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Presentation to IES ALC 2011 … Wilmington North Carolina

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The purpose of this presentation is to provide an update of Transport Canada activity in regard to aviation lighting.

The main areas of activity have been with respect to …

--- Revision of TP312 – *Aerodromes Standards and Recommended Practices* (development of 5th edition)

--- Standard 621 – *Obstacle Marking and Lighting Standards*
---- *This standard is equivalent to the combination of AC 70/7460-1 and AC 150/5345-43*

--- Advisory Circulars

--- ICAO Work – Aerodrome Design Manual, *Part 4, Visual Aids*

Revision of TP312

There has been substantial work to produce the 5th edition TP312. The TP312 is Transport Canada equivalent to Annex 14. Important areas of the draft are ….

--- Focus on "Aircraft Groups" for runway/taxiway physical characteristics.

--- Inclusion of all the FAA approach lighting systems.

--- Inclusion of colour diagrams (CIE Chromaticity Diagrams).

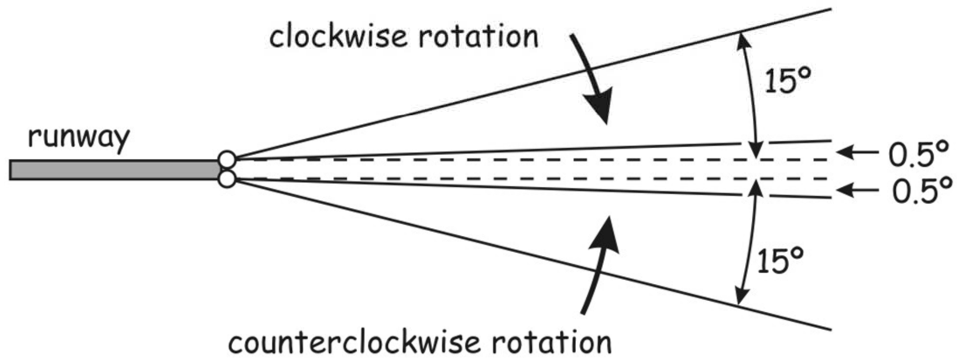
--- More detailed figures for signage (application of legend characters)

--- Adoption of FAA low and medium intensity lighting. The threshold/end lighting for medium intensity, however, is defined by an isocandela diagram for which the main beam average intensity is 600cd for both red and green. This exceeds L-861SE

--- Inclusion of new systems such as VAGS [Visual Azimuth Guidance System]; STDZ [Simplified Touch Zone] lighting; LAHSO [Land and Hold Short Operations] lighting; and Distance Remaining Signs

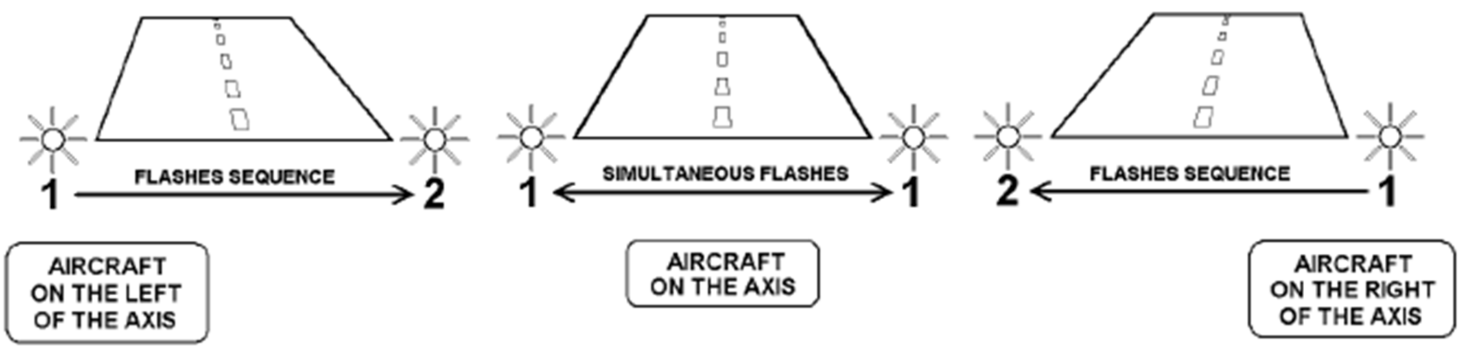
It is hoped to get the new TP312 out by 2013

Revision of TP312



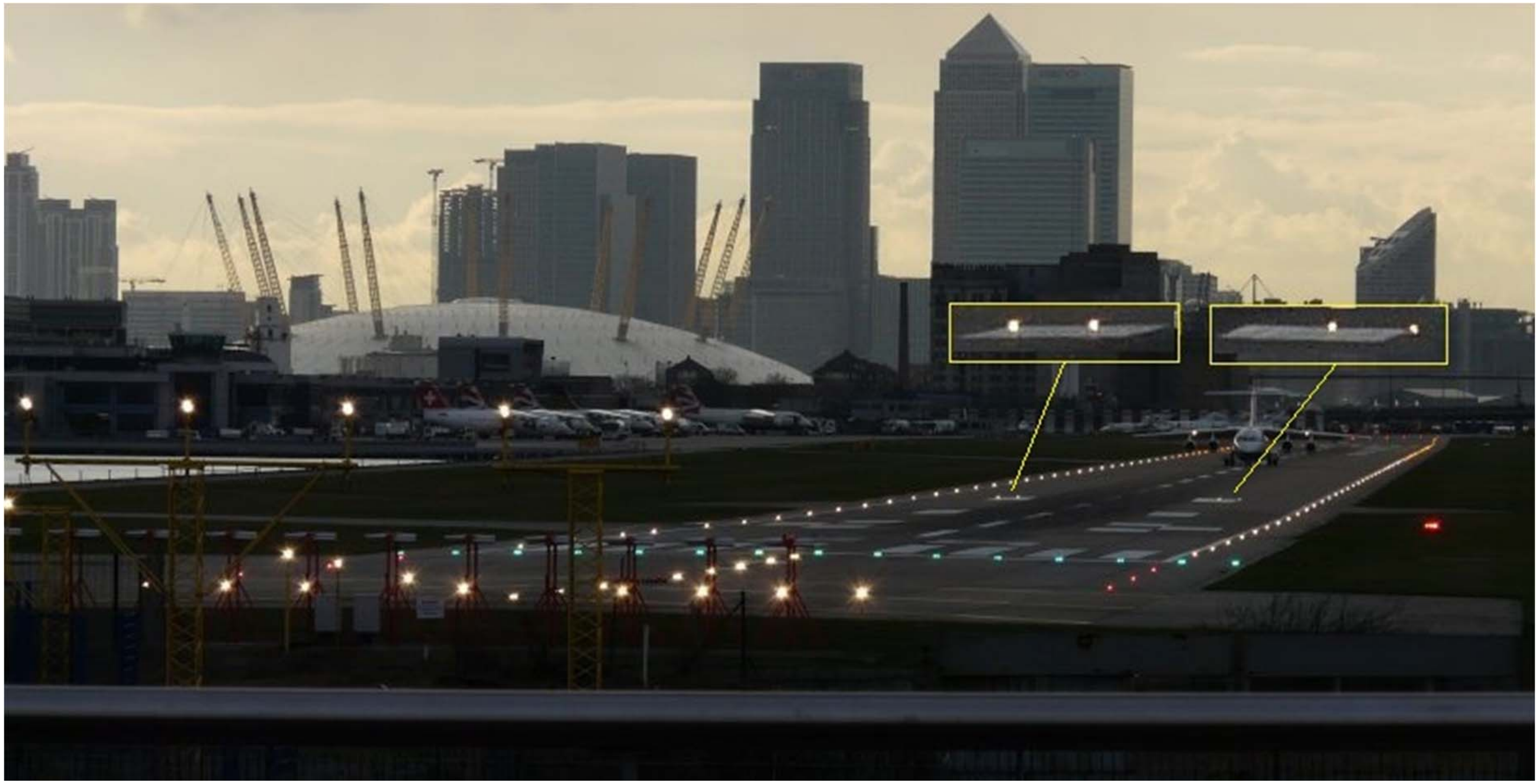
VAGS – Visual Azimuth Guidance System

Similar to flashing REILs except the particular rotation of the mirrors within the light units enables a display of a directional instruction.



Revision of TP312

---- STDZ (Simple Touchdown Zone Lighting)



Simple Touchdown Zone Lighting at London City Centre Airport

Revision of TP312

---- Aiming Angles for ALSF-2 and MALSR

It is desired to use the ICAO aiming angles for the ALSF-2 approach lighting systems rather than continue with FAA.

