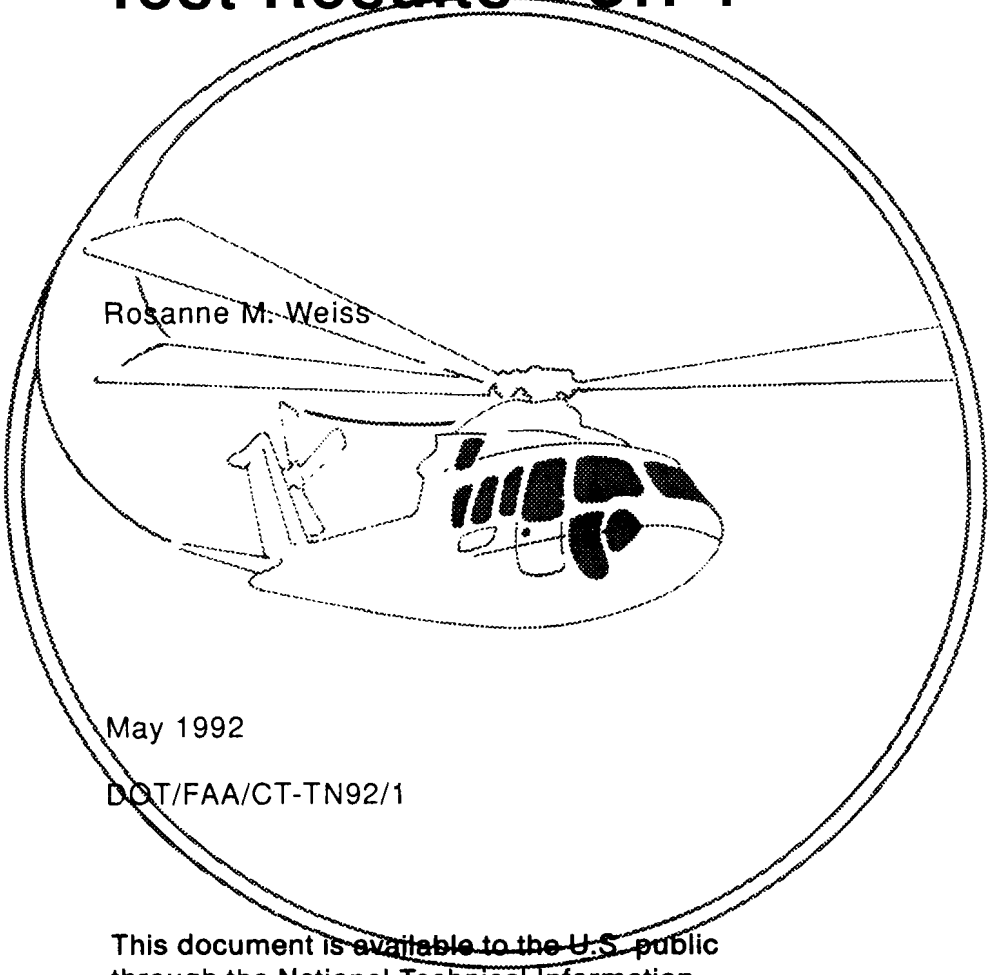
technical note technical note

Helicopter Nighttime Parking Test Results - UH-1



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DOT/FAA/CT-TN92/1

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16. Abstract

Flight tests had previously been conducted at the Federal Aviation Administration (FAA) Technical Center to examine issues regarding rotortip separation in ground maneuver areas at heliports. Technical Note DOT/FAA/CT-TN88/30, "Heliport Surface Maneuvering Test Results," details the results of those tests. However, those tests were conducted under visual flight conditions (VFR) daylight conditions. Given the limitations of scoptic vision, it was determined that nighttime testing was needed to determine whether pilot parking separation performance and perception deteriorates under night, low ambient light conditions.

This report documents the results of nighttime parking tests conducted at the Technical Center between January 1989 to August 1989. Over 100 parking maneuvers were conducted using a UH-1H helicopter. All were conducted under head, tail, and crosswind conditions, with an unlit and a lit obstacle and without an obstacle in place. Pilot subjective data in reference to these maneuvers were collected via post-maneuver ratings and post-flight questionnaire.

Data collection and analysis methodology and objective as well as subjective issues are discussed. Statistical and graphical analysis of pilot performance and perception data and subjective input are provided. Conclusions are drawn about the considerations that must be given to parking space size at heliports permitting nighttime operations.

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EXECUTIVE SUMMARY

Flight tests were conducted at the FAA Technical Center to measure pilot performance and perception during helicopter parking maneuvers. These tests were initiated as a follow-on to previous parking tests as documented in DOT/FAA/CT-TN88/30, "Heliport Surface Maneuvering Test Results." This work was conducted under nighttime, low ambient lighting conditions, between January 1989 and August 1989.

This report documents the results of this activity. In addition, it describes the data collection and analysis methodology, and discusses objective as well as subjective issues. Statistical and graphical analysis of pilot performance and perception data and subjective input are provided.

Over 100 parking maneuvers were conducted using a UH-1H helicopter. All were conducted under head, tail, and crosswind conditions, with an unlit and a lit obstacle and without an obstacle in place. Pilot subjective data in reference to these maneuvers were collected via post-maneuver ratings and post-flight questionnaire. Seven pilots with a varied background of experience participated in the tests. Due to constraints on the use of the test vehicle (a U.S. Army UH-1H), only one of the subject pilots had less than 1600 hours helicopter experience.

Performance statistics and plots indicate that pilots require additional safety precautions when maneuvering their helicopter on the surface under nighttime, low ambient lighting conditions. The clearances believed by the pilots to be required do not adequately reflect the clearances actually experienced during execution of the procedures, particularly when maneuvers were conducted near an unlit object with crosswind conditions. When given only a ground mark for reference the pilots tended to overestimate their clearances. For safe ground operations at night, pilots need more space than what they realize.

An examination of the pilot subjective input from post-maneuver as well as post-flight questionnaires reveals that the pilots were less comfortable with parking their aircraft under tailwind conditions. This is consistent with the daytime test results documented in FAA/CT-TN88/30.

Therefore, as seen with the previous daytime tests, prevailing winds are a major factor in parking/maneuvering performance as well as in pilot perceived comfort levels when maneuvering a helicopter at the surface.

Additional pilot input regarding safe parking maneuvers is also discussed in this report.

INTRODUCTION

PURPOSE.

Technical Notes DOT/FAA/CT-TN87/10, "Heliport Night Parking Area Criteria Test Plan," and DOT/FAA/CT-TN88/30, "Heliport Surface Maneuvering Test Results," addressed issues regarding rotortip separation in ground maneuver areas at heliports. These issues included separation between rotorcraft and objects or other rotorcraft.

DOT/FAA/CT-TN88/30 examined these issues under visual flight rules (VFR) daylight conditions. Given the limitations of scoptic vision, it was determined that nighttime testing was needed to determine whether pilot parking separation performance and perception deteriorates under night, low ambient light conditions. DOT/FAA/CT-TN87/10 spelled out the procedures to be used to examine the issues of rotor tip clearances from obstacles, e.g., parked vehicles, structures, etc., but not another helicopter, under limited lighting/night conditions. This report discusses the results of that activity.

These tests were conducted at the Federal Aviation Administration's (FAA) National Concepts Development and Demonstration Heliport located at the FAA Technical Center, Atlantic City International Airport, NJ.

The following test objectives were addressed:

1. To determine the safe rotor tip clearances preferred by pilots when parking an aircraft near objects under night, low ambient light conditions.

2. To determine how well pilots can judge tip clearances when asked to park a set distance from an edge marking or an object under night, low ambient light conditions.

3. To provide data to the Vertical Flight Program Office to aid in the verification of the current Heliport Design Advisory Circular (AC150/5390-2) separation criteria for parking areas.

BACKGROUND.

The focus of this test was on the issue of rotor tip clearances as discussed in AC 150/5390-2. Section 26a describes the recommended location and separation criteria for parking areas as follows: "Except for helipads and helidecks located in the final approach and take off area (FATO) or takeoff and landing area, the parking area shall be located such that parked helicopters are clear of the approach and departure surfaces and have at least 1/3 rotor diameter but not less than 10-foot (3-meter (m)) clearance from a takeoff and landing area or a fixed or movable object."

This criteria was based on operational judgement. Flight test data were collected at the Technical Center during the fall of 1987 and early winter of 1988 under daylight VFR daylight conditions. Conclusions from that test activity suggested that further flight testing was needed under low ambient light, nighttime conditions.

The data collected during this activity were designed to measure pilot performance during parking operations at night and to obtain pilot perception and preferences with reference to rotor tip clearances under night time, low light conditions.

These tests were conducted between January 1989 and August 1989.

METHODS

DATA COLLECTION.

TEST LOCATIONS. All parking maneuvers were conducted at the FAA Technical Center's National Concepts Development and Demonstration Heliport, Atlantic City International Airport, NJ.

PROCEDURES. Each pilot was asked to maneuver the helicopter on the heliport under head, tail, and cross wind conditions. One third of the maneuvers had an unlit obstacle on the heliport, one third had a lit obstacle, and the final third had only a ground marking for reference. The obstacle used for these tests was a full size 18-foot long, 7-foot wide, 6.5-foot tall Dodge pickup truck with cap.

During the first portion of the test, prior to parking the helicopter, the pilot was asked to state the rotor tip clearance with which he would be comfortable. The pilot was then instructed to park parallel to the obstacle or the ground marking with his stated clearance. When the pilot was satisfied with the helicopter's position, he was asked to estimate his actual rotor tip clearance from either the obstacle or the ground marking. An onboard technician then placed markers at the edge of the skids. Measurements of the marker locations were taken by ground personnel after the helicopter departed the heliport.

During the second portion of the test the pilot was instructed to park the helicopter with a fixed 12-foot tip path clearance. Again, the technician positioned markers and measurements were taken after the helicopter's departure from the landing zone. Also, following each maneuver, the pilot was asked to rate the maneuver in terms of controllability, safety, and pilot workload using a modified version of the Cooper Harper rating scale, as seen in figure 1.

Each subject pilot completed at least three maneuvers with the unlit obstacle on the heliport, three with only the ground marking as a reference, and three with a red flashing beacon on the obstacle. One beacon was placed in the center top of the truck's cab and one on the rear most part of the cap near the driver's side. The lights were approximately eye level to the subject pilot.

The UH-1H Flight manual places the following environmental restrictions on operation of the aircraft: maximum 30 knot crosswind and 30 knot tail wind for hover, maximum gust spread of 15 knots. Table 1 presents the actual wind conditions during each test period along with number of runs flown per flight. Note that the maximum winds encountered are well below the flight manual restrictions. Subject pilot experience is also listed in this table to show that wind conditions and pilot experience were independent of each other and appear to be of random sampling. The obstacle and ground markings on the heliport were adjusted to the wind conditions so all subjects

evaluated equivalent head, tail, and cross wind conditions. Figure 2 shows a sample layout of the heliport as used during these tests.

TABLE 1. WIND CONDITIONS AND PILOT EXPERIENCE FOR NIGHT PARKING TESTS

Flight Number	Wind Condition Direction (deg)	Wind Condition Speed (kt)	Number of Runs	Subject Pilot Rotorcraft Flt Time (hr)
1	190	7	11	6200
2	180-200	9	9	3000
3	90	10	9	500
4	250-270	13	18	8100
5,6	40-50, 330	8-12	18	1600
7	330-350	10	10	6200
8	220-240	4-7	18	2600
9		calm	18	3000

PARTICIPANTS. Seven subject pilots were used for these nighttime tests. These subjects came from the private sector, FAA, and the military. Table 2 shows the breakdown of experience of these subjects. Their flight experience is presented in table 3 by total flight hours, total helicopter hours, total time in type, and total helicopter hours over the past 6 months. All had more than 1500 total flight hours and six had more than 1500 hours in helicopters. Of those six, five had greater than 1500 hours in type.

FACILITIES AND INSTRUMENTATION.

TEST AIRCRAFT.

Bell UH-1H. At the time of these tests the UH-1H was assigned to, and maintained by, the Department of the Army, U.S. Army Communications and Electronics Command (CECOM), Fort Monmouth, NJ. This aircraft was obtained by the FAA through an Interagency Agreement, DTFA01-80-Y-10530. It is a single engine helicopter equipped with electromechanical displays representative of civil certified helicopters. For this project, it was configured to carry a pilot, copilot, and six passengers. The UH-1H has a rotor diameter of 48 feet, is capable of speeds up to 124 knots, with a maximum takeoff weight of 9,500 pounds. Additional specifications can be found in appendix A.

DATA PROCESSING AND ANALYSIS

SOURCE OF DATA.

Data for this project came from the following sources:

TABLE 2. PILOT AFFILIATION AND EXPERIENCE

Affiliation	Experience
Military	Military
Military	FAA/Military/Industry
FAA	FAA/Industry
Military	Military
FAA	FAA/Military/Industry
Military	Military/Industry
Industry	Military/Industry

TABLE 3. SUBJECT PILOT FLIGHT EXPERIENCE

Total Flight Hours	Number of Pilots
0-500	0
501-1500	0
1501-3000	1
>3000	6

Total Helicopter Hours	Number of Pilots
0-500	0
501-1500	1
1501-3000	3
>3000	3

Total Time in Type	Number of Pilots
0-500	2
501-1500	0
1501-3000	4
>3000	1

Total Helicopter Hours Last 6 Months	Number of Pilots
<10	0
10-50	3
>50	4

1. The onboard log which included pilot clearance estimates and pilot post-maneuver ratings.

2. Pilot comments.

3. Ground measurements taken at the heliport.

4. Post-flight questionnaires.

ONBOARD LOG. The onboard observer was responsible for filling in the onboard log. Information recorded on this log included the following:

1. Subject pilots estimates of the tip clearances with which they would feel comfortable parking their aircraft with the given wind conditions.

2. Subject pilot estimates of the actual tip clearance achieved.

3. Pilots post-maneuver ratings of the maneuver's controllability, safety, and demand using the modified Cooper Harper rating scale.

4. Pilot comments made during the procedure.

5. Local weather and wind conditions.

A sample of this onboard log can be found in appendix B.

GROUND MEASUREMENTS. All distances were measured from two corners of the helipad to the midpoint between the two markers positioned by the onboard observer. This midpoint was considered to be the location of the aircraft's mast. The X and Y coordinates of the midpoint were calculated using simple geometric procedures. With these coordinates, it was possible to calculate the shortest distance from the mast to either the obstacle or the ground marking. The rotor tip clearance was computed by subtracting the rotor radius from that calculated distance.

POST-FLIGHT QUESTIONNAIRE. At the conclusion of the flight each subject was given a post-flight questionnaire to complete. A sample of this questionnaire can be found in appendix C. This questionnaire required the pilot to rate how comfortable he felt parking 12 feet from both the ground marking and from the obstacle with the different wind conditions. This questionnaire provided comparative subject pilot measures across all maneuvers. In addition, the subjects were asked their opinion concerning parking near objects with limited lighting, under head, tail, and crosswind conditions. Pilot background information such as total number of flight hours and aircraft experience were also collected. This background information was referenced to their performance.

ANALYSIS PROCEDURES.

PARKING PROCEDURE DATA. Two types of errors were computed: perception error and performance error.

The perception errors were calculated by comparing the actual rotor tip clearances to the pilot estimated clearances. The actual clearances were determined by the geometric computations carried out on the ground measurements. Separate errors were calculated based on the presence or absence of the obstacle.

Performance errors were computed by comparing the actual tip clearances to the requested 12-foot clearances. Separate errors were calculated based on the presence or absence of the obstacle.

Plots were produced for these errors for each type of wind condition and for all wind conditions together. Plots of the actual tip clearances versus perceived clearances both with and without an obstacle were also produced. Mean and standard

deviations of both the pilot's stated and actual tip clearances were calculated and presented in table form for the three wind conditions, both with and without an obstacle. The error means and standard deviations are also presented in table form. These tables are presented in the Results section.

INFLIGHT/POST-MANEUVER PILOT RATINGS. The Cooper Harper ratings given by the pilots immediately following each maneuver were tabulated. Frequency plots were produced for these ratings by grouping all similar runs.

POST-FLIGHT QUESTIONNAIRE DATA. Plots were produced to graphically depict the pilot responses for the post-flight questions referencing pilot workload comfort levels while parking under tailwind, headwind, and crosswind conditions. Responses to other post-flight questions were tabulated. Pilot comments were examined and can be found in the Results sections.

RESULTS

PILOT CHOICE MANEUVERS.

For each of these pilot choice maneuvers the pilots were asked what was a safe tip clearance from the lit and unlit obstacle as well as from the ground marking. All of the values given were less than the 1/3 rotor diameter value recommended in the Heliport Design Advisory Circular. This 1/3 rotor diameter value for the UH-1H is 16 feet. When given a choice, the pilots' actual tip clearance varied from 38.55 feet clearance to 9.75 feet overlap of the lit obstacle. The actual data along with computed errors can be found in appendix D. Table 4 lists the means and standard deviations of their stated safe tip clearances. Of these 65 responses: (1) >12 feet, 1 response, (2) 10-12 feet, 52 responses, and (3) <10 feet, 12 responses. Plots showing the percentages of pilot responses referencing their preferred tip clearances are found in figure 3. These responses show a pattern similar to that seen with the daytime parking tests as reported in FAA report FAA/CT-TN88/30. However, the means of the preferred clearances for the nighttime tests are slightly larger, but the standard deviations are smaller.

However, when the pilots attempted to perform to their stated comfort levels, the resulting tip clearances averaged from 0.4 to 1.7 times the stated comfort levels. These figures also reflect those seen during the daytime tests where their performance averaged between 1.1 to 1.6 times the stated comfort levels. Comparisons of daytime vs. nighttime test results can be found in appendix E.

The means and standard deviations of the actual tip clearances regardless of wind conditions with no obstacle, an unlit obstacle, and a lit obstacle are found in table 5 and by wind conditions in table 6. Percentage plots of the actual tip clearances regardless of winds and by winds for the three test conditions are found in figures 4 and 5, respectively.

In comparing the means from table 6 for each obstacle/light condition, taken separately by wind conditions, some large differences are seen. However, results of statistical analysis procedures indicate these differences are not significant.

TABLE 4. PILOT STATED SAFE TIP PATH CLEARANCES (PILOT PREFERENCE)

In Feet

	Headwind	Crosswind	Tailwind
With Unlit Obstacle			
Mean	10.13	10.00	10.00
Standard Deviaion (SD)	2.03	1.07	1.07
Number (N)	8	7	7
With Lit Obstacle			
Mean	9.71	10.00	10.00
SD	0.70	1.07	1.07
N	7	7	7
Without Obstacle			
Mean	10.00	9.43	9.75
SD	1.07	0.90	1.20
N	7	7	8

(The 1/3 rotor diameter criteria for a UH-1H is 16 feet)

When comparing the means for table 6 for each wind condition taken separately by obstacle/light condition, using a 10 percent level of significance, the statistical analysis procedures resulted in a significant difference only for the crosswind conditions. This difference is particularly noticeable with the unlit obstacle under crosswind conditions when compared to the no object crosswind conditions. The significant difference is seen in two of the seven runs with the unlit obstacle.

In order to determine how well pilots were able to estimate their rotor tip clearances, analysis of their errors in perception were computed by subtracting their estimated clearances from the actual clearances. Perception errors ranged from an underestimate of 19.75 feet (that overlapped the lit obstacle) to an overestimate of 28.55 feet. Table 7 contains means and standard deviations of these perception errors. Plots of actual versus estimated tip clearances are found in figure 6. The diagonal line on both plots helps to provide a quick way to determine whether the pilot's perceived clearance was larger or smaller than the actual clearance.

