



IES-ALC CONFERENCE

TUCSON AZ 21.-24.OCT 2013

High Intensity LED-Flashlights for Airport Lighting

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High intensity flash lights for airport lighting

What they be need for?

Operational requirements

The 5C's for flashlights

Comparison of discharge lights and LED light sources



What high intensity flashlights to be need for?

- Sequence Approach Flash Lights SFL
- Threshold Identification TIL
- Runway End Identification Lights REILS
- Lead in Lights LDIL
- Land And Hold Short LAHSO



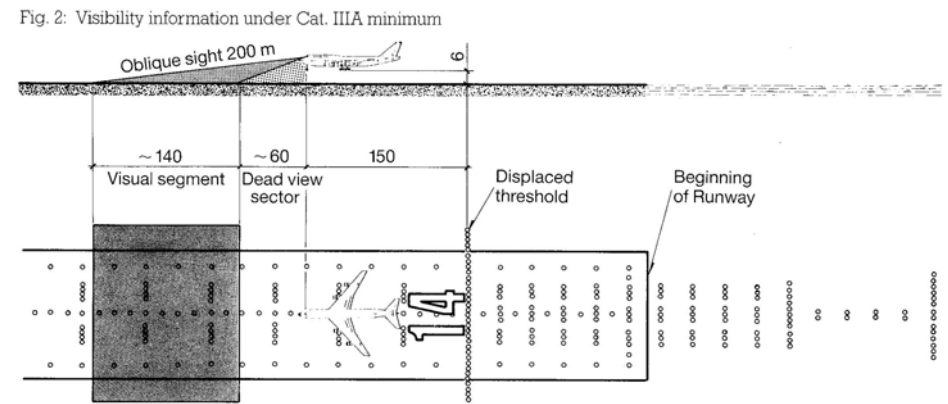
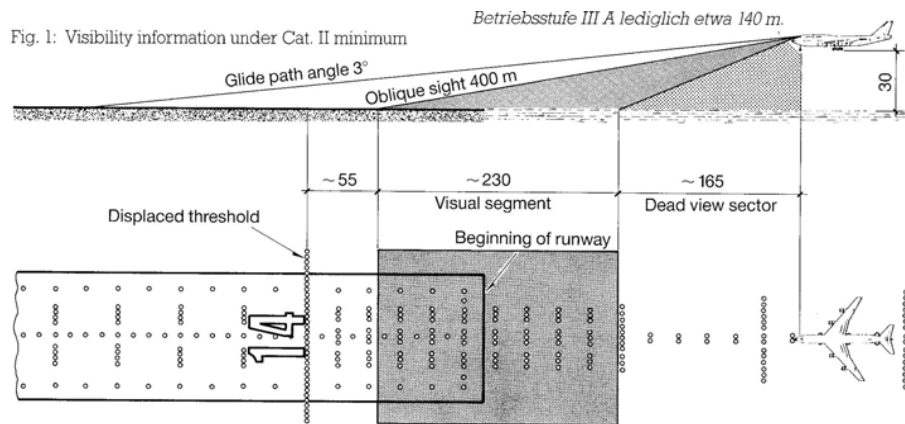
Operational requirements for Airport Lighting

- Good visibility (under all weather conditions)
- Free from glare
- Self explaining configuration
- Continuous guidance (from first perception to the gate)
- Availability -> 1
- Probability of failures -> 0
- No impact to the aircraft in collisions with lighting infrastructure
- (Frangibility) and no harm to tires (heat, cuts, penetrations) from lights.

Operational requirements

Minimum Visibilities:

	Runway Visual Range (RVR)	Decision Altitude (DA)
Category I	800m	60m
Category II	400m	30m (Flash not applied)
Category IIIA	200m	6m (Flash not applied)

