EEP13/11/10

Report of the Expert Meeting on Standardization of New Lighting Method for Marine Aids to Navigation

November 25 to 28

2008

Tokyo, JAPAN

60th anniversary of Japan Coast Guard

Japan Coast Guard / Ocean Police Research Foundation

Contents

JAPAN COAST GUARD

Expert Meeting on Standardization of New Lighting Method for Marine Aids to Navigation

Tokyo, JAPAN
25 – 28 November, 2008

Executive Summary

The Expert Meeting on Standardization of New Lighting Method for Marine Aids to Navigation was held from 25th to 28th November 2008 in Tokyo, hosted by the Japan Coast Guard under the auspices of the Ocean Policy Research Foundation. Four overseas experts and one Japanese expert in the field of marine visual aids to navigation and optics were invited to the meeting. Unfortunately Mr. KERGADALLAN of FRANCE was unable to come for certain reasons however he submitted his presentation. Eventually four experts participated in the meeting with the Japan Coast Guard (JCG) officers. The participants list of the meeting is attached as Annex 1.

On the first day, the open symposium was held at the Mita Conference Hall in Tokyo and three experts and one JCG officer made presentations regarding visual signal. Mr. ERIKSSON of DENMARK kindly made the presentation of Mr. KERGADALLAN on behalf of him. There were about seventy audiences at the symposium and they asked various questions after the each presentation.

On the second day, the meeting was held at the Mita Conference Center and the four experts and the 13 JCG officers attended the meeting. The main topic of the first session was on “Effective Intensity and Apparent Intensity”, of the second session was on “Conspicuity” and of the third session was on “Flicker range” and the participants made an active and eager discussion on the topics. In the evening, an onboard welcome reception was held and the experts had a chance to observe the background light environment of Port of TOKYO.

On the third day, the technical tour to the JCG Research Centre in Tachikawa, Tokyo was carried out. The experts observed a latest aids to navigation simulator, laboratories and other relevant facilities and exchanged comments and opinions with the staff of the centre.

On the final day, the experts and JCG officers summarized the meeting and agreed the conclusion that was drafted by the JCG and amended by the experts. The conclusion of the meeting is attached at the end of this executive summary.

CONCLUSION

THE MEETING,

RECALLING that the marine visual aids to navigation have more than 23 centuries of service and have contributed to the safety of navigation;

RECOGNIZING that while the new type of aids to navigation such as GPS, AIS, has emerged, the importance of the visual signal has not been lost in the least;

ALSO RECOGNIZING that new technologies in the field of light sources continue to evolve; and LED sources, in particular, enable the presentation of new intensity profiles and spectral compositions;

HAVING NOTICED the development of the discussion in the CIE TC2-49 especially the draft technical report on CIE Recommendation for Measurement of Effective Intensity of Flashing Lights;

HAVING ALSO NOTICED the draft IALA Recommendation E-200 series especially E-200-4 on Marine Signal Lights Part 4 – Determination and Calculation of Effective Intensity and the development of the discussion in the IALA EEP Committee;

HAVING CONSIDERED that the need for more conspicuous visual signals is increasing in built up area while marine traffic increases and ships are becoming faster and bigger;

CONCLUDES

1. *That a flickering LED light is conspicuous and therefore has the possibility of becoming a new lighting method for marine aids to navigation however the flicker range is shorter than the nominal luminous range of the flickering light under certain conditions and thus the designing the flickering light should be done carefully. Further study and research are needed for its practical application;*

2. *That Effective Intensity still is a useful tool for designing of marine visual aids to navigation. The Modified Allard Method developed by CIE TC2-49 has paved the way for calculating the effective intensity of all intensity profiles including a train of pulses used in marine aids to navigation;*

3. *That Apparent Intensity - brightness at supra-threshold levels - is an important concept for designing marine visual aids to navigation and therefore the development of a robust and universal model is required;*

4. *That Conspicuity is becoming a more important consideration when designing marine visual aids to navigation in built-up areas with many rival lights. However conspicuity is a complex matter and therefore further research on this matter is desired;*

AND RECOMMENDS

5. *That research bodies as well as marine visual aids to navigation authorities are encouraged to conduct research on both apparent intensity and conspicuity. CIE and IALA should promote such research;*

6. *That CIE and IALA should strengthen their relationship further through higher level liaison;*

7. *That as the host nation of the meeting, the Japan Coast Guard should submit the report of the meeting including the copy of the presentations to the relevant committees of both IALA and CIE.*

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Report of the Expert Meeting on Standardization of New Lighting Methods for Marine Aids to Navigation

1. Background

Marine aids to navigation such as lighthouse, lighted buoy have mainly used an incandescent lamp for its light source for a long time. A flash light of incandescent lamp is usually made by switching on and off of electric current or rotation of beacon lens. Therefore the profile of the flashing pattern is gradual and is not suitable for ultra quick light or flickering light that have good conspicuity. However a recent emergence of Light Emitting Diode (LED) enables wide variety of flashing pattern as well as saturated color spectrum and reduction of energy consumption.

At the same time, as the world marine trade is increasing, the light situation of marine traffic, especially around major ports is largely changed. By increase of both number and intensity of the light such as port light, security light, city light, a light of marine aids to navigation is becoming buried in these lights and thus marine aids to navigation under such situation need to be more conspicuous.

In order to develop a more conspicuous light, the Japan Coast Guard (JCG) has studied a new lighting method using LED since 2006 and developed flickering flash light that combines flickering effect with the conventional IALA flashing light by Pulse Width Modulation (PWM) in 2007. The JCG reported the results of the study at the 11th IALA EEP Committee and at the same time planned to hold a international expert meeting oh the new lighting method under the auspices of the Ocean Policy Research Foundation that is a private non-profit organization on the whole range of ocean affairs. The purpose of the expert meeting is to discuss the new lighting method of LED pulsed light including calculation of effective intensity in order to standardize the method for marine aids to navigation. Therefore the JCG decided to invite the experts from both the CIE that is an international organization on standardization of optical matters and IALA that is an international organization on marine aids to navigation.

The invited experts were as follows:

Mr. Omar Frits ERIKSSON (Denmark)	Chairman, IALA EEP Committee & Head, AtoN & SAR Div., Danish Maritime Safety Administration
Mr. Xavier KERGADALLAN (France)	Member, IALA EEP Committee & Light Specialist, CETMEF
Mr. Larry JAEGER (USA)	Member, IALA EEP Committee & General Engineer, Ocean Engineering Div., USCG

Dr. Yoshi OHNO (USA)	Director, CIE Div. 2-Physical Measurement of Light and Radiation & Group Leader, NIST
Dr. Ken SAGAWA (Japan)	Former Director, CIE Div. 1-Vision and Color & Prime Senior Researcher, AIST

Unfortunately Mr. KERGADALLAN of FRANCE was unable to come for certain reasons however he submitted his presentation.

The meeting named "The Expert Meeting on Standardization of New Lighting Method for Marine Aids to Navigation" was held from 25^{th} to 28^{th} November 2008 in Tokyo. The expert meeting mainly consisted of an open symposium, technical tour and five sessions of meeting. The program of the meeting is attached as Annex 2.

2. Courtesy Call to the JCG

Mr. ERIKSSON, Mr. JAEGER, Dr. OHNO made a courtesy call to Mr. Shuichi YONEOKA, Director General, Maritime Traffic Department, JCG at the JCG Headquarters on the first day morning. At first Mr. YONEOKA expressed his appreciation to the all experts for accepting the invitation and coming to Japan. He emphasized importance of visual aids as the primary means of the aid to navigation and stated his expectation toward the fruits of the meeting. In replay to his remarks, all experts thanked to the JCG for the invitation to the meeting and said that they were anticipating the discussion at the meeting.

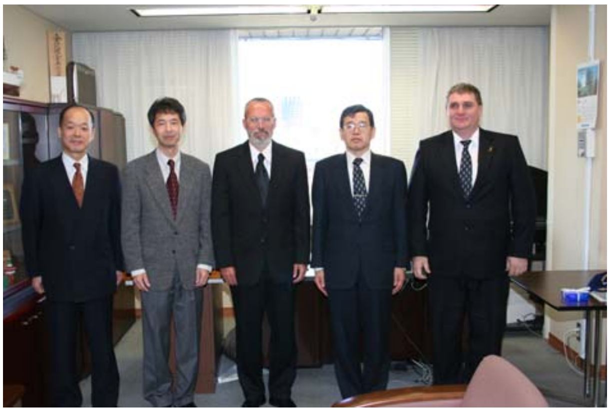

Photo 1: Courtesy Call to JCG
From left to right: Mr. Tane, Dr. Ohno, Mr. Jaeger, Mr. Yoneoka, Mr. Eriksson

3. Open Symposium

The Open Symposium of the meeting was held on the first day of the meeting, 25^{th} November 2008 at the Mita Conference Hall, Tokyo. Commander Hideki NOGUCHI of the JCG was the MC of the symposium. He announced the opening of the symposium and then introduced Mr. Akihiro TANE, Director, Aids to Navigation Engineering Division, to give opening remarks.

3.1 Welcome Remarks from Mr. Akihiro TANE, Japan Coast Guard

At the beginning of his remarks, Mr. TANE extended his deepest appreciation to the Ocean Policy Research Foundation (OPRF) for its support and cooperation to the meeting. He then also thanked to the experts for coming all the way to Japan to make the presentations. He mentioned that Mr. Xavier KERGADALLAN of France who had also been invited to the meeting was unable to attend the meeting for certain reasons but he submitted his presentation regarding flicker light which Mr. Omar Frits Eriksson kindly made on his behalf. He stated that visual aids to navigation had more than twenty centuries of history but the technologies of the visual aids were still developing such as new lighting method of LED that had conspicuity. He said that the presentations to be made by the experts would be from basic matters of effective intensity of flashing light to its experiments for the practical application including some demonstrations of LED flicker lights from the Japan Coast Guard Research Center. Then he handed his microphone to the MC for the first speaker.

Photo 2: Welcome remarks from Mr. Tane

3.2. Mr. Larry JAEGER, USCG, USA

After an introduction by the MC, Mr. Jaeger started by thanking the JCG and the OPRF for inviting him to the meeting. He said that his presentation had three main topics, effective intensity, apparent intensity and conspicuity. He then described the effective intensity of a flashing light as a concept that has meaning only at threshold. He mentioned that effective intensity is typically not a useful concept for the mariner because, at threshold, a light can barely be detected and neither its color nor its flash rhythm can be discerned.

He then explained that apparent intensity is a supra-threshold concept that relates to a light's perceived brightness. The apparent intensity of a flashing is the intensity of a steady light that would appear equally bright. He showed a famous Broca & Sulzer model (1902) that indicates that a flashing light with the same intensity of a steady light may appear brighter than the steady light. However he added that there have been a limited number of apparent intensity studies and that a comprehensive apparent intensity model will require more research.

Finally he indicated that conspicuity relates to how easy it is to locate a light-of-interest against a background of rival lights. He showed several examples that demonstrated how color and flash rhythm can increase conspicuity. He noted that conspicuity is a complex concept and that there are many factors that will influence conspicuity including the intensity, color, flash rhythm, shape, and movement of both the light-of-interest and the rival lights. He indicated that he was not aware of any single measure of conspicuity, but that in many studies the measure of conspicuity is the time it takes to locate a light-of-interest against a background of rival lights.

After the presentation, he was asked how to describe the conspicuity of a light to mariners. He answered that aids-to-navigation authorities need to adequately describe the nature of a light (color, temporal pattern [including flicker], and intensity [expressed as nominal range]), but that he did not foresee the need to publish a separate conspicuity measure. He was also asked if there was a concrete maximum amount of time for locating an aid to navigation and he replied that there was a no such standard.

The copy of the presentation slide is attached as Annex 3.

Photo 3: Presentation of Mr. Jaeger

3.3. Dr. Yoshi OHNO, NIST, USA

At the beginning of his presentation, he extended his appreciation to the JCG and the OPRF for the invitation to this interesting meeting. Then he introduced the National Institute of Standards and Technology (NIST) that maintains and disseminates national standards for optical radiation and added that the NIST is the only national lab that provides calibration service for flashing lights.

Next he described the effective intensity that was a luminous intensity of a steady light which had the same luminous range of a flashing light under the identical condition such as threshold of detection, white light, dark background, foveal vision, point source. He showed the three methods of the effective intensity; Blondel-Rey(-Douglas) which is good for a rectangular pulse, Form Factor Method which is good for non-rectangular pulse but not for train of pulse, and Allard method which is based on a vision model considering the eye as a low pass filter. He said that the Allard method seemed to work well for all pulses but there was a deviation from the Brondel-Ray.

He then mentioned that he and his colleague therefore developed the Modified Allard Method to solve the problem by modifying the visual impulse response function q(t) of Allard. He said that the Modified Allard matched the results with Blondel-Rey for rectangular pulses; the calculation of effective intensity of all pulses seemed accurate but an experimental verification was missing at that time. But he added that after a long search by CIE TC2-49, the Committee finally found the 1986 USCG paper reporting vision experiments on the effective intensity of multiple-flick flashtube signals and confirmed that the calculation by Modified Allard matched the experimental result of the paper surprisingly well. This was considered as experimental verification for Modified Allard method. Finally, he stated that in 2007 the CIE TC2-49 adopted the Modified Allard method for the current draft, which will be finalized and to be published as CIE recommendation for effective intensity.

Photo 4: Presentation of Dr. Ohno

The copy of the presentation slide is attached as Annex 4.

3.4. Mr. Omar Frits ERIKSSON, Danish Maritime Safety Administration, Denmark

After thanking the JCG and the OPRF for the invitation, Mr. ERIKSSON started his presentation by mentioning that, since the shortcomings of existing models became obvious with the advent of the LED based light sources, IALA has been searching for a better model for calculating the sensation of flashing and flickering light. He added that IALA is seeking an all encompassing model for flashing light of any pulse shape and spectral composition.

