Federal Aviation Administration

Heliport Perimeter Lighting

Research, Findings, Future Prospects

Airport Technology Transfer Conference, Atlantic City 2010

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Vertical Flight

- Advisory Circular (AC) 150/5390-2B provides guidance for illuminating the heliport landing and taxi areas

U.S. Department
of Transportation

Federal Aviation
Administration

Advisory Circular

Subject: HELIPORT DESIGN | Date: 09/30/04 | Initiated by: AAS-100 | AC No: 150/5390-2B | Change:

1. PURPOSE. This advisory circular (AC) provides recommendations for heliport design and describes acceptable requirements to develop a heliport. This AC applies to anyone who is proposing to construct, activate or deactivate a heliport.

2. APPLICABILITY. This AC is not mandatory and does not constitute a regulation except when Federal funds are specifically dedicated for heliport construction.

3. EFFECTIVE DATE. The effective date is September 30, 2004.

4. CANCELLATION. AC 150/5390-2A, *Heliport Design*, dated January 20, 1994, is canceled.

5. EXECUTIVE SUMMARY. The modern helicopter is one of the most versatile transportation vehicles known to man. Typically, a heliport is substantially smaller than an airport providing comparable services. The helicopter has the capability of providing a wide variety of important services to any community that integrates this aircraft

Vertical Flight

- The AC details the requirements in respect to the color, number and spacing of heliport perimeter lights at the Touchdown and Liftoff (TLOF) area and the Final Approach and Takeoff (FATO) area

- The operational specifications for the perimeter lighting fixture are not stated

