Transport Canada Transports Canada

Advisory Circular

Subject: **Precision Approach Path Indicator Harmonization with Instrument Landing System**

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1.0 INTRODUCTION

This Advisory Circular (AC) is provided for information and guidance purposes. It may describe an example of an acceptable means, but not the only means, of demonstrating compliance with regulations and standards. This AC on its own does not change, create, amend or permit deviations from regulatory requirements, nor does it establish minimum standards.

1.1 Purpose

The purpose of this document is to provide information on the installation of Precision Approach Path Indicator (PAPI) light units to enable harmonization of the PAPI signal with Instrument Landing System (ILS).

1.2 Applicability

This document is applicable to all manufacturers/suppliers involved with provision of equipment of this nature for installation at Canadian aerodromes.

1.3 Description of Changes

Not applicable.

2.0 REFERENCES AND REQUIREMENTS

2.1 Reference Documents

(1) It is intended that the following reference materials be used in conjunction with this document:

(a) Transport Canada publication TP 312, 4th Edition – March 1993 – *Aerodrome Standards and Recommended Practices* (revised 03/2005);

(b) Annex 14 to the Convention on International Civil Aviation (ICAO) 4th Edition, July 2004 – *Aerodromes*; and

(c) ICAO Aerodrome Design Manual, Part 4, *Visual Aids* 4th Edition, 2004, Appendix 6.

2.2 Cancelled Documents

Not applicable.

2.3 Definitions and Abbreviations

(1) The following definitions and abbreviations are used in this document:

(a) **ADM:** Aerodrome Design Manual;

(b) **AP:** Abbreviated PAPI (APAPI);

(c) **EAH:** Eye to Aerial Height – ILS Glideslope;

(d) **EWH:** Eye to Wheel Height;

(e) **GPI:** Glide Path Intercept;

(f) **ICAO**: International Civil Aviation Organization;

(g) **ILS:** Instrument Landing System;

(h) **MEHT**: Minimum Eye Height over Threshold;

(i) **PAPI:** Precision Approach Path Indicator;

(j) **TCH:** Threshold Crossing Height (with respect to ILS); and

(k) **WTH:** Wheel to Threshold Height.

3.0 BACKGROUND

(1) A PAPI system is installed at an aerodrome to provide the pilot with visual (vertical) approach path guidance to facilitate the establishment of a stabilized descent during an approach to landing.

(2) The ILS at an aerodrome provides the pilot with an electronic approach path guidance on the aircraft's instrument panel.

(3) TP312 stipulates:

> **5.3.6.19 Standard.** When the runway is equipped with an ILS, the sitting and the angle of elevation of the light units shall be such that the visual approach slope conforms as closely as possible with the glide path of the ILS.

(4) This AC discusses the siting of PAPI to accomplish this harmonization.

4.0 DISCUSSION

4.1 Precision Approach Path Indicator Light Unit

The PAPI light unit, as shown in Figure 1, produces a colour coded light beam the top half of which is white and the bottom half red. Between the top and bottom halves is the transition sector of some 3 minutes of arc which is an area of progressive change from white to red and sometimes referred to as the "pink sector".

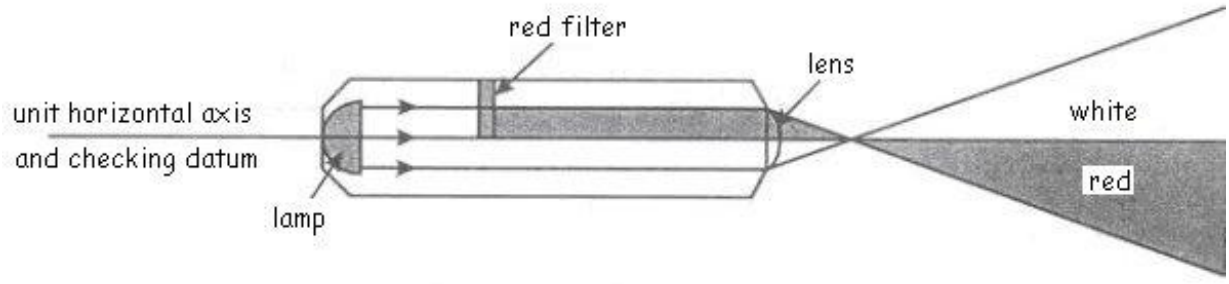

Figure 1. PAPI light unit and signal

4.2 Precision Approach Path Indicator System

(1) In as much as the light output from the PAPI unit is colour coded, it is possible to install a number of light units and thereby produce a display, as shown in Figure 2, by which the pilot can know the aircraft's [actually the pilot's eye] position. The standard installation is of 4 light units each with a unique vertical angle as shown in Figure 3.