He then said that under certain conditions flickering light is perceived brighter than a steady light of the same luminous intensity. This may be due to the so-called Broca Sulzer effect or other similar effects. He also mentioned that the brightness of flickering light is perceived differently at different observation distances. Therefore he and his colleague at IALABATT/IALALITE and EEP committee had conducted a test using a lantern that emitted two types of flash profiles. While one was a steady flash, the other had a flickering part at the beginning of the flash. The result of test was that the perceived brightness and conspicuity of the two flash profiles were not so different at a distance of 1,5 nautical miles, however at shorter ranges, the flickering flash was more conspicuous. He then said that it was concluded that flickering light could be useful for providing easy identification of certain Aids to Navigation at close range. He added that Mr. KERGADALLAN of the French lighthouse authority also had conducted a study of perception of flickering light with distance and he would be reporting the findings on behalf of Mr. KERGADALLAN.

Mr. ERIKSSON then talked about conspicuity and proposed an analogy between measuring conspicuity and measuring signal to noise ratio of a radio signal. He explained that the concept of signal demodulation was similar to the concept of recognizing an Aids to Navigation signal, however the model of the radio signal was a simple one compared to the complexity of visual perception. He said that the human visual system is complex and that the eye is constantly changing its state. Therefore there is a need to define of one or more standard observers with well defined visual properties.

He made the point that due to the shortcomings of existing models which are relatively simple, there is a need for more detailed modeling of the visual system, a model capable of capturing both complex temporal and spectral characteristics of the stimulus at any eye adaptation level.

He also said that the IALA EEP Committee now has flickering light on their work program and that IALA also has a small group of light expert looking into the issue. In conclusion Mr. Eriksson expressed that flickering light should be only be applied a few aids in any one region in order to harvest conspicuity. Finally he urged everyone to continue to conduct visual experiments and to support IALA in its search for the all encompassing model for calculating the sensation of any flash profile.

Photo 5: Presentation of Mr. Eriksson

The copy of the presentation slides is attached as Annex 5.

3.5. Mr. Xavier KERGADALLAN, CETMEF, France, substituted by Mr. ERIKSSON

Mr. ERIKSSON kindly made the presentation on the behalf of Mr. KERGADALLAN. Mr. ERIKSSON explained that Mr. KERGADALLAN had conducted a visual experiment on the perception of flickering light at various distances, in both direct (foveal) and peripheral (at an angle of 45 degrees) vision.

He then described how the experiment had been conducted, and the apparatus used. The illumination level at the eye of the 5 observers, placed 12,5 meters away from the light source, had been varied using a neutral density filter to simulate an observation distance of 235, 715, 2035 and 5035 meters. The nominal luminous range of the light source had been 8149 meters. The light was then flickered at the rate of 5, 10 and 20 Hz with a duty cycle of 20%.

Mr. Eriksson then explained that the experiment had yielded some interesting results. Firstly, the data suggests that the flickering effect disappears as the observation distance is increased - and thus the level of illumination at the eye of the observer is decreased. Secondly the data suggest that the flicker can be observed at larger distances when flickered at a lower frequency. Thirdly the observers detected flicker at greater distances using direct vision rather than peripheral vision.

In conclusion, Mr. ERIKSSON said that Mr. KERGADALLAN is of the opinion that it is better to use low flicker frequencies and that there is a need to define the useful range of flickering lights. Thus, in addition to the nominal luminous range of a light, a flickering range for direct vision and a flickering range for peripheral vision should be stated.

Finally Mr. Eriksson conveyed from Mr. KERGADALLAN his regrets for not being present and greetings to the all participants of the symposium.

After the presentation Mr. ERIKSSON was asked if the energy saving effect of the flicker had been considered. He answered that the flicker light had such effect, but only under certain conditions. He then was asked if a standard LED light source should be defined and he replied that the question was related to the measurement and Dr. OHNO was more suited to answer the question. Dr. OHNO answered that developing such a standard light source is difficult, but for example, with Modified Allard method, the ratio of effective intensity to physical quantity (candela second) can indicate energy efficiency of the lights. Finally there was a question on the border between a flash and a flicker. Mr. Jaeger answered that there appears to be an overlap near 5 Hz: an IALA ultra-quick flashing light flashes at 5 Hz, but 5 Hz is also being tested as a flicker frequency.

The copy of the presentation slides is attached as Annex 6.

3.6. Mr. Yoshiyasu FUKUSUMI, JCG Research Center, Japan

At first, he explained that the origin of his research was to save energy of aids to navigation using flicker light. Then he summarized the result of the flicker experiment of a red LED lantern until 2007 that although the most conspicuous flicker is frequency of 5 Hz and duty ratio of 20%, it was decided to use higher frequency because 5 Hz is already used as ultra quick light of IALA character. He added that considering a cost performance of lantern, the flicker of 10 Hz and 30% is finally decided to be the most appropriate to use. During his explanation, he also demonstrated various combinations of flicker light using special equipment.

Then he explained the experiment in 2008 that studied green and white LED lantern by comparing combinations of frequency and duty ratio. He stated that this experiment was conducted at a beach and 52 observers attended. He said that fixing frequency at 10 Hz and comparing duty ration, the result shows the lower duty ratio is more conspicuous. He added that fixing duty ratio at 30%, the lower frequency is more conspicuous and the Modified Allard Method almost matches the result of the experiment.

After the presentation, he was asked how he estimated if there is only one pulse in three seconds and he answered such lighting has more conspicuity and the Modified Allard Method probably shows the same result.

The copy of the presentation slide is attached as Annex 7.

Photo 6: Presentation of Mr. Fukusumi

4. The First Meeting

The first meeting was also held at the Mita Conference Hall on 26th November 2008. Dr. Ken SAGAWA, prime senior researcher, National Institute of Advanced Industrial Science and Technology, Japan was joined the meeting and accordingly four experts and thirteen JCG officers attended the meeting. There were originally two main topics in the meeting, one was “Effective Intensity and Apparent Intensity” and another was “Conspicuity”. However the addition of the third main topic “Flicker Range” was proposed and amended to include in the topics.

4.1. Opening

At the beginning of the first meeting, Mr. TANE, the chairman of the meeting, reported that the total number of audiences at the open symposium was 66 and thanked those who made the presentation. He also assigned Cdr. NOGUCHI as the vice-chairman since his specialty was not visual engineering and handed the chair to Cdr. NOGUCHI. As Cdr. NOGUCHI took over the chair, he announced the schedule of the day.

4.2. First Session “Effective Intensity and Apparent Intensity”

Cdr. NOGUCHI started the first session by stating that the apparent intensity was a new concept for the JCG and confirmed that if a supra-threshold illuminance level of 0.2 microlux of the IALA recommendation should be used for the experiment of the apparent intensity. Mr. JAEGER replied that 0.2 microlux is the most suitable value for mariners to recognize an aid by color and character.

Dr. SAGAWA asked if it is better to use luminous intensity or not. Mr. ERIKSSON replied that eye is a complex sensor and that the condition of the eye should be considered when designing aids to navigation. Mr. Jaeger added that when calculating nominal range an illuminance level at the eye (0.2 microlux) and a meteorological visibility (10 nm) are assumed, but sometimes mariners detect a light at a distance greater than the nominal range because the true threshold of detection is less than 0.2 microlux.

Dr. SAGAWA commented that it should be recognized that such threshold could be different by its condition. Mr. ERIKSSON said that the eye is constantly changing back and forth between photopic, mesopic and scotopic state and that mariners probably most often are in mesopic state. He also believed that an eye illumination of 0.2 microlux would result in some state higher than scotopic.

Dr. OHNO asked to Dr. SAGAWA that Modified Allard Method was applied under the foveal vision and therefore should the photopic state is considered to calculate to effective intensity. Dr. SAGAWA answered that it depended on colors.

Then Cdr. NOGUCHI asked if the model of the apparent intensity should be separately established by each color of light. Mr. ERIKSSON replied that he would prefer an all-encompassing model that also takes the spectral composition of the light into account. Mr. JAEGER added that effective intensity models were developed using white light, but for a long time IALA (and others) have applied the models for other colors because no effective intensity models for colored lights have been developed.

Dr. SAGAWA commented that although the CIE used two photometry systems of photopic state and scotopic state, the scotopic photometry is not realistic and therefore the photopic photometry can be used for visual signal. Mr. ERIKSSON stated that with modern technology, it is quite possible to build a scotopic, and even a mesopic photometer. This could be achieved by using a spectroradiometer and applying the proper response function mathematically to its output. He admitted that such a device is currently not available off the shelf.

Dr. OHNO commented that when the model of the apparent intensity was developed, correction factors such as for color of light, brightness of field may be considered, as only the model of the effective intensity is defined and useable at this moment. Mr. ERIKSSON noted that for modeling purposes it probably is necessary to define a set of standard observers each in a different adaptation state. Dr. SAGAWA stated that it could be better to separate a discussion on temporal form from a discussion on color.

Mr. ERIKSSON then asked Dr. SAGAWA if it would be possible to derive a model based on the actual physiology of eye using modern computer technology. Dr. SAGAWA answered that from spectral component, it is possible but from temporal form, it is difficult. He however admitted that it needs to seek the best possible way using the present knowledge. Mr. JAEGER stated that from a practical standpoint, aids-to-navigation authorities need to provide the mariner the best possible information available regarding a light, even though the information may not be fully supported by research. He noted that, considering all the real-world viewing uncertainties, the information AtoN authorities provide now fundamentally meets the needs of the mariner.

Dr. SAGAWA said that as considering the practical use, it is possible to stand the model of effective intensity under certain condition. Cdr. NOGUCHI stated that although more precious model is preferable, it is necessary to simplify the model for the practical use because of the technological limitation and announced a coffee break.

After taking the official photo and taking a coffee break, Mr. JAEGER described some apparent intensity research conducted by Toulmin-Smith and Green in 1933. He showed a diagram that summarized the Toulmin-Smith and Green results. The diagram showed that the apparent intensity (brightness) of a flashing light at supra-threshold levels is higher than would be obtained using effective intensity models. He added that when designing a leading light, matching the brightness of front light and rear light is important and therefore the concept of interest is apparent intensity and not effective intensity.

Cdr. NOGUCHI then said that the draft IALA recommendation E-200-4 mentions several models for the effective intensity although the Modified Allard Method is recommended and the former IALA recommendation selects only one method which is the Schmidt-Clausen Method for the effective intensity. He added that the Japan Coast Guard thinks that selecting only one method is preferable and he asked how the IALA think on this matter. Mr. JAEGER answered that the IALA work group regarding this matter, and concluded that the ultimate goal is to develop apparent intensity models that can be applied at supra-threshold illuminance levels. The apparent intensity models would ultimately be used to calculate practical ranges for publication in the List of Lights and on charts. But in the meantime, aids-to-navigation authorities are free to continue to use the effective intensity models that they have been using. The IALA work group does not feel that it would be right to take action that forces lighthouse authorities to switch from one effective intensity model to another, and then possible switch to an apparent intensity model in a few years.

After introducing by himself, Mr. HANANO said that there was a concern that applying the different model could make mariners confused and asked what model the Danish and US authority would apply regarding E-200-4. Mr. JAEGER answered that the USCG would continue to use the Schmidt-Clausen model for “well-behaved” intensity profiles but would use the Modified Allard Method for complex intensity profiles that are incompatible with Schmidt-Clausen. Mr. ERIKSSON answered that the Danish Maritime Safety Administration would do the same.

Dr. OHNO stated that, while he recognizes the practical needs in USCG and IALA, the task of the CIE is to internationally standardize the definition of effective intensity with only one method, and so the TC2-49 was established. Dr. SAGAWA commented that the Allard Method uses the convolution that assumed the human eye is a liner system and therefore using the Allard again is meaningful while other methods are empirical formula. He added that the Allard impulse response is rather simple however recent studies show that the impulse response is actually bi-phasic or tri-phasic and further study is needed.

Dr. OHNO commented that the CIE standpoint is to make the recommended model method for effective intensity as soon as possible because of the strong needs for standardization; however he recognized the necessity of the further study. Dr. SAGAWA mentioned that the important point for the application of the Modified Allard is to clarify its condition.

Then Mr. ERIKSSON proposed to add one more topic to the agenda for further discussion, namely ‘the range of flickering light’ as proposed by Mr. KERGADALLAN. The chairman approved his proposal.

Cdr. NOGUCHI asked to Dr. OHNO, in order to develop a model for apparent intensity, which would be better; to extend the Modified Allard Method or to develop a completely new model. Dr. OHNO answered that he thought a new model would be necessary; the apparent intensity is quite interesting topic for the CIE and the CIE would like to investigate it and if a good model of the apparent intensity can be found, it could become a new standard. Mr. JAEGER mentioned that apparent intensity experimental data is limited and it will take time to develop comprehensive apparent intensity models. He added that the rectangular pulse profiles associated with LEDs are different from old rectangular pulse profiles produced using shutters and therefore more research is needed. Dr. SAGAWA commented that for the practical purpose, handling the supra-threshold brightness was very important for signaling.

Finally Cdr. NOGUCHI summarized the morning session as the more research and study is obviously needed for the applicable model of the flashing light and announced the morning session was finished.

4.3. Second Session “Conspicuity”

After the lunch, Cdr. NOGUCHI asked if there was any question or comment regarding the first session. Dr. OHNO asked to Dr. SAGAWA what kind of problem would be expected if the Modified Allard Method is applied to double pulses flashing light. Mr. JAEGER added that the USCG report on the effective intensity of train of pulse matched with the Modified Allard Method and found no problem. Dr. SAGAWA answered as he showed graphs of his experiment that when two pulses are very close, the profiles of intensity or brightness of two pulses are not matched with the Allard Method or other methods.

