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DEPARTMENT OF NATIONAL DEFENCE

CANADA

CHIEF OF OPERATIONAL REQUIREMENTS

DIRECTORATE OF SYSTEMS EVALUATION

ROYAL CANADIAN AIR FORCE

A STUDY OF WEAPONS COVERAGE OBTAINED BY SCRAMBLING THE CF-105 ON PENETRATION OF THE MID-CANADA LINE

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Submitted by

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ABSTRACT

In this report, CF-105 missions are analysed in which the interceptors are scrambled on enemy penetration of the Mid-Canada Line (as suggested some years ago within Air Defence Command). Comparisons are made between the coverage obtained with a fixed profile mission in which the target is under cover of contiguous radar during the whole flight of the interceptor and the coverage obtained with missions based on Mid-Canada Line scramble. Particular reference is made to the limitations of the rate of application of the interceptors to the bomber stream.

This report provides a treatment of weapons coverage which should be considered with other factors in evaluating the value of scrambling interceptors on Mid-Canada Line warning.

A STUDY OF WEAPONS COVERAGE OBTAINED BY SCRAMBLING THE CF-105 ON PENETRATION OF THE MID-CANADA LINE

1. INTRODUCTION

The limitations which presently programmed radar impose on the use of the CF-105 interceptor in Eastern Canada against a high speed raid approaching from the North have been discussed in DSE Memo No. 57/4. In that memo it was suggested that an extension of present radar cover would be desirable if the CF-105's were to be scrambled against specific targets with established tracks. Further study revealed that a Mid-Canada Line scramble of interceptors and a loiter mission could be used to great advantage in reducing the time required to place the interceptors in the battle. (See DSE Memo No. 57/10). In this report three missions are compared:

(1) The original fixed profile mission considered in Memo No. 57/4 in which the fighter is scrambled after the target track is established in contiguous radar cover.

(2) A point loiter mission (as considered in Memo No.57/10) in which the squadron flies to an optimal point due north of the base and awaits vectoring instructions.

(3) A fanned loiter mission in which the interceptors fly out line abreast with a lateral separation of approximately 25 miles to individual optimal points and await vectoring instructions.

Appendix "B" contains typical mission profiles for the CF-105 which were extrapolated from data supplied by A.V. Roe Canada Ltd. . From these profiles, curves were drawn to show the effect of loitering on supersonic flight distance and total range. (See Figure 1). It is evident from these curves that if a M1.5 mission is used, loitering up to 30 minutes has only a small effect on the range. When a M2.0 mission is used, loitering for long periods of time has a more pronounced effect due to the inherently shorter range. However, in the loiter missions discussed in this report, the a/c seldom need to loiter for more than five minutes.

The assessment is made in terms of the intercept coverage obtained and the number of intercepts possible when application rate is limited to one per minute. Two deployments of fighter bases are considered: a northern deployment at Kapuskasing, Val d'Or, Casey and Bagotville and a southern deployment at North Bay, Uplands, Bagotville and St. Hubert.

2. METHOD

2.1 A bombing raid of indefinite number but concentrated so that it is operationally possible to apply interceptors at one point only, is assumed to be travelling due south. Upon penetration of the Mid-Canada Line, a warning is transmitted but it is assumed that no information concerning speed, heading or position is obtained. On interceptor missions using Mid-Canada Line scramble, the interceptors are assumed to reach altitude in an additional 5 1/2 minutes. It is further assumed that the interceptors can be vectored six minutes after the bombers enter contiguous radar cover. A tactical rule has been introduced that interceptors do not fly north of a line 120 n.m. south of the limits of contiguous radar cover. This ensures that a target travelling at M2.0 is not south of the interceptor when vectoring orders are given. For missions not using Mid Canada Line scramble, the

interceptors are assumed to have wheels up 10 minutes after penetration of contiguous radar cover and are vectored immediately. A detailed list of assumptions are given in Appendix "A".

2.2 The rate at which interceptors may be applied to a bombing raid is severly limited by ground control capability and by tactical difficulties due to congestion of the interceptors. It is assumed in this study that the interceptors can be applied to the raid at a rate of one per minute, which is approximately the rate achieved at present in Air Defence Command. In each case, after an interceptor is vectored into the raid, the next closest interceptor, regardless of its home base is vectored to reach the raid one minute later or as soon thereafter as possible.

2.3 For a given fighter speed and range, bomber speed, and radar cover it is possible by simple geometry to determine the most northerly points at which interceptors can make the first, second, third and succeeding intercepts. The resulting family of curves gives a pictorial representation of intercept weapons coverage and application rate.

3. RESULTS

3.1 Figure 2 shows the coverage obtained for M1.5 interceptors based in the northern deployment at Kapuskasing, Val d'Or, Casey and Bagotville against M1.5 targets if no MCL scramble is used. Figures 3 and 4 show the coverage obtained with MCL scramble point loiter missions and fanned loiter missions respectively.

Comparison of Figures 2,3 and 4 in order reveals a gradual improvement in the cover to the east, west and north. Comparison of Figures 2 and 4 indicates that with the fanned loiter mission there is a very significant improvement in northerly cover particularly in the region between the bases. Notice that since the a/c are spread out in the fanned loiter mission, interceptors from more than one base can be vectored into the raid. Thus, although only seven a/c are sent out from each base, between the 70th and 80th parallel 10 to 12 a/c are able to intercept.

3.2 Figures 5,6 and 7 show cover obtained with M1.5 interceptors against a M1.5 threat for the southern deployment at North Bay, Uplands, Bagotville and St. Hubert. Figure 5 shows the cover obtained with a fixed profile mission and Figures 6 and 7 show the coverage for MCL scramble missions.

Comparison of Figures 5,6 and 7 in order reveals, as before, that there is a worthwhile improvement from figure to figure and comparison of the fanned loiter mission (Figure 7) with the fixed profile mission (Figure 5) reveals that MCL scramble allows intercepts to be carried out much farther north and west than otherwise. It is interesting to note that the base at St. Hubert does not extend the northern cover when MCL scramble missions are used. There is little improvement in cover to the east. The number of intercepts achieved is not significantly different in the fanned loiter mission since in the west the interceptors are range limited.

3.3 The next three figures (8,9 and 10) deal with M2.0 interceptors at the northern bases, used against M2.0 targets.

From Figure 8, it can be seen that against M2.0 targets, a fixed profile mission allows no coverage except to the south and east of Bagotville and south of the Canadian/US border.

Figures 9 and 10 show the cover obtained when MCL scramble missions are employed, and indicate that the fanned loiter mission offers superior lateral and northerly cover particularly between interceptor bases. The fanned loiter tactic allows missions to be flown from the bases of the northern deployment against targets of speeds of at least M2.0. Comparison of Figure 10 with Figure 14 (discussed in section 3.5) shows that this deployment is superior to the southern deployment.

3.4 Figure 11 shows the cover obtained using the fanned loiter mission from bases of the northern deployment, for M1.5 interceptors agains M2.0 targets. It can be seen that very little cover is obtained West of the 80th parallel. A comparison of Figure 1 with Figure 10 reveals that for intercepts due north of the bases, there is no significant difference between M1.5 interceptors and M2.0 interceptors against M2.0 targets. Howev for interceptors vectored in an easterly or westerly direction, a speed of M2.0 is requirec to obtain satisfactory cover. In addition, a speed of M2.0 allows more interceptors to att the raid.

3.5 Figure 12 is a coverage diagram for a fixed profile mission for interceptor from North Bay, Uplands, Bagotville and St. Hubert, M2.0 against M2.0 targets. Compari son of this diagram with Figures 13 and 14 (which refer to Mid-Canada Line scramble mission under similar conditions) reveals that once again the fanned loiter mission is superior.

3.6 Finally subsonic targets are considered for each of the deployments. Figure 15 shows that a fixed profile mission is satisfactory for the northern deployment when M1.5 interceptors are used against 500 kt targets. However, comparison of Figure with Figure 15 shows that the fanned loiter mission allows intercepts to be carried out a considerable distance farther north. Figures 18 and 19 indicate the cover obtained when MCL scramble missions are employed at the southern deployment.

[illegible] many [illegible] scrambled fires are unable to affect interceptions because they are out of position?

ASSUMPTIONS

RADAR AND GROUND CONTROL SYSTEM

1. Radar coverage at assumed target height.	1. Presently programmed radar coverage.
2. Radius of target detection from radar.	2. 200 n.m.
3. Radius from each GCI within which control of intercepts is possible.	3. 150 n.m.
4. Amount and quality of early warning information.	4. Early warning from DEW line. Sufficient information from MCL to scramble a/c.
5. Time required to scramble and vector a/c.	5. (a) Ten minutes is required from MCL warning to wheels up.
	(i) detection 2 min.
	(ii) identification 2 min.
	(iii) transmission of scramble orders 2 min.
	(iv) scramble order to wheels up 4 min.
	5. (b) Aircraft cannot be vectored until target is six minutes within contiguous radar cover.
	(i) detection 2 min.
	(ii) re-identification 2 min.
	(iii) transmission of vector orders 2 min.

HOSTILE AIRCRAFT

1. Altitude	1. 45,000 ft.
2. Speed	2. Three speed were used in the analysis 500 kts M1.5 and M2.0.
3. Aircraft formation	3. Raid of no fixed formation flying due South.

CF-105 INTERCEPTOR

1. Time to altitude	1. Climb at M0.92 to 30,000 ft. in 3.6 minutes: accelerate to M1.5 in 1.1 min. climb to 45,000 ft. at M1.5 in 0.55 min. Total time to 45,000 ft - 5.25 minutes.
2. Radius of missions	2. (a) For M1.5 cruise out, radius is 300 n.m.
	(b) For M2.0 cruise out radius is 200 n.m.

TYPICAL MISSION PROFILES FOR THE CF-105

MACH 1.5 LOITER MISSION

Condition	Fuel	Distance
Engine start	100 lb	
Take-off	182 lb	
Accelerate to 527 K	560 lb	4.6 n.m.
Climb to 40,000 ft. at 527 K	1600 lb	36.0 n.m.
Cruise out to loiter point	135 lb	10.0 n.m.
Loiter at maximum endurance	65 lb/min	
Accelerate to M1.5	1430 lb	19.3 n.m.
Climb to 50,000 ft. at M1.5	810 lb	13.5 n.m.
Cruise out at M1.5	25.9 lb/nm	
Combat at M1.5 (5 mm)	3500 lb	
Cruise back at M0.92 and 42,500 ft.	10.25 lb/nm	
Stack at 40,000 ft. (15 min)	976 lb.	
Descent	350 lb.	
5 min reserve	526 lb.	
Total internal fuel	19,428 lb.	
Fixed fuel consumption	10,169 lb.	
Fuel available for cruise out, loiter and cruise back.	9,269 lb.	