Annex 14, Figure A2-1

distance from threshold	vertical main beam coverage	Aiming angle
threshold to 315 m	0° — 11°	5.5
316 m to 475 m	0.5° — 11.5°	6.0
476 m to 640 m	1.5° — 12.5°	7.0
641 m and beyond	2.5° — 13.5°	8.0

Angle of elevation settings for ALSF-2 lighting systems						
	Vertical setting angle (degrees)				Vertical setting angle (degrees)	
Station	Steady burning white	Red Side Row Barrettes	Flashing lamps	Station	Steady burning white	Flashing lamps
0	5.5	5.5				
30	5.5	5.5		390	6.0	6.0
60	5.5	5.5		420	6.0	6.0
90	5.5	5.5		450	6.0	6.0
120	5.5	6.0		480	7.0	6.0
150	5.5	6.0		510	7.0	6.0
180	5.5	6.0		540	7.0	6.0
210	5.5	6.0		570	7.0	6.0
240	5.5	6.5		600	7.0	6.0
270	5.5	6.5		630	7.0	6.0
300	5.5		6.0	660	8.0	6.0
330	6.0		6.0	690	8.0	6.0
360	6.0		6.0	720	8.0	6.0

But how were the FAA angles in Order JO 6850.2B derived?? Knowing the derivation will facilitate transition to ICAO angles and the need for re-aiming.

Revision of TP312

---- Aiming Angles for ALSF-2 and MALSR

FAA Order 6850.2, Visual Guidance Lighting Systems

TABLE 2-1. Elevation-Setting Angles for Q20A/PAR56 Approach Lighting Lamps (ALSF-2)

Station	Setting Angle (Degrees)	Station	Setting Angle (Degrees)
3000	8.0	1400	7.0
2900	7.9	1300	6.9
2800	7.9	1200	6.9
2700	7.8	1100	6.8
2600	7.7	1000	6.7
2500	7.7	900	6.7
2400	7.6	800	6.6
2300	7.6	700	6.5
2200	7.5	600	6.5
2100	7.4	500	6.4
2000	7.4	400	6.3
1900	7.3	300	6.3
1800	7.2	200	6.2
1700	7.2	100	6.2
1600	7.1	0	6.1
1500	7.0		

Revision of TP312

---- Aiming Angles for ALSF-2 and MALSR

FAA Order 6850.2, Visual Guidance Lighting Systems

TABLE 2-2. Elevation-Setting Angles for 150PAR38/SP Approach Light Lamps (MALS)

Station	Setting Angle (Degrees)
0	3.1
200	3.2
400	3.3
600	3.4
800	3.4
1000	3.5
1200	3.6
1400	3.7

Revision of TP312

---- Aiming Angles for ALSF-2 and MALSR

The derivation of aiming angles in JO 6850.2 is described in Report FAA-RD-78-137 by Charles A. Douglas, dated 4 December 1978. This report explains a number of methods for deriving aiming angles, but makes recommendation that the VS [Visual Segment] method be used for MALSR and a VS Modified for ALSF-2.

The basic principle of the VS-method is have the light beam cover the ICAO flightpath envelope at all distances equal to or greater than the **"designated distance"**.

Note: Use of the equations gives only some of the angles that appear in the report for MALSR. Other angle could not be obtained. Time was not available to resolve this problem so as to obtain all the angles. It is apparent that Douglas applied selected beam spreads as indicated in Note 3 to his Table 1. Just how these beam spreads were applied is not yet understood.

Revision of TP312

--- Aiming Angles for ALSF-2 and MALSR

--- ICAO Flightpath envelopes representing 99% probability of aircraft location when following ILS.

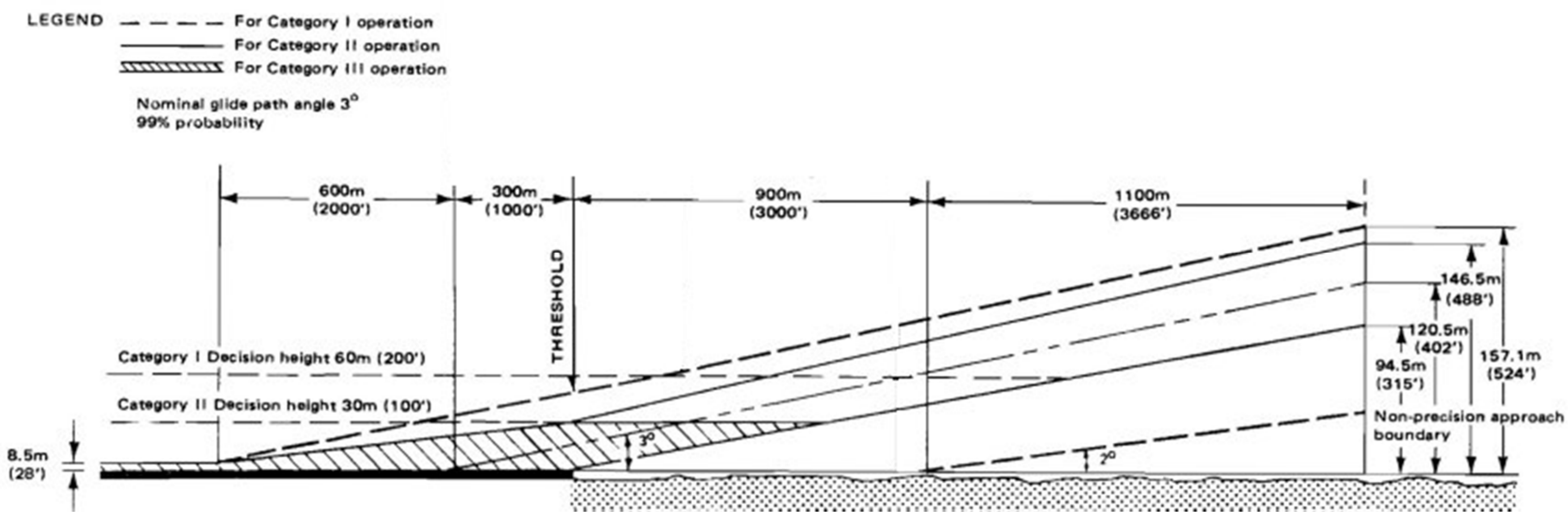


Figure 5-9 Annex 14, 7th edition 1976 (old series)

NOTE: The above figure is that referenced in the report. It appears in Annex 14, dated 2009 as Figure A-5

Revision of TP312

---- Aiming Angles for ALSF-2 and MALSR

---- Designated distance.

The first step determining the aiming angles is to obtain the values for **designated distance** Do.

This value Do is used in the equations for determining aiming angles and also in the re-aiming of the lights when above or below the horizontal datum.

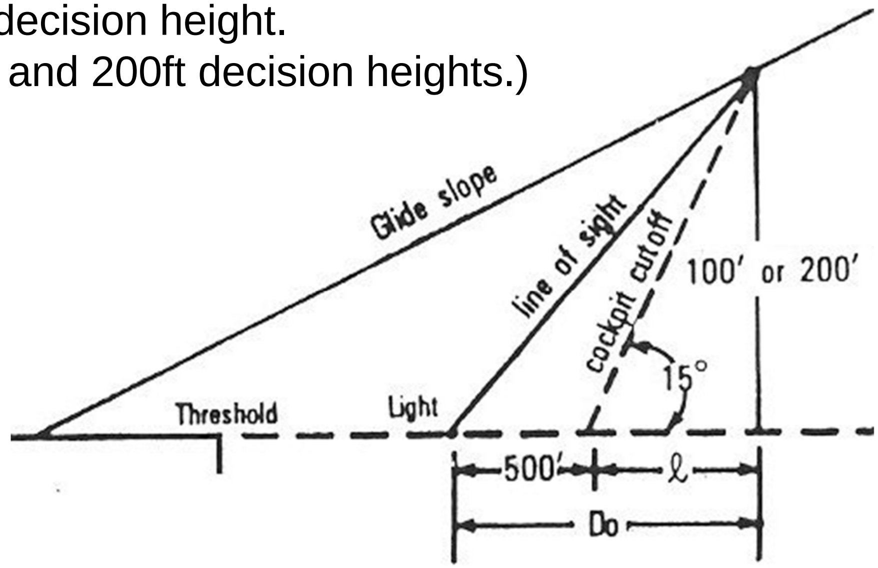
Revision of TP312

---- Aiming Angles for ALSF-2 and MALSR

---- Designated distance

Computing **designated distance** Do for VS-Method when approach light system **extends to cockpit cutoff** at decision height.

(This applies to 100ft and 200ft decision heights.)