TABLE 5. ACTUAL ROTOR TIP CLEARANCES REGARDLESS OF WIND DIRECTION (PILOT PREFERENCE)

In Feet

	With Unlit Obstacle	With Lit Obstacle	Without Obstacle
Mean	13.44	9.98	7.66
SD	9.28	9.29	9.00
N	22	21	22

(The 1/3 rotor diameter criteria for a UH-1H is 16 feet)

TABLE 6. ACTUAL ROTOR TIP CLEARANCES BY WINDS (PILOT PREFERENCE)

In Feet

	Headwind	Crosswind	Tailwind
With Unlit Obstacle			
Mean	13.80	16.46	10.00
SD	8.11	11.21	6.97
N	8	7	7
With Lit Obstacle			
Mean	7.64	10.04	12.26
SD	7.77	5.80	12.41
N	7	7	7
Without Obstacle			
Mean	11.16	4.86	7.06
SD	12.19	5.55	6.92
N	7	7	8

(The 1/3 rotor diameter criteria for a UH-1H is 16 feet)

TABLE 7. PERCEPTION ERRORS

(Actual clearances - Pilot Estimated Clearances)

In Feet

	Headwind	Crosswind	Tailwind
With Unlit Obstacle			
Mean	3.80	5.75	.15
SD	7.32	11.36	6.14
N	8	7	7
With Lit Obstacle			
Mean	-2.36	-.96	2.54
SD	7.59	5.63	11.74
N	7	7	7
Without Obstacle			
Mean	1.01	-5.00	-2.45
SD	12.09	5.00	7.28
N	7	7	8

(The 1/3 rotor diameter criteria for a UH-1H is 16 feet)

Examination of perception errors, regardless of wind conditions, revealed that with the unlit object, 6 of the 22 perceived clearances were overestimated, that is the pilot's perceived clearances were greater than the actual clearances. Four of those

overestimated clearances with the unlit object were by more than 3 feet. Two of these cases actually overlapped the obstacle which was several feet shorter than the height of the rotor tips in rotor-level configuration.

With the lit obstacle 10 of the 21 perceived clearances were overestimated; 5 by more than 3 feet. In three of these cases the rotor tips overlapped the object.

These perception errors indicate the potential hazard involved in operating close to obstacles at night.

In comparison, 14 of the 22 perceived clearances for the ground marking were overestimated; 9 by more than 3 feet and 5 by 1 to 3 feet. In three cases the rotor tips would have overlapped the ground marking.

The perception errors were also examined taking wind conditions into consideration. Clearances with the unlit obstacle under the tailwind conditions were overestimated the largest percent of the time followed by those under the crosswind conditions. The clearances with the lit object under the tailwind conditions tended to be overestimated. When there was no obstacle, they tended to overestimate their clearances regardless of wind conditions.

REQUESTED 12-FOOT CLEARANCE. During this portion of the testing the pilots were requested to park the helicopter with a 12-foot rotor tip clearance from either the obstacle or the ground mark.

Means of the actual tip clearances achieved under this restriction are found in table 8.

TABLE 8. ACTUAL ROTOR TIP CLEARANCES WHEN ATTEMPTING 12-FOOT CLEARANCES

	In Feet		
	Headwind	Crosswind	Tailwind
With Unlit Obstacle			
Mean	13.40	13.43	12.57
SD	3.81	4.53	3.90
N	6	5	5
With Lit Obstacle			
Mean	16.88	16.92	13.31
SD	6.64	4.53	2.20
N	5	5	5
Without Obstacle			
Mean	10.11	11.92	9.15
SD	3.87	3.83	4.19
N	5	5	5

(The 1/3 rotor diameter criteria for a UH-1H is 16 feet.)

When directed to park with a 12-foot tip clearance, the pilots' actual tip clearance varied from 4.51 to 29.22 feet clearance. Plots were created comparing the

requested 12-foot clearances to the actual clearances. These plots are found in figure 7. Examination of the errors in performance, regardless of wind conditions, revealed that the pilots parked their helicopter parallel to the unlit obstacle with rotor tip clearances less than the 12-foot requested clearance 5 of the 16 times. With a lit obstacle they were closer than the 12-foot requested clearance 4 of the 15 times. In contrast, when there was no obstacle their rotor tips were closer than the requested clearance from the ground mark 11 out of 15 times. This tendency to be closer than requested from the ground marking is much larger than that seen during the daytime parking tests (see appendix E).

Performance errors were generated by subtracting the 12-foot requested clearance (or his estimated clearance if different than 12 feet) from the actual clearance. Performance errors ranged from 7.49 feet less than the directed 12-foot clearance to 17.22 feet greater than the directed 12-foot clearance. Means and standard deviations of these performance errors are found in table 9. These means support the tendency for improved performance when an obstacle is lit, and for the pilots to misjudge the tip clearances when there is no obstacle in place. Further statistical analysis, however, revealed no significant differences among the three conditions for any of the three wind conditions.

TABLE 9. PERFORMANCE ERRORS

Actual Clearance - 12 feet, In Feet

	Headwind	Crosswind	Tailwind
With Unlit Obstacle			
Mean	1.23	1.83	-0.23
SD	3.72	5.13	4.12
N	6	5	5
With Lit Obstacle			
Mean	4.68	4.92	1.31
SD	6.62	2.89	2.80
N	5	5	5
Without Obstacle			
Mean	-1.89	-1.08	-2.05
SD	3.66	4.16	3.49
N	5	5	5

(The 1/3 rotor diameter criteria for a UH-1H is 16 feet.)

COOPER-HARPER/POST-MANEUVER RATINGS. The Cooper-Harper rating scale used for the post-maneuver questionnaire employs a 1 to 10 scale where a 1, 2, or 3 indicates the maneuver is acceptable for routine operations. Ratings of 4, 5, or 6 indicate the pilot felt the maneuver would be acceptable only on rare occasions, e.g., flight control system failure or even atmospheric conditions. These ratings indicate there were more deficiencies and that the safety margin was deteriorating.

Figures 8, 9, and 10 present the results of the Cooper-Harper ratings in graphic form for the control factor. As can be seen, the control margin was rated as unacceptable for routine operations in 13 of 110 responses (4 out of 37 with no

obstacle, 4 out of 37 with an unlit obstacle, and 5 out of 36 with a lit obstacle). The larger number of 3's and 4's indicate the pilots felt there were more deficiencies under tailwind conditions.

Figures 11, 12, and 13 show the plots for safety margin. Ratings for the safety issue were similar to those for the control factor. The safety margin was rated unacceptable for routine operations in 12 of 111 responses (4 out of 37 with no obstacle, 4 out of 38 with a unlit obstacle, and 4 out of 36 with a lit obstacle). In addition, as with the control factor, the ratings for safety margin indicate the pilots found more objectional deficiencies under tailwind conditions. These ratings included several 5's in addition to numerous 4's.

As with the ratings for safety and control, the manevuer was rated as unacceptable for routine operations in 14 of 111 responses (6 out of 37 with no obstacle, 3 out of 38 with an unlit obstacle, and 5 out of 36 with a lit obstacle). As with the control factor and with the safety margin, the ratings for workload indicate that the pilots found more objectional deficiencies under tailwind conditions. Even with the lit object, the pilots tended to feel the procedure had deficiencies. See figures 14, 15, and 16 for plots of these ratings.

INFLIGHT PILOT COMMENTS. During the actual flights the pilots were encouraged to comment on the maneuvers. Some of the remarks indicated that the light on the object does not influence the clearances when there is natural illumination such as from the moon. One item mentioned that they felt determined their tip clearances, was whether they could see the tip path plane. This comment occurred both during the flights and on the post-flight questionnaire.

POST-FLIGHT QUESTIONNAIRE. Table 10 presents the responses to the post-flight questions. The first questions dealt with the 12-foot tip clearance parking maneuvers. Each employed a 1 to 5 scale where 1 is not comfortable, 3 is somewhat comfortable, and 5 is comfortable - no problem. For the three wind conditions when parking 12-feet from an obstacle, there were 5 (of 18 total) ratings of 1's and 2's indicating that the pilots were uncomfortable with a 12-foot tip clearance. Prior to the ground maneuver testing, the subject pilots had indicated that the safe tip clearance was 12 feet or less in 110 of 111 maneuvers. After the ground maneuver testing, 18 of 21 total pilot responses indicate that the minimum safe roter tip clearance is between 8 and 22 feet. The other 3 responses indicate that the minimum safe rotor tip clearance is 15 feet. As with the in-flight ratings, the post-flight questionares indicate that the pilots are more uncomfortable under tailwind conditions.

When asked what they considered a minimum safe rotor tip clearance when parking in close proximity to an object under low ambient lighting conditions with tailwind and crosswind conditions, the pilot responses varied from 8 to 15 feet, while with headwinds the responses varied from 8 to 12 feet. This corresponds closely to the preferred tip clearances stated during the actual flight.

If required to park near an object, all pilots stated a preference for having the object lit. One suggestion was to use flood lights to illuminate the area. Another suggestion was to have the underside of the rotorblades painted with reflective paint so the pilot can see the tip path plane in low light conditions. Another pilot concurred with this by commenting that the lighting does not illuminate the

TABLE 10. RESPONSES TO POST-FLIGHT QUESTIONS

a) How comfortable did you feel parking 12 feet from the ground mark with a....

	1	2	3	4	5	**
Headwind?		1			5	1
Tailwind?	1	1		2	2	1
Crosswind?		1	1	2	2	1

b) How comfortable did you feel parking 12 feet from the obstacle with a....

	1	2	3	4	5	**
Headwind?	1			1	4	1
Tailwind?	2		2		2	1
Crosswind?	1	1	1	1	2	1

c) When parking in close proximity to an object, under low ambient lighting conditions, what do you consider the minimum safe rotor tip clearance (in feet) with a ...

	8	10	11	12	13	14	15
Headwind?	1	5		1			
Tailwind?		4		2			1
Crosswind?	1	2		2			2

d) Which type condition(s) did you feel was better for the type operations performed?

Lit Object	Unlit Object
7	

Note: For a and b, 1 indicates the pilot was not comfortable with the maneuver while 5 indicates the pilot was comfortable with it.

** One pilot did not complete the 12' portion of the tests.

rotor disc, and without being able to see the rotor disc the distance estimates from the disc are extremely difficult.

While parking the underside of the rotor tips may sound attractive, discussion with industry indicates that such markings have induced pilot vertigo under some circumstances. For this reason, painting any portion of the underside of the rotors is not recommended.

CONCLUSIONS

1. In the interest of designing heliports for the full spectrum of the pilot population, one should choose subject pilots that represent that population with particular emphasis on pilots with median and less than median capabilities. At the time of this test, however, the UH-1H test aircraft belonged to the U.S. Army and there were strict constraints on who could fly it. As a result, virtually all of the test subjects were high time helicopter pilots (only one subject pilot had less than 1600 hours of helicopter experience). Thus, the results of this effort should be read with an understanding that pilots with less helicopter time will require larger parking and maneuvering areas.

2. Additional analysis of data in "Heliport Surface Maneuvering Test Results" (FAA/CT-TN88/30) indicates that the helicopter requiring the largest tip clearance is the small, light, skid-equipped helicopter. Since this test was done with a large, heavy UH-1H helicopter, the results do not represent the most demanding case. The results of FAA/CT-TN88/30 also indicated that pilots desire more tip clearance when the obstacle is another aircraft. In this test, the obstacle was a truck. Thus, the results are likely to be less demanding that what would have been seen if the obstacle had been another helicopter.

3. When given a choice, the pilots' actual tip clearance varied from 38.55 feet clearance to 9.75 feet overlap of the lit obstacle. During this portion of the testing, each pilot was asked to state the rotor tip clearance with which he/she would be comfortable. The pilot was then instructed to park parallel to the obstacle with this stated clearance. Though their stated preferred tip clearances were less than the 1/3 rotor tip clearance called for in the design advisory circular, actual clearances indicate the 1/3 criteria is not adequate. During this portion of the test there were five occasions when the main rotor blades overlapped the test obstacle. Three of these occurred when the obstacle was lit and two when it was unlit.

4. During the second portion of the testing each pilot was asked to park parallel to either the obstacle or the ground mark with a clearance of 12 feet. When directed to park with a 12-foot tip clearance, the pilots' actual tip clearance varied from 4.51 to 29.22 feet clearance. During this portion there were 20 occasions where the rotor tips were closer than the requested 12 feet; 4 with the lit obstacle, 5 with the unlit obstacle, and 11 with only the ground marking.

5. From the analysis of the pilot post-procedure ratings, clearance statistics and plots, and pilot comments it can be seen that parking an aircraft on the heliport near other objects during nighttime conditions requires added safety precautions.

6. Although the actual clearance means and standard deviations as seen in tables 6 and 8, and the perception and performance errors found in tables 7 and 9 do not indicate a significant difference in performance with tailwind conditions, the Cooper-Harper ratings for all three post-maneuver issues, control, safety, and workload, show the pilots are less comfortable with parking their aircraft under tailwind conditions. This could indicate the pilots tended to overcompensate for what they perceive as adverse wind conditions. Thus, as seen in the daytime testing, this emphasizes the need to thoroughly account for wind conditions when developing spacing limitations for parking at any particular heliport.

7. For safety sake, the height of the obstacle was a few feet shorter than the main rotor height in a rotor-level configuration. Had the obstacle been a few feet higher during any of the five overlaps experienced during the testing, it is likely that a serious accident would have resulted. Both the aircraft and the truck could have been destroyed. This alone is a powerful demonstration that the current one-third rotor diameter tip clearance is inadequate, even with high time helicopter pilots in a helicopter that is not the most demanding aircraft in this regard.