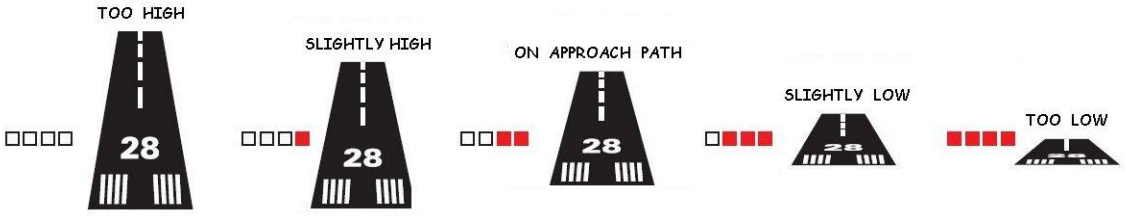

Figure 2. PAPI system display

(2) It is to be noted that when the display indicates "on approach'' path this is not specific to the glide slope (e.g. 3 degrees) but rather the "approach corridor" which is defined by the angles C and B, as shown in Figure 3. When a display of "on approach" is observed, the pilot eye can be anywhere within the approach corridor which for normal installation has a width of 20 minutes of arc.

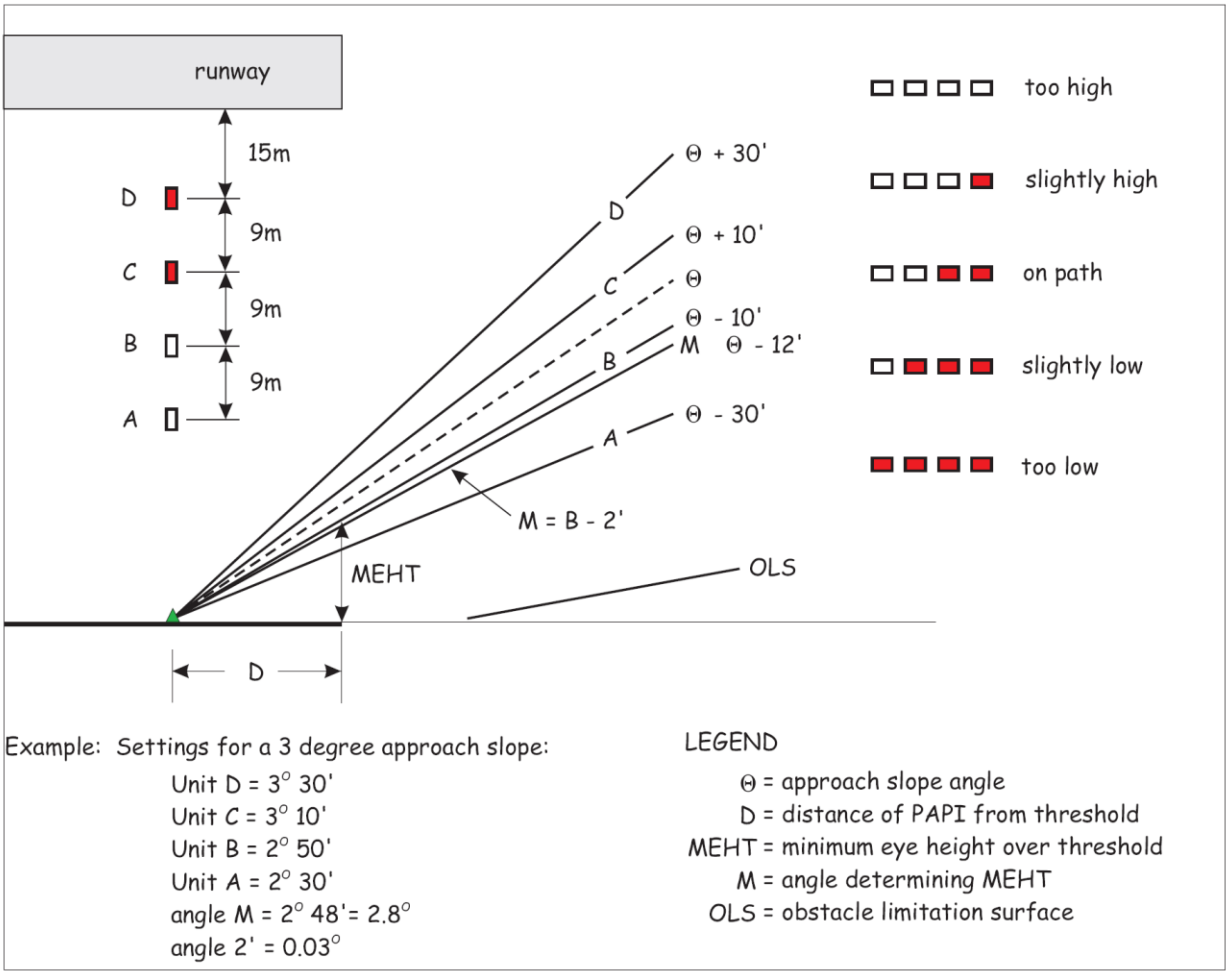

Figure 3: PAPI Profile

