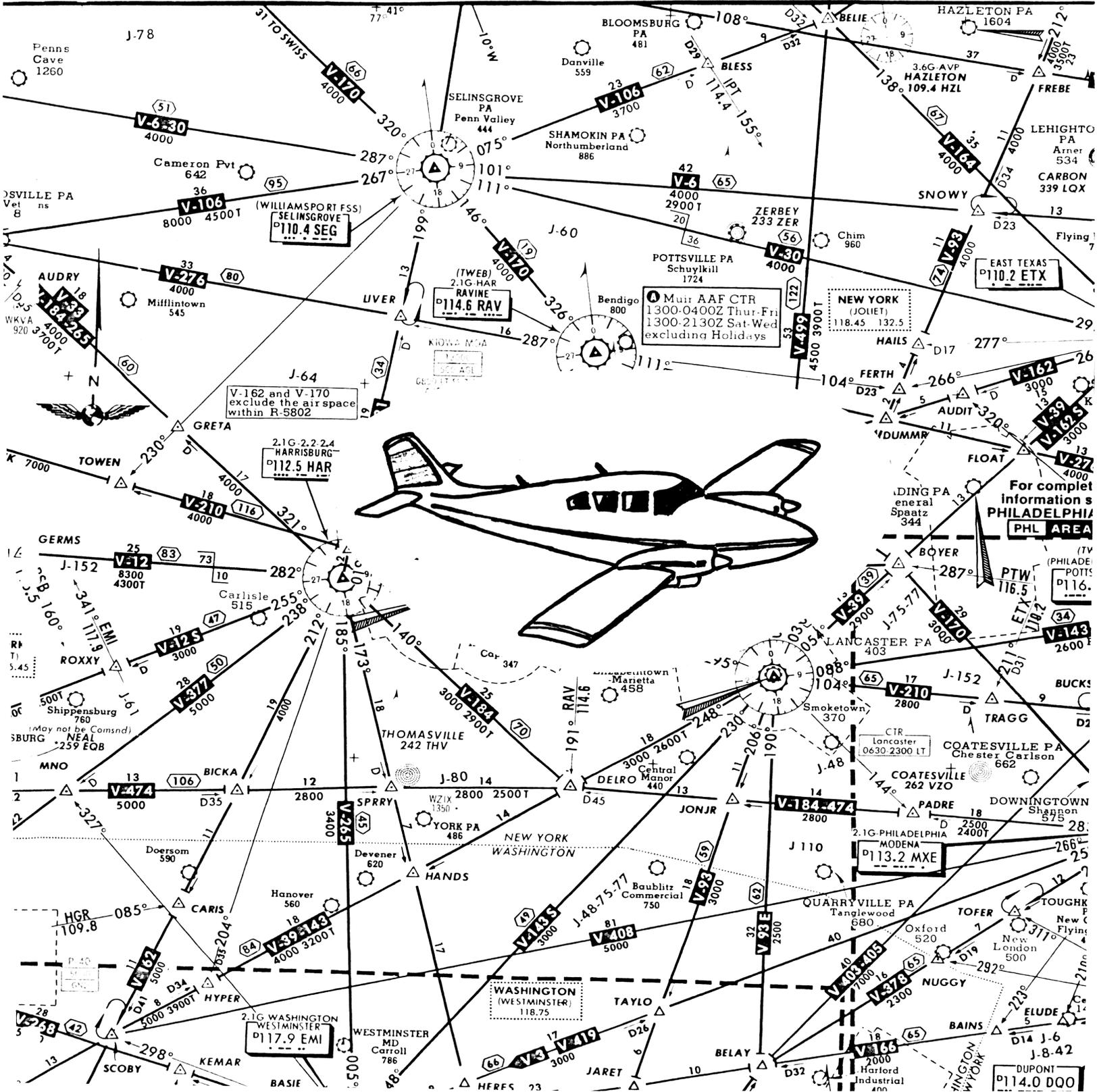


AREA NAVIGATION  
RNAV Program for the HP 41C/CV

by  
Robert A. Tims



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# PROGRAM DESCRIPTION I

Program Title AREA NAVIGATION (RNAV)  
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**Program Description, Equations, Variables** This program computes the magnetic course and distance between each leg's starting fix and its ending fix. RNAV waypoints along each leg's course can be computed, dividing the primary leg into two or more secondary legs. The program will compute a RNAV waypoint over the departure point and the destination. The total trip distance is computed.

Each primary leg consists of a starting and an ending navigation fix. A leg's starting fix will either be the departure point or the ending fix of the previous leg. A navigation fix may be defined by its latitude and longitude coordinates along with the appropriate magnetic variation; or by its magnetic direction and nautical distance from the previous fix (as in the case of an airway intersection); and if the previous fix isn't a practical reference, then the fix (such as a waypoint) can be defined in magnetic direction and

**Necessary Accessories** 2 memory modules; 1 memory module w/o card reader and printer

**Operating Limits and Warnings** A leg's starting fix must not be the same coordinates as its ending fix, i.e. the distance of a leg must be greater than zero.

**Reference(s)** \_\_\_\_\_

This program has been verified only with respect to the numerical example given in *Program Description II*. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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# PROGRAM DESCRIPTION I

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nautical distance from any given reference fix. The reference fix must be defined by latitude and longitude coordinates. In the last two cases the magnetic variation used in the program will be that of the prior fix, or of the reference fix if one is used.

Coordinate inputs are in degrees, minutes and seconds north or south of the equator, and east or west of the prime meridian. North latitude and west longitude are positive numbers. South latitude is a negative number. East longitude is a negative number; but with the card reader, east longitude can't be used with the present data format. Please see the appendix and Data Record Program Description I for more information. A Radial (or from bearing) used to define a fix is in degrees and a decimal fraction of a degree. All distances are in nautical miles.

Each fix is labeled with an assigned alpha "identifier." National location identifiers are usually three letters for airports and navigation aids and may be found in the Airport/Facility Directory and on aviation charts. Intersections are identified with a five letter name and may be found on aviation charts. The program will accept up to six letters to identify a fix. However, in the case of a waypoint, the identifier of the reference fix is appended to the characters "WP:" which means only the first three letters will be used.

If a card reader is being utilized the alpha identifiers are used to locate the proper coordinates in memory. However, even if a card reader isn't used, the identifiers are used in the prompts to avoid confusion and to help you keep track of the fix for which you are inputting data.

After the starting fix and the ending fix of each primary leg is defined, the program can be used to compute waypoints. Each waypoint will

# PROGRAM DESCRIPTION I

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be defined by a radial, that is perpendicular to the course, and the nautical distance from the navigational aid. When a waypoint is being computed the program will only allow the reference fix to be defined by latitude and longitude coordinates. Requested waypoints will be ignored by the program if the nav aid selected will place the waypoint before the leg's starting fix, beyond its ending fix, or behind a previously computed waypoint.

When asking for data, the program will first prompt for the primary leg's data and then compute the course and distance. After which it will prompt for the data necessary to compute waypoints. If waypoints are computed, then the primary leg will be divided into two or more secondary legs. The data will be displayed without distinction between primary and secondary legs. Each displayed leg will be from one navigation fix, intersection, or waypoint to the next one.