Dr. OHNO thanked Dr. SAGAWA for his answer and he admitted that there is a need to study more on the difference between Dr. SAGAWA's experiment and the USCG report. Dr. OHNO added as he showed other charts that while an impulse response of point source light is rather simple, when the stimulus or brightness of the light becomes higher, the impulse response becomes bi-phasic or tri-phasic. He said that the impulse response of human eye is so complicated.

Then Cdr. NOGUCHI started the second session on conspicuity as he introduced Mr. JAEGER as the starting presenter of the session. Mr. JAEGER showed one picture which became the framework for the discussion of conspicuity. The picture showed some aids to navigation lights along with background or rival lights. Mr. JAEGER explained that there were two sets of leading lights and the synchronized set was more conspicuous than the non-synchronized one although the two sets had the same apparent intensity.

Mr. ERIKSSON commented that it had been clearly demonstrated that conspicuity is a complicated concept and quite difficult to quantify. He mentioned that one could however mentally picture conspicuity as the combination of four 'contrast-like' properties: brightness/intensity contrast, spectral/color contrast, temporal contrast and spatial contrast. He suggested that perhaps conspicuity could be quantified by somehow 'summing up' the effect of these four contrasts.

Then Cdr. NOGUCHI commented that in Japan, the background lighting problem had became serious in 1980's and the Japan Coast Guard took various countermeasures such as synchronized lighting, illumination of tower and flickering light. He asked to Mr. ERIKSSON and Mr. JAEGER if there is any action taken to increase conspicuity at the Danish Maritime Safety Administration or the US Coast Guard.

Mr. ERIKSSON answered that aids to navigation in Denmark had not yet suffered from lighting pollution to the same degree as in Japan, which is why one mostly still uses traditional countermeasures such as increased intensity, color and in some cases synchronization which now has become available and seems to be very useful for this kind of problems. Mr. JAEGER answered that background lights, particularly those associated with new security lighting have become a serious problem in the US and only countermeasure has been increasing the intensity of lights. He further noted that the use of new LED lights has made it easier to achieve higher intensities with lower power consumption.

Mr. FUKUSUMI commented that the conspicuity is changed by the surrounding condition. Then he added that emerging of LED enables to make rectangular pulse and this rectangular pulse has very steep edge which other waves such as sound do not have and this steep edge makes the light very conspicuous. He concluded that, as his personal opinion, therefore the conspicuity problem could be solved if there is a calculation that solely dealt with the rectangular pulse.

Mr. JAEGER asked if the comment concerned a comparison between LED and incandescent lights. After confirmation he said that the intensity profile of a rectangular LED flash is obviously different from that of an incandescent flash, and that the steep leading edge of the LED flash likely makes the flash more conspicuous than that of an incandescent flash. He further cautioned that one must separately consider effective intensity, apparent intensity and conspicuity because they are different concepts.

Mr. FUKUSUMI commented that because of cost-performance, increasing of intensity has limit and therefore flickering light is effective to increase conspicuity. Mr. ERIKSSON also commented that the typically rectangular flash profile of LED’s is more conspicuous than the smooth flash of incandescent lamps; also the saturated color of LED’s makes them rather conspicuous. He added that a red light of an incandescent lamp using red filter has a relatively broad color spectrum while a red LED light has a very narrow spectrum of only a few nano-meters and therefore conspicuous.

Mr. Jaeger said that effective and apparent intensity studies used white, incandescent light sources but the models developed from these studies have been applied to all spectral distributions. The applicability of these models for other spectral distributions is unclear and ideally will be a subject for further research.

Then Cdr. NOGUCHI asked to Mr. JAEGER if the increasing of intensity of light has actual effect against the background light since the port security lights seemed very strong. Mr. JAEGER answered that conspicuity was certainly increased but whether it was increased enough is uncertain therefore additional methods of increasing conspicuity such as synchronization or flicker should be considered.

Cdr. NOGUCHI asked again what kind of guideline on conspicuity the IALA EEP committee has considered while the conspicuity is difficult to quantify. Mr. JAEGER answered that the study group on conspicuity in the EEP committee has not yet started the work and the goal of the work is to find conspicuity models but it is uncertain when the goal will be accomplished. He added that the first step would be the identification of factors that impact conspicuity, hopefully followed by a measure of the impact of the factors on conspicuity.

Dr. SAGAWA commented that the conspicuity is quite new concept even in the field of perception and the important point is to consider that human eye finds a signal with an interaction of the surrounding environment. He added that when regarding the interaction it seems to be helpful to study a pop-up effect which stimulus find out from the surrounding environment of noise and the elements of the pop-up effect are for example color difference, direction of stimulus, size of stimulus. He also said that the flicker has the pop-up effect however the extent of the flicker effect was unknown and these elements of the pop-up effect are different by where the location of retina felt the element. He finally stated that a study on pop-up effect is proceeded in the field of the perception science and it could be useful to refer the result of the study for the conspicuity of the aids to navigation.

Mr. JAEGER agreed with Dr. SAGAWA's comment and added that the USCG had conducted some conspicuity research but the parameters were limited. A parameter not considered in the USCG study was the impact of illuminance on the conspicuity of a flickering light. This is important because Mr. KERGADALLAN of France found that the conspicuity effect was lost when the intensity was decreased. He stated that the impact of illuminance on the perception of a flickering light needs further study. Dr. SAGAWA commented that the findings of French study could be explained by using a Temporal Modulation Transfer Function that is used in the perception science and the effect of rectangular pulse also could be explained by using the function.

Mr. HANANO then said that when the JCG conducted the flicker experiment, one question was emerged. The question was that when four 0.1 second pulses were put in a 0.4 seconds flash light, some observer found only three pulses in the flash. Therefore it became a question when human eye feels the flicker whether by sensing light stimulus or sensing the gap of the pulses. He also said that it also seems that the possible cause is simply missing of the first pulse.

Dr. SAGAWA answered the question that the impulse response of pulse by human eye is vary because some responses have only one phase while other have positive and negative phase and if the positive phase and negative phase are met each other then it became zero. Therefore the answer could be found by predicting the output of human vision that what type of and how many phase are emerged. He added that according to his study, even a single pulse was felt as two or three pulses and therefore it is important to predict what would be happened in the brain as the impulse response of the flicker.

Mr. ERIKSSON commented that he had got the idea that the most energy efficient signaling method could be to match the stimulus flash profile to the impulse response function. Dr. SAGAWA replied that the idea is theoretically correct. Dr. OHNO commented that it is very difficult to match because the impulse response function is changed by the surrounding conditions.

Mr. ERIKSSON stated that it would be best if it were possible to generalize the function and then asked Dr. SAGAWA if in his opinion there is a large variation in the impulse response function of humans of different ethnic origin. Dr. SAGAWA answered that the factor is vary by humans however by collecting data of situation and defining the standard function it seems to be possible.

Mr. HANANO commented that the JCG experiment was carried out in the three areas, conspicuity, recognizability and brightness however the some observers could not distinguish conspicuity between recognizability. He added that it was also found that if a light has high effective intensity calculated by the Modified Allard Method, the light also has high conspicuity therefore the effective intensity and conspicuity seem co-related.

Cdr. NOGUCHI then asked if there were the definitions of conspicuity and recognizability. Dr. OHNO answered that although the effective intensity is clearly defined, the conspicuity and recognizability are not defined by the CIE terminology. Mr. ERIKSSON said that IALA uses the terms ‘detection’ and ‘recognition’ and that detection means that the observer has sensed that a signal was there and that recognition then means that the observer has understood the signal. He added that recognition is more important in the field of aids to navigation.

Dr. SAGAWA commented that the threshold becomes just a baseline if the recognition is more important for the application of aids to navigation. Mr. ERIKSSON replied that from that standpoint, the concept of apparent intensity is important. Mr. JAEGER added that 0.2 microlux become the level for recognition in IALA.

Then Cdr. NOGUCHI announced that the session was closed.

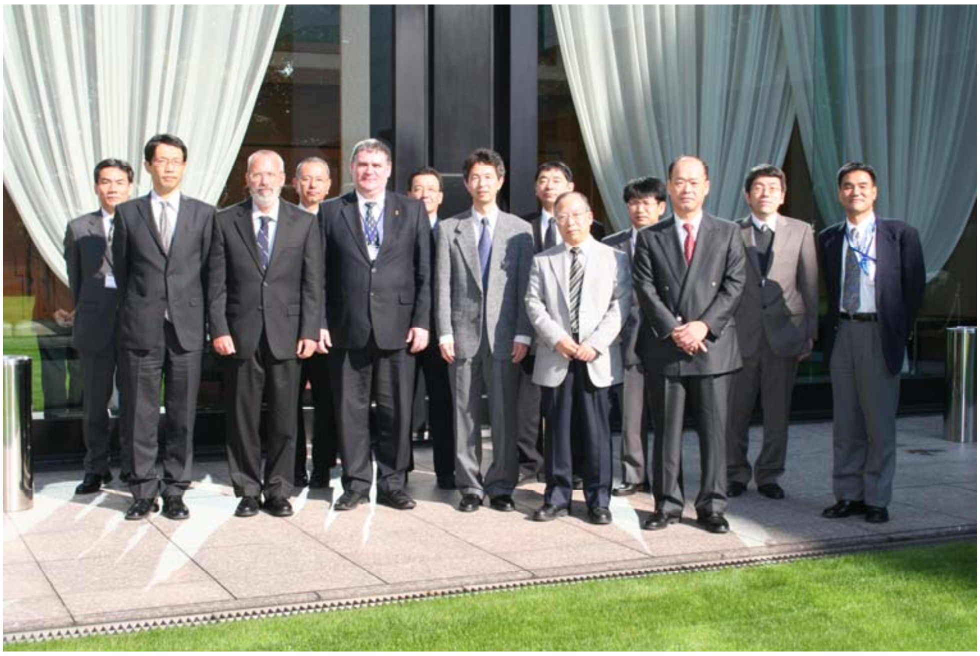

Photo 7: Participants

From left to right: Mr. Okajima, Mr. Igarashi, Mr. Jaeger, Mr. Yokoji, Mr. Eriksson, Mr. Nii, Dr. Ohno, Mr. Kawasaki, Dr. Sagawa, Mr. Fukusumi, Mr. Tane, Mr. Hanano, Cdr. Noguchi

4.4. Third Session "Flicker Range"

Cdr. NOGUCHI started the third session by asking if there was any comment on conspicuity. After confirming that there was no more comment on conspicuity, he summarized the second session that although conspicuity is a very important concept for designing marine aids to navigation, conspicuity is a very complicated matter and therefore further study or experiment is needed to find something that may lead to the development of a conspicuity model.

He then moved the discussion to the topic of third session, "flicker range" and asked to Mr. ERIKSSON to introduce the topic. Mr. ERIKSSON started the topic by giving a short version of the presentation of Mr. KERGADALLAN for those who did not attend the opening symposium and he said that Mr. KERGADALLAN's study showed that the range at which the flicker was clearly seen was shorter than the nominal luminance range of the light. Then he said that Mr. KERGADALLAN had proposed a so-called "flicker range" should be introduced. This is a range at which the flicker is clearly seen. He also had proposed that for flickering lights, the flicker range should be published along with the nominal luminous range. Finally Mr. ERIKSSON asked the participants to give comments to the proposal.

Mr. FUKUSUMI commented that the result of Mr. KERGADALLAN's study is same as the result of the JCG's study and the result of the study in the last year shows that 10 Hz or 20 Hz flicker light is less conspicuous than 5 Hz flicker at the range of 1 km. He added that as the observers are approaching to the light source, the evaluations of the observers are changed and 20 Hz flicker becomes more conspicuous than 5 Hz flicker. He concluded that the flicker range is changed by the frequency and if an aid needs longer flicker range, 5 Hz flicker is better to use. If an aid needs shorter flicker range, 10 Hz could be the practical frequency for the flicker.

Mr. HANANO commented that when he engaged in the study on flicker, his concern was that the mariner possibly saw a different character of a light when the light had flicker and it made the mariner confused. He added that the experiment of the JCG shows that the perception of the observer is different according to the distance even though the observer sees the same flicker light and the mariner should be aware of this effect. He said that the JCG made a proposal that when using the flicker, the chart symbol of the aid should clearly indicate that the light has the flicker and a word "with flicker" should be added to the symbol. He also said that if the flicker light becomes familiar to mariners, the marine aids to navigation become more conspicuous.

Mr. JAEGER commented that the Japanese study and the French study both show that as distance is increased, the flicker effect decreases or is completely lost. He then expressed a concern about the use of an IALA ultra-quick flash by AtoN authorities (while noting that the U.S. Coast Guard does not use the ultra-quick flash characteristic). His concern was that an ultra-quick flash with a 5 Hz frequency could look like a steady light when reviewed at a distance. The mariner could be confused if the light is advertised as a flashing light but looks like a steady light. He stated that it would probably be appropriate to publish that when a light is flickered the flicker effect decreases with increasing range.

Mr. ERIKSSON thanked for all the comments and said that as Japan proposed, the first step was to clearly indicate on the charts or other publications that the light is flickering and that one also needs to provide a general remark saying that the perception of flickering lights is dependent on viewing distance. He added that he welcomed any experimental data relating to this matter, since such data are essential for calibrating a future model for perception of flickering lights. He concluded that while the proposal of publishing the flicker range was not supported by those present, the ability to calculate flicker range is still needed from an Aid to Navigation engineering point of view.