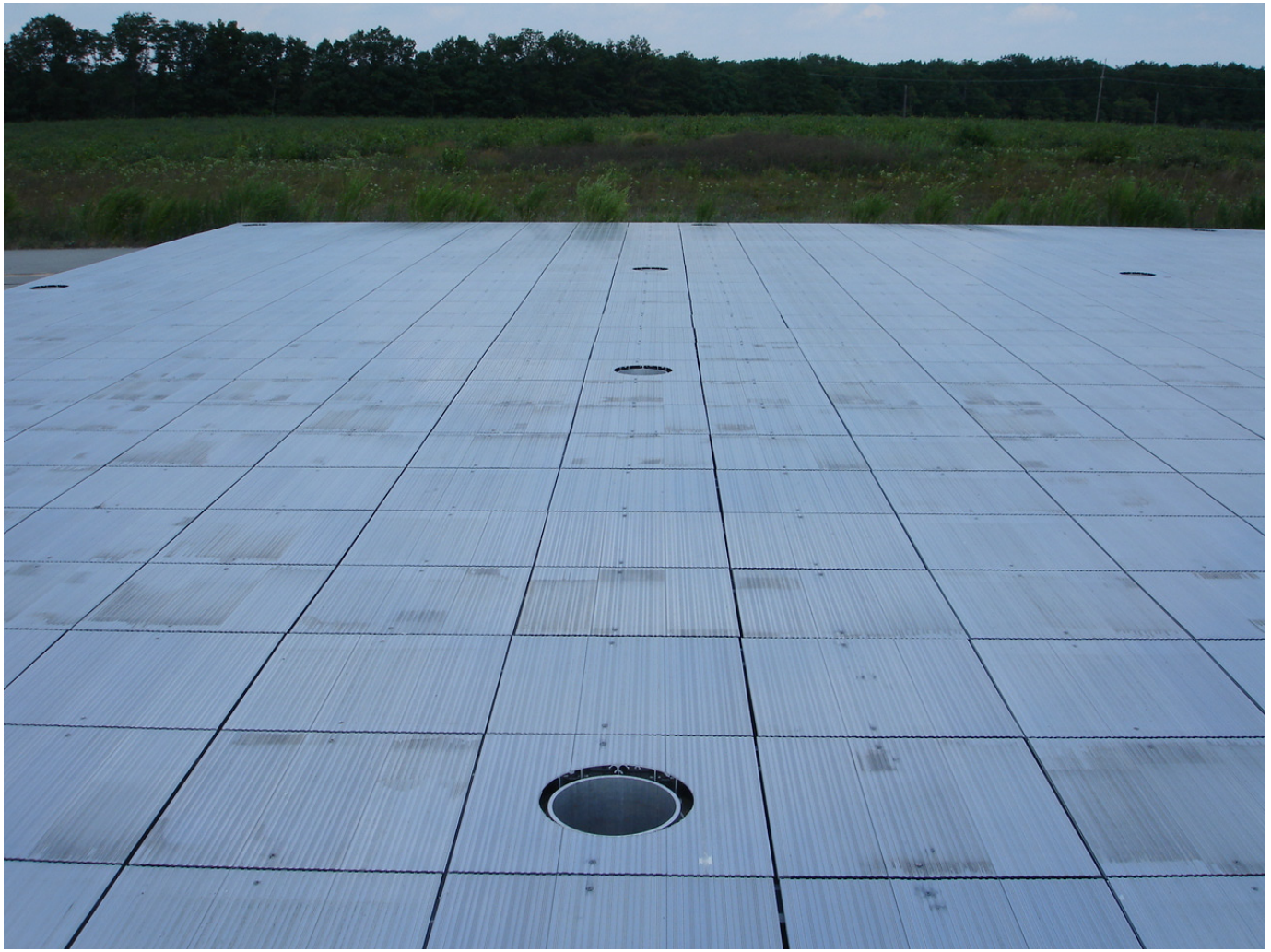
Vertical Flight

- A research effort was initiated by the Federal Aviation Administration (FAA) to define the operational specifications and performance criteria for heliport perimeter lighting

- To support this initiative the FAA Williams J Hughes Technical Center (WJHTC) Heliport was fully refurbished to be representative of heliports around the country

FAA WJHTC Standard Heliport

FAA WJHTC Experimental Heliport



Vertical Flight

A pilot has to execute many difficult tasks when approaching a heliport at night, including:

- acquiring the heliport lighting patterns from the surrounding ambient lighting environment
- determining and controlling the descent rate using information from the immediate environment
- judging and controlling the closure rate of the aircraft to the heliport in the final approach

Vertical Flight

- The heliport perimeter lighting is intended to be the cue that pilots use to acquire the heliport

- To be effective the lighting should enable the pilot to both establish the position of the heliport and identify the outline shape

FAA WJHTC Flight Trials

- The research initiative comprised a number of nighttime flight trials at the FAA WJHTC Heliport in Visual Meteorological Conditions (VMC)

- The trials were used to establish the applicable intensity and coverage of the heliport perimeter lighting fixtures

FAA WJHTC Flight Trials

- During the flight trials certain assumptions were made, namely that:

1. The heliport lighting is the predominant visual feature
2. The fixture is considered to be a point source
3. The visibility is uniform vertically, as well as horizontally
4. The atmosphere is not significantly spectrally selective over the distances involved

FAR Requirements

- The minimum operating visibility and cloud base that was assumed is three miles and 1200 feet to meet Federal Aviation Regulations (FAR) Part 91.155 requirements for basic Visual Flight Rules (VFR) weather minimums

Part 91.155

(b) Class G Airspace. Notwithstanding the provisions of paragraph of this section, the following operations may be conducted in Class G airspace below 1,200 feet above the surface:

(1) Helicopter. A helicopter may be operated clear of clouds if operated at a speed that allows the pilot adequate opportunity to see any air traffic or obstruction in time to avoid a collision

Airspace	***Flight Visibility***
Class G, Night	***3 statute miles***

FAA WJHTC Flight Trials

- The aircraft used was the FAA WJHTC Sikorsky S-76A helicopter operated by two FAA pilots

FAA WJHTC Flight Trials

- Weather for the evening was 5 MPH winds, visibility 9 statute miles and clear with moonlight horizon
- For each run the pilots were instructed to proceed out to 11 statute miles, turn and start an approach to the heliport
- When a steep approach was required, the start point was at a range of five statute miles from the heliport

FAA WJHTC Flight Trials

- The profile flown during each approach was representative of a normal helicopter approach in VMC conditions
- During each run the pilot reported the range at which the perimeter lighting became visible and then when the lighting became usable as a final approach cue
- An onboard data collection system was used to collect data on helicopter speed, heading and the vertical approach path for each run