Do = 500 + H/tan 15

With H = 200 and 100ft

Do = **1246ft** for Cat I operations, and

Do = 873ft for Cat II operations

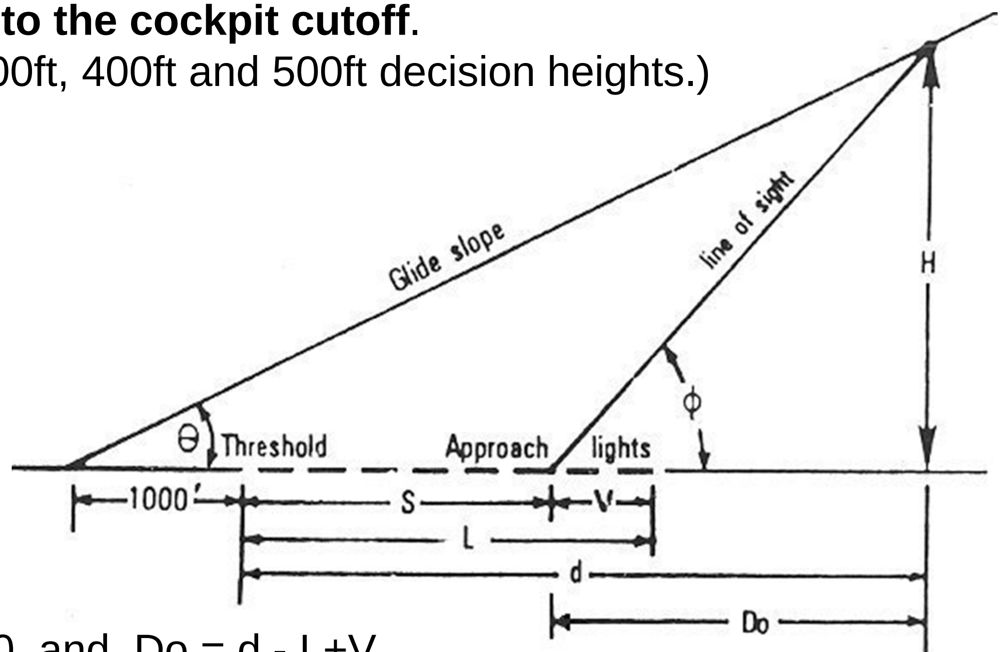
Revision of TP312

---- Aiming Angles for ALSF-2 and MALSR

---- Designated distance

Computing the **designated distance** for the VS method when the approach light system **does not extend to the cockpit cutoff**.

(This applies to 300ft, 400ft and 500ft decision heights.)



$d = H/\tan\theta - 1000$ and $Do = d - L + V$

combining terms and inserting the values of θ (3deg), V (500ft) and L (2400ft)

$Do = (H/\tan 3) - 2900$

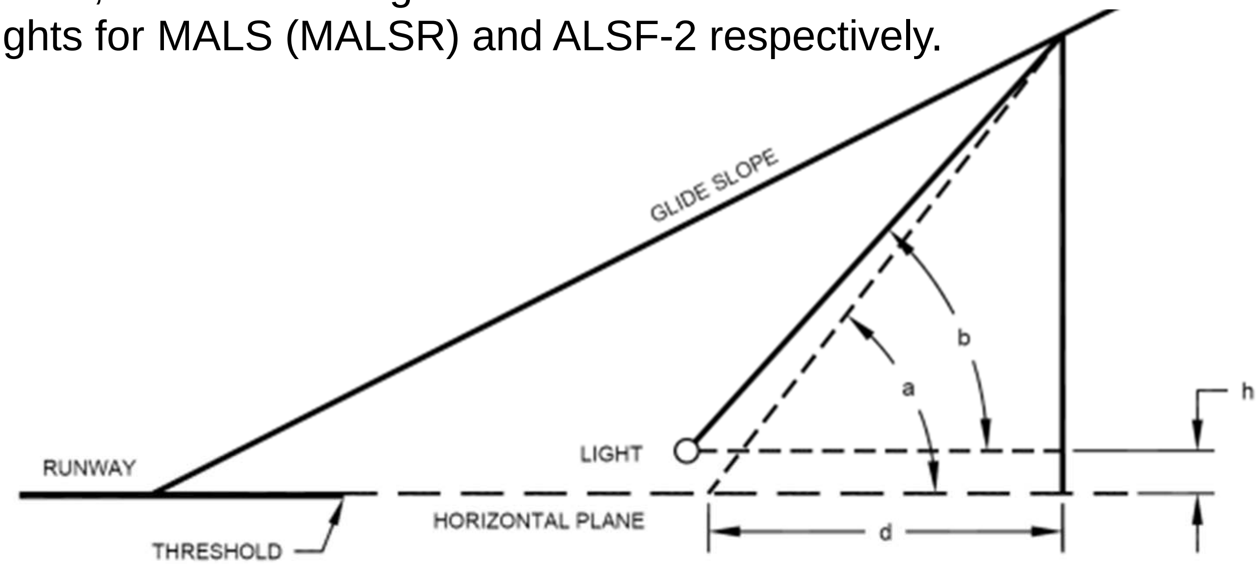
The values of Do for decision heights of 300, 400, and 500ft are 2824, **4732**, and 6640ft, respectively.

Revision of TP312

---- Aiming Angles for ALSF-2 and MALSR

---- Designated distance

Knowing the designated distance Do allows re-aiming of lights when above or below the horizontal datum, as shown in Figure 2-10 of JO 6850.2B. The Do is for 400ft and 200ft decision heights for MALS (MALSR) and ALSF-2 respectively.



LIGHT ABOVE THE HORIZONTAL PLANE b = a - Arctan (h/d)
LIGHT BELOW THE HORIZONTAL PLANE b = a + Arctan (h/d)

LEGEND
- a: THE ELEVATION SETTING ANGLE FOR THE PARTICULAR STATION TAKEN FROM FROM TABLE 2-1 FOR ALSF-2 AND TABLE 2-2 FOR MALS.
- b: CORRECTED ELEVATION SETTING ANGLE.
- d: DESIGNATED DISTANCE: BEING 4732 FEET FOR MALS AND 1246 FOR ALSF-2.
- h: HEIGHT OF THE LIGHT ABOVE THE HORIZONTAL PLANE PASSING THROUGH THE THRESHOLD.

NOTE: FOR ALSF-2 THE ANGLE b SHALL BE ALWAYS 6° OR MORE AND 9° OR LESS.

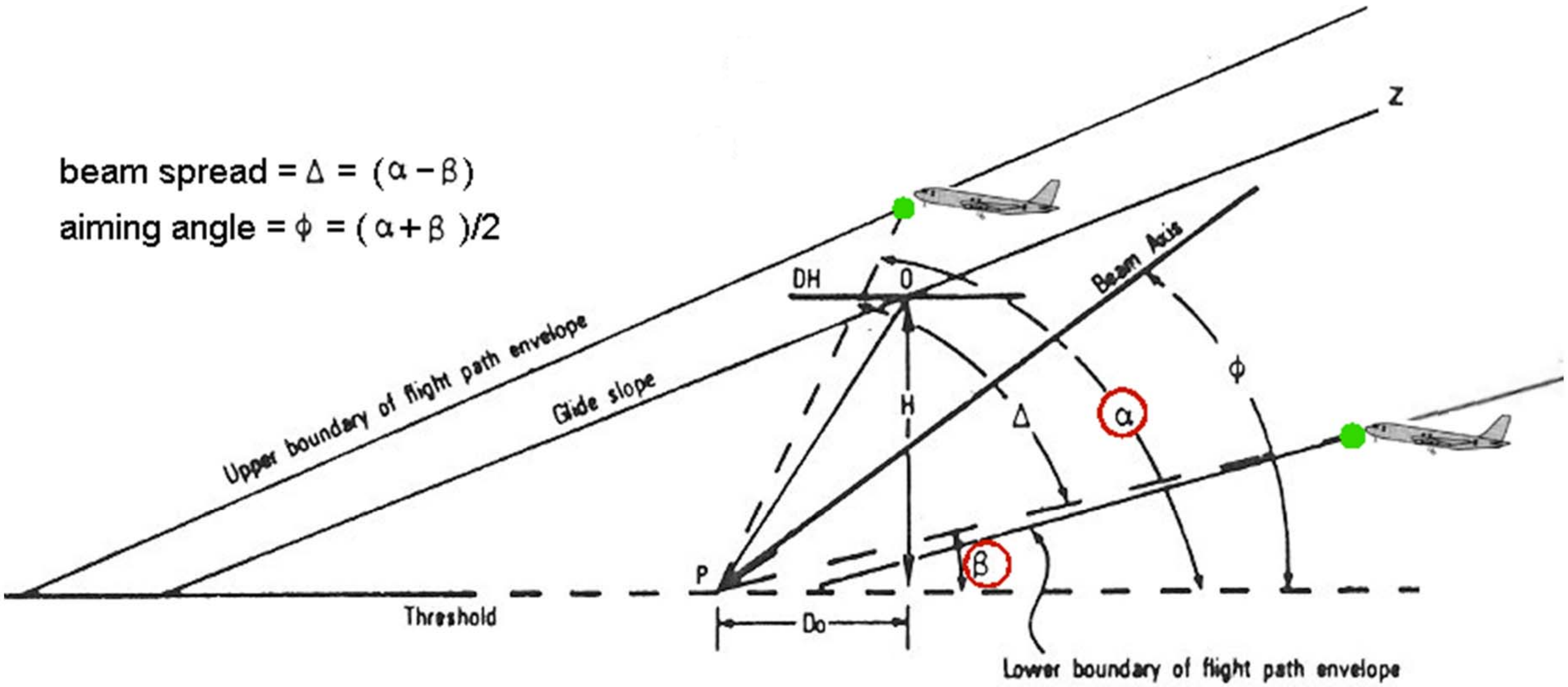
4732 ft MALS
1246 ft ALSF-2

FIGURE 2-10. CORRECTION OF ELEVATION-SETTING ANGLE FOR APPROACH LIGHTS DISPLACED FROM THE HORIZONTAL PLANE PASSING THROUGH THE THRESHOLD

Report FAA-RD-78-137

--- Computation of Upper and Lower Limits of the Beam

The aiming angles for MALSR are obtained by means of calculating the angles of view of the aircraft when on the upper and lower boundaries of the Category 1 flightpath envelope with use of the designated distance Do of 4732ft.