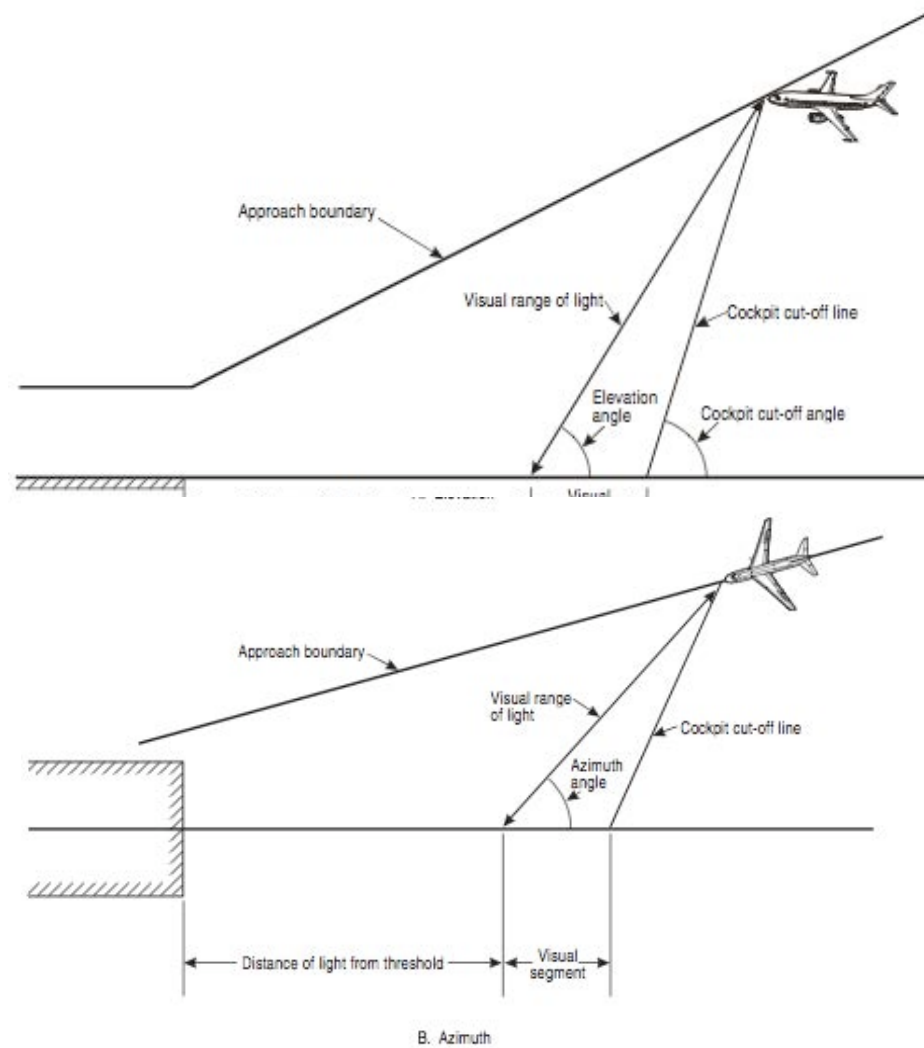


High intensity flash lights for airport lighting

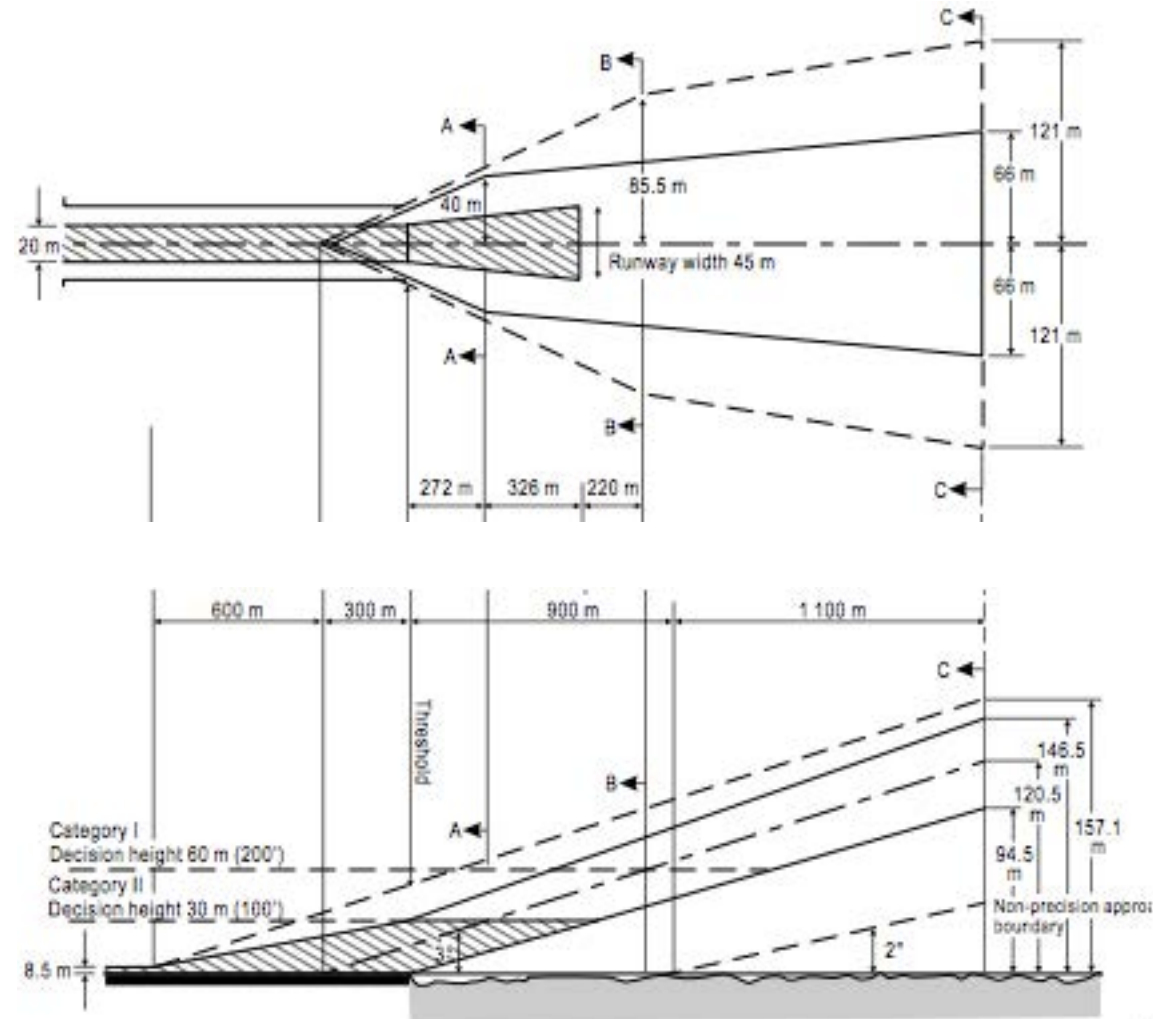
The 5C's for flashlights

- Coverage
- Configuration
- Colours
- Candelas
- Controls

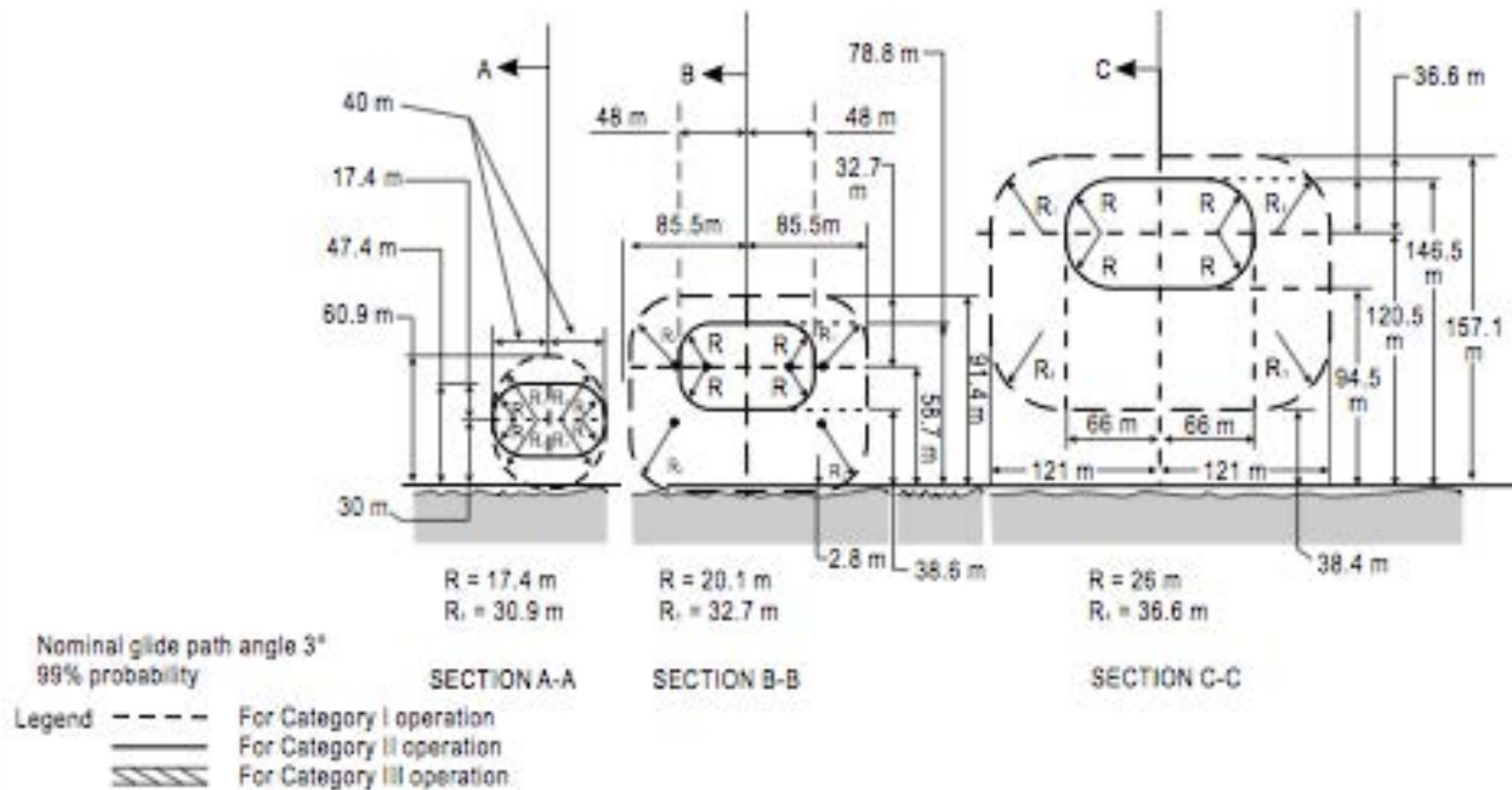
Coverage (Approach lighting)



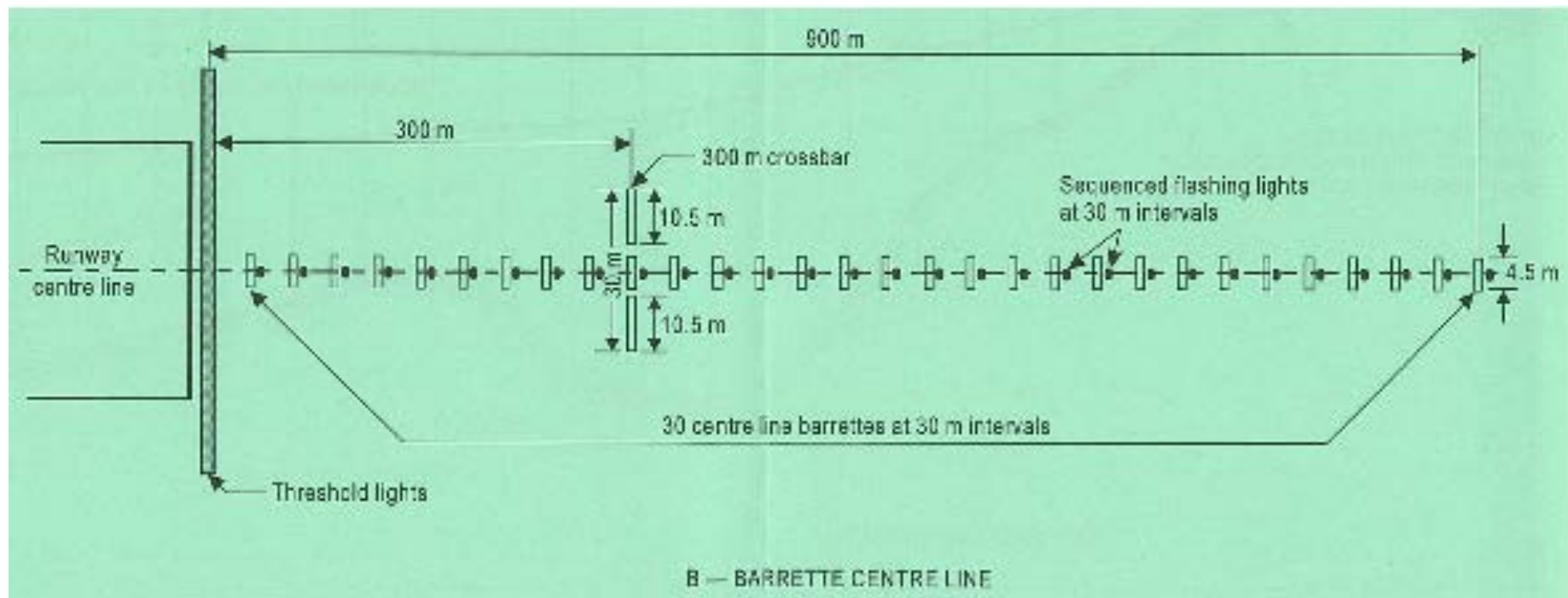
Coverage (Approach)



Coverage (Approach)

