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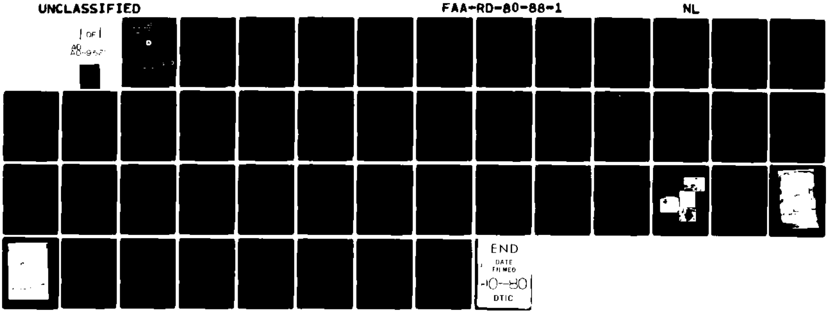

Report No. FAA-RD-80-88, I

LEVEL

RECOMMENDED SHORT-TERM ATC IMPROVEMENTS FOR HELICOPTERS. VOLUME I. SUMMARY OF SHORT-TERM IMPROVEMENTS.

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August 1980

Task Report

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Prepared for

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FEDERAL AVIATION ADMINISTRATION

Systems Research & Development Service

Washington, D.C. 20590

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16. Abstract
The recommended Short Term ATC Improvements for Helicopters are documented in three volumes, i.e.:

- Vol. I is a summary report of all improvements studied. Improvements are categorized as to those that can be recommended for immediate operational consideration or use and those that require limited short term simulation or test.

The recommendations for immediate use include: (1) Helicopter ATC training material, (2) Operational Description of LOFF, (3) Recommendations concerning military training routes and (4) Survey data for use in Gulf communications and route structure planning.

The recommendations for short term simulation include: (1) Dual waypoint holding patterns, (2) other holding patterns and (3) shortened entry procedures for intercepting final approach path.

- Vol. II is the complete training material for helicopter ATC. It contains major sections on Helicopter Capabilities and Limitations, on Helicopter Navigation and on Helicopter Control Procedures.
- Vol. III is the complete Operational Description of the Experimental Loran Flight Following (LOFF) in the Houston Area. It describes both airborne and ground components and states the objectives that are being sought in the experiment.

17. Key Words
Helicopter ATC, Helicopter Air Traffic Control, Helicopter ATC Controller Training, Loran Flight Following (LOFF) Helicopter Holding Patterns

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METRIC CONVERSION FACTORS

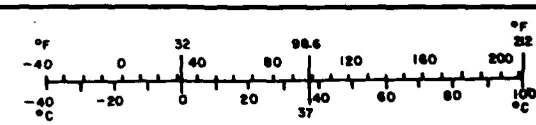
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liter	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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* This Document

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ACKNOWLEDGEMENT

The information and effort reflected in this report could not have been achieved without the cooperation and assistance of other Divisions of SRDS, the FAA Technical Center and the Transportation System Center. The FAA Headquarters, Regional and facility operations support received was essential to this effort. The cooperation and assistance received from the many trade associations, helicopter manufactures, helicopter operators and their respective regional associations as well as the various industries and public organizations using helicopter services was invaluable. These organizations provided time, facilities and other available resources to support the program manager and his staff in conducting this effort.

I wish to express my sincerest gratitude to all the above stated organizations and look forward to continued association with them during my continued involvement in the helicopter program.

Raymond J. Hilton
ATC Helicopter Program Mgr.

RECOMMENDED SHORT TERM IMPROVEMENTS FOR HELICOPTERS

SUMMARY OF SHORT-TERM IMPROVEMENTS

VOLUME I

1. Background

In May 1979 an initial study was completed on "Helicopter Air Traffic Control Operations" (Report No:FAA-RD-78-150). It was considered to be the first phase of work under the ATC task in the Helicopter Operations Development Plan.

The purpose of this document is to explore and analyze in greater depth the recommended helicopter ATC improvements that are short term in nature. This includes a review and further development of the short term improvements identified after the publication of that study. The ATC improvements addressed in this document fall in two categories, i. e.

a. Those that do not require further R&D and are appropriate to be considered for operational use or implementation.

b. Those that require some form of short term R&D simulation or testing before they can be recommended for operational use.

2. Short Term Helicopter ATC Improvements Recommended for Immediate Operational Consideration

In studying short term ATC improvements for helicopters it readily became apparent that one item had a far greater potential for early implementation than any other. This was a recommendation for the training of ATC controllers to better prepare them for controlling helicopters. Helicopter ATC training was generally accepted as an important objective and it could be developed, planned and instituted with very little delay. Accordingly, considerable emphasis was placed on the preparation of helicopter training material to be used in training controllers. Nevertheless, work and analysis was also performed in several other areas -- all of which are reported on herein. (Note: The ATC recommendations requiring short term R&D are contained in par. 3 below.)

a. Item (a). Helicopter ATC Training Program

(1) Helicopter growth trends and Operational Characteristics

Figures 1-1 and 1-2 show the past and projected growth of civil helicopters and helicopter operations in the U.S. They reflect the fact that helicopters are the fastest growing segment of civil aviation.

It is particularly significant from an ATC viewpoint that by the end of the 1980's, at least 50 percent (about 7,000) of the combined business/ corporate helicopters in the U.S. will have an IFR capability. These trends reinforce the urgency to make adjustments in the ATC system that will enable the increased number of helicopters to be assimilated efficiently.

Until recently the number of helicopter operations was not of sufficent significance to be a problem from an ATC standpoint. Now, however, they are becoming a factor -- a factor that will become increasingly important in the years ahead.

Helicopters have a number of unique capabilities that have an important influence on ATC operations. Some of these characteristics constrain the efficient mixing of traffic. For example, on final approach, the generally slower speeds of helicopters prevent orderly spacing with high speed aircraft and result in decreased runway capacity.

Other characteristics provide a measure of flexibility that assists in traffic efficiency. An example of this is the ability of the helicopter to hover-taxi. After making an approach to a minimum descent altitude or decision height, the helicopter can proceed directly to a helipad and