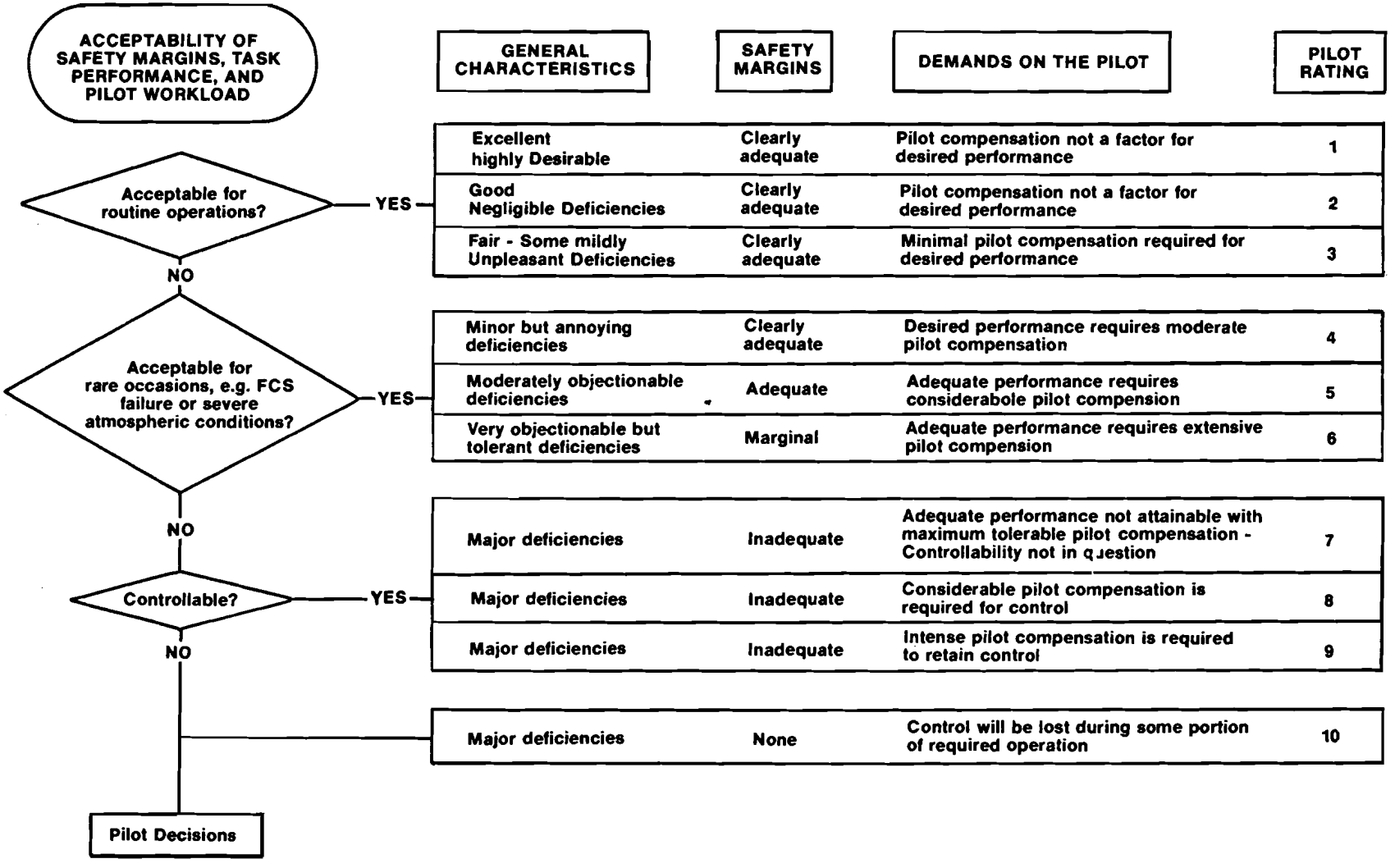


FIGURE 1. COOPER-HARPER RATING SCALE

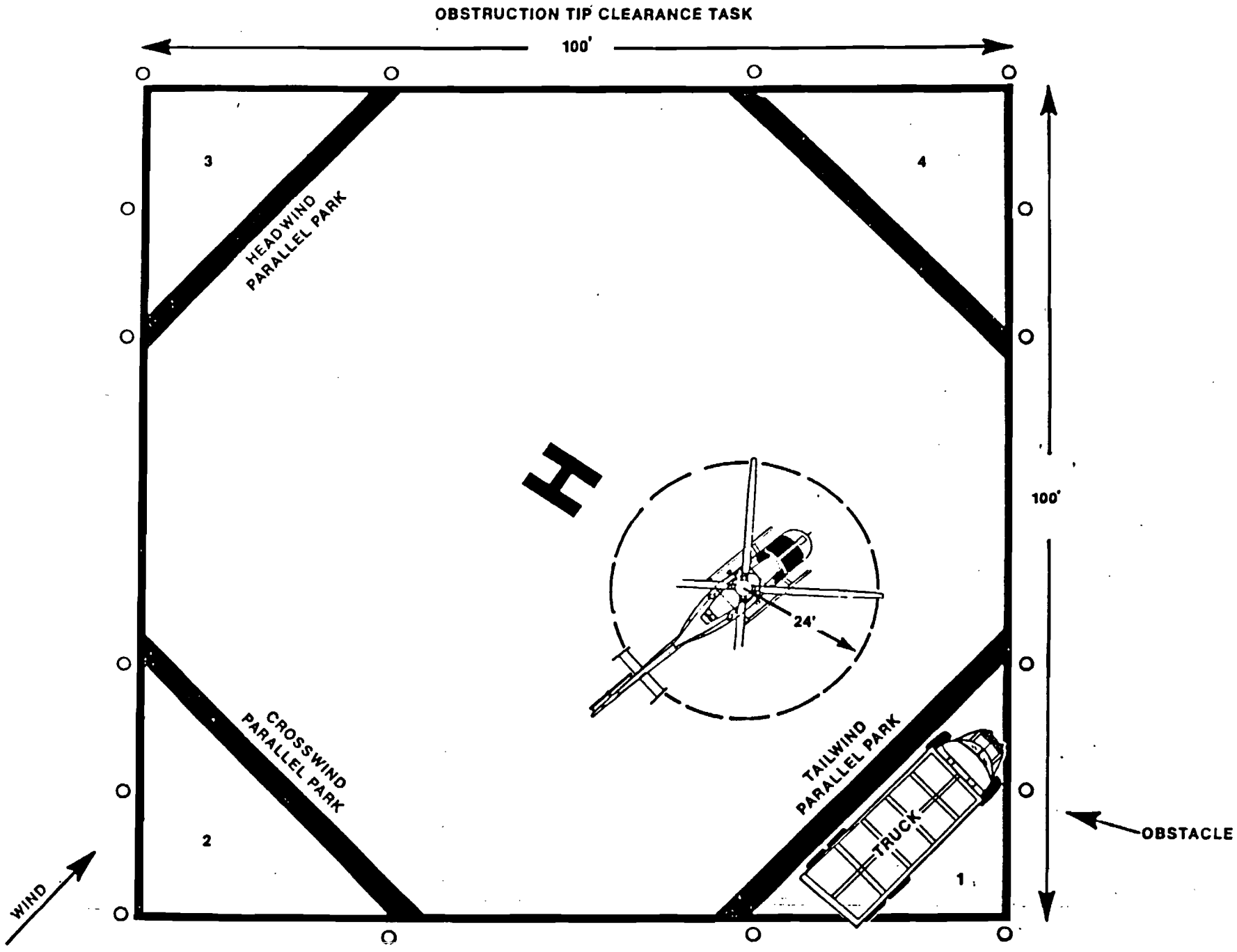


FIGURE 2. HELIPORT LAYOUT FOR PARKING TESTS

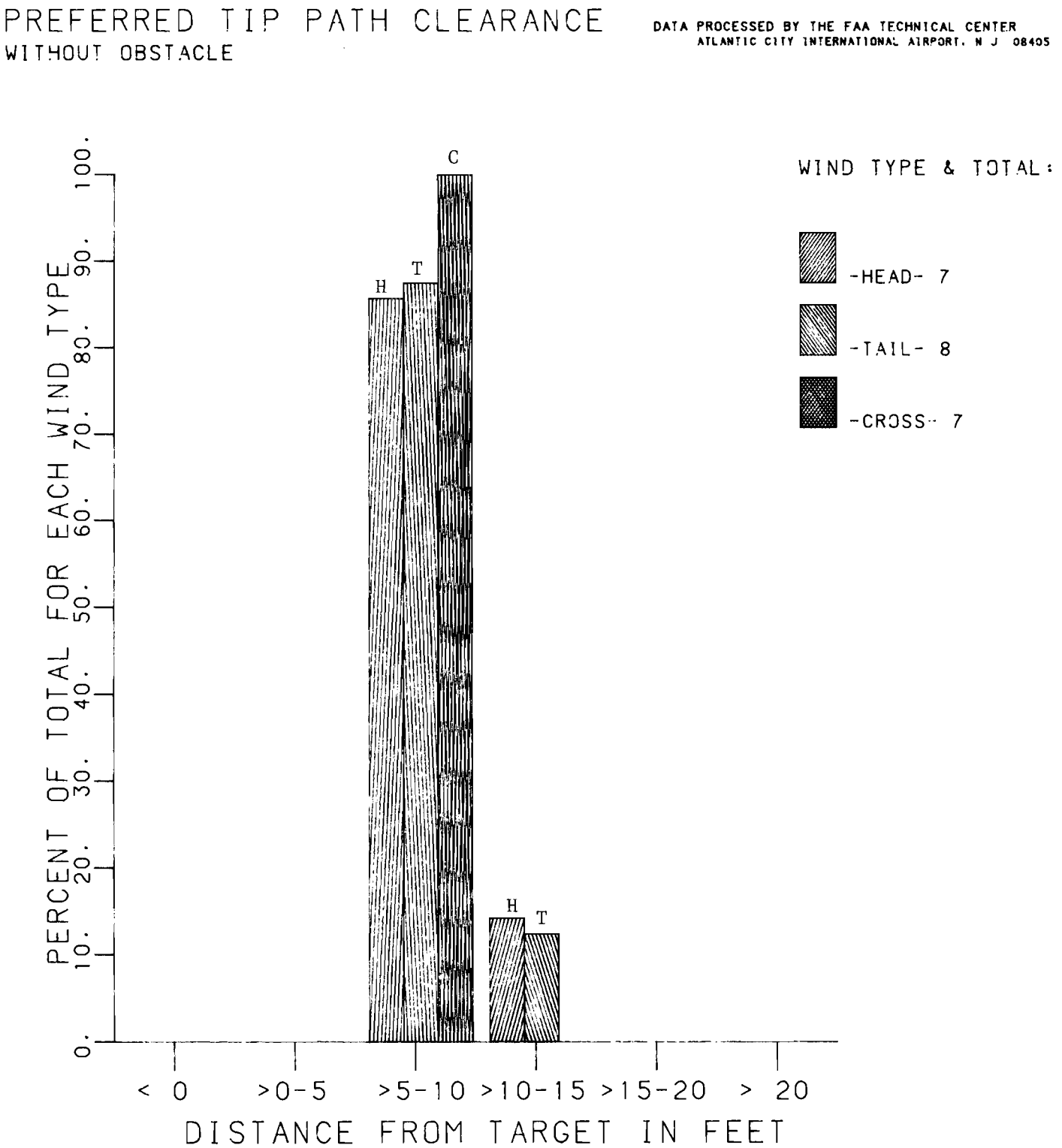


FIGURE 3. PERCENTAGE PLOT FOR PREFERRED TIP PATH CLEARANCES (SHEET 1 OF 3)

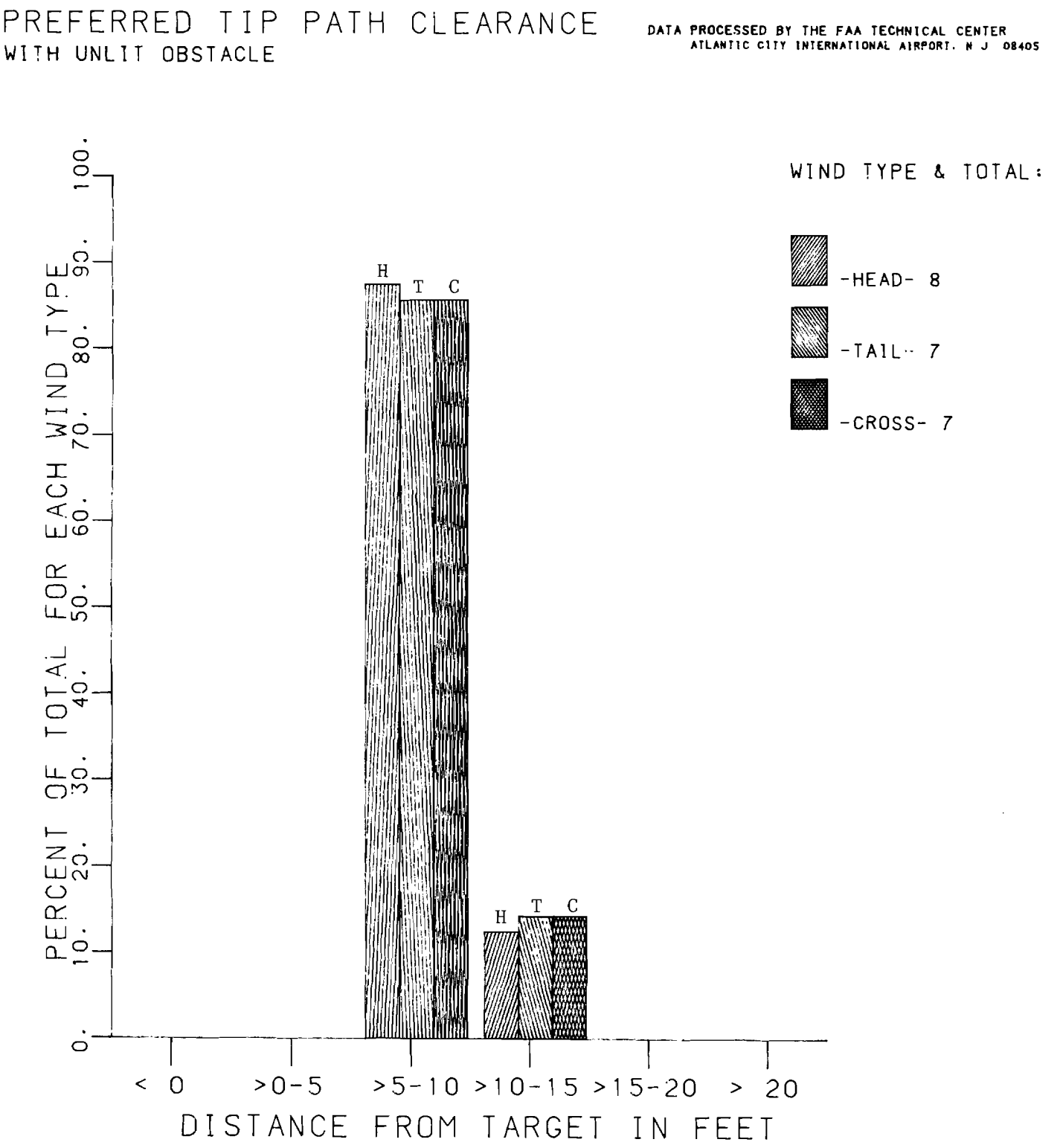


FIGURE 3. PERCENTAGE PLOT FOR PREFERRED TIP PATH CLEARANCES (SHEET 2 OF 3)

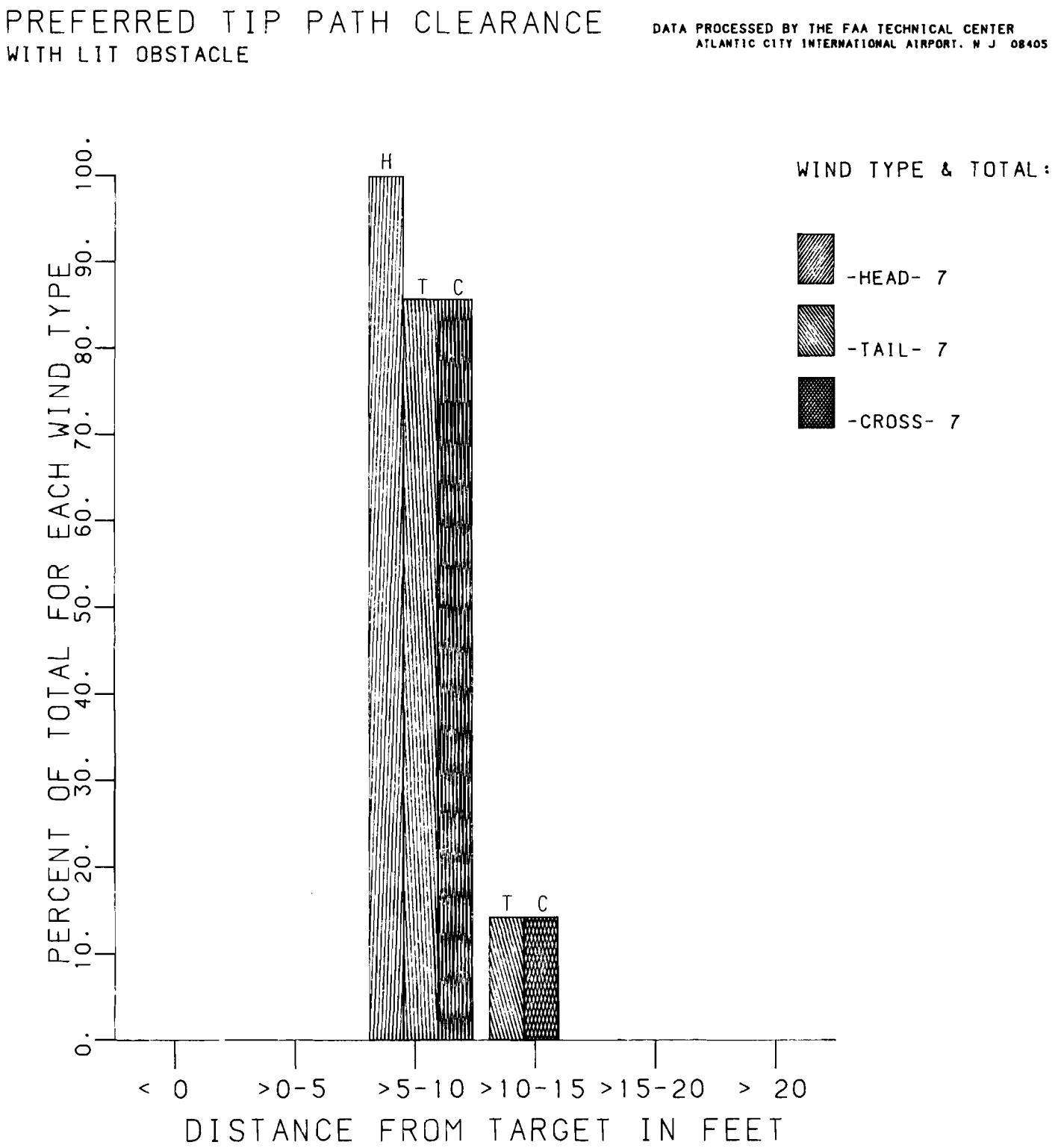
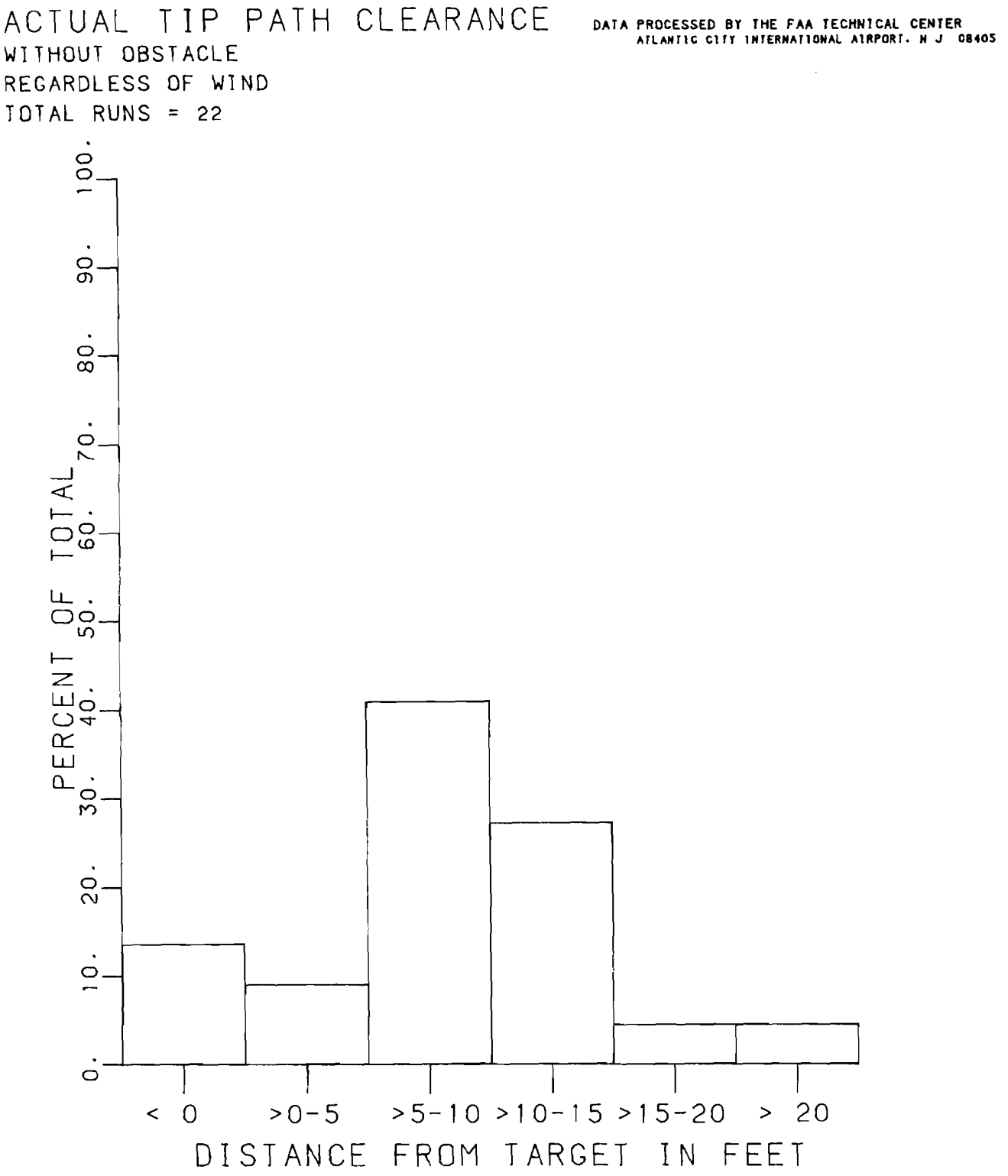
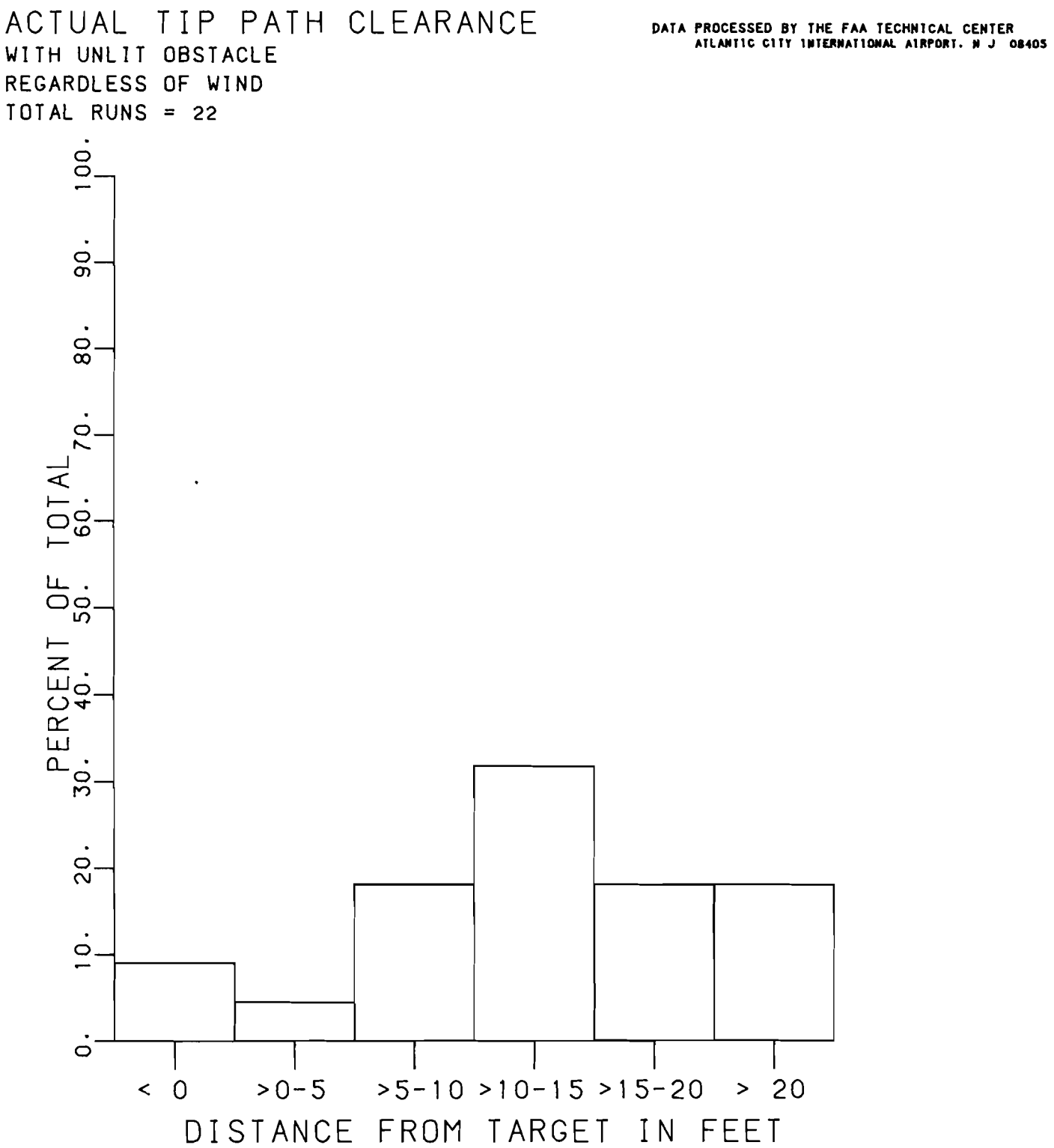