MACH 2.0 LOITER MISSION

Condition	Fuel	Distance
Engine start	100 lb.	
Take-off	182 lb.	
Accelerate to 527 K	560 lb.	4.6 n.m.
Climb to 40,000 ft. at 527 K	1600 lb.	36.0 n.m.
Cruise out to loiter point	135 lb.	10.0 n.m.
Loiter at maximum endurance	65 lb/min	
Accelerate to M2.0	3175 lb.	42 n.m.
Climb to 60,000 ft. at M2.0	2320 lb.	47.2 n.m.
Cruise out at M2.0	28.6 lb/nm	
Combat at M2.0 (5 min)	3350 lb.	
Descent to 42,500 ft.	291 lb.	
Cruise back at M0.92 and 42,500 ft.	10.25 lb/nm	
Stack at 40,000 ft (15 min)	976 lb.	
Descent	350 lb.	
5 minute reserve	526 lb.	
Total internal fuel	19,438 lb.	
Fixed fuel consumption	13,565 lb.	
Fuel available for cruise out loiter and cruise back	5,875 lb.	

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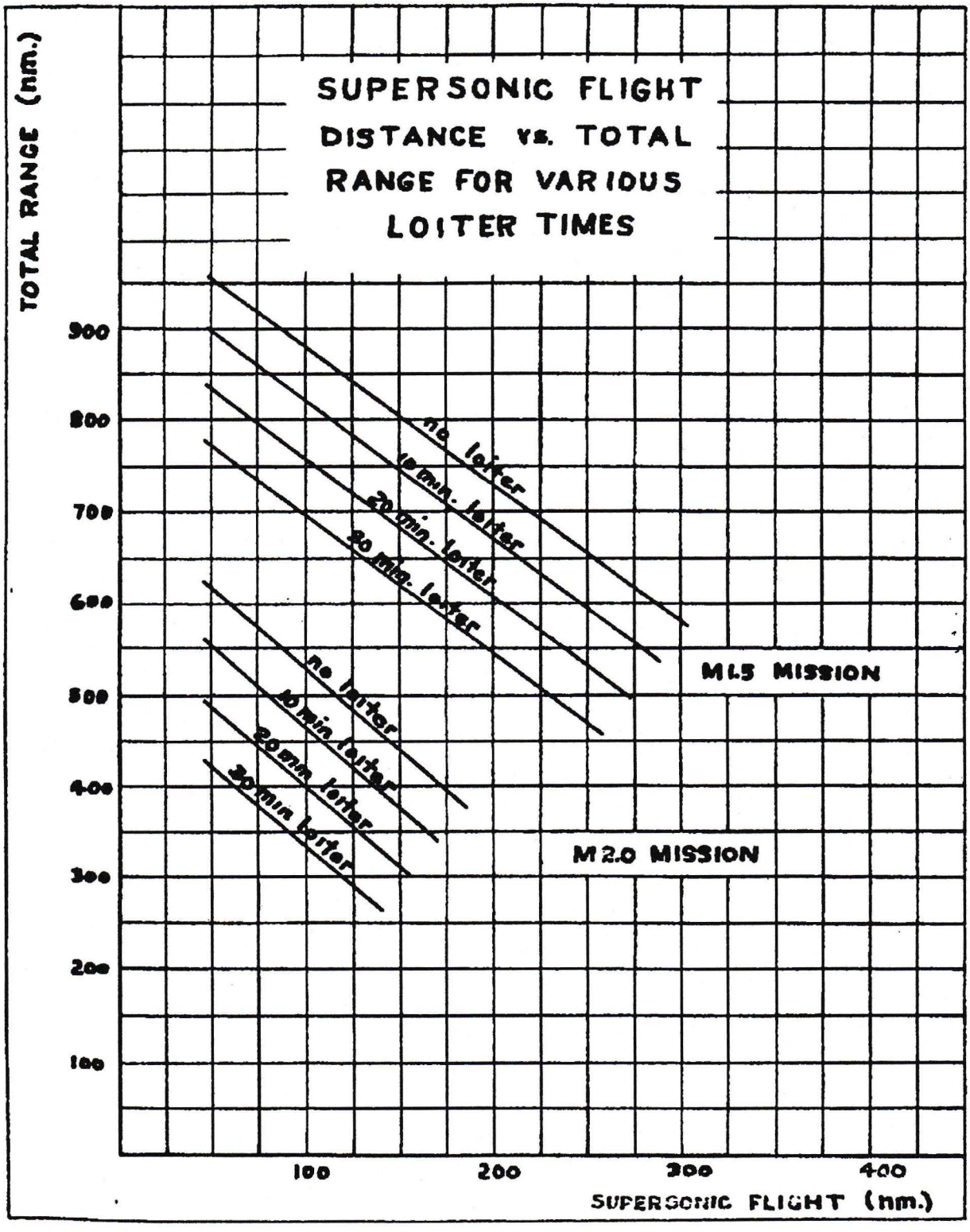
FIGURE 1