FAA WJHTC Flight Trials

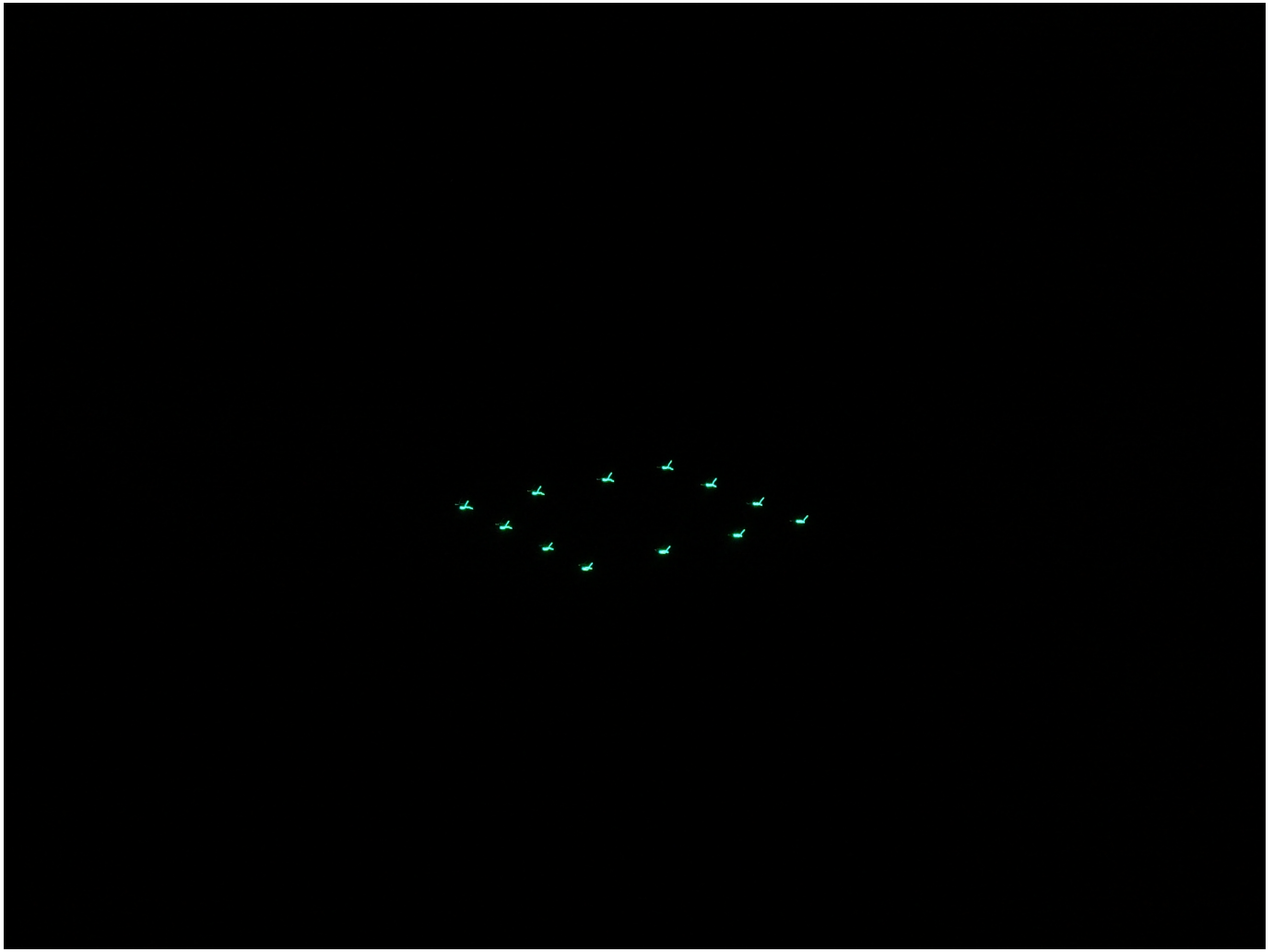
- The onboard data collection system was used to estimate the pitch, roll and yaw attitude of the helicopter

- Comments were elicited from the subject pilots on the color of the perimeter light so as to determine if the perimeter lights appeared green in color

Test Matrix/Subjective Results

Test Run #, Lighting Configuration	Descent Angle	Visible Range (NM)	Usable Range (NM)
1. TLOF only	3 degree	6.0	1.5
2. TLOF only	6 degree	4.8	2.0
3. TLOF only	12 degree	5.0	2.6
4. FATO only	3 degree	7.5	2.0
5. FATO only	6 degree	6.2	2.5
6. FATO only	12 degree	5.0	2.5
7. TLOF and FATO	6 degree	8.0	2.6