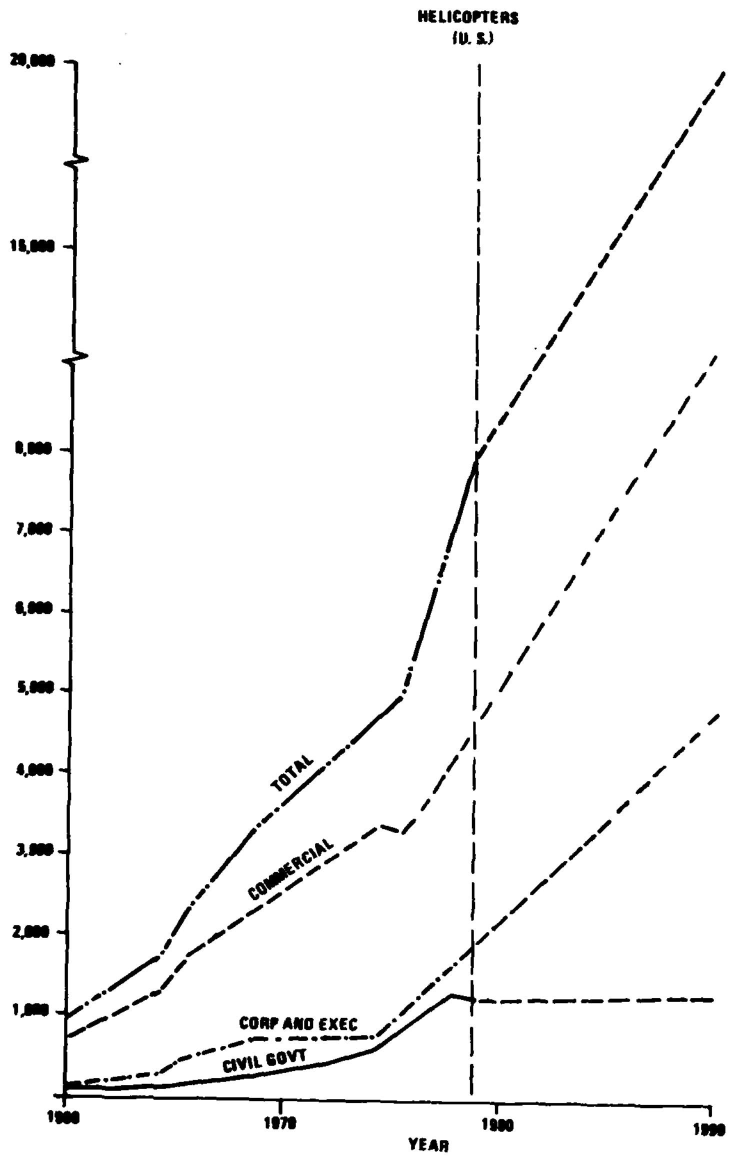


Figure 1-1

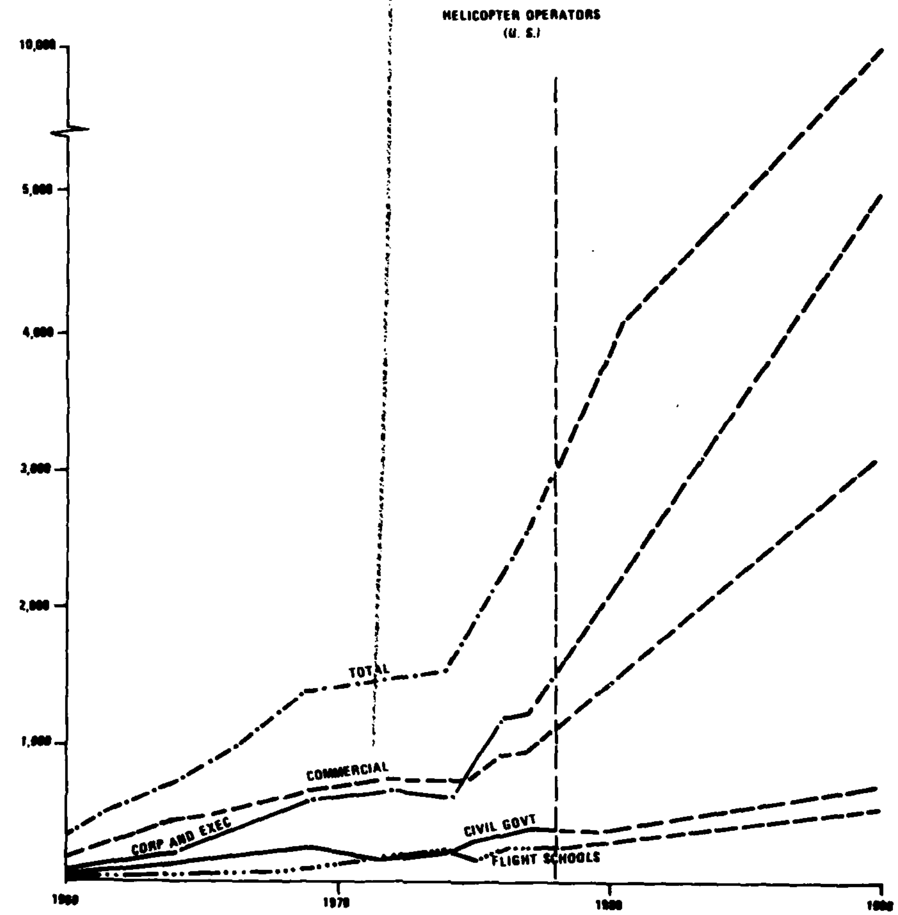


Figure 1-2

therefore have zero runway occupancy time. Nevertheless, studies performed to date indicate that, in general, it is desirable to segregate helicopters from airplanes in the terminal area whenever it is possible to do so. Even in the enroute area, it appears that in many circumstances such as the Northeast Corridor, it will be desirable to establish separate helicopter routings.

Potentially, helicopters have the ability to navigate to and land on virtually any portion of the earth that has a flat surface not much larger than the helicopter's rotor diameter. As a result, the NAS will eventually have to provide the services of navigation, communications, and surveillance to many places where these services were not needed before. Already the requirements of offshore helicopter operators have indicated the need for these services beyond the coverage now provided by shore based radars, VOR's and VHF Communications. Similarly, helicopter operations in the Appalachian area (which is representative of remote areas generally) have shown that an urgent need exists for traffic separation, navigation and communications at the low altitudes in mountainous areas. Even in the Northeast Corridor, the use of VOR/DME to establish the reduced airway widths of four miles requires closely spaced waypoints which tend to increase pilot workload. Eventually an accurate navigation system having broad area coverage to low altitudes will be needed.

The low speed and good maneuverability of the helicopter enable it to maintain visual reference to the ground under worse weather conditions than can be done by conventional airplanes. While greater advantage should be taken of this capability, doing so will aggravate what is perhaps the most difficult and hazardous problem of aviation today, namely the separation of

IFR and VFR traffic. Additional studies are needed to prescribe routings or procedures for helicopters in such circumstances so that safety is assured.

(2) Recommended Helicopter ATC Training Material

The Helicopter ATC Training Program was instituted as a means of providing information to traffic controllers on the unique capabilities and characteristics of helicopters that have an impact on Air Traffic Control. A primary element of the program is the Recommended Helicopter ATC Training Material which has been prepared as a part of the task to examine short-term ATC improvements. A copy of that document is attached as Volume II.

The main topical headings of the manual are listed below:

RECOMMENDED HELICOPTER ATC TRAINING MATERIAL

SECTION 1 BACKGROUND

SECTION 2 HELICOPTER CAPABILITIES AND LIMITATIONS

Introduction
Size
Controls
Ground Operations and Hover Taxiing
Height/Velocity Diagram
Takeoff
Transition and Climbout
Cruising Speed
Cruising Altitude
Range
Wind
Icing
Holding
Speed Control
Descent
Settling with Power
Landing
Shutdown or Startup
Emergencies
- Autorotation
- Tail Rotor Failure
- Choice of Landing Site

Noise Abatement
Conclusion
Acknowledgements

SECTION 3 HELICOPTER NAVIGATION

LORAN C
- Introduction
- Principles
- Geometrical Considerations
- Variable Errors
- Fixed Errors
- Weather Effects
- Warning Signals
- Avionics
- Transmitter Failure
- Receiver

LOFF (LORAN Flight Following)
- Operating Concept
- Objectives
- Airborne Components
- Communications Links
- Ground Equipment
- Conclusions

Omega/VLF

Airborne Radar (ARA)
- Weather Avoidance
- Navigation
- ARA Approach Concepts
- Single Platform Approach
- Platform Cluster Approach

TACAN

SECTION 4 HELICOPTER CONTROL PROCEDURES

Terminal Procedures
- General
- HSVFR
- IFR Arrivals
- Sequential Approaches on Common Path to Airport
- Sequential Approaches on Different Paths to Airport
- Simultaneous Approaches on Different Paths to Airport
- Approaches to Heliport
- Missed Approaches
- IFR Departures

Enroute Control

SECTION 5 TRAINING RECOMMENDATIONS

(3) Recommendation

The training material (Volume II) is recommended as an item that can be used immediately to improve the air traffic control of helicopters. It can be used either as a text for controllers or as a basis for the preparation of lesson plans if the material is to be presented by an instructor.

b. Item (b). Loran Offshore Flight Following (LOFF)

(1) Background

The LOFF system can be considered from two viewpoints. From one viewpoint, it is an experimental system that is currently being implemented. The experiment will be used to examine the LOFF system's capability to perform certain flight following functions. From the second viewpoint LOFF is the first stage of an evolving ATC concept for helicopters in the Gulf that will explore the possibility of using aircraft reported position information as a tool for providing traffic separation and control by ATC centers. As a flight following system, LOFF is discussed in this task report. As a system to be used for traffic separation and control it is discussed in a separate document titled: Gulf of Mexico Helicopter ATC Concept

The management of the LOFF project is outlined below:

(a)	Project management	ARD-300
(b)	Concept Description and Report	Vitro
(c)	Loran-C interface definition	Offshore Navigations, Inc.
(d)	Communication design	Aeronautical Radio, Inc.
(e)	Data processing, display and software development	Transportation Systems Center
(f)	Installation and operation	Southwest Region (with ARD and TSC support)

This discussion reports on the work prepared under paragraph (b) above.

(2) LOFF System

The material below is a summarized version of a more complete description of LOFF provided in a separate document titled: Operational Description of Experimental Loran Flight Following (LOFF) in the Houston Area. A copy of the LOFF document is documented as Volume III of this report.

(a) General

The fundamental concept of LOFF is to provide a pictorial display of helicopter traffic in the Gulf. Furthermore, this will be done at one center (i.e., Houston) where a single sector will be established to monitor all offshore helicopter traffic at 10,000 feet and below.

The system is intended to be used initially only by IFR helicopters. Each participating aircraft will transmit the position data received by Loran-C to the ATC Center. These transmissions will include the identification of the aircraft. They will be processed by a special computer at the Center and appear on a separate PPI display. This display will enable the Center to see each participating aircraft in relation to the Gulf offshore route structure.

In the aircraft, the experimental LOFF system will use LORAN-C data from the TDL-711 LORAN-C receiver. Outputs will be in the form of time differences (TD's), which will be fed to an interface box which stores the aircraft identification code and the latest LORAN-C navigation data, for automatic transmission over one of the aircraft VHF transmitters. A digital message will be sent whenever a trigger pulse is received from a clock circuit in the interface box. The basic message repetition rate will be controllable, and will be randomized to reduce garble. Each message will require about ¼ second to transmit.

A chart showing the functional concept of LOFF is shown in Figure 1-3. A representation of the display in the ATC center is shown in Figure 1-4.

(b) Communications

The Southwest Region of the FAA is planning for the installation of several remote VHF outlets on strategically located offshore platforms, plus some improved and additional RCAG facilities on shore. The offshore FAA facilities will be connected to shore facilities via microwave relays owned by the petroleum industry; the shore facilities will be linked to the Houston Center via land lines. Completion of this network will not only provide the necessary channels for LOFF transmissions, but will initiate the much-needed capability for direct ATC air/ground communication between the Houston Center and helicopters operating beyond the horizon, in the offshore area.

(c) Route Structure

Since LOFF is in the experimental phase, it will not be the basis for any fundamental change in the Gulf of Mexico offshore route structure.

(d) LOFF Objective

LOFF is being installed initially as an experimental system. Accordingly, it cannot be used operationally to provide traffic separation and control. Nevertheless, there are several specific objectives for the experiment and there will clearly be some corollary benefits to ATC controllers in Houston Center. The main objectives are:

- Assurance of Navigation System Integrity. An important objective of the LOFF test program will be to monitor the integrity of the

