford it, they will use very sophisticated and expensive ground and airborne computers. Most departments, however, cannot afford what is available.

When pilots see the HP41C being used for Rnav planning, they are impressed and desire one for themselves. Until they find out they have to program it themselves for the capabilities needed. Not everyone has the desire or time needed to do the programming, and few capable enough mathematically to do it. Nor is it easy to find someone else to do the programming for the pilot, because even if they are capable, they do not understand the world of the cockpit.

A practical aviation program needs to be offered to the aviation world that meets their needs and is supplemented with programs such as weight and balance, TAS, Mach, wind, flight management, etc. The proposed program meets this need. It provides preflight planning as well as inflight route changes; it provides for all types of navigation fixes, not only airports and vortacs, but intersections and Rnav waypoints as well. It is this program which is most needed by the average professional pilot who flies IFR and/or Rnav, and which can meet their real world needs. It will make the HP41C a viable and justifiable tool to the general aviation community and flight departments, which will result in an increase of HP41C system sales.

This program is submitted to Hewlett Packard for consideration to help meet the challenge presented by the aviation market.

Robert A. Tims
10-14-81

AVIGATION/RNAV
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PROGRAM DESCRIPTION I

Program Title AVIGATION - AVIATION NAVIGATION

Contributor's Name _____

Address _____

City _____ State/Country _____ Zip Code _____

Program Description, Equations, Variables This program prompts for navigation fixes and computes the course and distance for each leg. These primary legs, if desired, can be divided into secondary legs by Area Navigation (RNAV) Waypoints. The individual legs, with their associated data, are stored in proper sequence; each leg in 5 data registers.

The primary legs have starting and terminating fixes determined by latitude and longitude coordinates; or if desired, as an intersection or waypoint defined by a heading or radial and by a distance from the coordinates of the reference fix.

The program will, if desired, calculate a waypoint over the departure and destination airports.

Each leg has its starting fix Identifier stored with the next register the waypoint fix if the fix is a waypoint. The true course and distance is stored next, followed by the altitude and magnetic variation. The final leg data will be the interpolated wind for that altitude.

At anytime a waypoint is not desired (either a terminal or enroute WP) input may be declined. Input is declined by resumming program execution with **R/S**.

The flight may be terminated by declining the next primary leg terminating fix; the program will then prompt for the destination waypoint. Finally the airport elevations and climb/descent winds are prompted for, also the performance data. Program execution is then passed to the Aviation Fly Program.

Necessary Accessories A card reader is recommended.

Operating Limits and Warnings The following subroutines are used: "NFIK", "CRS", "WP", "TWP", "WIND", & "PRF". If a mistake is made on data entry, the program must be started over. Ident may be corrected as long as the incorrect isn't in the data registers.

PROGRAM DESCRIPTION II

Sample Problem (Sketch if Desired)

Flight: Depart the McGhee Tyson airport, Knoxville, TN; fly direct to COWAN intersection with WP's off of Hinch Mt. Vortac and Chattanooga Vortac; Thence V54N to the Rocket Vortac, V54 to Muscle Shoals Vortac, and direct to Muscle Shoals, AL airport.

Coordinates:

McGhee Tyson - TYS 981' Elev.

35°48'45"N 83°59'34"W, 1°W

Knoxville Vortac - TYS (on Data Card - TYSV)

35°54'17"N 83°53'41"W, 1°W

Hinch Mt. Vortac - HCH (on Data Card - HCHV)

35°46'51"N 84°58'43"W, 1°E

Chattanooga Vortac - CHA (on Data Card - CHAV)

34°57'40"N 85°09'12"W, 1°E

Rocket Vortac - RQZ (on Data Card - RQZV)

34°47'49"N 86°38'02"W, 2°E

Muscle Shoals Vortac - MSL (on Data Card - MSLV)

34°42'24"N 87°29'29"W, 1°E

Muscle Shoals - MSL 550' Elev.

34°44'43"N 87°36'37"W, 1°E

FORECAST WINDS ALOFT

3000' 6000' 9000'

TYS 0410 0615 0718

CHA 0610 0918 1124

MSL 0710 1125 1530

AIRCRAFT PERFORMANCE

Climb: TAS 115 kts, F/F 54 gph

Cruise: TAS 180 kts, F/F 34 gph

Descent: TAS 190 kts, F/F 24 gph

ROC 900 fpm, ROD 500 fpm

Data from Weight & Balance:

Gross Wt. 5000 lbs

Fuel 100 gal. = 600 lbs

SOLUTION:

PERTINENT DATA REGISTERS

AVNAV RESULTS USED LATER
IN THE AVFLY PROGRAM

R10= 70

R14= 4000

R15= 192

R19= 981.0000

R20= 50.0125

R21= 550.0000

R22= 70.0100

R23= 115.0000

R24= 180.0000

R25= 190.0000

R26= 900.0000

R27= 500.0000

R28= 54.0000

R29= 34.0000

R30= 24.0000

R33= 34.745

R34= 0.000

R35= 600.000

R36= 5000.000

R37= "WP:TYS"

R38= 2218.007

R40= "TYS"

R41= 0.0000

R42= 244.0440

R43= 8000.0010

R44= 67.0170

R45= "WP:HCH"

R46= 1531.0193

R47= 244.0290

R48= -8000.0010

R49= 103.0220

R50= "WP:CHA"

R51= 3331.0211

R52= 244.0320

R53= -8000.0010

R54= 103.0220

R55= "COWAN"

R56= 0.0000

R57= 247.0380

R58= -4000.0010

R59= 70.0127

R60= "RQZV"

R61= 0.0000

R62= 263.0430

R63= -4000.0020

R64= 83.0150

R65= "MSLV"

R66= 0.0000

R67= 292.0060

R68= -4000.0010

R69= 83.0150

R70= "MSL"

Comments

LEG #1 Data

LEG #2 Data

LEG #3 Data

LEG #4 Data

LEG #5 Data

LEG #6 Data

Destination Identifier

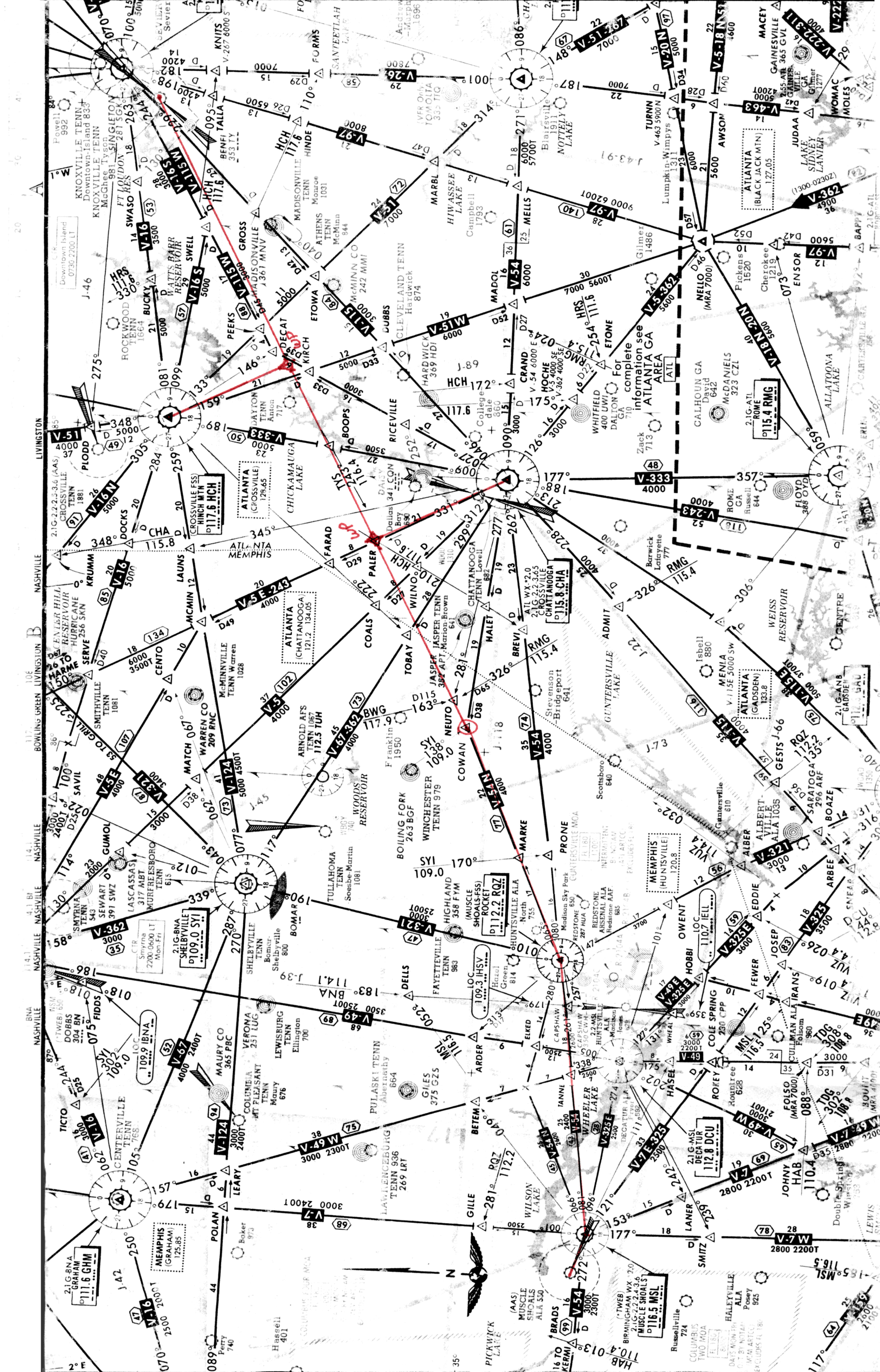
PROGRAM DESCRIPTION II

Input	Function	Display	Comments
TYS	XEQ AVNAV R/S	FROM? CARD	Asking for Departure airport TYS isn't on the data card, but
35.4845	Load Data Card	TYS LAT?	load card for next fix to save
83.5934	R/S	TYS LNG?	having to push R/S twice to
1	R/S	TYS VAR?	continue the program.
TYSV	R/S	TYS WP?	
COWAN	R/S	TYS TO?	
	R/S	CARD	COWAN INTERSECTION IS 277°, 38 DME
	R/S	COWAN	from CHA Vortac.
	R/S	COWAN LAT?	
CHAV	R/S	NEED FIX?	
277	R/S	LEG MC?	
38	R/S	LEG DIST?	
HCHV	R/S	TYS TO WP?	
8000	R/S	ALT= 0?	
060.015	R/S	WA6?	Use TYS Winds
70.018	R/S	WA9?	
CHAV	R/S	WP:HCH TO WP?	
	R/S	ALT= 8000?	
	R/S	WA6?	
90.018	R/S	WA9?	Use CHA Winds.
110.024	R/S	WP:CHA TO WP?	
RQZV	R/S	WP:CHA TO WP?	RQZ improper waypoint, it is
	R/S	ALT= 8000?	beyond terminating fix.
	R/S	WA6?	Same altitude and winds
	R/S	COWAN TO?	
RQZV	R/S	COWAN TO WP?	
	R/S	ALT= 8000?	
4000	R/S	WA3?	
	R/S	WA3?	New altitude, need new winds!
60.01	R/S	WA6?	Use CHA winds
90.018	R/S	RQZV TO?	
MSLU	R/S	CARD	Spelling mistake
	R/S	MSLU	
	R/S	MSLU LAT?	
	R/S	NEED FIX?	
	R/S	LEG MC?	
MSLV	R/S	MSLU	
	R/S	RQZV TO WP?	
	R/S	ALT= 4000?	
70.01	R/S	WA3?	
110.025	R/S	WA6?	Use MSL Winds
MSL	R/S	MSLV TO?	
	R/S	CARD	
	R/S	MSL	
	R/S	MSL LAT?	
34.4443	R/S	MSL LNG?	
87.3637	R/S	MSL VAR?	
-1	R/S	MSLV TO WP?	
	R/S	ALT= 4000?	
	R/S	WA3?	Same altitude, same winds.
	R/S	MSL TO?	
	R/S	MSL WP?	Terminate flight as MSL is the
	R/S	DEPART EL?	Destination airport
981	R/S	WA3?	Terminal waypoint is declined.
40.01	R/S	WA6?	
60.015	R/S	DEST EL?	Using TYS winds
550	R/S	WA3?	Use MSL Winds

Sample Problem (Sketch if Desired)

SOLUTION:

Input	Function	Display	Comments
70.01	R/S	CLIMB TAS?	
115	R/S	CRUISE TAS?	
180	R/S	DESCENT TAS?	
190	R/S	R.O.C.?	
900	R/S	R.O.D.?	
500	R/S	CLIMB F/F?	
54	R/S	CRUISE F/F?	
34	R/S	DESCENT F/F?	
24	R/S	Program is transfered to the AVFLY program!	