TLOF Lighting Configuration Viewed



Specifying Heliport Lighting Chromaticity

- Photometric testing was conducted at the FAA WJHTC Photometric Laboratory on several heliport lighting fixtures
- The chromaticity coordinates of the fixtures were evaluated using a Photo Research PR-655 SpectraScan Spectroradiometer
- Individual fixtures were tested using the LSI photometric system to determine the luminous intensity and beam spread characteristics

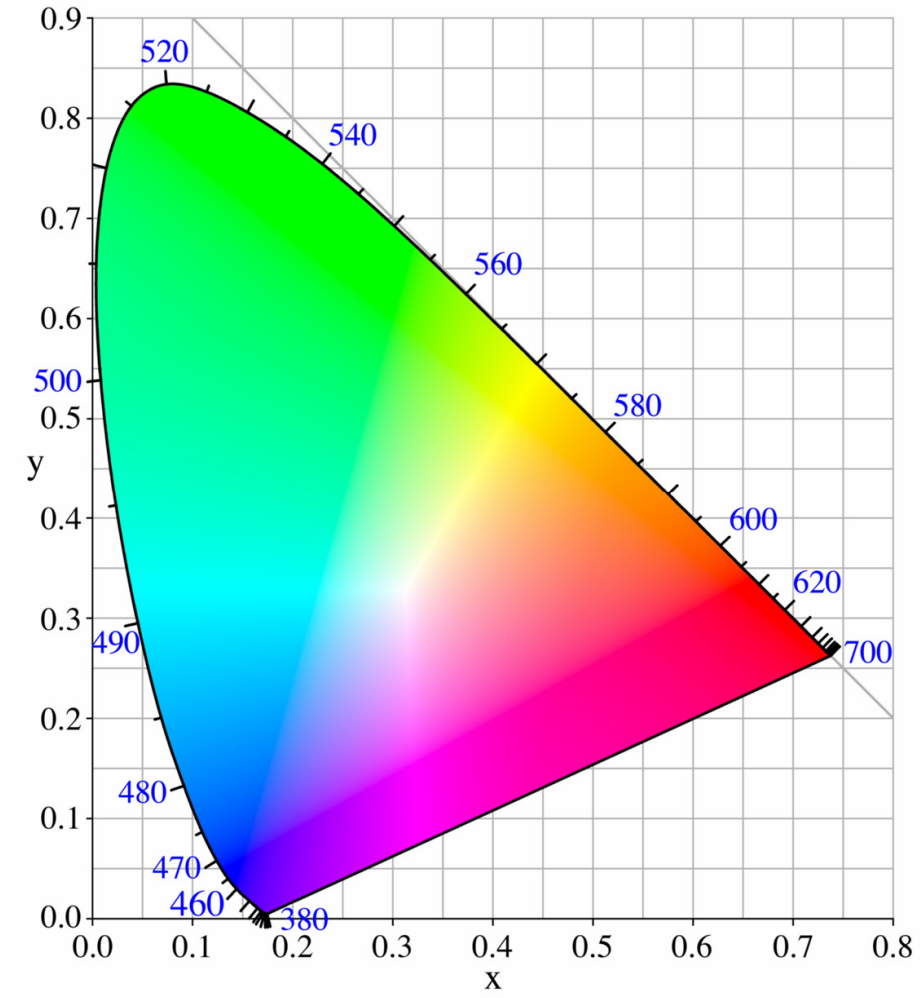
Specifying Heliport Lighting Chromaticity

- The resulting chromaticity results were compared with the International Commission on Illumination (CIE) chromaticity coordinate system to determine where the coordinates fall in relation to the FAA's aviation color boundaries for signal colors

- These coordinates were plotted on the CIE chart

- Ultimately the data collected will be used to define the acceptable chromaticity boundary limits for green heliport perimeter lights

CIE Chart


0.9
0.8
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500
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520
540
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620
700
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480
470
460
380
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0.5
0.6
0.7
0.8
x