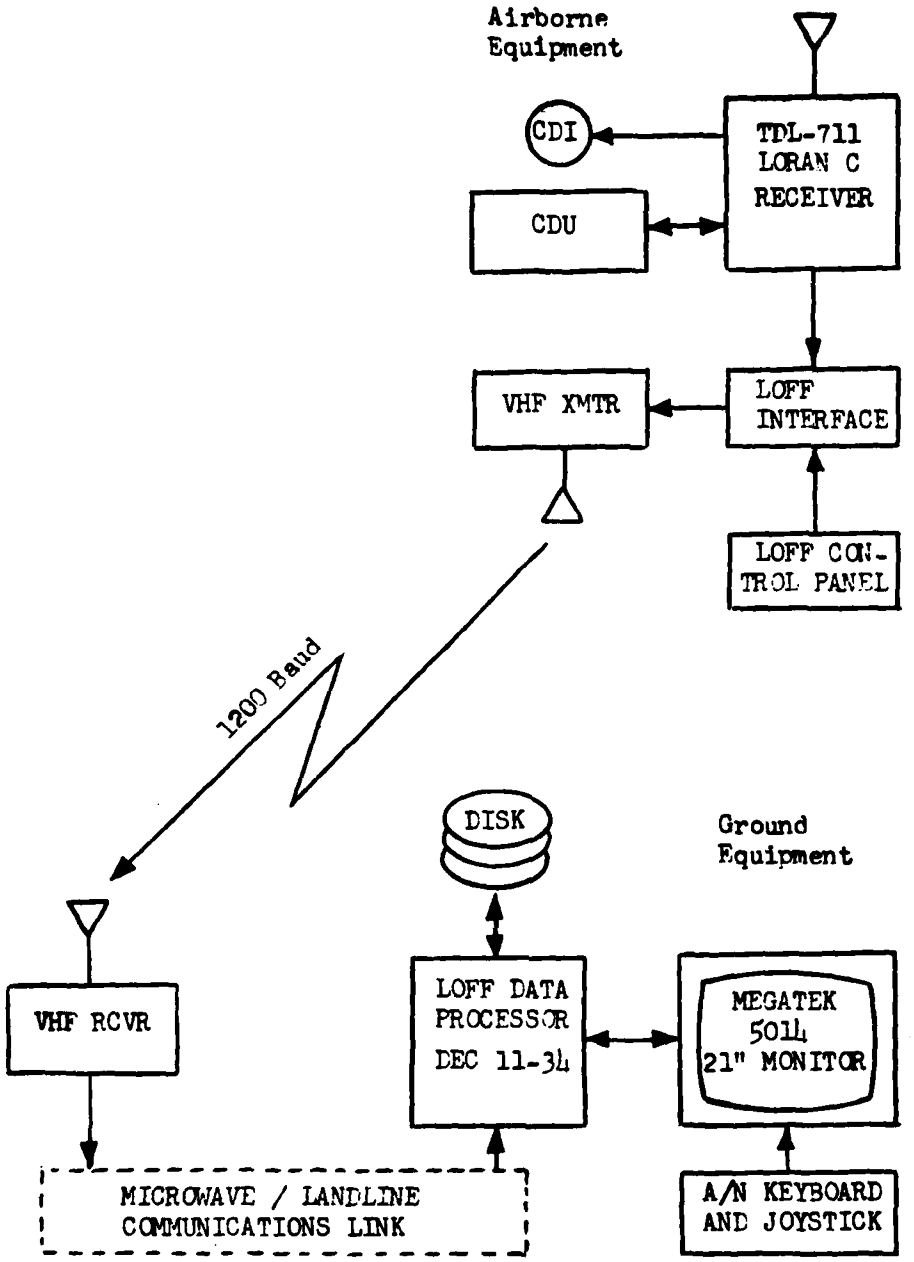


FIGURE 1-3 LOFF Concept

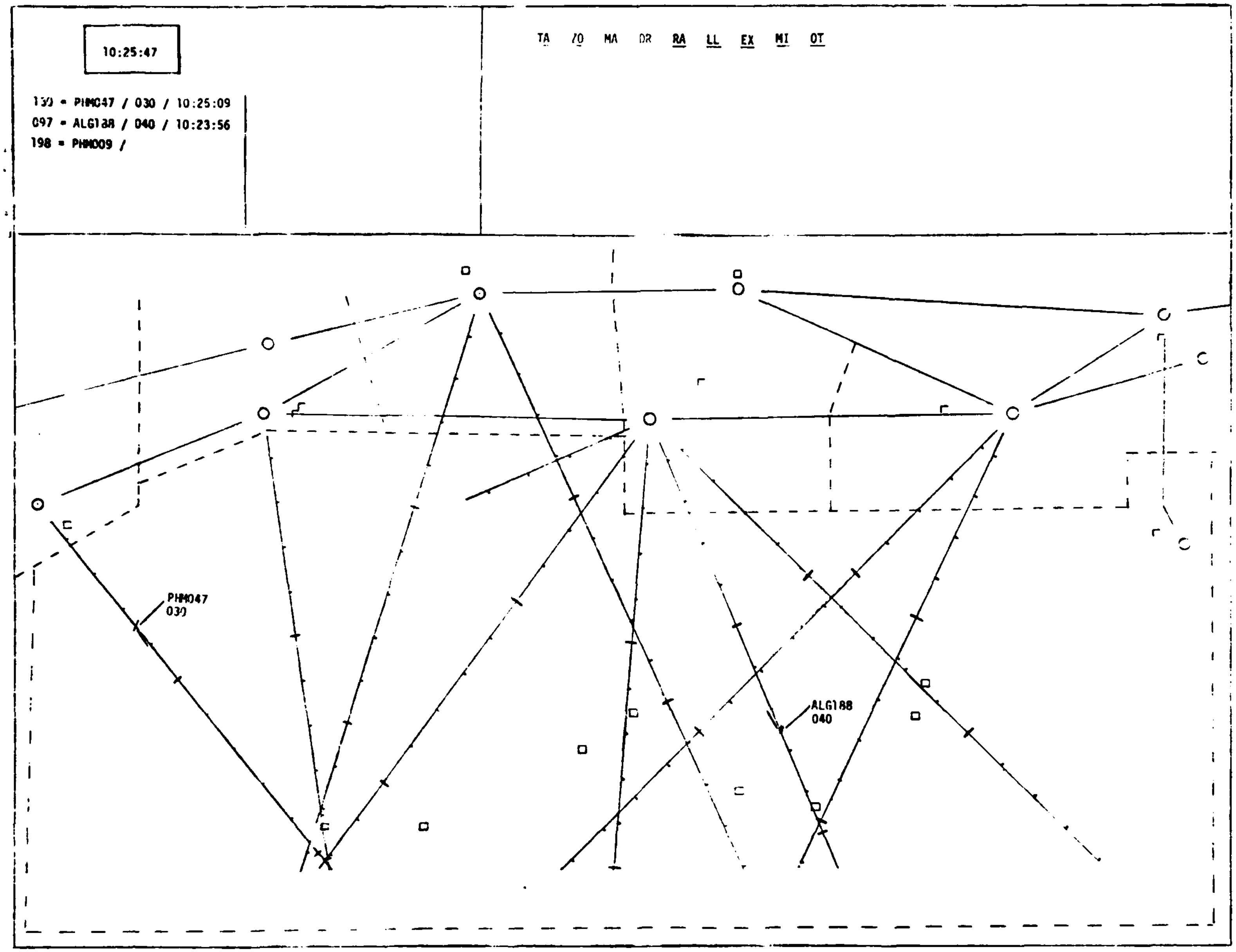


FIGURE 1-4. TYPICAL LOFF DISPLAY

- Increased Safety. By being able to display the intended routes as well as the targets, LOFF will enable controllers to detect any navigational errors before they become critical. Other safety advantages are the ability to expedite medevac missions on direct routes, and to enhance search and rescue missions by the ability to record and recall the last reported position of an aircraft in distress and to guide other aircraft to the same position.
- Increased Flexibility. LOFF will provide the controller with a new degree of flexibility by being able to call up and display additional routes for off-airway traffic. These routes can be displayed on an as-needed basis, and erased instantly when not needed. This capability will be especially useful in handling special flights such as Medevac or Coast Guard operations.
- Enhancement of Procedural Control. Although it is intended that offshore traffic will continue to be controlled using procedural separation standards, the use of LOFF as a visual aid should enable controllers to make optimum use of such standards by being able to exploit situations which might not be immediately obvious from scanning the flight progress strips alone.
- Reduction of Controller Workload. LOFF will provide the controller with a graphic (CRT) display of aircraft identify, altitude, and position, along with the route structure being used. This will enable the controller to analyze the traffic situation much more quickly and with less mental effort, than from tabular information on the flight progress strips. The time savings per aircraft can be used for improved planning, or for greater sector capacity.

- Assessment of LOFF Feasibility. An underlying objective of the LOFF experiment is to explore the feasibility of using aircraft-derived position information for traffic control purposes in instances where radar surveillance cannot be provided.

(e) Air Traffic Control

Although LOFF will provide the benefits listed above as objectives, no fundamental changes in traffic control criteria are planned during LOFF experiment. Air Traffic Control will continue to be conducted strictly in conformance with procedural disciplines published in the Air Traffic Control Manual (FAA Order 7110.65B).

(3) Recommendation

Volume III of this report (i.e., Operational Description of Experimental Loran Flight Following (LOFF) in the Houston Area) prepared under this contract task, is a current and valid description of LOFF and can be appropriately distributed to those interested in the LOFF system.

c. Item (c), Military Training Routes (MTR)

(1) Background

Military training routes are corridors of low altitude airspace used by the Air Force for low level, high speed training flights. Over the past year or two there has been a growing concern about the potential conflict between the MTR flights in the Appalachian area with the flights at low altitude of the many helicopters in that area. Such routes are deliberately placed in remote areas because of the need to avoid noise problems. However, the 100 or more helicopters presently based in the

Appalachian Region do much of their flying in and across these routes and hence a potential traffic conflict exists. There have been several near misses which have required evasive action on the part of the pilots. Some means of warning helicopter pilots of approaching high-speed aircraft is desired.

Normally, pilots can obtain information on the activity status of any Military Training Route by contacting the appropriate ATC Center (for IFR operations) and Flight Service (for IFR operations). Helicopter radio communication with FAA facilities is often difficult or impossible because of the low cruising altitude puts the helicopter beyond line of sight from the ground antenna.

(2) Studies Conducted

One early suggestion that was made was to print military routes on aeronautical charts so civil pilots would at least know where to watch out for low-flying jets. There has been acceptance of this idea and the first such chart (S. E. region) was published in the spring of 1980.

Another proposal was to install automatic recorders at flight service stations, and connected to toll-free lines, so that helicopter pilots could call the station before takeoff and receive the latest status report on the military training route of interest to the pilot. This suggestion is diagrammed in Figure 1-5. However, Appalachian Helicopter pilots have stated that this would not be a practical solution for them because they often land at coal mines and other remote sites which may be several miles from a telephone.