(3) The MEHT is composed of two values: the EWH [the eye to wheel height] plus the WTH [wheel to threshold height]. It is to be noted that both of these values are for the aircraft in the approach configuration and are not the dimensions as may be measured for a parked aircraft resting on the ground. The MEHT assumes that the pilot eye would follow the lower limit of the approach corridor which is defined by angle M = B minus 2 minutes of arc.

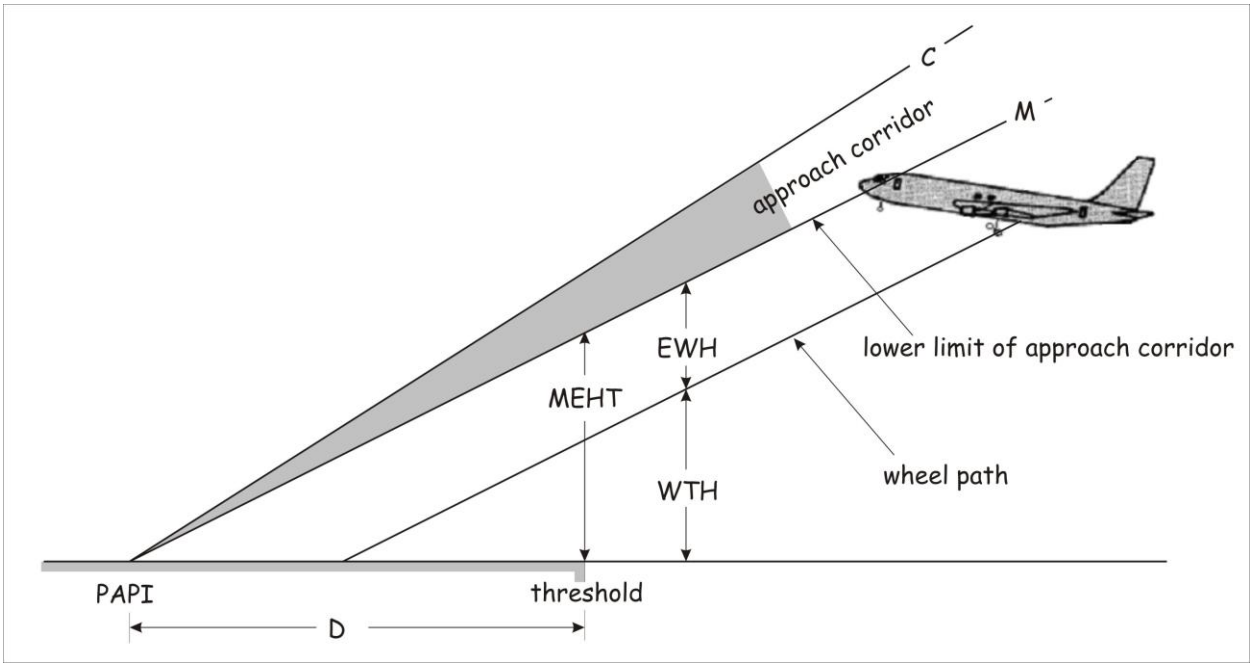

Figure 4: Visual Approach

(4) Values of EWH and WTH (desired and minimum) for categories of aircraft are given in Table 5-5 of TP312 as shown in Table 1 below.