The display will show first the identifiers of the beginning and ending fix for the leg. The magnetic course will be displayed next. If the magnetic variation at the beginning of the leg is different than it is at the ending, both magnetic bearings will be displayed. The "from" bearing first, separated from the "to" bearing by the character "/". Bearings will be displayed to the nearest whole degree. The distance is then displayed to the nearest whole nautical mile. If the leg's ending fix is a RNAV waypoint, its data will follow after the leg's data. Its identifier, followed by the bearing and distance will be displayed. Both the waypoint bearing (radial) and the distance will be to the nearest tenth of a degree and nautical mile.

If the departure airport is defined by latitude and longitude coordinates, a waypoint located at the Airport Reference Point may be computed from any

# PROGRAM DESCRIPTION I

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given nav aid. This waypoint will be displayed before the first leg's data. A waypoint may be computed in the same manner for the destination airport, and will be displayed after the last leg. If the airport is defined as a bearing and distance from a reference nav aid, than by definition it is already a waypoint, and the program will not prompt for a terminal waypoint.

The final display will show the departure and destination identifiers and will display the total trip distance between them.

After the departure point is entered, any prompt thereafter may be declined by resuming program execution without any input. If data has mistakenly been entered, and execution has not been resumed, you may still decline the input by clearing the appropriate flag (flag 22 or 23), and then resuming program execution. When input is declined the program continues to the next phase.

A card reader is highly recommended in order to utilize the RNAV program to its fullest. It is more efficient to be able to enter a nav fix or a station's identifier and coordinates by magnetic card. The coordinates to VORTACs and often used airports may be stored on the cards and utilized with the program quickly and easily. A Data Record program is included so that station data can be recorded on the magnetic cards in the proper format.

The program will run without either a card reader or printer. In the appendix, variations to the program are given in order to reduce its size and execution time if either accessory is never used. Sometimes the printer may not be practical; however the program, especially with the magnetic cards, can compute course changes and new waypoints quickly and easily.

# PROGRAM DESCRIPTION I

(CONTINUATION PAGE)

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This program makes your flight planning easy and simple. Using an avigation chart, determine if you can go direct RNAV or if part of the trip will be on a convenient airway. Then determine which nav aids will be used for waypoint fixes along the RNAV portion. If a terminal waypoint is needed, pick the VORTAC closest to the airport. Then put the data into the RNAV program and the HP-41C/CV will compute your magnetic course, distance, and waypoints with as great or greater accuracy than can be obtained with a plotter and pencil.

Three sample problems will be given. The first two will be a trip from the McGhee Tyson airport at Knoxville, TN to the Muscle Shoals, AL airport. The first will be without a printer or card reader, the second will be with them. The last sample problem will be a navigation problem that could result if one had to divert off course. If one diverted north of the previous course to a position 12 NM DME on the Hinch Mountain VORTAC 240° radial and then received a direct clearance to the Muscle Shoals VORTAC will illustrate how easy it is to compute a course change. The sample problems are illustrated on part of an avigation chart. The facilities used in the RNAV sample problems are recorded on a magnetic card in the Data Record Program Description II sample problem.

Westerly magnetic variation is a positive number while Easterly variation is a negative number.



# PROGRAM DESCRIPTION II

## Sample Problem

Flight: Depart the McGhee Tyson airport, Knoxville, TN. Fly direct to COWAN intersection with waypoints of Hinch Mountain and Chattanooga VORTACs. Fly V54N to the Rocket VORTAC, V54 to Muscle Shoals VORTAC, and then direct to the Muscle Shoals, AL airport.

Card reader and printer are not used. The station coordinates are below:

McGhee Tyson (TYS)	35°48'45"N	83°59'34"W	1°W
Knoxville VORTAC (TYS)	35°54'17"N	83°53'41"W	1°W
Hinch Mt. VORTAC (HCH)	35°46'51"N	84°58'43"W	1°E
Chattanooga VORTAC (CHA)	34°57'40"N	85°09'12"W	1°E
Rocket VORTAC (RQZ)	34°47'49"N	86°38'02"W	2°E
Muscle Shoals VORTAC (MSL)	34°42'24"N	87°29'29"W	1°E
Muscle Shoals airport (MSL)	34°44'43"N	87°36'37"W	1°E

This route is depicted on the avigation chart following the sample problems.

## SOLUTION:

Input	Function	Display	Comments
	XEQ RNAV	FROM?	Asking for departure fix
TYS	R/S	TYS LAT?	
35.4845	R/S	TYS LNG?	
83.5934	R/S	TYS VAR?	
1	R/S	TYS WP?	Asking if we want a terminal
TYS (vortac)	R/S	TYS LAT?	waypoint.
35.5417	R/S	TYS LNG?	
83.5341	R/S	TYS VAR?	
1	R/S	TYS * WP:TYS	Terminal waypoint from Knoxville
	R/S	221.8, 7.3 NM	Vortac for McGhee Tyson airport
	R/S	TYS TO?	is 221.8° and 7.3 NM
COWAN	R/S	COWAN LAT?	Asking for ending fix for this leg
	R/S	NEED FIX?	This is an intersection so input
CHA	R/S	CHA LAT?	will be declined
34.574	R/S	CHA LNG?	COWAN intersection is 277°, 38 NM
85.0912	R/S	CHA VAR?	DME from the Chattanooga VORTAC
1	CHS		Easterly variation is negative
-1	R/S	FIX RADIAL?	
277	R/S	FIX DIST?	
38	R/S	TYS TO WP?	Asking if we want waypoints
HCH	R/S	HCH LAT?	
35.4651	R/S	HCH LNG?	
84.5843	R/S	HCH VAR?	
1	CHS		
-1	R/S	TYS-WP:HCH	First leg identifiers
	R/S	MC=245/243	MC from Tys is 245° and MC to
	R/S	DIST=44 NM	the waypoint off of the Hinch
	R/S	WP:HCH	Mt. VORTAC is 243°.
	R/S	153.1, 19.3 NM	Distance of first leg
	R/S	WP:HCH TO WP?	Waypoint identifier and the WP
	R/S		bearing is 153.1 degrees and
	R/S		19.3 NM DME
	R/S		Asking for the next waypoint

# PROGRAM DESCRIPTION II

SOLUTION: (CONTINUATION PAGE)