Two other proposals have been developed which are based on the concept that the military aircraft (which are doing contour flying at extremely low altitudes) can use their airborne mapping radar. The proposal would be to install a number of repeater stations at intervals along the designated military training routes. This proposal is illustrated in Figure 1- 6.

The warning station would receive the radar interrogations of an approaching military aircraft. Such reception could be very brief, as the aircraft may be engaged in contour flying, spending a minimum amount of time above the ridges. Therefore, the signal generated by the warning station should be extended to a minimum of 15 seconds. The warning signal would be broadcast by a low powered VHF transmitter with a maximum range of 20 miles.

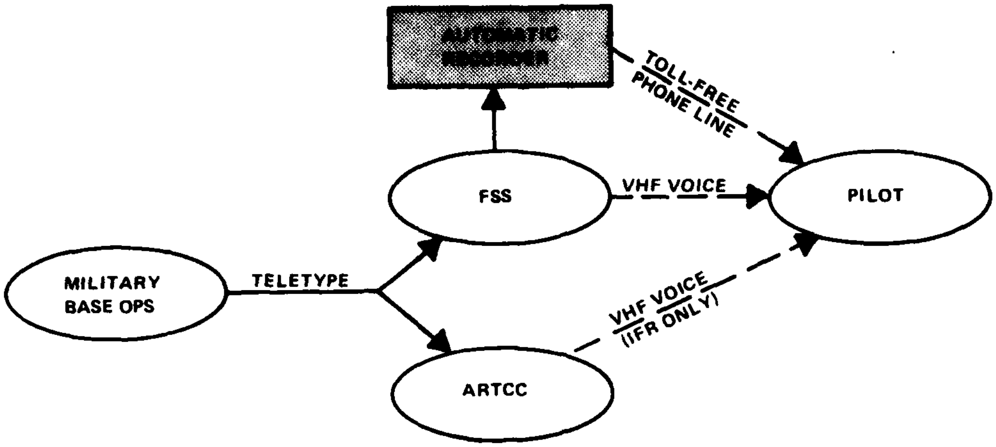


Figure 1-5. Automatic Recorder

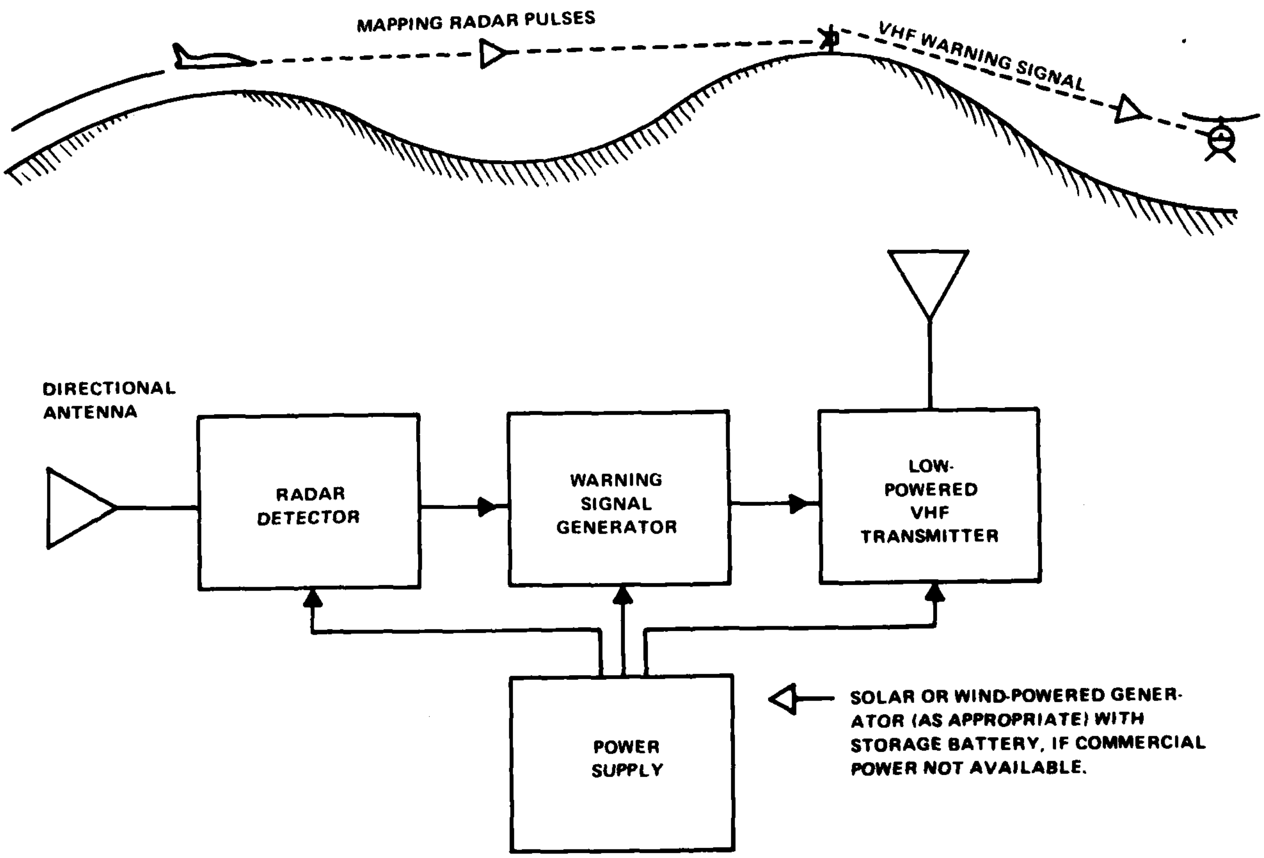


Figure 1-6. Automatic Warning Station

It is visualized that the entire warning station would be enclosed in a small weatherproof cabinet, pole mounted on high ground, for best coverage of its very localized broadcast area. Such stations would be spaced 10-15 miles apart on the centerlines of military training routes.

It is anticipated that in very remote locations, where it was not feasible to install commercial power, warning systems would be powered by their own wind generator or solar collector, using battery storage.

One advantage of this concept is that no additional equipment would be required in the helicopter, as the warning signal could be a warbling tone signal imposed on an existing VHF channel. Another advantage is that in mountainous country, a helicopter could receive a warning signal even though it was not within line-of-sight of the military aircraft. The disadvantage of this concept is that a very large number of warning stations would be required to instrument all the domestic military routes. The implementation costs are probably prohibitive.

An alternate proposal would not require any warning stations but would simply install a radar detector in each helicopter, using the same techniques presently used for "Fuzzbuster" radar detectors presently sold for automobiles. This proposal is shown in Figure 1-7.

Because the military aircraft could be approaching the helicopter from any direction, (from above or below) the antenna system should have spherical coverage. This might be possible by switching alternately between two antennas on the helicopter. The receipt of radar pulses would trigger off an audible warning signal and a visual display lasting at least 10 seconds. With a means of comparing the signal strength received from the two antennas, it might be possible to show the helicopter pilot whether the military aircraft was approaching from above, below, or from approximately the same level.

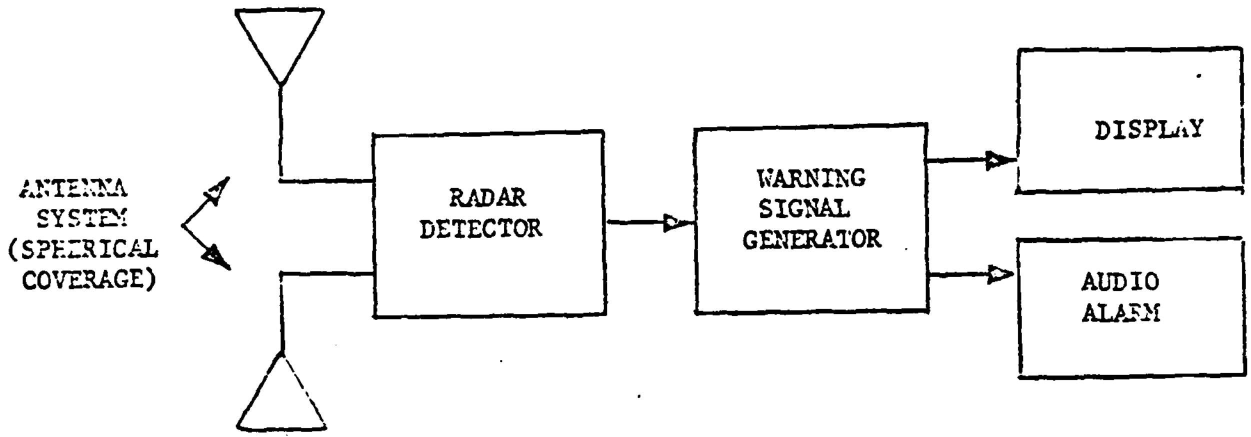


Figure 1-7. AIRBORNE FUZZBUSTER

The advantage of this concept is that it should work anywhere and that it would not entail the immense logistic problems associated with installing and maintaining hundreds of ground warning stations. The disadvantage of this concept is that it would require an investment in the equipment by the helicopter operator. It is believed that penalties associated with weight and power would be small.

Most of the candidate solutions to the MTR problem discussed above have been exposed to and by the Appalachian Helicopter Pilots Association. Aside from the obvious benefits of printing military training routes on aeronautical charts, the suggestions requiring some new equipment on the ground or in the aircraft were considered to be not feasible. The costs were high and the benefits marginal at best.

In view of this situation the Appalachian Helicopter Pilots Association aggressively pursued with the Air Force the possibility of improved operational procedures. This has resulted in a solution that, at least for the time being, is satisfactory both to the Air Force and Appalachian helicopter pilots. In essence, the Air Force will publish its routes 24 hours in advance and will specify precise schedules for take-off and major check points. Then, in flying the routes, the Air Force will maintain these schedules as closely as possible. Thus the helicopter pilots can plan their own flights with good assurance as to when and where the MTR missions will be conducted.

(3) Recommendation/Conclusion

The analyses of potential MTR solutions has revealed that there are operational and economic inadequacies in all of the solutions that depend upon new or modified equipment on the ground or in the aircraft.