Example of Intensity Data – Incandescent Fixture

		Horizontal Angle - Degrees																							
		-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	12	14	16
	10	19	16	16	21	27	38	47	59	72	85	86	92	95	100	96	98	103	106	102	100	102	98	94	90
	9	23	19	17	25	37	50	61	77	95	105	115	118	120	127	125	134	136	141	145	142	146	135	135	131
	8	27	22	22	32	49	64	85	105	128	142	159	163	164	169	171	177	171	174	178	179	175	168	164	161
Vert.	7	33	28	31	45	59	77	99	126	147	166	181	193	188	193	197	197	198	198	200	203	195	180	176	169
Angle	6	39	36	41	52	65	80	112	138	150	175	192	205	208	213	213	209	208	209	208	204	197	181	175	171
Degrees	5	40	43	49	56	64	85	107	127	142	160	171	178	181	190	183	177	175	181	177	165	164	150	141	130
	4	38	43	51	50	54	71	90	101	113	127	135	138	151	152	148	146	145	150	145	134	132	120	108	95
	3	27	33	34	36	35	48	58	62	66	75	80	78	86	89	86	81	85	86	80	67	64	63	54	44
	2	15	17	18	17	17	24	27	24	28	31	31	33	33	34	32	31	32	31	29	29	28	26	24	22
	1	9	9	9	9	11	12	14	15	18	18	21	21	22	22	22	21	21	20	20	20	18	17	16	15

Example of Chromaticity Data – Incandescent Fixture

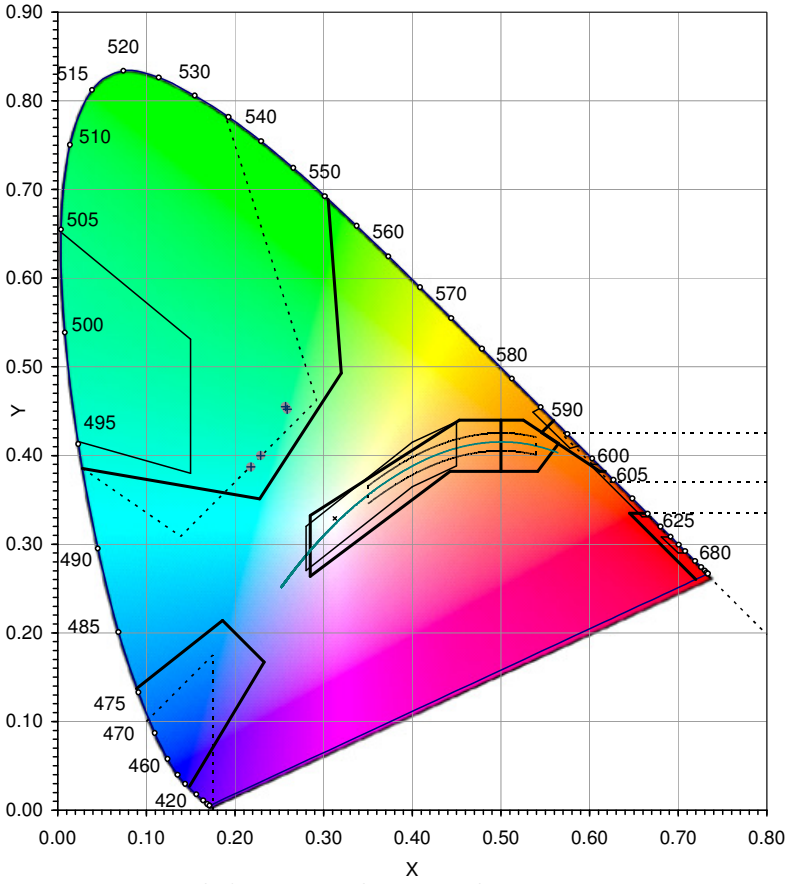


Figure. ICAO Aeronautical Ground Light Colors (thick solid) with MIL-C-25050A Aviation Colors (dotted) and ITE (thin solid) overlay