Input	Function	Display	Comments
CHA	R/S	CHA LAT?	
34.574	R/S	CHA LNG?	
85.0912	R/S	CHA VAR?	
1	CHS		
-1	R/S	WP:HCH-WP:CHA	Second leg identifiers
	R/S	MC=243	
	R/S	DIST=29 NM	
	R/S	WP:CHA	
	R/S	333.1, 21.1 NM	
	R/S	WP:CHA TO WP?	Asking for another Waypoint
	R/S		Decline input to terminate the first primary leg
		WP:CHA-COWAN	Third leg identifiers
	R/S	MC=243	
	R/S	DIST=32 NM	
	R/S	COWAN TO?	Asking for next primary leg fix
RQZ	R/S	RQZ LAT?	
	R/S	NEED FIX?	Accidentally declined LAT input
	R/S	FIX RADIAL?	Decline reference fix
	R/S		Decline prior fix for reference chance to change identifier
		RQZ	
	R/S	RQZ LAT?	Let's do it correct this time!
34.4749	R/S	RQZ LNG?	Don't mess up here! Or we will
86.3802	R/S	RQZ VAR?	have to start over.
2	CHS		
-2	R/S	COWAN TO WP?	No waypoint, so we'll decline
	R/S	COWAN-RQZ	Fourth leg identifiers
	R/S	MC=246/245	
	R/S	DIST=38 NM	
	R/S	RQZ TO?	
MSL (vortac)	R/S	MSL LAT?	
34.4224	R/S	MSL LNG?	
87.2929	R/S	MSL VAR?	
1	CHS		
-1	R/S	RQZ TO WP?	Decline input
	R/S	RQZ-MSL	Fifth leg identifiers
	R/S	MC=261/262	
	R/S	DIST=43 NM	
	R/S	MSL TO?	
MSL (airport)	R/S	MSL LAT?	
34.4443	R/S	MSL LNG?	
87.3637	R/S	MSL VAR	
1	CHS		
-1	R/S	MSL TO WP?	No waypoint, so decline input
	R/S	MSL-MSL	Sixth and last leg identifiers
	R/S	MC=291	
	R/S	DIST=6 NM	
	R/S	MSL TO?	End of trip, so decline input
	R/S	MSL WP?	Need a terminal waypoing for MSL?
	R/S		No so decline input
		TYS TO MSL	Start and destination identifiers
	R/S	T/DIST 192	Total trip distance in NM

# PROGRAM DESCRIPTION II

## Sample Problem

Flight: Depart the McGhee Tyson airport, Knoxville, TN. Fly direct to COWAN intersection with waypoints of Hinch Mountain and Chattanooga VORTACs. Fly V54N to the Rocket VORTAC, V54 to Muscle Shoals VORTAC, and then direct to the Muscle Shoals, AL airport.

A card reader and printer will be used. VORTAC identifiers will have the letter "V" added on to them to differentiate them from the airport identifiers. Write the data on a magnetic card using the sample problem in Data Record Program Description II. This route is depicted on the avigation chart following the sample problems.

Stations used and their identifiers:

McGhee Tyson airport	TYS
Knoxville VORTAC	TYSV
Hinch Mountain VORTAC	HCHV
Chattanooga VORTAC	CHAV
Rocket VORTAC	RQZV
Muscle Shoals VORTAC	MSLV
Muscle Shoals airport	MSL

## SOLUTION:

Input	Function	Display	Comments
TYS	XEQ RNAV R/S	FROM? CARD	Asking for departure fix Load card for fix coordinates
TYSV	Load Data Card R/S	TYS WP?	We'll use the TYS VORTAC for a terminal waypoint. Printer outputs waypoint data.
COWAN	R/S	TYS TO? CARD	Intersection, so no card data
	R/S	COWAN	
	R/S	COWAN LAT?	We have no coordinates
	R/S	NEED FIX?	Yes, as the McGhee Tyson airport is not a good reference point. CHA VORTAC on the other hand is excellent because of the airway from it to the COWAN intersection. The chart shows COWAN to be 277°, 38 NM from CHA VORTAC.
CHAV	R/S	FIX RADIAL?	
277	R/S	FIX DIST?	
38	R/S	TYS TO WP?	Asking if we want waypoints
HCHR	R/S	CARD	We made an error
	R/S	HCHR	Yes, input should have been HCHV
	R/S	HCHR LAT?	
	R/S	HCHR	Correction may be made now
HCHV	R/S	WP:HCH TO WP?	Printer outputs Leg 1 and waypoint data
CHAV	R/S	WP:CHA TO WP?	Printer outputs Leg 2 and waypoint data
HCHV	R/S	WP:CHA TO WP?	Invalid waypoint, behind previous waypoint
	R/S		Input declined will terminate the first primary leg.
		COWAN TO?	Printer outputs leg 3 data
RQZ	R/S	CARD	Must have made an error
	R/S	RQZ	Yes, should have been RQZV
	R/S	RQZ LAT?	We will cycle through the prompts until we can correct it
	R/S	NEED FIX?	



# PROGRAM DESCRIPTION II

SOLUTION: (CONTINUATION PAGE)

PRINTER OUTPUT:

TYS \* WP:TYS  
221.85°, 7.5 NM

TYS to WP:HCH  
MC=245°/243°  
DIST=44 NM

WP:HCH  
153.1°, 19.3 NM

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

WP:CHA  
333.1°, 21.1 NM

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

COWAN to R02V  
MC=246°/245°  
DIST=38 NM

R02V to MSLV  
MC=261°/262°  
DIST=43 NM

MSLV to MSL  
MC=291°  
DIST=6 NM

TYS TO MSL  
T/DIST 192 NM

# PROGRAM DESCRIPTION II

## Sample Problem

While flying RNAV direct from the McGhee Tyson airport to the COWAN intersection on the way to Muscle Shoals, Alabama you are diverted around weather to the North. When clear of the weather, you are cleared from present position direct to the Muscle Shoals VORTAC. With the aircraft navigation receivers we can determine that we are 12 NM DME from the Hinch Mountain VORTAC on its 240° radial. One waypoint will be computed using the Shelbyville VORTAC.

A card reader will be used, but not a printer. VORTAC identifiers will have the letter "V" added on to them to differentiate them from an airport identifier. Write the data on a magnetic card using the sample problem in Data Record Program Description II. This route is depicted on the avigation chart following this sample problem.

Stations used and their identifiers:

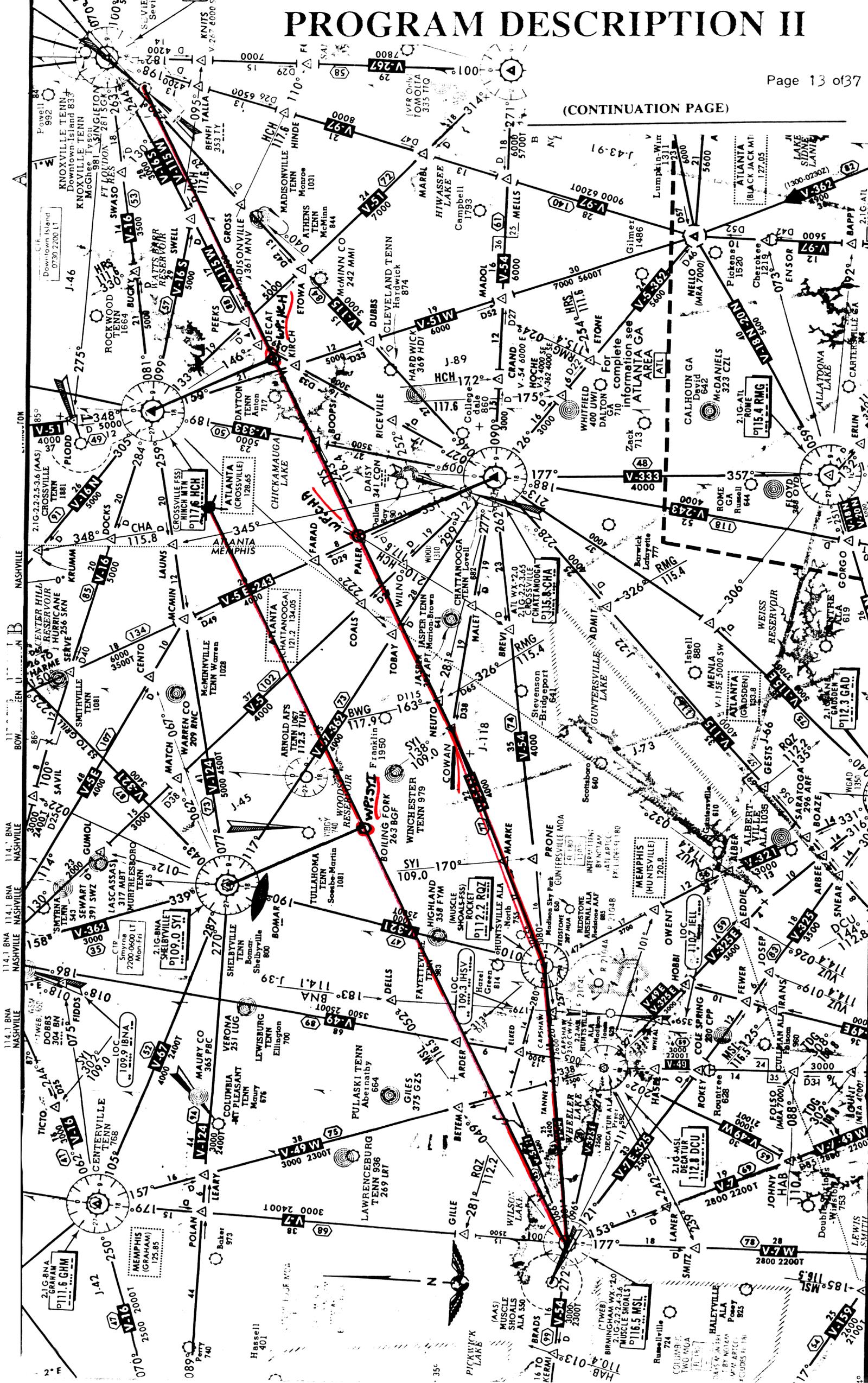
Hinch Mountain VORTAC	HCHV
Shelbyville VORTAC	SYIV
Muscle Shoals VORTAC	MSLV

## SOLUTION:

Input	Function	Display	Comments
X	XEQ RNAV R/S	FROM? CARD	Where are you at? Position "X" isn't on a card, but load the data card for the next fix (Hinch Mt. VORTAC) to save having to push R/S twice to continue the program. Coordinates are unknown
	Load Data Card R/S	X LAT? NEED FIX?	Yes, we know our position relative to the Hinch Mountain VORTAC.
HCHV	R/S	FIX RADIAL?	
240	R/S	FIX DIST?	
12	R/S	X TO?	
MSLV	R/S	X TO WP?	
SYIV	R/S	X - WP:SYI	Data output
	R/S	MC=241/240	
	R/S	DIST=57 NM	
	R/S	WP:SYI	
	R/S	150.5, 21.6 NM	
	R/S	WP:SYI TO WP?	Don't want any more waypoints. Data output continues
	R/S	WP:SYI - MSLV	
	R/S	MC=240/241	
	R/S	DIST=70NM	
	R/S	MSLV TO?	The rest of the trip to MSL has already been computed.
	R/S	MSLV WP?	Don't need a terminal waypoint.
	R/S	X TO MSLV	
	R/S	T/DIST 127	

# PROGRAM DESCRIPTION II

(CONTINUATION PAGE)



# USER INSTRUCTIONS

				SIZE: 35
STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
1	Size	35	<input type="checkbox"/> XEQ SIZE	
2	Start program		<input type="checkbox"/> XEQ RNAV	FROM?
3	Input departure airport/facility ident	IDENT'	<input type="checkbox"/> R/S	(see part A)
	From step A2, A7, or part A skipped			IDENT' WP?
	From step A11 - skip step 4			IDENT' TO?
4	Input terminal waypoint fix identifier	IDENT <sup>v</sup>	<input type="checkbox"/> R/S	(see part A)
	From part A or part A skipped			IDENT' TO?
5	Input primary leg end fix identifier	IDENT	<input type="checkbox"/> R/S	(see part A)
	From part A or part A skipped			IDENT' TO WP?
	Declined, skip to step 7		<input type="checkbox"/> R/S	
6	Input waypoint reference fix identifier	IDENT <sup>WP</sup>	<input type="checkbox"/> R/S	(see part A)
	Input declined, go to step 5		<input type="checkbox"/> R/S	IDENT TO?
	From part A or part A skipped, repeat step 6			IDENT <sup>WP</sup> TO WP?
7	Prior primary fix input from:			
	Step A11 - go to step 9.			
	Step A2, A7, or part A skipped			IDENT WP?
8	Input terminal waypoint fix identifier	IDENT <sup>v</sup>	<input type="checkbox"/> R/S	(see part A)
	Input declined or part A skipped, or from part A			
9	Program ends			
	Part A is on the next page and is the steps used to input data.			Above displays assumes that a printer was used to output leg and waypoint data.

# USER INSTRUCTIONS

Part A: Data input

STEP	INSTRUCTIONS	INPUT	FUNCTION	DISPLAY
A1	If data is already loaded from a prior card, skip part A, or if card reader isn't used, skip to step A4			CARD IDENT LAT?
A2	Load data card  Data not on the card, skip to step A4  Data on the card			IDENT LAT? Return to the original step
A3	Data card declined  Resume program execution		<input type="checkbox"/> R/S  <input type="checkbox"/> R/S	IDENT IDENT LAT?
A4	Input latitude  Input declined - skip to step A8	DD.MMSS	<input type="checkbox"/> R/S	IDENT LNG?
A5	Input longitude	DD.MMSS	<input type="checkbox"/> R/S	IDENT VAR?
A7	Input magnetic variation ( + W, - E)	DD	( <input type="checkbox"/> CHS ) <input type="checkbox"/> R/S	Return to the original step
A8	Coordinates to be computed  If a waypoint is being computed, go to step A1			IDENT
A9	Input reference fix (uses steps A1 - A7)  Input declined (uses prior fix for reference)	IDENT	<input type="checkbox"/> R/S  <input type="checkbox"/> R/S	LEG RADIAL? LEG RADIAL?
A10	Input radial from the reference fix  Input declined - go to step A1	DD.dd	<input type="checkbox"/> R/S  <input type="checkbox"/> R/S	LEG DIST? IDENT
A11	Input distance from reference fix	NM	<input type="checkbox"/> R/S	Return to the original step
	Explanation:			
	DD - Degrees			
	MM - Minutes of a degree			
	SS - Seconds of a degree			
	dd - Decimal fraction of a degree			

