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HELIPORT INSTRUMENT LIGHTING SYSTEM (HILS) AND CHASE HELICOPTER APPROACH PATH INDICATOR (CHAPI)

TEST PLAN

Suzanne Hogan

FEDERAL AVIATION ADMINISTRATION
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Engineering, Research, and Development Service
Research Directorate for Aviation Technology
FAA Technical Center
Atlantic City International Airport, NJ 08405

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EXECUTIVE SUMMARY

This test plan describes a test designed to obtain subjective and objective pilot data on precision approaches to heliports utilizing a Heliport Instrument Lighting System (HILS) in conjunction with a Chase Helicopter Approach Path Indicator (CHAPI). Results should identify the performance measures which will most closely correlate with the pilot's ability to visually acquire a HILS and CHAPI equipped heliport sufficiently to investigate the need for the 1/2 mile additive visibility value required when a Heliport Approach Lighting System (HALS) is not installed and identify if HILS and CHAPI qualifies for visibility credit. Results will enable the FAA to determine if criteria selected in FAA order 8260.3c, "Heliport Civil Utilization of Collocated Microwave Landing System (MLS)," are appropriate.

INTRODUCTION

Objective: The objective of this flight test is to provide subjective and objective data that can be used to determine if visibility values for Instrument Flight Rules (IFR) approaches to heliports, as defined in FAA order 8260.3C, "Heliport Civil Utilization of Collocated Microwave Landing System (MLS)," can be reduced with the use of the Heliport Instrument Lighting System (HILS) in conjunction with a Chase Helicopter Approach Path Indicator (CHAPI).

Background: This test is sponsored by AVN-210 through ARD-30. Approach lighting systems provide the basic aids for transition from instrument flight to visual flight prior to and including landing. The establishment of precision instrument approaches to heliports is hindered by the lack of suitable instrument approach lighting aids and procedures. A complex series of actions must occur before and during the transition to the visual segment. Prior to entering the visual segment the pilot must visually acquire the landing area, and determine the relative position of the landing area. Upon entering the visual segment, the rotorcraft pilot must decelerate the aircraft to zero or near zero ground speed prior to landing on the heliport. This deceleration must occur while the pilot continues to maintain a reference ground track and glidepath. Previous tests as documented in DOT/FAA/CT-TN89/21 Helicopter Approach Lighting System (HALS) Test Report and CT-ACD330-93/3 Helicopter Instrument Lighting System Report, have shown that the pilot can improve performance better during this critical phase of flight if certain visual approach aids are available.

Also an, FAA Order 8260.3C defines the visibility criteria for heliports with and without an approach lighting system. Many heliports cannot meet the space requirements needed for the full Heliport Approach Lighting System (HALS) (figure 1) but are able to install HILS and CHAPIs. HILS is composed of H-bar and perimeter lights and requires substantially less real estate compared to HALS which requires 1000 ft of real estate in the approach path direction. CHAPIs are visual glideslope indicators.

TEST PROCEDURES

Location. The flight tests will be conducted at the FAA Technical Center's National Concepts Development and Demonstration Vertiport, Atlantic City International Airport, NJ. The vertiport is located at the north end of the Technical Center, with an obstacle free approach course providing the necessary flexibility for the flight tests. The vertiport and the surrounding airspace is in clear view of the ground tracking