Report FAA-RD-78-137

The obtained aiming angles are given in Table I of the report and shown in the next slide. *The table shown here is reduced by removal of angles for other methods such as FAA, Engineering Requirement and ICAO which are not pertinent to this presentation.*

NOTE: A difficulty which has not yet been resolved is that although use of the equations provides values that are close to those given in Table I, in some instances the exact same values are not obtained. According to note 3, the elevation angles are based upon lights having the vertical beam spreads listed in Table II [shown below]. Just how this was done is not sufficiently described within the report. For that reason this presentation does not detail the actual calculation. Perhaps something for a future paper

Table II. Minimum vertical beam spreads for lights set in accordance with methods listed in Table 1

Method of Computation of Elevation Setting Angles	Beam Spread Required to Cover ICAO Flight Path Envelope
VS-200	10
-300	8
-400	5
-500	4
VS-modified	12

Report FAA-RD-78-137

--- summary of aiming angles – Table I

Method of Computation / Station of Light →	Threshold	400	800	1400	1600	2000	2400	2800	3000
VS-200 (3) For 200-foot Decision Height	5.2	5.3	5.5	5.7	5.8	6.0	6.2	6.5	
VS-300 (3) For 300-foot Decision Height	3.7	3.9	4.2	4.4	4.7	5.0	5.3	5.5	
VS-400 (3) For 400-foot Decision Height	3.1	3.3	3.4	3.7	3.8	4.0	4.2	4.4	
VS-500 (3) For 500-foot Decision Height	2.9	3.0	3.1	3.3	3.4	3.5	3.7	3.9	
For 100- and 200-foot Decision Heights VS-100 + VS-200 from above	5.2 (5)	5.9 (5)	6.6 (5)	5.7 (6)	5.8 (6)	6.0 (6)	6.2 (6)	6.5 (6)	
VS modified for Q20A/PAR56 lamp	6.1	6.3	6.6	7.0	7.1	7.4	7.6	7.9	8.0

NOTES: (3) Elevation angles given are based upon lights having the vertical beam spreads listed in Table II.
(5) From VS-100 computations
(6) From VS-200 listed under "For 200-foot Decision Height"

For MALSR, the VS-400 angles are recommended in the report.

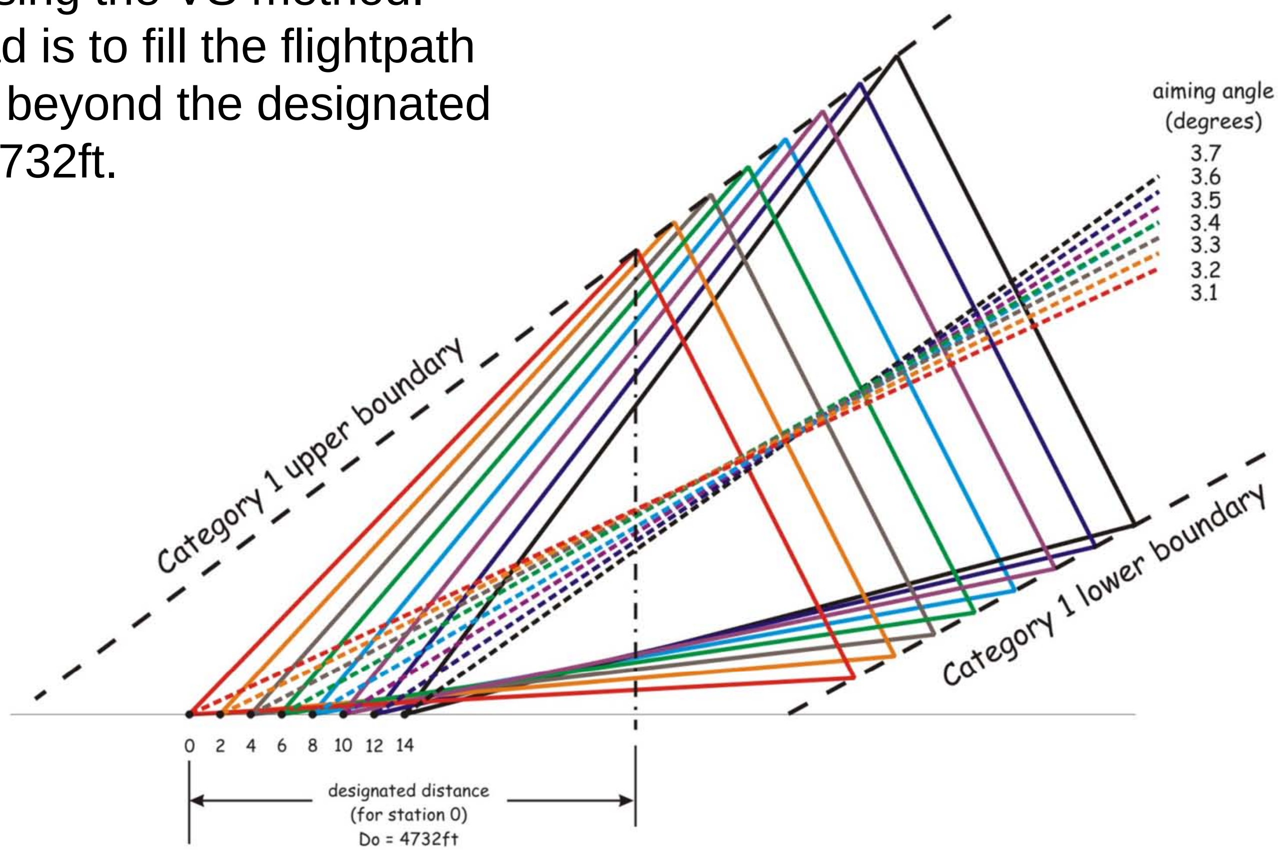
For ALSF-2, two stations are given aiming angles. At 800ft the angle of 6.6deg is that calculated for VS-100. The aiming at 3000ft is based on a beam spread of 12deg and a lower boundary at 2deg. Thus the aiming is 6.0 + 2.0 = 8.0deg. The aiming angles of the remaining stations are selected to provide a linear transition based upon these two angles.

Report FAA-RD-78-137

--- aiming angles – Table I

--- MALSR

Aiming angles using the VS method. The beam spread is to fill the flightpath envelope at and beyond the designated distance Do of 4732ft.