The procedural solution jointly arrived at by the DOD, FAA, Flight Safety Foundation, and the Appalachian Helicopter Pilots Association appears most satisfactory at the present time. This involves the preplanning and publication (24 hours in advance) of the precise routes and schedules that will be flown. This can then be used by the helicopter pilots in the planning and the conduct of their own flights.

For the longer term future, some of the projected NAS improvements such as ATARS are expected to provide a more complete resolution to this problem.

d. Item (d), Route Structure and Communications for Offshore Operations in the Gulf of Mexico

(1) Helicopter Survey

A questionaire was prepared and submitted to offshore helicopter operators in the Gulf region to determine the scope of present helicopter operations as well as estimates for 1982 activity. From the total of 14 completed questionaires, covering over 90% of the offshore operators in the Houston Center area, the following information was summarized:

SUMMARY	May 1979	May 1982	% GAIN
Total helicopters	421	667	58
Total VFR helicopters	399	593	49
Total IFR helicopters	22	74	236
IFR Flights per month	62	1098	1671
Passengers per month	235,401	316,150	34

On the basis of the replies received, it appears that the 1982 offshore IFR helicopter fleet will be made up of the following categories:

24% 6-8 passengers

27% 9-15 passengers

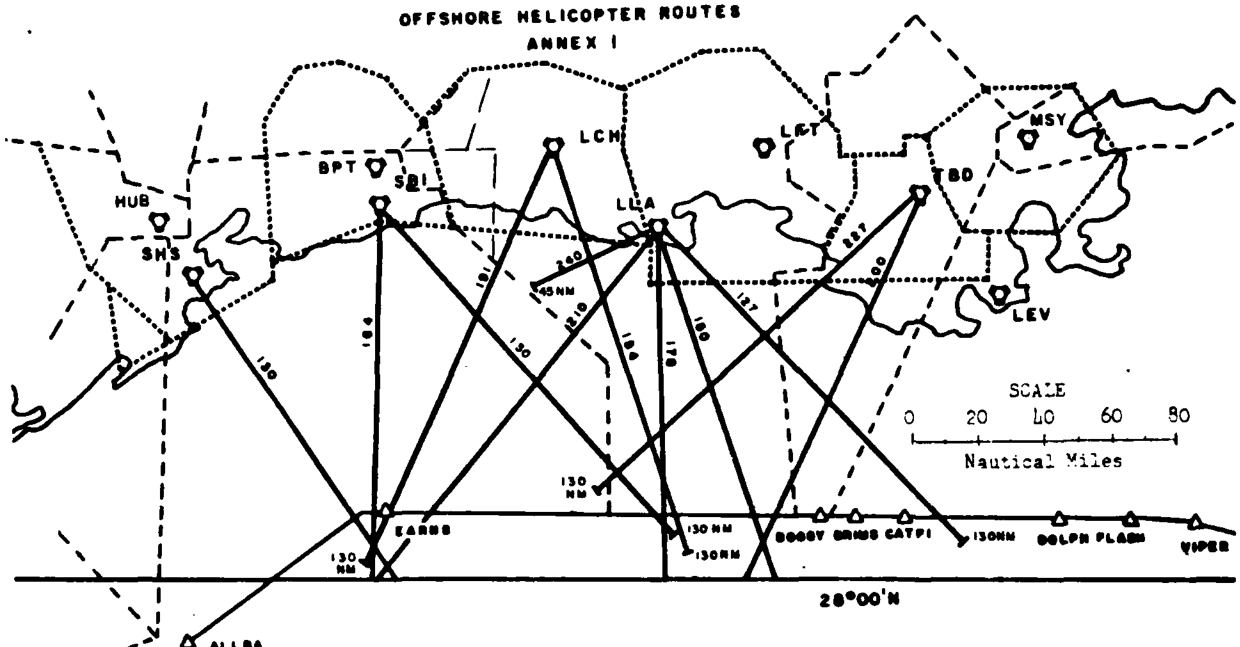
48% 16+ passengers

None of the replies showed any inclination to provide IFR capability for helicopters smaller than six passengers.

Although most of the present operations occur during daylight hours, emergency trips must be accommodated at any time. One operator commented that increasing traffic loads would force an extension of hours into night operations.

(2) Status

The above traffic survey was used as one input by the Southwest Region (working in coordination with other FAA officers) in establishing a structure of 11 IFR routes and improved VHF communications. Figure 1-8 shows the route structure; Figure 1-9 identifies some of the industry operated communications. In effect, an improved service for IFR operations in the Gulf has already been instituted by the Southwest Region establishing IFR routings and improved communications. Further improvements, particularly in communications, are planned for the future. The survey of Gulf helicopters operations under this contracted ATC task, and the participation in some of the deliberation on routes and communications were among the supporting inputs that led to the results achieved.



INBOUND CLEARANCE LIMITS

Houston	Beaumont	Lake Charles	Lafayette	New Orleans
SHS 130/20	SBI 164/10	LCH 154/35	LLA 240/20	TBD 200/23
	SBI 130/10	LCH 191/35	LLA 210/26	TBD 227/35
			LLA 178/21	
			LLA 150/22	
			LLA 127/30	

MEA all routes 1500
MAA all routes 10,000

Figure 1-8. Offshore Helicopter Routes in Houston Area

CHG 2
3/20/80

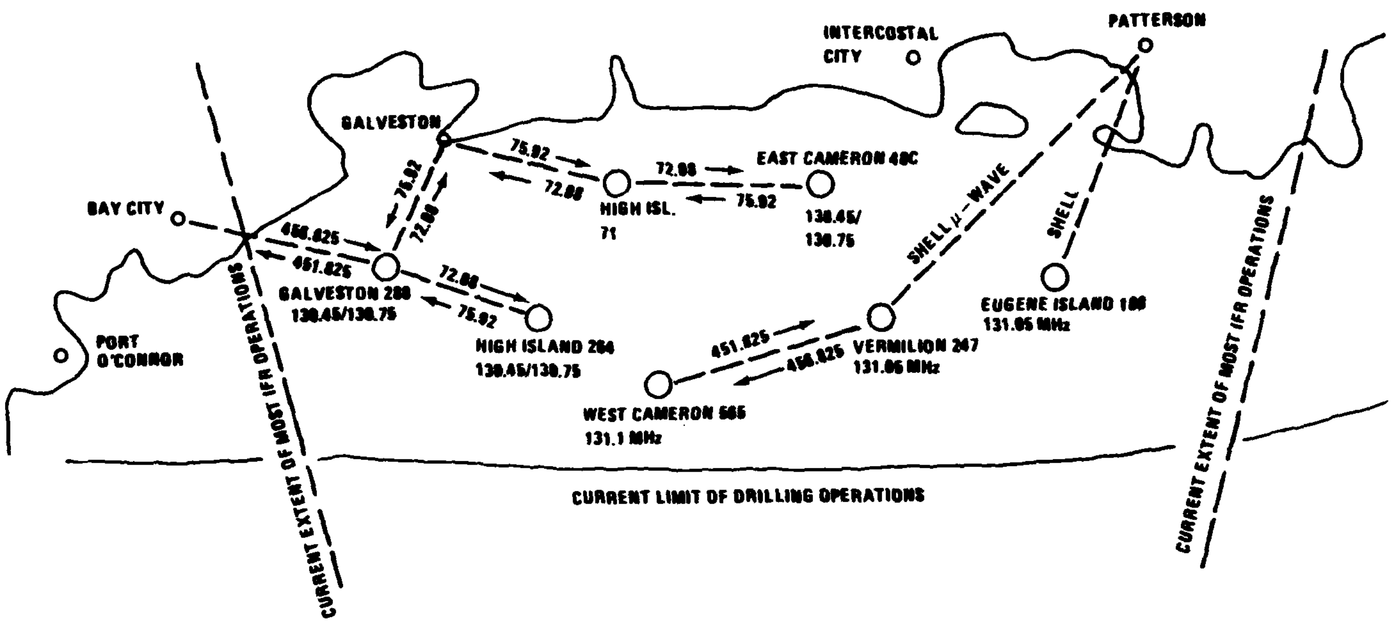


Figure 1-9. Some Major Existing Offshore Industry Communications Links in Gulf

e. Item (e), Recommendations of Phase I Helicopter ATC Study

In pursuing the Helicopter Operations Development Plan, published in September 1978, there have been two phases of work in the area of helicopter air traffic control.

Phase I was a contracted study performed during the one year period between the spring of 1978 and the spring of 1979 and was documented in Report FAA-RD-78-150, "Helicopter Air Traffic Control Operations". It made two categories of recommendations. One category consisted of items which showed promise and potential for making helicopter ATC improvements but which required further analysis or experimentation before a firm recommendation for operational use could be made. The purpose of Phase II was to further explore those recommendations and was conducted during the ensuing one year period between the spring of 1979 and the spring of 1980. It is that follow-on exploration of provisional ideas and concepts that is contained in this report.

However, in order to reflect the complete set of recommendations made in the combined phases (I and II) of the helicopter ATC study, the following chart is provided which lists the complete recommendations of Phase I. It includes the items recommended for immediate use and therefore, not addressed in this report. The detailed discussion of the items on the chart is contained in the Phase I report.

RECOMMENDATION	APPLICATION			STATUS
	Inter City	Off Shore	Remote Area	
• Separate helicopter approach paths	X		X	Various stages of implementation
• Update ATC handbook	X	X	X	In preparation
• 2 NM Separation	X			Additional simulations planned.
• TERPS Update	X	X	X	In process
• Dual waypoint holding pattern	X	X	X	In simulation (synthetic flight simulator)
• Helicopter familiarization training	X	X	X	In process
• Missed approach waypoints at landmarks	X	X	X	Under FAA consideration
• Non radar training	X	X	X	In process in Gulf Area
• Additional RCAG sites		X	X	Procurement plannned in Gulf
• Communication repeaters		X	X	Under consideration
• Loran-C navigation	X	X	X	Being used in Gulf and Atlantic offshore operations
• Procedural control		X	X	Being used in Gulf and Atlantic offshore operations
• Reduced offshore MDA		X		FAA test and evaluation completed. Advisory Circular in preparation.
• Military Low Level routes		X	X	Procedural solution being considered for implementation.