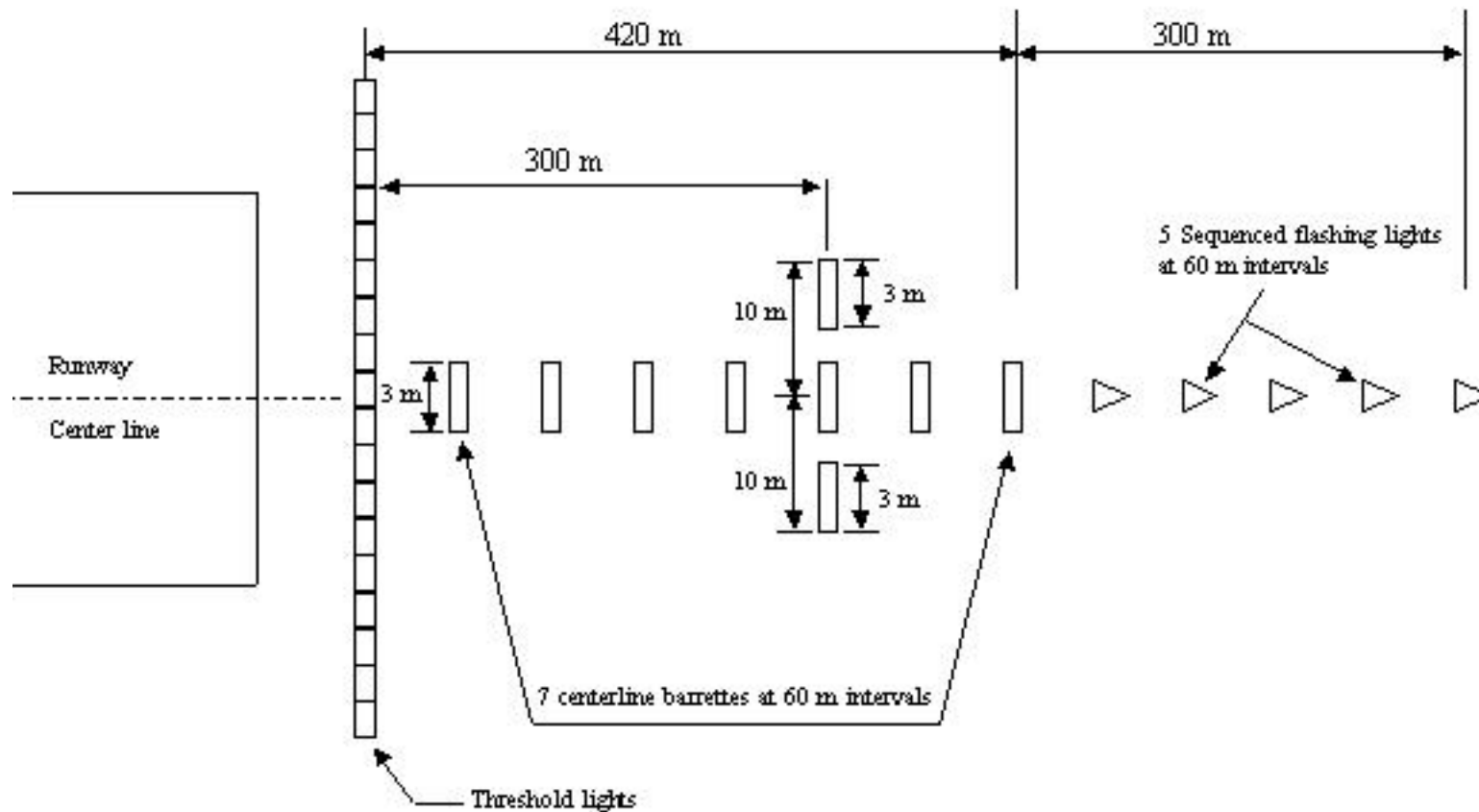


Configuration (CAT I Approach)



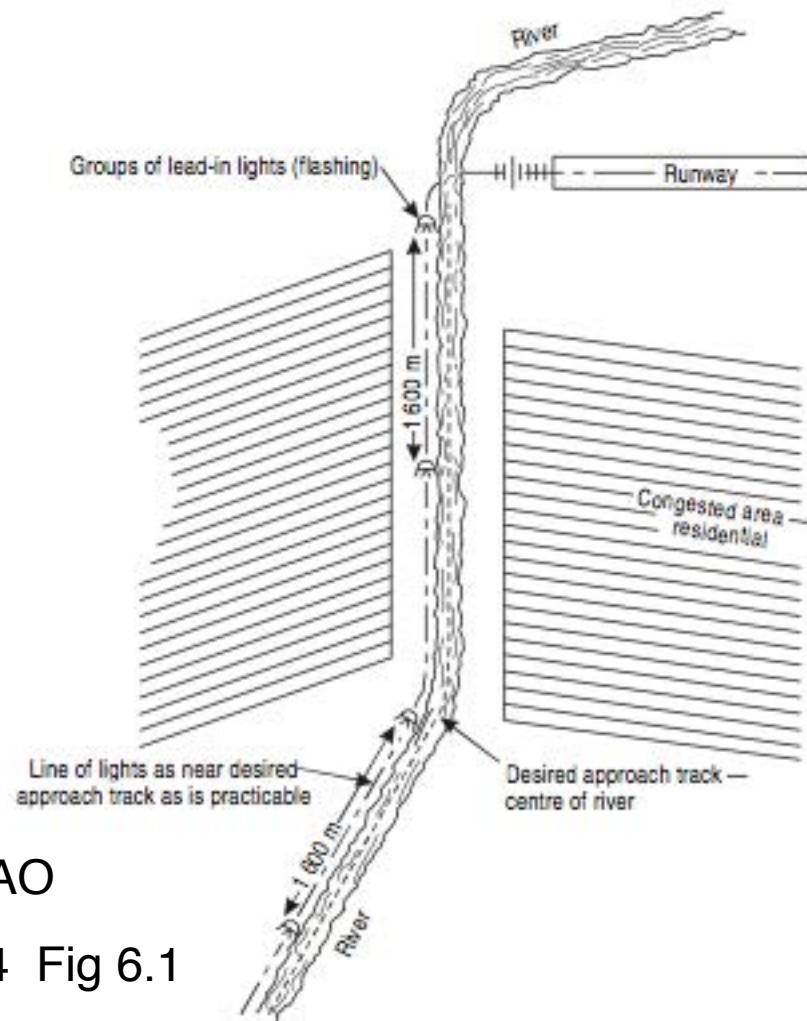
CAT I Approach lighting system according ICAO Annex 14 Fig A-7-B

Configuration (MALSR)



MALSR Approach lighting system according FAA

Configuration (Lead in lights)

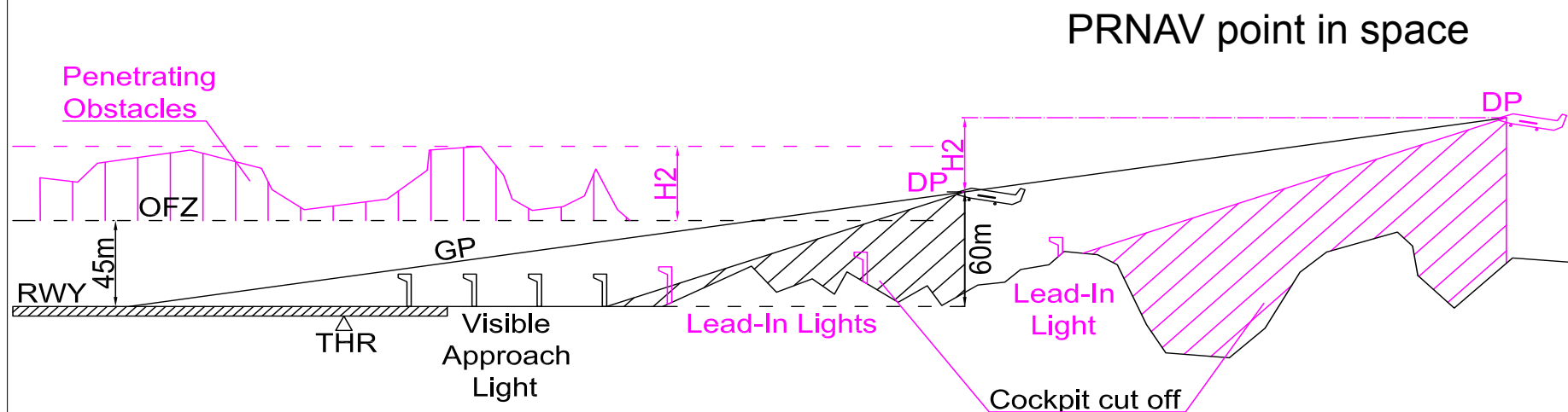


Lead in lights according ICAO

Aerodrome design Manual Part 4 Fig 6.1

Configuration (Lead in lights)

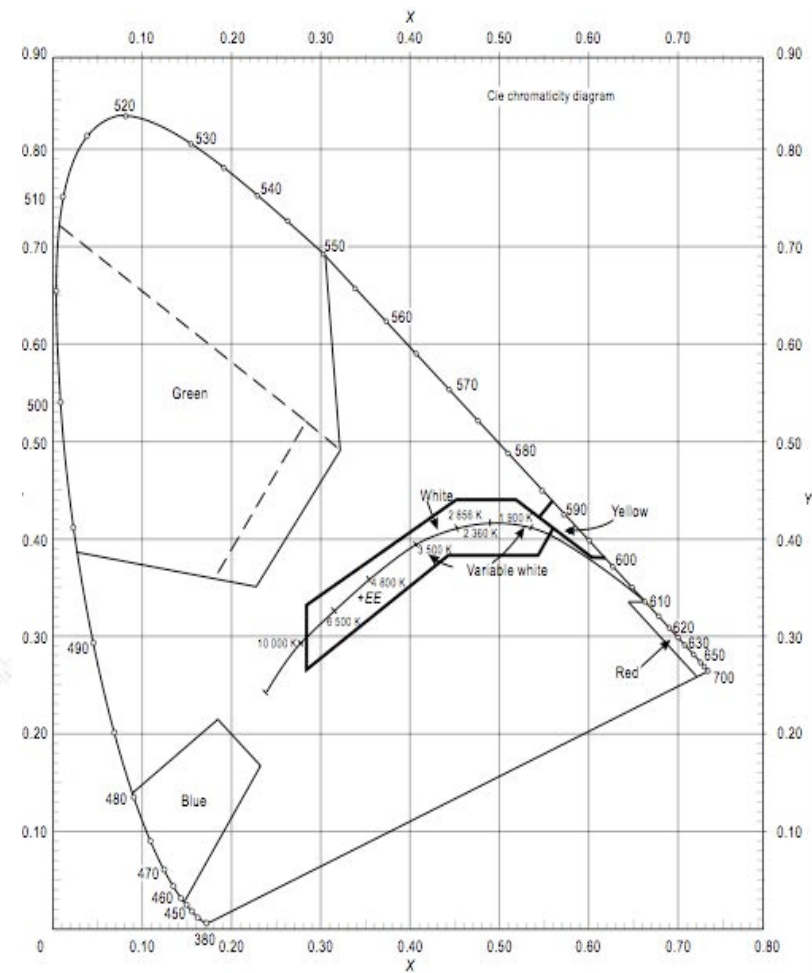
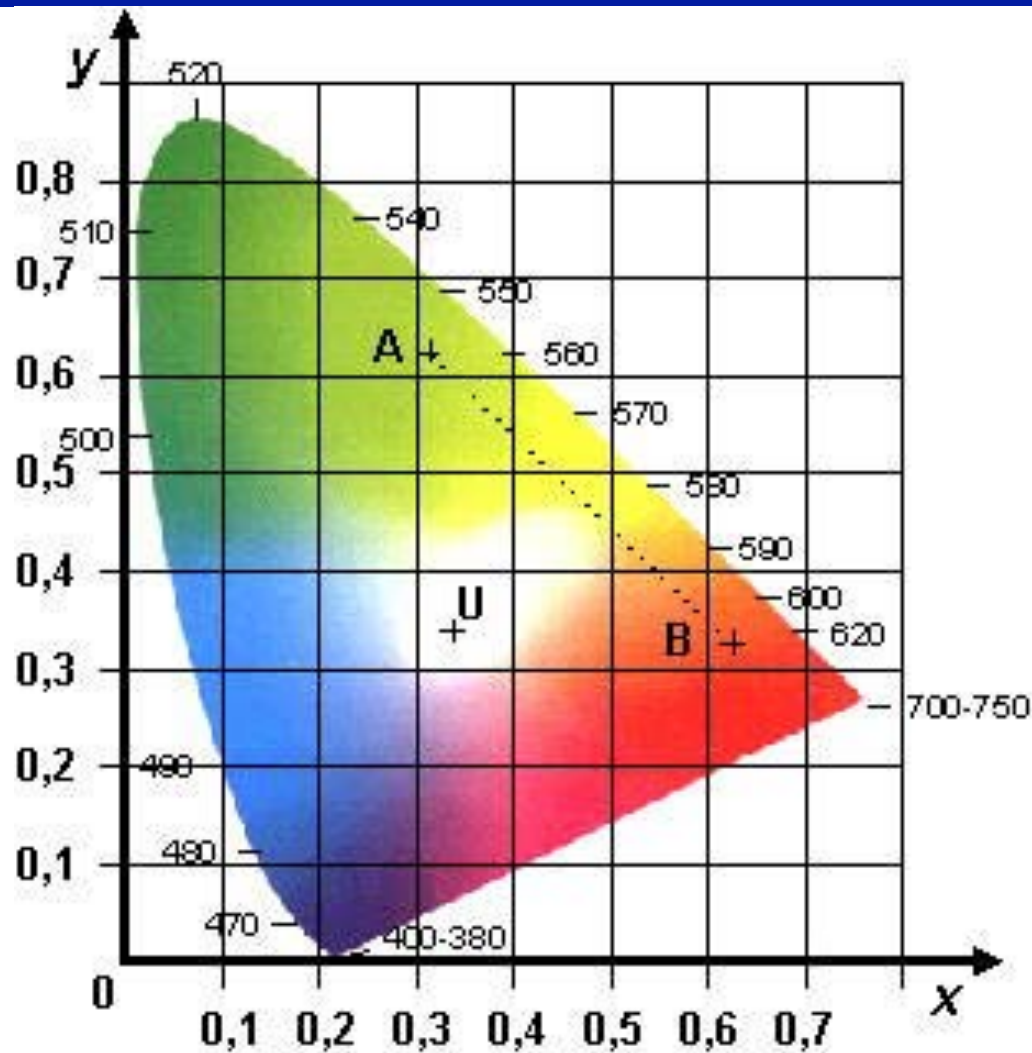
Lead in lights filling the gap from a PRNAV point in space to the approach lighting