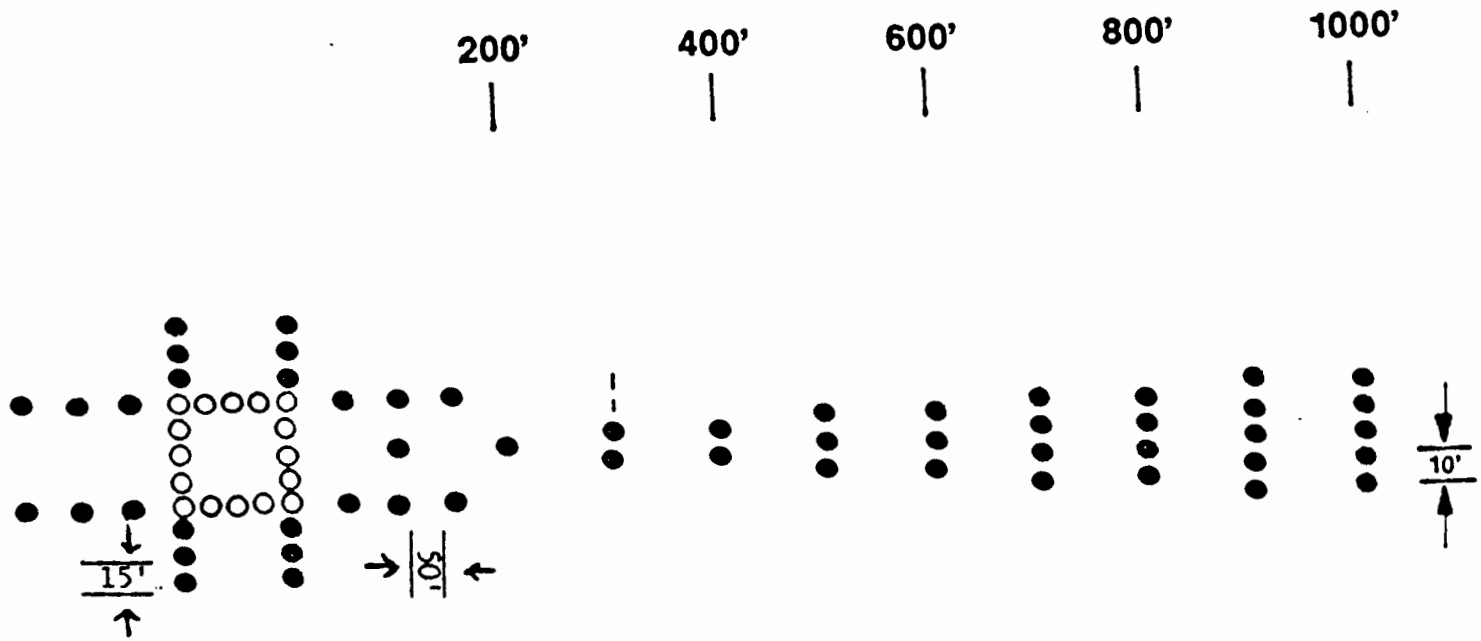


FIGURE 1. HELIPORT APPROACH LIGHTING SYSTEM (HALS)

facilities.

Aircraft. The aircraft to be used for this flight test will be a Sikorsky S-76A, a twin turbine, single main rotor helicopter. This aircraft is owned by the FAA and is certified for single pilot Instrument Flight Rules (IFR) operations. For this test it will be flown under Visual Meteorological Conditions (VMC), with subject pilots hooded with foggles.

Aircraft Equipment. The aircraft is equipped with Honeywell/Sperry EDZ-705 dual Electronic Flight Instrument System (EFIS), and a Honeywell/Sperry SPZ-7000 dual Digital Automatic Flight Control System (DAFCS). The S-76 is also equipped with a Bendix 211B MLS receiver. This aircraft is representative of IFR certified transport helicopters currently in use.

HILS. The heliport instrument lighting system being evaluated is the basic IFR configuration known as the H-bar (figure 2). It consists of omnidirectional amber (yellow) colored elevated lights defining the perimeter of the available helipad landing area. This is supplemented by high-intensity unidirectional white lights arranged in a pattern of dual wingbars on either side of the pad, and dual rows of alignment lights located in front of and beyond the pad. The distinctive pattern formed by these lights is that of a "cross" when viewed at a distance from the approach direction. The described configurations conform to the systems mentioned in AC 150/5390-2, Heliport Design Guide, as "Possible Heliport Approach Light Systems."

CHAPI: The CHAPI system consists of two sharp transition red/green/white light projection units. The units are horizontally spaced 20 feet apart. The on course signal is two green light units. Deviations below course are indicated by one green and one red light unit for slightly low and two red light units for below course. Deviations above course are indicated by one white and one green light unit for slightly high and two white light units for above course. The system requires 1200 watts to power 6 - 200 watt, 6.6 ampere lamps.