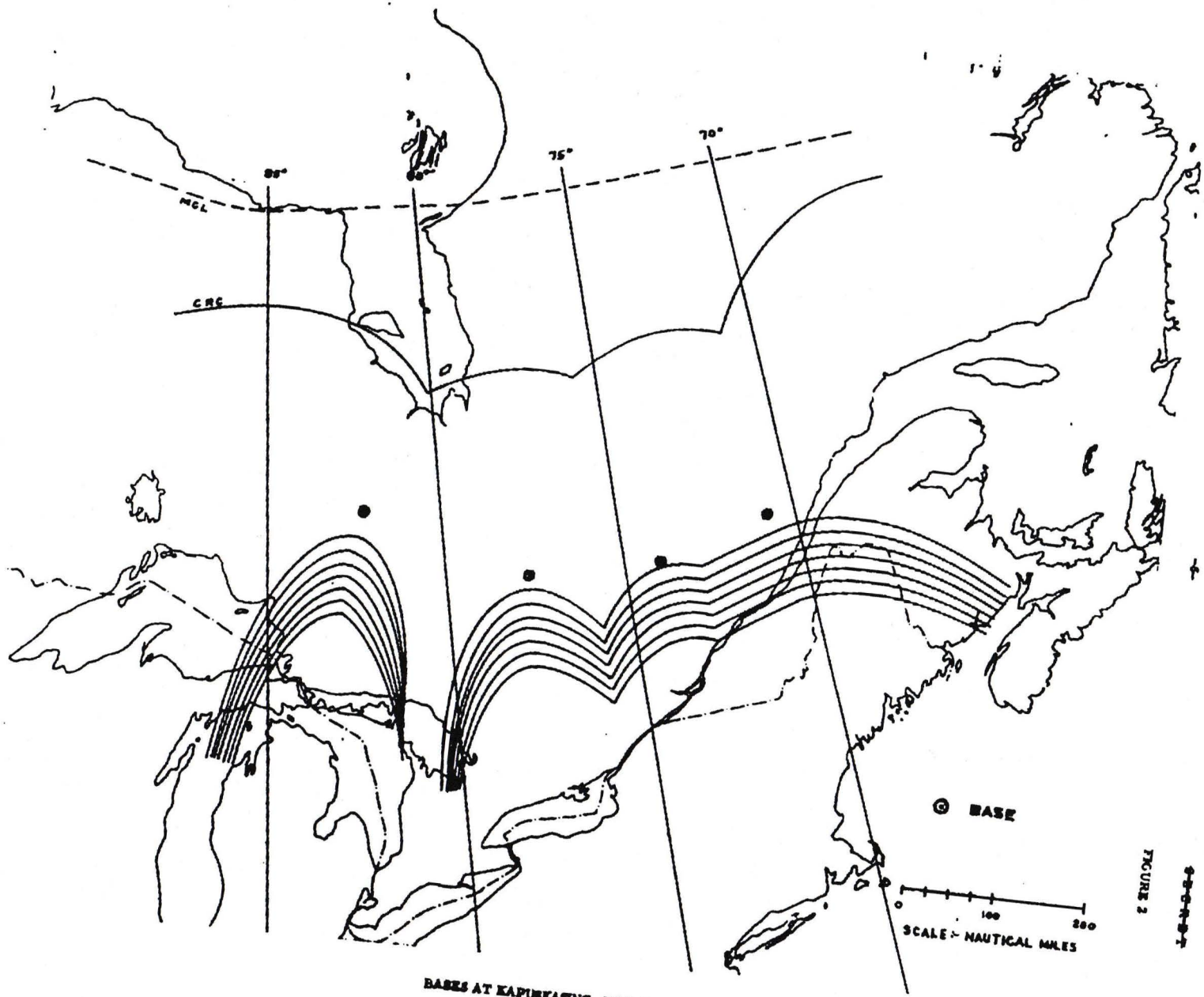


FIGURE 2

BASES AT KAPUSKASING, VAL d'OR, CASEY and BAGOTVILLE
CF-105: FIXED PROFILE MISSION, SPEED M 1.5
Target: SPEED M1.5

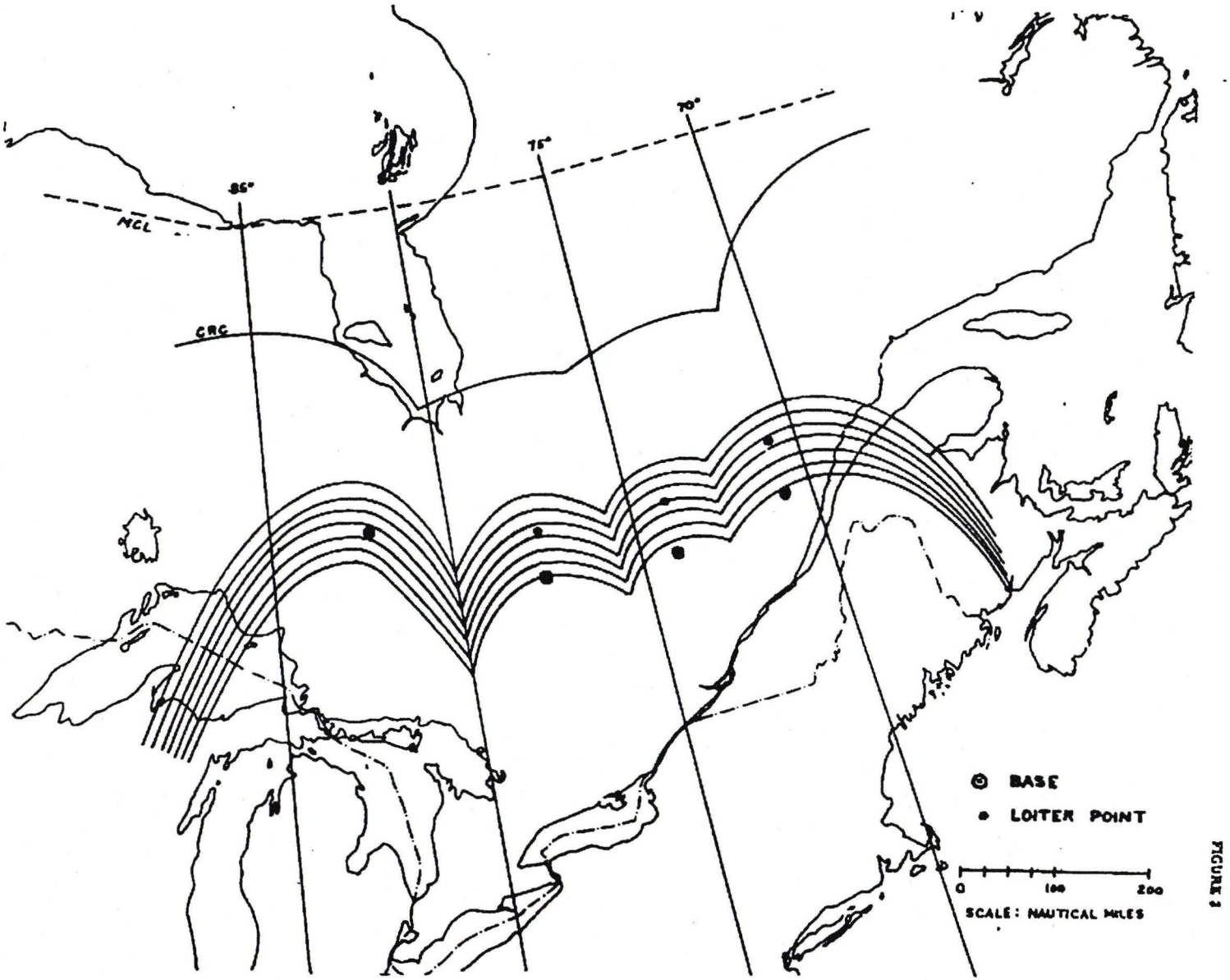
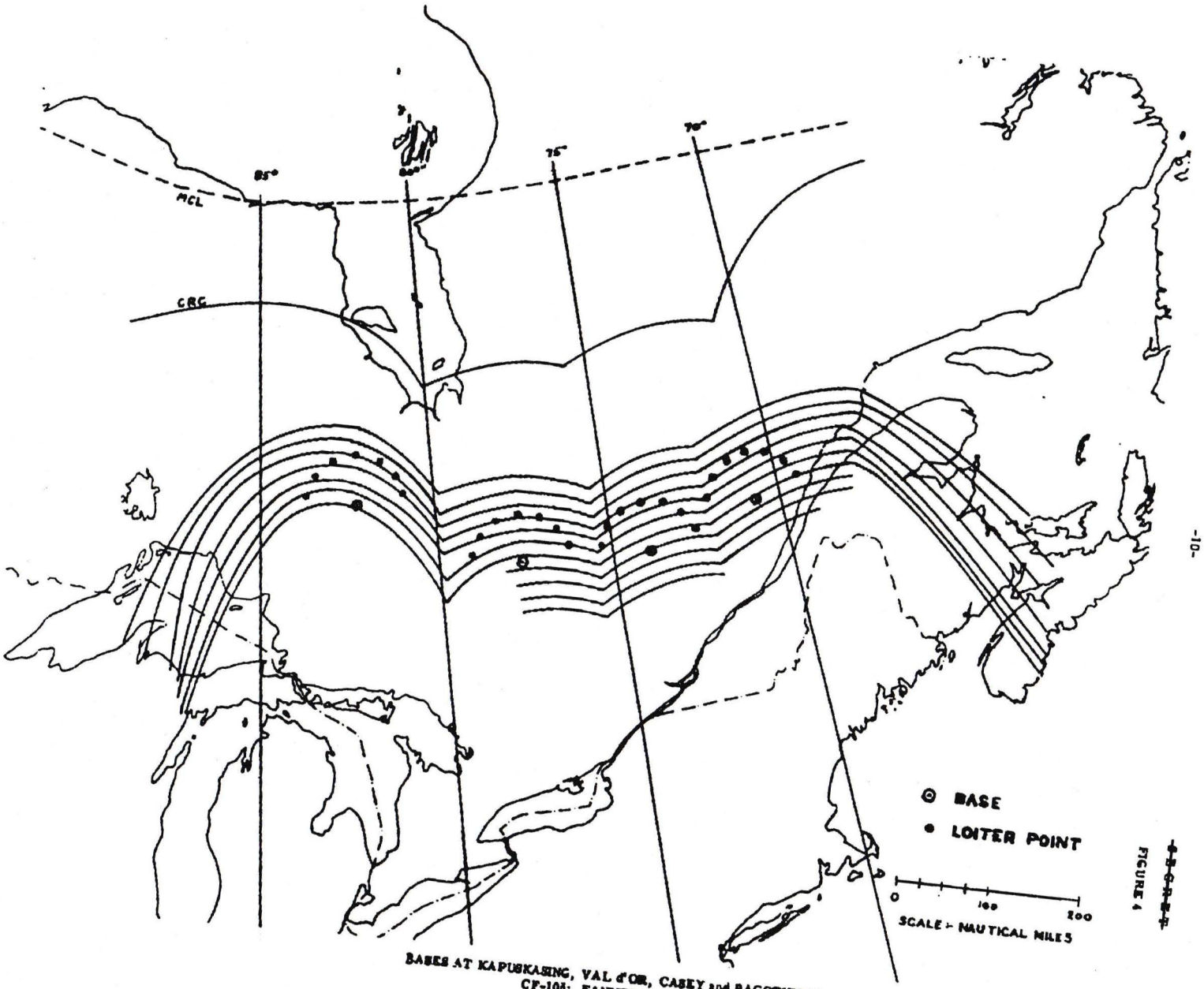