Table 1 (TP312 Table 5-5 of TP312). Wheel clearance over threshold for PAPI and APAPI

EWH of aeroplane in the approach configuration	Category	WTH desired	WTH minimum
up to but not including 3m	AP & P1	6m	3m
3m up to but not including 7.5m	P2	9m	4.5m
7.5m up to but not including 14m	P3	9m	6m

(5) The following Table 2 modifies Table 5-5 of TP312 by addition of a column for MEHT. As mentioned, MEHT is the sum of EWH and WTH. In this table, the minimum WTH is used rather than the desired.

Table 2 (TP312 Table 5-5 modified). Wheel clearance over threshold for PAPI and APAPI

EWH of aeroplane in the approach configuration	Category	WTH minimum	MEHT
up to but not including 3m	AP & P1	3m	6m
3m up to but not including 7.5m	P2	4.5m	12m
7.5m up to but not including 14m	P3	6m	20m

(6) Given the criteria of Table 2 (Table 5-5), the distance D from threshold for each of the PAPI categories can be determined using the formula:

$$D = MEHT / \tan(M)$$

Note:
The discussion in this advisory assumes a zero horizontal and transverse incline of the runway and that the PAPI light centres are within 0.3m of the adjacent runway crown and thus to the threshold crown elevation. If such is not the case for an actual installation, the difference between the PAPI light centres and threshold will need to be taken into account when determining the distance D. For example, if the PAPI light centres are below the threshold elevation, the units will need to be moved further upwind from the threshold in order to provide

the required MEHT.

(7) In the case of P1, P2 and P3 the angle M is B minus 2 minutes of arc. This subtraction of 2 minutes of arc is to allow for the pilot to make a clear discernment of change to full red just below the transition sector.

For a 3 degree PAPI, M = 2° 50' - 2' = 2° 48' = 2.8°

(8) In order to obtain an MEHT of 20m the PAPI would be installed at a distance of:

D = (EWH + WTH)/tan (M) = (14 + 6)/tan 2.8 = 20m/tan 2.8 = 408.9m

(9) In the case of AP the angle M is A minus 2 minutes of arc. Therefore, for a 3 degree AP,

M = 2° 45' - 2' = 2° 43' = 2.72°

(10) Using the above formula (1), the Table 3 of distances "D" is derived.

Table 3: Distance of PAPI from threshold

Category	EWH	WTH	MEHT	D
AP	3m	3	6	126.3
P1	3m	3	6	122.7
P2	7.5m	4.5	12	245.4
P3	14m	6	20	408.9

(11) As a general statement, the objective for "harmonization" of PAPI with ILS is to obtain a condition for which the pilot, when the aircraft is following the ILS signal, will observe an "on path" display [two whites and two reds] for the PAPI. That is, the pilot should obtain the same presentation from both the ILS instrumentation and visually from the PAPI.

(12) However, this is not possible to achieve completely because the pilot eye is above the aircraft antenna which senses the ILS signal and the angle "B" of the lower edge of the PAPI approach corridor is less than the angle of the ILS signal.

(13) The geometry is such that the pilot eye may exit from the approach corridor at some point prior to the threshold when the aircraft is following the ILS. Figure 5 illustrates a case for which the pilot eye exits from the bottom of the approach corridor.

(14) Similarly, for a particular PAPI location and pilot eye to aerial height (EAH), it might occur that the pilot eye exits from the top of the approach corridor, but this situation should be avoided for the installation design, since it would present a "fly-down" instruction to the pilot.