MLS: During the instrument segment of the approach, MLS will be used for guidance of the aircraft. The MLS equipment currently installed at the FAA Technical Center's National Concepts Development and Demonstration Vertiport is a Hazeltine model 2600 system. The Hazeltine Model 2600 meets ICAO Standards And Recommended Practices (SARPS) Annex 10, FAA-STD-022d "Microwave Landing System Interoperability and Performance Requirements" and FAA-E-2721 "Microwave landing System Specifications." It is a standard microwave landing system utilizing phased array antenna technology, microprocessor control, and solid-state electronics. The Time Reference Scanning Beam (TRSB) format is transmitted on one of 200 C-band frequency channels. In addition to the MLS, there is an E-Systems precision distance measuring equipment

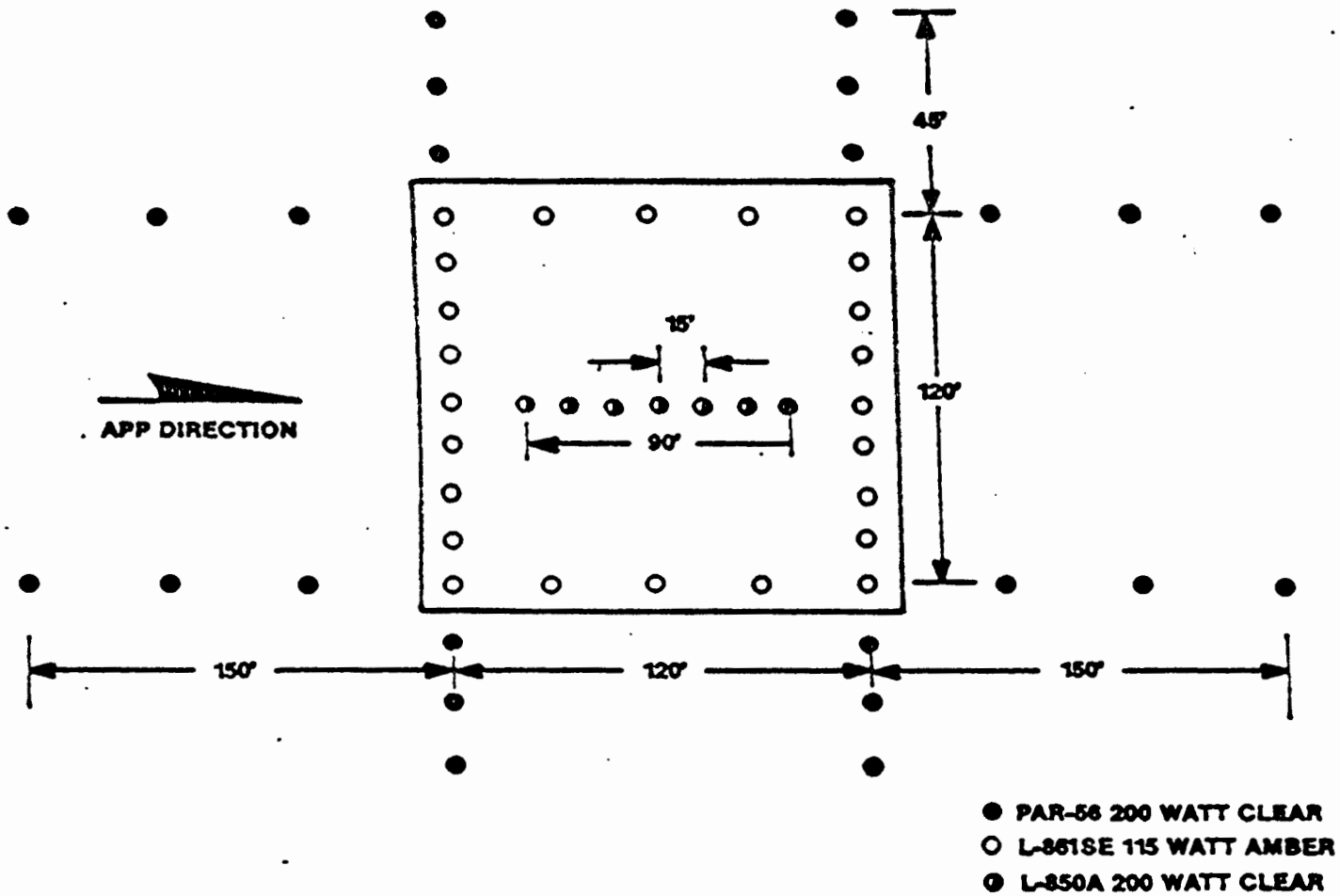


Figure 2. Heliport Instrument Lighting System (HILS)

(DME/P) system installed at the vertiport.