Cdr. NOGUCHI commented that the important matter of the flicker light is how the mariners perceive the flicker light and therefore an actual experiment to the mariners is necessary. Mr. FUKUSUMI showed a demonstration of comparison between a conventional flashing light and a flickering flashing light (10 Hz frequency and 10 % duty ration) of the same luminous energy and said that the flickering flashing light was brighter than the conventional one. He added that the flickering flashing light had 10 times more peak intensity and therefore if the mariner sees the both lights by binoculars beyond the nominal luminous range, there is possibility of finding the flickering light first. He finally said that therefore the word “flicker range” needs to be defined more clearly.

Mr. JAEGER said that the demonstration included three concepts, effective intensity, apparent intensity and conspicuity however the French study was just an early stage of the experiment. He suggested that it may be better to publish only nominal luminous range with an annotation that the light has flicker and with a general comment that when a light if flickered the flicker effect decreases with increasing range of observation.

Dr. SAGAWA commented that the temporal modulation transfer function greatly depends on brightness level and if the brightness level is high, it becomes a band pass filter which means that the flicker is easy to detect and if the brightness is low, it becomes a low pass filter which means a sensitivity of low frequency becomes increasing and therefore the data here is quite reasonable and understandable. He then asked that in the field of visual science the perception of eye is described by using intensity of light, however, in the field of visual signal, if the perception of eye is described by using distance or not.

Cdr. NOGUCHI answered that when designing visual aids to navigation, a range is the first thing to consider and therefore the distance is important factor for aids to navigation authority. Mr. ERIKSSON added that 0.2 microlux is used for the calculation of the nominal luminous range. Mr. JAEGER also added that 0.2 microlux is based on the assumption that there are no rival lights, and if there are rival lights then an illuminance level higher than 0.2 microlux is required.

Dr. OHNO commented that these phenomena are described by using the temporal modulation transfer function and the temporal modulation transfer function is calculated from the impulse response function thus it seems that the discussion goes back to the morning session. Dr. SAGAWA agreed to Dr. OHNO and commented that the temporal modulation transfer function and the impulse response function are mathematically convertible and for understanding the phenomena, the temporal modulation transfer function is better on, the other hand, for calculating the wave form, the impulse response function is practical.

Photo 8: Discussion

After confirming no more comment, Cdr. NOGUCHI summarized the session that although it is not necessary to publish the flicker range, it should be published that the light has flicker and it might to be necessary to calculate the flicker range and therefore the further researches of temporal modulation transfer function and impulse response function are needed.

After the summarization, Dr. SAGAWA commented that his recent research theme is aging effect of human eye and the aging greatly influences the temporal visual function. He added that therefore designing of aids to navigation could be needed the consideration of the aging effect and it is expected that some research regarding the aging effect would be carried out in the future. Cdr. NOGUCHI said that Japan is one of the most aging countries and therefore the JCG has to start the research in the future. Mr. ERIKSSON also commented that it might be necessary to conduct a research on gender difference in addition to the aging. Then he thanked the Ocean Police Research Foundation and the JCG for arranging the discussion and remarked that the discussion was quite informative and the research of the JCG on the flicker light was very advanced and still progressing; therefore the JCG results are very inspiring for other IALA activities in this field.

Cdr. NOGUCHI returned back the chair to Mr. TANE. Mr. TANE firstly thanked the all participants for their active discussion and made the final remarks of the day that the JCG could actively contribute more to the research and study in the field of visual signaling and then announced that the meeting was adjourned.

5. Onboard Welcome Reception

Mr. Shuichi YONEOKA, the Director General of the Maritime Traffic Department, the Japan Coast Guard, hosted a welcome reception onboard the cruising restaurant ship "SYMPHONY MODERNA" from 7 to 9.30 pm on 26th November. The reception was started by the welcome address from Mr. YONEOKA. He firstly welcomed the experts and the guests and then explained that the reason of this onboard reception was to make a chance of observing the real situation of Japanese background lighting environment and viewing condition of aids to navigation and by using this observation to stimulate and activate the discussion. He then introduced the field experiment on the flicker lighting and hoped that this new lighting method would become the new technology of aids to navigation. Finally he proposed a toast and started the reception.

Photo 9: Reception

Toast by Mr. Yoneoka

During the reception, there were a greeting from V-Adm. Eisuke KUDO (JCG-Ret.), the executive director of the Ocean Policy Research Foundation and some words from the experts. The experts and the guests enjoyed not only conversation and food but also the night view of the port of Tokyo. They also observed numerous lights in the port including lighted buoys and offshore lights and exchanged opinions and comments especially regarding the high intensity of the port lights and the flicker light of the port vehicle such as forklift truck, security car.

Photo 10: Reception

Greetings from V-Adm. Kudo

Photo 11: Reception

Photo 12: Night view observation

6. Technical Tour

The technical tour to the Japan Coast Guard Research Center was conducted on 27th November. Three experts and five JCG officers participated in the tour. The JCG Research Center is located at Tachikawa city, Tokyo, about one and a half hour bus trip from central Tokyo. First they made a courtesy call to Mr. Keizouh NOBUNAGA, Director of the center and received the introduction presentation on the center from Mr. NOBUNAGA.

Photo 13: Technical tour

Presentation by Mr. Nobunaga

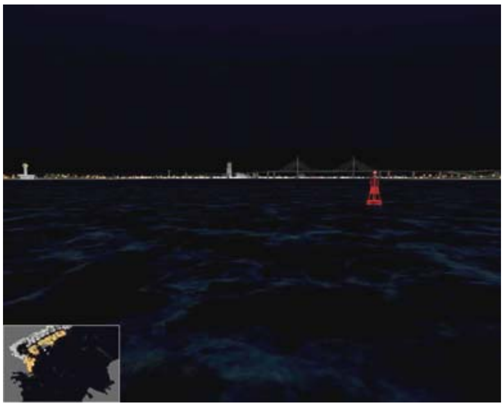

Photo 14: AtoN Simulator

Then they went to a room with an aids-to-navigation simulator developed by the center that is one of the most advanced simulators of its kind in the world. Mr. FUKUSUMI who developed the simulator explained and demonstrated the simulator. According to his explanation, the simulator is powered by two computers and is able to simulate about thirty ports in Japan. He described what the simulator displays especially focusing the brightness of lights, not the exact intensity of lights. He added that the simulator is able to change the height of the observer’s eye and atmospheric

Photo 15: Museum

transmissivity and to display any type of aids-to-navigation lights. He said that it was also possible to insert new aids to navigation and to change the color, intensity and character of the lights to evaluate the system of aids to navigation in a port. The demonstration showed the port of Yokohama and he controlled the simulator to display entering to the port. The experts asked various question and highly praised Mr. FUKUSUMI for the development of the simulator.

After the simulator room, they toured the various laboratories of the center including a museum of aids to navigation and a circulation water tank. Having a lunch in the meeting room of the center, the experts exchanged views and opinions on various topics with the staff of the center.

7. The Final Meeting

The second and final meeting was held on 28th November at the same place of the first meeting. The final meeting was allocated to mainly the summarization and the conclusion of the meeting. The participants were the same as the first meeting.

7.1. Summarization

Mr. TANE started the meeting by brief explanation of the overall view of the expert meeting including the social events and handed the chair to Cdr. NOGUCHI. Cdr. NOGUCHI then asked all participants if there were any comments or questions before the summarization.

Mr. ERIKSSON thanked Dr. SAGAWA for providing valuable information on the impulse function of the human eye. Cdr. NOGUCHI asked if the experts know of any research center or organization that conducted a research and study on visual signal. Mr. JAEGER commented that much of the work that needs to be done involves an understanding of perception, and perception involves many concepts that are new to AtoN engineers. He added that for that purpose, exchanging the data or materials was important and the material from Dr. SAGAWA was quite valuable.

Dr. SAGAWA mentioned that researches of temporal aspect of vision started from 1960s, however the temporal aspect is very complicated matter and therefore challenging and the researches are still continued. He added that the application of the result of researches to practical use is important and applying visual characteristic of flashing light to marine aids to navigation is therefore necessary. He also commented that from such reason, providing the information from the CIE is very important.

Dr. OHNO commented that the CIE is a good place for gathering and providing the information of the research, however the research on flashing light is recently not a hot issue. He added that the advent of LED is a good chance to reactivate the research on temporal aspect of human vision and advocating the needs of new research in the CIE and other international bodies is also important. Mr. JAEGER added that information on the temporal aspect of vision from visual scientists is a new concept for many aids to navigation authorities and there are a lot of things to learn from the visual scientists.

Mr. FUKUSUMI commented that there could be two topics for the future study, one is the number of the pulse in one flashing light and another is energy saving lighting method. Mr. ERIKSSON said that the IALA EEP committee would continue with the small group of experts and visual scientists to seek for an all encompassing model at least over the next work period of four years. Cdr. NOGUCHI mentioned that although there are few chances to go abroad for attending the IAIA committees because of the budgetary constraint, it becomes possible to communicate and exchange information through internet and the JCG would actively contribute to the CIE and IALA using the internet.

Dr. SAGAWA commented that for proceeding both fundamental and application researches in visual signal, this kind of meeting that both engineers and scientists participated in is important and the liaison among the CIE, IALA and aviation fields is essential to have the larger meeting in order to promote the researches especially on the LED applications and technologies. Dr. OHNO added that such researches on human vision and perception should be driven by needs from industries or practical applications and it probably needs to hold a joint style meeting such as CIE symposium in the future.

Mr. ERIKSSON commented that the IALA EEP committee established a group of experts to promote this topic. He also said that IALA represents both AtoN service providers and industry and that IALA looked toward scientific organization such as the CIE for scientific research and relevant standards. He urged CIE and IALA to join forces, and strengthen even further their liaison on the topics of this expert meeting. Mr. JAEGER stated that the IALA EEP working group on light which primarily conducts business through the internet or on telephone would ask the JCG to participate in the group.

Mr. IGARASHI said that if possible the JCG was willing to participate in the group. Mr. TANE also commented that the JCG would consider the possibility of holding this kind of meeting in the future.

After confirming no more comment, Cdr. NOGUCHI asked the all experts and participants to check the executive summary that was drafted by the JCG. After some amendments the executive summary was approved by the experts and participants. The executive summary is attached at the head of this report.

7.2. Conclusion

The conclusions and recommendations of the expert meeting were drafted by the JCG, amended by the experts and participants, and agreed to by all. The conclusions and recommendations are attached to the end of the executive summary.

8. Closing

Mr. TANE thanked the all experts for their contributions and commented that this type of meeting was very beneficial in that it promoted collaboration between CIE, IALA and JCG. He also thanked the interpreters and JCG young staff for their efforts to make the meeting successful. Mr. ERIKSSON, Mr. JAEGER, Dr. OHNO and Dr. SAGAWA all thanked the OPRF and JCG for hosting the expert meeting and commented that the meeting was very informative and beneficial for all involved, including the experts. They were also pleased that the meeting laid the groundwork for further research, exchange of ideas, and meetings to promote advancements in visual signal theory. They also thanked the interpreters and the JCG staff for the work they did to make the meeting smooth and fruitful. Finally Mr. TANE announced that the meeting was officially closed.

Photo 16: Making Conclusion

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Annex 1 – List of Participants

Denmark **Danish Maritime Safety Administration**

Mr. Omar Frits ERIKSSON
Head, Aids to Navigation and Search and Rescue Division

Japan **National Institute of Advanced Industrial Science and Technology**

Dr. Ken SAGAWA
Prime Senior Researcher

Japan Coast Guard Headquarters

Mr. Akihiro TANE (Chairman)
Director, Aids to Navigation Engineering Division

Mr. Ko IGARASHI
Director, Floating Aids Office

Mr. Hideki KAWASAKI
Director, Vessel Traffic Service System Engineering Office

Mr. Tsunao YOKOJI
Deputy Director, Aids to Navigation Engineering Division

Cdr Hideki NOGUCHI
Senior Engineering Officer, Aids to Navigation Engineering Division

Mr. Kazushige HANANO
Deputy Director, Aids to Navigation Management Division

Mr. Fuminori OKAJIMA
Senior Operation Officer, Aids to Navigation Management Division

Japan Coast Guard Research Center

Mr. Katsuhiro NII
Chief, Navigation Aids Engineering Division

Mr. Yoshiyasu FUKUSUMI
Engineer, Navigation Aids Engineering Division

USA National Institute of Standards and Technology

Dr. Yoshi OHNO
Group Leader, Optical Technology Division

US Coast Guard

Mr. Larry JAEGER
General Engineer, Ocean Engineering Division

Special Participant

France CETMEF

Mr. Xavier KERGADALLAN
Chef du Group Optique

Expert Meeting on Standardization of New Lighting Method for Marine Aids to Navigation

Program

Day 1 – Tuesday, November 25, 2008

Time	*Activity*	*Venue*
1000 - 1030	Administrative Meeting	JCG Headquarters
1030 - 1100	**Courtesy Call to Director General, Maritime Traffic Department**	Ditto
1130 - 1300	Lunch	Japanese Restaurant HOTARU
1300 - 1330	Meeting with interpreters	Mita Conference Hall
1330 - 1720	**Open Symposium**	Ditto
1330 - 1340	Welcome from JCG	Ditto
1340 - 1420	Presentation from Mr. Jaeger “Effective Intensity, Apparent Intensity and Conspicuity”	Ditto
1420-1500	Presentation from Dr. Ohno “Modified Allard Method and CIE TC2-49”	Ditto
1500 - 1520	Refreshment Break	Ditto
1520 - 1600	Presentation from Mr. Eriksson “On the Use of Flicker in Maritime Signaling Application”	Ditto
1600 - 1640	Presentation from Mr. Kergadallan “Effect of Distance of Observation about Flickering Light”	Ditto
1640 - 1720	Presentation from JCG “New Lighting Method of LED Light”	Ditto
1720	End of Day	

Welcome Friendship Dinner
(Japanese Cuisine “Shabu-Shabu”)
Venue: Japanese Restaurant YAMATO-JI
Time: 1900 – 2100 hrs
Dress Code: Casual

Day 2 – Wednesday, November 26, 2008

Time	*Activity*	*Venue*
0930 - 1200	**Meeting: Session 1 "Effective Intensity and Apparent Intensity"**	Mita Conference Hall
0930 - 1030	Meeting	Ditto
1030 - 1040	Official Photo	Ditto
1040 - 1100	Refreshment Break	Ditto
1100 - 1200	Meeting	Ditto
	Overview of Session	
1200 - 1330	Lunch	Sushi Restaurant SHOUZAN
1330 - 1700	**Meeting: Session 2 "Conspicuity"**	Mita Conference Hall
1330 - 1500	Meeting	Ditto
1500 - 1530	Refreshment Break	Ditto
1530 - 1700	Meeting	Ditto
	Overview of Session	Ditto
1700	End of Day	

Onboard Welcome Reception
hosted by Director General, Maritime Traffic Department, JCG
(Beverages and finger food will be served)
Venue: Restaurant Ship SYMPHONY MODERNA
Time: 1900 – 2140 hrs
Dress Code: Lounge Suit (No Black Tie)

Day 3 – Thursday, November 27, 2008

Time	*Activity*	*Venue*
0900 - 1700	**Technical Tour: JCG Research & Development Center** Bus will leave the hotel at 0900. Lunch will be served at Showa Memorial Park or JCG R&D Center.	