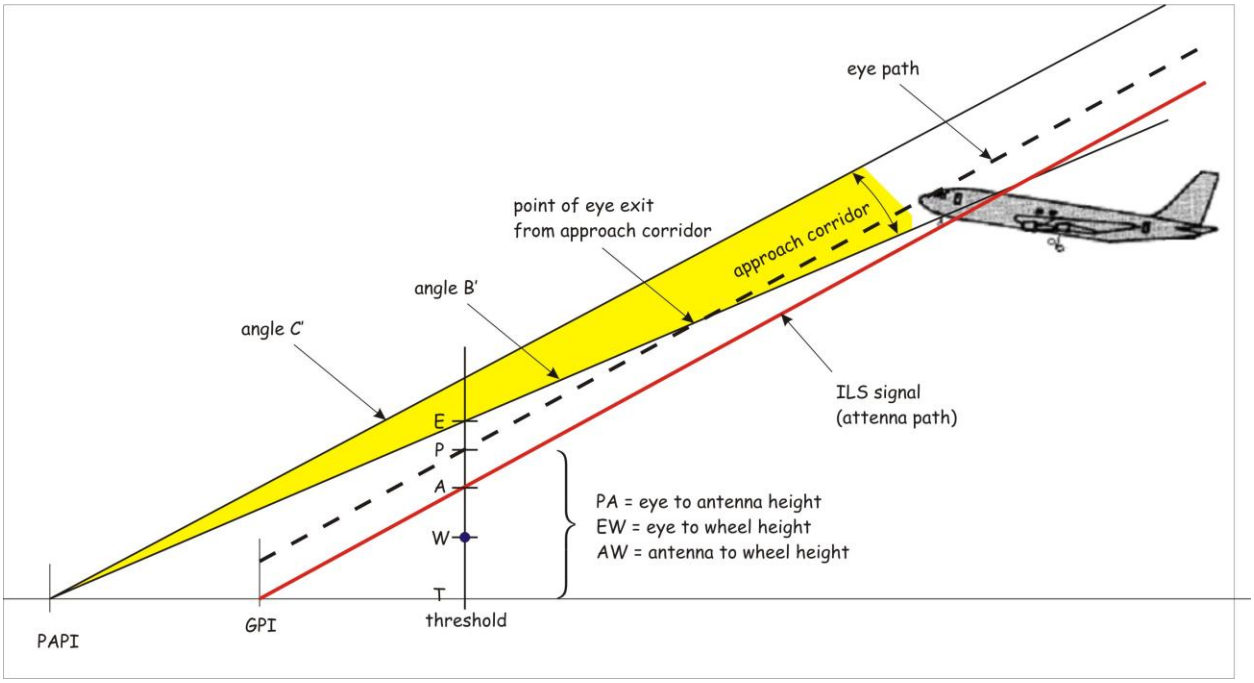

Figure 5: PAPI approach corridor ILS signal

(15) In Figure 5 the TCH is the crossing height of the ILS beam which is normally taken to have a value of 50ft (15.24m), although it may vary from 40ft to 60ft. The designer should consult with NAV CANADA as to the exact value. Although Figure 5 indicates the runway intercept of the ILS beam is at the GPI antenna location, this also is not necessarily the case and thus the designer should not use the physical location of the Glide Path Intercept (GPI) antenna as a basis of calculating the TCH or positioning of the PAPI. The position of the PAPI should always be referenced to the threshold.

(16) Of the various categories of PAPI listed in Table 5-5 of TP312 only the P3 is suitable for harmonization with ILS. Figure 6 (see Appendix A) shows a 20 minute wide approach corridor of a P3 PAPI with respect to an ILS signal for a 3 degree approach slope. The PAPI is located at 408.9m from threshold to provide a 20m MEHT where the light centres of the PAPI are within 0.3m of the runway threshold crown.

(17) The other PAPI categories of P1 and P2, for MEHTs of 6m and 12m respectively, do not provide a suitable harmonization with ILS. The approach corridor of the P1 PAPI is entirely below the ILS signal. The approach corridor of the P2 PAPI incorporates the ILS signal but is still too low such that pilot eye will exit from the top of the approach corridor and thereby the pilot will observe a display [3 white and 1 red] which gives a "fly-down" signal. It is preferable that the pilot when exiting the approach corridor will see a "fly-up" signal, as illustrated in Figure 5.

(18) The Figure 6 shows an installation of P3 PAPI along with number of eye paths in increments of 1m up to 7m. For the 20 minute of arc opening of the approach corridor, the initial eye exit ocurs at 1359.8m prior to threshold for EAH of 0m. An aircraft of 1m EAH (which includes the B737) will have a pilot eye exit from the bottom of the approach corridor at about 1074m from threshold. For aircraft with large EAH such as the B747 [at 6.4m] the pilot eye will remain within the approach corridor past the threshold.

(19) The point of pilot eye exit can be improved, that is, brought closer to threshold, by widening the approach corridor of the P3 PAPI to 30 minutes of arc. This, however, changes the B angle to 2 degrees 45 minutes and thus M to 2 degrees 43 minutes = 2.72 degrees. The PAPI would then need to be displaced further from the threshold in order to maintain the MEHT of 20m. Figure 7 (see Appendix A) shows an installation of P3 PAPI with 30-minute wide approach corridor. The PAPI is located at 421.0m to maintain the 20m MEHT. The eye exit for an EAH of 0m is at 971m

and for an EAH of 1m it is 767m prior to threshold.