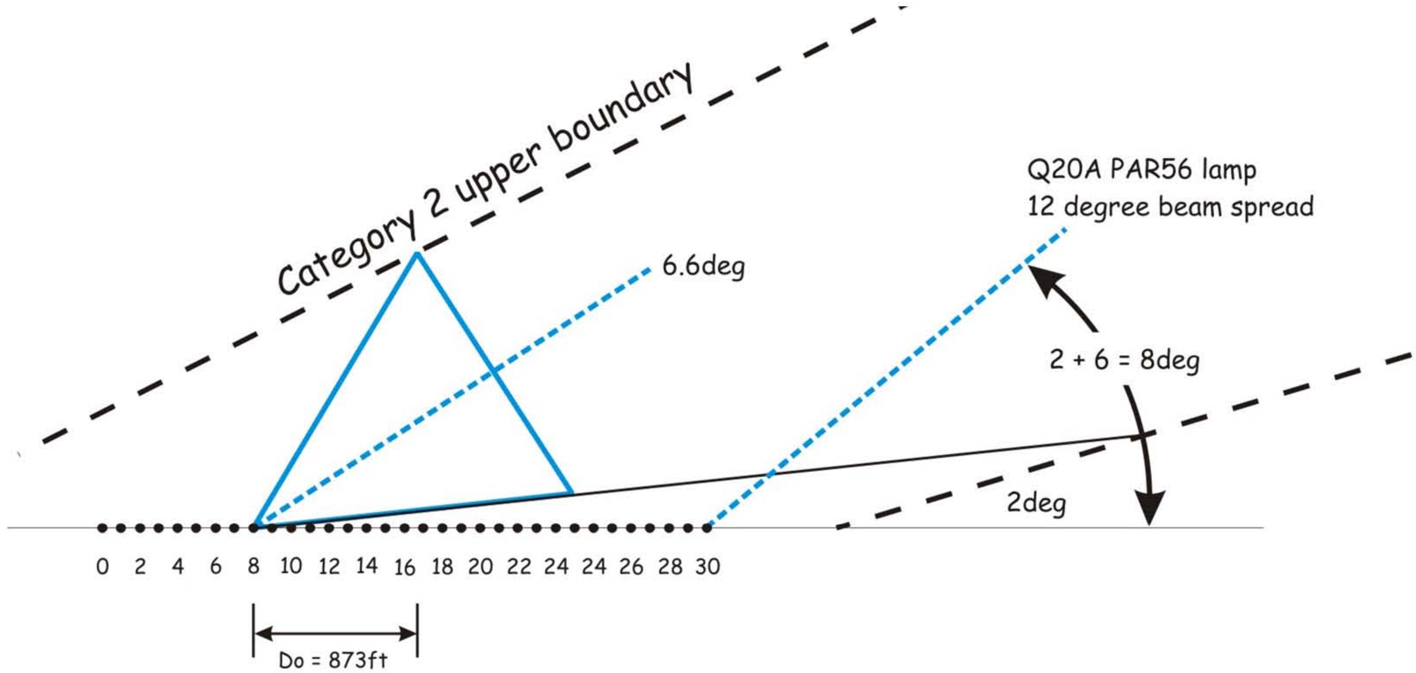


Report FAA-RD-78-137

--- aiming angles – Table I

--- ALSF-2

Two points are selected. For 800ft the VS-100 method is used for an angle 6.6 degrees. For 3000ft half the beam spread is added to the lower boundary angle to give 2 + 6 = 8 degrees. The remaining angles are interpolated.



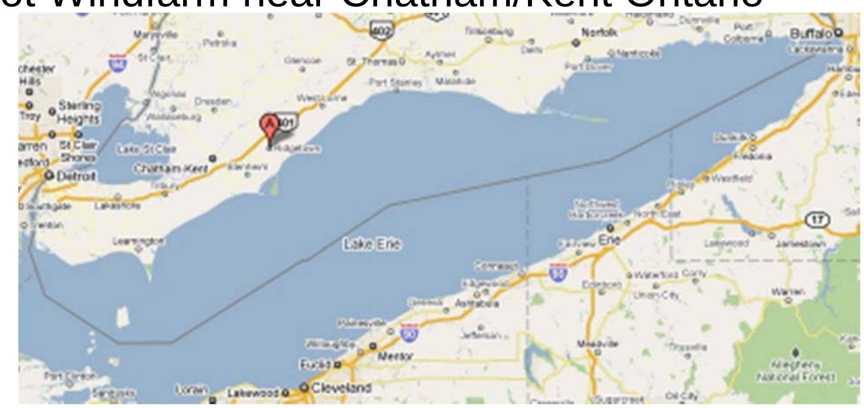
Standard 621 – *Obstacle Marking and Lighting Standards*
--- ADS - Aircraft Detection System

The Standard 621 which was previously referred to as CAR 621.19 is at the point of publication. There are a number of new standards areas such as that of **ADS [Aircraft Detection System]**. This system is referred by the FAA as the AVWS [Audio Visual Warning System].

--- The **ADS** enables lighting to be turned on only when required. That is, when an aircraft is detected.

--- The system consists of a radar which tracks aircraft and will turn on the lights for a predicted 30 seconds from the "impact boundary". A voice message is also broadcast such as for a catenary … "Wires" … "Wires" … "Wires".

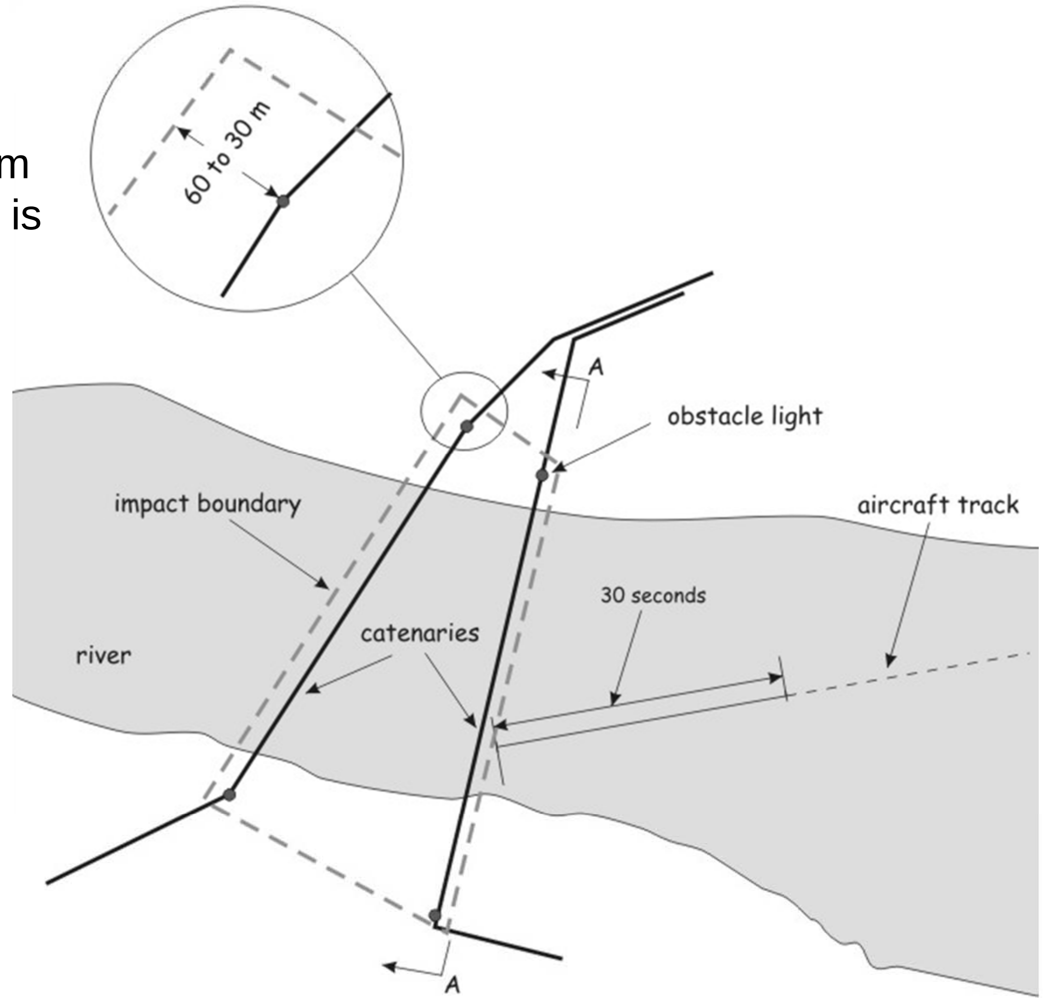
--- The **ADS** can be used for a number of applications. In particular for windfarms whose aviation lighting has been cause for public complaint. The first such installation in North America is for the Talbot Windfarm near Chatham/Kent Ontario on the north shore of Lake Erie.