FIGURE 3. PERCENTAGE PLOT FOR PREFERRED TIP PATH CLEARANCES (SHEET 3 OF 3)



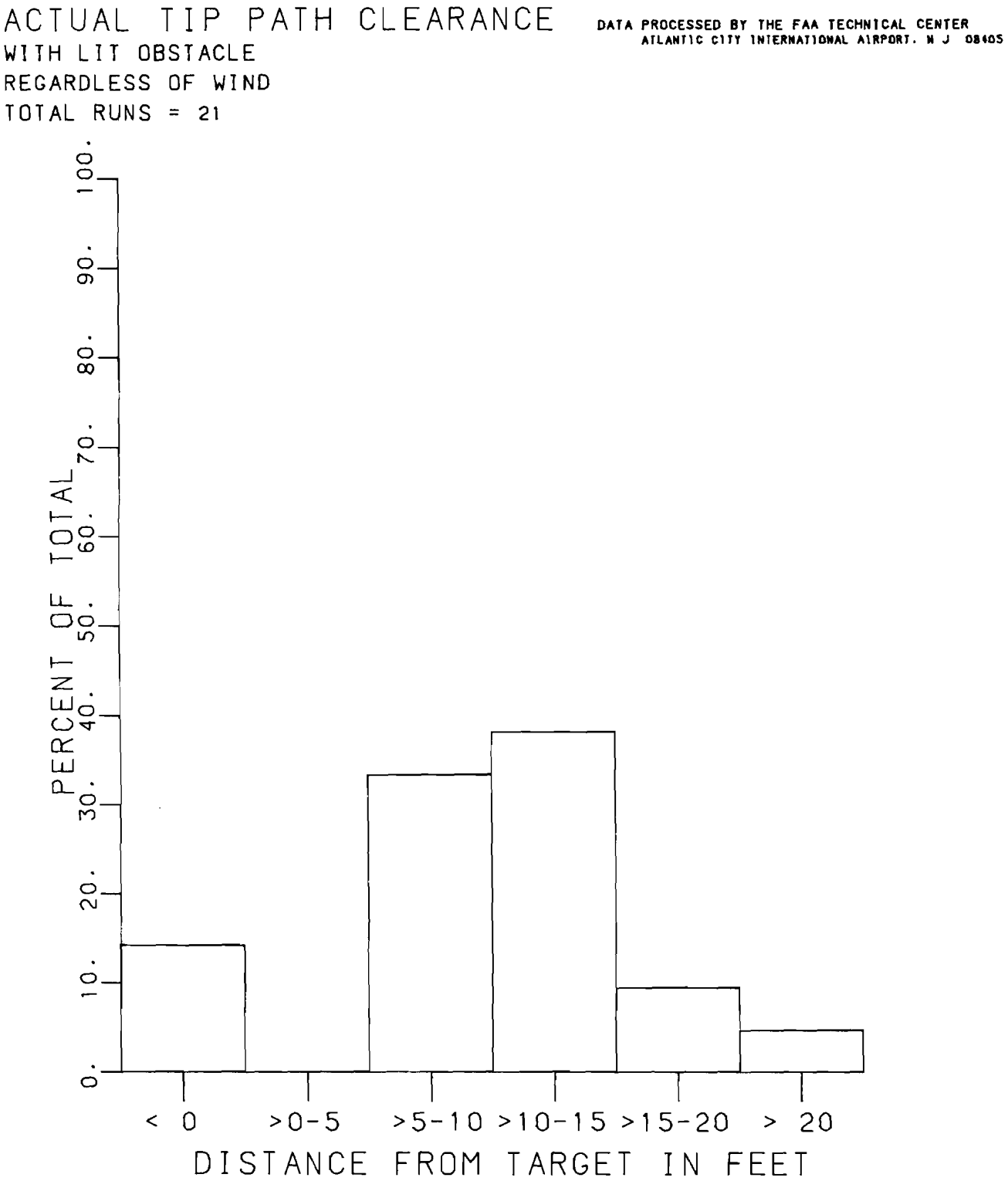
NOTE: The pilots were trying to park a "pilot choice" distance from a ground marking. The bin labeled "<0" indicates the percentage of occurrences where the rotor tip path overlapped the ground marking.

FIGURE 4. PERCENTAGE PLOT FOR ACTUAL TIP PATH CLEARANCES FOR PILOT CHOICE MANEUVERS REGARDLESS OF WINDS (SHEET 1 OF 3)



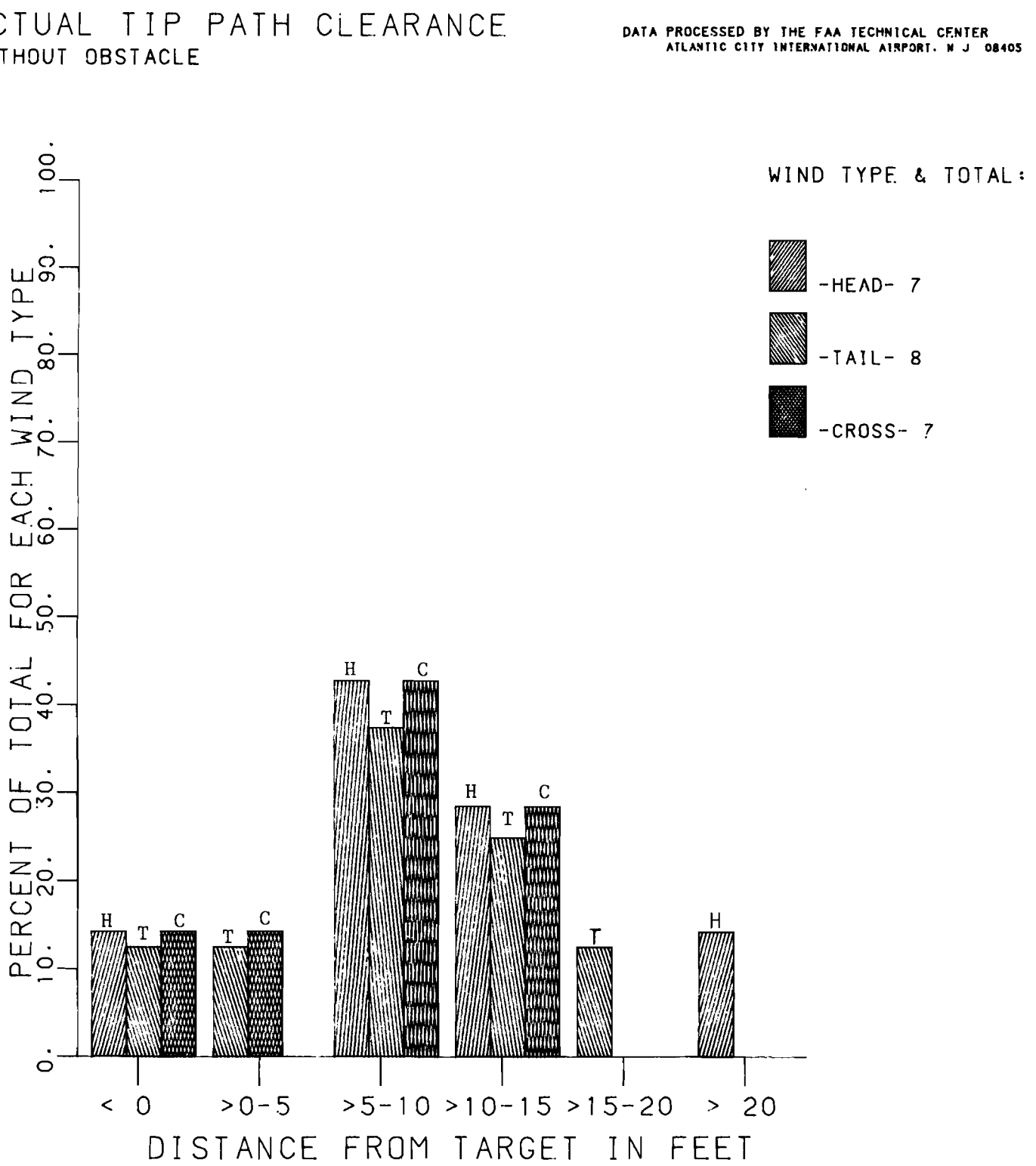
NOTE: The pilots were trying to park a "pilot choice" distance from an unlit obstacle. The bin labeled "<0" indicates the percentage of occurrences where the rotor tip path overlapped the obstacle which was shorter than the height of the main rotor blade in a rotor-level configuration.

FIGURE 4. PERCENTAGE PLOT FOR ACTUAL TIP PATH CLEARANCES FOR PILOT CHOICE MANEUVERS REGARDLESS OF WINDS (SHEET 2 OF 3)



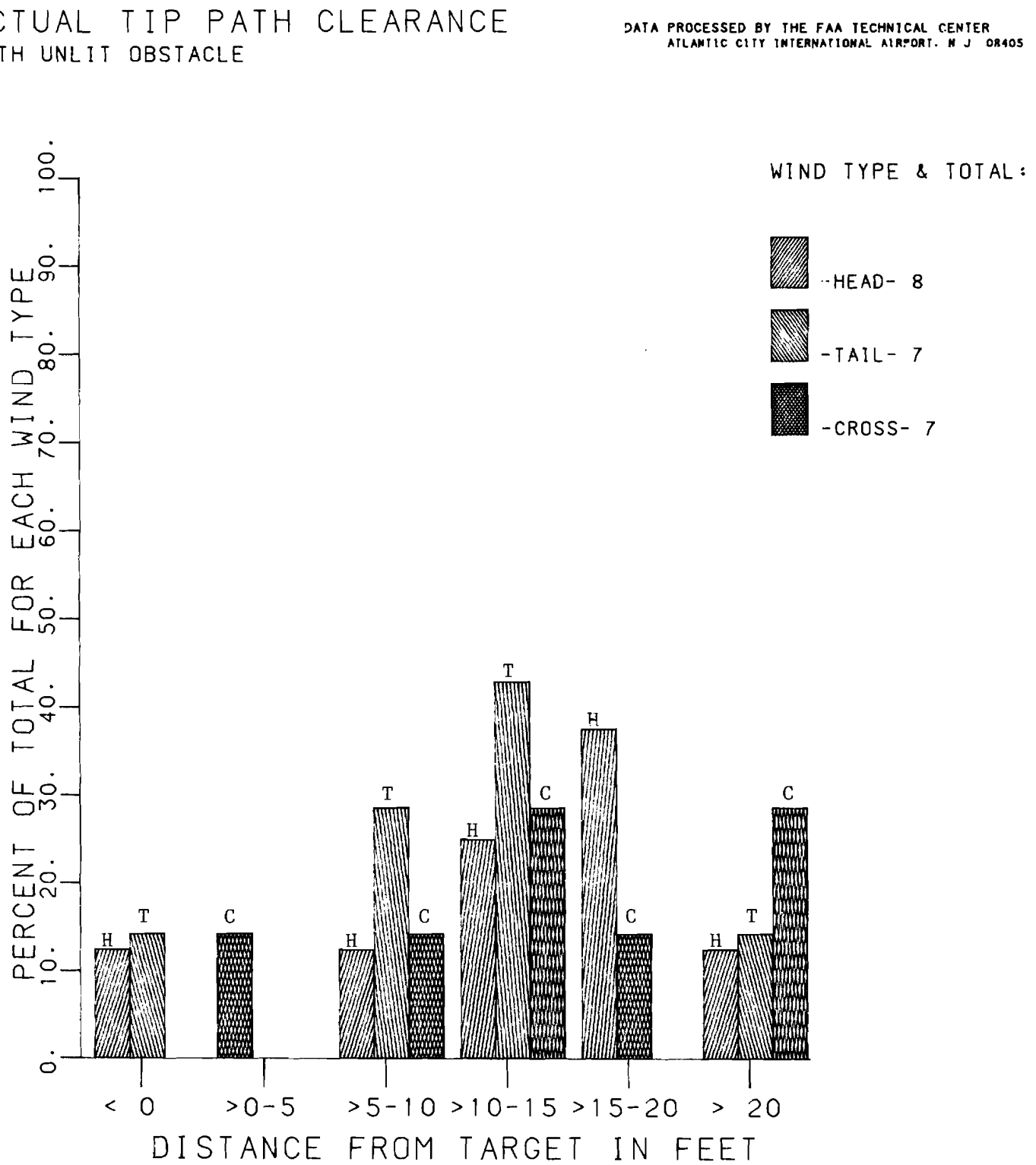
NOTE: The pilots were trying to park a "pilot choice" distance from a lit obstacle. The bin labeled "<0" indicates the percentage of occurrences where the rotor tip path overlapped the obstacle which was shorter than the height of the main rotor blade in a rotor-level configuration.

FIGURE 4. PERCENTAGE PLOT FOR ACTUAL TIP PATH CLEARANCES FOR PILOT CHOICE MANEUVERS REGARDLESS OF WINDS (SHEET 3 OF 3)



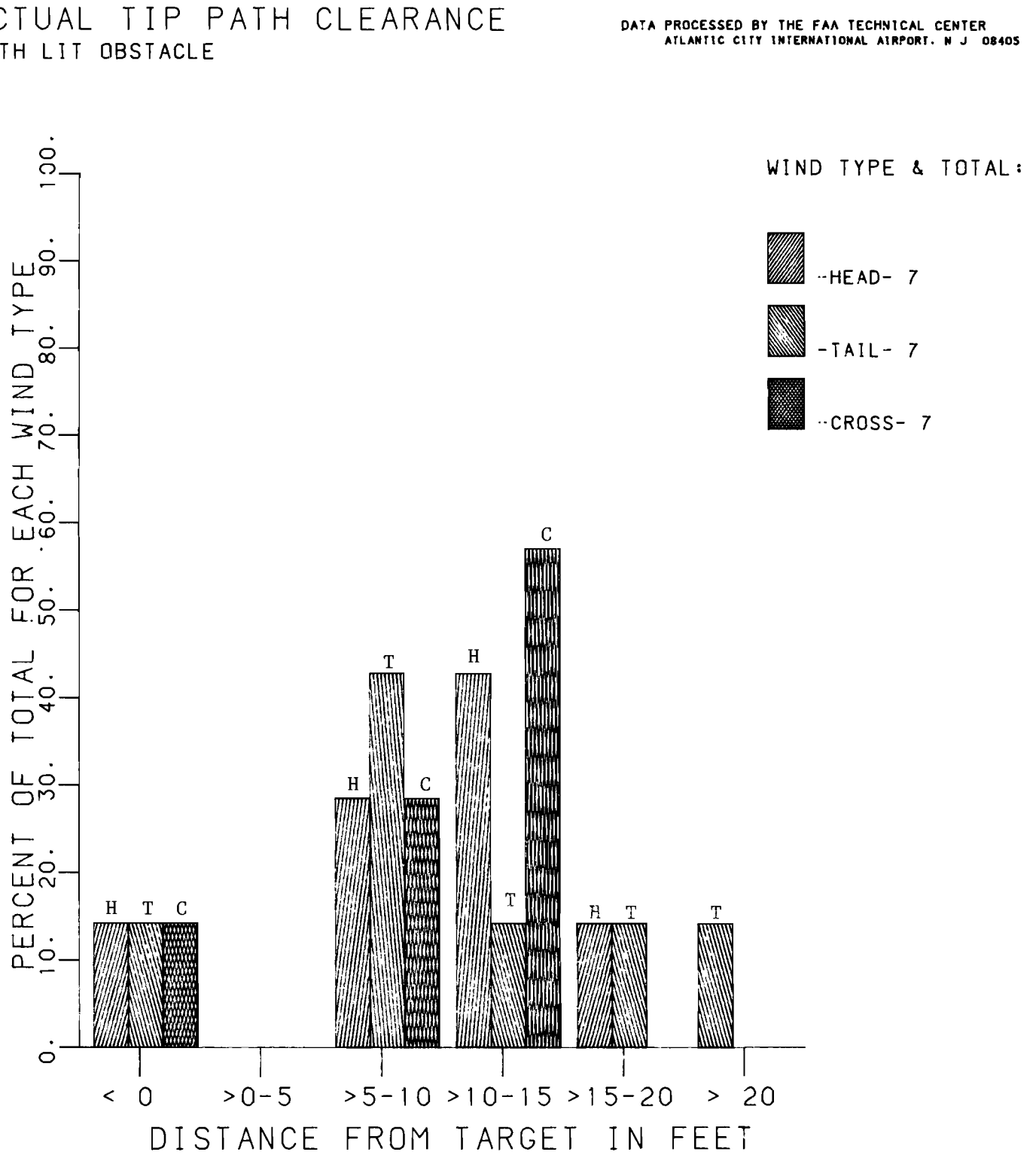
NOTE: The pilots were trying to park a "pilot choice" distance from a ground marking. The bin labeled "<0" indicates the percentage of occurrences where the rotor tip path overlapped the ground marking.

FIGURE 5. PERCENTAGE PLOT FOR ACTUAL TIP PATH CLEARANCES FOR PILOT CHOICE MANEUVERS BY WINDS (SHEET 1 OF 3)



NOTE: The pilots were trying to park a "pilot choice" distance from an unlit obstacle. The bin labeled "<0" indicates the percentage of occurrences where the rotor tip path overlapped the obstacle which was shorter than the height of the main rotor blade in a rotor-level configuration

FIGURE 5. PERCENTAGE PLOT FOR ACTUAL TIP PATH CLEARANCES FOR PILOT CHOICE MANEUVERS BY WINDS (SHEET 2 OF 3)



NOTE: The pilots were trying to park a "pilot choice" distance from a lit obstacle. The bin labeled "<0" indicates the percentage of occurrences where the rotor tip path overlapped the obstacle which was shorter than the height of the main rotor blade in a rotor-level configuration.