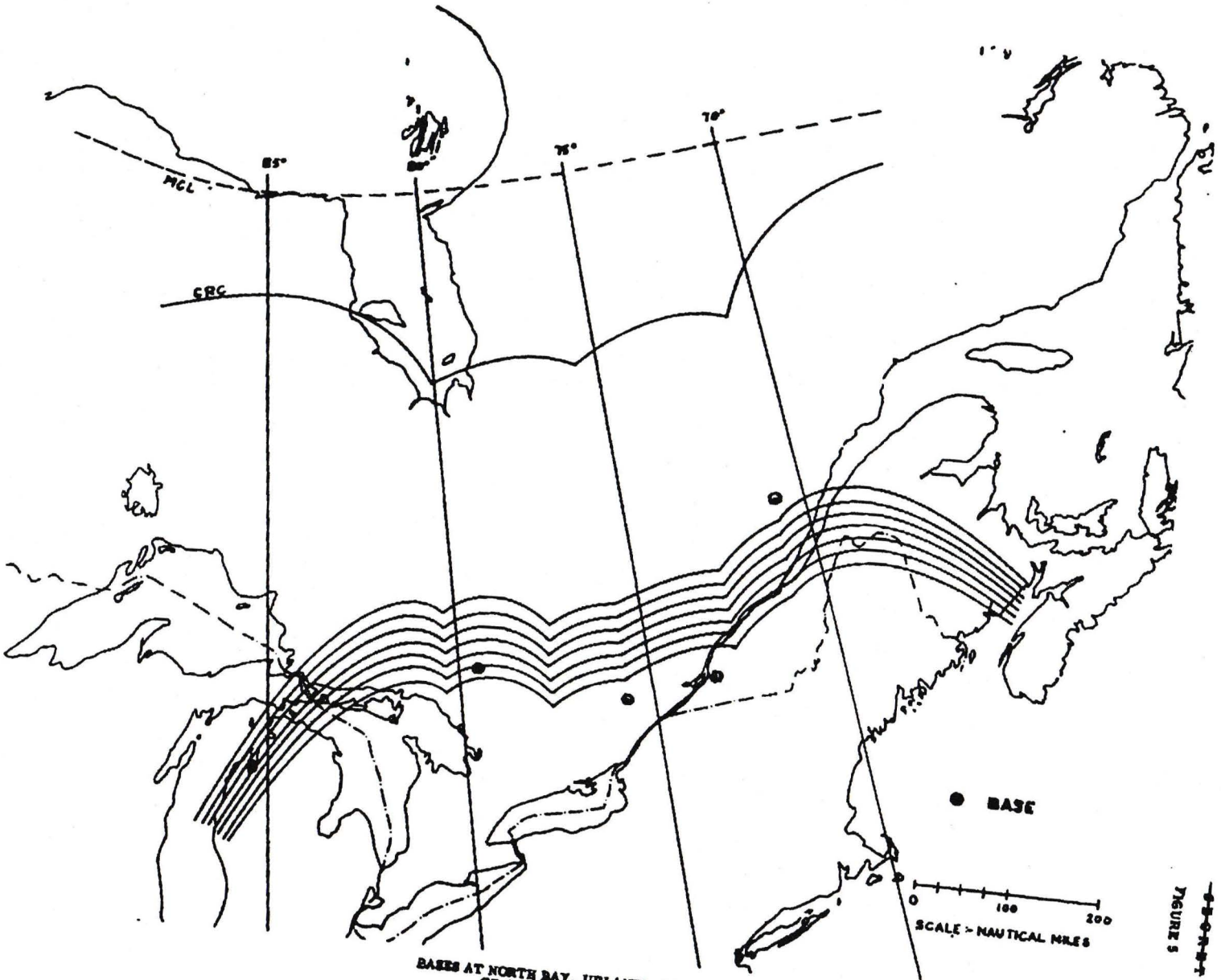
FIGURE 3

BASES AT KAPUSKASING, VAL d'OR, CAREY and BAGOTVILLE
CF-105: POINT LOITER MISSION, SPEED M1.5
TARGET: SPEED M1.5



BASES AT KAPUSKASING, VAL d'OR, CASEY and BAGOTVILLE
CF-105: FANNED LOITER MISSION, SPEED M1.5
TARGET: SPEED M1.8

FIGURE 4



BASES AT NORTH BAY, UPLANDS, BAGOTVILLE and ST. HUBERT
CF-105: FIXED PROFILE MISSION, SPEED MI.5
TARGET: SPEED MI.8

FIGURE 5

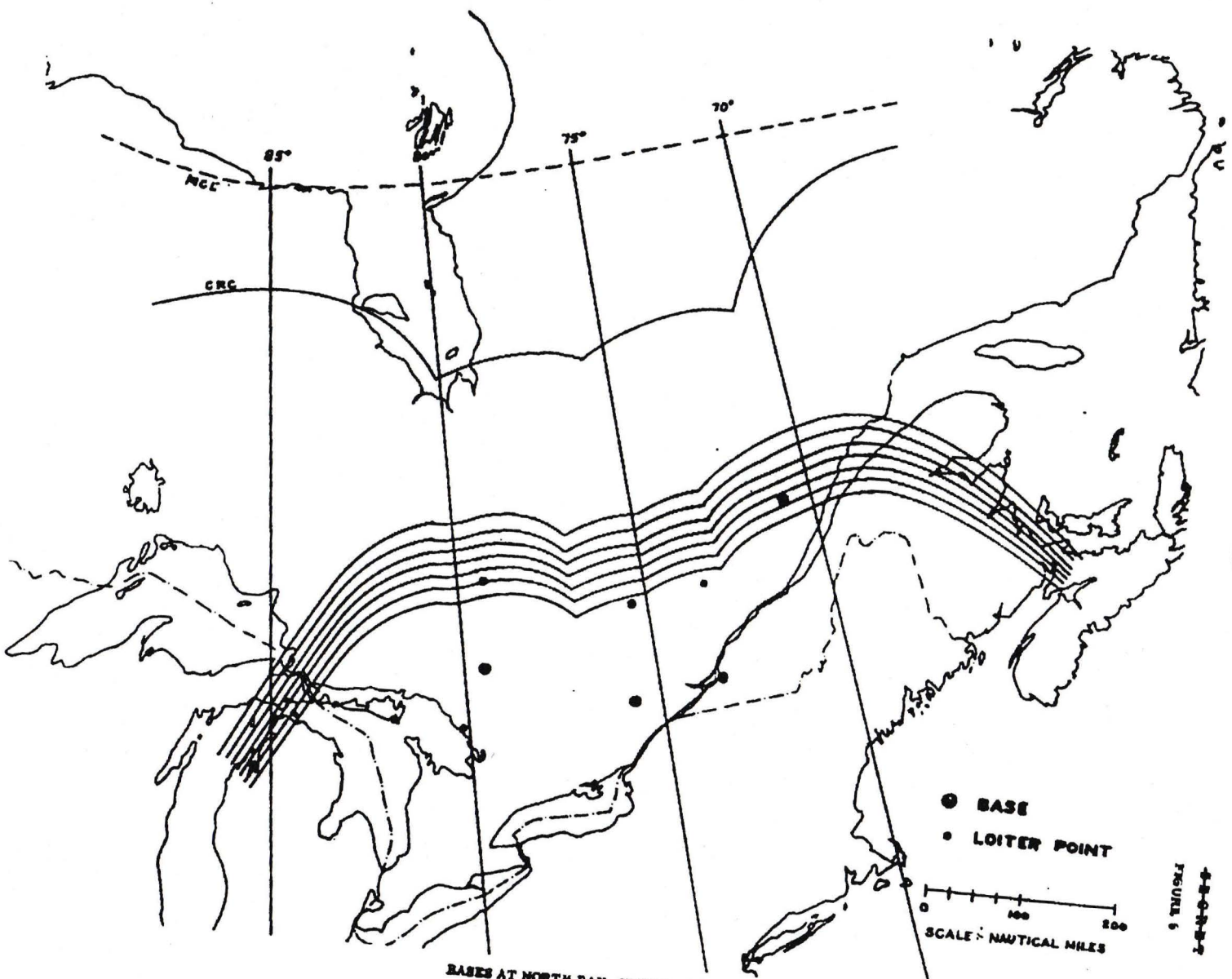


FIGURE 5

BASES AT NORTH BAY, UPLANDS, BAGOTVILLE and ST. HUBERT
CF-105: POINT LOITER MISSION, SPEED MI.
TARGET: SPEED MI.

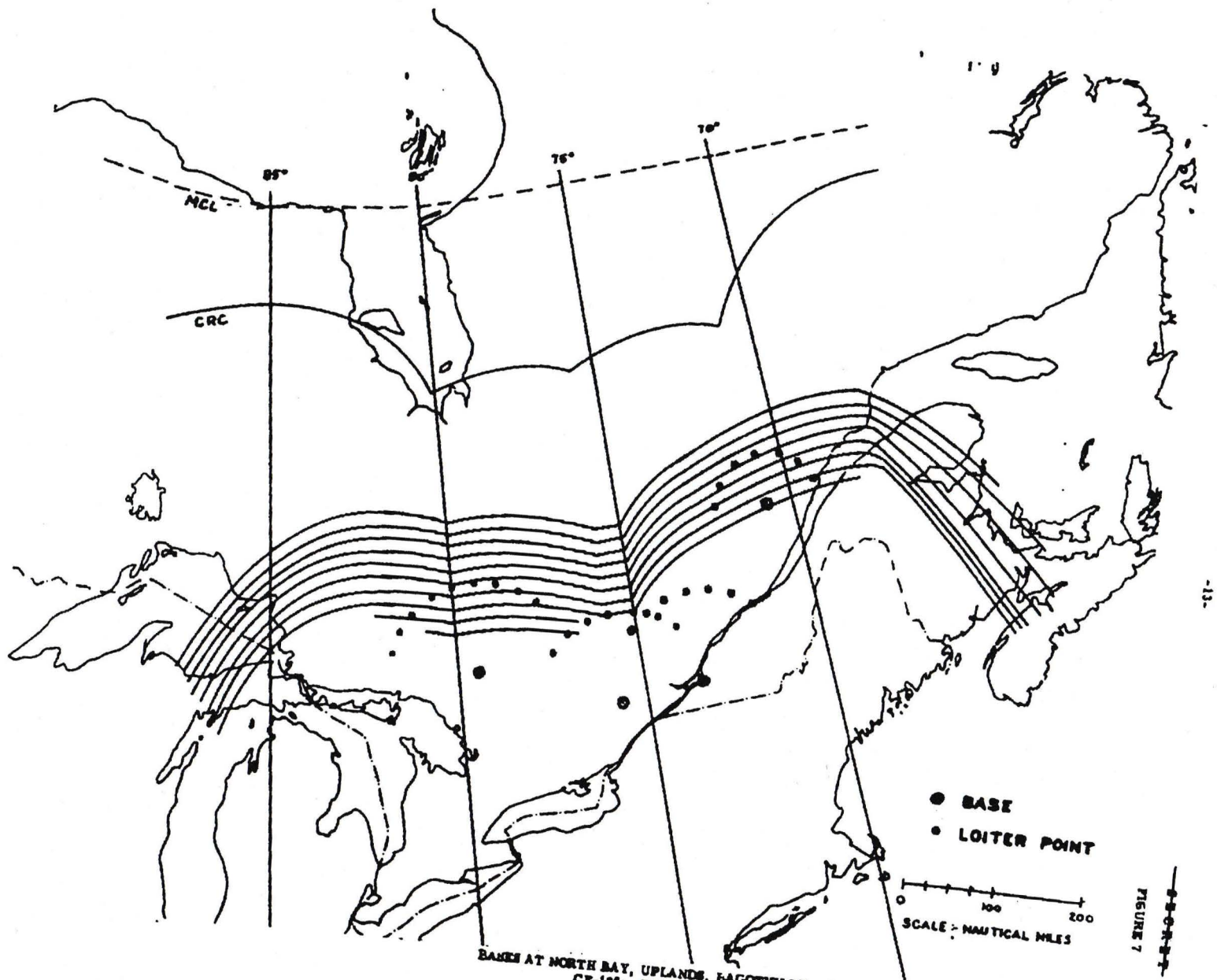


FIGURE 7

BASES AT NORTH BAY, UPLANDS, BAGOTVILLE and ST. HUBERT
CF-105: FANNED LOITER MISSION, SPEED M1.8
TARGET : SPEED M1.8

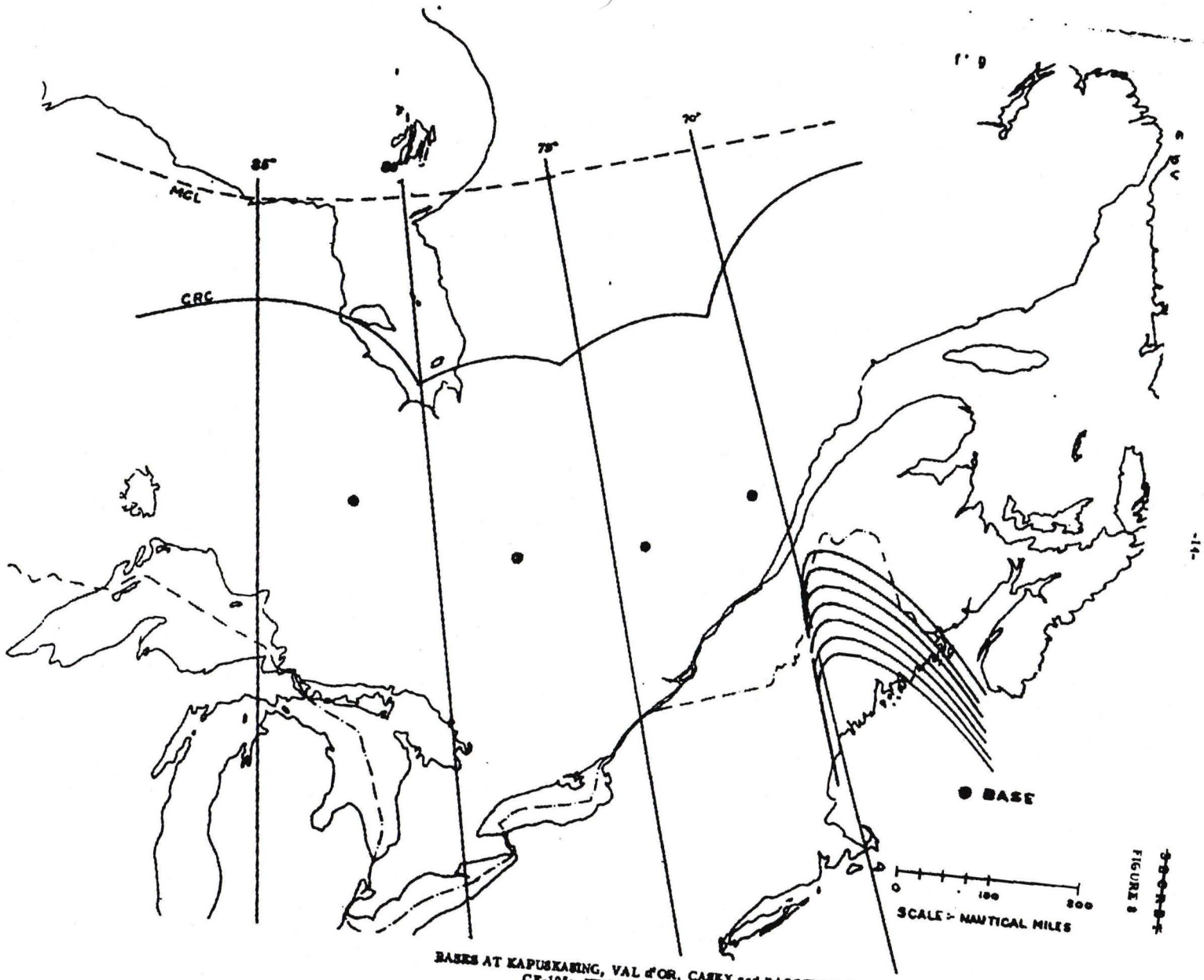
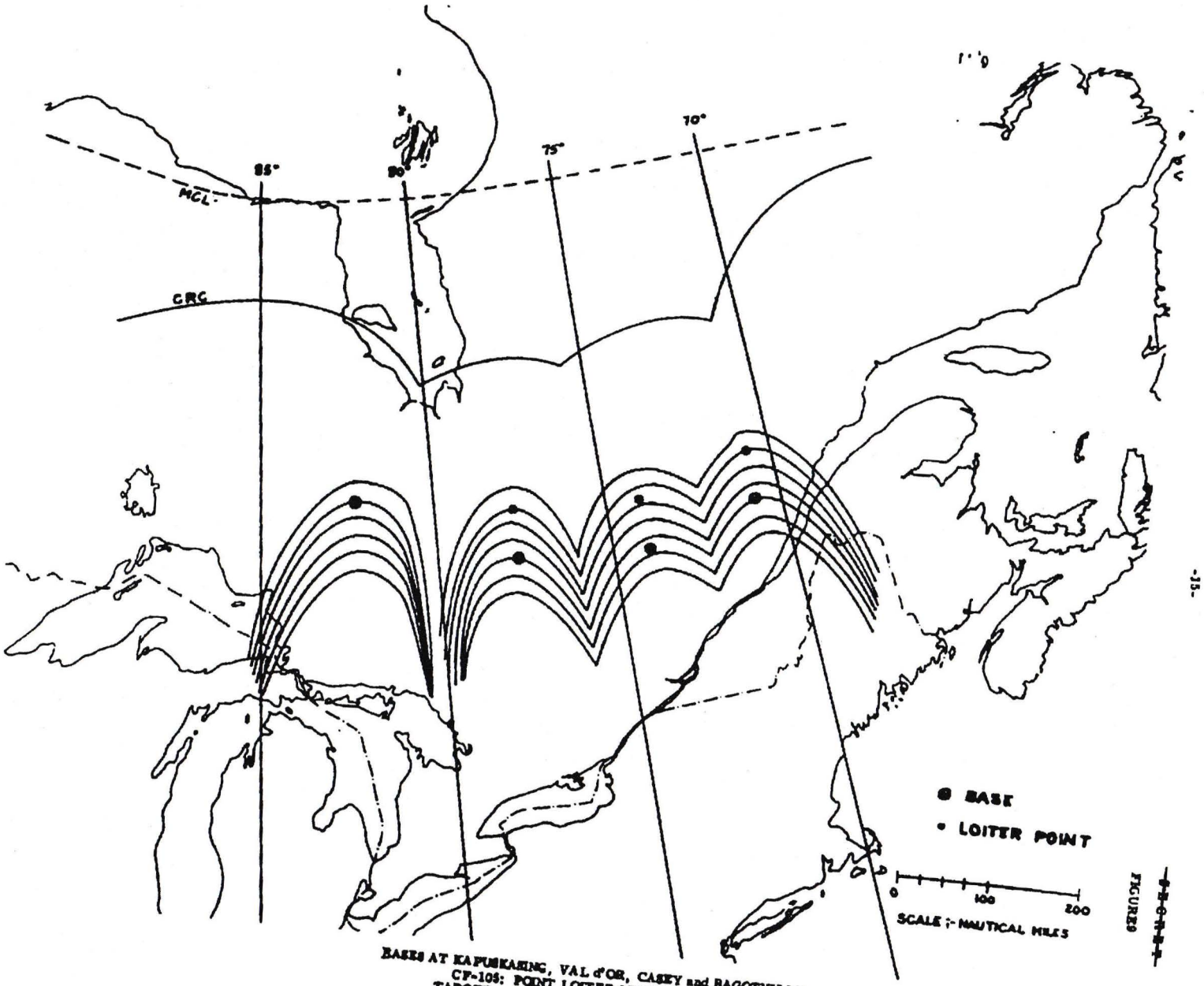