Example of Intensity Data – LED Fixture

		Horizontal Angle - Degrees																								
		-30	-28	-26	-24	-22	-20	-18	-16	-14	-12	-10	-8	-6	-4	-2	0	2	4	6	8	10	12	14	16
	10	12	13	13	13	14	14	14	14	14	13	14	13	13	13	13	13	13	13	13	13	13	13	13	14
	9	12	12	12	13	13	13	14	14	14	14	14	13	13	13	12	13	13	13	13	13	13	13	13	13
	8	12	13	12	13	13	13	14	13	13	14	13	13	13	13	12	12	12	12	12	12	13	13	13	12
Vert.	7	12	12	13	12	13	13	13	13	13	13	12	12	12	12	12	12	12	12	12	12	12	12	12	11
Angle	6	12	12	12	12	12	12	13	12	12	12	12	12	12	12	12	12	12	11	12	11	11	11	11	11
Degrees	5	11	12	12	12	12	12	12	12	11	11	11	11	11	11	11	11	11	11	11	11	11	10	10	10
	4	11	11	11	11	11	11	11	11	11	10	10	10	11	11	11	10	11	10	11	10	10	10	10	10
	3	10	11	11	11	11	11	11	10	10	9	10	10	10	10	10	10	10	10	10	10	10	9	9	9
	2	9	10	10	10	10	10	10	10	9	9	9	10	10	10	9	9	9	9	10	9	9	9	9	9
	1	9	9	9	10	9	9	9	9	8	9	9	9	9	9	9	8	9	9	9	9	9	8	8	8

Example of Chromaticity Data – LED Fixture

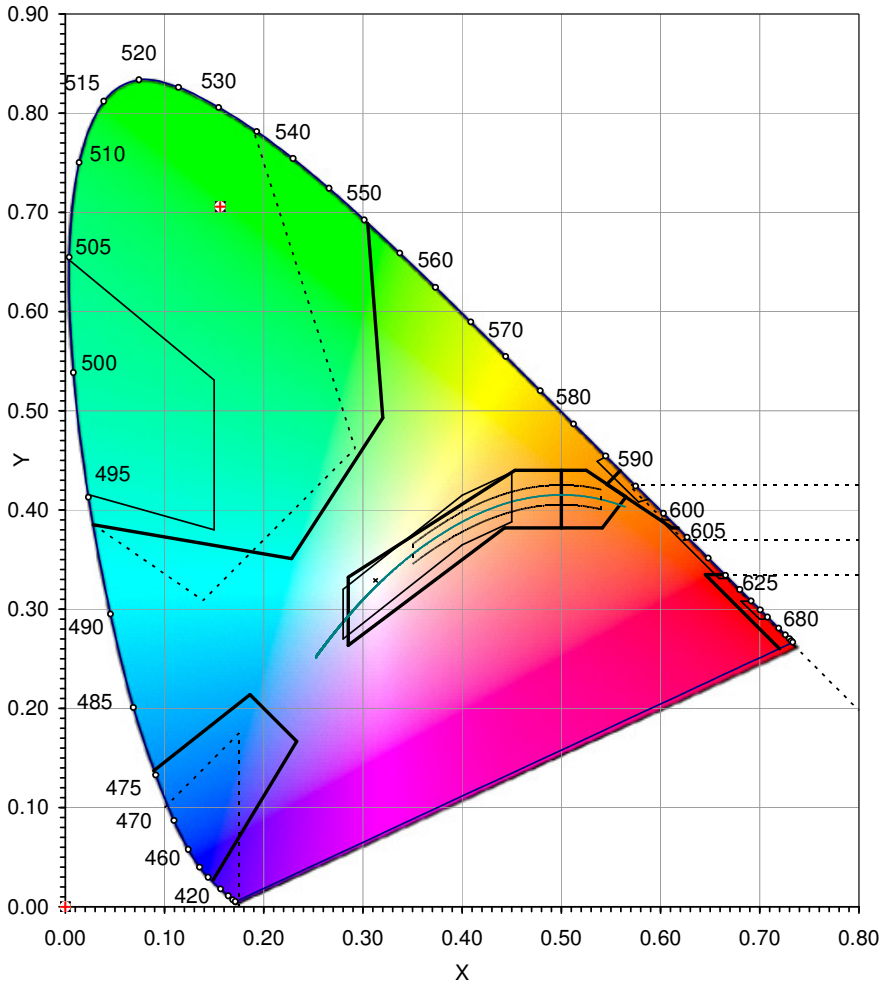


Figure. ICAO Aeronautical Ground Light Colors (thick solid) with MIL-C-25050A Aviation Colors (dotted) and ITE (thin solid) overlay

Specifying Heliport Lighting Intensity

The four main factors that were used to determine the intensity of lighting required are:

1. The ambient lighting environment
2. The helicopter approach angles
3. The meteorological conditions in which it is required
4. The range at which the signal needs to be seen