Standard 621 – *Obstacle Marking and Lighting Standards*

--- ADS - Aircraft Detection System

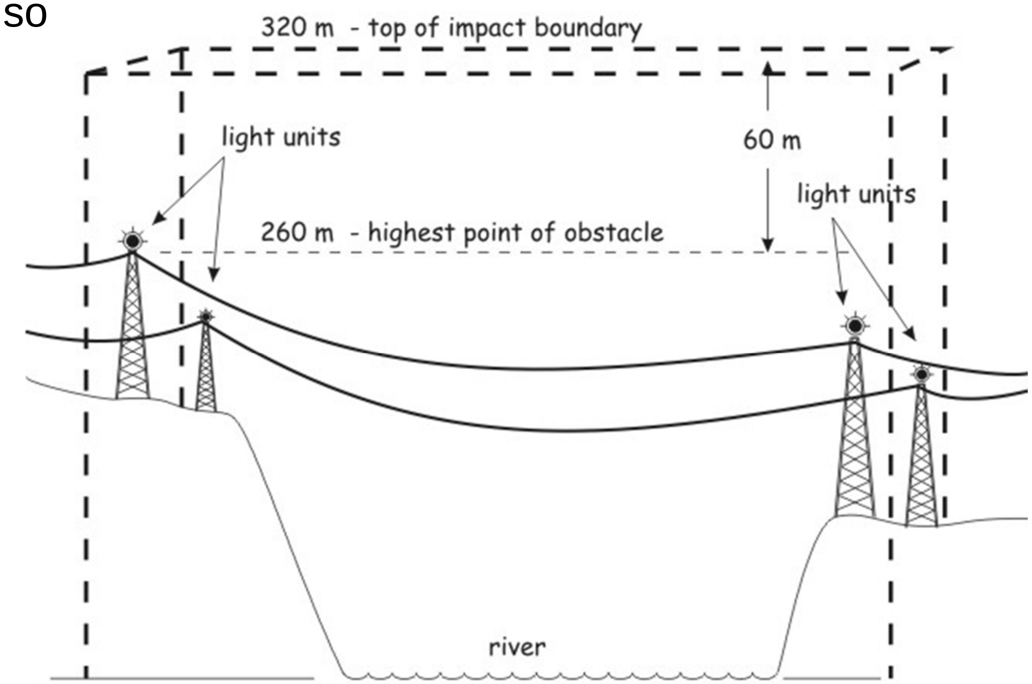
The ADS turns the lights on when the aircraft is at a predicted 30 seconds from the impact boundary. A voice message is also broadcast on fm frequencies.



Standard 621 – *Obstacle Marking and Lighting Standards*

--- ADS - Aircraft Detection System

The impact boundary is 3 dimensional so as to account for aircraft coming from above.



Advisory Circulars

A number of advisory circulars [ACs] have been produced. The objective is to provide technical information that supplements standards. The advisories, however, are not of themselves standards. This differs from the manner in which advisory circulars are used by FAA.

So far there are ACs on

Design ….

- Runway Guard Lights,
- PAPI Harmonization with ILS, and
- Marking of Meteorological Towers

Maintenance

- Of runway and taxiway lighting
- Mobile Photometric Measurement Unit

Advisory Circulars

The AC can be found at …..

http://www.tc.gc.ca/eng/civilaviation/standards/aerodromeairnav-standards-visual-ac-3822.htm

Advisory Circulars
--- AC 302-009 PAPI Harmonization with ILS

PAPI is installed at a location upwind of threshold so that the required MEHT is met.

The MEHT can be obtained from ICAO Table 5-2 …

MEHT = Eye-to-wheel height for the aircraft height group + minimum clearance

Table 5-2. Wheel clearance over threshold for PAPI and APAPI

Eye-to-wheel height of aeroplane in the approach configuration	Desired wheel clearance (metres)	Minimum wheel clearance (metres)	MEHT (metres)
up to but not including 3m	6	3	6
3m up to but not including 5m	9	4	9
5m up to but not including 8m	9	5	13
8m up to but not including 14m	9	6	20

This is similar to the Transport Canada criteria for which PAPI are categorized as P1, P2 and P3 [refer next slide].

Advisory Circulars
--- AC 302-009 PAPI Harmonization with ILS

Transport Canada table of wheel clearances versus aircraft groups

Table 5-5. Wheel clearance over threshold for PAPI and APAPI

Eye-to-wheel height of aeroplane in the approach configuration	Category	Desired wheel clearance (metres)	Minimum wheel clearance (metres)
(1)	(2)	(3)	(4)
up to but not including 3 m	AP & P1	6	3
3 m up to but not including 7.5 m	P2	9	4.5
7.5 m up to but not including 14 m	P3	9	6

MEHTs (using minimum wheel clearance)

3 + 3 = 6m

7.5 + 4.5 = 12m

14 + 6 = 20m

Advisory Circulars
--- AC 303-009 PAPI Harmonization with ILS

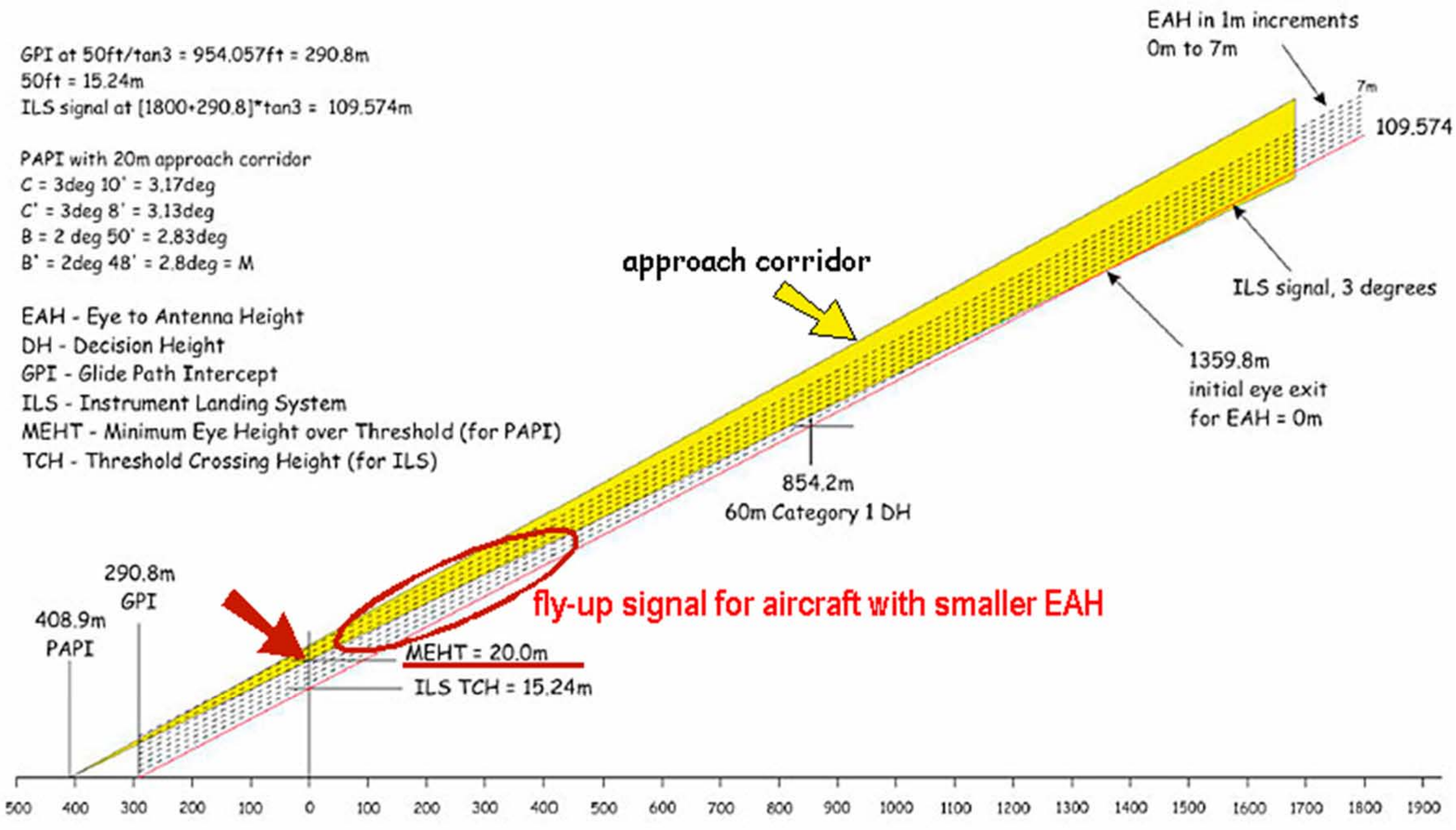
The AC provides a case for PAPI harmonization with ILS.

However, the AC does not describe a PAPI design [i.e. location from threshold] which is developed from basic principles for harmonization with ILS. At this time there are no internationally defined basic principles for harmonization.

The AC describes the P3 installation for which the MEHT is 20m. With the PAPI installed for this MEHT, pilots of aircraft with smaller EAH [eye-to-antenna height] observe a fly-up signal prior to threshold crossing. This then becomes the Transport Canada criteria for harmonization.

Advisory Circulars

--- AC 302-009 PAPI Harmonization with ILS



P3 PAPI - 20 minute approach corridor - with 3 degree ILS

Advisory Circulars
--- AC 302-009 PAPI Harmonization with ILS

Only the last aircraft height group [*eye-to-wheel range from 8m to 14m*] [*TC category P3*] can have harmonization with ILS because of the constraint for MEHT. The PAPI is located 408.9m [1341.5ft] from threshold or 118.1m [387.5ft] upwind of the GPI.

It should also be noted that if the approach corridor is opened to 30 minutes of arc, the PAPI has to be moved further upwind from the threshold to maintain the same MEHT.

Yet this is <u>not</u> the way in which harmonization or even simple PAPI installation is dealt with internationally.