# PROGRAM LISTING

■ 41C

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
01	*LBL "RNAV"		49	CLA	
02	CF 05		50	ARCL 10	
03	CF 06	Initialize	51	"+ TO WP?"	
04	CF 09		52	CF 23	
05	SF 21		53	XEQ 03	Coordinates
06	CF 29		54	FC? 23	Waypoint declined?
07	DEG		55	GTO 01	
08	ADV		56	"WP:"	
09	"FROM?"	Departure point	57	ARCL 06	
10	SF 08		58	ASTO 06	
11	SF 23		59	XEQ 10	$\theta^V$
12	XEQ 03	Coordinates	60	STO 02	
13	CF 08		61	180	
14	CLX		62	+	$\theta^V$
15	STO 15		63	90	
16	RCL 06		64	RCL 00	$\emptyset$
17	STO 14	Departure identifier	65	RCL 02	
18	FC?C 07	Fix not a waypoint?	66	-	$\alpha^{WP}$
19	XEQ 11	Prompt for terminal WP	67	1	
20	FIX 0		68	P-R	$-180^\circ \leq \alpha^{WP} \leq 180^\circ$
21	*LBL 20	PRIMARY LEGS	69	R-P	
22	ADV		70	RDN	
23	CLA		71	X<0?	
24	ARCL 06		72	SF 05	
25	ASTO 10		73	ABS	$ \alpha^{WP} $
26	"+ TO?"		74	STO 02	
27	CF 23		75	-	$\beta^{WP}$
28	XEQ 03	Coordinates	76	X<=0?	WP behind starting fix?
29	FC? 23	Input declined?	77	GTO 21	
30	GTO 22		78	STO 03	
31	XEQ 10	True course & distance	79	FC?C 05	
32	STO 00	$\emptyset$	80	CHS	
33	RCL 02	Distance	81	+	
34	RND		82	RCL 11	$VAR^V$
35	ST+ 15	Distance sum	83	+	Waypoint radial
36	STO 05	Leg distance	84	X<> 03	$\beta^{WP}$
37	RCL 11		85	SIN	
38	STO 16	Store the primary leg's	86	RCL 01	$\sin d^V$
39	RCL 12	ending fix	87	*	
40	STO 17		88	ASIN	
41	RCL 13		89	60	
42	STO 18		90	*	
43	RCL 06		91	RND	L
44	STO 19		92	RCL 05	
45	$\emptyset$		93	X<=Y?	WP beyond ending fix?
46	STO 04		94	GTO 21	
47	SF 09	Waypoints being computed	95	X<>Y	
48	*LBL 21	SECONDARY LEGS	96	RCL 04	

# PROGRAM LISTING

■ 41C

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
97	X>Y?	WP behind last WP?	145*	LBL 02	LEG OUTPUT Subroutine
98	GTO 21		146	-	
99	RDN		147	STO 12	Leg distance
100	ENTER↑	L	148	CLA	
101	X<> 04	Last L	149	ARCL 10	
102	XEQ 02	Output Leg data	150	FC? 55	
103	ADV		151	GTO 00	
104	FIX 1		152	ACA	
105	CLA		153	CLA	
106	ARCL 06		154	SF 13	
107	XEQ 15	Output WP identifier	155	" T0 "	Identifiers
108	CLA		156	ACA	
109	RCL 03	WP radial	157	CF 13	
110	XEQ 12	Azimuth format	158	CLA	
111	"f, "		159*	LBL 00	
112	RCL 02	$\alpha^{WP}$	160	FC? 55	
113	SIN		161	"f--"	
114	RCL 01	Sin d <sup>v</sup>	162	ARCL 06	
115	*		163	XEQ 15	Output
116	ASIN		164	"MC="	
117	00		165	RCL 00	∅
118	*	WP radial distance	166	RCL 07	VAR'
119	ARCL X		167	+	MC'
120	"f NM"		168	STO 13	
121	XEQ 15	Output WP data	169	XEQ 12	Azimuth format
122	RCL 11		170	RCL 13	MC'
123	STO 07	VAR update	171	RCL 00	∅
124	ADV		172	RCL 11	VAR
125	FIX 0		173	+	MC
126	RCL 06		174	X*Y?	
127	STO 10		175	"f/"	
128	GTO 21		176	X*Y?	Variation changed?
129*	LBL 01		177	XEQ 12	Azimuth format
130	CF 09		178	XEQ 15	Output magnetic course
131	RCL 16		179	"DIST="	
132	STO 11	VAR update	180	ARCL 12	Leg distance
133	RCL 19		181	"f NM"	
134	STO 06		182	GTO 15	Output leg distance
135	RCL 05		183*	LBL 03	
136	RCL 04		184	13	COORDINATE INPUT
137	XEQ 02	Output leg data	185	FS? 00	Subroutine
138	RCL 11		186	9	
139	STO 07	Last leg's ending fix	187*	LBL 04	
140	RCL 17	becomes the new leg's	188	STO 01	
141	STO 08	starting fix.	189*	LBL 05	
142	RCL 18		190	AOH	
143	STO 09		191	PROMPT	
144	GTO 20		192	AOFF	

# PROGRAM LISTING

■ 41C

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
193	FC? 23	Input declined?	241	RCL IND 02	
194	RTH		242	X=Y?	
195	FC? 09		243	GTO 00	
196	CF 07		244	ISG 02	
197	ASTO 06		245	GTO 07	
198	20.03403		246	RTH	
199	STO 02		247*LBL 00		COORDINATE DECODE Subroutine
200	STO 03		248	SF 05	
201	XEQ 07	Data search	249	I	
202	FS?C 05	Data found?	250	ST+ 02	
203	RTH		251	RCL IND 02	
204	RCL 03		252	HR	
205	STO 02		253	STO IND 01	
206	SF 25		254	DSE 01	
207	AON		255	I	
208	RDTAX	Prompt for data card	256	ST+ 02	
209	AOFF		257	RCL IND 02	
210	CF 25		258	FRC	
211	XEQ 07	Data search	259	LASTX	
212	FS?C 05	Data found?	260	INT	
213	RTH		261	ABS	
214	CF 22		262	I E4	
215	CLA		263	/	
216	ARCL 06		264	HR	
217	"I LAT?"	Latitude prompt	265	STO IND 01	
218	PROMPT		266	DSE 01	
219	CLA		267	RDN	
220	ARCL 06		268	100	
221	FC? 22	Input declined?	269	*	
222	GTO 09	Intersection coordinates	270	STO IND 01	
223	HR		271	RTH	
224	STO IND 01		272*LBL 09		INTERSECTION Subroutine
225	DSE 01		273	FC? 09	WP or Reference fix?
226	CLA		274	FS? 06	
227	ARCL 06		275	GTO 03	
228	"I LNG?"	Longitude prompt	276	RCL 07	Prior fix coordinates to be used for the reference fix.
229	PROMPT		277	STO 11	
230	HR		278	RCL 08	
231	STO IND 01		279	STO 12	
232	DSE 01		280	RCL 09	
233	CLA		281	STO 13	
234	ARCL 06		282	RCL 06	
235	"I VAR?"	Magnetic Variation prompt	283	STO 16	
236	PROMPT		284	SF 06	Reference fix flag
237	STO IND 01		285	CF 23	
238	RTH		286	I3	
239*LBL 07		DATA SEARCH Subroutine	287	"NEED FIX?"	Prompt for reference fix if not prior fix
240	RCL 06		288	XEQ 04	