USER INSTRUCTIONS

				SIZE: 41 + 5N
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Size and run weight & Balance. GW in R36, Fuel Weight in R35.			
2	Begin AVNAV		☐ XEQ AVNAV	FROM?
3	Input departure airport identifier. from Step A (2/7) or Step A skipped. from Step A (11), skip Step 4	IDENT	☐ R/S	see Step A (ident) WP? (ident) TO?
4	Input terminal waypoint fix identifier. from Step A (2/7) or Input declined	IDENT	☐ R/S	see Step A (ident) TO?
5	Input identifier for leg terminating fix. from Step A or Step A skipped.	IDENT	☐ R/S	see Step A (ident) TO WP?
6	Input waypoint identifier Input declined, skip to step 11 from Step A	IDENT	☐ R/S	see Step A ALT=0? WA#?
7	Input Altitude If declined displayed altitude will be entered.	Alt feet	☐ R/S	WA#?
8	Input Wind aloft as required by Alt. (# thousands of ft = 3,6,9,12,18,24,30,34,49,45,53) Cannot be declined if new altitude or if it is the first leg. If declined, prior wind aloft is entered and step 9 skipped.	DDD.VVV	☐ R/S	WA#?
9	Input next higher Wind Aloft if required. If declined, step 8 input will be entered.	DDD.VVV	☐ R/S	WP:(ident) TO WP?
10	Repeat starting with step 6.			
11	Input Alt. & Winds (same as steps 7, 8, & 9)		☐ R/S	(Ident) TO?
12	Input Ident. for new legs term. fix. If declined skip to Step 14 from Step A	IDENT	☐ R/S	see Step A (ident) TO WP?
13	Repeat starting with Step 6			

USER INSTRUCTIONS

				SIZE: 41 + 5N
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
14	Trip is terminated. Last leg's term.			
15	fix is the Destination Airport Input terminal waypoint fix identifier from Step A, or input declined	IDENT	☐ R/S	(ident) WP? see Step A DEPART EL?
16	Input Departure airport's elevation	Elev.	☐ R/S	WA#?
17	Input Winds (same as steps 8 & 9)	DDD.VVV	☐ R/S	DEST EL?
18	Input Destination airport's elevation	Elev.	☐ R/S	WA#?
19	Input Winds (Same as steps 8 & 9)	DDD.VVV	☐ R/S	CLIMB TAS?
20	Input Aircraft Performance:			
	Climb TAS (if declined skip to 21)	TAS _c	☐ R/S	CRUISE TAS?
	Cruise TAS	TAS _{cr}	☐ R/S	DESCENT TAS?
	Descent TAS	TAS _d	☐ R/S	R.O.C.?
	Rate of Climb	ROC	☐ R/S	R.O.D.?
	Rate of Descent	ROD	☐ R/S	CLIMB F/F?
	Climb Fuel Flow	FF _c	☐ R/S	CRUISE F/F?
	Cruise Fuel Flow	FF _{cr}	☐ R/S	DESCENT F/F?
	Descent Fuel Flow	FF _d	☐ R/S	Transfers to the AVFLY Program.
21	Prompts for the same information as Step 20, and gives opportunity to record the aircraft performance data on a Data Card. then transfers to the AVFLY Program.			

PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
01	LBL "AVNAV"		51	STO IND Y	
02	CF 02		52	SF 02	
03	CF 29		53	LBL 21	
04	FIX 0		54	CLA	
05	"FROM?"		55	ARCL IND 10	
06	SF 01		56	"- TO WP?"	
07	SF 23		57	CF 23	
08	XEQ "NFIK"	Departure coordinates	58	XEQ "NFIK"	Waypoint declined?
09	CF 01		59	FC? 23	
10	RCL 06		60	GTO 01	
11	STO 33	Store From Ident.	61	XEQ "CRS"	
12	CLX		62	XEQ "WP"	Compute WP Fix
13	STO 14		63	FC?C 07	Waypoint computed?
14	STO 15		64	GTO 21	
15	STO 38		65	STO 13	
16	38		66	RCL 12	
17	FC?C 03		67	ENTER↑	
18	XEQ "TWP"	Departure WP	68	X<> 04	
19	RCL 33	Recall From Ident	69	XEQ 10	Leg Dist, Alt, & Wind
20	STO 06		70	RCL 11	Update variation
21	40		71	STO 07	
22	STO 10	Initialize leg pointer	72	"WP:"	
23	LBL 20		73	ARCL 06	
24	CLA		74	ASTO IND 10	WP Ident
25	ARCL 06	Store Identifier	75	RCL 10	
26	ASTO IND 10		76	1	
27	"- TO?"		77	+	
28	CF 23		78	RCL 13	WP Fix
29	XEQ "NFIK"	Coordinates for Primary	79	STO IND Y	
30	FC? 23	leg terminating coord.	80	GTO 21	
31	GTO 22	Flight terminated?	81	LBL 01	
32	XEQ "CRS"	TC and Distance	82	CF 02	
33	STO 00	TC	83	RCL 05	
34	RCL 02	Distance	84	RCL 04	
35	RND		85	XEQ 10	Leg Dist, Alt, & Wind
36	ST+ 15		86	RCL 31	
37	STO 05	Primary leg distance	87	STO 07	Recall Leg Data
38	RCL 11		88	RCL 32	Terminating Fix
39	STO 31	store leg data	89	STO 08	becomes
40	RCL 12		90	RCL 33	the Starting Fix
41	STO 32		91	STO 09	
42	RCL 13		92	RCL 34	
43	STO 33		93	STO 06	
44	RCL 06		94	GTO 20	
45	STO 34		95	LBL 10	
46	RCL 10		96	-	Leg Distance
47	1		97	1 E3	
48	+		98	/	True Course
49	0		99	RCL 00	
50	STO 04		100	RND	

PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
101 +			151 STO 34		
102 2			152 34		
103 ST+ 10			153 FC?C 03		
104 RDN			154 XEQ "TWP"	Destination WP	
105 STO IND 10	CRS.DIS		155 CLX		
106 1			156 "DEPART EL?"		
107 ST+ 10			157 PROMPT		
108 "ALT="			158 STO 19		
109 ARCL 14			159 RCL 43		
110 "1?"			160 INT		
111 RCL 14	Last Altitude		161 ABS		
112 CF 22			162 +		
113 PROMPT			163 2	Average climb altitude	
114 RND			164 /		
115 STO 14	New altitude		165 XEQ "WIND"		
116 FS? 22	Altitude new?		166 STO 20		
117 SF 06			167 CLX		
118 RCL 07	VAR!		168 "DEST EL?"		
119 1 E3			169 PROMPT		
120 /			170 STO 21		
121 SIGN			171 RCL 14		
122 X<>Y			172 +		
123 LASTX			173 2	Average descent alt.	
124 ABS			174 /		
125 +			175 XEQ "WIND"		
126 *	Alt.var		176 STO 22		
127 STO IND 10			177 XEQ "PRF"		
128 1			178 GTO "AVFLY"		
129 ST+ 10			179 END		
130*LBL 11					
131 RCL 14					
132 XEQ "WIND"					
133 FS? 22	Winds entered?				
134 GTO 00					
135 44	Wind cannot be declined				
136 RCL 10	if leg is the first or				
137 X*Y?	new altitude entered,				
138 FS? 06	otherwise, previous legs				
139 GTO 11	wind will be entered.				
140 5					
141 -					
142 RCL IND X					
143*LBL 00					
144 STO IND 10					
145 1					
146 ST+ 10					
147 CF 06					
148 RTN					
149*LBL 22					
150 CLX					

REGISTERS, STATUS, FLAGS, ASSIGNMENTS

DATA REGISTERS				STATUS			
00	True course			SIZE 41+5N	TOT. REG.		USER MODE
01	scratch			ENG	FIX	SCI	ON OFF
02	scratch			DEG	x	RAD	GRAD
03	scratch			FLAGS			
04	WP Dist			#	INIT S/C	SET INDICATES	CLEAR INDICATES
05	Leg Dist			00		Fuel in LBS	Fuel in US GAL.
06	Identifier			01	C	Coord.!	
07	VAR!			02	C	Computing waypoints	
08	LNG!			03	C	Term. fix is a WP	
09	LAT!			06	C	New altitude	
10	Leg pointer			07	C	Waypoint calculated	Improper WP
11	VAR						
12	LNG						
13	LAT						
14	Altitude						
15	Total distance						
16		19	Departure Elev.				
17	CARD DATA	20	Climb Wind				
18		21	Destination Elev.				
19		22	Descent Wind				
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31	Leg var						
32	Leg lng						
33	Leg lat / Destination WP Ident.						
34	Leg ident / Destination WP Fix						
35	reserved for fuel weight						
36	reserved for gross weight						
37	Departure WP Ident.						
38	Departure WP Fix						
39	not used						
40	Leg #1: Ident						
41	WP Fix						
42	CRS.DIS						
43	Alt.var						
44	Wind data						
45	Leg #2:						
46	etc.						
47	Destination Identifier						
48	N is the number of legs.						
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PROGRAM DESCRIPTION I

Program Title AVIATION FLY PROGRAM

Contributor's Name _____

Address _____

City _____

State/Country _____

Zip Code _____

Program Description, Equations, Variables This program utilizes the data generated by the AVNAV program. It calculates the descent point along the flight path for a continuous descent to the destination airport. Each leg is prefaced with the starting and ending fix identifiers. If the starting fix is a waypoint that fix will be listed next. The magnetic course and leg distance conclude the leg preface. Changes in altitude while in flight are detected and calculated at the first part of the leg. Changes of altitude are output separately, than followed by the level portion of the leg.

Regardless of how many legs it takes on the first climbout to altitude, the altitude and wind aloft of the first leg is used instead of what was input. The same is true for the descent, the altitude and wind aloft is assigned to the leg in which the descent point falls regardless of what was input originally. This should be taken into account when generating the data with AVNAV Program, especially if the rate of climb or descent is slow.

Necessary Accessories Printer is recommended, but is optional.

Operating Limits and Warnings Data Error will be displayed if a level altitude isn't established prior to the final descent. Care should be taken on assigning altitudes to legs to assure practical climbs and descents.

PROGRAM DESCRIPTION II

Sample Problem (Sketch if Desired)

The Aviation Fly Program output is listed below, using the data calculated by the Aviation Navigation Program. Execution of the AVFLY program is automatic from the previous program.