FIGURE 5. PERCENTAGE PLOT FOR ACTUAL TIP PATH CLEARANCES FOR PILOT CHOICE MANEUVERS BY WINDS (SHEET 3 OF 3)

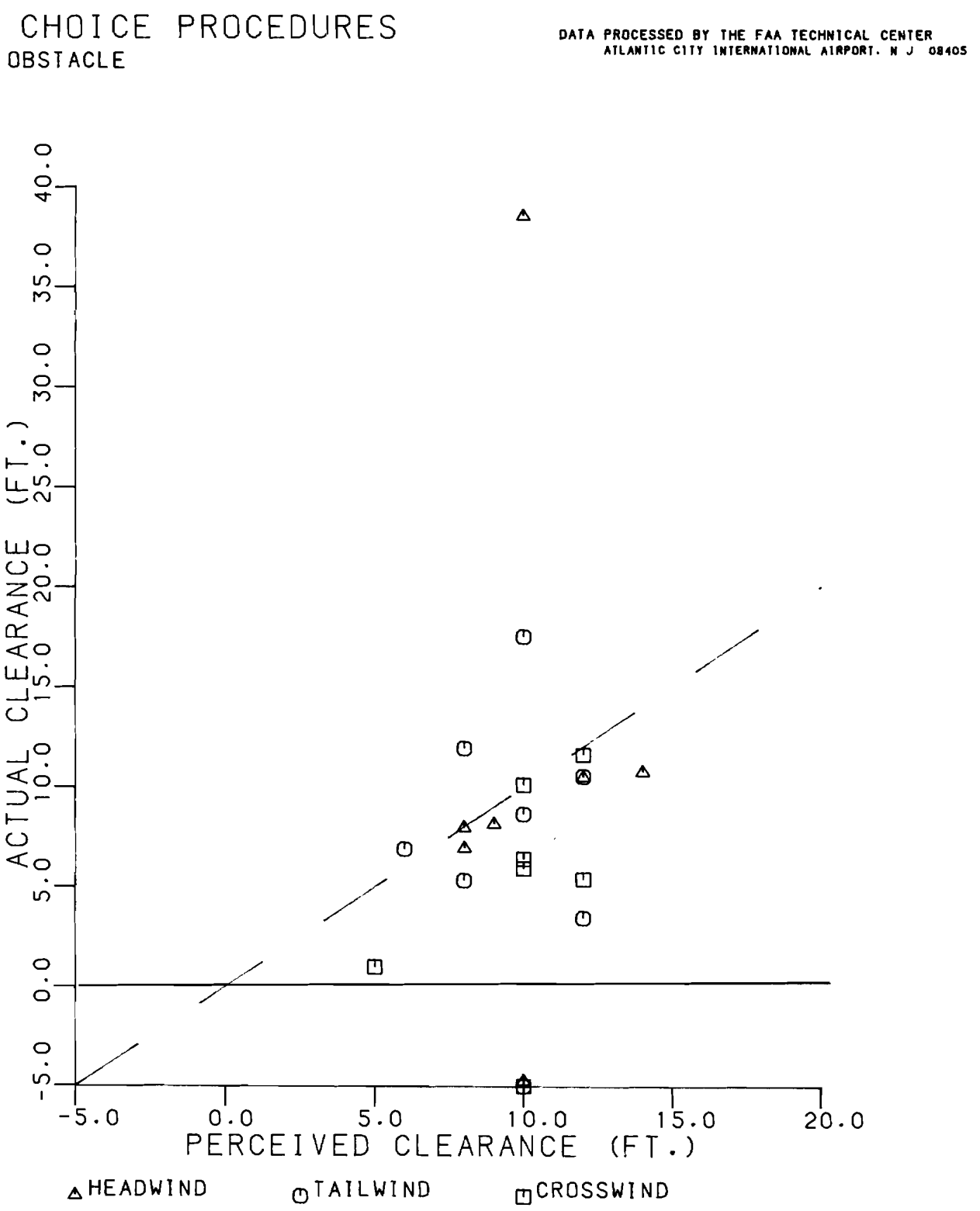


FIGURE 6. PILOT CHOICE MANEUVERS: ACTUAL VS. ESTIMATED TIP CLEARANCES BY WINDS (SHEET 1 OF 3)

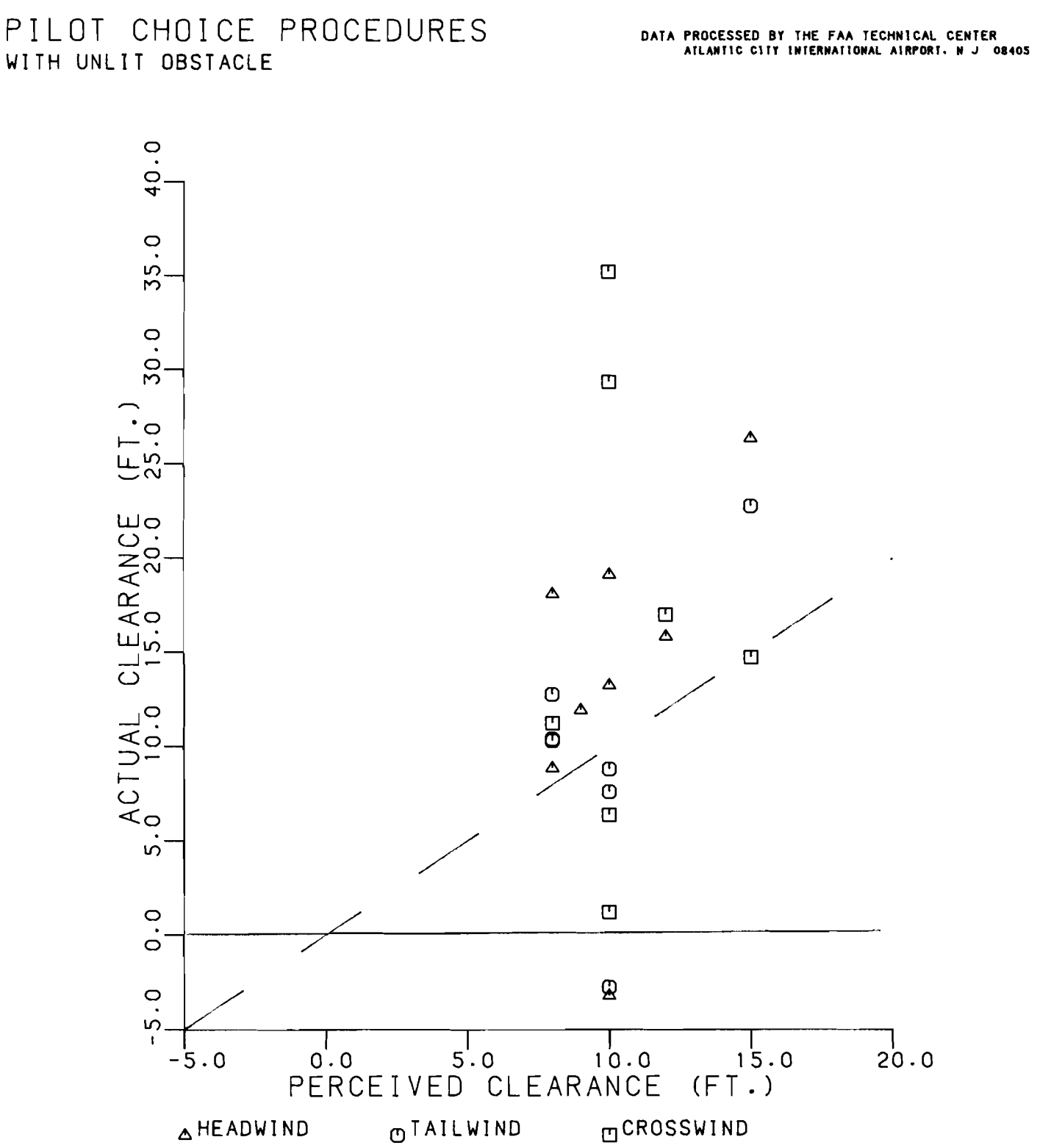


FIGURE 6. PILOT CHOICE MANEUVERS: ACTUAL VS. ESTIMATED TIP CLEARANCES BY WINDS (SHEET 2 OF 3)

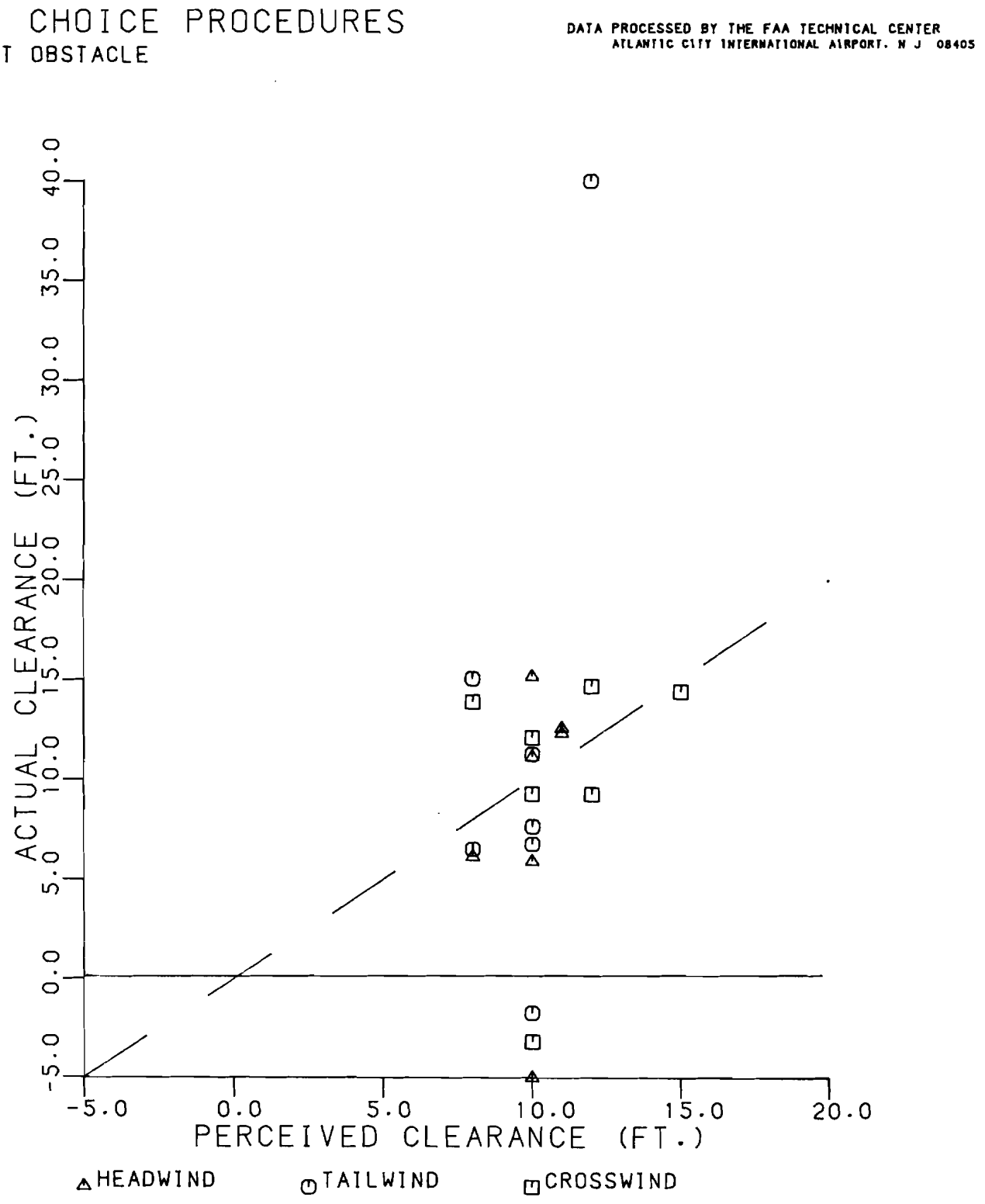


FIGURE 6. PILOT CHOICE MANEUVERS: ACTUAL VS. ESTIMATED TIP CLEARANCES BY WINDS (SHEET 3 OF 3)

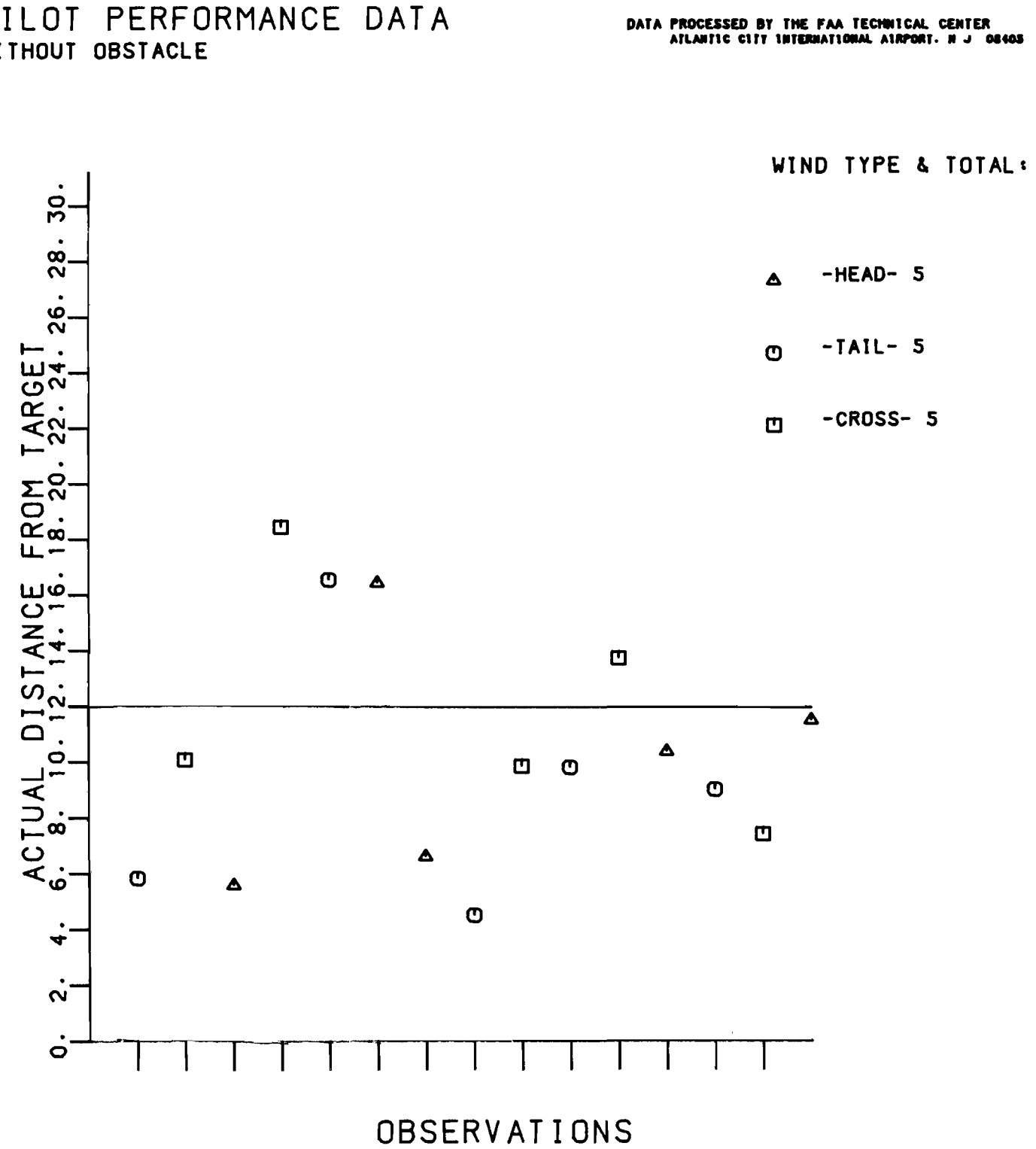


FIGURE 7. REQUESTED 12-FOOT TIP CLEARANCES: ACTUAL CLEARANCES BY WINDS (SHEET 1 OF 3)

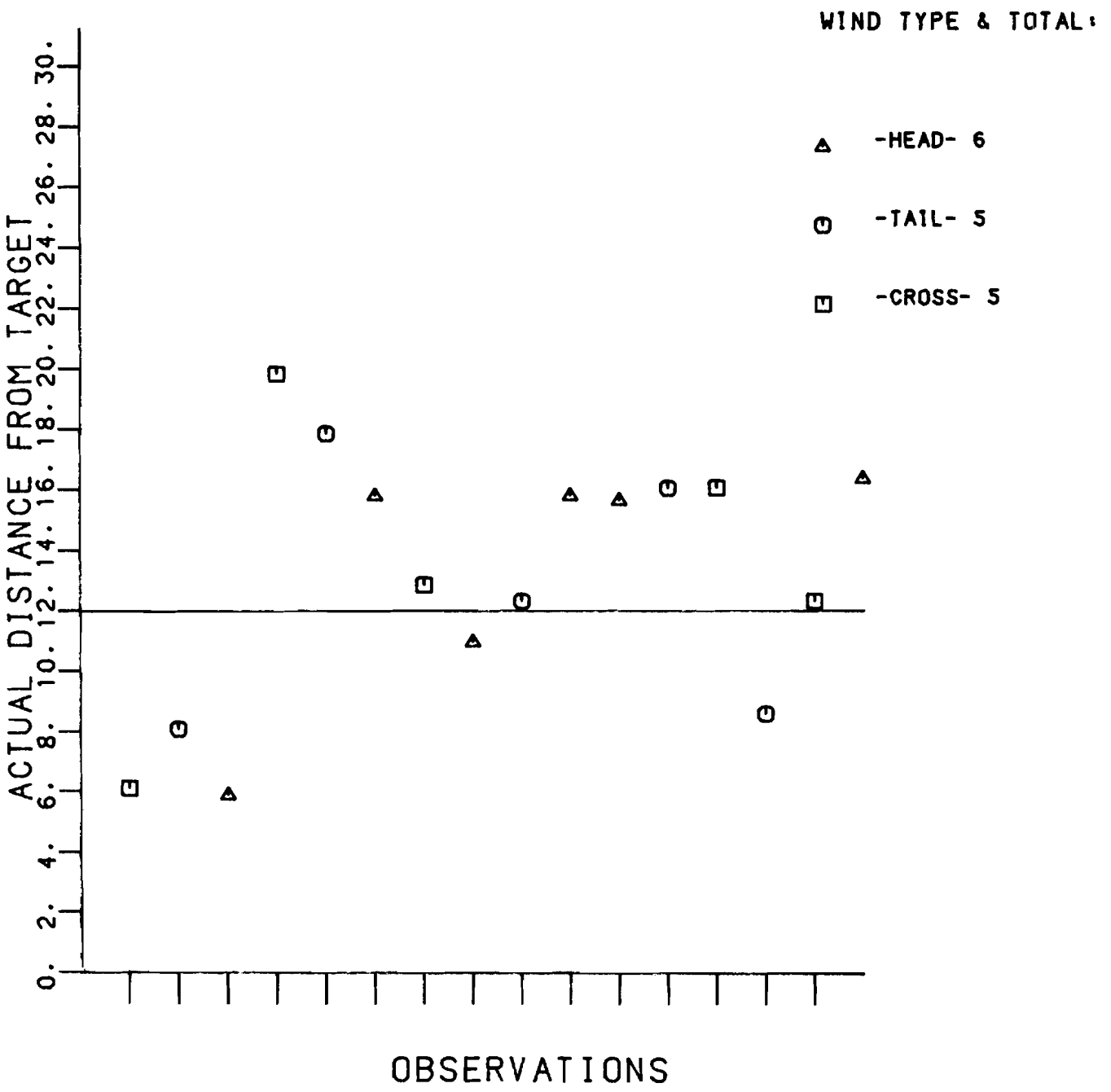


FIGURE 7. REQUESTED 12-FOOT TIP CLEARANCES: ACTUAL CLEARANCES BY WINDS (SHEET 2 OF 3)