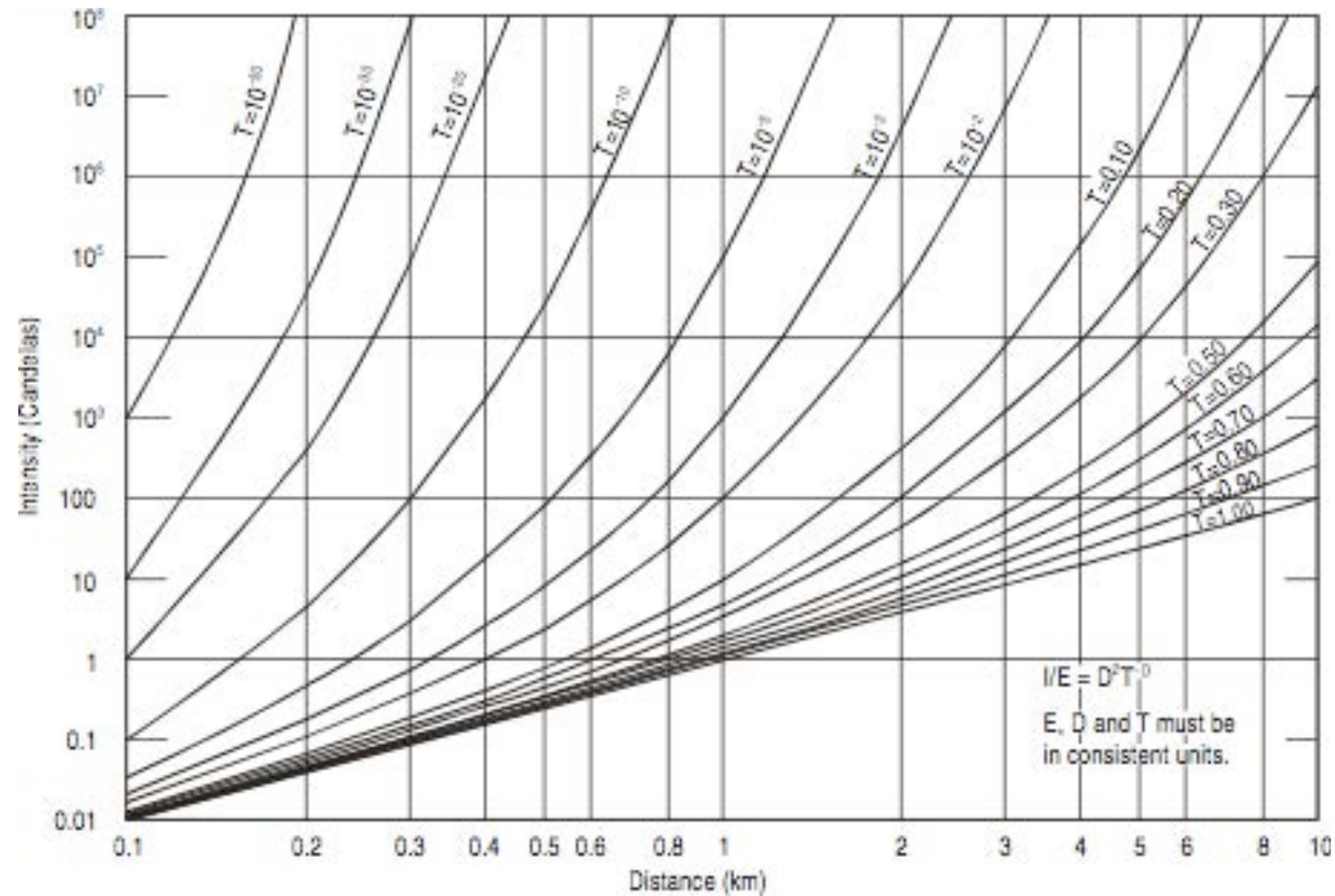
Colours (Approach & High intensity flash lights)

Applications:	Code:	Colour:
Approach flash light	SFL	white
Threshold Identification light	TIL	white
Runway End Identification Lights	REIL	white
Land and hold short	LAHSO	white
Runway lead in lights	LDIL	white

Colours (ICAO Annex 14 chromatic diagram)



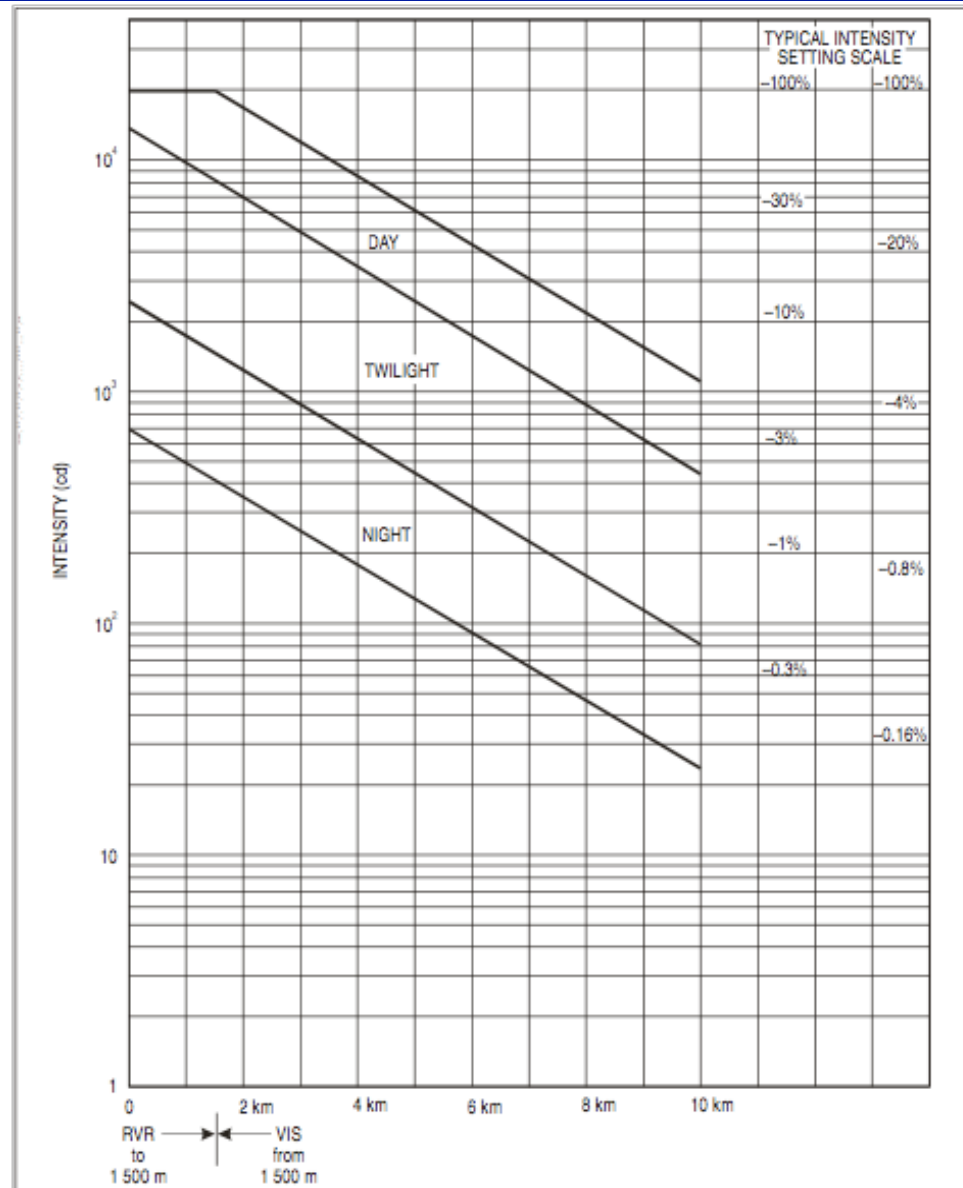
Candelas



Candelas (for approach lights)