# PROGRAM LISTING

■ 41C

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
289	CF 06		337	RCL 13	
290	RCL 16		338	SIN	
291	STO 06		339	RCL 09	
292	"FIX RADIAL?"	Prompt for radial $\phi$	340	SIN	
293	PROMPT		341	*	Sin LAT Sin LAT'
294	CLA		342	STO 01	
295	ARCL 06		343	RCL 13	
296	SF 23		344	COS	
297	FC? 22	Input declined	345	RCL 09	
298	GTO 03		346	COS	
299	RCL 11		347	*	Cos LAT Cos LAT'
300	FS? 08	Departure fix?	348	STO 02	
301	STO 07		349	+	
302	-		350	ACOS	
303	STO 01		351	SIN	Sin a
304	"FIX DIST?"	Prompt for distance	352	RCL 13	
305	PROMPT		353	RCL 09	
306	60		354	-	
307	/	d	355	SIGN	+ Northerly
308	SIN		356	*	- Southerly
309	STO 02	Sin d	357	RCL 02	
310	RCL 01	$\phi$	358	RCL 12	
311	SIN		359	RCL 08	
312	*		360	-	
313	ASIN		361	X<0?	
314	RCL 01		362	SF 05	Easterly
315	COS		363	COS	
316	RCL 02		364	*	
317	*		365	RCL 01	
318	ASIN		366	+	
319	RCL 13	LAT'	367	ACOS	d
320	+		368	SIN	Sin d
321	STO 13	LAT	369	STO 01	
322	FS? 08	Departure fix?	370	LASTX	
323	STO 09		371	60	
324	LASTX		372	*	DIST
325	+		373	STO 02	
326	2		374	RDN	
327	/		375	/	
328	COS		376	ASIN	$\alpha$
329	/		377	FS? 05	
330	ST- 12		378	CHS	
331	RCL 12	LONG	379	90	
332	FS? 08		380	+	
333	STO 08		381	180	
334	SF 07		382	FS?C 05	
335	RTN		383	CLX	
336*LBL 10		TO & DEPARTING Subroutine	384	+	$\phi$

# PROGRAM LISTING

■ 41C

STEP/ LINE	KEY ENTRY	COMMENTS	STEP/ LINE	KEY ENTRY	COMMENTS
385	RTN		433	X>Y?	
386	*LBL 11	TERMINAL WAYPOINT	434	"F0"	
387	RCL 06	Subroutine	435	ARCL Y	
388	STO 10		436	FC? 55	
389	CLA		437	RTN	
390	ARCL 06		438	ACA	
391	"F WP?"	Terminal WP prompt	439	0	Degree Character
392	SF 09	Waypoint being computed	440	ENTER↑	
393	CF 23		441	BLDSPEC	
394	XEQ 03	Coordinates	442	6	
395	CF 09		443	BLDSPEC	
396	FC? 23	Terminal WP declined?	444	9	
397	RTN		445	BLDSPEC	
398	"WP:"		446	9	
399	ARCL 06		447	BLDSPEC	
400	ASTO 06		448	9	
401	CLA		449	BLDSPEC	
402	ARCL 10		450	6	
403	"F * "		451	BLDSPEC	
404	ARCL 06		452	ACSPEC	
405	XEQ 15	Output identifier	453	CLA	
406	CLA		454	RTN	
407	RCL 10		455	*LBL 22	Destination
408	STO 06		456	FC?C 07	Fix not a waypoint
409	XEQ 10		457	XEQ 11	Prompt for terminal WP
410	100		458	ADV	
411	+		459	CLA	
412	RCL 11		460	ARCL 14	
413	+		461	"F TO "	Terminal identifiers
414	FIX 1		462	ARCL 19	
415	XEQ 12	Azimuth format	463	AVIEW	
416	"F, "		464	FIX 0	
417	RCL 02		465	"T/DIST "	
418	ARCL X		466	ARCL 15	Total trip distance
419	"F NM"		467	FS? 55	
420	GTO 15	Output waypoint data	468	"F NM"	
421	*LBL 12	AZIMUTH Subroutine	469	*LBL 15	OUTPUT Subroutine
422	360		470	FC? 55	
423	MOD		471	GTO 00	
424	X#0?	Degree format	472	ACA	
425	GTO 00		473	PRBUF	
426	LASTX		474	RTN	
427	+		475	GTO "RNAV"	
428	*LBL 00		476	*LBL 00	
429	100		477	AVIEW	
430	X>Y?		478	END	
431	"F0"				
432	SQRT				



Without Printer

---

If a printer is not going to be used, the program may be changed in order to reduce program size and running time. Total registers needed is 145.

Whenever a line is deleted or inserted it will change the line numbering for every line that follows it. In order to maintain orientation with the Program Listing while changing the program, start at the end of the program and work forward.

The steps below start at the end of the program and complete the needed changes.

<u>Step</u>	<u>Command/Function</u>	<u>Comments</u>
1.	GTO• 477 ← PROMPT	Delete AVIEW Insert PROMPT
2.	GTO• 467 DEL 010	Delete lines 467 thru 476
3.	GTO• 463 ← PROMPT	Delete AVIEW Insert PROMPT
4.	GTO• 458 ←	Delete ADV
5.	GTO• 436 DEL 018	Delete lines 436 thru 453
6.	GTO• 420 ← PROMPT RTN	Delete GTO 15 Insert PROMPT Insert RTN
7.	GTO• 405 ← PROMPT	Delete XEQ 15 Insert PROMPT
8.	GTO• 182 ← PROMPT RTN	Delete GTO 15 Insert PROMPT Insert RTN

Without Printer

(CONTINUATION PAGE)

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<u>Step</u>	<u>Command/Function</u>	<u>Comments</u>
9.	GTO. 178 ← PROMPT	Delete XEQ 15 Insert PROMPT
10.	GTO. 163 ← PROMPT	Delete XEQ 15 Insert PROMPT
11.	GTO. 150 DEL 011	Delete lines 150 thru 160
12.	GTO. 124 ←	Delete ADV
13.	GTO. 121 ← PROMPT	Delete XEQ 15 Insert PROMPT
14.	GTO. 107 ← PROMPT	Delete XEQ 15 Insert PROMPT
15.	GTO. 103 ←	Delete ADV
16.	GTO. 022 ←	Delete ADV
17.	GTO. 008 ←	Delete ADV
18.	GTO. 005 ←	Delete SF 21

Without Card Reader

---

If a card reader is not going to be used, the program may be changed in order to reduce program size and running time. Total registers needed is 131; size will be 20.

Whenever a line is deleted or inserted it will change the line numbering for every line that follows it. In order to maintain orientation with the Program Listing while changing the program, start at the end of the program and work forward.

The steps below start at the end of the program and complete the needed changes.

<u>Step</u>	<u>Command/Function</u>	<u>Comments</u>
1.	GTO• 239 DEL 033	Delete lines 239 thru 271
2.	GTO• 216 ← ←	Delete line 216 Delete line 215
3.	GTO• 198 DEL 016	Delete lines 198 thru 213

Without Printer and Card Reader

---

If neither a printer or card reader is going to be used the program size and running time can be greatly reduced. The total registers needed will be 117 and the size needed is 20.