Specifying Heliport Lighting Intensity

Ambient lighting environment

- The eye threshold of illuminance is the minimum amount of perceived brightness required for an observer to detect a visual cue with a high degree of certainty

- The relationship between illuminance thresholds and background luminance for steady burning point sources for about 98 percent probability of detection have been established and referenced in the NBS monograph 159 “Visual Range: Concepts, Instrumental Determination, and Aviation Applications”, by C. A. Douglas and R. L. Booker, June 1977

Illuminance Threshold versus Background Luminance

98 percent probability of detection

Horizon Sky	Background Luminance (cd/m2)	Illuminance Threshold (mile candles)
Overcast, no moon	0.000034	0.06309
Clear, no moon	0.00034	0.06309
Overcast with Moon	0.0034	0.06309
Clear, Moonlight	0.034	0.07943
Deep Twilight	0.34	0.1585
Twilight	3.4	1

Specifying Heliport Lighting Intensity

Meteorological conditions

- For the light to be easy to find the identified illuminance, threshold values are to be increased by a factor of 10
- Therefore the eye threshold of illuminance for a clear, moonlight background horizon is inferred to be 0.79432
- Given the meteorological visibility, the eye illumination threshold and the required viewing range, Allard's law was used to compute the intensity of a steady light that is necessary

Specifying Heliport Lighting Intensity

Helicopter approach angles

- Helicopter approaches are subject to variability in terms of their vertical and horizontal profiles

- The distribution of intensity of the perimeter lighting as a function of elevation should be such that the lighting is bright enough to be seen at the required range (lower elevation angles) without glare or dazzle at closer ranges (higher elevation angles)

Specifying Heliport Lighting Intensity

Helicopter approach angles

- Given that approaches to heliports are typically performed into the wind, helicopters can in principle approach the heliport from any direction
- Consequently the specified intensity for heliport perimeter lighting must be maintained for all angles of azimuth

Specifying Heliport Lighting Intensity

Helicopter approach angles

- According to Flight standards typical vertical approach paths used by helicopters making approaches to a heliport (assuming VMC conditions)

Approach	Typical Descent Angle
Shallow	Less than 3 degrees
Normal	3 degrees to 10 degrees
Steep	10 degrees to 15 degrees

Specifying Heliport Lighting Intensity

- Allard's law was used to compute the intensity of a steady light that would be detectable.

- The equation to define Allard's law is:

$$E = (I/[R^2]) \times (e^{-\sigma R})$$

Where E = Eye Illuminance Threshold (lux)

I = Luminous intensity of the light unit (candelas)

σ = Extinction coefficient (m^-1)

R = Visual range of the light (m)

Specifying Heliport Lighting Intensity

Range of Signal

- The assumed VMC operating minima being used for the evaluation comprises of a minimum operating visibility of 3 miles and a minimum decision range of 2 miles

- Applying these values for usable range and meteorological visibility, together with a value of 0.79432 for eye illumination threshold to Allard's law yields an intensity of 23 candelas

- This value of intensity should be maintained for elevations from 3 to 10 degrees above the horizontal (i.e. the main beam)