XEQ "AVFLY"

TYS TO MSL
T/DIST 192 NM

TYS * WP:TYS
221.8°, 7.3 NM

TYS to WP:HCH
MC=245° DIST=44 NM

CLIMB 981 + 8000
HDG=247°
GS=127
DIST=17
REM DIST=175
FUEL=7.0
REM FUEL=93.0
TIME=0:07:48

LEVEL AT 8000
HDG=245°
GS=197
DIST=27
REM DIST=148
FUEL=4.7
REM FUEL=88.3
TIME=0:08:13
T/TIME=0:16:01

WP:HCH to WP:CHA
153.1°, 19.3 NM
MC=243° DIST=29 NM

LEVEL AT 8000
HDG=239°
GS=197
REM DIST=119
FUEL=5.0
REM FUEL=83.3
TIME=0:08:51
T/TIME=0:24:52

WP:CHA to COWAN
333.1°, 21.1 NM
MC=243° DIST=32 NM

LEVEL AT 8000
HDG=239°
GS=197
REM DIST=87
FUEL=5.5
REM FUEL=77.8
TIME=0:09:46
T/TIME=0:34:38

COWAN to RQZY
MC=246° DIST=38 NM

DESCENT 8000 + 4000
HDG=244°
GS=206
DIST=27
REM DIST=60
FUEL=3.2
REM FUEL=74.6
TIME=0:08:00
T/TIME=0:42:38

LEVEL AT 4000
HDG=246°
GS=193
DIST=11
REM DIST=49
FUEL=1.9
REM FUEL=72.6
TIME=0:03:26
T/TIME=0:46:04

RQZY to MSLV
MC=261° DIST=43 NM

LEVEL AT 4000
HDG=261°
GS=195
DIST=26
REM DIST=23
FUEL=4.5
REM FUEL=68.1
TIME=0:08:00
T/TIME=0:54:04

DESCENT 4000 + 1462
HDG=262°
GS=200
DIST=17
REM DIST=6
FUEL=2.0
REM FUEL=66.1
TIME=0:05:05
T/TIME=0:59:08

MSLV to MSL
MC=291° DIST=6 NM

DESCENT 1462 + 550
HDG=293°
GS=197
FUEL=0.7
REM FUEL=65.3
TIME=0:01:49
T/TIME=1:00:58

LANDING WT= 4792 LBS
RESERVE TIME=1:55:17

HAPPY FLYING

PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
01	LBL "AVFLY"		49	RCL IND X	
02	CF 07		50	SIGN	
03	CF 29		51	LASTX	
04	RCL 10		52	FRC	Present variation
05	STO 16	Preserve number of registers	53	ABS	
06	0		54	RCL 21	Leg's lowest altitude
07	STO 06		55	RND	
08	STO 09		56	+	
09	STO 18		57	*	
10	2.96295		58	STO IND Y	Low Alt.var
11	ST- 10	Leg pointer value	59	GTO 10	
12	RCL 14	Last leg altitude	60	LBL 11	
13	RCL 21	Destination elevation	61	RCL 02	Groundspeed
14	STO 13		62	*	
15	-		63	1 E3	
16	RCL 27	ROD	64	/	
17	/		65	STO 32	Descent point
18	60		66	RCL 10	
19	/		67	6	
20	STO 11	Time to descend	68	+	
21	RCL 25		69	RCL IND X	
22	STO 07	Descent TAS	70	SIGN	
23	LBL 10		71	LASTX	
24	RCL 13		72	FRC	Present variation
25	STO 21	Leg lowest altitude	73	ABS	
26	RCL IND 10		74	RCL 14	Last leg altitude
27	STO 05	Leg CRS.DIS	75	RND	
28	SF 06		76	+	
29	DSE 10	SFO6 if 1st leg	77	*	Last leg alt.var
30	CF 06		78	STO IND Y	
31	RCL 22	Descent wind	79	ADV	
32	XEQ "WC"		80	CLA	
33	RCL 11		81	SF 12	
34	X<=Y?	Enough time for the	82	SF 21	
35	GTO 11	descent in this leg?	83	ARCL 40	Departure airport
36	X<>Y		84	"- TO "	
37	ST- 11	Descent time used in leg	85	ARCL IND 16	Destination airport
38	60		86	AVIEW	
39	*		87	CF 12	
40	RCL 27	ROD	88	"T/DIST "	
41	*		89	ARCL 15	
42	ST+ 13	Legs highest altitude	90	"- NM"	
43	CLX		91	XEQ "PR"	
44	FS? 06	Error Trap:	92	ADV	
45	LN	Not enough time for descent	93	CLA	
46	RCL 10		94	ARCL 40	
47	6		95	"- * "	
48	+		96	ARCL 37	

PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
97	RCL 38		145	FIX 0	
98	X=0?	Terminal waypoint?	146	"MC="	
99	GTO 00		147	RCL IND 10	
100	ADV		148	ISG 10	
101	XEQ "PR"		149	STO 05	CRS.DIS
102	XEQ "WPD"		150	INT	TC
103	LBL 00		151	RCL IND 10	
104	RCL 19		152	FRC	
105	STO 13	Departure elevation	153	I E3	
106	SF 05	Climbout indicator	154	*	Var
107	RCL 10		155	STO 06	
108	INT		156	+	MC
109	2		157	XEQ "DGR"	
110	+		158	FC? 55	
111	I E3		159	AVIEW	
112	/		160	CLA	
113	40		161	"DIST="	
114	FS?C 06	Descent in first leg?	162	RCL 05	
115	GTO 21		163	FRC	
116	+		164	I E3	
117	STO 10	New pointer value	165	*	Leg Distance
118	LBL 20		166	STO 08	
119	ADV		167	ARCL X	
120	CLA		168	"- NM"	
121	ARCL IND 10		169	XEQ "PR"	
122	ISG 10		170	ADV	
123	FC? 55		171	RCL 18	Present wind and alt.
124	GTO 01		172	STO 17	become the previous
125	ACA		173	RCL 13	wind and altitude.
126	CLA		174	STO 14	
127	SF 13		175	FS? 05	Error trap: The alt.
128	"TO "	Leg Preface	176	FC? 07	must be the same if
129	ACA		177	GTO 00	the climbout and
130	CF 13		178	RCL 43	descent point are in
131	CLA		179	INT	the same leg!
132	GTO 02		180	RCL IND 10	
133	LBL 01		181	INT	
134	"-"		182	X*Y?	
135	LBL 02		183	CLX	
136	RCL 10		184	/	
137	4		185	LBL 00	
138	+		186	RCL 43	
139	ARCL IND X		187	FC? 05	
140	XEQ "PR"		188	RCL IND 10	Alt.Var
141	RCL IND 10		189	ISG 10	
142	ISG 10		190	INT	
143	X=0?	Is the starting fix a	191	ABS	
144	XEQ "WPD"	waypoint?	192	STO 13	Present altitude

PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
193	RCL IND 10		241	RTN	
194	STO 18	Present wind	242	*LBL 02	
195	X<>Y		243	ISG 10	
196	RCL 14	Previous altitude	244	GTO 20	
197	FS?C 06		245	RCL 10	Present leg
198	RTN		246	INT	
199	X*Y?	Altitude change?	247	*LBL 21	Descent leg calculations
200	XEQ "UPDN"		248	RCL 16	Last register used
201	RCL 05		249	1	
202	FRC	.DIS	250	-	
203	FC? 07	Not Descent leg?	251	1 E3	
204	GTO 00		252	/	
205	RCL 32	Descent point	253	+	
206	X>Y?	Enough time?	254	STO 10	New pointer value
207	CF 07	- if not	255	SF 07	Descent leg
208	RCL 05	True course	256	XEQ 20	
209	INT		257	RCL 25	Descent TAS
210	X<>Y		258	STO 07	
211	+	CRS.DP	259	RCL 13	Highest altitude
212	STO 32		260	STO 14	
213	LASTX		261	RCL 21	Leg lowest altitude
214	FIX 3		262	STO 13	
215	RND		263	RCL 32	Descent point
216	ST- 05	remaining distance	264	STO 05	
217	CLX		265	GTO 03	
218	FC? 07	Error Trap:	266	*LBL 04	
219	LN	Not enough time for	267	SF 06	Descent continued
220	GTO 01	descent!	268	XEQ 20	
221	*LBL 00		269	*LBL 03	
222	X=0?	Leg dist. flown?	270	RCL 22	Descent wind
223	GTO 02		271	XEQ "WC"	
224	*LBL 01		272	RCL 30	Descent F/F
225	RCL 24	Cruise TAS	273	*	
226	STO 07		274	STO 11	
227	RCL IND 10	Wind	275	XEQ "DN"	
228	FS?C 05	Climbout?	276	ISG 10	
229	RCL 44	First Leg wind	277	GTO 04	
230	XEQ "WC"		278	CLA	
231	RCL 29	Cruise F/F	279	ARCL IND 16	
232	*		280	" + " "	
233	STO 11	Fuel	281	ARCL 33	
234	"LEVEL "		282	RCL 34	
235	FS? 55		283	X=0?	Terminal Waypoint?
236	"FAT "		284	GTO 00	
237	ARCL 13		285	XEQ "PR"	
238	XEQ "PR"		286	XEQ "WPD"	
239	XEQ "DSPLY"		287	FIX 0	
240	FS?C 07		288	ADV	

PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
289	*LBL 00				
290	RCL 36	Gross weight			
291	"LANDING WT= "				
292	FS? 55				
293	GTO 00				
294	AVIEW				
295	CLA				
296	*LBL 00				
297	ARCL X				
298	"LBS"				
299	XEQ "PR"				
300	6				
301	1/X				
302	RCL 35	Remaining fuel			
303	FC? 00	Fuel displayed in lbs?			
304	*				
305	RCL 29	Cruise F/F			
306	/				
307	X<0?	Fuel left?			
308	CLX				
309	STO 12	Remaining flight time			
310	"RESERVE "				
311	XEQ "TD"				
312	ADV				
313	"HAPPY FLYING"				
314	SF 12				
315	RCL 12				
316	.75	45 min. reserve			
317	X>Y?	sufficient fuel?			
318	"FUEL TOO LOW"				
319	BEEP				
320	AVIEW				
321	CF 12				
322	ADV				
323	END				

REGISTERS, STATUS, FLAGS, ASSIGNMENTS

DATA REGISTERS				STATUS			
00	not used			SIZE 41+5N	TOT. REG.		USER MODE
01	Distance			ENG	FIX	SCI	ON OFF
02	Ground speed			DEG	RAD	GRAD	
03	Time						
04	Magnetic heading						
05	CRS.DIS						
06	Variation						
07	TAS						
08	Leg Distance						
09	Total Flying Time						
10	Leg pointer						
11	Fuel						
12	scratch						
13	Present Altitude						
14	Previous Altitude						
15	Total distance						
16	Last Register (40+5N						
17	Previous wind						
18	Present wind						
19	Departure elevation						
20	Climb wind						
21	Destination elevation / Descending Alt.						
22	Descent wind						
23	Climb TAS						
24	Cruise TAS						
25	Descent TAS						
26	ROC						
27	ROD						
28	Climb F/F						
29	Cruise F/F						
30	Descent F/F						
31	not used						
32	Descent point						
33	Destination WP Identifier						
34	Destination WP Fix						
35	Fuel weight						
36	Gross weight						
37	Departure WP Ident						
38	Departure WP Fix						
39	not used						
40	Leg #1: Ident						
41	WP Fix						
42	CRS.DIS						
43	Alt.var						
44	Wind						
45	Leg #2						
etc.							
40+5N	Destination Identifier						
	N is the number of legs						

PROGRAM DESCRIPTION I

Program Title NAVIGATION

Contributor's Name _____

Address _____

City _____

State/Country _____

Zip Code _____

Program Description, Equations, Variables

This program computes course and distance from one fix to another along with intermediate waypoint fixes. Each leg data is displayed as the data is entered. The output consists of: Start and ending fix ident, MC, DIST, WP Ident and fix if the ending fix is a waypoint.

The program will calculate a waypoint over the first and the final fixes. Any prompt, except for the first one (FROM?) may be declined by resuming program execution with no input.

This program is similar to the AVNAV/AVFLY program, but of more use in the cockpit.

Necessary Accessories A card reader is recommended.

Operating Limits and Warnings The following subroutines are used: "NFI", "CRS", "WP", "TWP", "PR", "WPD", "DGR", & "SYM".

PROGRAM DESCRIPTION II

Sample Problem (Sketch if Desired)

A flight from the McGhee Tyson airport, Knoxville, Tn to the Muscle Shoals, Al airport. A printer is not used. The route will be from McGhee Tyson airport direct to Cowan intersection, with waypoints off of Hinch Mt. and Chattanooga vortacs, V54N to the Rocket vortac, V54 to the Muscle Shoals vortac, direct to the Muscle Shoals airport. The coordinates for the facilities are given under the Program Description II for the AVNAV Program. The coordinate data for the vortacs is recorded on a data card with a "V" added after the identifiers to differentiate them from an airport identifier.