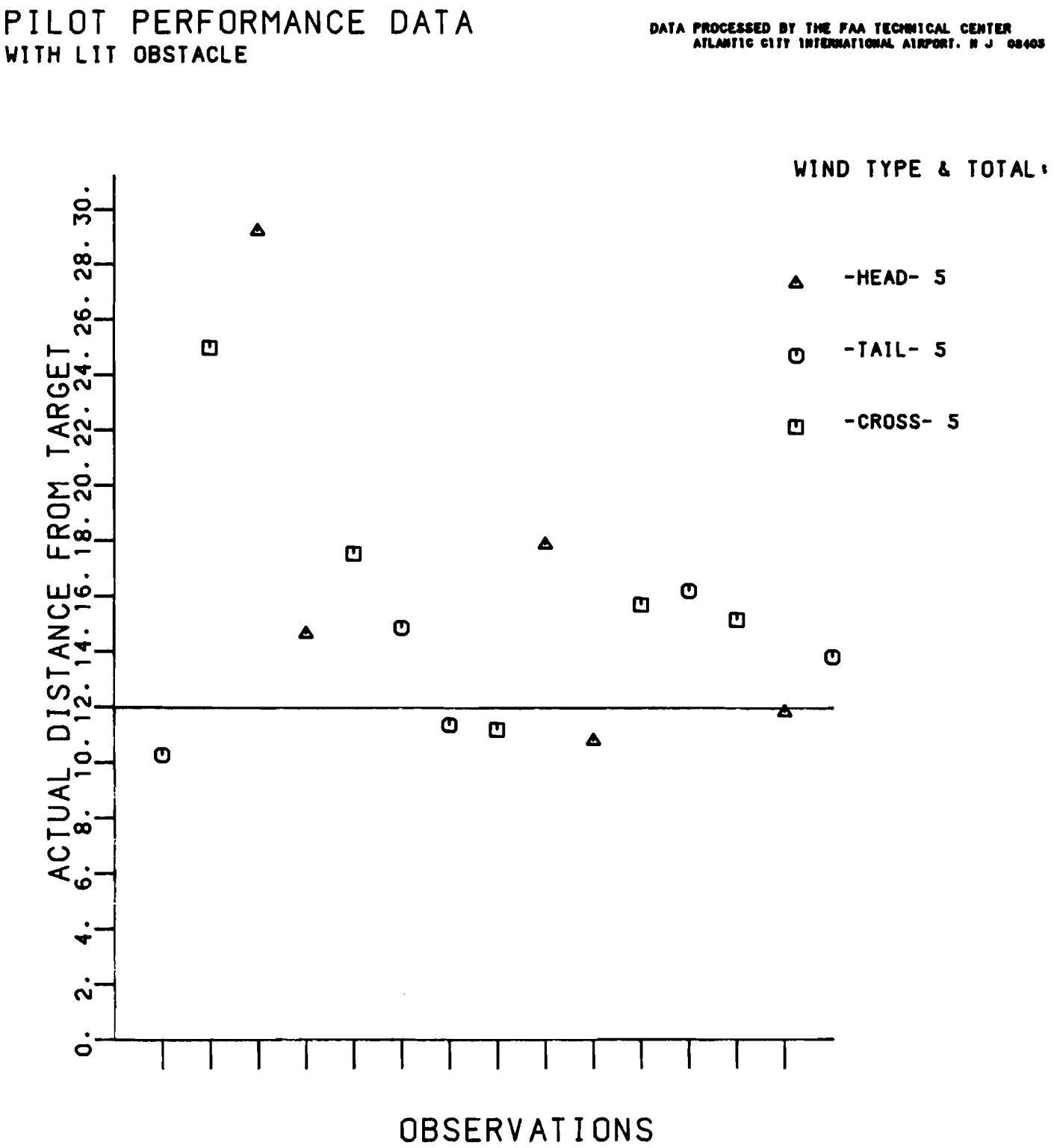


FIGURE 7. REQUESTED 12-FOOT TIP CLEARANCES: ACTUAL CLEARANCES BY WINDS (SHEET 3 OF 3)