ICAO Annex 14 simply states …

> *Harmonization of the PAPI signal and ILS glide path and/or MLS minimum glide path to a point closer to the threshold may be achieved by increasing the on-course sector from 20' to 30'.*

But that is not necessarily the case. You cannot achieve harmonization by opening the on-course sector for PAPI intended for aircraft of a lesser height group.

Also the present ADM, Part 4, leads one to use an MEHT which is less than that in Table 5-2.

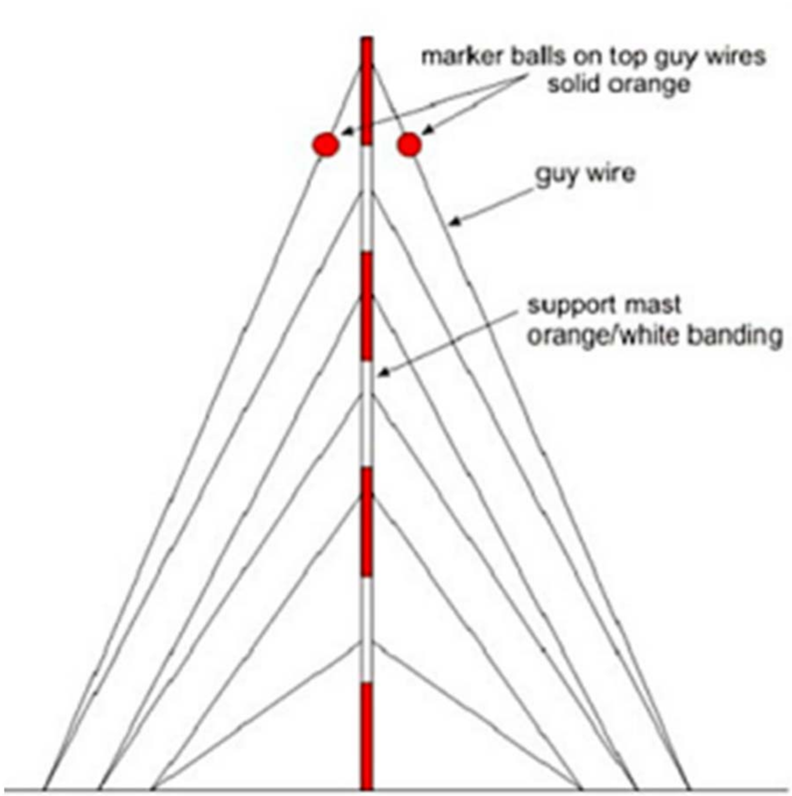
It is apparent that further work is needed within ICAO and specifically for the ADM4 to define harmonization and provide a better example of how this may be achieved.

Advisory Circulars

--- AC 600-001 Marking of Meteorological Towers

After an incident in Manitoba in which a crop sprayer struck a meteorological tower [MET tower], an advisory circular was prepared to recommend the marking of these towers.

In Canada, objects become obstacles when their height exceeds 90m [300ft]. Thus MET towers [of less than 60m] which are used to assess wind resource for a later windfarm installation have not been addressed in standards. Since it is not practical to lower the criteria for obstacles, the AC points out that it is both reasonable and prudent to apply marking as shown.



ICAO Work – Aerodrome Design Manual, *Part 4, Visual Aids*

Although work is being done for other ICAO manuals, the largest portion is with respect to the Aerodrome Design Manual, Part 4 and specifically for PAPI. With respect to PAPI there are 3 work items……

(1) Revision to eliminate the Appendix 6 and have the aircraft dimensions H and H1 put on the manufacturers' websites.
(2) Provide a new description/example for PAPI installation
(3) Provide a definition for Harmonization with ILS.

ICAO Work – Aerodrome Design Manual, *Part 4, Visual Aids*

--- removal of Appendix 6 Tables

Appendix 6 in the ADM4 contains dimensional values for various aircraft. The values which would be referenced by the PAPI designer are H and H1. The designer requires at least the H1 value so as to know into what height group aircraft using the airport will fall. The height group determines the MEHT and thus the location of the PAPI from threshold. The values H3 and H4 in Table A6-1 do not take into account the glidepath angle and therefore are not of use to the designer.

ICAO ADM4 A6-1 lists two glideslopes at 2.5 and 3.0 degrees. Within this range is considered that it is only necessary to list values for 3.0 degree glideslope since the values are essentially the same. If an airport has a significant different glideslope then the aircraft manufacturer should be contacted directly.

Table A6-1. Vertical distances between critical points on aircraft at maximum pitch attitude (approach at V_{REF}) (ILS)

	2.5-degree glide slope						3.0-degree glide slope					
Aircraft model	Pitch att (deg) Flap setting Gross weight (kg)	Eye path to ILS beam (ft) H2	ILS beam to wheel path (ft) H	Eye path to wheel path (ft) H1	ILS antenna above wheels (ft) H3	Pilot's eye above wheels (ft) H4	Pitch attitude (degrees)	Eye path to ILS beam (ft) H2	ILS beam to wheel path (ft) H	Eye path to wheel path (ft) H1	ILS antenna above wheels (ft) H3	Pilot's eye above wheels (ft) H4
A300-B2, B4	5.3 25 130 000	9.1	22.9	32.0	19.6	28.7	4.9	9.1	22.9	32.0	18.9	28.1
A300-600	5.9 40/30 139 000	9.1	23.4	32.5	20.1	29.2	5.4	9.1	23.4	32.6	19.5	28.6

<u>ICAO Work – Aerodrome Design Manual, *Part 4, Visual Aids*</u>

--- removal of Appendix 6 Tables

The Table 5-1 in 6850.2 is another example of listing of aircraft. Having the manufacturers provide the values H and H1 on their websites will make available other aircraft not presently listed.

TABLE 5-1. VISUAL THRESHOLD CROSSING HEIGHTS

Representative Aircraft Type	Approximate Cockpit-To-Wheel Height	Visual Threshold Crossing Height	Remarks
<u>Height group 1</u> General aviation Small commuters Corporate turbojets	10 feet or less	40 feet +5, -20 12 meters +2, -6	Many runways less than 6,000 feet long with reduced widths and/or restricted weight bearing, which would normally prohibit landings by larger aircraft.
<u>Height group 2</u> F-28, CV-340/440/580 B-737, DC-9, DC-8	15 feet	45 feet +5, -20 14 meters +2, -6	Regional airport with limited air carrier service.
<u>Height group 3</u> B-727/707/720/757	20 feet	50 feet +5, -15 15 meters +2, -4	Primary runways not normally used by aircraft with ILS glidepath-to-wheel heights exceeding 20 feet.
<u>Height group 4</u> B-747/767, L-1011, DC-10, A-300	Over 25 feet	75 feet +5, -15 22 meters +2, -4	Most primary runways at major airports.

ICAO Work – Aerodrome Design Manual, *Part 4, Visual Aids*
--- removal of Appendix 6 Tables

The present Appendix 6 in the ADM4 is includes only a few aircraft types … mainly Boeing and Airbus models. It does not include Bombardier, Embraer and many others.

It is considered that rather than ICAO updating the Appendix 6, that it be eliminated and aircraft manufacturers requested to put the values [i.e. H and H1) on their websites. The request would most likely be made through the International Coordinating Council of Aerospace Industries Associations (ICCAIA)

Boeing already reports the values on their site at ….

http://www.boeing.com/commercial/airports/faqs/icaoadmpart4.pdf

A template is being prepared so as to ensure that each manufacturer is using the same method for determination of H and H1 values. This template will likely become the new Appendix 6 to ADM4.