SOLUTION:

Input	Function	Display	Comments
TYS	XEQ NAV	FROM?	
	R/S	CARD	Load card for next fix.
	Load data card	TYS LAT?	
35.4845	R/S	TYS LNG?	
83.5934	R/S	TYS VAR?	
1	R/S	TYS WP?	will use TYS Vortac
TYSV	R/S	TYS * WP:TYS	
	R/S	221.8, 7.3 NM	
	R/S	TYS TO?	need term. fix for primary leg
COWAN	R/S	CARD	
	R/S	COWAN	
	R/S	COWAN LAT?	Cowan is an intersection 277°,
	R/S	NEED FIX?	38 NM from CHA Vortac
CHAV	R/S	LEG MC?	
277	R/S	LEG DIST?	
38	R/S	TYS TO WP?	Intermediate fix for secondary leg
HCHV	R/S	TYS - WP:HCH	
	R/S	MC=245	Leg #1 Data
	R/S	DIST=44	
	R/S	WP:HCH	
	R/S	153.1, 19.3 NM	
	R/S	WP:HCH TO WP?	
CHAV	R/S	WP:HCH - WP:CHA	
	R/S	MC=243	Leg #2 Data
	R/S	DIST=29	
	R/S	WP:CHA	
	R/S	333.1, 21.1 NM	
	R/S	WP:CHA TO WP?	Don't need any more intermediate
	R/S	WP:CHA - COWAN	fixes.
	R/S	MC=243	Leg #3 Data
	R/S	DIST=32	
	R/S	COWAN TO?	
RQZV	R/S	COWAN TO WP?	No intermediate fix
	R/S	COWAN - RQZV	Leg #4 Data
	R/S	MC=246	

PROGRAM DESCRIPTION II

Sample Problem (Sketch if Desired)

Problem from the preceding page continued -

SOLUTION:

Input	Function	Display	Comments
	R/S	DIST = 38	Leg #1 Data continued
	R/S	RQZV TO?	
MSLV	R/S	RQZV TO WP?	No intermediate fix.
	R/S	RQZV - MSLV	Leg #5 Data
	R/S	MC = 261	
	R/S	DIST = 43	
MSL	R/S	MSLV TO?	
	R/S	CARD	Need data
	R/S	MSL	
	R/S	MSL LAT?	
34.4443	R/S	MSL LNG?	
87.3637	R/S	MSL VAR?	
1	CHS, R/S	MSLV TO WP?	no intermediate fix
	R/S	MSLV-MSL	Leg #6 Data
	R/S	MC = 291	
	R/S	DIST = 6	
	R/S	MSL TO?	Terminate the flight
	R/S	MSL WP?	Do not need a terminal waypoint
	R/S	TYS TO MSL	Total trip data
	R/S	T/DIST = 192	
	R/S	0	End of program
	R/S	FROM?	Program starts over

PROGRAM DESCRIPTION II

Sample Problem (Sketch if Desired)

Sample Problem, but a printer is used:

PRINTOUT:

TYS * WP:TYS
221.8°, 7.3 NM

TYS to WP:HCH
MC=245°
DIST=44

WP:HCH
153.1°, 19.3 NM

LEG #1

WP:HCH to WP:CHA
MC=243°
DIST=29

WP:CHA
333.1°, 21.1 NM

WP:CHA to COWAN
MC=243°
DIST=32

COWAN to RQZV
MC=246°
DIST=38

LEG #2

LEG #3

LEG #4

RQZV to MSLV
MC=261°
DIST=43

LEG #5

MSLV to MSL
MC=291°
DIST=6

LEG #6

TYS TO MSL
T/DIST 192 NM

SOLUTION:

Input	Function	Display	Comments
TYS	XEQ "NAV"	FROM?	
	R/S	CARD	
35.4845	Load data card	TYS LAT?	35° 48' 45"
83.5934	R/S	TYS LNG?	83° 59' 34"
1	R/S	TYS VAR?	1° W
TYSV	R/S	TYS WP?	
COWAN	R/S	TYS TO?	TWP data printout
	R/S	CARD	
	R/S	COWAN	
	R/S	COWAN LAT?	
CHAV	R/S	NEED FIX?	
277	R/S	LEG MC?	277° from CHA
38	R/S	LEG DIST?	38 DME
HCHV	R/S	TYS TO WP?	
CHAV	R/S	WP:HCH TO WP?	Leg #1 data printout
	R/S	WP:CHA TO WP?	Leg #2 data printout
	R/S	COWAN TO?	Leg #3 data printout
RQZV	R/S	COWAN TO WP?	
	R/S	RQZV TO?	Leg #4 data printout
MSLV	R/S	RQZV TO WP?	
	R/S	MSLV TO?	Leg #5 data printout
MSL	R/S	CARD	
	R/S	MSL	
34.4443	R/S	MSL LAT?	34° 44' 43"
87.3637	R/S	MSL LNG	87° 36' 37"
1	R/S	MSL VAR?	1° E
	CHS	-1	
	R/S	MSLV WP?	
	R/S	MSL TO?	Leg #6 data printout
	R/S	MSL WP?	
	R/S	TYS TO MSL	Total trip printout
	R/S	FROM?	Program starts over

USER INSTRUCTIONS

				SIZE: 35
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Size	35	☐ XEQ SIZE	
2	Start program		☐ XEQ NAV	FROM?
3	Input departure airport identifier From Step A (stp 2, 7, or skipped) From Step A (stp 11) skip to step 5	IDENT	☐ R/S	see Step A (ident) WP? (ident) TO?
4	Input terminal waypoint fix identifier From Step A, Step A skipped	IDENT	☐ R/S	see Step A (ident) TO?
5	Input primary leg end fix identifier From Step A, Step A skipped Declined, skip to step 7	IDENT	☐ R/S	see Step A (ident) TO WP?
6	Input waypoint identifier Input declined, skip to step 5 From Step A, Step A skipped, repeat step 6	IDENT	☐ R/S ☐ R/S	see Step A (ident) TO? (ident) TO WP?
7	Prior primary fix input from: Step A (stp 11) - program end! Step A (stp 2, 11, or skipped)			(ident) WP?
8	Input terminal waypoint fix identifier Input declined - program end! From Step A, Step A skipped - program end!		☐ R/S	see Step A
*	Steps for input of fix coordinates:			
A	If data already loaded from a prior card, skip Step A!			
1	If card reader not used, skip to step 4			CARD
2	Load data card Data not on card skip to step 4 Data on the card			Return to the original step (ident)
3	Data card load declined		☐ R/S	

USER INSTRUCTIONS

[illegible]

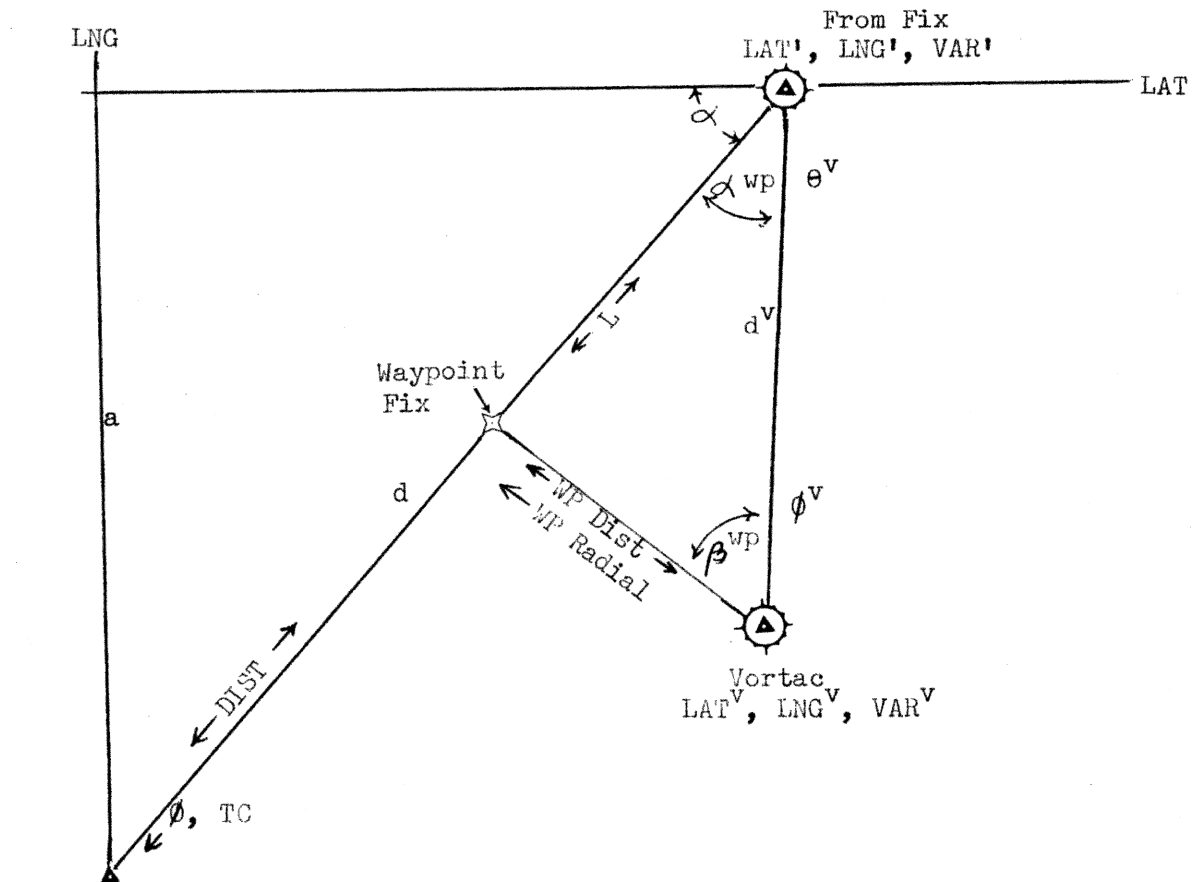
PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
01	LBL "NAV" <i>DEG</i>		49	STO 32	
02	CF 02		50	RCL 13	
03	SF 21		51	STO 33	
04	CF 29		52	RCL 06	
05	"FROM?"		53	STO 34	
06	SF 01		54	0	
07	SF 23		55	STO 04	
08	XEQ "NFIK"	Departure Coord.	56	SF 02	
09	CF 01		57	LBL 21	
10	RCL 06		58	CLA	
11	STO 14	Departure Ident	59	ARCL 10	
12	CLX		60	"+ TO WP?"	
13	STO 15		61	CF 23	
14	STO 32		62	XEQ "NFIK"	
15	32		63	FC? 23	Waypoint declined
16	FC?C 03	Terminal fix not a WP?	64	GTO 03	
17	XEQ "TWP"	Terminal waypoint	65	XEQ "CRS"	
18	RCL 14		66	XEQ "WP"	
19	STO 06		67	FC?C 07	Waypoint completed?
20	ADV		68	GTO 21	
21	CLA		69	STO 13	
22	ARCL 14		70	"WP:"	
23	"+ * "		71	ARCL 06	
24	ARCL 31		72	ASTO 06	
25	RCL 32		73	RCL 12	"L"
26	X=0?	TWP?	74	ENTER↑	
27	GTO 20		75	X<> 04	
28	XEQ "PR"		76	XEQ 10	Data output
29	XEQ "WPD"		77	RCL 11	
<i>FIXD</i> → 30	LBL 20		78	STO 07	
31	ADV		79	ADV	
32	CLA		80	CLA	
33	ARCL 06		81	ARCL 06	
34	ASTO 10		82	XEQ "PR"	
35	"+ TO?"	Primary leg's starting fix.	83	RCL 13	
36	CF 23		84	XEQ "WPD"	
37	XEQ "NFIK"		85	ADV	
38	FC? 23		86	RCL 06	
39	GTO 22		87	STO 10	Starting fix ident
40	XEQ "CRS"		88	GTO 21	
41	STO 00	TC	89	LBL 03 <i>FIXD</i>	
42	RCL 02	Distance	90	CF 02	
43	RND		91	RCL 34	
44	ST+ 15	Total distance	92	STO 06	
45	STO 05	Primary leg distance	93	RCL 05	
46	RCL 11		94	RCL 04	
47	STO 31	Store primary leg's starting fix.	95	XEQ 10	Data output
48	RCL 12		96	RCL 31	

PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
97	STO 07	Primary terminating fix becomes the starting fix.	145	XEQ "PR"	
98	RCL 32		146	XEQ "WPD"	
99	STO 08		147	ADV	
100	RCL 33		148	LBL 05	
101	STO 09		149	SF 12—?	
102	GTO 20		150	CLA	
103	LBL 10		151	ARCL 14	
104	-	Secondary leg distance	152	"T TO "	Total Trip Output
105	STO 12		153	ARCL 34	
106	CLA		154	AVIEW	
107	ARCL 10		155	CF 12—?	
108	FC? 55		156	FIX 0	
109	GTO 01		157	"T/DIST "	
110	ACA		158	ARCL 15	
111	CLA		159	FS? 55	
112	SF 13	Leg Output	160	"T NM"	
113	" TO "		161	XEQ "PR"	
114	ACA		162	ADV	
115	CF 13		163	END	
116	CLA				
117	LBL 01				
118	FC? 55				
119	"T--"				
120	ARCL 06				
121	XEQ "PR"				
122	FIX 0				
123	"MC="				
124	RCL 00	TC			
125	RCL 07	VAR!			
126	+	MC			
127	XEQ "DGR"				
128	XEQ "PR"				
129	"DIST="				
130	ARCL 12				
131	GTO "PR"				
132	LBL 22				
133	CLX				
134	STO 32				
135	32				
136	FC?C 03				
137	XEQ "TWP"	TWP			
138	CLA				
139	ARCL 34				
140	"T * "				
141	ARCL 31				
142	RCL 32				
143	X=0?	TWP?			
144	GTO 05				

[illegible]



To Fix
LAT, LNG, VAR

$$\text{WP Radial} = \theta^v \pm \beta^{\text{WP}} + \text{VAR}^v$$

$$\text{WP Dist} = 60 \sin^{-1}(\sin |\alpha^{\text{WP}}| \sin d^v)$$

$$\text{LAT} = \text{LAT}' + \sin^{-1}(\sin d \cos \phi)$$

$$\text{LNG} = \text{LNG}' - \sin^{-1} \frac{(\sin d \sin \phi)}{\cos (\text{LAT} - \text{LAT}')/2}$$

$$\text{DIST} = 60 d$$

$$d = \cos^{-1}((\sin \text{LAT} \sin \text{LAT}' + \cos \text{LAT} \cos \text{LAT}' \cos (\text{LNG} - \text{LNG}')))$$

$$a = \cos^{-1}(\sin \text{LAT} \sin \text{LAT}' + \cos \text{LAT} \cos \text{LAT}')$$

$$\phi = \text{TC} = 270^\circ + \alpha \text{ or } 90^\circ - \alpha$$

$$\alpha = \frac{\sin a}{\sin d}$$

PROGRAM DESCRIPTION

Program Title Subroutines Navigation Fix and Intersection/Waypoint coordinates

Contributor's Name _____

Address _____

City _____

State/Country _____

Zip Code _____

Program Description, Equations, Variables "NFI" prompts for: Facility alpha-numeric identifier; Data card if card reader is being used; and if data hasn't been read from a data card, prompts for the latitude, longitude, and magnetic variation. If latitude prompt is passed by and FLO2 is clear, "I/WP" is used to prompt for data to calculate the coord. If FLO2 is set the prgm starts at the beginning to give opportunity to check and correct data input.