MLS provides a precision approach procedure that pilots can fly to a 200 and 262 foot MSL decision height (DH) for 4.50° and 6.00° respectively. The display characteristics of the MLS are similar to the instrument landing system (ILS).

Ground Tracking: Two different tracking systems will be used for tracking the aircraft during the approaches. The two systems are the GTE Sylvania Precision Automated Tracking System (PATS) and Vitro RIR778 Tracking Radar.

The GTE Sylvania PATS measures the azimuth (AZ), elevation (EL), and range automatically by transmitting a laser pulse to a target on the aircraft and measuring the angle of return and round trip time. The angle coverage for the AZ is 540° and for EL it is .5° to .85°. The angle of accuracy or maximum error for both AZ and EL is 20 arc seconds at all ranges. The maximum reliable range coverage is 25 nmi. Accuracies are 1 foot for target ranges up to 5 nmi, 2 feet for target ranges of 5 nmi to 10 nmi, and 3 feet for target ranges of 10 nmi to 25 nmi. The system is capable of tracking an aircraft through touchdown. However, the operational range is limited at the Technical Center to ranges of 7 nmi to 10 nmi due to visibility conditions.

The VITRO RIR778 Tracking Radar uses a NIKE Hercules radar antenna. It is capable of operating either in beacon (cooperative) mode or in skin paint mode. It is calibrated to a one sigma range error, 3.3 meters for the beacon mode and 6.0 meters for the skin paint mode. The standard deviation of short term variations or jitter is within 0.009° for both AZ and EL and within 3.0 meters for range.

Instrument Meteorological Conditions (IMC) Simulator Goggles. The IMC simulator goggles restrict the perceived outside visibility of the pilot without hindering his ability to see the instruments. A sensor is mounted on the back of the goggles and a reflective plate is mounted on the ceiling of the aircraft. When the sensor does not detect the reflective plate (when the pilot is looking out of the aircraft) the Simpaq lenses are obscured. When the sensor detects the reflective plate, the lower portion of the lenses clear to give the pilot an unimpeded view of the instruments. The safety pilot controls the visibility for the subject pilot using the Runway Visual Range (RFR) adjustment settings on the control box connected to the goggles. If the subject pilot were to get into a situation where safety is in any way compromised, the safety pilot can clear the lenses instantly.

FLIGHT TEST PROCEDURES

Subject Pilot Briefings. The objectives of the flight test and the flight procedures will be explained to each subject pilot during a preflight briefing. The responsibilities of each crew member, subject pilot, safety pilot and technician, will be described and local area conditions and aircraft information will be discussed. The subject pilots will be briefed on the use of the Modified Cooper Harper rating scale for the in-flight questions. These questions covered issues of:

1. Overall visual segment
2. Assistance in visual alignment for landing
3. Deceleration cueing
4. Overall workload
5. Aircraft controllability

The pilot will also be informed of the post flight questionnaire but will not be shown the questions till after the flight.

Copies of the in-flight questionnaire, post-flight questionnaire, the post-flight pilot background questionnaire and modified Cooper Harper rating scale are found in appendix A.

Subject Pilots. The 20 subject pilots who will participate in this test will be from industry, the FAA, and military. All subjects will be current and qualified in the S-76 and hold at least an FAA commercial rotorcraft and instrument rating.

Developmental Flights. Three developmental flights will be conducted to determine if the flight scenario for this test meets the scope. These flights will be flown by FAA pilots.

Flight Procedures. Each flight will consist of a total of 10 approaches with 4 approaches at 4.5° with a DH of 200 feet and 4 approaches at 6° with a DH at 262 feet. Additionally, 2 runs will be conducted at each glideslope angle without the CHAPIs. These runs will be used for comparison. All the runs will be conducted at night with the HILS and CHAPIS. The scenarios for the flights will be centerline approaches with varying visibilities of 1/2, 3/4, 1, and 1-1/4 mile. The visibilities will be varied with use of the foggles. The flight test profiles are presented in table 1. The starting elevation angles will be varied for each pilot so as not to have a learning curve. After each approach the subject pilot will be asked a series of questions and will answer them according to the Modified Cooper Harper rating scale.