Day 4 – Friday, November 28, 2008

Time	*Activity*	*Venue*
0930 - 1200	**Meeting: Summary and Conclusion**	Mita Conference Hall
0930 - 1030	Meeting	Ditto
1030 - 1100	Refreshment Break	Ditto
1100 - 1200	Meeting	Ditto
1200 - 1210	**Closing of the Meeting**	Ditto

Farewell Friendship Dinner (Optional)
(Japanese Cuisine)
Venue: Japanese Restaurant TORIKAKU
Time: 1900 – 2100 hrs
Dress Code: Casual

Annex 3

Presentation of Mr. Larry JAEGER

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THREE CONCEPTS:

Effective Intensity

Apparent Intensity

Conspicuity

Larry Jaeger
U.S. Coast Guard
Ocean Engineering

Effective Intensity: **Luminous intensity of a fixed light, of the same relative spectral distribution as the flashing light, which would have the same luminous range as the flashing light under identical conditions of observation.**

Luminous Range: **The maximum distance at which a light can be seen, as determined by the luminous intensity of the light, the atmospheric transmission factor, and the threshold of illuminance on the eye of the observer.**

At Threshold:

- The probability of detection is greater than chance, but not dependably high (typically 60% in lab studies)
- The observer can not determine color.
- The observer can not determine flash duration.
- Dark background with no rival lights.

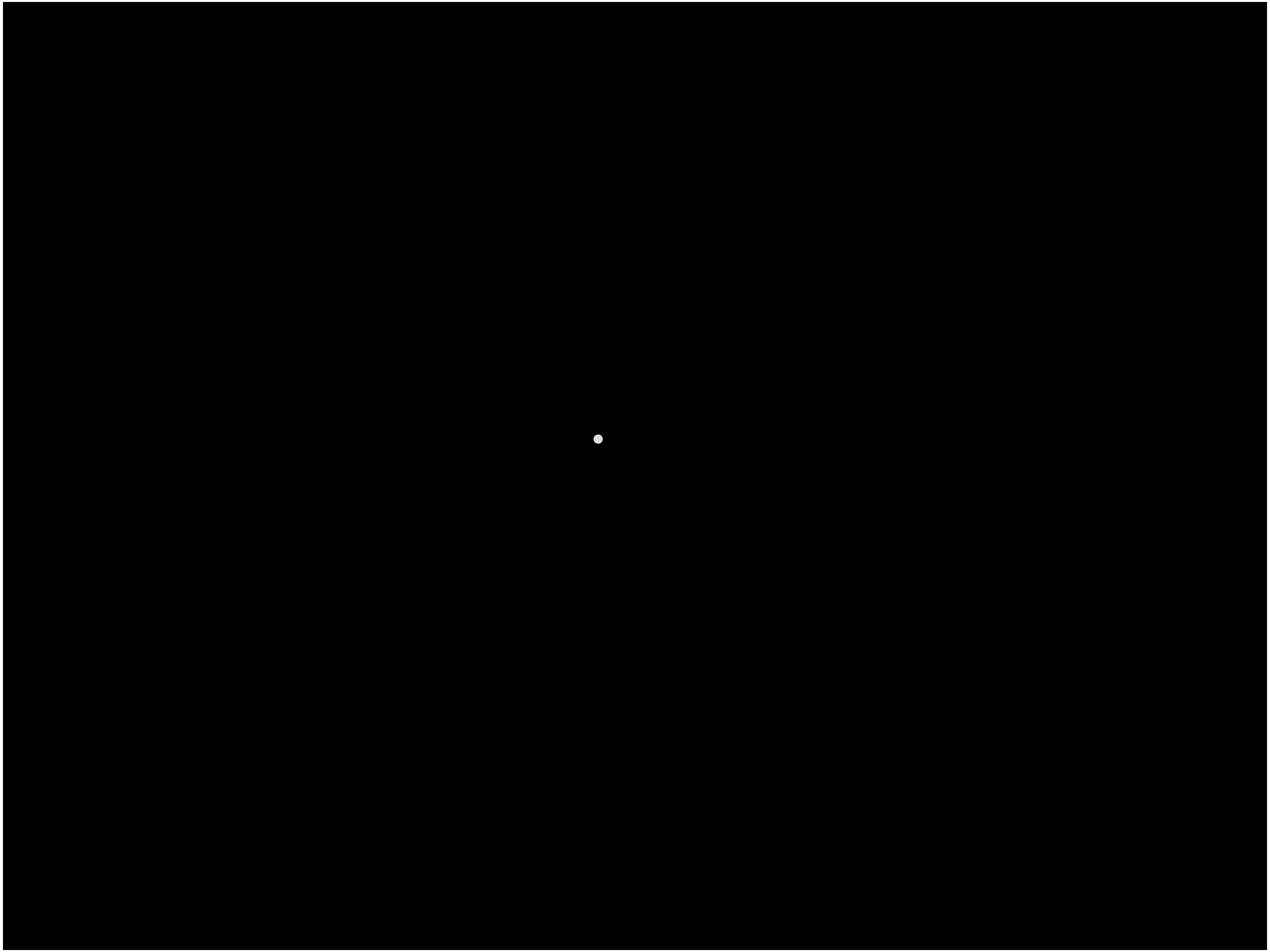
Not a useful concept for the mariner for most viewing situations.

Effective Intensity Lab Studies:

- Observers look at a single flashing light.
- Increase intensity until flash can be detected (find intensity level where flash is detected 60% of the time by an observer).
- Compare to intensity of a steady light that can just barely be detected.
- Change the flash duration and repeat.

Effective Intensity ← Can you see the light?

[redacted]



After collecting data from lab studies, assemble a <u>model</u>.

Models: Allard (1876)
Blondel-Rey (1911)
Blondel-Rey-Douglas (1957)
Schmidt-Clausen (1968)
Modified Allard Method
(Ohno and Couzin; 2002)

Dr. Yoshi Ohno is the world expert on the use of the Modified Allard Method.

Effective Intensity Summary

1. **Same effective intensity means same <u>luminous range</u>.**
2. **It is a concept with meaning only at the <u>threshold of detection</u>.**
3. **Typically not a concept of interest to the mariner.**

Second Concept:

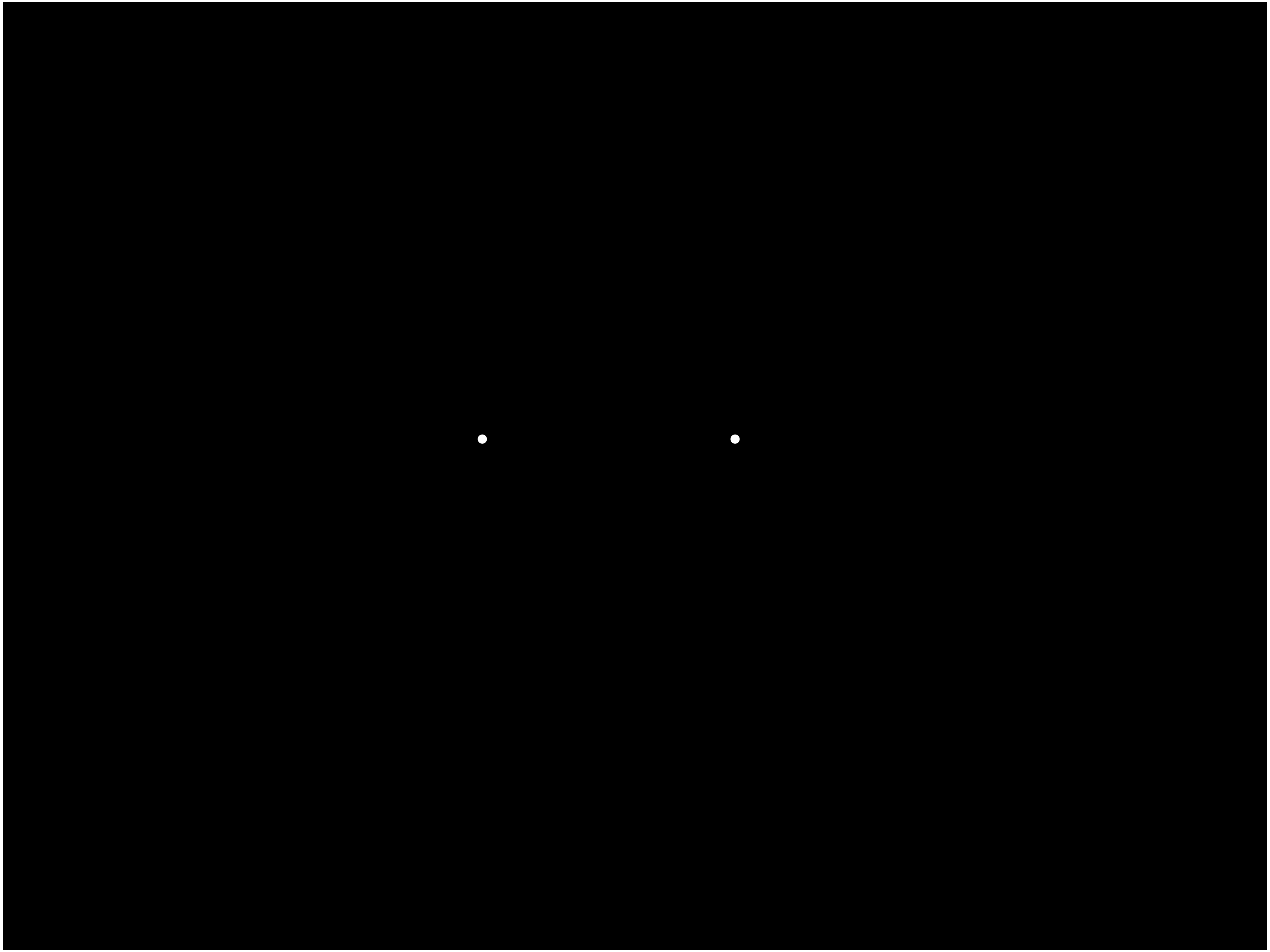
Apparent Intensity: The luminous intensity of a spectrally similar steady light that matches the flash in <u>brightness</u>.

IMPORTANT NOTE: The apparent intensity of a flashing light will be a function of illuminance at the eye of the observer.

Apparent Intensity <u>Lab Studies</u>:

- **Observers look at <u>two</u> lights.**
- **Observer adjusts the intensity of one of the lights until the observer believes that the lights appear equally bright.**

Apparent Intensity ← <u>Brightness</u> of a flashing light (compared to a steady light)



Four apparent intensity studies:

Broca & Sulzer (1902)

Toulmin-Smith and Green (1933)

Naus (1970)

Japanese Coast Guard (Imai, 2007?)