"I/WP" calculates coordinates from given latitude and longitude. It prompts for fix coordinates using "NFI" and if none are given will use prior coordinates stored in R08, R09, & variation stored in R07. If FLO1 is set the new coord. are stored in R07-R09, if clear then in R11-R13. If data is not entered than prgm cycles back to the beginning of "NFI".

"I/WP" uses the following equations:

$$LAT = LAT' + \sin^{-1}(\sin d \cos \phi)$$

$$LNG = LNG' - (\sin^{-1}(\sin d \sin \phi)) / \cos((LAT + LAT')/2)$$

d is dist/60; ϕ is MC-VAR' = TC (True Course)

NOTE: If Sub "I/WP" is used FLO5 controls program flow if no data is entered. With FLO5 cleared, Sub"NFI" will prompt for data; if FLO5 is set then the program will be returned to the main program.

Necessary Accessories Card reader is recommended, but optional.

Operating Limits and Warnings Destination must not be point of departure.

West magnetic variations are positive, East magnetic variations are negative numbers.

LBL*FIX
 LBL*I/WP
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PROGRAM LISTING

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STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
01	LBL "FIX"	Start	51	HR	
02	CF 05		52	STO IND 01	
03	CF 06		53	DSE 01	
04	LBL 03		54	CLA	
05	13		55	ARCL 06	
06	FS? 01		56	"I VAR?"	
07	9		57	PROMPT	
08	LBL 04		58	STO IND 01	
09	STO 01	Data Pointer	59	RTN	
10	LBL 05		60	LBL 06	Search for data
11	AON		61	RCL 06	
12	PROMPT	for Identifier	62	RCL IND 02	
13	AOFF		63	X=Y?	
14	FC? 23		64	GTO 07	
15	RTN		65	ISG 02	
16	FC? 02		66	GTO 06	
17	CF 03		67	RTN	
18	ASTO 06		68	LBL 07	Decode coordinate data
19	16.03003		69	SF 05	
20	STO 02		70	1	
21	STO 03		71	ST+ 02	
22	XEQ 06	Search for data	72	RCL IND 02	
23	FS?C 05		73	HR	
24	RTN		74	STO IND 01	
25	RCL 03	If coord. data not	75	DSE 01	
26	STO 02	stored ask for data	76	1	
27	SF 25	card if the card	77	ST+ 02	
28	AON	reader is used	78	RCL IND 02	
29	RDTAX		79	FRC	
30	AOFF		80	LASTX	
31	CF 25		81	INT	
32	XEQ 06	Search for data again,	82	A8S	
33	FS?C 05	if not found than	83	I E4	
34	RTN	prompt for coord.	84	/	
35	CF 22		85	HR	
36	CLA		86	STO IND 01	
37	ARCL 06		87	DSE 01	
38	"I LAT?"		88	RDN	
39	PROMPT		89	100	
40	CLA		90	*	
41	ARCL 06		91	STO IND 01	
42	FC? 22	No input, skip to	92	RTN	
43	GTO 08	intersection/waypoint	93	LBL 08	
44	HR	prompts	94	FC? 02	If FLO2 & FLO6 set
45	STO IND 01		95	FS? 06	start over
46	DSE 01		96	GTO 05	
47	CLA		97	LBL "I/WP"	Calculates coord. for
48	ARCL 06		98	RCL 07	intersection or
49	"I LNG?"		99	STO 11	waypoint.
50	PROMPT		100	RCL 08	

LBL'NFI
 LBL'I/WP
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PROGRAM LISTING

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STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
101	STO 12		151	/	
102	RCL 09		152	ST- 12	
103	STO 13		153	RCL 12	LNG
104	RCL 06		154	FS? 01	
105	STO 31		155	STO 08	
106	SF 06		156	SF 03	
107	CF 23		157	END	
108	13				
109	"NEED FIX?"				
110	XEQ 04				
111	CF 06				
112	RCL 31				
113	STO 06				
114	"FIX MC?"				
115	PROMPT				
116	CLA				
117	ARCL 06				
118	SF 23				
119	FC? 22				
120	GTO 03				
121	RCL 11				
122	FS? 01				
123	STO 07				
124	-				
125	STO 01				
126	"FIX DIST?"				
127	PROMPT				
128	60				
129	/				
130	SIN	Sin d			
131	STO 02				
132	RCL 01				
133	SIN	Sin ϕ			
134	*				
135	ASIN				
136	RCL 01				
137	COS	Cos ϕ			
138	RCL 02	Sin d			
139	*				
140	ASIN				
141	RCL 13	LAT'			
142	+				
143	STO 13	LAT			
144	FS? 01				
145	STO 09				
146	LASTX	LAT'			
147	+				
148	2				
149	/				
150	COS				

DATA REGISTERS

01	Data Storage Pointer
02	Data Pointer
03	Counter value
06	Facility Identifier
07	VAR'
08	LNG'
09	LAT'
11	VAR
12	LNG
13	LAT
16	Magnetic card
30	data
31	Temporary Ident storage

FLAGS

#	INIT S/C	SET INDICATES	CLEAR INDICATES
01		Store coordinates in Registers: R07, R08, & R09	R11, R12, & R13
02		Disables "NFI" from using "I/WP"	
03		Indicates that the coordinates were calculated with "I/WP"	
05	C	Ident & coord. located & decoded.	
06	C	Fix coord. are being asked for by "I/WP"	
23	C		No input, RTN

PROGRAM DESCRIPTION

Program Title Subroutine Course and Distance

Contributor's Name _____

Address _____

City _____ State/Country _____ Zip Code _____

Program Description, Equations, Variables This subroutine calculates the great circle distance between two points defined by latitude and longitude coordinates and calculates the average true course.

$$\text{Dist} = 60 d, \quad d = \cos^{-1}((\sin \text{LAT}' \sin \text{LAT} + \cos \text{LAT}' \cos \text{LAT} \cos (\text{LNG} - \text{LNG}'))$$

$$\text{TC} = 270 + \alpha ; \text{ for West (FLO5 clr).} \quad \text{TC} = 90 - \alpha ; \text{ for East (FLO5 set).}$$

$$\alpha = \sin^{-1}(\sin a / \sin d), \quad \alpha \text{ is negative if direction is Southerly.}$$

$$\text{where } a = \cos^{-1}(\sin \text{LAT} \sin \text{LAT}' + \cos \text{LAT} \cos \text{LAT}')$$

Necessary Accessories _____

Operating Limits and Warnings Destination must not be point of departure.

North latitudes and West longitudes are positive and South latitudes and East longitudes are negative numbers.

PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
01	LBL "CRS"		49	CLX	
02	CF 05		50	+	True Course
03	RCL 13		51	END	
04	SIN				
05	RCL 09				
06	SIN				
07	*	(Sin LAT Sin LAT')			
08	STO 01				
09	RCL 13				
10	COS				
11	RCL 09				
12	COS				
13	*	(Cos LAT Cos LAT')			
14	STO 02				
15	+				
16	ACOS	a			
17	SIN				
18	RCL 13				
19	RCL 09				
20	-				
21	SIGN	+ Northerly direction			
22	*	- Southerly direction			
23	RCL 02				
24	RCL 12				
25	RCL 08				
26	-				
27	X<0?				
28	SF 05	set - Easterly			
29	COS	clr - Westerly			
30	*				
31	RCL 01				
32	+				
33	ACOS	d			
34	SIN				
35	STO 01				
36	LASTX				
37	60				
38	*	Distance			
39	STO 02				
40	RDN				
41	/				
42	ASIN	α			
43	FS? 05				
44	CHS				
45	90				
46	+				
47	180				
48	FS?C 05				

DATA REGISTERS

01	Scratch		
02	Distance		
08	LNG'		
09	LAT'		
12	LNG		
13	LAT		

FLAGS

#	INIT S/C	SET INDICATES	CLEAR INDICATES
05	C	Easterly course	Westerly course

PROGRAM DESCRIPTION

Program Title Subroutine Waypoint Fix

Contributor's Name _____

Address _____

City _____

State/Country _____

Zip Code _____

Program Description, Equations, Variables Calculates waypoint fix from the coordinates of a vortac which has a radial from it that is perpendicular to the course between the departure point and destination. It will reject any waypoint that falls behind the departure point, beyond the destination, or behind a prior waypoint.

$$\text{Waypoint Radial} = \left(\theta^V + \beta^{WP}; \alpha^{WP} < 0 \quad \text{or} \quad \theta^V - \beta^{WP}; \alpha^{WP} \geq 0 \right) + \text{VAR}^V$$

$$\text{where } \theta^V = \phi^V \pm 180^\circ \quad \text{and} \quad \beta^{WP} = 90 - |\alpha^{WP}|$$

$$\alpha^{WP} = \phi - \phi^V; \quad \phi \neq \text{TC}$$

$$\text{Waypoint Distance} = 60 \sin^{-1}(\sin \alpha^{WP} \sin d^V)$$

$$\text{Distance from Departure point to the Waypoint} = 60 \sin^{-1}(\sin \beta^{WP} \sin d^V) = L$$

Note: α^{WP} must be expressed as: $-180^\circ \leq \alpha^{WP} \leq 180^\circ$

Necessary Accessories _____

Operating Limits and Warnings _____

Subroutine "CRS" must be run first in order to calculate

the values for d^V and TC^V (ϕ^V) between the departure point and the vortac. The

departure point is defined as the beginning of the leg between two navigation fixes,

This leg will be divided into smaller legs by the waypoints generated in the prgm.

PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
01	LBL "WP"		49	*	
02	FIX 0		50	RND	
03	CF 05		51	RCL 02	$ \alpha^{WP} $
04	CF 07		52	SIN	
05	STO 02	$TC^V = \phi^V$	53	RCL 01	$\sin d^V$
06	180		54	*	
07	+	θ^V	55	ASIN	Waypoint Distance
08	90		56	.06	
09	RCL 00	ϕ	57	*	
10	RCL 02		58	+	Waypoint fix (Rad. Dist)
11	-	α^{WP}	59	SF 07	
12	1		60	END	
13	P-R				
14	R-P				
15	RDN	$-180^\circ \leq \alpha^{WP} \leq 180^\circ$			
16	X<0?				
17	SF 05	$ \alpha^{WP} $			
18	ABS				
19	STO 02	β^{WP}			
20	-				
21	X<=0?	Waypoint behind depart. fix?			
22	RTN				
23	STO 03				
24	FC?C 05				
25	CHS				
26	+				
27	RCL 11	VAR^V			
28	+	Waypoint Radial			
29	X<> 03				
30	SIN				
31	RCL 01				
32	*				
33	ASIN				
34	60				
35	*				
36	RND				
37	STO 12	Distance "L"			
38	RCL 05				
39	X<=Y?	WP beyond destination fix?			
40	RTN				
41	X<>Y	WP behind last WP?			
42	RCL 04				
43	X>Y?				
44	RTN				
45	RCL 03	Waypoint Radial			
46	360				
47	MOD				
48	10				

DATA REGISTERS

"X" 0 ^V from "CRS"		
00 TC		
01 $\sin d^V$ from "CRS"		
02 $ \alpha^{WP} $		
03 WP Radial		
04 Cumulative WP distance in leg		
05 Distance in leg		
11 VAR^V		
12 Distance "L"		

FLAGS

#	INIT S/C	SET INDICATES	CLEAR INDICATES
05	C	$\alpha^{WP} < 0$	$\alpha^{WP} \geq 0$
07	C	WP is valid	WP is invalid

PROGRAM DESCRIPTION

Program Title Subroutine Terminal Waypoint

Contributor's Name _____

Address _____

City _____ State/Country _____ Zip Code _____

Program Description, Equations, Variables Calculates a radial and distance from
a vortac to a facility and stores them together in a specified data register;
stores the identifier in the preceding data register. This provides a waypoint
over an airport.