5.0 SUMMARY

Airport operators are responsible for installation of PAPI in accordance with the requirements of TP312. The provision of category P3 PAPI enables harmonization with ILS. The harmonization can be enhanced by opening the on course sector [approach corridor] to 30 minutes of arc from the nominal of 20 minutes of arc. Such opening results in moving the point of eye exit from the approach corridor to a closer distance prior to threshold. However, the PAPI is to be located further upwind of the nominal location so that the MEHT is maintained.

6.0 CONTACT OFFICE

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Suggestions for amendment to this document are invited, and should be submitted via the Transport Canada Civil Aviation Issues Reporting System (CAIRS) at the following Internet address:

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or by e-mail at: CAIRS_NCR@tc.gc.ca

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APPENDIX A

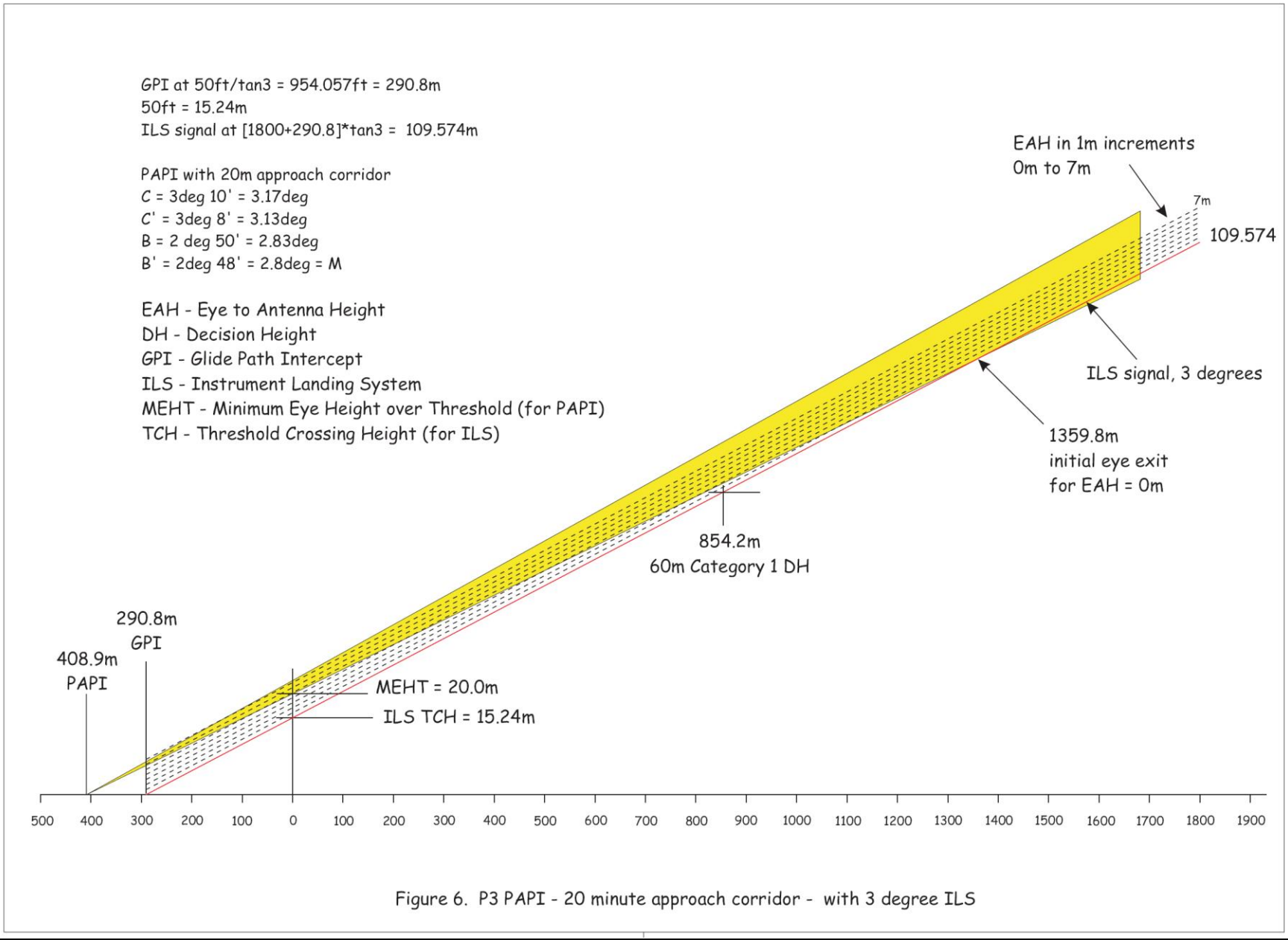

Figure 6. P3 PAPI - 20 minute approach corridor - with 3 degree ILS

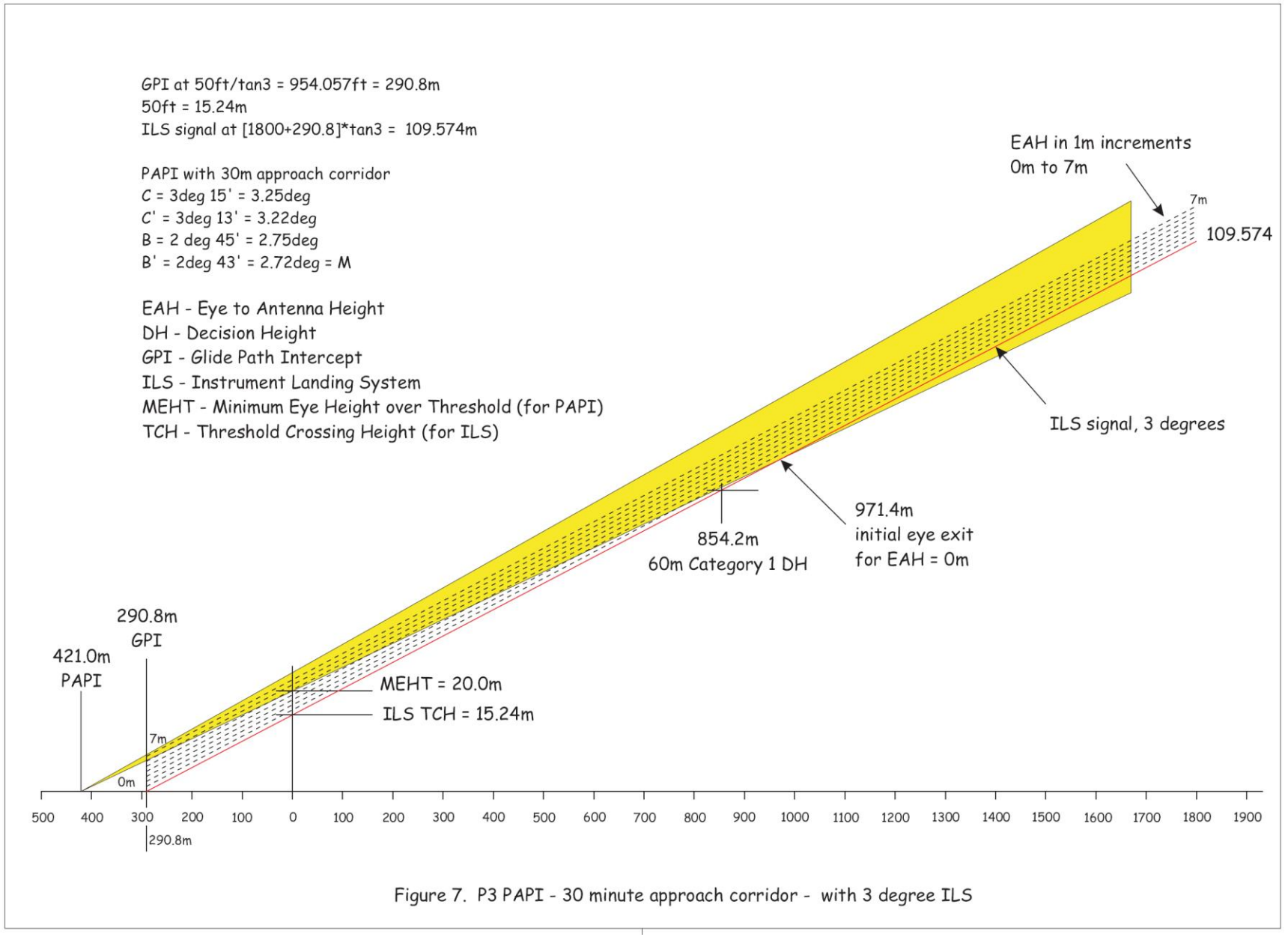

Figure 7. P3 PAPI - 30 minute approach corridor - with 3 degree ILS