3. Helicopter ATC Improvements Requiring Short Term Simulation or Testing

The procedures and criteria presently used in IFR operations were developed originally for fixed wing aircraft and did not take into consideration some of the unique flight characteristics of helicopters. As a consequence, the procedures place unnecessary penalties on helicopter oporations.

For example, helicopter holding pattern airspace may be considerably larger than might be necessary if patterns were modified to take advantage of current navigation capabilities, as well as the low speed and short turning radius of helicopters. Such modifications may also be able to simplify entry procedures and pilot workload. Another potential improvement would be to eliminate, where possible, the need for time-consuming procedure turns that are used to align helicopters on the inbound final approach path.

The main emphasis in this area of study was on helicopter procedures that could be investigated in preliminary fashion with flight simulators. In part this was done because it was possible to arrange for simulator time in conjunction with normal pilot training at the Army Synthetic Flight Training Facility in Annville, Pa. The purpose of these simulator flights was to perform an initial screening and validation of flight procedures that could be subsequently explored in detail in a formal simulator or flight test program. Some analysis was also done in other areas and all items are reported herein.

a. Item (a) Helicopter Holding Patterns

For most helicopters, holding pattern speeds of 60 to 90 knots are practical. Furthermore, most helicopters certified for IFR operations have RNAV equipment. This combination of slow speed and RNAV equipment makes it possible to fly patterns that are considerably smaller in size as well as being much simpler to fly. However, even for helicopters not having an RNAV system a number of improvements in holding patterns are possible simply because of the slow speed at which the helicopter can fly in a holding configeration. Also important is the fact that at these speeds there is no large attitude change (as there is with airplanes) and very little difference in the pilot workload needed to keep the aircraft under control.

(1) Dual waypoint holding pattern

This pattern offers the greatest potential benefits of all patterns studied. However, it does require the helicopter to have an RNAV system that can easily accomodate a fairly rapid and repeated shift (back and forth) between two waypoints.

The details of the pattern are shown in Figure 1- 10. One waypoint is setup at the primary fix. The second is placed at the auxiliary fix and establishes an outer limit for the outbound leg of the pattern. Although helicopters when flying holding patterns at 60 to 90 knots, are more sensitive to wind effects than most airplanes, the dual waypoint procedure significantly reduces the effect of wind and confines the pattern to fairly precise boundaries. The distance between waypoints can be as little as 1 1/2 to 2 miles.

Trials of this pattern in a UH-1H synthetic trainer have shown the pattern to be very simple to fly. Once the pilot is in the pattern he simply homes to the first waypoint. When he arrives there he switches to the other waypoint, makes a 180° turn and then homes to the

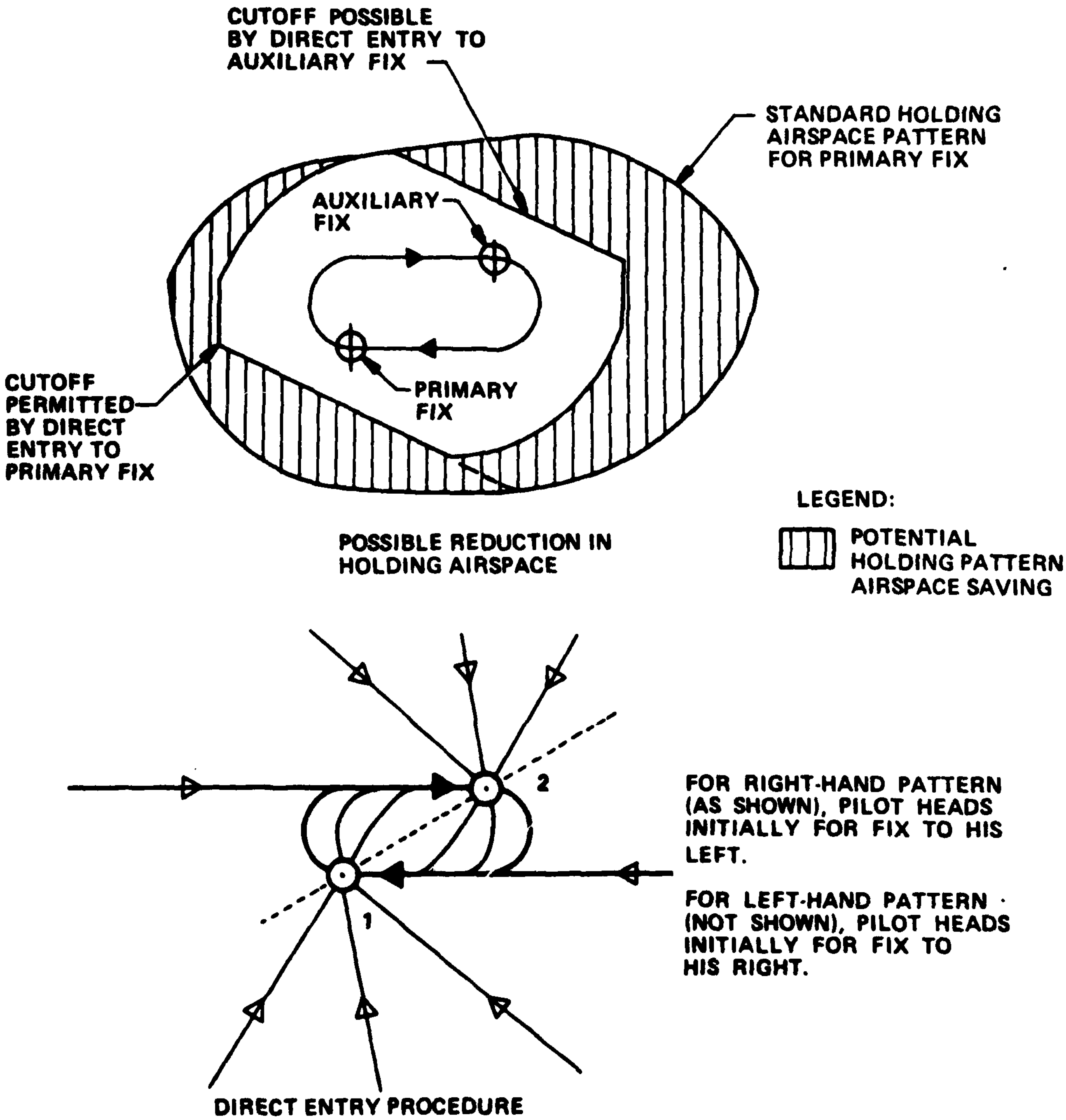


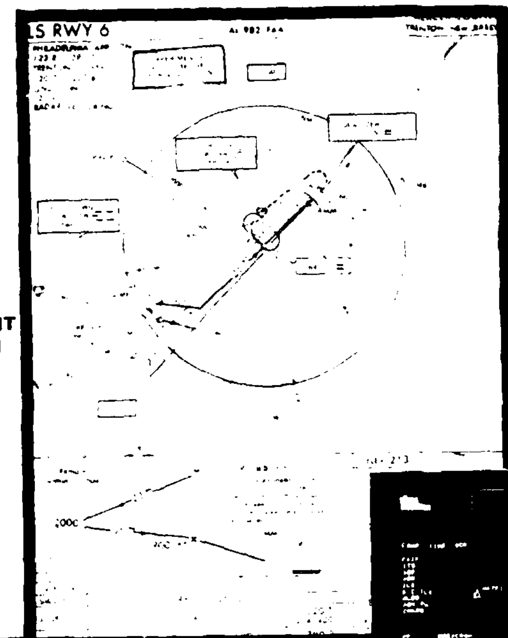
Figure 1-10. Dual-Waypoint Holding Pattern

second waypoint to complete the cycle. The pilot workload to maintain headings, times and wind correction angles is greatly reduced and the procedure therefore allows him more time to devote to other flight activities.

Since the pattern is small in size and also precisely defined, it makes only a small difference (in the amount of protected airspace required) as to whether the pattern is flown to the right or to the left. This characteristic has a great effect in simplifying holding pattern entry procedures. The entry is simple because it is not a matter of computing and flying precise headings to be flown, but rather a matter of homing to a waypoint. For example (see Figure 1-11) for a right hand pattern, the pilot, in making a pattern entry, heads initially for the waypoint to his left. Upon reaching that waypoint, he makes a right turn to the other waypoint and is then established in the pattern.

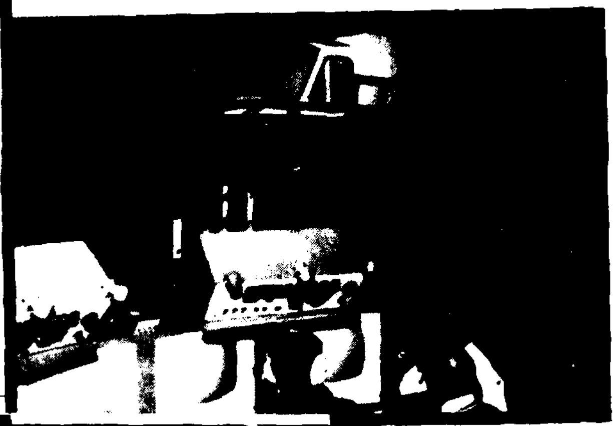
Figure 1-11 is a composite photograph of some of the validation trials of holding patterns that were conducted at the Army Synthetic Flight Training Facality in Annville, Pa.