FIGURE 8

BASES AT KAPUSKASING, VAL d'OR, CASEY and BAGOTVILLE
CF-105: FIXED PROFILE MISSION, SPEED M2.0
TARGET : SPEED M2.0



BASES AT KAPUSKASING, VAL d'OR, CASEY and BAGOTVILLE
CF-105: POINT LOITER MISSION, SPEED M2.0
TARGET : SPEED M2.0

FIGURE 9

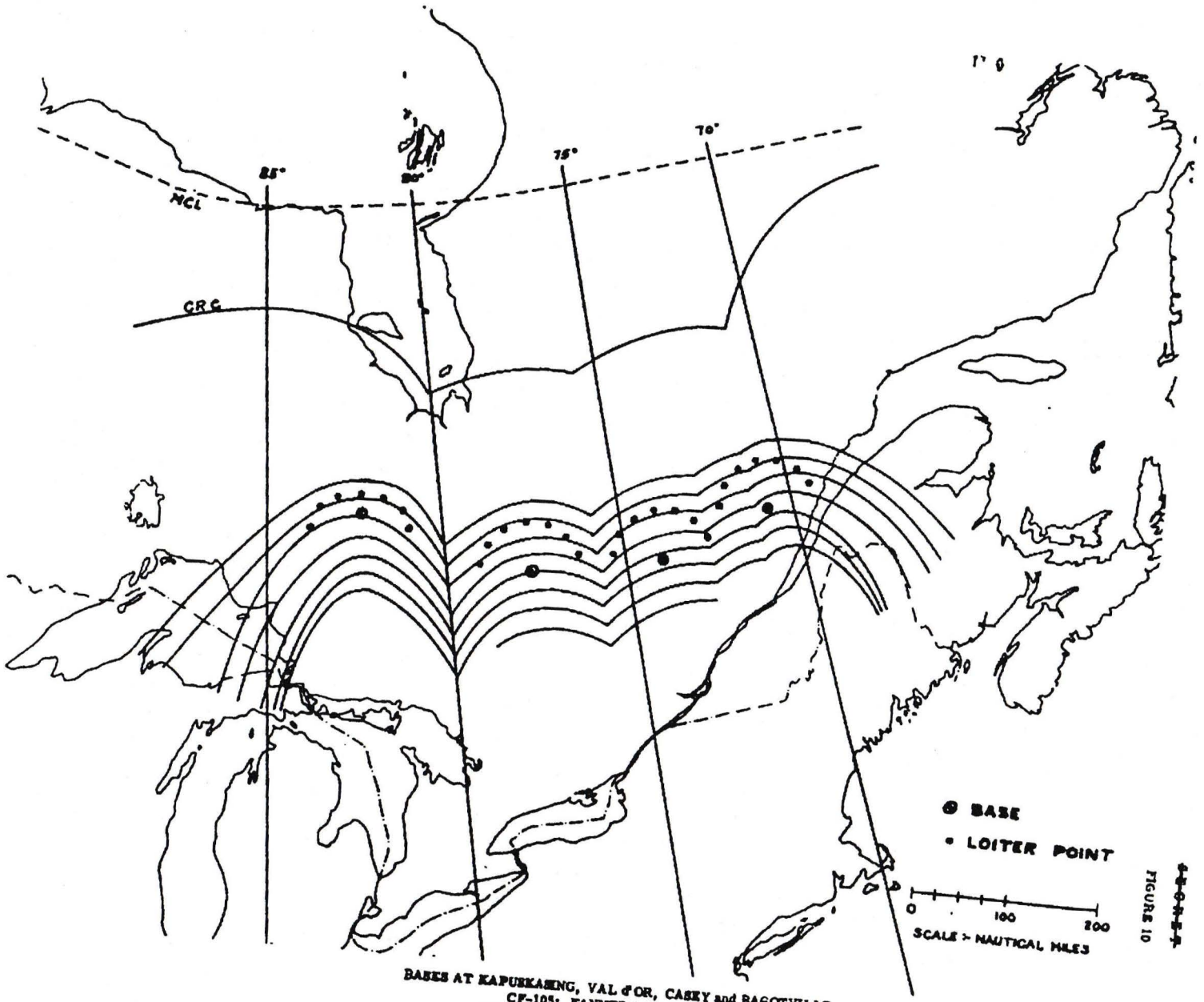
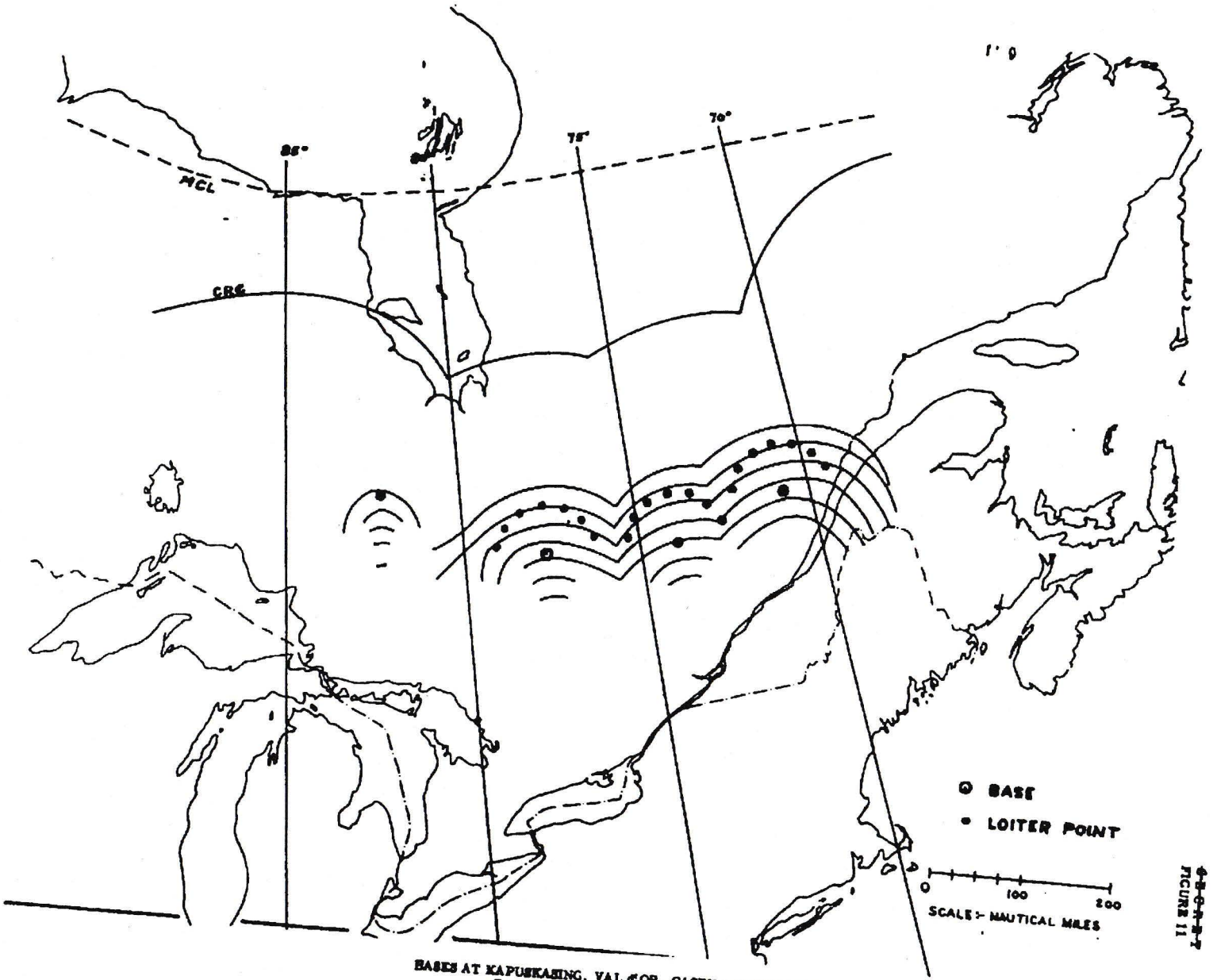