The coordinates of the terminal facility must be in R08 & R09, the terminal
identifier in R06, and the data register number in the X Register prior to
running the subroutine.

Necessary Accessories Subroutines "NFIK" & "CRS"

Operating Limits and Warnings _____

PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
01	LBL "TWP"				
02	FIX 0				
03	STO 05	Data register pointer			
04	CLA				
05	ARCL 06				
06	"I WP?"	Prompt for Vortac			
07	SF 02	Disable "I/WP"			
08	CF 23				
09	XEQ "NFI"				
10	CF 02				
11	FC? 23	WP declined?			
12	RTN				
13	XEQ "CRS"				
14	180				
15	+				
16	RCL 11	VAR ^v			
17	+				
18	360				
19	MOD				
20	10				
21	*				
22	RND	WP radial			
23	RCL 02	WP distance			
24	1 E3				
25	/				
26	+	WP Fix			
27	STO IND 05				
28	DSE 05				
29	"WP:"				
30	ARCL 06	WP Ident			
31	ASTO IND 05				
32	END				

DATA REGISTERS			
02	Distance,	calculated by "CRS"	
05	Data storage	pointer	
06	Terminal	identifier	
07	VAR [!]		
08	LNG [!]		
09	LAT [!]		
11	VAR ^v		
12	LNG ^v		
13	LAT ^v		

FLAGS			
#	INIT S/C	SET INDICATES	CLEAR INDICATES
02	S	Disables "I/WP"	
23	C	Term. WP desired	Term. WP declined

PROGRAM DESCRIPTION

Program Title Subroutine Winds Aloft

Contributor's Name _____

Address _____

City _____ State/Country _____ Zip Code _____

Program Description, Equations, Variables This subroutine prompts for the forecast winds aloft above and below the flight altitude and interpolates the wind for the flight altitude. Winds aloft will be prompted for in thousands of feet in the following increments: 3, 6, 9, 12, 18, 24, 30, 34, 39, 45, & 53. The flight altitude must be stored in the X Register prior to subroutine execution. The interpolated wind will be in the X Register upon completion of the subroutine, unless input was declined and than zero will be in the X Register.

Winds must be entered in the following format: DIR.VEL, where DIR is wind direction in degrees true, and VEL is the wind velocity in knots. Example: if the wind is reported as "2415" the wind is 240°, 15 kts and would be entered as 240.015.

Necessary Accessories _____

Operating Limits and Warnings If departure airport is above 3000' and the flight altitude is relatively low; than the lower wind prompted for could be below the airport elevation. In that case it is recommended that the next higher forecasted winds be entered and when the higher wind is prompted for decline entry. The output will be the same as the wind entered.

PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
01	LBL "WIND"		49	INT	
02	FIX 0		50	-	
03	CF 05		51	LASTX	
04	CF 22		52	X<>Y	
05	1 E3		53	1	
06	/		54	P-R	
07	30		55	R-P	
08	X<Y?	Alt. above FL 300?	56	RDN	
09	GTO 03		57	RCL 03	Interpolation of the
10	X<>Y		58	*	
11	12		59	+	Wind Direction
12	X<>Y		60	RND	
13	X>Y?	Alt. above 12,000'?	61	360	&
14	SF 05		62	MOD	
15	3		63	RCL 02	Wind Velocity
16	ENTER↑		64	FRC	
17	FC?C 05		65	RCL 01	
18	CLX		66	FRC	
19	+	Alt. increment	67	-	
20	STO 02		68	LASTX	
21	X>Y?	Alt. < 3,000'?	69	X<>Y	
22	SF 05		70	RCL 03	
23	/		71	*	
24	FRC	Interpolation value	72	+	
25	STO 03		73	+	
26	X=0?	Alt. same as forecast	74	RTN	
27	SF 05	wind?	75	LBL 02	
28	CLX		76	/	Interpolation value
29	STO 01		77	STO 03	(higher winds)
30	LASTX		78	X=0?	
31	INT		79	SF 05	
32	X=0?		80	CLX	
33	1		81	X<> 01	
34	RCL 02		82	GTO 01	
35	*	lower wind level	83	LBL 03	
36	LBL 01		84	STO 01	
37	FS?C 05		85	-	
38	GTO 04		86	4	
39	ST+ 02		87	STO 02	
40	XEQ 04	prompt for lower wind	88	X>Y?	Alt. < FL 340?
41	FC? 22		89	GTO 02	
42	RTN		90	ST+ 01	
43	STO 01		91	-	
44	RCL 02		92	5	
45	XEQ 04	prompt for higher wind	93	STO 02	
46	STO 02		94	X>Y?	Alt. < FL 390?
47	INT		95	GTO 02	
48	RCL 01		96	ST+ 01	

LBL'WIND
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PROGRAM LISTING

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STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
97	-				
98	6				
99	STO 02				
100	X>Y?	Alt. < FL 450?			
101	GTO 02				
102	ST+ 01				
103	-				
104	8				
105	STO 02				
106	X>Y?	Alt. < FL 530?			
107	GTO 02				
108	0				
109	X<> 01				
110	+				
111	LBL 04				
112	"WA"	Prompt for Wind			
113	ARCL X				
114	"I?"				
115	RCL 01				
116	PROMPT				
117	END				

DATA REGISTERS			
01	Lower wind level	/	lower wind value
02	Altitude increment	/	higher wind value
03	interpolation value		

FLAGS			
#	INIT S/C	SET INDICATES	CLEAR INDICATES
05	C	Alt > 12,000'	Alt < 12,000'
05	C	Prompt for lower wind only.	
22	C	Wind entered	Entry declined

PROGRAM DESCRIPTION

Program Title Subroutine for Aircraft Performance

Contributor's Name _____

Address _____

City _____ State/Country _____ Zip Code _____

Program Description, Equations, Variables Prompts and stores aircraft performance figures into registers 23 thru 30. If input is declined the program will reprompt until data is entered; except when fuel flow figures are requested, than a zero will be entered.

When a card reader is used the program will request a data card if the first prompt is declined. If a data card isn't read; than the program will give oppourtunity to to record the data, not only in the allocated registers, but also by writting the data on a card. If the first prompt (Climb TAS?) is declined again the cycle will start over.

Label "PR" allows the performance figures for an aircraft to be recorded on a magnetic card without having to use the entire subroutine.

Necessary Accessories Card reader is recommended, but optional.

Operating Limits and Warnings The program will not except an entry of zero for any of of the airspeeds, R.O.C., or R.O.D.

PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
01	LBL "PRF"		49	PROMPT	
02	CF 05		50	FS?C 22	
03	LBL 01		51	X=0?	
04	23.03	Counter value	52	GTO 03	
05	STO 01		53	STO 25	
06	CLX		54	LBL 04	
07	"CLIMB TAS?"		55	"R.O.C.?"	
08	PROMPT		56	PROMPT	
09	STO 23		57	FS?C 22	
10	X=0?	Data entered?	58	X=0?	
11	GTO 02		59	GTO 04	
12	FS? 06	Using "PR"?	60	STO 26	
13	GTO 01		61	LBL 05	
14	FS?C 05	Going to record?	62	"R.O.D.?"	
15	RTN		63	PROMPT	
16	RCL 01		64	FS? 22	
17	SF 25		65	X=0?	
18	"RECORD PERF"		66	GTO 05	
19	AON		67	STO 27	
20	RDTAX		68	CLX	
21	AOFF		69	"CLIMB F/F?"	
22	FC?C 25	Using card reader?	70	PROMPT	
23	GTO 01		71	STO 28	
24	RCL 23		72	CLX	
25	X=0?	Data entered?	73	"CRUISE F/F?"	
26	RTN		74	PROMPT	
27	LBL 06		75	STO 29	
28	SF 05		76	CLX	
29	XEQ 01	Prompt data for card	77	"DESCENT F/F?"	
30	FC?C 05	Data entered?	78	PROMPT	
31	GTO 01		79	STO 30	
32	CF 06		80	END	
33	RCL 01				
34	WDTAX				
35	RTN				
36	LBL "RP"				
37	SF 06				
38	GTO 06				
39	LBL 02				
40	CF 22				
41	"CRUISE TAS?"				
42	PROMPT				
43	FS?C 22				
44	X=0?				
45	GTO 02				
46	STO 24				
47	LBL 03				
48	"DESCENT TAS?"				

DATA REGISTERS

01	counter value	27	rate of descent
23	climb TAS	28	climb fuel flow
24	cruise TAS	29	cruise fuel flow
25	descent TAS	30	descent fuel flow
26	rate of climb		

FLAGS

#	INIT S/C	SET INDICATES	CLEAR INDICATES
05	C	data to be recorded	
06		disable data card request	

PROGRAM DESCRIPTION

Program Title Subroutine Climb / Descent

Contributor's Name _____

Address _____

City _____ State/Country _____ Zip Code _____

Program Description, Equations, Variables If the previous altitude flown is entered into the Y Register and the altitude desired in the X Register the subroutine will detect if a climb or descent is required, determine the average wind from the winds of the previous and present legs, determine how much time is needed, and determine how much time is available.

Climb or Descent with the starting and ending altitudes will be given; then the Display subroutine is used to give the flight data during the altitude change. If a printer is being used the data will be printed, if not than it will be displayed. If the data is being displayed the program execution will be halted as each line is displayed.

If F105 is set prior to subroutine execution the flight data will be calculated with the wind data stored in R20 instead of averaging the leg winds.

Necessary Accessories Subroutines "WC" & "DSPLY". Printer is recommended, but optional.

Operating Limits and Warnings TAS and vertical speed must not equal zero.

PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
01	LBL "UPDN"		49	RCL 11	Alt. change
02	FIX 0		50	ABS	
03	CF 06		51	RCL 12	rate of change
04	-	altitude change	52	/	
05	STO 11		53	60	
06	X<Y?	Climb?	54	/	total time needed
07	SF 06		55	X<Y?	not enough time?
08	RCL 26	ROC	56	GTO 00	
09	FC? 06	Descent?	57	STO 03	time taken to change alt.
10	RCL 27	ROD	58	RCL 02	ground speed
11	STO 12	vertical speed	59	*	
12	RCL 25	Descent TAS	60	RND	distance traveled during
13	FS? 06	Climb?	61	STO 01	the climb/descent
14	RCL 23	Climb TAS	62	1 E3	
15	STO 07	TAS	63	/	
16	RCL 20	Special wind data	64	GTO 01	
17	FS? 05	Special wind?	65	LBL 00	
18	GTO 00		66	X<Y	available time
19	RCL 18		67	60	
20	INT	present wind direction	68	*	
21	RCL 17		69	RCL 12	vertical speed
22	INT	previous wind direction	70	*	altitude change
23	-		71	FC? 06	Descent?
24	LASTX		72	CHS	
25	X<Y		73	RCL 14	starting altitude
26	1		74	+	ending altitude
27	P-R		75	STO 13	
28	R-P		76	RCL 05	GRS.DIST
29	RDN		77	FRC	.DIST
30	2		78	LBL 01	
31	/		79	ST- 05	subtract distance travel-
32	+		80	RCL 30	descent f/f ed
33	RND		81	FS? 06	Climb?
34	360		82	RCL 28	climb f/f
35	MOD	Average wind direction	83	RCL 03	Time
36	RCL 18		84	*	
37	FRC	present wind velocity	85	STO 11	Fuel used
38	RCL 17		86	"CLIMB"	
39	FRC	previous wind velocity	87	LBL "DN"	
40	-		88	FC?C 06	Descent?
41	LASTX		89	"DESCENT"	
42	X<Y		90	FC? 55	
43	2		91	GTO 02	
44	/		92	ACA	
45	+	Average wind velocity	93	RCL 14	Display or Printout
46	+	Average wind	94	ACX	
47	LBL 00		95	1	
48	XEQ "WC"		96	SKPCHR	

LBL'UPDN
 LBL'DN
 END 192 BYTES
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PROGRAM LISTING

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STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
97	125				
98	ACCHR				
99	RCL 13				
100	ACX				
101	PRBUF	Display or			
102	GTO 03				
103	LBL 02	Printout			
104	AVIEW				
105	CLA				
106	ARCL 14				
107	"I--"				
108	ARCL 13				
109	AVIEW				
110	LBL 03				
111	GTO "DSPLY"				
112	END				

DATA REGISTERS			
01	Distance		
02	Ground speed		
03	Time		
05	True course + Dist/1000		
07	TAS		
11	Altitude change / Fuel used		
12	Vertical speed		
13	Ending altitude		
14	Starting altitude		
17	Previous wind aloft		
18	Present wind aloft		
20	Special wind aloft		
23	Climb TAS		
25	Descent TAS		
26	Rate of Climb		
27	Rate of Descent		
28	Climb Fuel Flow		
30	Descent Fuel Flow		

FLAGS			
#	INIT S/C	SET INDICATES	CLEAR INDICATES
05		Recall winds in R20	
06	C	Climbing	Descending
55		Using Printer	No Printer

PROGRAM DESCRIPTION

Program Title Subroutine Wind Correction

Contributor's Name _____

Address _____

City _____

State/Country _____

Zip Code _____

Program Description, Equations, Variables The subroutine calculates Wind Correction Angle (WCA), Magnetic Heading (MH), and ground speed (GS) from the true airspeed (TAS), true course (TC), and the wind aloft located in the X register at the beginning of the subroutine. From the GS and leg distance the time is calculated. The subroutine is considerably shortened by the use of Polar - Rectangular conversion.