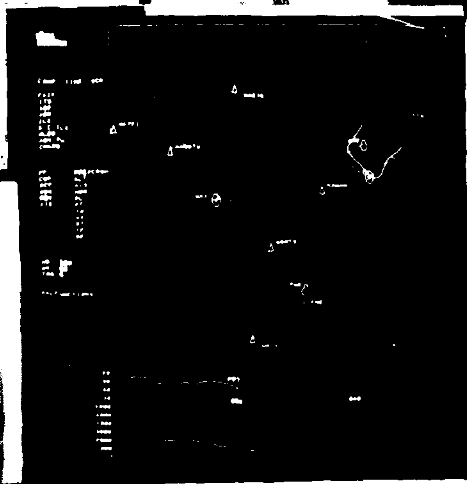
- The top center illustration shows the expermental approach plate that was prepared for the tests. The holding pattern was developed for use with the ILS Runway 6 ILS approach at Trenton, N. J. Since the simulator did not have an RNAV system the VOR was used to establish a waypoint at the Yardley VOR station and the ADF was used for the auxiliary fix located at the Trenton outer marker compass locater. The missed approach is shown by a dashed line leading to an entry for a left hand holding pattern.



EXPERIMENTAL APPROACH PLATE FOR DUAL WAYPOINT HOLDING PATTERN AT TTN

UH-1H SIMULATOR





CRT TRACE OF ABBREVIATED INTERCEPT ON *FINAL TO TTN ILS* (ON UH-1H SIMULATOR)

CRT TRACE DF DUAL WAYPOINT *HOLDING PATTERN* (IN UH-1H SIMULATOR)

CONSOLE: UH-1H SIMULATOR

Figure 1-11

The heading to the outer marker is 127° ; the return heading to Yardley VOR is 327°.

- The left center illustration is a photograph of the CRT trace of the synthetic trainer during about 1 3/4 counterclockwise circuits of the pattern. The race track shaped pattern was flown in a no-wind condition. A second pattern was flown with a strong crosswind from the West (i.e. 260°/35kt). The trace shows the left turn at Yardley to be considerably foreshortened and the left turn at the compass locator to be elongated. Despite these distortions from an ideal pattern the complete trace is well confined to a small area. The normal holding pattern protected airspace for the smallest sized standard holding pattern is shown by a dashed overlay on the face of the CRT display.
- The photograph on the top right shows the UH-1H simulator (including the cockpit) and the controller console.

Figure 1-12 is an expanded view of the pattern when flown with a 260°/35kt cross wind. Figure 1-13 shows a smaller scale representation of a number of holding pattern circuits with various wind speeds and two different helicopter speeds (90kts and 60 kts).

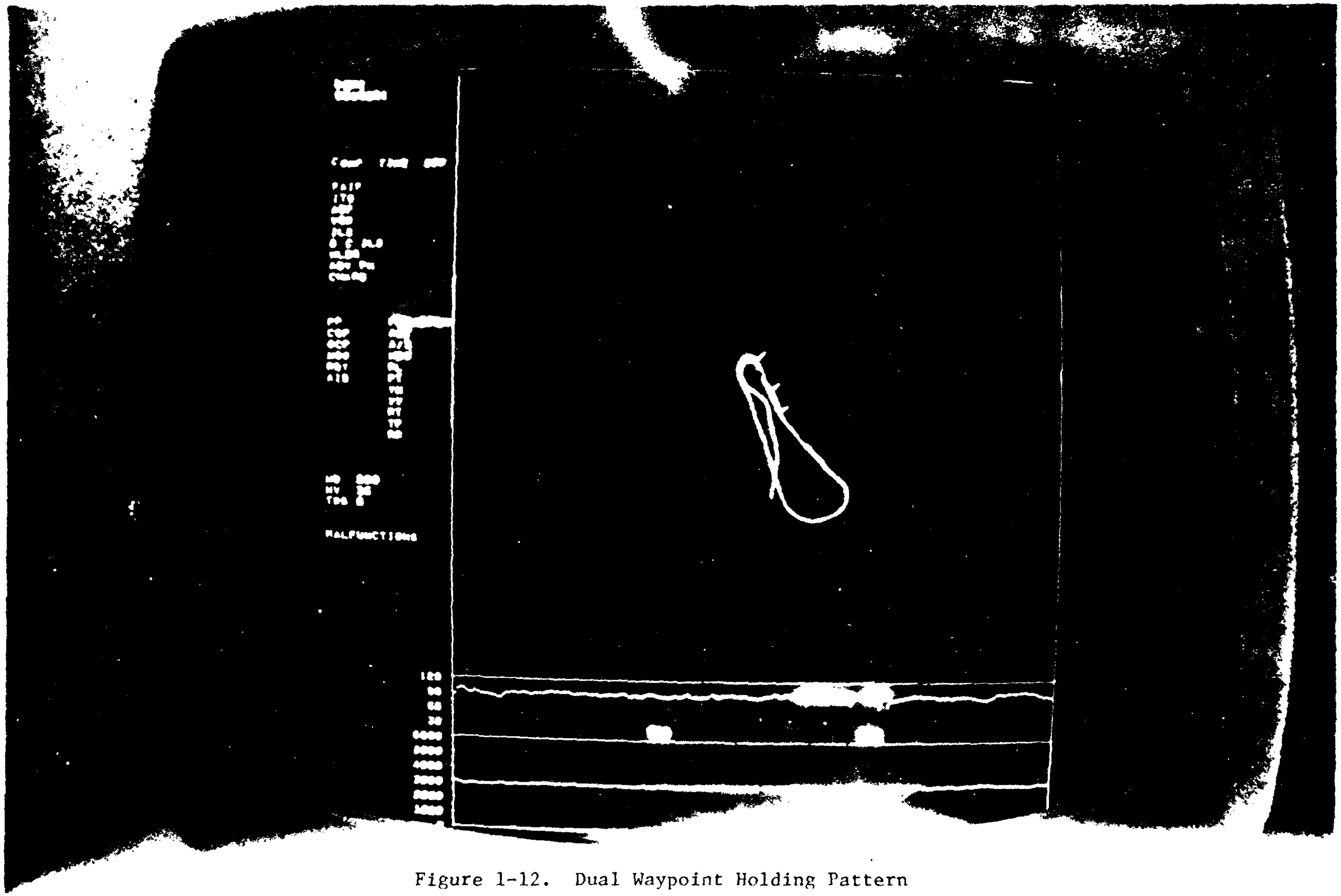


Figure 1-12. Dual Waypoint Holding Pattern

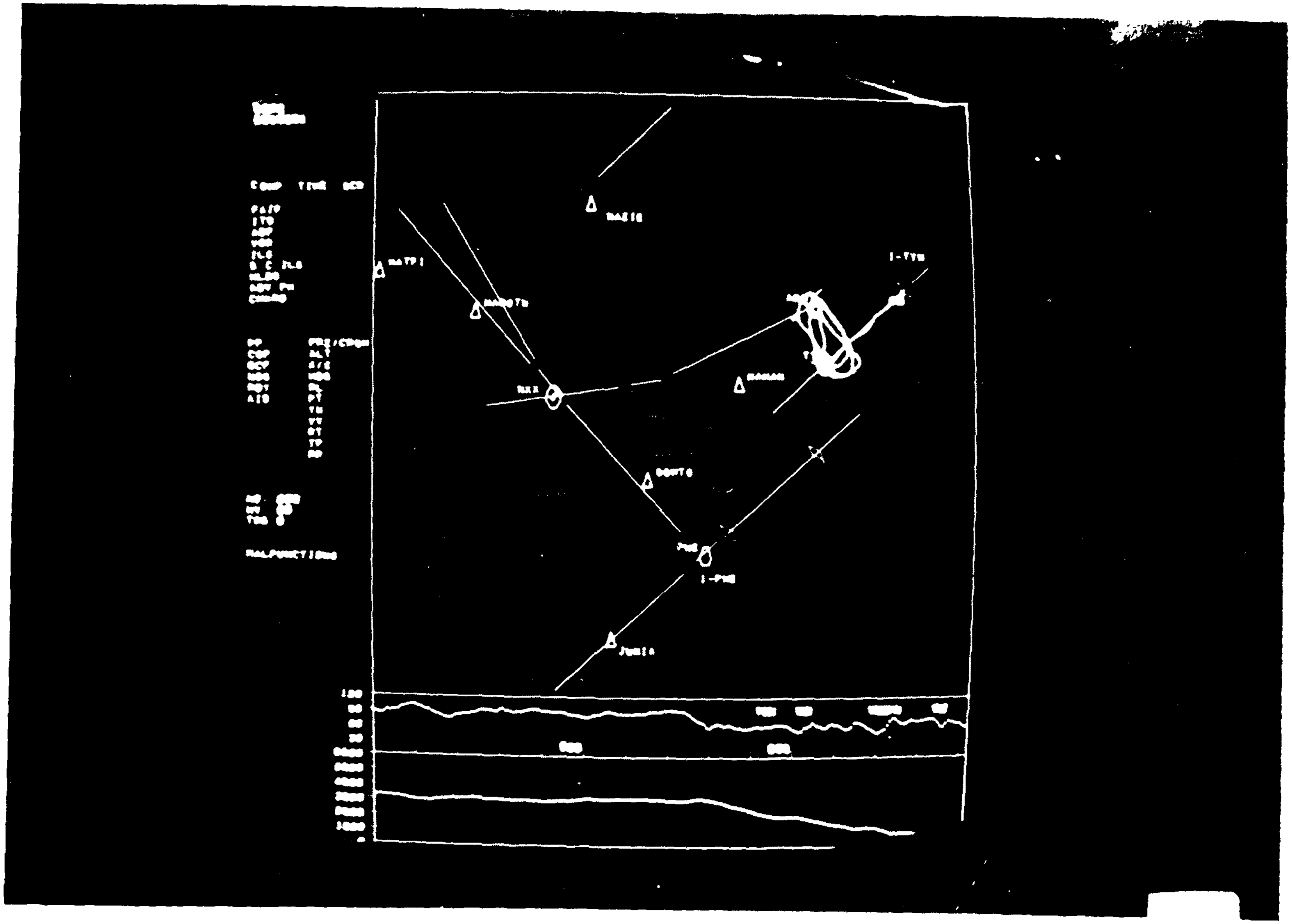


Figure 1-13. Dual Waypoint Holding Pattern
(Various Winds)

(2) Recommendation -- Dual Waypoint Pattern

As stated earlier the dual waypoint holding pattern has excellent potential to reduce pilot workload and to reduce the amount of protected airspace that must be reserved for helicopter holding patterns. While the preliminary experiments at Annville, Pa. indicated this potential they were not rigorous enough to validate the pattern for operational use. Accordingly a more comprehensive series of simulations are recommended. In a separate document (i.e. Simulation of Short Term Improvements In ATC Procedures For Helicopters) a specific test program is recommended with variations in:

- Helicopter airspeed
- Wind
- Turbulence

The total program can be completed in 20 simulation runs. Several actual helicopter flights could then be conducted to further validate the results of the simulations.