Toulmin-Smith & Green 1933

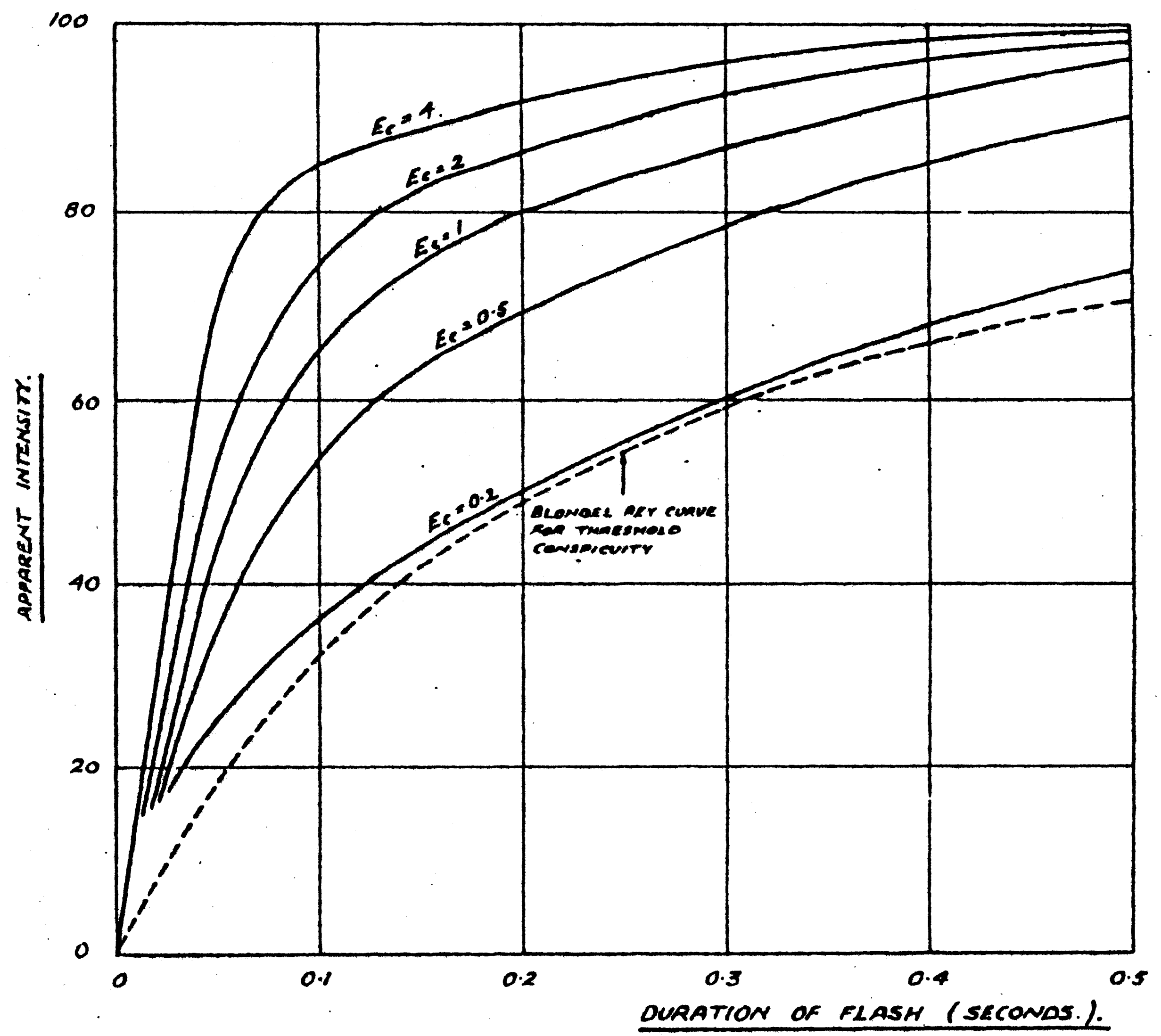


FIG. 5.—Fixed light equivalents at different conspicuity levels.

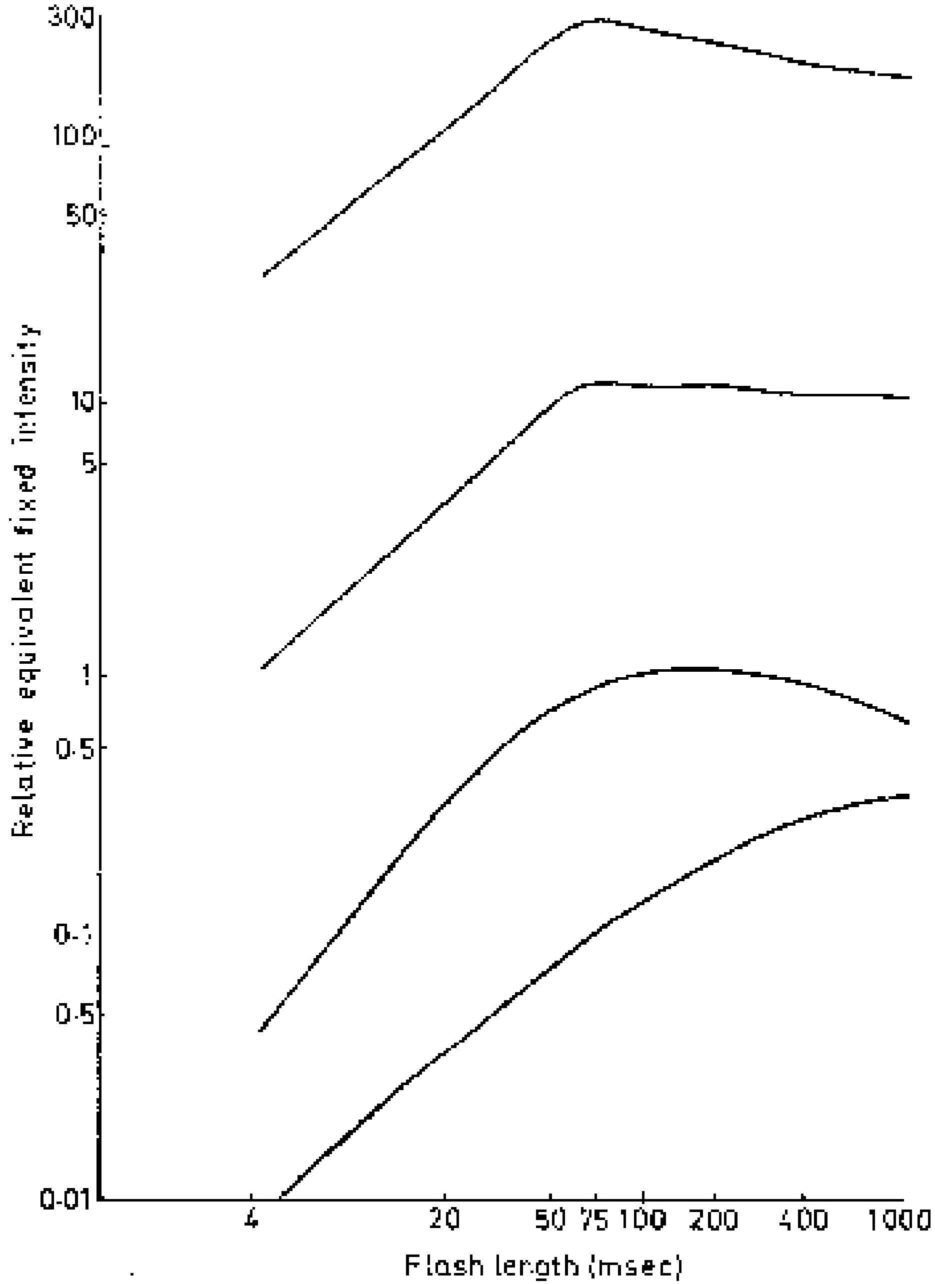


FIG. 4. Bottom curve from Blondel–Rey at threshold. Top three curves from experimental data at three different supra-threshold levels.

Broca & Sulzer (1902)

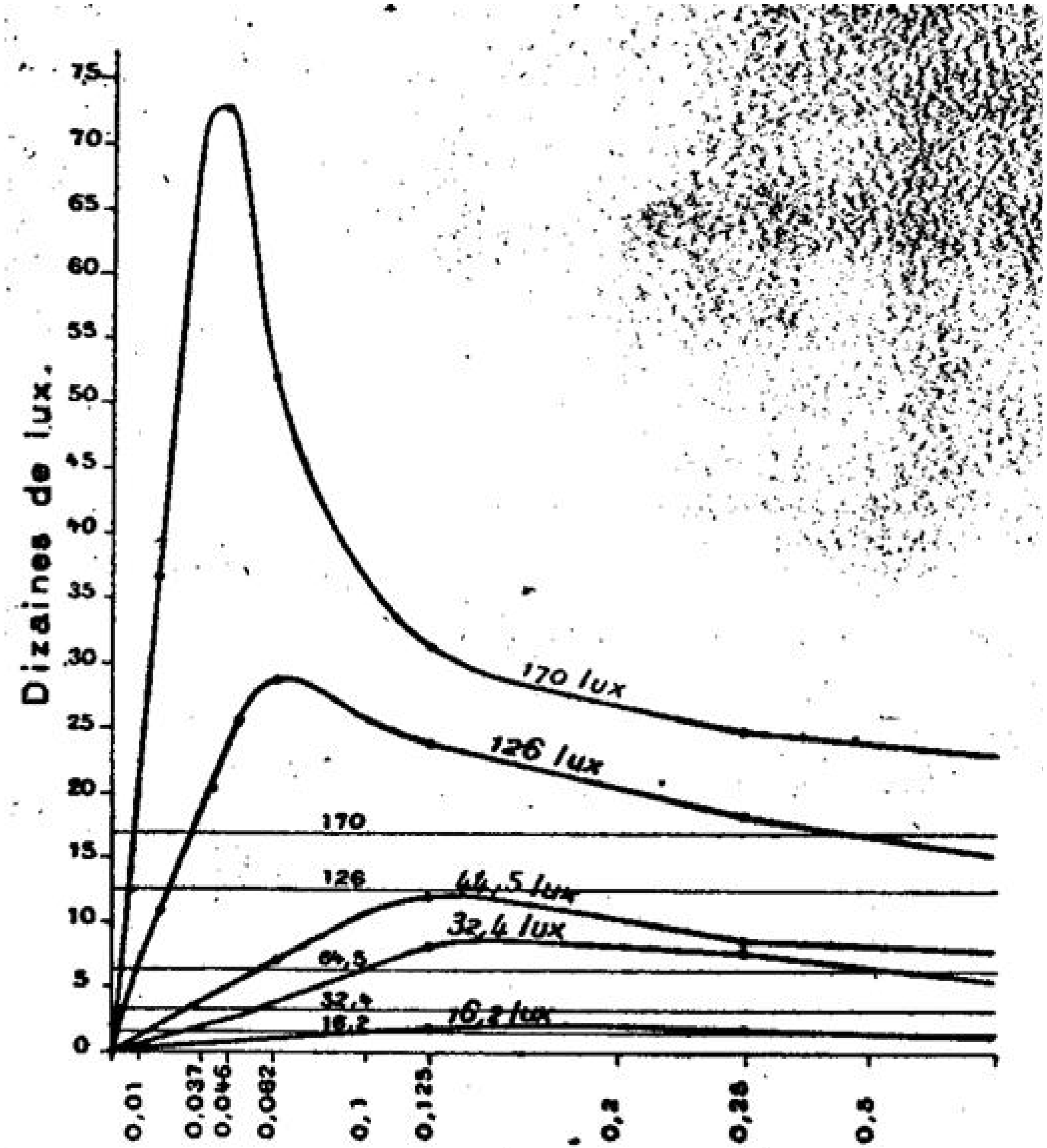


Fig. 6.

Apparent Intensity Summary

1. **Apparent intensity ↔ brightness.**
2. **It is a concept with meaning only at supra-threshold illuminance values.**
3. **Apparent intensity is a function of illuminance.**
4. **More data needed (different illuminance levels, flash profiles, spectral distributions).**

Third Concept:

Conspicuity: **The conspicuity of a light relates to how easy it is to locate the light against its background. A more conspicuous light will be located more quickly than a less conspicuous light; it will stand out from its surroundings more than a less conspicuous light.**

It is complex!

Conspicuity of a light will depend on:

- The light's illuminance level,
- The light's color,
- The light's Intensity profile,
- The light's spectral distribution,
- Synchronization with other flashing lights,
- The light's size and shape,
- Movement of the light,
- All the characteristics of the background that the light of interest is viewed against.

No overall “number” used to quantify conspicuity.

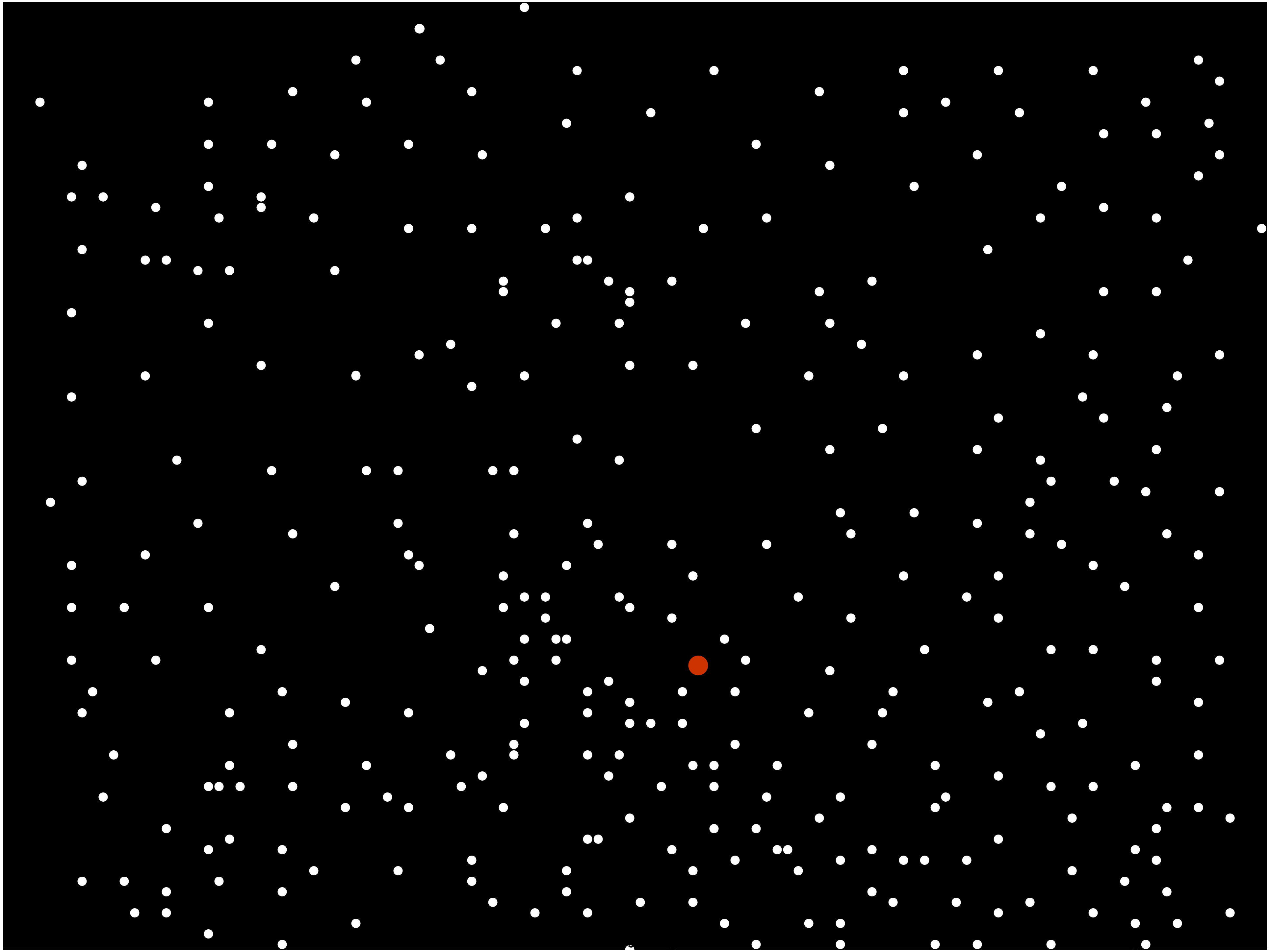
Conspicuity Lab Studies:

Observers try to locate a light of interest against a background of rival lights.