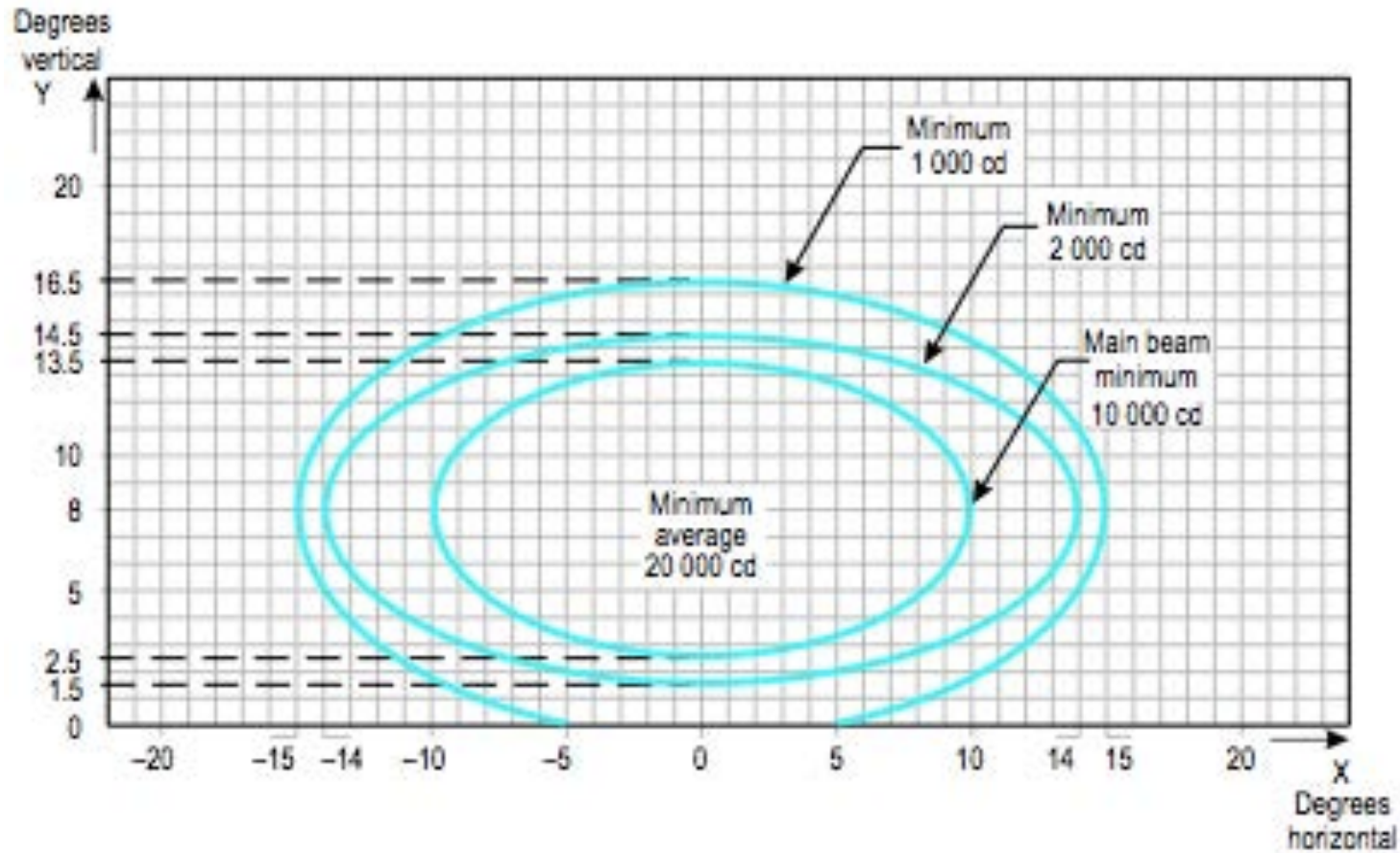
Intensity of approach lights

According ICAO ADM Part 4



Candelas (SFL)

Isocandela diagram for Approach Lights according ICAO Annex 14 A2-1



Comparison of discharge lights and LED light sources

- Coverage (no difference for LED and for Xenon lamp)
- Configuration (no difference for LED and for Xenon lamp)
- Colours (no difference for LED and for Xenon lamp)
- Candelas (same intensity, less spill-over for LED flash, different form of trigger signal)
- Controls (Signal form is different)
- Installation (smaller copper wire demand for LED)
- Work safety (HV for Xenon, SELV for LED)

Candelas (Isocandela diagram Xenon flash)

WAP

Lichtmessung Waren-Ausgangsprüfung

ERNI AGL AG

MessNr.: 7510	Feuer Typ: EL 217-SFL/TIL-80W-w Blitzfeuer
Mess Datum: 18.07.2012	Art Nr: 217.200 Strahl 1
Bemerkungen: 217.200 12217-2255 SFL EL Nr.01	

Toe-in	Spezifikation	Feldmontage	Messung	Auswertung	Meldungen	Korrektur
hor. [°]	0	0	0	0	ok	0
vert. [°]	0	0	0	0	ok	0

VH	-20	-19	-18	-17	-16	-15	-14	-13	-12	-11	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20				
18	3055	3712	3812	3658	3595	4354	4151	4243	4208	4358	4542	4542	4531	4540	4591	4889	4885	4883	4885	4885	4845	4531	4551	4542	4483	4483	4445	4200	4151	4054	3955	3858	3812	3712	3614	3517	3410	3301	3204	3175	3058				
17	4845	4786	4694	4692	5177	5235	5421	5519	5617	5714	5783	5881	5950	6027	6096	6067	6096	6067	6096	6067	6007	6027	6059	5959	5783	5714	5686	5586	5470	5373	5324	5228	5177	5021	4884	4736	4581	4365	4258	4103	3956				
16	6088	6084	6038	7033	7131	7621	7670	7668	7812	8012	8158	8158	8401	8305	8303	8303	8303	8303	8303	8303	8158	8158	8012	7863	7661	7717	7570	7473	7271	7229	7382	7682	8042	8417	8792	9056	9281	9468	9573	9177	8203				
15	9133	9133	8377	9071	8984	10005	10050	10794	10888	11282	11429	11575	11722	11868	11965	12015	12064	12015	11966	11868	11655	11500	11623	11722	11824	11986	12131	12331	12589	12822	13053	13281	13528	13815	14072	14382	14636	14833	14915	1424	7033				
14	12748	13187	13576	13988	14213	14855	14957	15199	15404	15778	15824	15922	16118	16365	16468	16519	16500	16118	16099	15871	15502	15324	15727	15895	16434	16485	16411	16345	16759	16803	16912	17025	17188	17443	17625	17885	18143	18398	18659	18915	19178	19398			
13	18886	17387	17676	18281	18362	18861	19282	19438	19683	19827	19976	20171	20286	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220	20220			
12	21090	21734	22076	22320	22711	23064	23151	23395	23641	23737	23883	23930	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983	23983			
11	24672	24714	25027	25300	25739	25883	26305	26521	26818	26914	27127	26980	27359	27359	27359	26983	27359	26983	26911	26911	26814	26769	26769	26769	26867	26818	26570	26423	26228	26228	26228	26228	26228	26228	26228	26228	26228	26228	26228	26228	26228	26228	26228		
10	28614	27158	27437	27742	28084	28474	28621	28767	28914	29129	29129	29065	29255	29065	29012	28983	29158	29108	29158	28914	29043	29043	28914	28914	28914	28914	28914	28914	28914	28914	28914	28914	28914	28914	28914	28914	28914	28914	28914	28914	28914	28914	28914		
9	27487	27937	28276	28572	28914	28983	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	29255	
8	27332	27546	27588	27639	28132	28377	28219	28328	28372	28513	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	28572	
7	23030	25555	25153	25446	25544	25768	25827	25963	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	26032	
6	22885	22711	23053	23152	23385	23461	23757	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	23688	
5	18850	20813	20582	20585	20580	20584	21069	21148	21295	21346	21395	21197	21148	21148	21187	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	21148	
4	16880	18804	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580	18580
3	16806	17680	17620	18120	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	18216	
2	16362	18459	18055	18051	18048	18057	17984	17143	17192	17094	17182	16987	16987	17040	17040	16989	17040	16987	17040	17143	17341	17182	17269	17269	17269	17269	17269	17269	17269	17269	17269	17269	17269	17269	17269	17269	17269	17269	17269	17269	17269	17269	17269	17269	17269
1	15111	15336	15180	15727	15824	15871	16023	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215	16215
0	14852	14739	14994	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082	15082
-1	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038	13038

Auswertung		Spezifikation: ICAO Ann.14, Vol.1, Fig. A2- 1, 0-11° APH										
Bereich		Sollwertkuven				Sollwerte			Auswertung Messung			
		Umte/Unten: 0		Form: Ellipse		Mittelwert	Minimum	Max / Min.	Mittelwert	Minimum	Maximum	Max / Min.
		Mitte H	Mitte V	Rad a	Rad b							
1	Mainbeam	0	5.5	10	5.5	20000	10000	3	22944	15141	29940	1.98
3	Outer beam	0	5.5	15	8.5		1000			14945		

Candelas (Isocandela diagram LED flash)