TABLE 1. FLIGHT PROFILES

Run	EL Angle	DH (ft)	Visibility (nmi)
1	4.5°	200	0.50
2	4.5°	200	0.75
3	4.5°	200	1.00
4	4.5°	200	1.25
5	6.0°	262	0.50
6	6.0°	262	0.75
7	6.0°	262	1.00
8	6.0°	262	1.25
9	4.5°	200	
10	6.0°	262	

DATA ANALYSIS

Objective Data. Results will be drawn from the evaluation of the ground tracking data and the pilots responses. Isoprobability plots will be generated. The data will be binned in 50 foot increments from 1000' outside of DH to touchdown. Means with six standard deviation envelopes will be generated from each type of run. Additionally, plots will be prepared of vertical position/range rate versus range and lateral position versus range plots. Composite plots of the above parameters for the varying visibilities and two different glideslope angles will also be generated. Included in these plots are the decision heights and location of peak deceleration. Statistics compiled will be overall crosstrack total system error, overall vertical total system error, maximum overarc and underarc and location where these occurred and peak deceleration and location where these occurred.

Comparative statements about the quantified pilot performance will be made for the various test conditions. Performance from DH to landing will be of primary interest. Missed approaches and flight profile deviations beyond acceptable standards will be analyzed.

Subjective Data. Subjective data consisting of inflight post-procedure questionnaire and post-flight questionnaire responses will be evaluated to quantify pilot perception concerning the safety, aircraft controllability, visual segment deceleration, and perceived workload during a particular procedure. Pilots will be asked several questions on the preflight questionnaire. Each question will be answered with a single number response using the Cooper Harper modified rating scale. The inflight questionnaire will be used for comparison of pilot perceptions under the various test conditions. The post flight questionnaire will be used to collect general pilot perceptions about various aspects of the lighting system. Subjective pilot questionnaire responses will be

compared for different test conditions. Post-flight questionnaire responses will be reviewed to detect any inconsistency in responses.

TIME SCHEDULE

Task	Completion Date
FAA Pilot Test Flights (2)	2/93
Subject Pilot Flights (20)	4/93
Data Reduction	6/93
Draft Division Report	8/93
Final Division Report	9/93

RELATED DOCUMENTATION

1. United States Standard for Terminal Instruments Procedures (TERPS), FAA Handbook 8620.3b, July 1976.

2. Civil Utilization of Microwave Landing System at Heliports with Collocated MLS Facilities, U.S. Department of Transportation (DOT), Federal Aviation Administration (FAA) Draft Order 8260.3c, January 1988.

3. Heliport Design Guide, U.S. Department of Transportation FAA Advisory Circular (AC) 1501 5390-2, January 17, 1988.

4. Heliport Visual Segment Approach Lighting System (HALS) Test Report, U.S. Department of Transportation (DOT), Federal Aviation Administration (FAA) CT-TN89/21, June 1989.

5. Helicopter Instrument Lighting System Report, U.S. Department of Transporation (DOT), Federal Aviation Administration (FAA) CT-ACD330-93/3, January 1993.

6. Test Plan for Helicopter Visual Segment Instrument Approach Lighting System (HILS), U.S. Department of Transportation (DOT), Federal Aviation Administration (FAA) CT-TN90/61, September 1991.

APPENDIX A

INFLIGHT QUESTIONAIRE

NOTE: These questions will be asked after each run by the data technician. All responses will be given using the Cooper Harper Rating Scale.

1. How would you rate the Heliport Lighting System (HILS) in providing visual guidance, to allow you to complete the approach to landing?

2. How would you rate the HILS in providing alignment guidance to permit proper maneuvering to the centerline of the helipad prior to landing?

3. Did the HILS provide adequate visual cues for determining rate of closure and/or deceleration during the visual segment of the approach? YES NO

4. How would you rate your workload during the visual segment of the approach?

5. How would you rate the aircraft controlability during the visual segment of the approach?

IN-FLIGHT QUESTIONNAIRE

POST FLIGHT QUESTIONAIRE

1. Do you feel the Heliport Lighting System (HILS) by itself provides an adequate visual guidance to perform a safe landing using the 4.5° and 6° approach angles?

2. In general, do you feel that your ability to execute a safe and expeditious transition from instrument flight to visual flight was aided by having HILS?