Definitions: Wind is given traditionally as a true direction and 180° out of phase.

W° is the wind direction and W^V is the wind velocity.

The polar coordinates (θ, r) : $\theta = W^\circ - TC$ and $r = W^V/TAS$

Formulas: $WCA = \sin^{-1}(W^V \sin(W^\circ - TC)/TAS)$; $MH = TC + WCA + VAR$

$GS = TAS \cos WCA - W^V \cos \theta$ Time = DIST/GS

Derivations: $Y = r \sin \theta = W^V \sin(W^\circ - TC)/TAS$; $WCA = \sin^{-1} Y$

$A = \cos WCA - r \cos \theta = \cos WCA - W^V \cos(W^\circ - TC)/TAS$

$GS = TAS \times A = TAS \cos WCA - W^V \cos \theta$

Polar - Rectangular conversion converts θ and r to X and Y where:

$Y = r \sin \theta$ and $X = r \cos \theta$.

Necessary Accessories _____

Operating Limits and Warnings TAS must not equal zero.

PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
01	LBL "WC"				
02	FIX 0				
03	FRC	$W^V/1000$			
04	LASTX				
05	INT	W^O			
06	RCL 05				
07	INT	TC			
08	-	θ			
09	X<>Y				
10	1 E3				
11	*	W^V			
12	RCL 07	TAS			
13	/	r			
14	P-R	r Cos θ			
15	RDN	r Sin θ			
16	ASIN	WCA			
17	COS				
18	R↑	r Cos θ			
19	LASTX	WCA			
20	RCL 05				
21	INT	TC			
22	+				
23	RCL 06	VAR			
24	+				
25	RND	MH			
26	STO 04				
27	RDN				
28	-	A			
29	RCL 07	TAS			
30	*				
31	STO 02	GS			
32	RCL 05				
33	FRC				
34	1 E3				
35	*				
36	STO 01	DIST			
37	RCL 02				
38	/				
39	STO 03	Time			
40	END				

DATA REGISTERS

01	Distance		
02	Ground speed		
03	Time		
04	MH		
05	CRS.DIS		
06	VAR		
07	TAS		

PROGRAM DESCRIPTION

Program Title Display Subroutines

Contributor's Name _____

Address _____

City _____ State/Country _____ Zip Code _____

Program Description, Equations, Variables "DSPLY" displays magnetic heading as HDG, DIST (only if less than the leg distance), Remaining distance as REM DIST if it isn't zero, fuel used and remaining fuel if there is a fuel amount stored in R35, Time, and Total time as T/TIME.

"TD" displays time in HR:MM:SS format. The alpha register must be cleared prior to execution or contain a prefix for "TIME".

"WPD" decodes waypoint fix data for display.

"PR" prints the data if the printer is used; if not, will display it and halt execution.

"DGR" displays direction in degrees in proper format. Displays 0° as 360°.

"SYM" generates the degree symbol (°).

Necessary Accessories The printer is recommended, but optional.

Operating Limits and Warnings If fuel and gross weight are not stored prior to program execution, fuel data will not be displayed if R35 is zero or less. If R36 is zero the fuel weight used will be totaled as a negative number.

LBL'DSPLY END 329 BYTES
 LBL'TD AVIGATION/RNAV
 LBL'PR
 LBL'WPD
 LBL'DGR
 LBL'SYM

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PROGRAM LISTING

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STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
01	LBL "DSPLY"		49	RCL 03	
02	FIX 0		50	HMS	
03	"HDG="		51	RND	
04	RCL 04		52	HR	
05	XEQ "DGR"		53	STO 03	
06	XEQ "PR"		54	ST+ 09	
07	"GS="		55	CLA	
08	ARCL 02		56	XEQ "TD"	
09	XEQ "PR"		57	"T/"	
10	"DIST="		58	RCL 03	
11	ARCL 01		59	RCL 09	
12	RCL 08		60	X*Y?	
13	RCL 01		61	XEQ "TD"	
14	X*Y?		62	ADV	
15	XEQ "PR"		63	RTN	
16	ST- 15		64	LBL "TD"	
17	"REM DIST="		65	CF 29	
18	ARCL 15		66	FIX 0	
19	RCL 15		67	HMS	
20	RND		68	INT	
21	X>0?		69	"HTIME="	
22	XEQ "PR"		70	ARCL X	
23	FC? 00		71	10	
24	FIX 1		72	XEQ 10	
25	"FUEL="		73	X<>Y	
26	ARCL 11		74	XEQ 10	
27	1		75	LBL "PR"	
28	RCL 11		76	FC? 55	
29	FC? 00		77	GTO 00	
30	6		78	ACA	
31	*		79	PRBUF	
32	RND		80	RTN	
33	ST- 36		81	LBL 00	
34	ST- 35		82	AVIEW	
35	RCL 35		83	RTN	
36	X<=0?		84	LBL 10	
37	GTO 00		85	"H:"	
38	XEQ "PR"		86	LASTX	
39	"REM FUEL="		87	FRC	
40	6		88	100	
41	1/X		89	*	
42	RCL 35		90	X<Y?	
43	FC? 00		91	"H0"	
44	*		92	INT	
45	ARCL X		93	ARCL X	
46	XEQ "PR"		94	RTN	
47	LBL 00		95	LBL "WPD"	
48	FIX 4		96	CLA	

LBL'DSPLY
LBL'TD
LBL'PR
LBL'WPD
LBL'DGR
LBL'SYM

END 329 BYTES
AVIGATION/RNAV

PROGRAM LISTING

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STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
97	STO 11		145	END	
98	FIX 1				
99	INT				
100	10				
101	/				
102	XEQ "DGR"				
103	"F, "				
104	RCL 11				
105	FRC				
106	1 E3				
107	*				
108	ARCL X				
109	"F NM"				
110	GTO "PR"				
111	LBL "DGR"				
112	360				
113	MOD				
114	X#0?				
115	GTO 00				
116	LASTX				
117	+				
118	LBL 00				
119	100				
120	X>Y?				
121	"F0"				
122	SQRT				
123	X>Y?				
124	"F0"				
125	ARCL Y				
126	FC? 55				
127	RTN				
128	LBL "SYM"				
129	ACA				
130	0				
131	ENTER↑				
132	BLDSPEC				
133	6				
134	BLDSPEC				
135	9				
136	BLDSPEC				
137	9				
138	BLDSPEC				
139	9				
140	BLDSPEC				
141	6				
142	BLDSPEC				
143	ACSPEC				
144	CLA				

DATA REGISTERS

01	Distance		
02	Ground speed		
03	Time		
04	Magnetic heading		
08	Leg distance		
09	Total time		
11	Fuel used / WP Fix		
15	Total Distance		
35	Fuel weight		
36	Gross weight		

FLAGS

#	INIT S/C	SET INDICATES	CLEAR INDICATES
00		Fuel is in LBS	Fuel is in US Gal.
55		Printer being used	Printer not used

PROGRAM DESCRIPTION I

Program Title Data Record

Contributor's Name _____

Address _____

City _____ State/Country _____ Zip Code _____

Program Description, Equations, Variables This program prompts for navigation fix data, encodes it, and writes it on a magnetic card. The recorded data includes the facility identifier, latitude & longitude coordinates, and the magnetic variation. Each facility takes 3 data registers, so a total of five facilities may be recorded on each track. The data, after it is input may be reviewed for correctness and changed if needed. After the data is input and after it has been viewed, the program prompts to write it on a card. If a card track is loaded by simply inserting it into the card reader, that data ^{MAY} will can be viewed. Anytime the program prompts for the ident, if input is declined, the program will proceed to view the contents.

REGISTERS, STATUS, FLAGS, ASSIGNMENTS

DATA REGISTERS			STATUS			
00 to			SIZE 12	TOT. REG.	USER MODE	
14 Facility data			ENG	FIX	SCI	ON OFF
15 Counter value			DEG	RAD	GRAD	
16 Identifier						

Necessary Accessories Card Reader

Operating Limits and Warnings If the viewing is terminated while viewing the variation the variation data will be lost from that data register. This isn't important as the data ^{IF} will already have been recorded, unless "DR" is being used in a master program.

Terminating the viewing anywhere else will not change the data in the registers.

PROGRAM DESCRIPTION II

Sample Problem (Sketch if Desired)

Write the Identifiers, coordinates, and magnetic variation of the following facilities on a magnetic card. Add the letter "V" to the end of each identifier to show that it is a vortac and not an airport.

1. Knoxville Vortac:	TYS	35° 54' 17"N	83° 53' 41"W	1°W
2. Hinch Mt. Vortac:	HCH	35° 46' 51"N	84° 58' 43"W	1°E
3. Chattanooga Vortac:	CHA	34° 57' 40"N	85° 09' 12"W	1°E
4. Rocket Vortac:	RQZ	34° 47' 49"N	86° 38' 02"W	2°E
5. Muscle Shoals Vortac:	MSL	34° 42' 24"N	87° 29' 29"W	1°E

* *Simulation also* It is recommended that the data be viewed *for corrections* after being written on a data card, whether it is the first time the data is written or after corrections have been made, to insure accuracy.

SOLUTION:

Input	Function	Display	Comments
	XEQ "DR"	IDENT?	If input declined will view all 5 data groups.
TYSV	R/S	TYSV LAT?	Mistake made!
35.5341	R/S	TYSV LNG?	
83.5341	R/S	TYSV VAR?	
1	R/S	IDENT?	If input declined will view next 4 data groups.
HCHV	R/S	HCHV LAT?	
35.4651	R/S	HCHV LNG?	
84.0912	R/S	HCHV VAR?	Monday morning, another mistake!
1	CHS	-1	
	R/S	IDENT?	Input declined, will view 3 groups
CHAV	R/S	CHAV LAT?	
34.5740	R/S	CHAV LNG?	
85.0912	R/S	CHAV VAR?	
1	CHS, R/S	IDENT?	-1 entered for E variation
RQZV	R/S	RQZV LAT?	
34.4749	R/S	RQZV LNG?	
86.3802	R/S	RQZV VAR?	
2	CHS, R/S	IDENT?	
MSLV	R/S	MSLV LAT?	
34.4224	R/S	MSLV LNG?	
87.2929	R/S	MSLV VAR?	
1	CHS, R/S	RDY 01 OF 01	Ready to write data card
	Insert Card	TYSV	View - correct?
35.5417	R/S	TYSV = 35.5341	Incorrect LAT, correct it!
	R/S	TYSV = 83.5341	View LNG
	R/S	TYSV = 1.0	View VAR
	R/S	HCHV	View Ident
	R/S	HCHV = 35.4651	View LAT
	R/S	HCHV = 84.0912	View LNG, incorrect - correct it!
84.5843	R/S	HCHV = -1.0	View VAR
	R/S	CHAV	
11 steps viewed	R/S (11 steps	MSLV = -1.0	Ready to rewrite data card with corrections.
	Insert Card	RDY 01 OF 01	
		View started over*	

USER INSTRUCTIONS

				SIZE: 17
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Size	17	☐ XEQ "SIZE"	
2	Start program		☐ XEQ "DR"	IDENT?
3	Input identifier (6 characters or less)	Ident	☐ R/S	(ident) LAT?
	Input declined, skip to step 8		☐ R/S	(ident)
4	Input Latitude	DD.MMSS	☐ R/S	(ident) LNG?
5	Input Longitude	DD.MMSS	☐ R/S	(ident) VAR?
6	Input magnetic variation (-W, -E)	DD	(☐ CHS), ☐ R/S	
	Less than 5 data groups input, repeat steps 3 thru 6			IDENT?
	Five Nav fix data groups are input			RDY 01 OF 01
7	Write data card	Insert Card		(ident)
8	View identifier, (correct if necessary)	(Ident)	☐ R/S	(ident) = (lat)
9	View latitude, (correct if necessary)	(lat)	☐ R/S	(ident) = (lng)
10	View longitude, (correct if necessary)	(lng)	☐ R/S	(ident) = (var)
11	View magnetic variation, (correct if)	(var)	☐ R/S	
	Repeat steps 8 thru 8 thru 11 until... see note			(ident)
	Viewing and corrections completed			RDY 01 OF 01
12	If corrections were needed, skip to step 7			
	If no corrections were needed, terminate prgm		☐ R/S	
*	NOTE: All five nav fix data groups will be viewed, unless input was declined in step 3 - then that group and remaining groups will be viewed.			

PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
01	LBL "DR"		49	ARCL IND 15	
02	.014	Counter value	50	PROMPT	View Identifier/ correct & store
03	STO 15		51	AOFF	
04	LBL 01		52	ASTO 16	
05	CF 23		53	ASTO IND 15	
06	"IDENT?"		54	ISG 15	
07	AON		55	FIX 4	
08	PROMPT		56	RCL IND 15	
09	AOFF		57	CLA	
10	FC?C 23	Input declined?	58	ARCL 16	
11	GTO 03	start viewing data	59	"I="	
12	ASTO 16	Store Ident	60	ARCL X	
13	ASTO IND 15		61	PROMPT	View lat/ correct & store
14	ISG 15		62	STO IND 15	
15	CLA		63	ISG 15	
16	ARCL 16		64	RCL IND 15	
17	"I LAT?"		65	INT	
18	PROMPT		66	ABS	
19	STO IND 15		67	I E4	*
20	ISG 15		68	/	
21	CLA		69	CLA	
22	ARCL 16		70	ARCL 16	
23	"I LNG?"		71	"I="	
24	PROMPT		72	ARCL X	
25	I E4		73	PROMPT	View lng/ correct & store
26	*		74	I E4	
27	CLA		75	*	
28	ARCL 16		76	X<> IND 15	
29	"I VAR?"	Code LNG.VAR	77	FIX 1	
30	PROMPT		78	FRC	
31	SIGN		79	100	
32	X<>Y		80	*	
33	LASTX		81	CLA	
34	ABS		82	ARCL 16	
35	100		83	"I="	
36	/		84	ARCL X	
37	+		85	PROMPT	View Var/ correct & store
38	*		86	100	
39	STO IND 15		87	/	
40	ISG 15		88	ABS	
41	GTO 01		89	ST+ IND 15	
42	LBL 02		90	LASTX	
43	.014		91	SIGN	
44	STO 15		92	ST* IND 15	
45	WDIAX	Write data card	93	ISG 15	
46	LBL 03		94	GTO 03	
47	CLA		95	GTO 02	
48	AON		96	END	

PROGRAM DESCRIPTION I

Program Title Mach Number and True Airspeed

Contributor's Name _____

Address _____

City _____ State/Country _____ Zip Code _____

Program Description, Equations, Variables

This program converts calibrated airspeed (CAS) to mach number (M) and true airspeed (TAS). Inputs required are pressure altitude (PALT), aircraft recovery coefficient (C_T) and indicated air temperature (IAT). Values for recovery coefficient vary from 0.6 to 1.0, but 0.8 is a good value for most aircraft.

The formulas used are less accurate for mach numbers above 1.0 (i.e., supersonic flight).

Pressure ratio $\left(\frac{P}{P_o}\right) = \left[\frac{518.67 - 3.566 \times 10^{-3} \text{ PALT}}{518.67}\right]^{5.2563}$

$M^2 = 5 \left[\left(\frac{P_o}{P} \left\{ \left[1 + 0.2 \left(\frac{\text{CAS}}{661.5} \right)^2 \right]^{3.5} - 1 \right\} + 1 \right)^{0.2857} - 1 \right]$

$\text{TAS} = 38.96M \sqrt{(IAT + 273) \left[C_T \left(\frac{1}{(1 + 0.2 M^2)} - 1 \right) + 1 \right]}$

				SIZE: 008
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	To compute mach number and true airspeed		XEQ 1:	PALT= (ALT)?
2	Input pressure altitude.	PALT, ft.	R/S	CAS= (CAS)?
3	Input calibrated airspeed.	CAS, kt.	R/S	CT= (CT)?
4	Input aircraft recovery coefficient.	C _T	R/S	IAT= (IAT)?
5	Input indicated air temperature.	IAT, °C	R/S	MACH M TAS= (TAS)

Necessary Accessories _____

Operating Limits and Warnings _____

PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
01	LBL *TAS*		49	1	
02	SF 21		50	-	
03	FIX 0		51	RCL 05	
04	RCL 01		52	/	
05	*PALT=*		53	1	
06	ARCL X		54	+	
07	*F?*		55	3.5	
08	PROMPT		56	1/X	
09	STO 01		57	Y↑X	
10	RCL 02		58	1	
11	*CAS=*		59	-	
12	ARCL X		60	5	
13	*F?*		61	*	
14	PROMPT		62	SQRT	
15	STO 02		63	STO 06	
16	RCL 03		64	FIX 2	
17	*IAT=*		65	*MACH *	
18	ARCL X		66	ARCL X	
19	*F?*		67	AVIEW	
20	PROMPT		68	RCL 06	
21	STO 03		69	X↑2	
22	FIX 1		70	5	
23	RCL 04		71	/	
24	*CT=*		72	1	
25	ARCL X		73	+	
26	*F?*		74	1/X	
27	PROMPT		75	1	
28	STO 04		76	-	
29	RCL 01		77	RCL 04	
30	-3566 E-6		78	*	
31	*		79	1	
32	518.67		80	+	
33	+		81	273	
34	LASTX		82	RCL 03	
35	/		83	+	
36	5.2563		84	*	
37	Y↑X		85	SQRT	
38	STO 05		86	RCL 06	
39	RCL 02		87	*	
40	661.5		88	38.96	
41	/		89	*	
42	X↑2		90	FIX 0	
43	5		91	*TAS=*	
44	/		92	ARCL X	
45	1		93	AVIEW	
46	+		94	END	
47	3.5				
48	Y↑X				

PROGRAM DESCRIPTION I

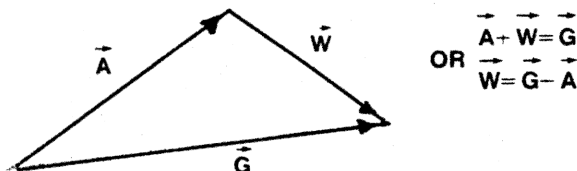
Program Title **IN-FLIGHT WINDS** | **HEADWINDS AND CROSSWINDS**

This program is actually in two parts: one to determine in-flight winds, and the other to resolve a wind into its headwind or tailwind and right or left crosswind components.

Determining In-Flight Winds

This program computes the winds at altitude from TAS, course of aircraft, ground speed and heading. Ground speed is automatically calculated from time-distance inputs. Winds can be computed as either magnetic or true. The latter must be used when verifying wind forecasts by the weather bureau. The program allows continuous updating of winds.

This program solves the wind triangle shown below.



W, A and G are all vector quantities representing wind direction and speed; TAS and heading; and ground speed and course respectively.

Since both A and G use magnetic directions, W is computed as a magnetic direction. It must be corrected to true heading by adding the variation V.

True wind direction = magnetic wind direction $\pm$ magnetic variation

Headwinds and Crosswinds

Also, this program calculates both the head wind and cross wind components from the aircraft heading and reported winds. The program works both at altitude, where magnetic variation must be considered, and at landing and takeoff, where winds are reported in magnetic directions rather than true directions.

The head wind (HW) and right cross wind (RCW) components are computed from

$$HW = K \cos (D - HDG + V)$$

$$RCW = K \sin (D - HDG + V)$$

where

K = the reported wind velocity

D = the reported wind direction

HDG = the aircraft heading

V = the magnetic variation (+ west, $\pm$ east)

HW= Head Wind
 RCW= RightCross Wind
 TW= Tail Wind
 LCW= Left Cross Wind

Necessary Accessories

Operating Limits and Warnings

Wind directions reported by the control tower are magnetic and the variation need not be input when using the program for takeoff and landings. Other wind directions are reported in true directions and variation must be included to find the wind components.

LBL*IFW
 LBL*HCW
 END 347 BYTES
 AVIGATION/RNAV ■ 41C

PROGRAM LISTING

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STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
01	LBL "IFW"		49	RCL 02	
02	CF 05		50	P-R	
03	LBL 01		51	X<>Y	
04	CF 29		52	ST- T	
05	FIX 1		53	RDN	
06	ADV		54	-	
07	RCL 06		55	R-P	
08	"VAR="		56	RND	
09	XEQ 03		57	STO 12	
10	STO 06		58	X<>Y	
11	FC? 55		59	RCL 06	
12	GTO 00		60	-	
13	CLA		61	RND	
14	ARCL X		62	STO 11	
15	XEQ "SYM"		63	SF 21	
16	PRBUF		64	ADV	
17	LBL 00		65	"WIND DIR="	
18	FIX 0		66	XEQ "DGR"	
19	RCL 04		67	XEQ "PR"	
20	"MH="		68	"WIND VEL="	
21	XEQ 04		69	ARCL 12	
22	STO 04		70	FS? 55	
23	FS? 55		71	GTO 07	
24	XEQ 05		72	CF 21	
25	FS?C 05		73	AVIEW	
26	RTN		74	RTN	
27	RCL 05		75	GTO 01	
28	"MC="		76	LBL "HCW"	
29	XEQ 04		77	LBL 02	
30	STO 05		78	SF 05	
31	FS? 55		79	XEQ 01	
32	XEQ 05		80	RCL 11	
33	RCL 07		81	"WIND DIR="	
34	"TAS="		82	XEQ 04	
35	XEQ 03		83	STO 11	
36	STO 07		84	FS? 55	
37	FS? 55		85	XEQ 05	
38	XEQ 06		86	RCL 12	
39	RCL 02		87	"WIND VEL="	
40	"GS="		88	XEQ 03	
41	XEQ 03		89	STO 12	
42	STO 02		90	FS? 55	
43	FS? 55		91	XEQ 06	
44	XEQ 06		92	ADV	
45	RCL 04		93	RCL 11	
46	RCL 07		94	RCL 04	
47	P-R		95	-	
48	RCL 05		96	RCL 06	

PROGRAM LISTING

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
97	+		145	*LBL 05	
98	RCL 12		146	CLA	
99	P-R		147	XEQ "DGR"	
100	"HW="		148	PRBUF	
101	X<0?		149	RTN	
102	"TW="		150	*LBL 06	
103	ASTO 00		151	CLA	
104	ABS		152	ARCL X	
105	RND		153	*LBL 07	
106	X<>Y		154	ACA	
107	"R"		155	SF 13	
108	X<0?		156	"KTS"	
109	"L"		157	ACA	
110	"FCW="		158	PRBUF	
111	ABS		159	CF 13	
112	ARCL X		160	CLA	
113	FC? 55		161	END	
114	"T"				
115	FS? 55				
116	XEQ 07				
117	ARCL 00				
118	ARCL Y				
119	FS? 55				
120	XEQ 07				
121	CF 21				
122	AVIEW				
123	SF 21				
124	RTN				
125	GTO 02				
126	*LBL 03				
127	FS? 55				
128	ACA				
129	ARCL X				
130	"T?"				
131	PROMPT				
132	RND				
133	RTN				
134	*LBL 04				
135	FS? 55				
136	ACA				
137	CF 21				
138	XEQ "DGR"				
139	SF 21				
140	"T?"				
141	RDN				
142	PROMPT				
143	RND				
144	RTN				