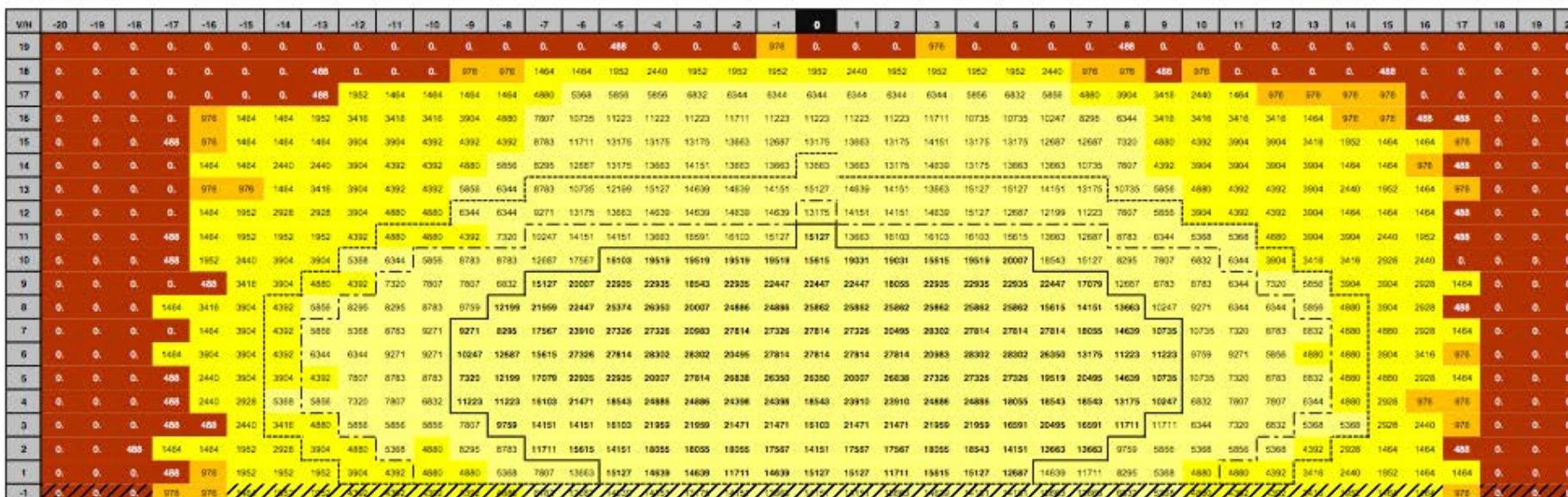
WAP

Lichtmessung Waren-Ausgangsprüfung

ERNI AGL AG

MessNr.: 8691	Feuer Typ: IL 817D Blitz LED SFL
Mess Datum: 21.03.2013	Art Nr: 817.200 Strahl 1
Bemerkungen: SN 817-200-013-0049 5.5° Toe in	

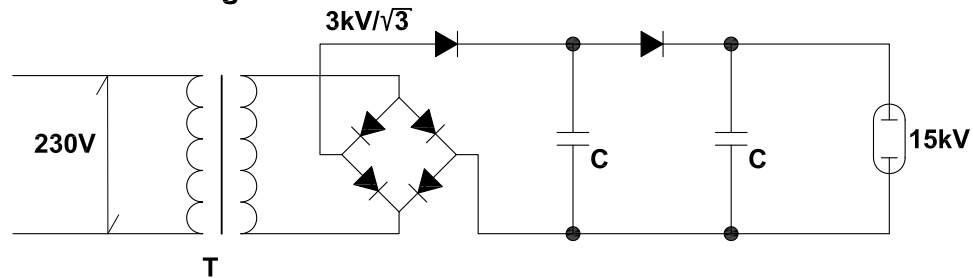
Toe-in	Spezifikation	Feldmontage	Messung	Auswertung	Meldungen	Korrektur
hor. [°]	0	0	0	0	ok	0
vert. [°]	0	0	0	0	ok	0



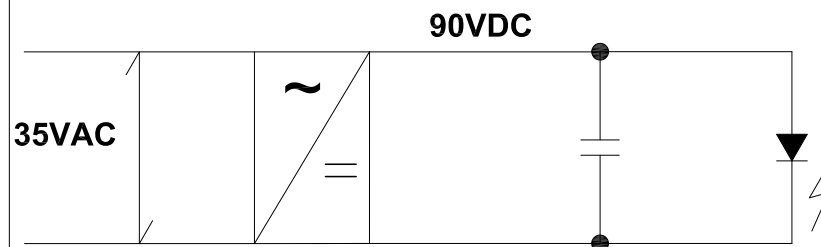
Auswertung		Spezifikation: Erni intern EL817 SFL (5.5° - 10'000 cd)										
Bereich		Sollwertkuven				Sollwerte			Auswertung Messung			
		LichteUnten: 0		Form: Ellipse		Mittelwert	Minimum	Max / Min.	Mittelwert	Minimum	Maximum	Max / Min.
		Mitte H	Mitte V	Rad a	Rad b							
1	Mainbeam	0	5.5	10	5.5				✓ 19848	✓ 7320	28302	🟡 3.87
2	Second beam	0	5.5	14	6.5					✓ 4392		
3	Outer beam	0	5.5	15	8.5					✓ 3416		

Candelas (Signal form)

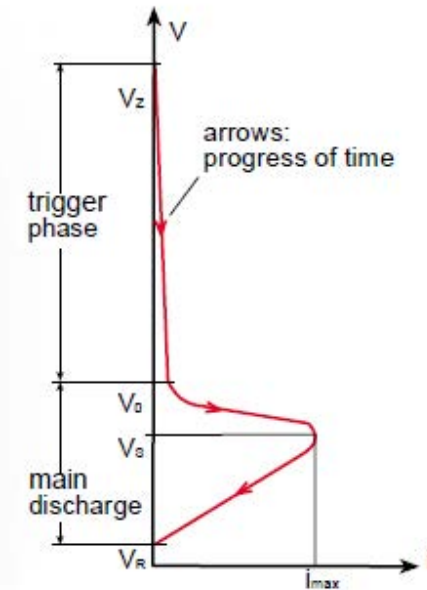
XENON Flash Light



LED Flash Light



Voltage / intensity



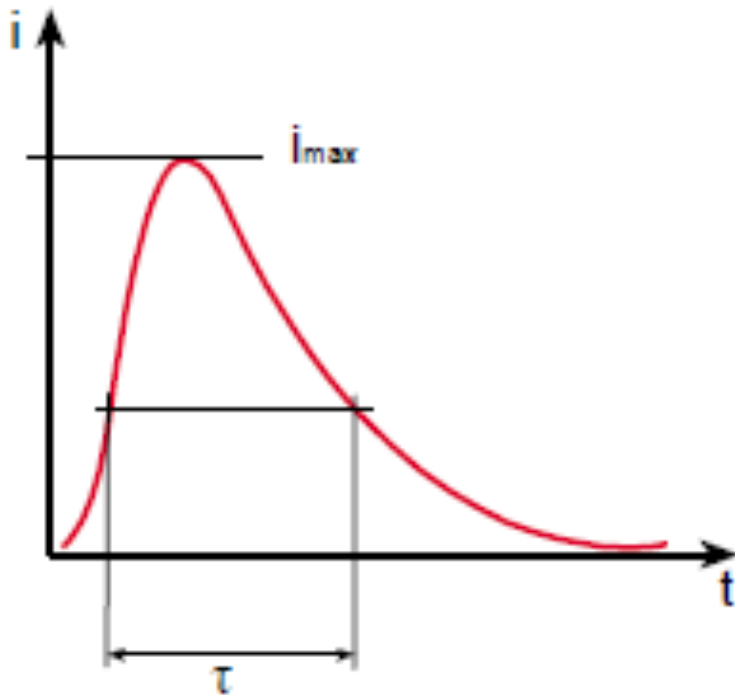
Xenon : $V_z > 9\text{kV}$

LED: $U < 100\text{ VDC (SELV)}$

Candelas (Signal form)

Illuminous flux dt Xenon

LED



Xenon : $t = 8\mu s$



LED: $t=100ms$ @ 2 Hz
 $t=200ms$ @ 1 Hz

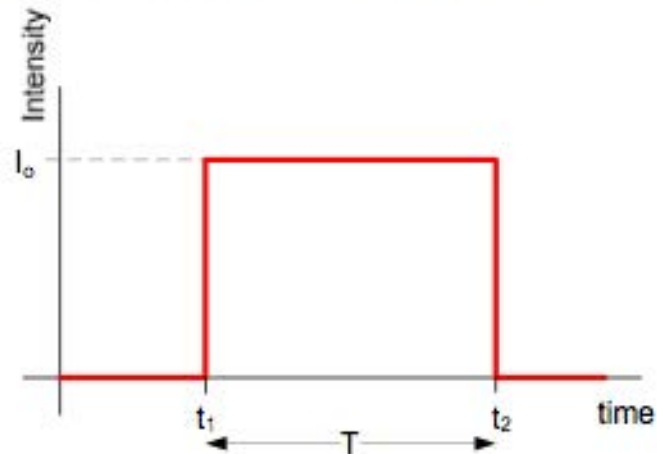
Signal form of LED flash

The existing calculation of the effective intensity of flashes according the Design 18.3 based on the Blondel & Rey equation

$$(I) \quad I_e = \frac{\int_{t_1}^{t_2} I dt}{\alpha \cdot (t_2 - t_1)} \quad \text{for} \begin{cases} \alpha = 0,2 \text{ s} \\ (t_2 - t_1) = T < 0,2 \text{ s} \\ I(t_2) = I(t_1) = I_e \end{cases}$$

$$(II) \quad I_e = \frac{\int_{t_1}^{t_2} I dt}{(t_2 - t_1)} \quad \text{for} \begin{cases} (t_2 - t_1) = T \geq 0,2 \text{ s} \\ I(t_1) = I(t_2) = I_e \end{cases}$$