Specifying Heliport Lighting Intensity

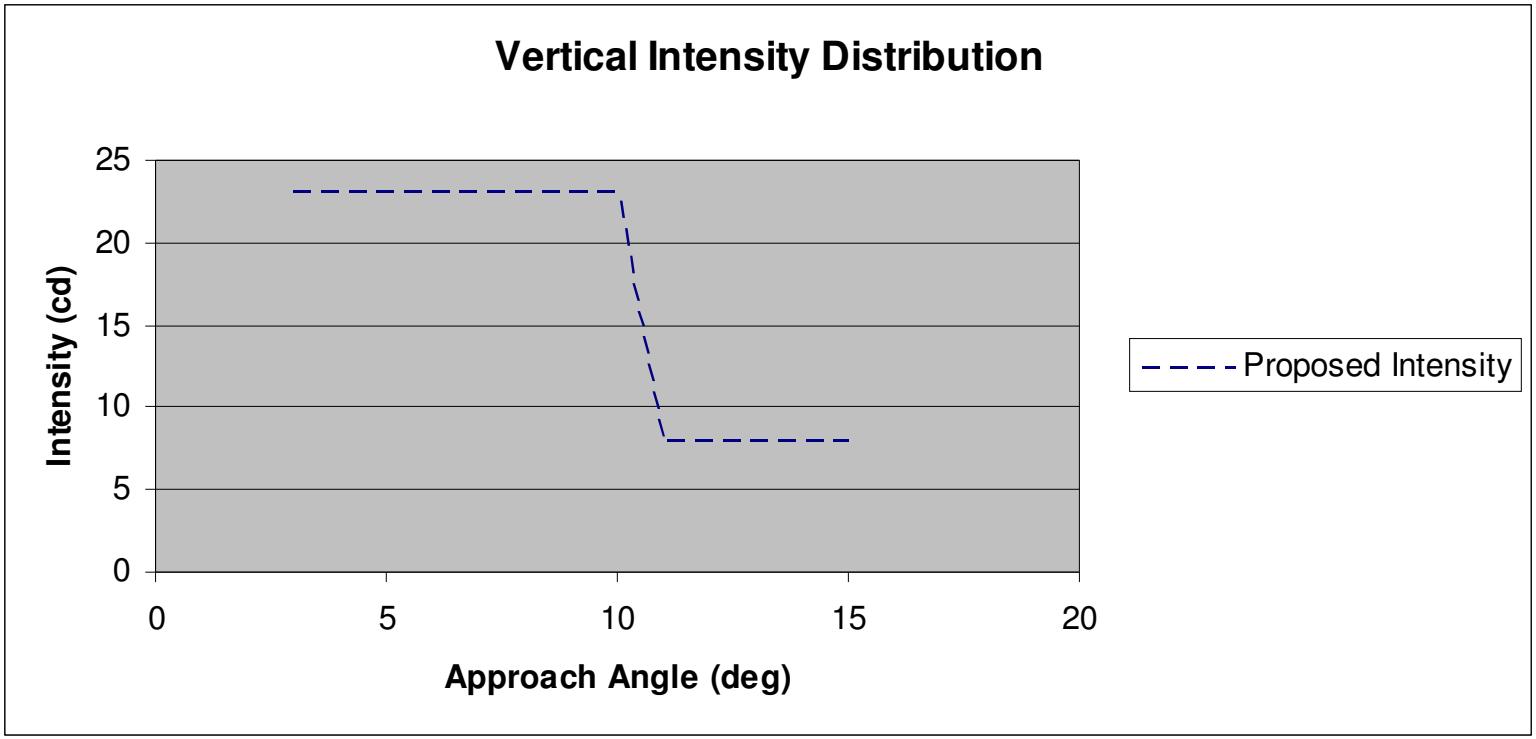
Range of Signal

- Higher elevation angles are encountered at shorter viewing ranges where less intensity is required to achieve the same level of conspicuity directed at 2 miles
- A usable range of 1.5 miles is assumed for coverage above 10 degrees
- Applying this values for usable range to Allard's law yield's an intensity of 8 candelas
- The main beam should roll off smoothly down to this value without marked discontinuity

Initial Findings

Vertical / Horizontal	Intensity
>3° - 10° / 360°	23 candelas min
>10° - 15° / 360°	8 candelas min

Initial Findings



Validation of Initial Findings

- The specification that has been described has been derived from empirical and theoretical studies
- It is therefore necessary to validate the specification with a large pilot population and in varied ambient lighting conditions before incorporating it in the FAA Advisory Circular
- Additional nighttime flight trials will be conducted at the Altru Hospital test helipad in Grand Forks, North Dakota by personnel from University of North Dakota (UND) Aerospace

Validation of Initial Findings

- The additional flight trials will be conducted in background horizons to include overcast skies with moon and deep twilight as well as a variation of approach angles

- High risk approaches will be flown using an Unmanned Aircraft System (UAS) helicopter

- Acquisition range and applicable intensity data will be compiled

Next Steps

- Using the assembled data, the mean and standard deviation of the required intensity values at the varied background horizons will be calculated

- Taking into account the performed calculations, propose the revised (mean) intensity requirements across the identified elevations (i.e. vertical intensity distribution) as the minimum intensity standards for heliport perimeter lighting

Next Steps

- Flight trials will be conducted at heightened perimeter light intensities to investigate a precautionary upper limit on the perimeter light intensity in order to avert glare

- Once validated, the intensity distribution and chromaticity specifications will be recommended for incorporation into the FAA Advisory Circular for Heliport Design

Questions or Comments?

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