The conspicuity of the light correlates (inversely) to the amount of time it takes to locate the light of interest.

Less time to locate → more conspicuous

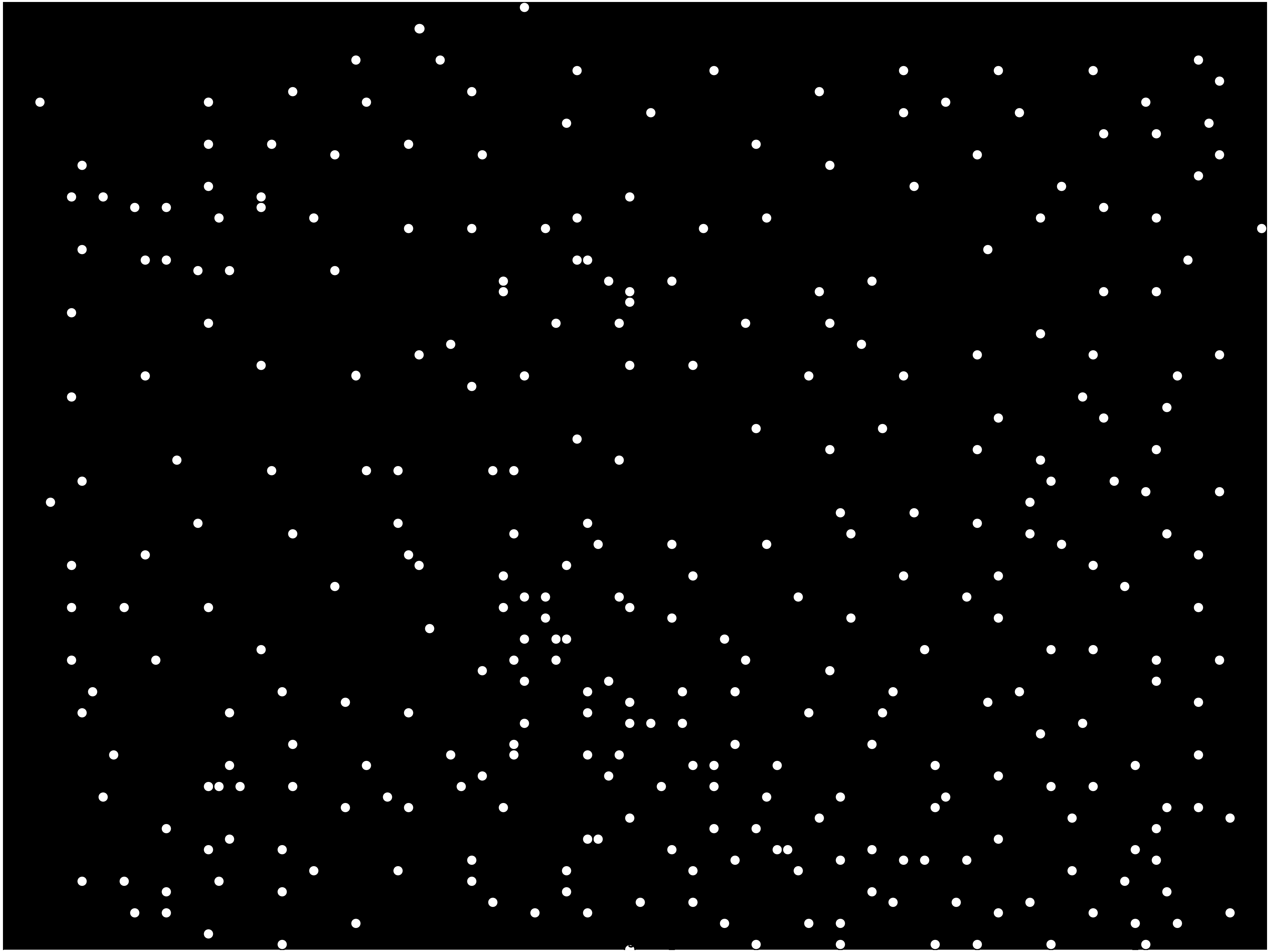
How long will it take you to locate the red, flashing light on the next slide?



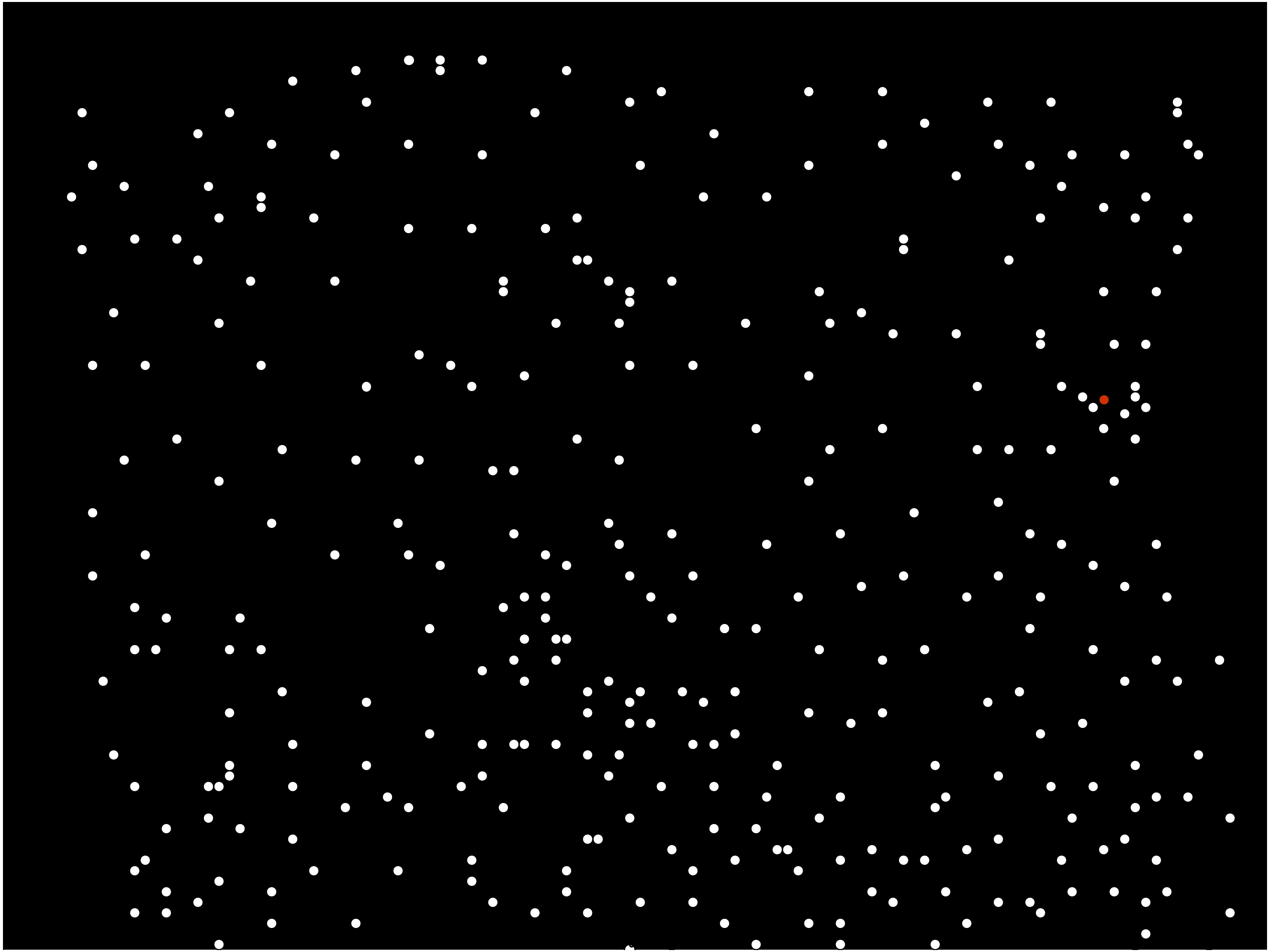
The flashing red light in the last slide could be located very quickly.

Therefore, against that background, the flashing red light has a high conspicuity.

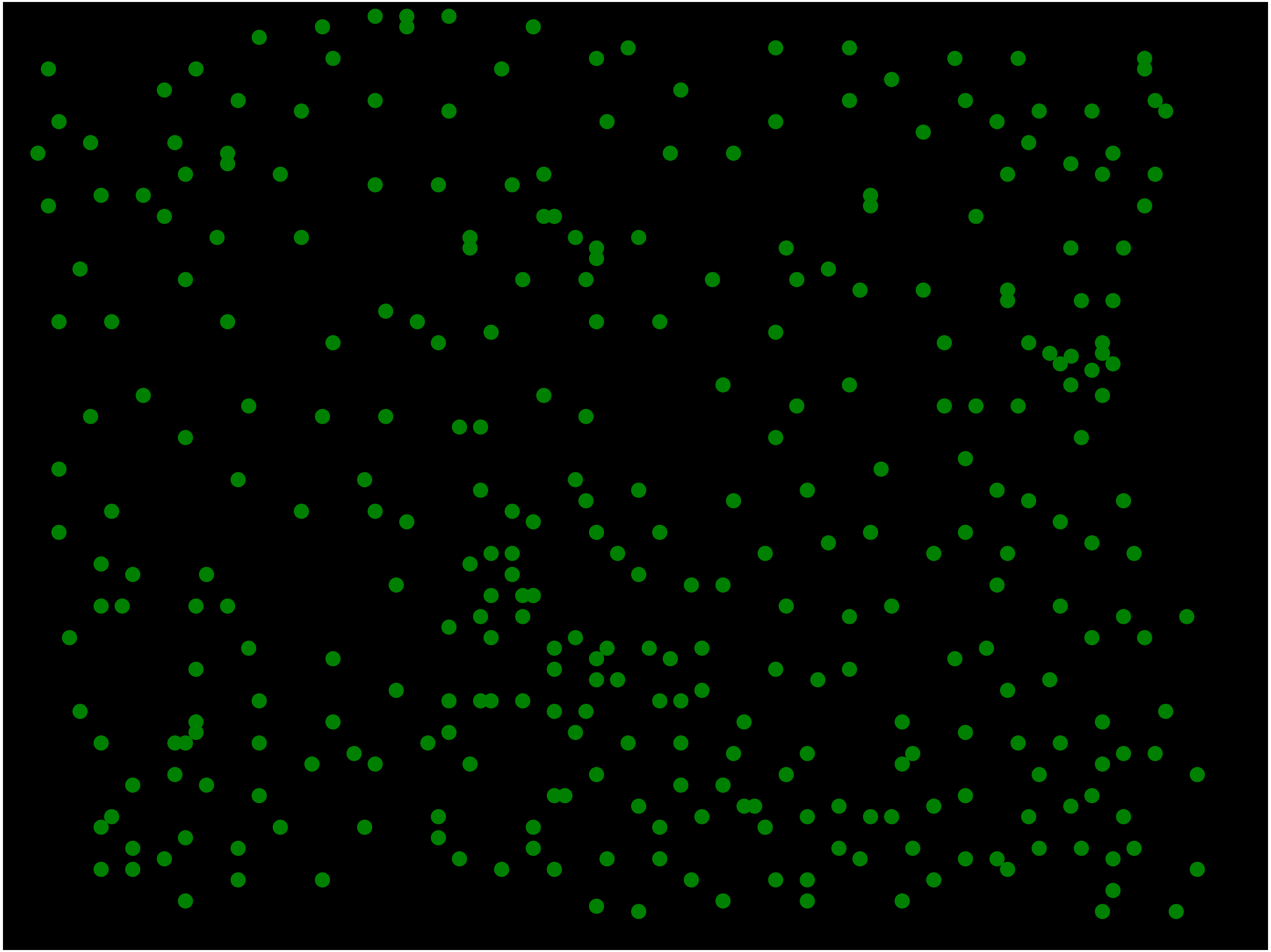
How long will it take you to locate the white, flashing light on the next slide?



How long will it take you to locate the <u>steady red light</u> on the next slide?



How long will it take you to locate the <u>steady green</u> aid-to-navigation light on the next slide?



The conspicuity of a light will depend as much on the character of the background as the character of the light!

USCG Study:

"Conspicuity of Aids to Navigation: Temporal Patterns for Flashing Lights" (Laxar and Benoit, 1993)

- **Looked at impact of frequency and duty cycle on conspicuity.**
- **Found that the most conspicuous light had the highest of 3 tested frequencies (3.85 Hz) and lowest of 3 tested duty cycles (30%).**
- **It is a good example of a conspicuity study.**

Summary (3 different concepts):

Same Effective Intensity ↔ Same Luminous Range.