In order to make the changes easily and maintain orientation with the Program Listing, start making the changes as listed in RNAV Appendix A and continue through step 7. When you finish making the change in step 7 make the changes listed in RNAV Appendix B. Then go back to RNAV Appendix A and continue making the changes starting with step 8.

The steps are listed below:

RNAV Appendix A	Steps 1 thru 7
RNAV Appendix B	All the steps
RNAV Appendix A	Steps 8 thru 18

## Home Base Fix

If you would like to program in a fix, such as the home base, on a permanent basis it is suggested that the following subroutine (LBL 06) be inserted after line 238. For illustration the Municipal Airport at Jonesboro, AR will be used, and its coordinates and identifier will be in parenthesis. That fix is: JBR, 35°49'52"N, 90°38'47"W, 4°E.

<u>Step</u>	<u>Command/Function</u>	<u>Comments</u>
1.	GTO• 238	
2.	LBL 06	Insert the subroutine
	RCL 06	
	(JBR)	Fix identifier
	ASTO Y	
	CLA	
	ARCL 06	
	X ≠ Y?	
	GTO 07	
	10	
	STO 02	
	(35.4952)	Fix latitude
	STO 11	
	(-903847.04)	Fix longitude & magnetic variation*
	STO 12	
	GTO 08	
3.	GTO• 201	
	←	Delete XEQ 07
	XEQ 06	Insert XEQ 06

\*NOTE: Longitude & magnetic variation format is ±DDMMSS.MV where:

±: sign of the magnetic variation  
 DD: degree of longitude  
 MM: minutes of longitude  
 SS: seconds of longitude  
 MV: degree of magnetic variation

## Degree Format

The HP-41C/CV computes angles which are given in degrees in the decimal degree format. This format is in degrees and fraction of a degree (DD.FD). The program needs the coordinates to be given in degrees, minutes, and seconds (DD.MMSS), which are changed to the decimal degree format with the HR function. This is done in lines 223 and 230 in subroutine LBL 05, and in lines 252 and 264 in subroutine LBL 08.

The Airport/Facility Directory, used in the United States, gives the coordinates in degrees, minutes, seconds. That is the reason the program uses that format. However, many use Jepp Charts and other publications which give the coordinates in a degree, minute, and fraction of a minute format (DD<sup>o</sup> MM.F" or DD.MMF) If this format is desired then insert the nine lines given below before each of the HR commands. This will convert the fraction of a minute to seconds so the HR command may then convert it to a decimal degree. If this program change is implemented and data cards used, then the coordinates are to be entered in the same format (DD.MMF) onto the data cards.

Program Lines

```

100
*
INT
LAST X
FRC
HMS
+
100
/

```

The lines above could be used as a subroutine. Add LBL 00 at the start of them and RTN at the end. Insert all eleven lines before LBL 09 (between lines 271 and 272). Insert XEQ 00 before each of the four HR commands.

## Negative Longitude

---

If a card reader is used and if the longitudes are negative, the present card storage format will have a problem. On the cards, the longitude and magnetic variation are combined, with the sign being that of the variation.

In the Data Record Appendix changes are suggested that will solve the problem. If those changes are made then the following changes need to be made in the RNAV program. The register size will be 36 and total registers needed will be 158.

<u>Step</u>	<u>Command/Function</u>	<u>Comments</u>
1.	GTO• 267 DEL 003	Delete lines 267 thru 269
2.	1 ST-02 RCL IND 02	Insert commands to recall the magnetic variation
3.	GTO• 258 DEL 006	Delete lines 258 thru 263
4.	GTO• 198 ← 20.03504	Delete the old counter value Insert the new counter value

# PROGRAM DESCRIPTION I

Program Title DATA RECORD (DR)  
Contributor's Name ROBERT A. TIMS  
Address P.O. Box 643  
City State University State/Country Arkansas Zip Code 72467

**Program Description, Equations, Variables** This program encodes the navigation fix data and writes it on a magnetic card. The data includes the identifier, latitude, longitude, and the magnetic variation.

The data may be viewed for correctness and change after it has been inputted and written on the card.

If a card track is loaded by the normal mode, the data may be viewed by declining input on the first prompt. Anytime during the program that a prompted Identifier is declined, the program will proceed to view the remaining data. After the program has prompted for all the data, it will write the data on a card track. After it has written the data it will then allow the data to be viewed. When the data is viewed it may be corrected by inputting the correct data and continuing. Viewing may be terminated during any display without changing storage register contents.

**Necessary Accessories** Card Reader

**Operating Limits and Warnings** It is recommended that the data be viewed for correctness 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.

**Reference(s)** 82104A Card Reader Owner's Handbook

This program has been verified only with respect to the numerical example given in Program Description II. User accepts and uses this program material AT HIS OWN RISK, in reliance solely upon his own inspection of the program material and without reliance upon any representation or description concerning the program material.

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# 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 navaid identifier to show that it is a vortac and not an airport. View data for correctness.

McGhee Tyson airport	TYS	35°48'45"N	83°59'34"W	1°W
Knoxville VORTAC	TYS	35°54'17"N	83°53'41"W	1°W
Chattanooga VORTAC	CHA	34°57'40"N	85°09'12"W	1°E
Hinch Mountain VORTAC	HCH	35°46'51"N	84°58'43"W	1°E
Rocket VORTEC	RQZ	34°47'49"N	86°38'02"W	2°E
Shelbyville VORTAC	SYI	35°33'43"N	86°26'21"W	2°E
Muscle Shoals VORTAC	MSL	34°42'24"N	87°29'29"W	1°E
Muscle Shoals airport	MSL	34°44'43"N	87°36'37"W	1°E

**SOLUTION:**

Input	Function	Display	Comments
	XEQ DR	IDENT?	Facility identifier prompt
TYS	R/S	TYS LAT?	If input declined will view
35.4845	R/S	TYS LNG?	all the data groups.
83.5934	R/S	TYS VAR?	
1	R/S	IDENT?	If input declined will view next
TYSV	R/S	TYSV LAT?	four data groups.
35.5341	R/S	TYSV LNG?	Mistake!
83.5341	R/S	TYSV VAR?	
1	R/S	IDENT?	If input declined will view next
CHAV	R/S	CHAV LAT?	three data groups
34.574	R/S	CHAV LNG?	
85.0912	R/S	CHAV VAR?	
1	CHS	-1	Easterly variation
	R/S	IDENT?	If input declined will view next
HCHV	R/S	HCHV LAT?	two data groups.
35.4651	R/S	HCHV LNG?	
84.5843	R/S	HCHV VAR?	
2	CHS	-2	Mistake! (today is a Monday!)
	R/S	IDENT?	
RQZV	R/S	RQZV LAT?	If input declined will view the
34.4749	R/S	RQZV LNG?	last data group.
86.3802	R/S	RQZV VAR?	
2	CHS	-2	Easterly variation
	R/S	RDY 01 OF 01	Ready to write data card
	Insert Card	TYS	View data for correctness!
	R/S	TYS=35.4845	View latitude
	R/S	TYS=83.5934	View longitude
	R/S	TYS=1.0	View magnetic variation
	R/S	TYSV	View identifier
35.5417	R/S	TYSV=35.5341	Incorrect
	R/S	TYSV=83.5341	
	R/S	TYSV=1.0	
	R/S	CHAV	
	R/S	CHAV=34.5740	
	R/S	CHAV= 85.0912	