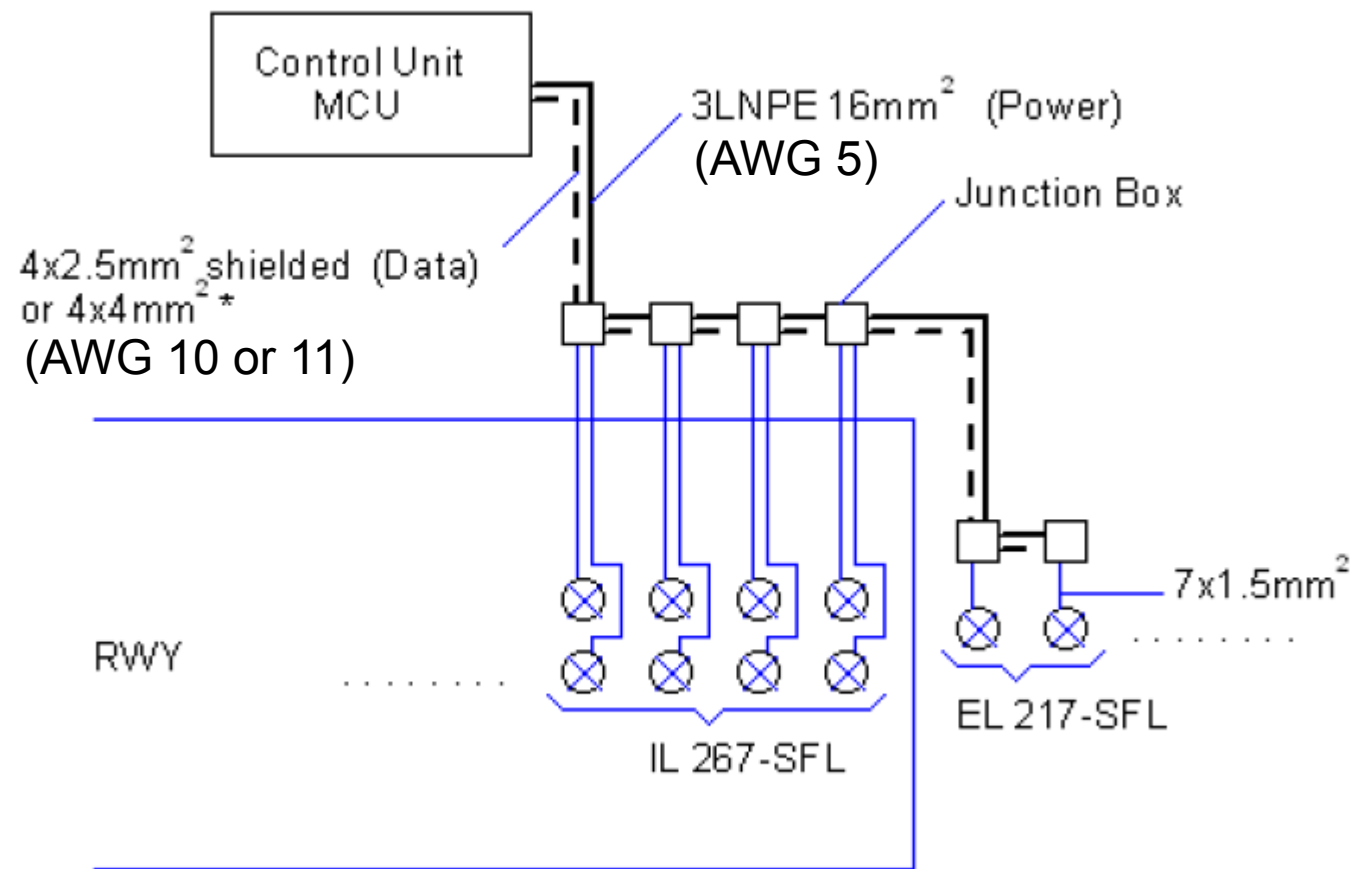
For LED-flashes, the light output shape can be assumed as rectangular



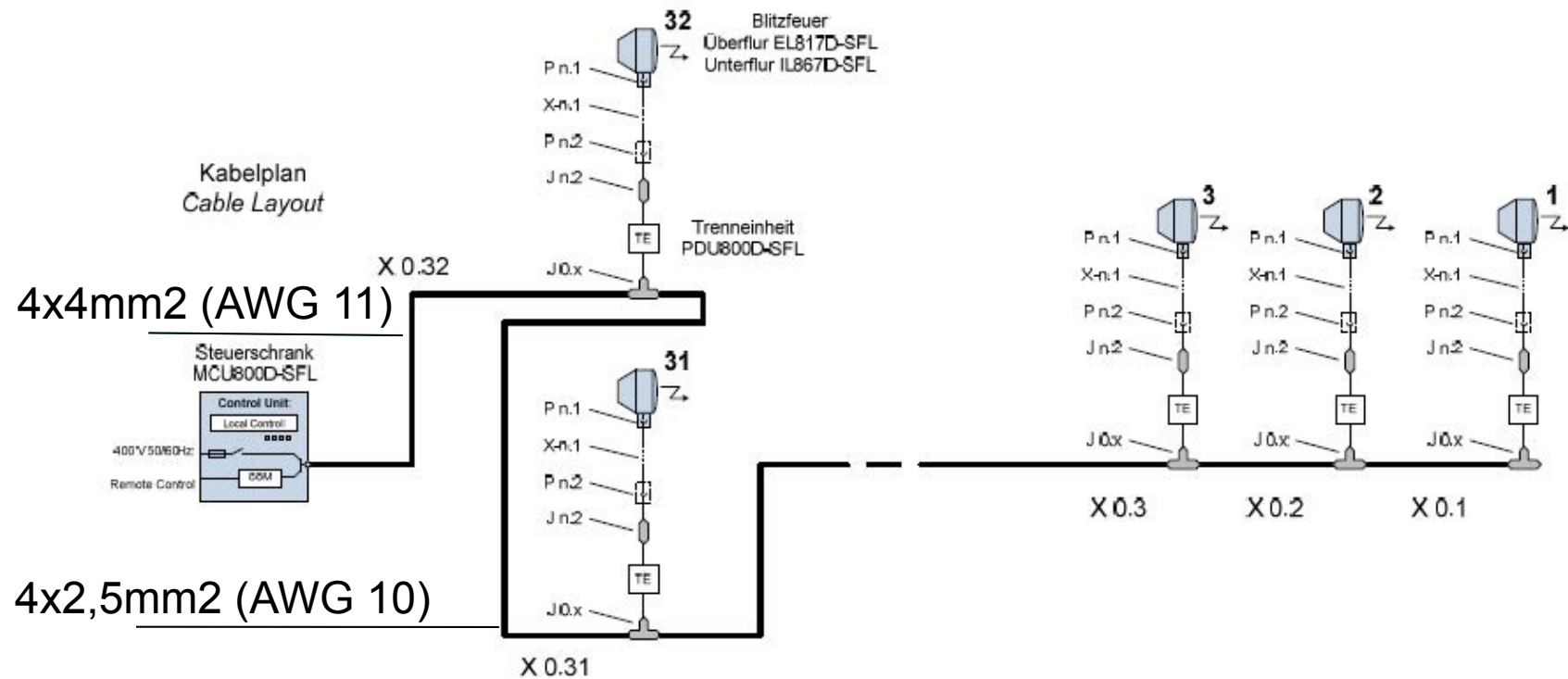
For the rectangular form the Equation (I) + (II) can be simplified to

$$(III) \quad I_e = I_0 \cdot \frac{T}{\alpha} \quad \text{where} \begin{cases} \alpha = 0,2 \text{ s} \\ T < 0,2 \text{ s} \end{cases}$$

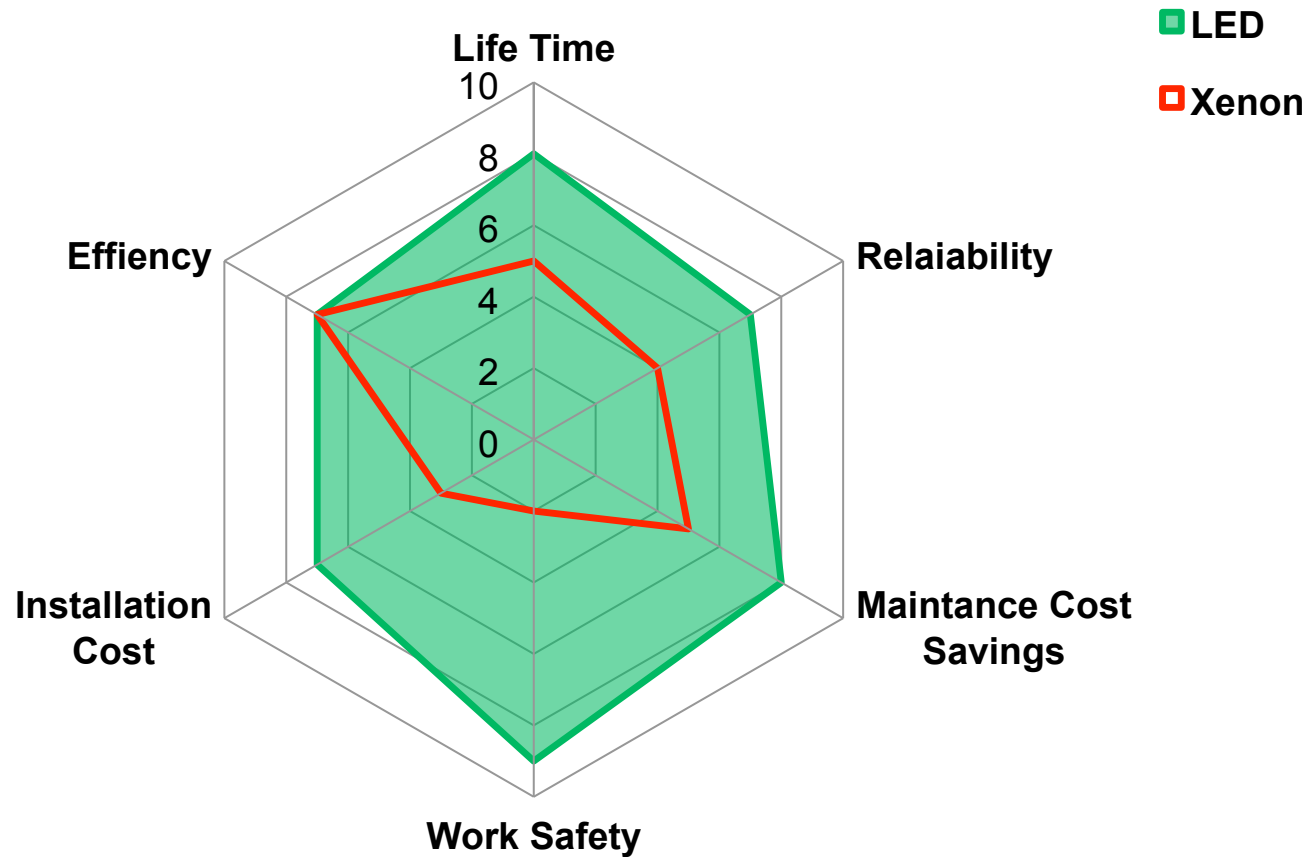
Installation (Xenon flash light)