FIGURE 10

BASES AT KAPUSKASING, VAL d'OR, CASEY and BAGOTVILLE
CF-105: FANNED LOITER MISSION, SPEED M2.0
TARGET : SPEED M2.0



BASES AT KAPUSKASING, VAL d'OR, CASEY and BAGOTVILLE
CF105 : FANNED LOITER MISSION, SPEED M1.5
TARGET : SPEED M2.0

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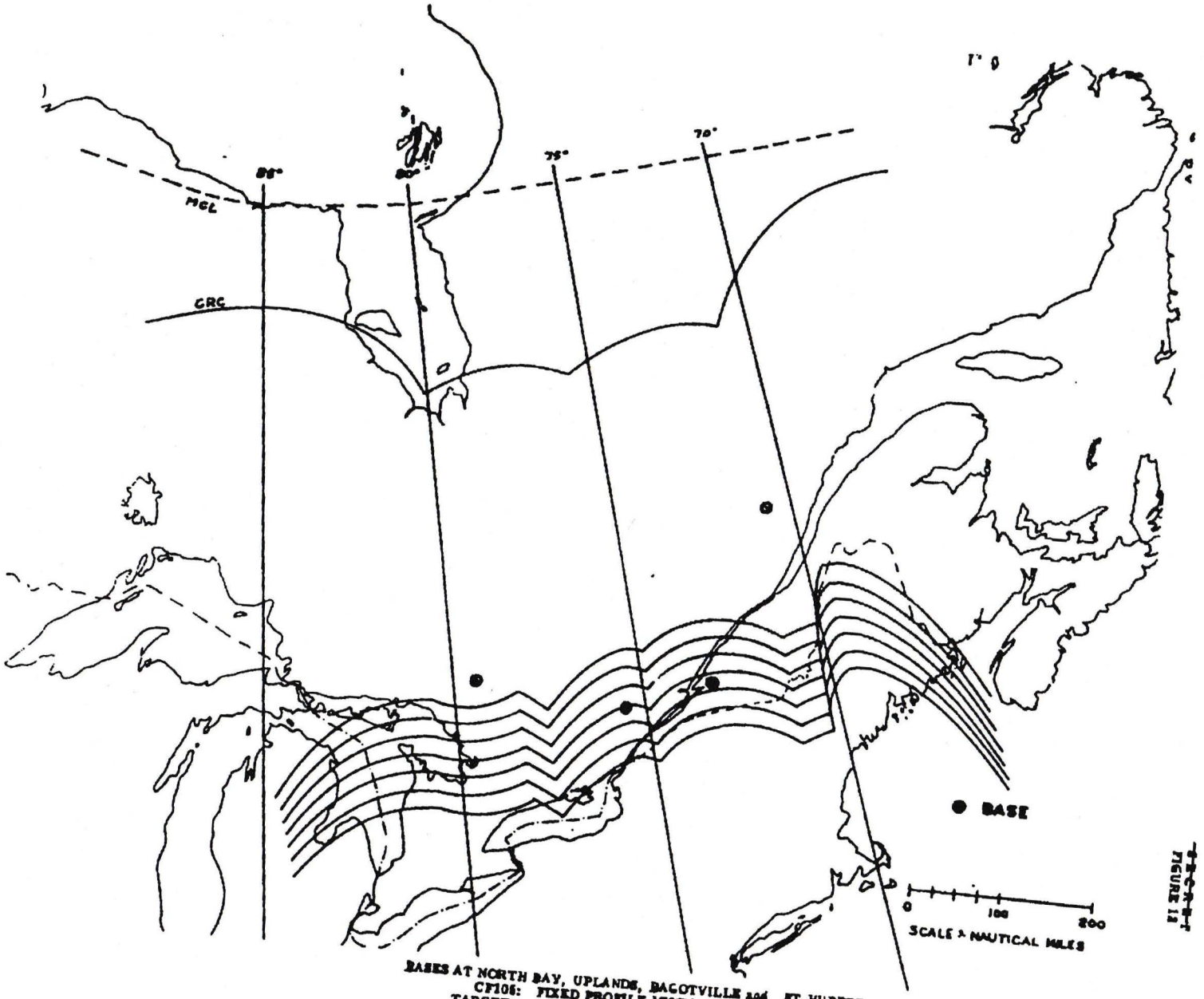
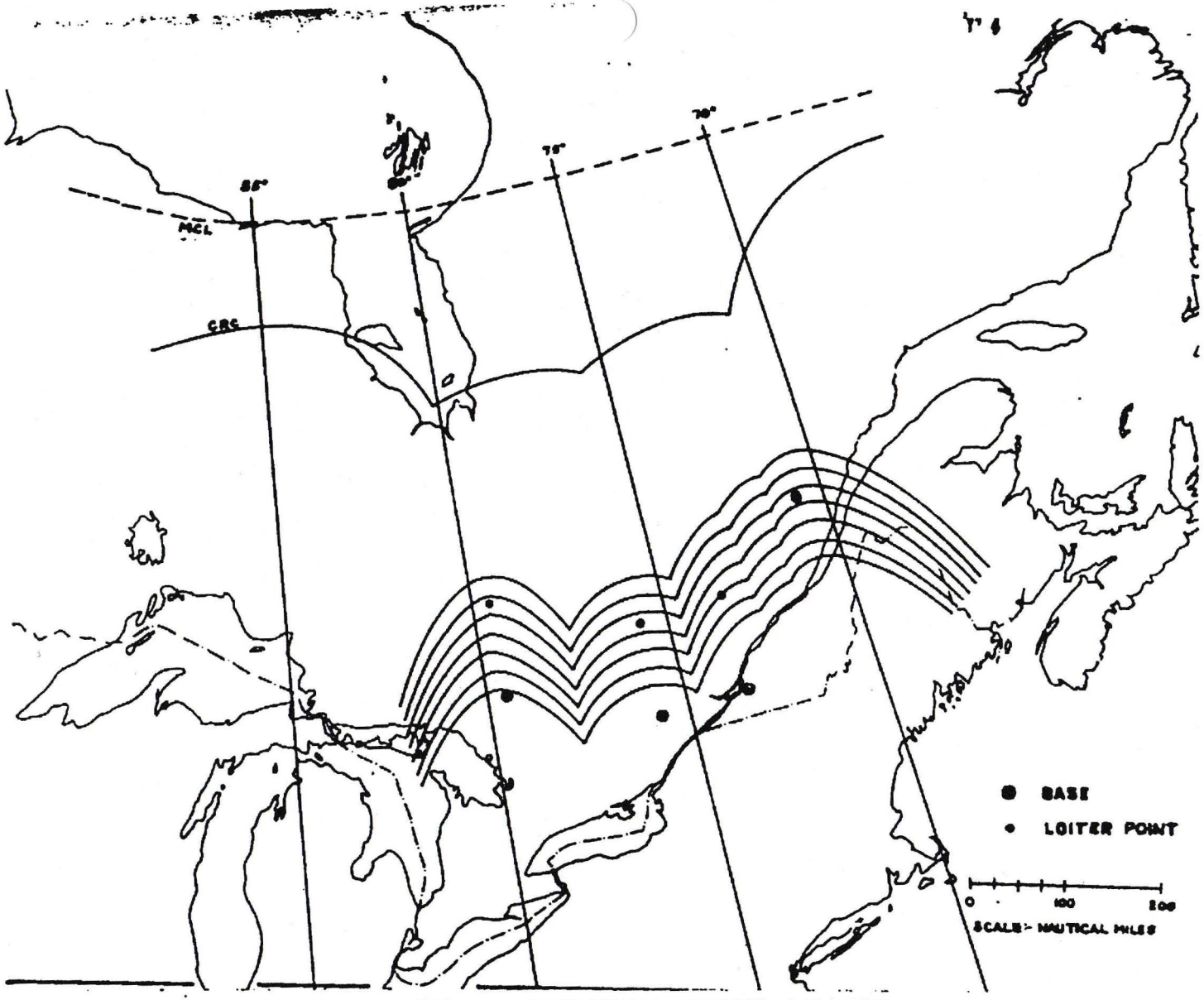
FIGURE 11