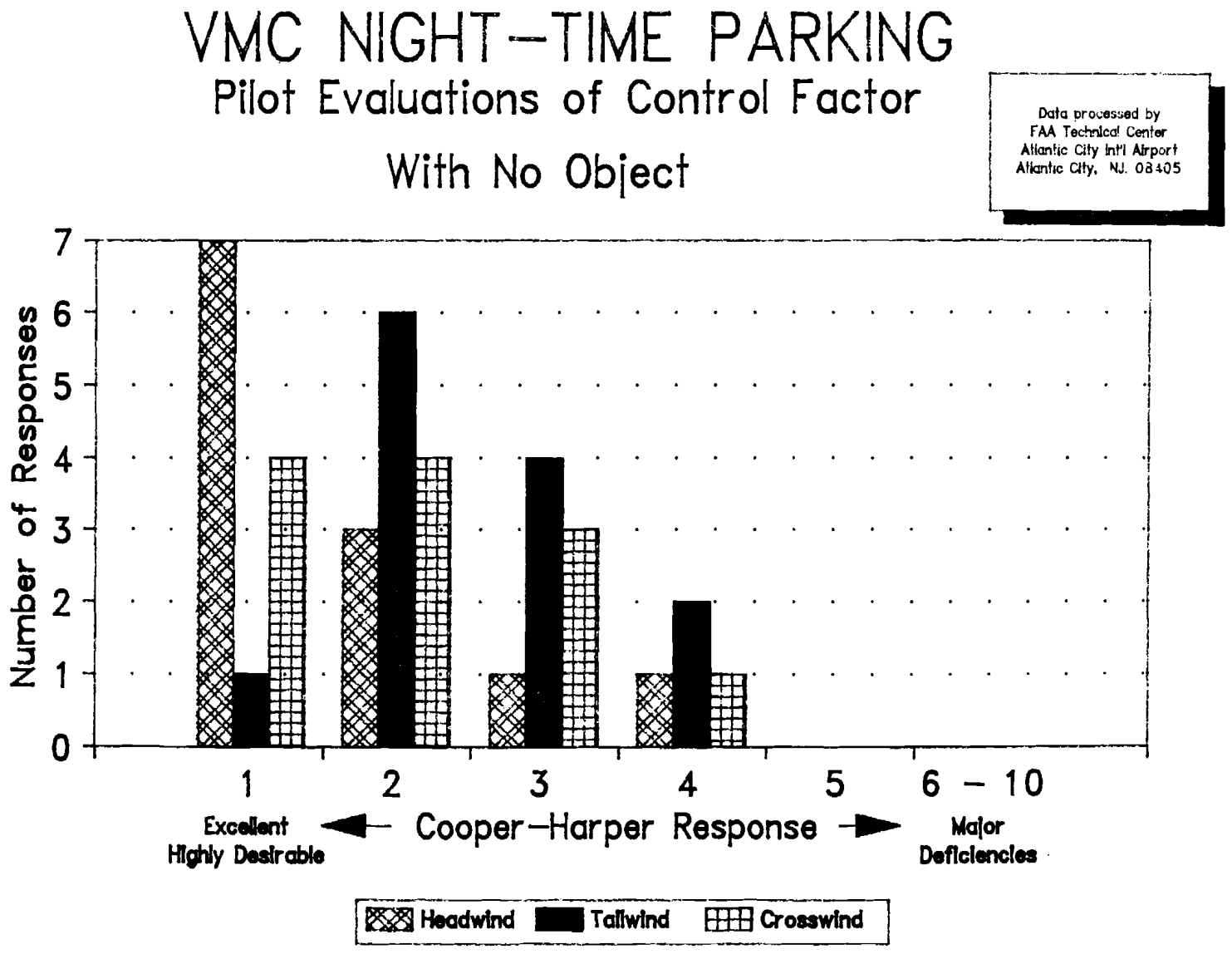


FIGURE 8. COOPER-HARPER RATINGS FOR CONTROL MARGIN: NO OBJECT

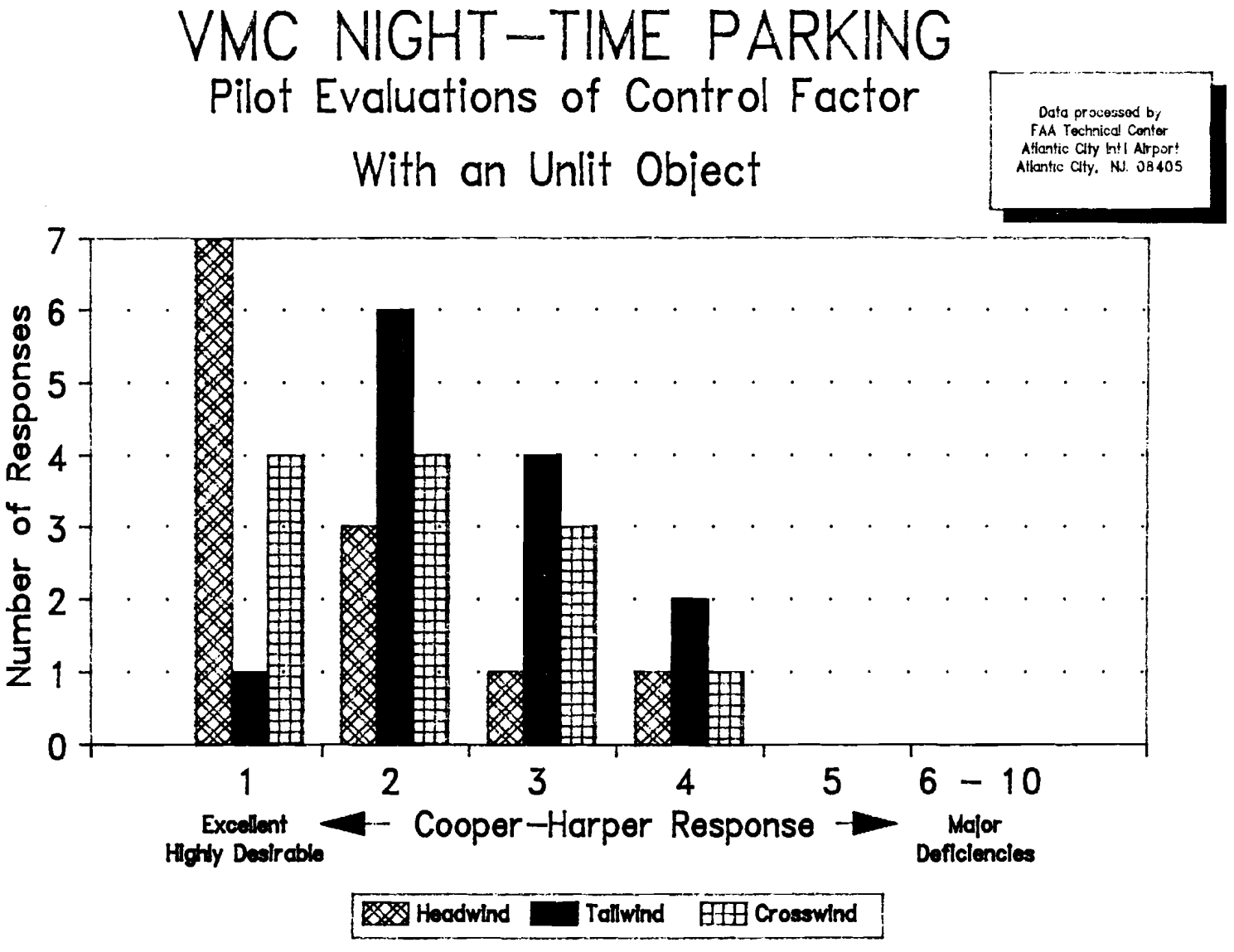


FIGURE 9. COOPER-HARPER RATINGS FOR CONTROL MARGIN: UNLIT OBJECT

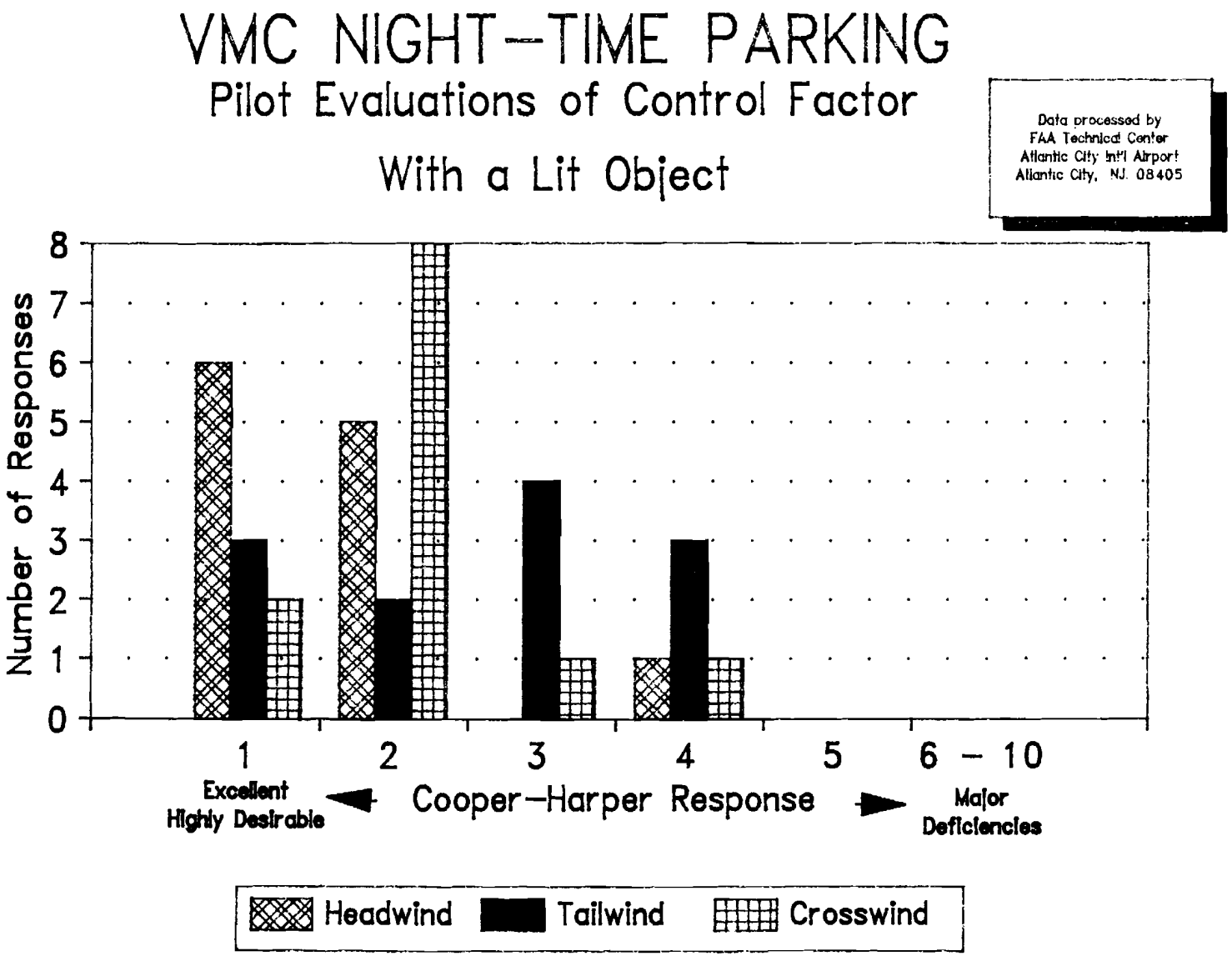


FIGURE 10. COOPER-HARPER RATINGS FOR CONTROL MARGIN: LIT OBJECT

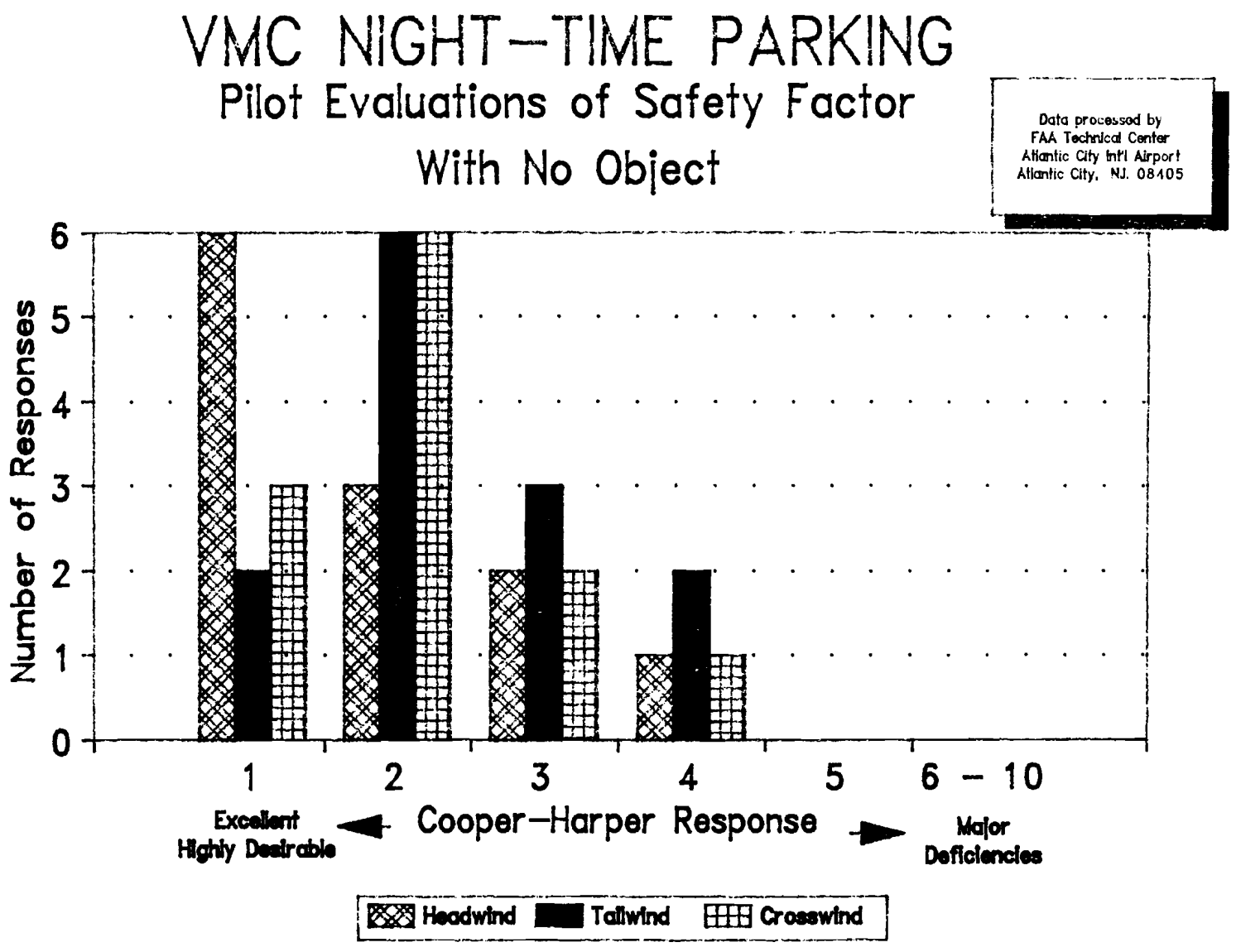


FIGURE 11. COOPER-HARPER RATINGS FOR SAFETY MARGIN: NO OBJECT

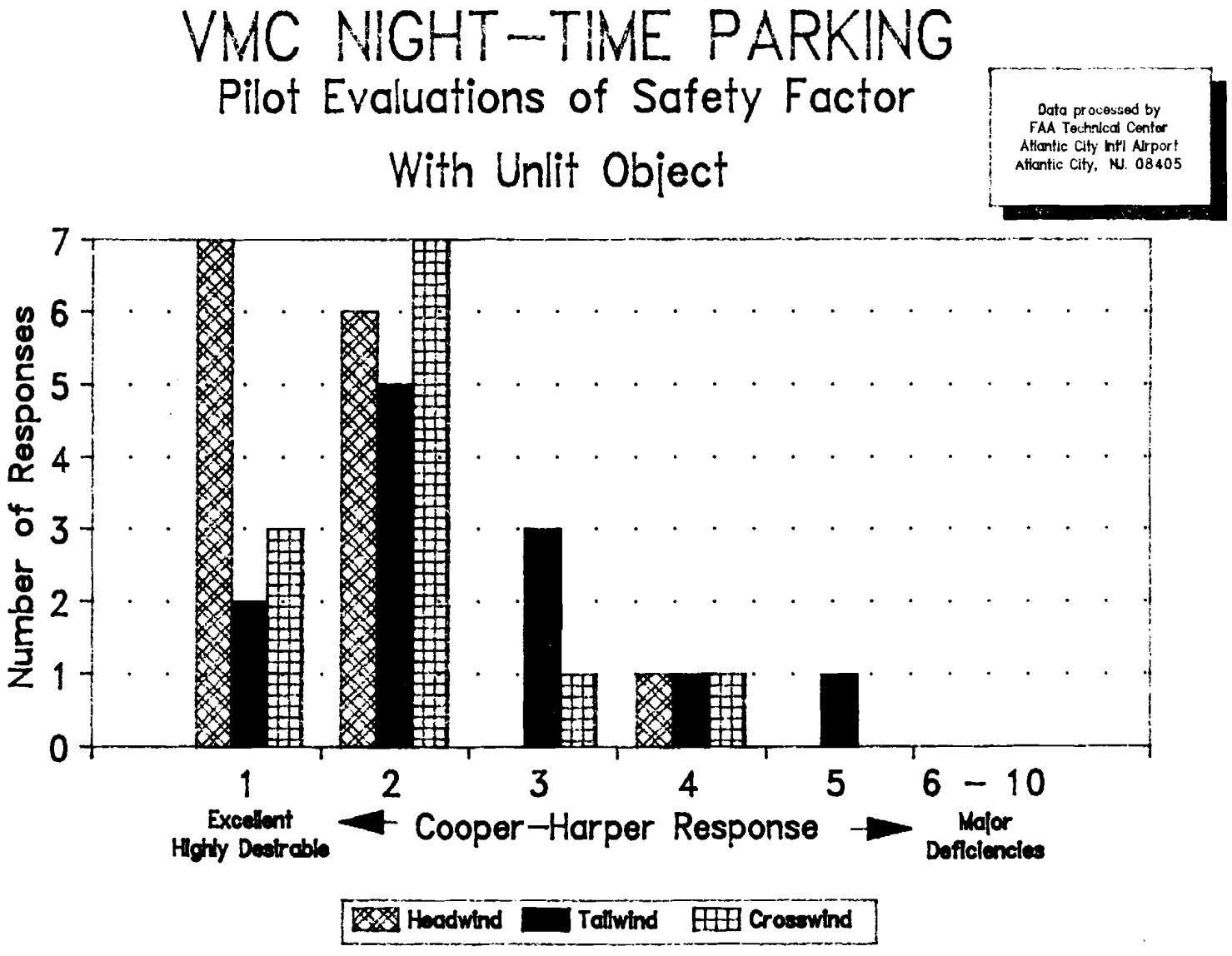


FIGURE 12. COOPER-HARPER RATINGS FOR SAFETY MARGIN: UNLIT OBJECT

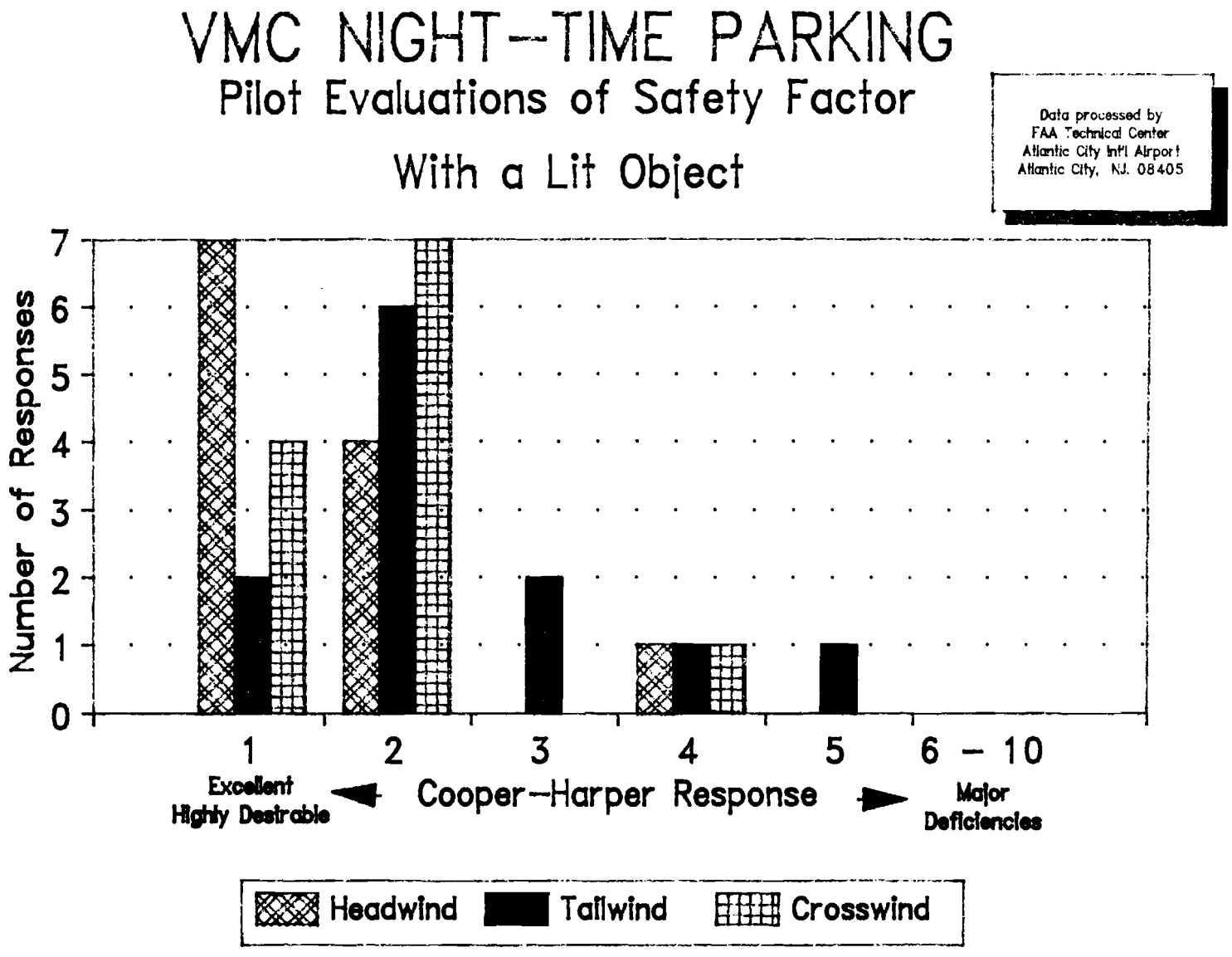


FIGURE 13. COOPER-HARPER RATINGS FOR SAFETY MARGIN: LIT OBJECT

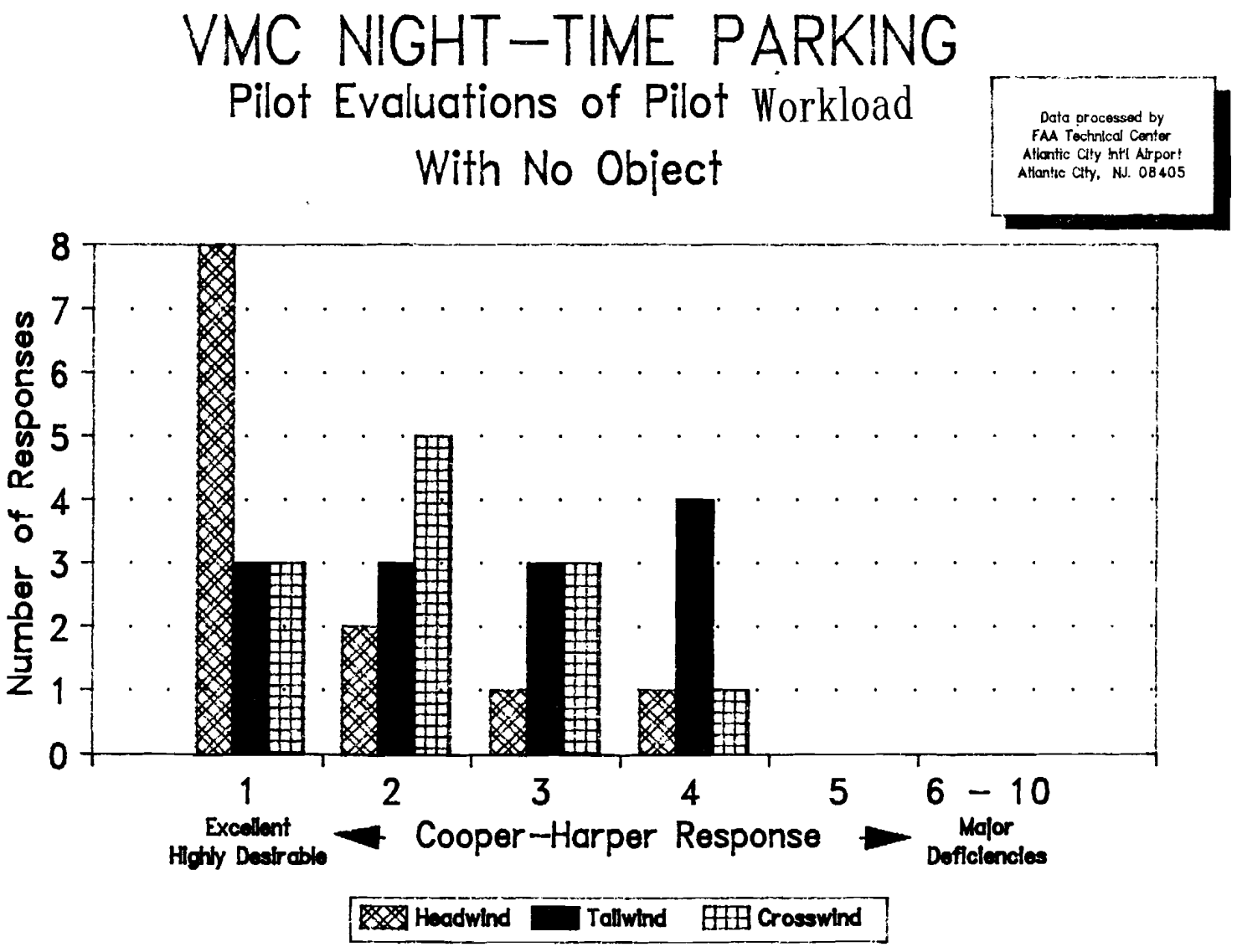


FIGURE 14. COOPER-HARPER RATINGS FOR WORKLOAD: NO OBJECT

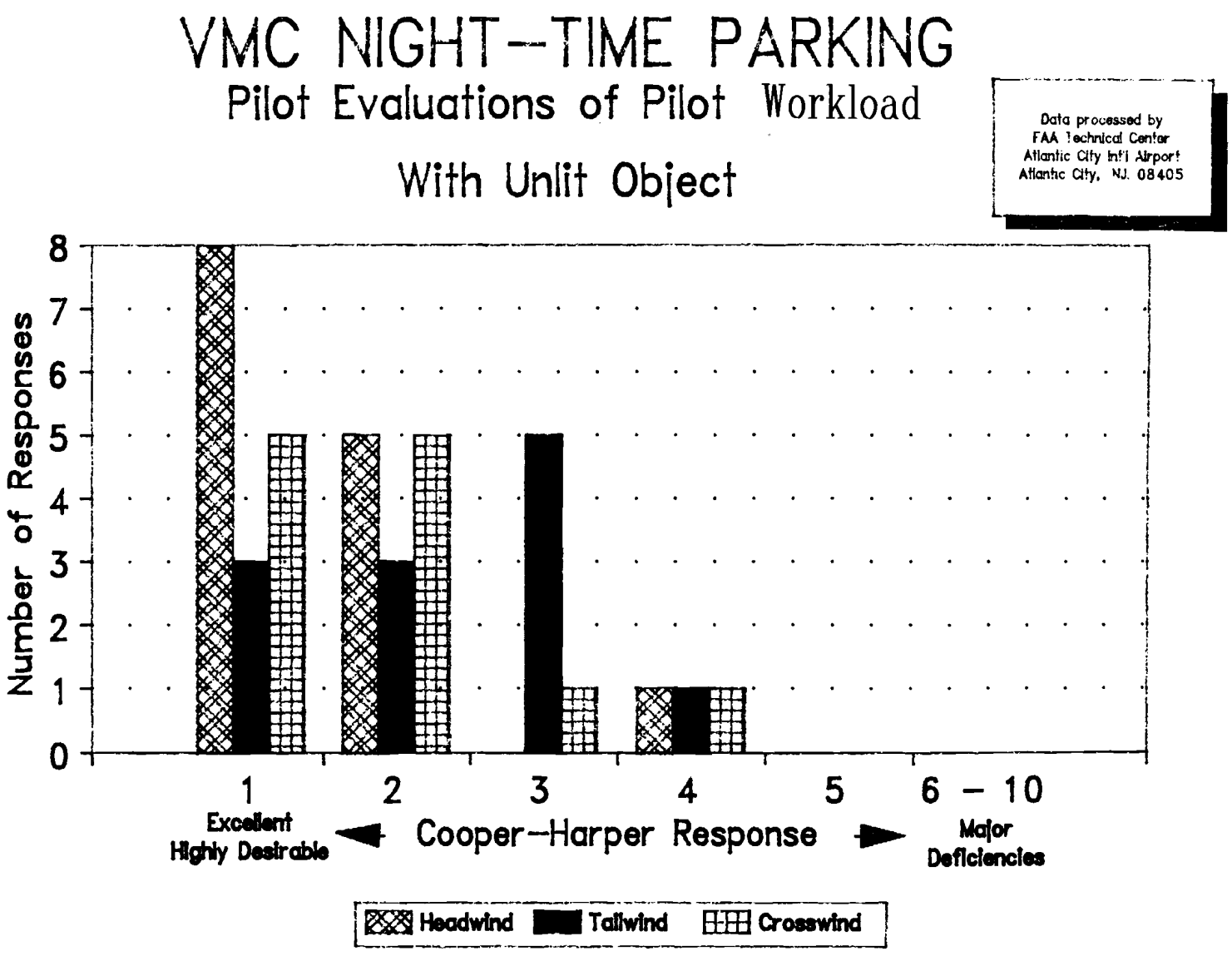


FIGURE 15. COOPER-HARPER RATINGS FOR WORKLOAD: UNLIT OBJECT

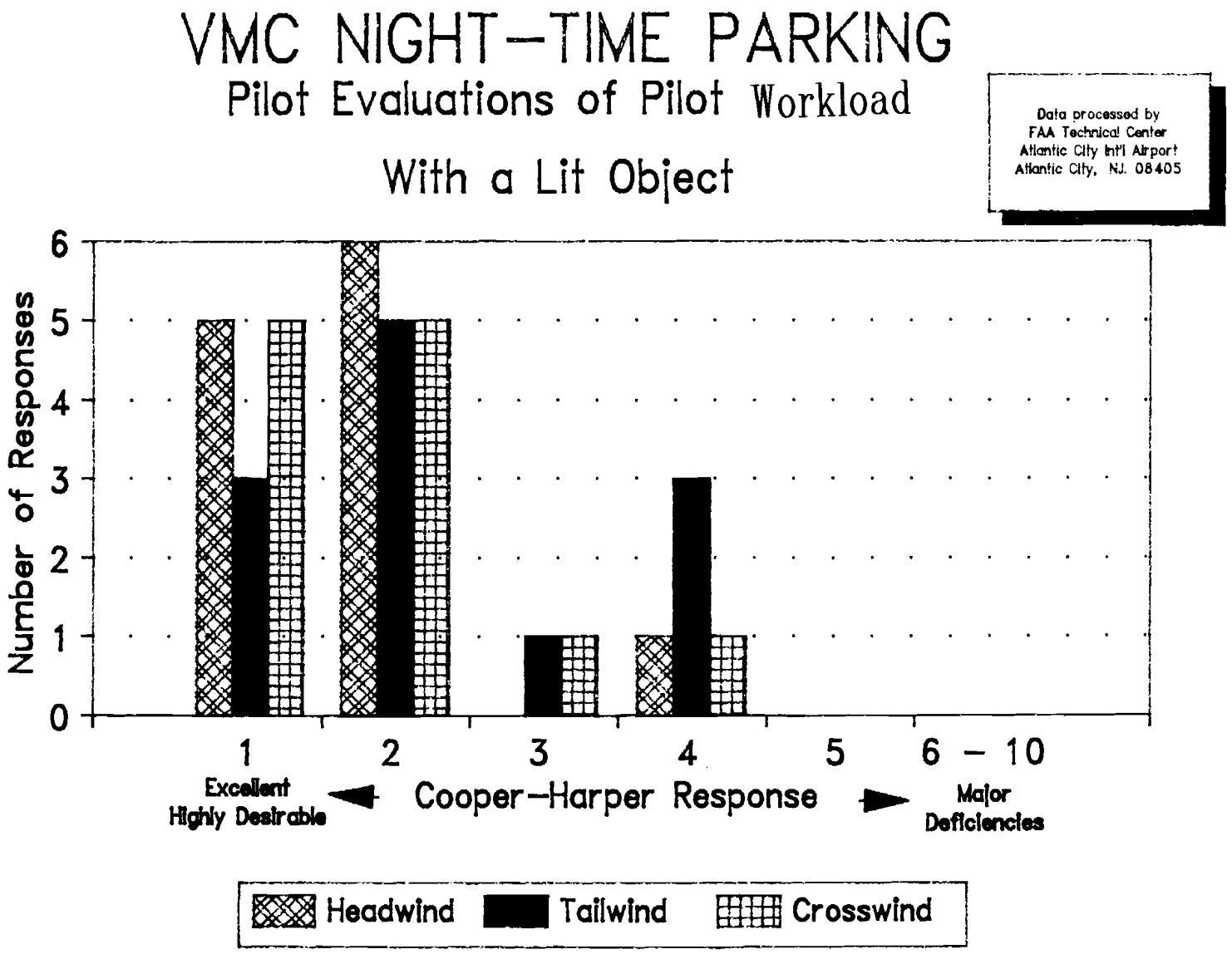
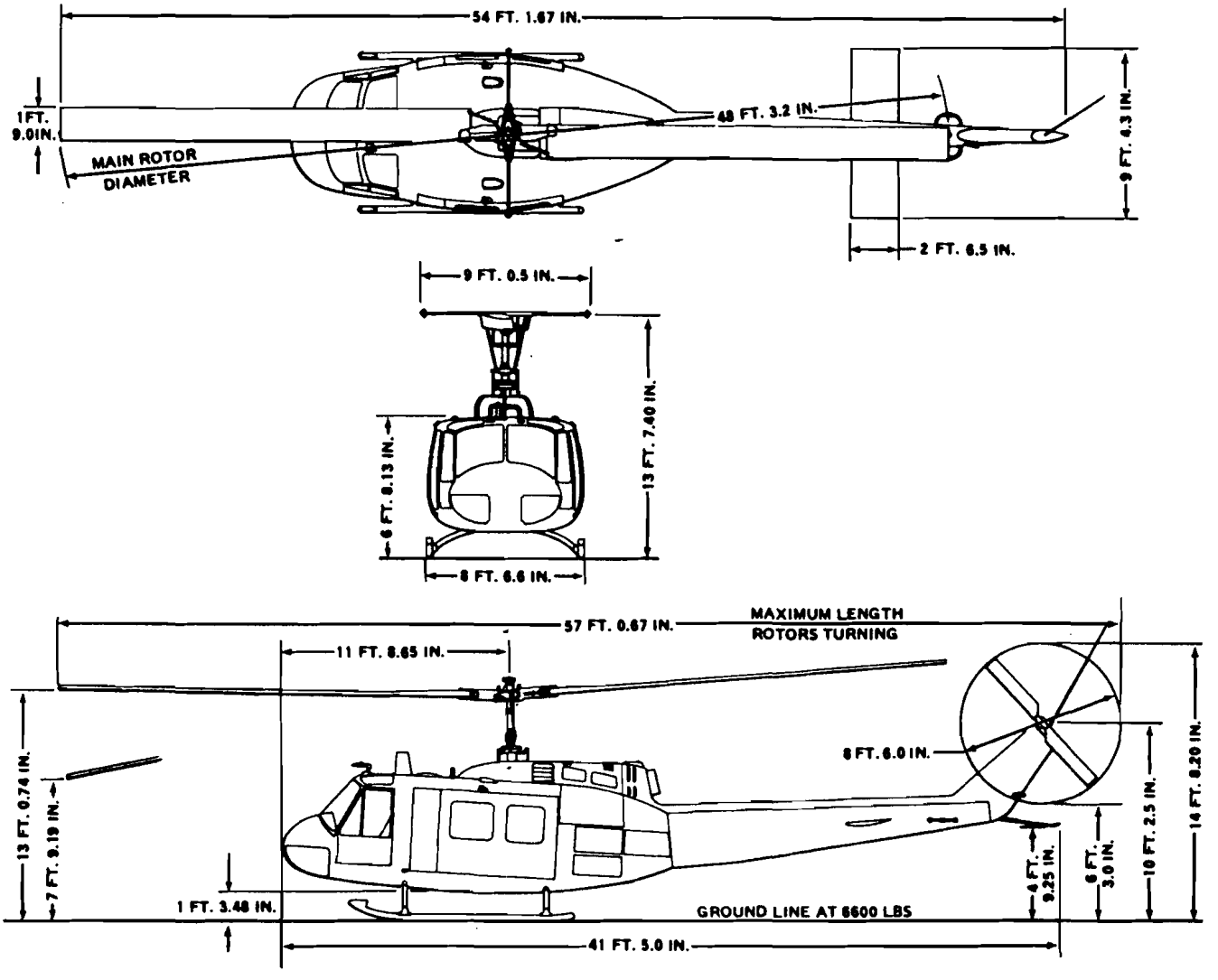


FIGURE 16. COOPER-HARPER RATINGS FOR WORKLOAD: LIT OBJECT

APPENDIX A

UH-1H SPECIFICATIONS


54 FT. 1.67 IN.
1 FT. 9.0 IN.
MAIN ROTOR DIAMETER
48 FT. 3.2 IN.
9 FT. 4.3 IN.
2 FT. 6.5 IN.
9 FT. 0.5 IN.
13 FT. 7.40 IN.
6 FT. 8.13 IN.
8 FT. 6.6 IN.
57 FT. 0.67 IN.
MAXIMUM LENGTH ROTORS TURNING
11 FT. 8.65 IN.
8 FT. 6.0 IN.
13 FT. 0.74 IN.
7 FT. 9.19 IN.
1 FT. 3.48 IN.
GROUND LINE AT 6600 LBS
4 FT. 9.25 IN.
6 FT. 3.0 IN.
10 FT. 2.5 IN.
14 FT. 8.20 IN.
41 FT. 5.0 IN.