# PROGRAM DESCRIPTION II

SOLUTION: (CONTINUATION PAGE)

Input	Function	Display	Comments
	R/S	CHAV=-1.0	Continue viewing data for correctness
	R/S	HCHV	
	R/S	HCHV=35.4651	
	R/S	HCHV=84.5843	
	R/S	HCHV=-2.0	Incorrect
1	CHS	-1	Easterly variation
	R/S	RQZV	
	R/S	RQZV=34.4749	
	R/S	RQZV=86.3802	
	R/S	RQZV=-2.0	
	R/S	RDY 01 OF 01	Ready to write data card
	Insert Card	TYS	View data again
(20 steps not shown)	R/S	...all data viewed	and found to be correct
	R/S	RDY 01 OF 01	Data is correct, terminate program
	R/S	Not applicable	Clip card corner
	XEQ VER	CARD	Verify track #1
	Insert Card	TYPE: D TR 01	Track #1 content verified
	XEQ DR	IDENT?	Write track #2 of the data card
SYIV	R/S	SYIV LAT?	
35.3343	R/S	SYIV LNG?	
86.2621	R/S	SYIV VAR?	
2	CHS	-2	Easterly variation
	R/S	IDENT?	
MSLV	R/S	MSLV LAT?	
34.4224	R/S	MSLV LNG?	
87.2929	R/S	MSLV VAR?	
1	CHS, R/S	IDENT?	
MSL	R/S	MSL LAT?	
34.4443	R/S	MSL LNG?	
87.3637	R/S	MSL VAR?	
1	CHS, R/S	IDENT?	Decline input and leave the last two data groups as is.
	R/S	HCHV	
	R/S	HCHV=35.4651	
	R/S	HCHV=84.5843	
	R/S	HCHV=-1.0	
	R/S	RQZV	
	R/S	RQZV=34.4749	
	R/S	RQZV=86.3802	
	R/S	RQZV=-2.0	
	R/S	RDY 01 OF 01	Ready to write data card
	Insert Card	SYIV	View data for correctness
(20 steps not shown)	R/S	...all data viewed	and found to be correct.
	R/S	(terminate program,	clip card corner
	XEQ VER	CARD	Verify track #2
	Insert Card	TYPE: D TR 01	Track #2 verified
			Card is now ready to use in the RNAV sample problems



# PROGRAM LISTING

■ 41C

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



## Negative Longitude

In the continental United States the longitudes are positive numbers, therefore the longitude and magnetic variation are combined, with the sign being that of the variation. This way, three storage registers are used per fix, and five fixes may be stored per card track. In the case of negative longitudes this will not be usable.

The storage format may be changed as is convenient as long as the Coordinate Decode subroutine, LBL 08, in the RNAV program is changed accordingly. The following are some suggested changes to store the data using four registers per fix, one register each for the identifier and for the latitude, longitude, and magnetic variation with each of their associated signs. This format will allow four fixes per card track and will need a total of 41 registers.

The corresponding changes to the RNAV program are given in the RNAV Appendix F.

<u>Step</u>	<u>Command/Function</u>	<u>Comments</u>
1.	GTO• 092	
	DEL 011	Delete lines 92 thru 102
	STO IND 17	Insert this command
2.	GTO• 078	
	DEL 009	Delete lines 78 thru 86
3.	GTO• 074	
	DEL 003	Delete lines 74 thru 76
	STO IND 17	Insert these commands
	ISG 17	
	RCL IND 17	
4.	GTO• 065	
	DEL 004	Delete lines 65 thru 68
5.	GTO• 043	
	←	Delete old counter value
	•015	Insert new counter value
6.	GTO• 031	
	DEL 008	Delete lines 31 thru 38

Negative Longitude

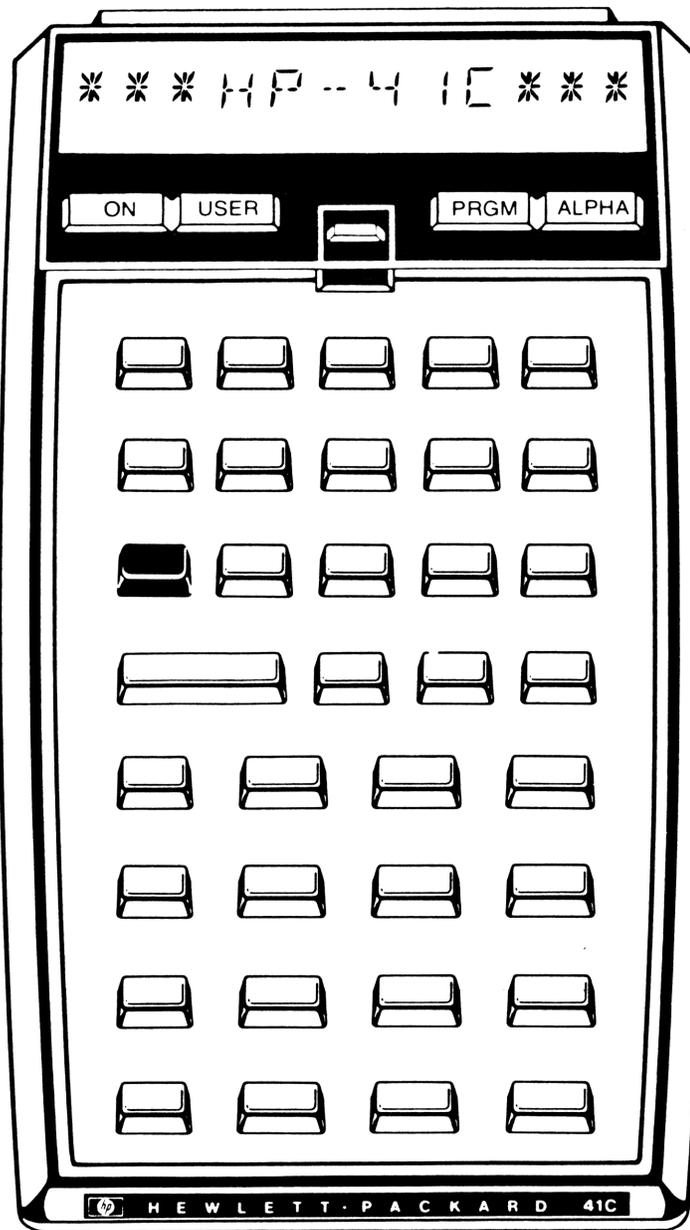
(CONTINUATION PAGE)

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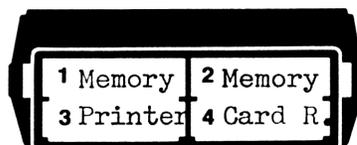
<u>Step</u>	<u>Command/Function</u>	<u>Comments</u>
7.	GTO• 026	
	←	Delete line 26
	←	Delete line 25
	STO IND 17	Insert these commands
	ISG 17	
8.	GTO• 002	
	←	Delete old counter value
	.015	Insert new counter value

# KEYBOARD CARD LABELING

KEYBOARD



SYSTEM  
CONFIGURATION



CARD