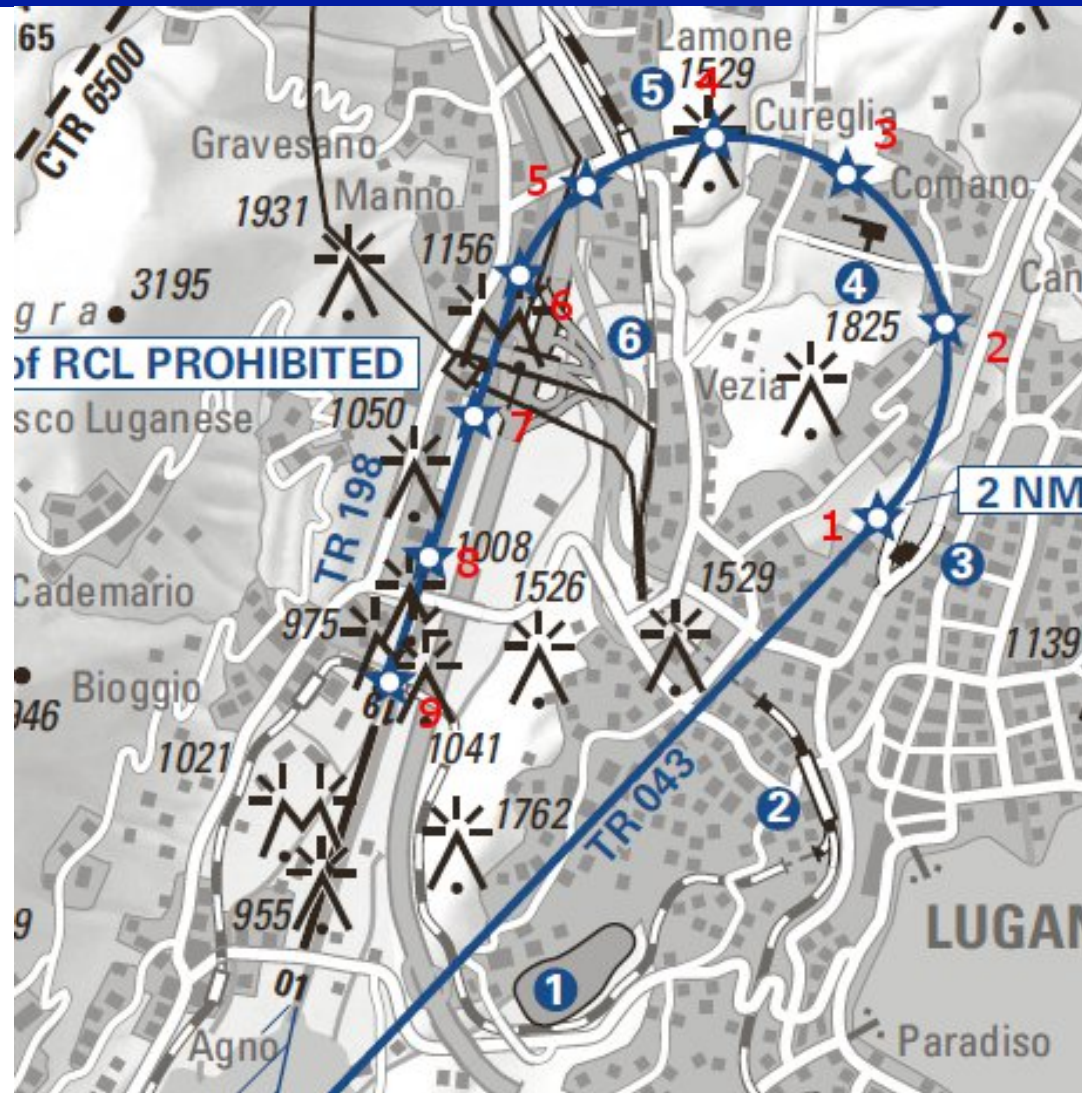
Installation (LED flash light)



Comparison of LED vs Xenon flash lights



Lead in lights - Example Lugano Airport Circling C



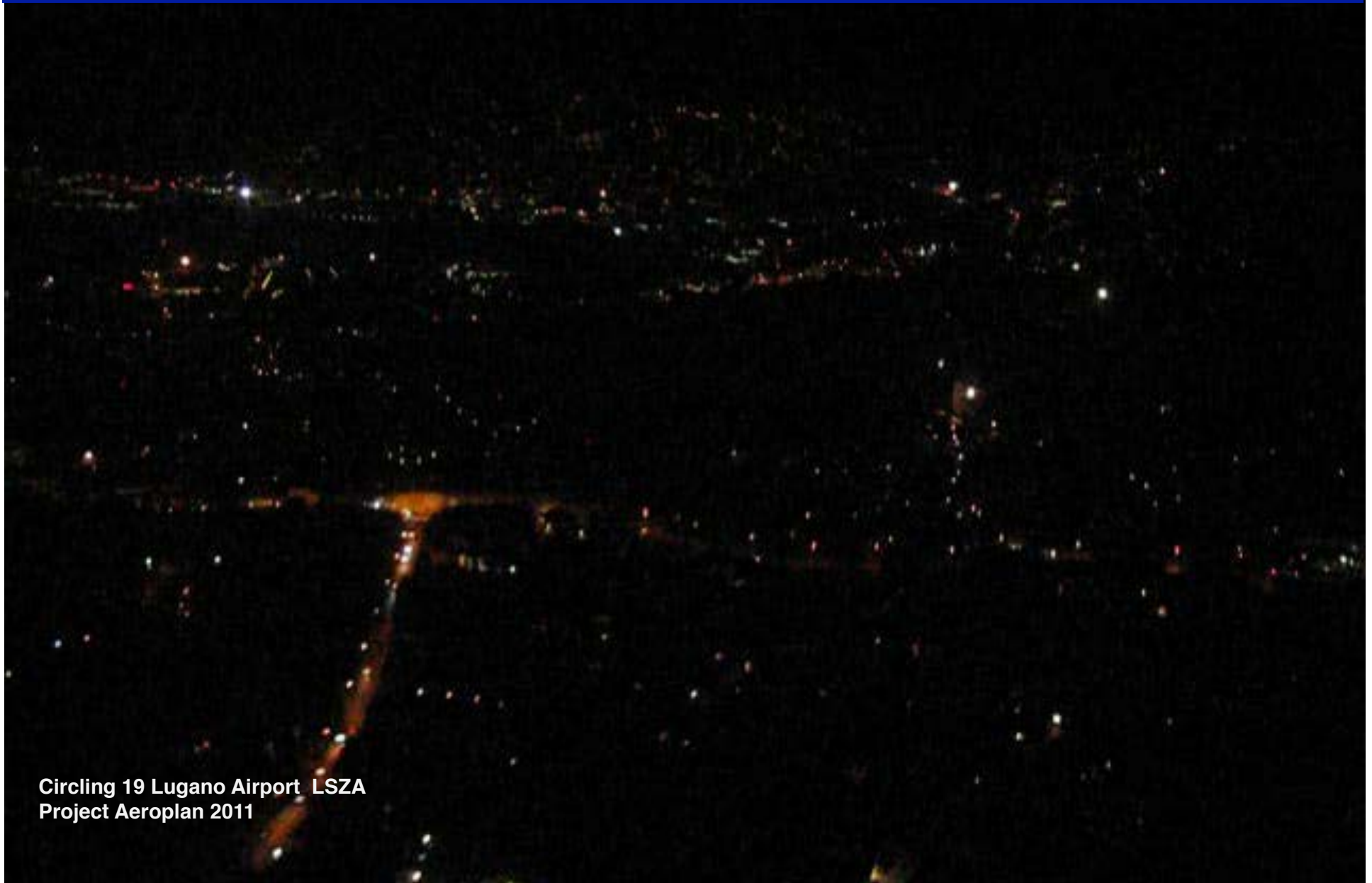
Lead in lights - Example Lugano Airport Circling C



Lead in lights - Example Lugano Airport Circling C



Lead in lights - Example Lugano Airport Circling C



Circling 19 Lugano Airport LSZA
Project Aeroplan 2011

Questions?

Thank you for your attention

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Literature

- ICAO Annex 14, Vol. 1 Aerodromes
- ICAO Manual of RVR Observation Practices
- ICAO Aerodrome Design Manual Part 4 Visual aids
- ICAO Aerodrome Design Manual Part 5 Electrical Systems
- ICAO Aerodrome Design Manual Part 6 Frangibility

Literature:

- Sanjurjo/Balcells, Aeronautical Ground Lighting ISBN 978 8495567-46-8
- Ashford / Wright, Airport Engineering, ISBN 0-471-52755-6
- Horonjeff / Mc Kelvey, Planning and Design of Airports ISBN 0-07-113352-6
- Wells, Airport Planning and Management
- Handbuch für Beleuchtung, ECO-med, ISBN 3-609-75405-2
- J.B. de Boer, Philips Research Laboratories, Calculations on the light distributions of Approach and runway lights, August 1951

Manufacturers Manuals:

- Erni AGL Sequential flash light system (Xenon)
- LED High Intensity Flash Light