BASES AT NORTH BAY, UPLANDS, BAGOTVILLE and ST. HUBERT
CF105: FIXED PROFILE MISSION SPEED M2.0
TARGET : SPEED M2.0

FIGURE 12



BASES AT NORTH BAY, UPLANDS, BAGOTVILLE and ST. HUBERT
CF-105: POINT LOITER MISSION SPEED M2.0
TARGET: SPEED M2.0

FIGURE 13

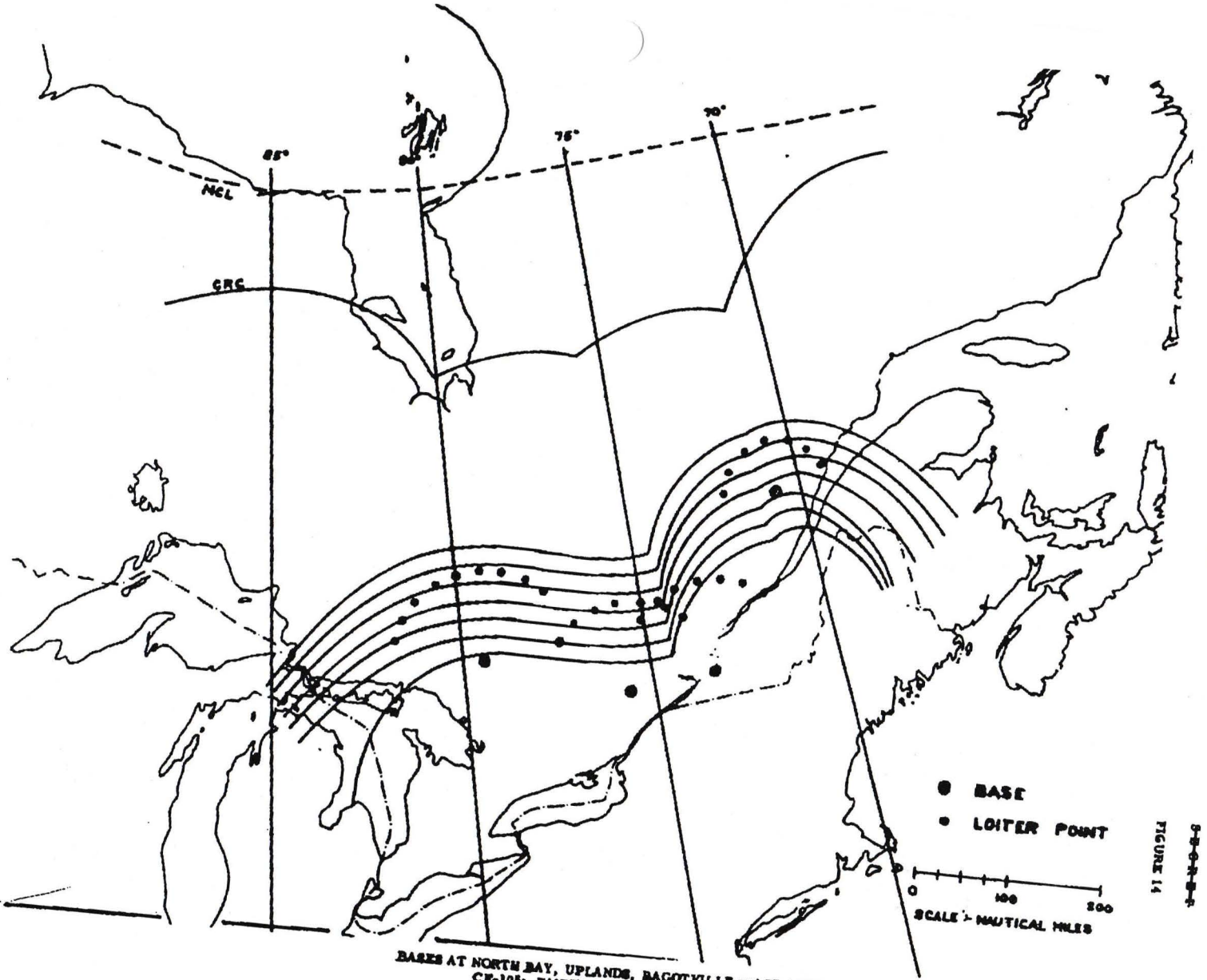
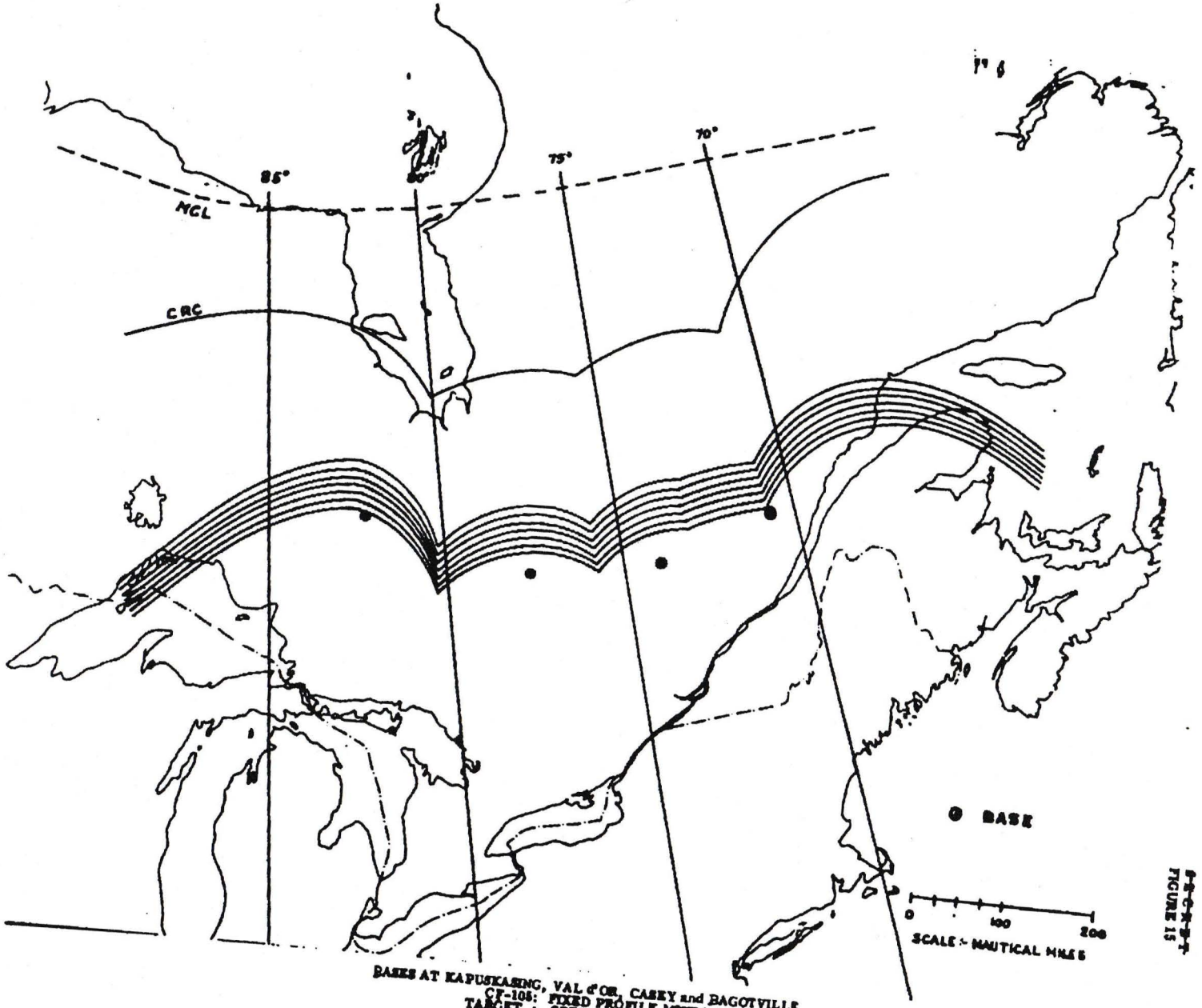


FIGURE 14

BASES AT NORTH BAY, UPLANDS, BAGOTVILLE and ST. HUBERT
CF-105: FANNED LOITER MISSION SPEED M2.0
TARGET : SPEED M2.0



BASES AT KAPUSKASING, VAL d'OR, CASEY and BAGOTVILLE
CF-105: FIXED PROFILE MISSION, SPEED M1.5
TARGET : SPEED 500 kts.

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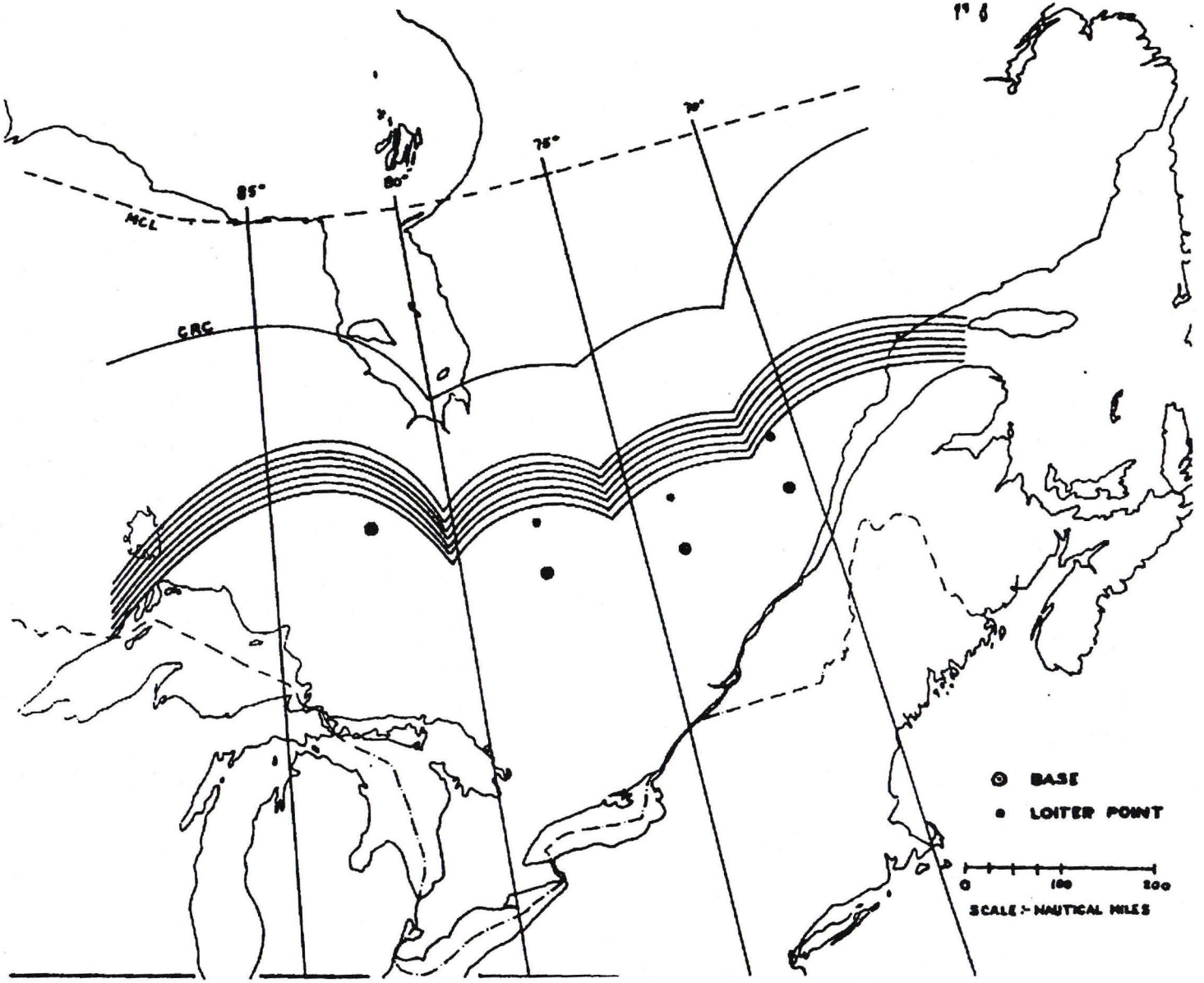
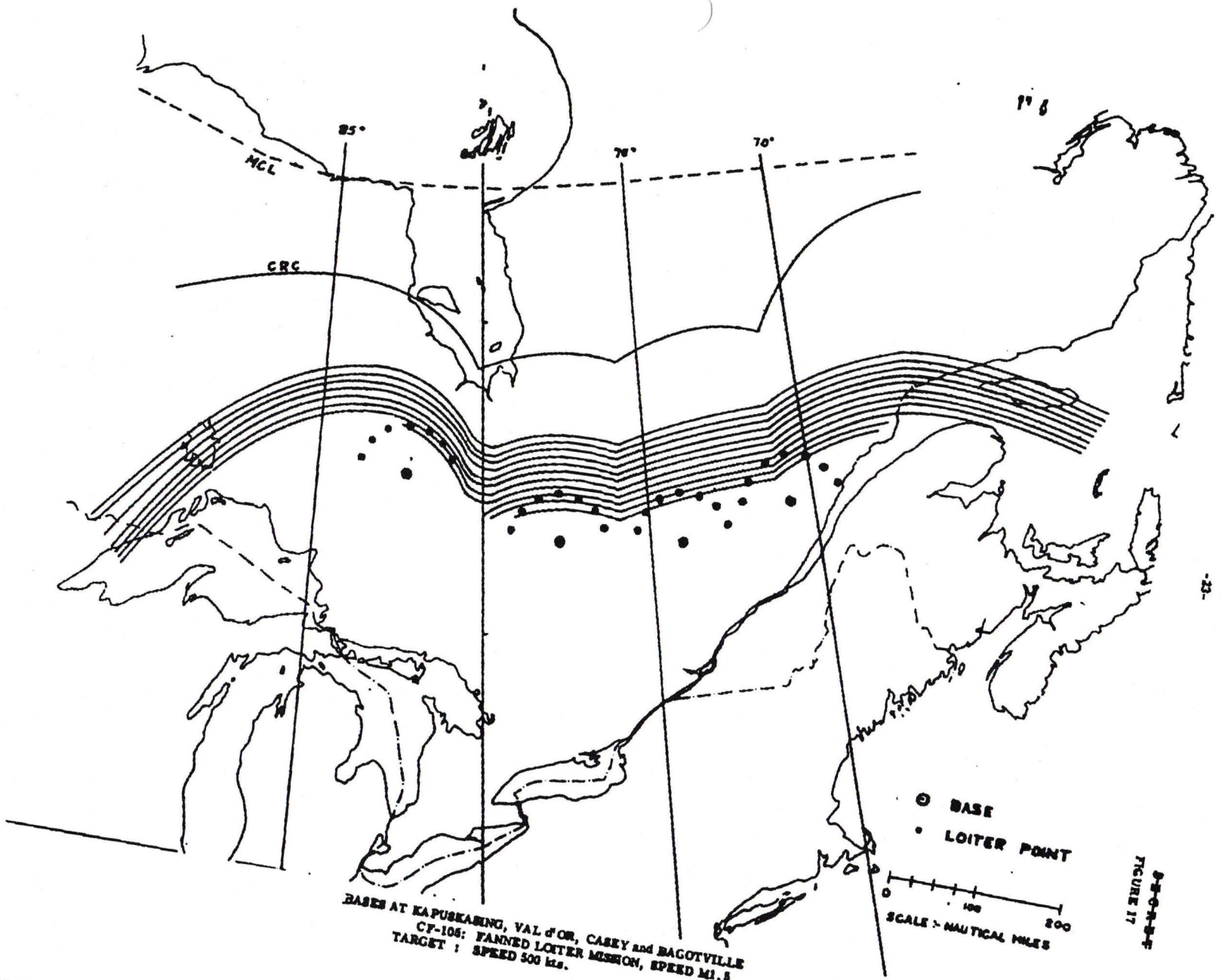
FIGURE 15