3. In your opinion, what is the minimum safe visibilty for:
   4.5° glideslope and 250 feet DH; _____ miles
   6.0° glideslope and 350 feet DH; _____ miles

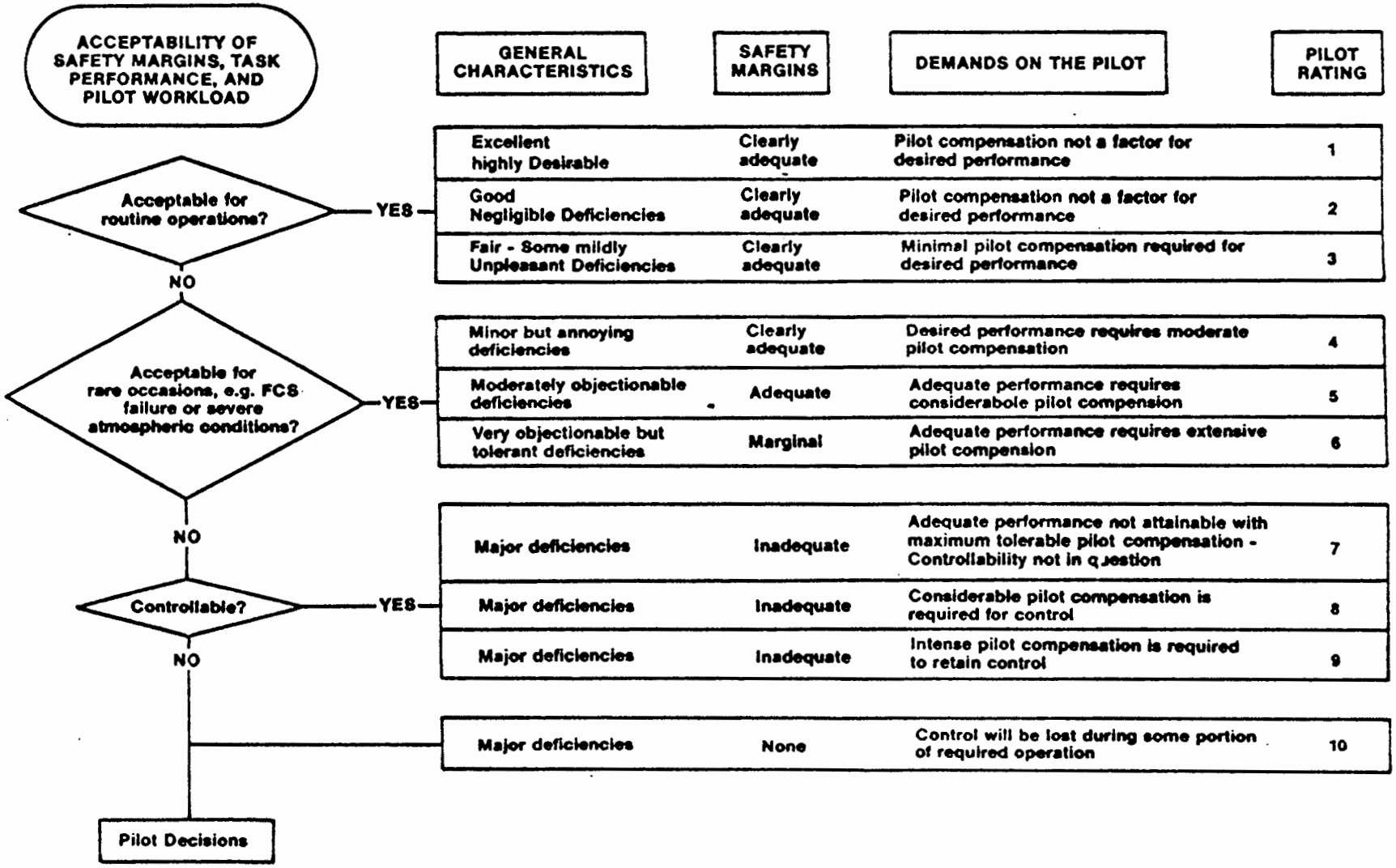
4. For a particular glideslope and DH combination, do you feel that the same visibilty minimum can be used for both day and night flights?

YES NO

5. Do you feel the wind play a significant factor in the workload of the approach during the visual segment?

6. Can you think of any changes or additions to HILS that would improve performance?

POST-FLIGHT QUESTIONNAIRE



MODIFIED COOPER-HARPER RATING SCALE