APPENDIX B

ONBOARD LOG

VMC NIGHT PARKING

DATE: _____ SUBJ. PILOT: _____ SAFETY PILOT: _____

FLT #: NVMC .LOG AC #: _____

RUN	TYPE /Obj/Wind	WINDS	SPOT #	Safe/Given Dist.	Est. Dist.	Actual Dist.	Spot M-Dist	Spot M-Dist	Ratings Cntr	Sfe	Dmd
1	/Unlit/HW										
2	/Noobj/TW										
3	/Unlit/CW										
4	/Noobj/HW										
5	/Unlit/TW										
6	/Noobj/CW										
7	/Litob/TW										
8	/Litob/HW										
9	/Litob/CW										
10	/Unlit/CW										
11	/Noobj/HW										
12	/Unlit/TW										
13	/Noobj/CW										
14	/Unlit/HW										
15	/Noobj/TW										
16	/Litob/HW										
17	/Litob/CW										
18	/Litob/TW										

Would you continuously perform this maneuver under these conditions in terms of:
controllability ; safety; demands on the pilot

Comments:

AWOS 127.55
RADIO FREQ FOR LIGHTS 123.2 CLICK 3X5

APPENDIX C

POST-FLIGHT QUESTIONNAIRE

VISUAL METEOROLOGICAL CONDITIONS (VMC)

NIGHT PARKING: POST TEST QUESTIONNAIRE

Location: FAA Technical Center Aircraft: _____

Test Date: _____

OPERATIONAL PILOT INFORMATION:

NAME: _____

AFFILIATION: _____

ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

PHONE (OPTIONAL): _____

FAA HELICOPTER RATINGS: _____

_____

TOTAL FLIGHT HOURS: _____

TOTAL HELICOPTER HOURS: _____

TOTAL TIME IN TYPE: _____

TOTAL HELICOPTER HOURS LAST 6 MONTHS: _____

TIME IN TYPE LAST 6 MONTHS: _____

PROCEDURAL QUESTIONS

1. How comfortable did you feel parking 12 feet from the ground mark:

a. With a headwind?	1	2	3	4	5
	Not Comfortable		Somewhat		No Problem- Ok
b. With a tailwind?	1	2	3	4	5
	Not Comfortable		Somewhat		No Problem-OK
c. With a crosswind?	1	2	3	4	5
	Not Comfortable		Somewhat		No problem- OK

2. How comfortable did you feel parking 12 feet from the obstacle:

a. With a headwind?	1	2	3	4	5
	Not Comfortable		Somewhat		No problem- OK
b. With a tailwind?	1	2	3	4	5
	Not Comfortable		Somewhat		No problem- OK
c. With a crosswind?	1	2	3	4	5
	Not Comfortable		Somewhat		No problem- OK

3. When parking in close proximity to an object, under low ambient lighting conditions, what do you consider the minimum safe rotor tip clearance: (in feet)

a. with a headwind?

b. with a tailwind?

c. with a crosswind?

4. Which type condition(s) did you feel was better for the type operations performed?

a. Lit object

b. Unlit object

5. Do you feel wind conditions influence your parking performance significantly?

If so, what type lighting condition(s) would you like to see for night parking under:

Headwind conditions:

Tailwind conditions:

Crosswind conditions:

APPENDIX D

ACTUAL TEST DATA

ACTUAL DATA FOR PILOT CHOICE MANEUVERS

Actual Winds	Light/Object Condition	Wind Type	Safe Dist.(ft)	Estimated Dist.(ft)	Actual Dist.(ft)	Actual-Estimated (Calculated Perception Errors)(ft)
FLIGHT DATE: 12-19-88						
190/7	unlit obj.	HW	8	8	18.11	10.11
190/7	no object	TW	8	10	17.50	7.50
190/7	unlit obj.	CW	8	10	29.34	19.34
190/7	no object	HW	8	8	6.94	-1.06
190/7	unlit obj.	TW	8	8	10.42	2.42
190/7	no object	CW	8	10	6.38	-3.62
190/7	unlit obj.	HW	8	8	8.90	.90
190/7	no object	TW	8	8	5.32	-2.68
190/7	lit object	CW	8	8	13.88	5.88
190/7	lit object	HW	8	8	6.14	-1.86
190/7	lit object	TW	8	10	6.76	-3.24
FLIGHT DATE: 1-18-89						
200/9	unlit obj.	CW	10	10	1.24	-8.76
200/9	no object	HW	10	10	-4.73	-14.73
200/9	unlit obj.	TW	10	10	-2.74	-12.74
200/9	no object	CW	10	10	-6.30	-16.30
200/9	unlit obj.	HW	10	10	-3.20	-13.20
200/9	no object	TW	10	10	-7.76	-17.76
200/9	lit object	CW	10	10	-3.19	-13.19
200/9	lit object	HW	10	10	-9.75	-19.75
200/9	lit object	TW	10	10	-1.73	-11.73
FLIGHT DATE: 1-25-89						
080/7	unlit obj.	CW	10	10	35.20	25.20
080/7	no object	HW	10	10	38.55	28.55
080/7	unlit obj.	TW	10	15	22.77	7.27
080/7	no object	CW	10	5	0.98	-4.02
080/7	unlit obj.	HW	10	10	19.14	9.14
080/7	no object	TW	10	10	8.64	-1.36
080/7	lit object	CW	10	15	14.38	-0.62
080/7	lit object	HW	10	10	15.16	5.16
080/7	lit object	TW	10	12	40.34	28.34

FLIGHT DATE: 2-8-89

250/12	unlit obj.	HW	15	9	11.96	2.96
250/12	no object	TW	12	12	3.44	-8.56
250/12	unlit obj.	CW	12	15	14.76	-0.24
250/12	no object	HW	12	12	10.47	-1.53
250/12	unlit obj.	TW	12	10	8.83	-1.17
250/12	no object	CW	8	10	5.90	-4.10
250/12	lit object	CW	12	12	9.24	-2.76
250/12	lit object	TW	12	8	6.50	-1.10
250/12	lit object	HW	10	10	5.90	-4.10

FLIGHT DATE: 2-15-89

050/12	unlit obj.	HW	10	10	13.28	3.28
050/12	no object	TW	10	6	6.89	.89
050/12	unlit obj.	CW	10	8	11.26	3.26
050/12	no object	HW	10	8	7.97	-0.03
050/12	unlit obj.	TW	10	8	12.78	4.78
050/12	no object	CW	10	10	10.09	0.09
050/08	lit object	TW	10	8	15.04	7.04
050/08	lit object	HW	10	10	11.15	1.15
040/10	lit object	CW	10	10	12.08	2.08

FLIGHT DATE: 7-27-89

220/5	unlit obj.	HW	10	15	26.37	11.37
220/5	no object	TW	10	8	11.91	3.91
220/5	unlit obj.	CW	10	12	17.02	5.02
220/5	no object	HW	10	9	8.15	-0.85
220/7	unlit obj.	TW	10	8	10.33	2.33
220/7	no object	CW	10	12	11.58	-0.42
220/5	lit object	TW	10	10	11.26	1.26
220/5	lit object	HW	10	11	12.57	1.57
220/5	lit object	CW	10	12	14.66	2.66

FLIGHT DATE: 8-14-89

calm	unlit obj.	HW	10	12	15.85	3.85
calm	no object	TW	10	12	10.50	-1.50
calm	unlit obj.	CW	10	10	6.41	-3.59
calm	no object	HW	10	14	10.74	-3.26
calm	unlit obj.	TW	10	10	7.63	-2.37
calm	no object	CW	10	12	5.37	-6.73
calm	lit object	TW	10	10	7.63	-2.37
calm	lit object	HW	10	11	12.31	1.31
calm	lit object	CW	10	10	9.26	-0.74

Total Number of Runs 65

ACTUAL DATA FOR REQUIRED 12' CLEARANCES

Actual Winds	Light/Object Condition	Wind Type	Safe Dist.(ft)	Estimated Dist.(ft)	Actual Dist.(ft)	Actual-Estimated Calculated Performance Errors (ft)
FLIGHT DATE: 2-8-89						
250/12	unlit obj.	CW	12	12	6.12	-5.88
250/12	no object	HW	12	10	5.59	-4.41
250/12	unlit obj.	TW	12	14	8.08	-5.92
270/13	no obj.	CW	12	14	10.09	-3.91
270/13	unlit obj.	HW	12	12	5.90	-6.10
270/13	no object	TW	12	10	5.83	-4.17
270/13	lit object	HW	12	12	29.22	17.22
270/13	lit object	CW	12	12	24.99	12.99
270/13	lit object	TW	12	12	10.27	-1.73
FLIGHT DATE: 2-15-89						
040/10	unlit obj.	CW	12	12	12.84	0.84
040/10	no object	HW	12	13	6.62	-6.38
040/10	unlit obj.	TW	12	12	12.30	0.30
040/10	no obj.	CW	12	12	9.87	-2.13
040/10	unlit obj.	HW	12	12	10.96	-1.04
040/10	no object	TW	12	10	4.51	-5.49
FLIGHT DATE: 2-16-89						
330/10	lit object	HW	12	13	17.88	3.88
330/10	lit object	CW	12	10	11.21	1.21
330/10	lit object	TW	12	10	11.36	1.36
FLIGHT DATE: 2-16-89						
330/10	unlit obj.	HW	12	13	15.79	2.79
330/10	no object	TW	12	12	9.83	-2.17
350/10	unlit obj.	HW	12	12	15.62	3.62
350/10	no object	HW	12	12	10.40	-1.60
350/10	unlit obj.	TW	12	14	16.04	2.04
350/10	no object	CW	12	14	13.74	-0.26
350/10	lit object	TW	12	14	16.21	2.21
350/10	lit object	HW	12	12	28.79	-1.20
350/10	lit object	CW	12	12	15.71	3.71
350/10	unlit obj.	CW	12	12	16.04	4.04
FLIGHT DATE: 7-27-89						
240/4	unlit obj.	CW	12	10	19.82	9.82
240/4	no object	HW	12	12	16.44	4.44
240/4	unlit obj.	TW	12	12	17.85	5.85
240/4	no object	CW	12	12	18.44	6.44
240/4	unlit obj.	HW	12	12	15.78	3.78
240/4	no object	TW	12	12	16.56	4.56

230/5	lit object	HW	12	12	14.65	2.65
230/5	lit object	CW	12	10	17.54	7.54
230/5	lit object	TW	12	10	14.88	4.88

FLIGHT DATE: 8-14-89

calm	unlit obj.	CW	12	12	12.31	0.31
calm	no object	HW	12	13	11.52	-1.48
calm	unlit obj.	TW	12	12	8.58	-3.42
calm	no object	CW	12	13	7.44	-5.56
calm	unlit obj.	HW	12	12	16.34	4.34
calm	no object	TW	12	12	9.04	-2.96
calm	lit object	HW	12	12	11.84	-0.16
calm	lit object	CW	12	12	15.16	3.16
calm	lit object	TW	12	12	13.83	1.83

Total Number of Runs 46

APPENDIX E

COMPARISON OF DAYTIME AND NIGHTTIME TEST RESULTS

PILOT PREFERENCES - TIP PATH CLEARANCE
A COMPARISON OF DAYTIME AND NIGHTTIME PREFERENCES

PILOT PREFERRED TIP PATH CLEARANCE - DAYTIME OPERATIONS
(TABLE 6 FROM REPORT FAA/CT-TN88/30)

In Feet

	Headwind	Crosswind	Tailwind
With Obstacle			
Mean	8.69	8.88	9.25
SD	2.93	2.93	3.09
N	16	16	16
Without Obstacle			
Mean	7.25	7.10	7.65
SD	3.51	3.62	3.68
N	20	20	20

PILOT STATED SAFE TIP PATH CLEARANCES - NIGHTTIME
OPERATIONS (PILOT PREFERENCES)
(FROM THIS REPORT)

In Feet

	Headwind	Crosswind	Tailwind
With Unlit Obstacle			
Mean	10.13	10.00	10.00
SD	2.03	1.07	1.07
N	8	7	7
With Lit Obstacle			
Mean	9.71	10.00	10.00
SD	0.70	1.07	1.07
N	7	7	7
Without Obstacle			
Mean	10.00	9.43	9.75
SD	1.07	0.90	1.20
N	7	7	8

ACTUAL ROTOR TIP CLEARANCES REGARDLESS OF WIND DIRECTION

A COMPARISON OF DAYTIME AND NIGHTTIME RESULTS

ACTUAL ROTOR TIP CLEARANCES REGARDLESS OF WIND DIRECTION - PILOT'S CHOICE - DAYTIME OPERATIONS (TABLE 7 FROM REPORT FAA/CT-TN88/30)

In Feet

	With Obstacle	Without Obstacle
Mean	10.85	7.29
97.5 Percentile Point	26.87	19.47
N	48	60

ACTUAL ROTOR TIP CLEARANCES REGARDLESS OF WIND DIRECTION (PILOT PREFERENCE) - NIGHTTIME OPERATIONS (TABLE 5 FROM THIS REPORT)

In Feet

	With Unlit Obstacle	With Lit Obstacle	Without Obstacle
Mean	13.44	9.98	7.66
SD	9.28	9.29	9.00
N	22	21	22

ACTUAL ROTOR TIP CLEARANCES BY WINDS - DAYTIME OPERATIONS (TABLE 8 FROM REPORT FAA/CT-TN88/30)

In Feet

	Headwind	Crosswind	Tailwind
With Obstacle			
Mean	11.16	11.70	9.68
97.5 Percentile Point	25.18	30.76	22.44
N	16	16	16
Without Obstacle			
Mean	8.52	7.61	5.74
97.5 Percentile Point	24.04	18.66	13.86
N	20	20	20

ACTUAL ROTOR TIP CLEARANCES BY WINDS (PILOT PREFERENCE) -
NIGHTTIME OPERATIONS
(TABLE 6 FROM THIS REPORT)

	In Feet		
	Headwind	Crosswind	Tailwind
With Unlit Obstacle			
Mean	13.80	16.46	10.00
SD	8.11	11.21	6.97
N	8	7	7
With Lit Obstacle			
Mean	7.64	10.04	12.26
SD	7.77	5.80	12.41
N	7	7	7
Without Obstacle			
Mean	11.16	4.86	7.06
SD	12.19	5.55	6.92
N	7	7	8

ACTUAL TIP CLEARANCES WHEN ATTEMPTING A 12-FOOT TIP CLEARANCE

A COMPARISON OF DAYTIME AND NIGHTTIME RESULTS

ACTUAL CLEARANCES WHEN ATTEMPTING 12-FOOT CLEARANCE - DAYTIME OPERATIONS
(TABLE 10 FROM REPORT FAA/CT-TN88/30)

	Headwind	Crosswind	Tailwind	Overall
With Obstacle				
Mean	14.37	14.24	13.49	14.03
SD	6.08	6.76	5.87	6.26
N	16	16	16	48
Without Obstacle				
Mean	14.10	13.40	12.55	13.55
SD	7.32	5.82	6.52	6.61
N	20	20	20	48

ACTUAL ROTOR TIP CLEARANCES WHEN ATTEMPTING 12-FOOT CLEARANCES - NIGHTTIME OPERATIONS
(TABLE 8 FROM THIS REPORT)

In Feet

	Headwind	Crosswind	Tailwind
With Unlit Obstacle			
Mean	13.40	13.43	12.57
SD	3.81	4.53	3.90
N	6	5	5
With Lit Obstacle			
Mean	16.88	16.92	13.31
SD	6.64	4.53	2.20
N	5	5	5

PERCEPTION ERRORS

A COMPARISON OF DAYTIME AND NIGHTTIME PERCEPTIONS

PERCEPTION ERRORS - DAYTIME OPERATIONS
(TABLE 9 FROM REPORT FAA/CT-TN88/30)

(Actual Clearance - Pilot Estimate in Feet)

	Headwind	Crosswind	Tailwind
With Obstacle			
Mean	3.04	2.70	.12
SD	6.57	9.13	5.61
N	16	16	16
Without Obstacle			
Mean	1.26	.86	-1.09
SD	8.48	6.43	4.42
N	20	20	20

PERCEPTION ERRORS (PILOT PREFERENCE) - NIGHTTIME OPERATIONS
(TABLE 7 FROM THIS REPORT)

(Actual Clearance - Pilot Estimated Clearances)

In Feet

	Headwind	Crosswind	Tailwind
With Unlit Obstacle			
Mean	3.80	5.75	.15
SD	7.32	11.36	6.14
N	8	7	7
With Lit Obstacle			
Mean	-2.36	-.96	2.54
SD	7.59	5.63	11.74
N	7	7	7
Without Obstacle			
Mean	1.01	-5.00	-2.45
SD	12.09	5.00	7.28
N	7	7	8

PERFORMANCE ERRORS

A COMPARISON OF DAYTIME AND NIGHTTIME ERRORS

PERFORMANCE ERRORS - DAYTIME OPERATIONS
(TABLE 11 FROM REPORT FAA/CT-TN88/30)

(Actual Clearance - 12 Feet in Feet)

	Headwind	Crosswind	Tailwind
With Obstacle			
Mean	2.37	2.24	1.49
SD	6.08	6.76	5.87
N	16	16	16
Without Obstacle			
Mean	2.10	1.40	0.55
SD	7.32	5.82	6.52
N	20	20	20

PERFORMANCE ERRORS - NIGHTTIME OPERATIONS
(TABLE 9 FROM THIS REPORT)

(Actual Clearance - 12 Feet in Feet)

	Headwind	Crosswind	Tailwind
With Unlit Obstacle			
Mean	1.23	1.83	-0.23
SD	3.72	5.13	4.12
N	6	5	5
With Lit Obstacle			
Mean	4.68	4.92	1.31
SD	6.62	2.89	2.80
N	5	5	5
Without Obstacle			
Mean	-1.89	-1.08	-2.05
SD	3.66	4.16	3.49
N	5	5	5

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