(3) Other holding patterns

A number of different holding patterns were studied in this investigation. In addition to the dual waypoint pattern already discussed, Figure 1-14 shows three race track patterns using a single holding fix and two figure eight patterns (one using a single fix and one using two fixes).

The purpose of the single fix experiments was to explore smaller patterns that could be flown by helicopters that were not RNAV equipped. In general the Annville experiments indicated that with a single holding fix and winds that were low to moderate ($\approx$30 kts.) any of the patterns are feasible except the 30 second pattern which is too small if a tailwind exists on the inbound course.

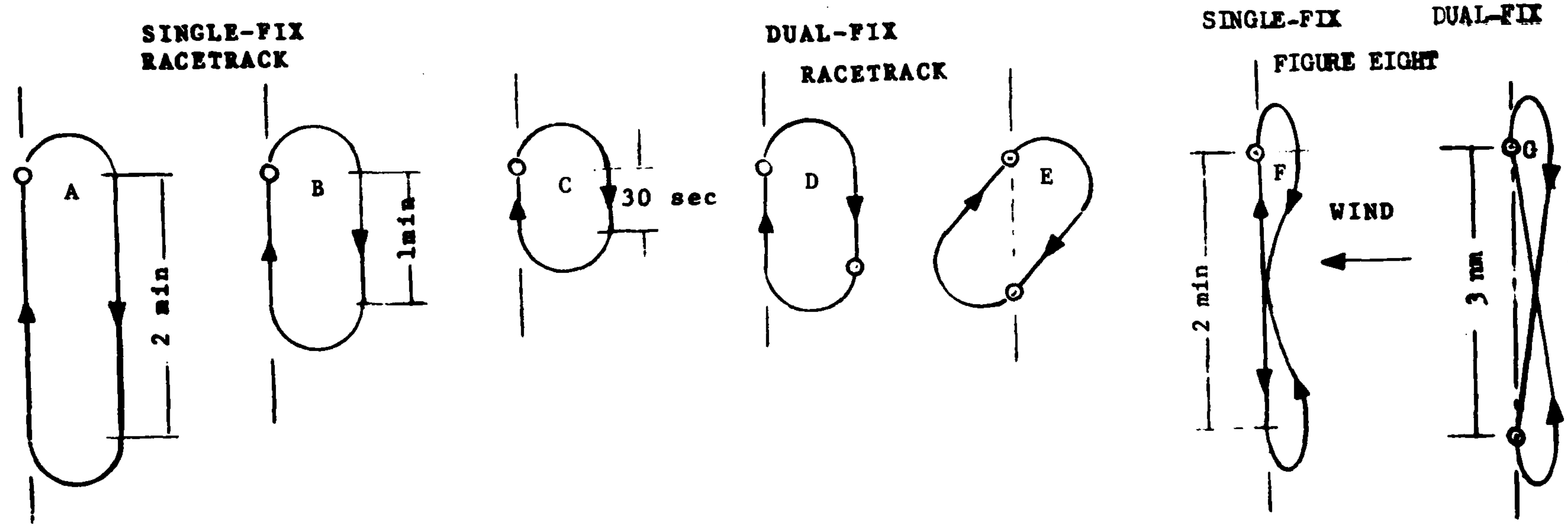


Figure 1-14. Helicopter Holding Patterns

The objective of the figure eight patterns was to determine what benefits, if any, would accrue if all turns were made into the wind. As a generality these patterns do keep the helicopter in a smaller area but they are more complex and hence increase pilot workload.

(4) Recommendations -- Other Holding Patterns

The document previously referenced (i.e., Simulation of Short Term Improvements In ATC Procedures for Helicopters) describes simulation programs for a diverse set for holding patterns. The programs were designed so as to require a minimum number of runs, to explore all essential parameters and yet to arrive at sample sizes that could be treated statistically. The runs required are too numerous to be conducted within reasonable costs by actual helicopters. Also, the key parameter of wind cannot be varied as easily in an actual flight program. It is believed that the conduct of these programs in a flight simulator will reveal simple yet improved procedures for helicopter holding patterns. It is likely that a combination alternatives will be shown to be advantageous depending on whether the helicopter is RNAV equipped, what air speed is flown by the helicopter, and what the wind conditions are.

b. Item (b), Final Approach Course Interceptions

(1) Background

The helicopter is a short-range vehicle with a relatively high operating cost per mile. There is a need to minimize the flight distance and fuel consumption required in completing approaches. Consequently, helicopter pilots prefer to avoid making unnecessary procedure turns, and to keep their approach paths as short as practicable, with due regard for pilot workload and safety.

The helicopter is particularly well adapted to making short approaches. Its capability to fly at a slow speed and make short-radius turns enables it to intercept the desired final approach course with a minimum amount of overshoot. Its ability to fly slowly enables it to descend on a considerably steeper glide slope than a CTOL aircraft, without picking up a high sink rate.

Until now, controllers have been required to use fixed-wing approach criteria when turning helicopters on final approach, although there is considerable evidence that helicopters could safely negotiate much shorter final approach paths.

The longer the common path, the longer the approach interval whenever a helicopter follows a faster aircraft down the final approach path. The longer the approach interval, the lower the airport capacity. Therefore, a short helicopter final approach path can be advantageous to ATC.

(2) Representative patterns investigated

Figure 1-15 shows several of the approach intercepts that were studied and flown in the simulator.

FINAL APPROACH COURSE INTERCEPT PATTERNS

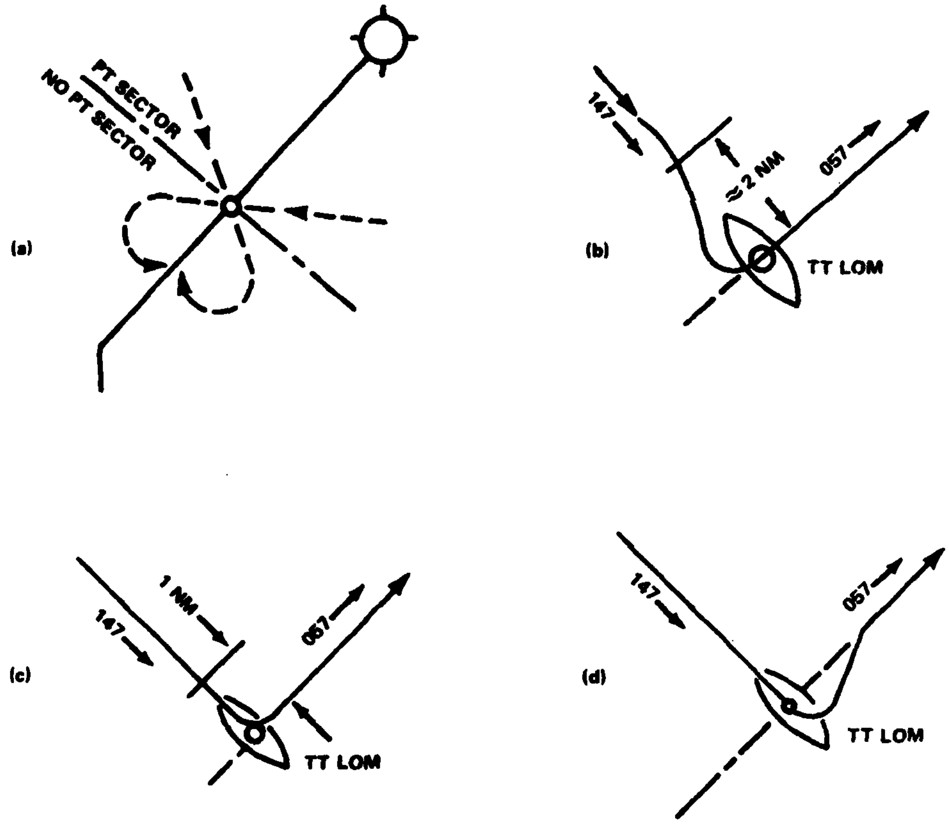


Figure 1-15

(a) Pattern (a) shows a simple tear drop intercept when approaching from the procedure turn (PT) sector, that is, the sector from which a procedure turn is normally required as a means of joining the final approach path. The use of the tear drop turn-around can be flown from the most convenient side. This is straight forward for the pilot and avoids the extra time and complexity of a standard procedure turn.

(b) Patterns (b), (c) and (d) show several patterns that were studied for intercepting the FAF at angles up to 90 degrees. They all exploit the slow speed and short turning radius of the helicopter.

- With reference to pattern (b), when reaching a distance of about two miles from the fix, the pilot deliberately turns about 20^{o} to drift outside of the fix; he then follows the ADF or RMI needle to cross the fix inbound.
- With reference to pattern (c), the pilot can anticipate that the helicopter is within one mile of the turning point, either by means of a lead radial, a DME reading the outer marker signal, or by the CDI moving off the peg on an ILS approach. A turn is then started so as to roll out on the final approach course.
- With reference to pattern (d), when the final approach course is sufficiently long to permit the helicopter time to get stabilized on the final approach path, the pilot can wait until the fix is reached before starting the turn. The final approach course is then intercepted from the opposite side.

(c) Recommendation

The preliminary studies and experiments conducted to date have not gone to the extent necessary to validate these procedures for operational use. Accordingly, a more extensive simulation program has been devised and is described in the previously referenced document (i.e., Simulation of Short-Term Improvements in ATC Procedures for Helicopters). It is recommended that the simulation of entry procedures described therein be pursued.