ICAO Work – Aerodrome Design Manual, *Part 4, Visual Aids*

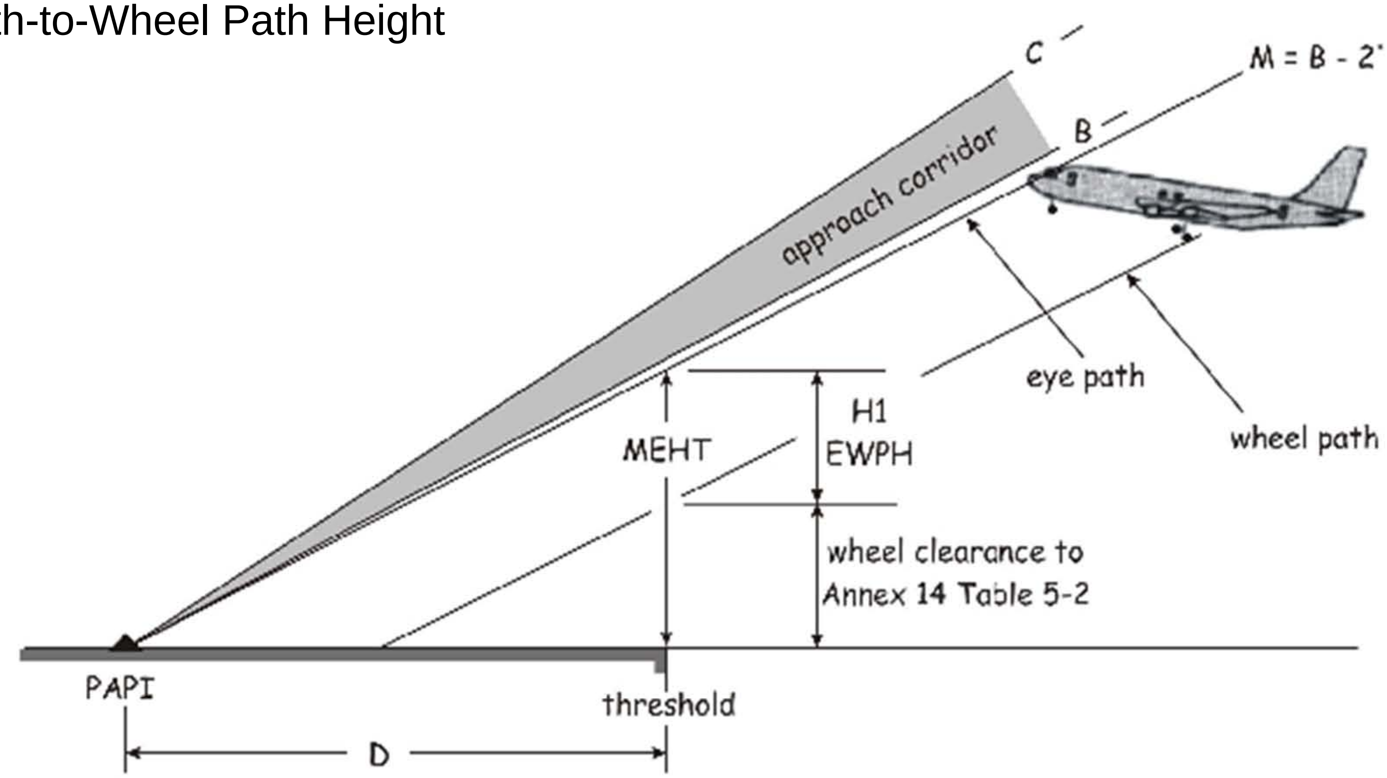
--- removal of Appendix 6 Tables

It is of importance to note that the eye-path-to-wheel-path is not the same as the dimension when the aircraft is parked on the apron. For determination of the eye-to-wheel-height in the landing configuration the pitch angle and glideslope angles have to be taken into account.

ICAO Work – Aerodrome Design Manual, *Part 4, Visual Aids*

--- removal of Appendix 6 Tables

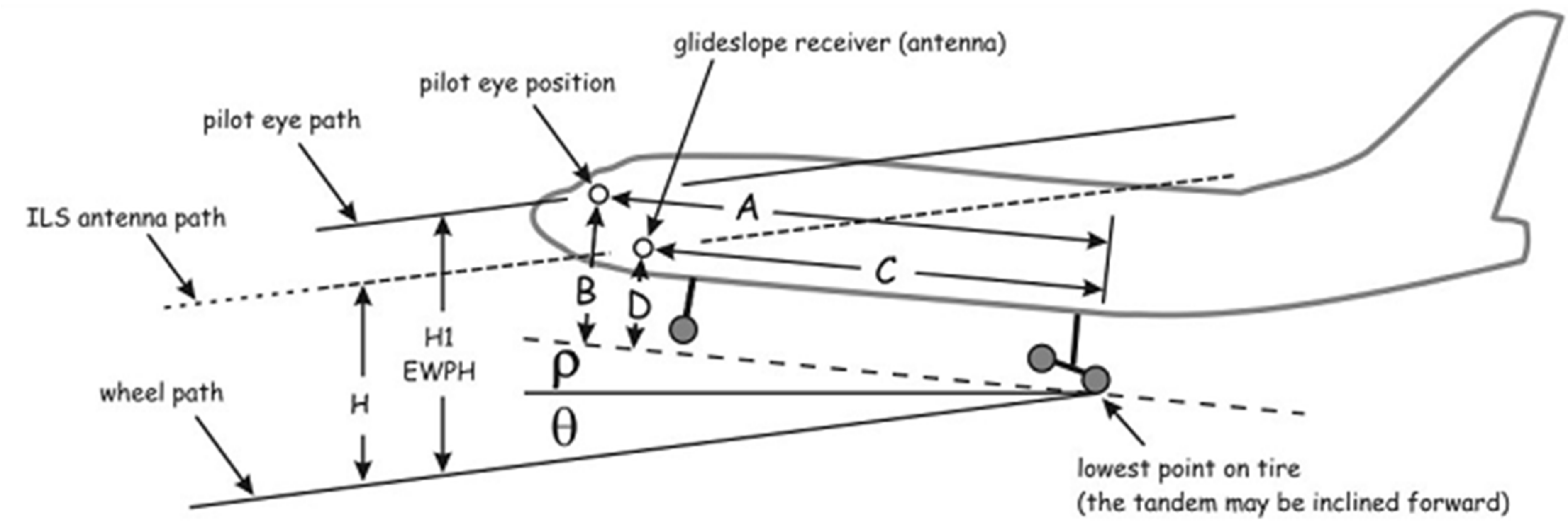
Eye-to-wheel height in the landing configuration is to have the new acronym EWPH for Eye-path-to-Wheel Path Height



ICAO Work – Aerodrome Design Manual, *Part 4, Visual Aids*

--- removal of Appendix 6 Tables

The values H and H1 (or EWPH) are dependent upon the pitch angle ρ of the aircraft in the landing configuration and the glidepath angle θ. The H and H1 are the **highest expected values** for **threshold crossing speed** at the **maximum certificated landing weight** in the landing configuration.



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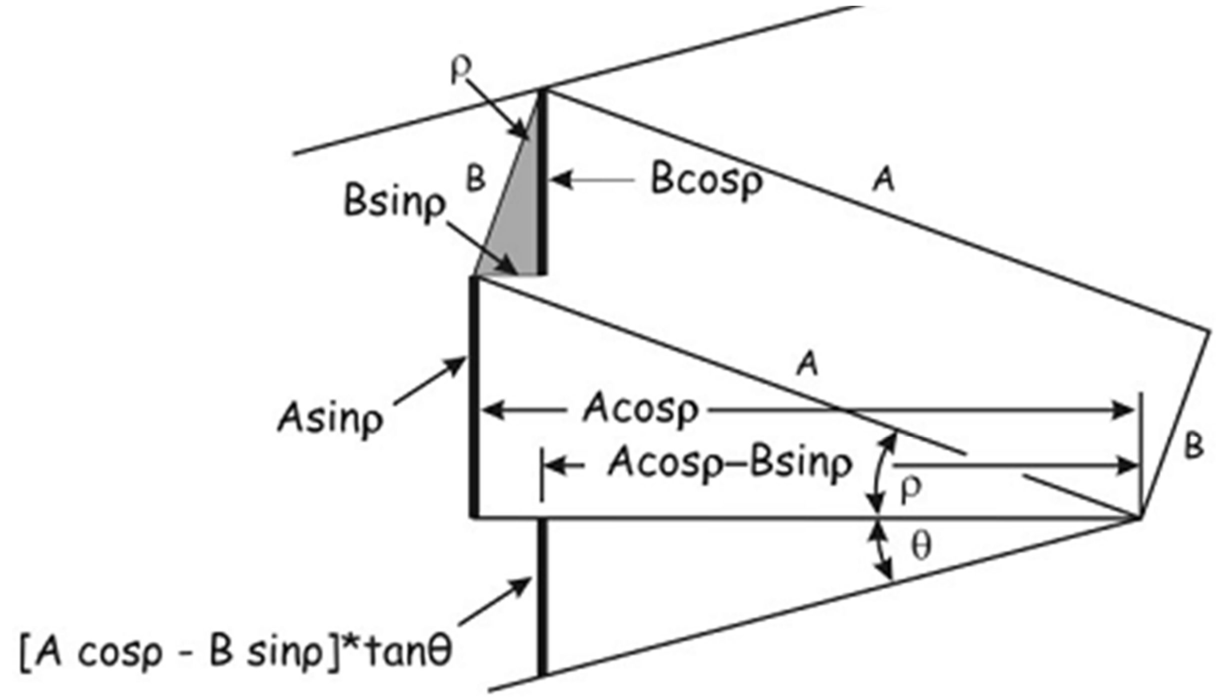
--- removal of Appendix 6 Tables

Equations to calculate the values H and H1



H = Antenna path to wheel path = Csinρ + Dcosρ + (Ccosρ-Dsinρ)*tanθ

H1 = Eye path to wheel path = Asinρ + Bcosρ + [Acosρ-Bsinρ]*tanθ

The End

Questions …