BASES AT KAPUSKASING, VAL d'OR, CASEY and BAGOTVILLE
CF-105: POINT LOITER MISSION, SPEED M1.5
TARGET : SPEED 500 kts.

FIGURE 19



BASES AT KAPUSKASING, VAL d'OR, CASEY and BAGOTVILLE
CF-105: FANNED LOITER MISSION, SPEED M1.8
TARGET : SPEED 500 kts.

FIGURE 17

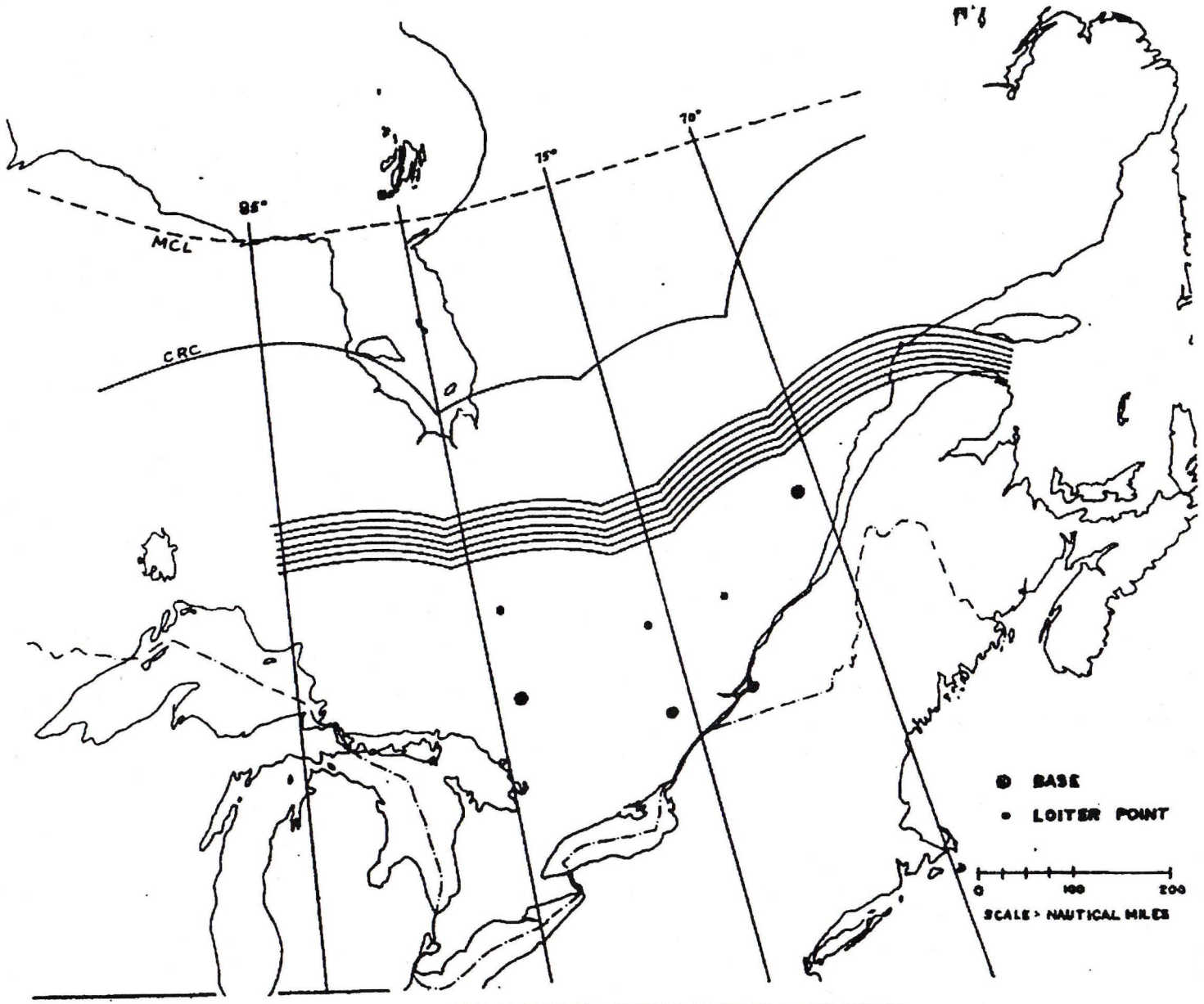
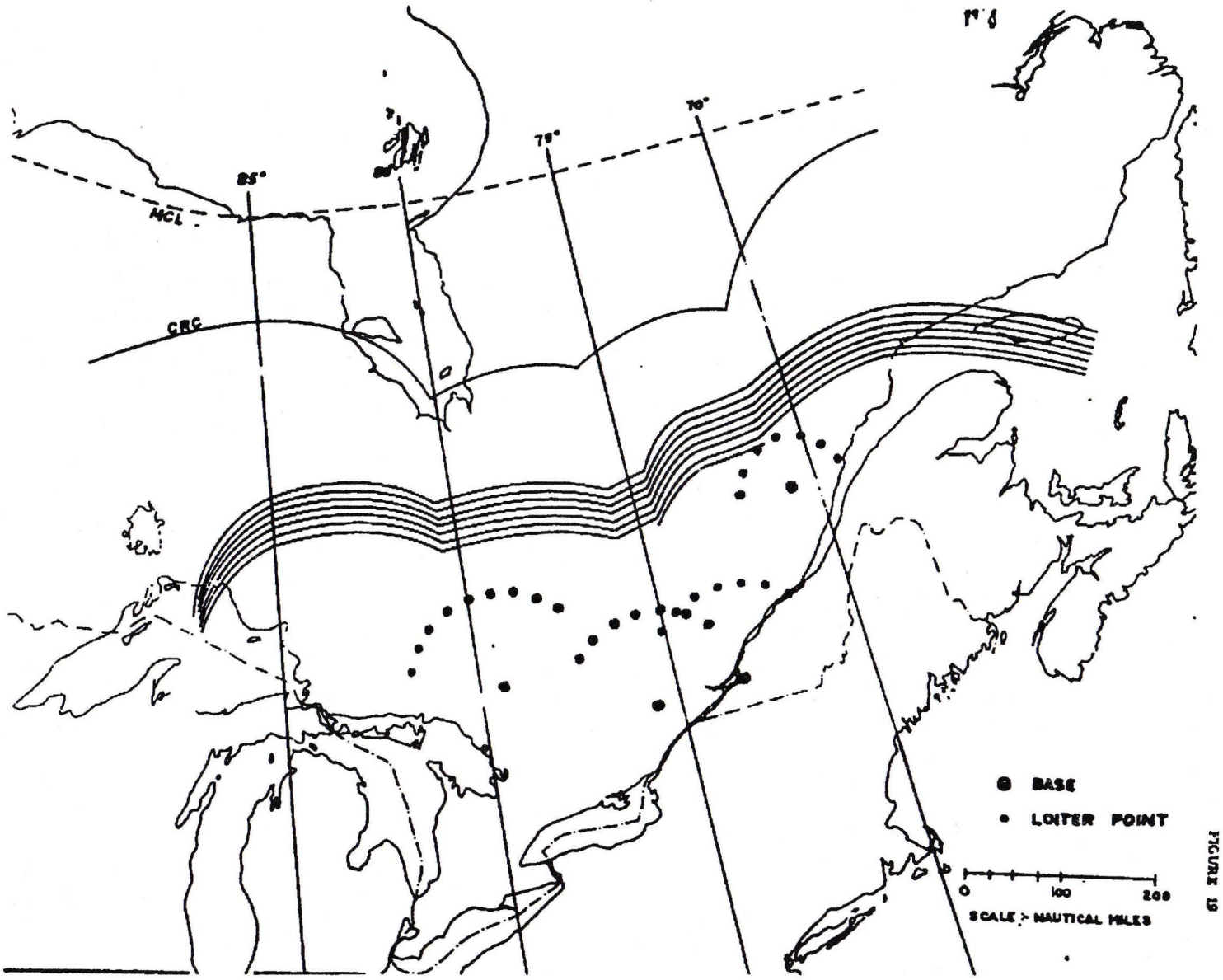


FIGURE 18

BASES AT NORTH BAY, UPLANDS, BAGOTVILLE and ST.HUBERT
CF-105: POINT LOITER MISSION, SPEED M1.5
TARGET : SPEED 500 kts.



BASES AT NORTHBAY, UPLANDS, BAGOTVILLE and ST.HUBERT
CF-105: FANNED LOITER MISSION, SPEED M1.5
TARGET : SPEED 600 kts.

FIGURE 19

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