Same Apparent Intensity ↔ Same Brightness.

Conspicuity ↔ Ease of locating light-of-interest against background (rival lights).

ありがとうございます。

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Annex 4

Presentation of Dr. Yoshi OHNO

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Modified Allard Method for Effective Intensity and CIE TC2-49

Yoshi Ohno, Ph. D.
(Director of CIE Division 2)

Group Leader, Optical Sensor Group
Optical Technology Division
National Institute of Standards and Technology
Gaithersburg, Maryland,USA

National Institute of Standards and Technology (NIST)

Federal agency under U.S. Dept. of Commerce.

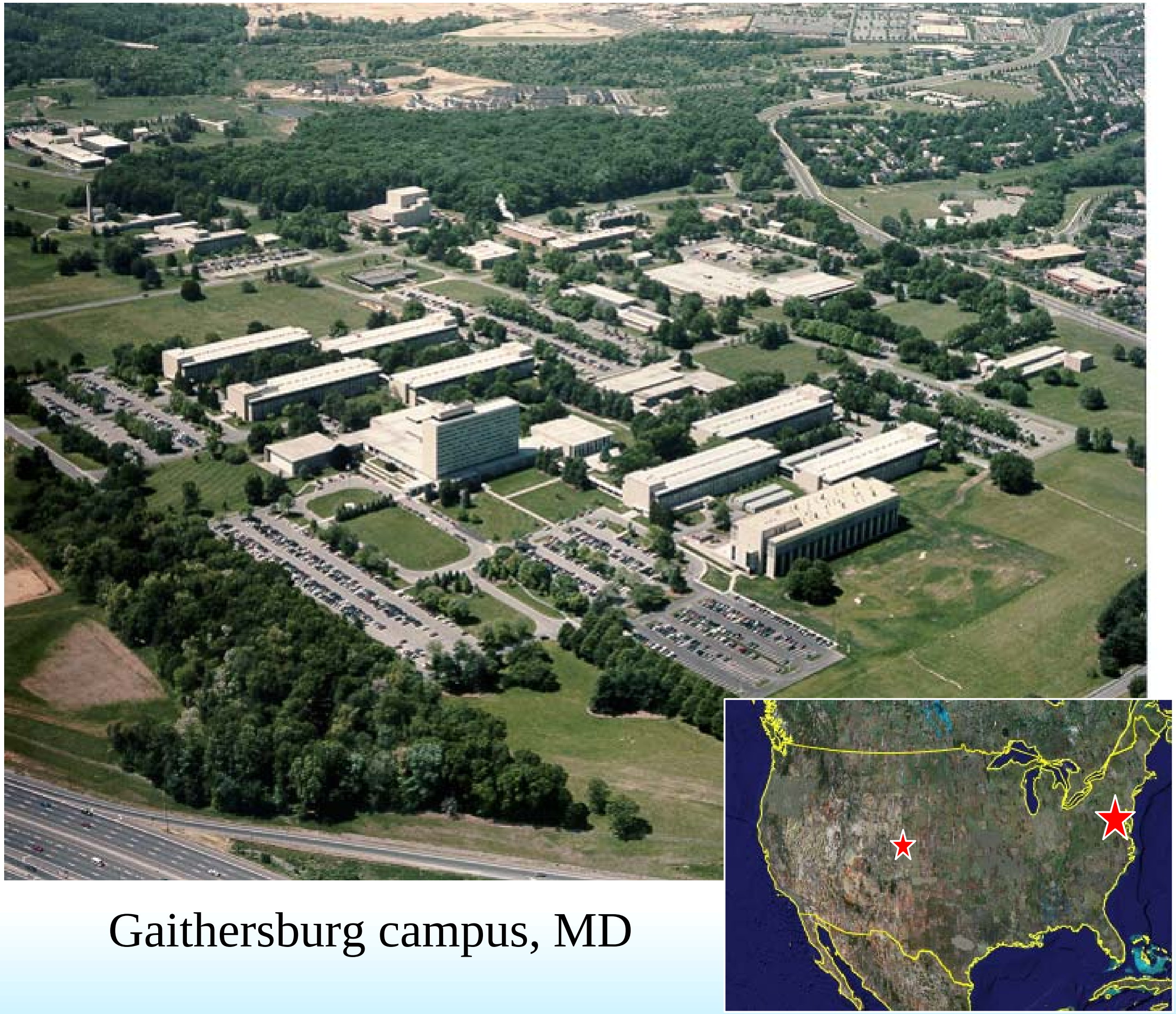
Formerly, National Bureau of Standards - founded in 1901.

NBS to NIST in 1988.

Main campus:
Gaithersburg, Maryland
Branch: Boulder, Colorado

~2800 employees + ~1600 associates

Annual budget ~$700 M



Gaithersburg campus, MD

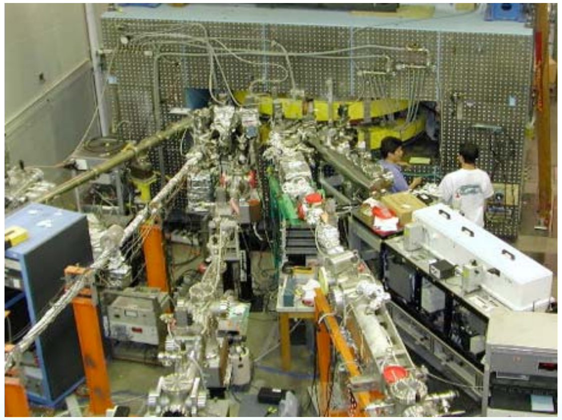
Optical Technology Division, Physics Laboratory

Maintains and disseminates national standards for optical radiation from UV to IR (200 nm - 20 μm)

- Optical power (watt)
- Spectral irradiance & radiance
- Spectral responsivity of detectors
- Radiation temperature (kelvin)
- Transmittance and reflectance of materials
- Photometry and colorimetry

Other research areas: remote sensing, biophysics, vision science, …

NIST Reference Cryogenic Radiometer



NIST Synchrotron Facility

NIST Photometry & Colorimetry

Calibration services

Photometry

- Luminous intensity (candela)
- Total luminous flux (lumen)
- Total spectral radiant flux (W/nm)
- Illuminance meters and luminance meters
- LEDs and Solid State Lighting products
- Flashing lights



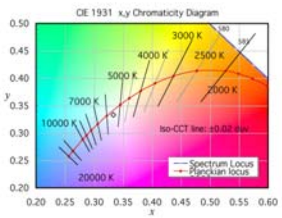




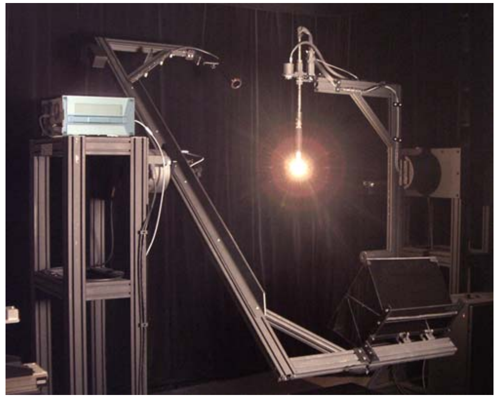
2.5 m integrating sphere

Colorimetry of light sources

- Color temperature (kelvin)
- Chromaticity, CCT







Goniospectroradiometer

Object color

- Spectral reflectance factor
- 0/45 surface color, gloss

Calibration of Flashing-Lights and Flash Photometers

NIST is the only national lab that provides calibration service for flashing lights

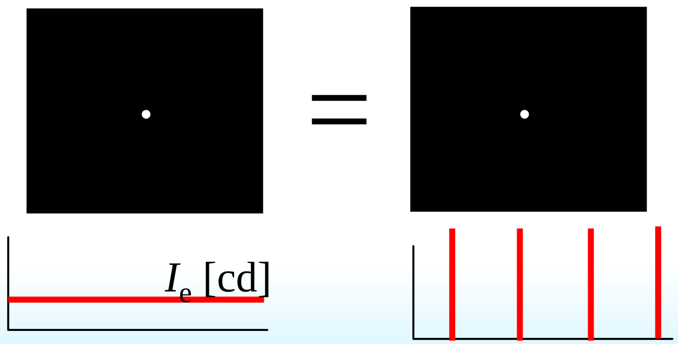
NIST Flashing Light Standard
Photometer System

Effective intensity

ILV (CIE 17.4 / IEC 50(845) 11-18

Effective intensity (of a flashing light)
Unit: **candela** (cd)
Symbol for quantity: I_e

Luminous intensity of a fixed (steady) light, of the same relative spectral distribution as the flashing light, which would have the same luminous range (or visual range in aviation terminology) as the flashing light under identical conditions of observation.



Application conditions under which effective intensity is defined:

- Threshold of achromatic detection
- White light
- Dark background
- Foveal vision
- Angular size should be visually zero.

Formulae for Effective Intensity

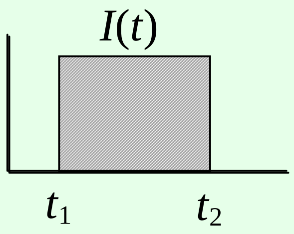
1. Allard (1876)

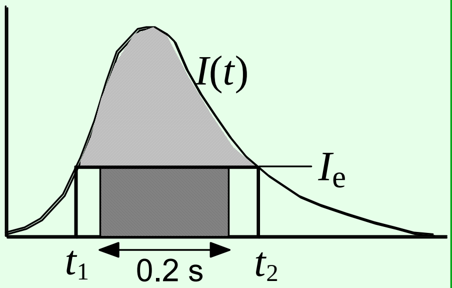
2. Blondel-Rey (1911), Blondel-Rey-Douglas (1957)

4. Form-Factor Method (Schmidt-Clausen, 1967)

5. Modified Allard Method (Ohno & Couzin, 2002)

Blondel-Rey (1911)





$$I_e = \frac{\int_{t_1}^{t_2} I(t)\mathrm{d}t}{a + (t_2 - t_1)}; \quad a = 0.2\ s$$

t_1, t_2 are determined to satisfy

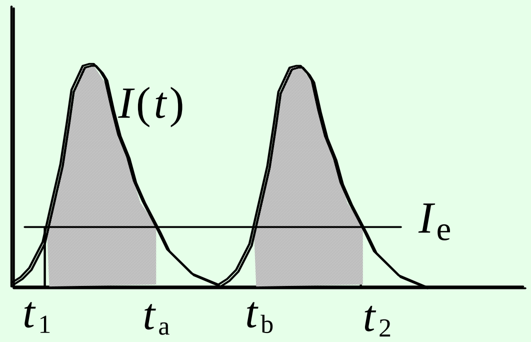
$I_e = I(t_1) = I(t_2)$

This is solved as

$$\int_{t_1}^{t_2} (I(t) - I_e)\mathrm{d}t = a \cdot I_e$$

Blondel-Rey-Douglas (1957)

(extension of B-R for a train of pulses)



$$I_e = \frac{\int_{t_1}^{t_a} I(t)\mathrm{d}t + \int_{t_b}^{t_2} I(t)\mathrm{d}t}{a + (t_2 - t_1)}$$

where $I_e = I(t_1) = I(t_2)$, $a = 0.2$ s

It is solved as

$$\int_{t_1}^{t_a} I(t)\mathrm{d}t + \int_{t_b}^{t_2} I(t)\mathrm{d}t = I(t_1)\{0.2 + (t_2 - t_1)\}$$

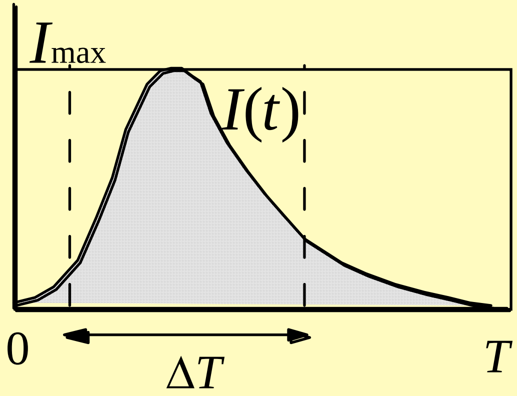
Then, $I_e = I(t_1)$.

Blondel-Rey(-Douglas)

- Empirical model from vision experiments on rectangular pulses.
- The formula for non-rectangular pulses was not experimentally verified.
- Calculation requires the pulse shape. Waveform must be measured accurately.
- For non-rectangular pulses, it requires iterative solution, thus needs a computer. (It cannot be realized by simple analog circuits.)

Adopted in **IES Guide** for Calculating the Effective Intensity of Flashing Signal Lights (1964)

Form Factor method



$$I_e = \frac{I_{max}}{1 + \frac{a}{F \cdot T}}; \quad F = \frac{\int_0^T I(t)dt}{I_{max} \cdot T}$$

$(a = 0.2\ \text{s})$

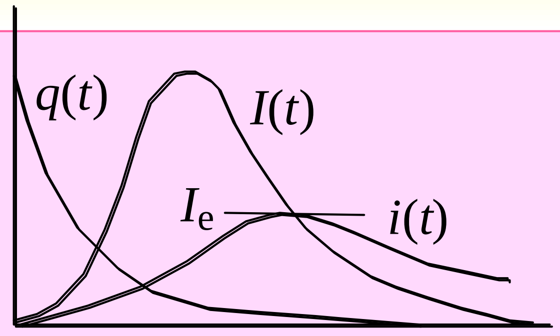
This is transformed to:

$$I_e = \frac{\int_0^T I(t)dt}{a + \Delta T}; \quad \Delta T = \frac{\int_0^T I(t)dt}{I_{max}}$$

- Modification of B-R for simpler calculation for non-rectangular pulses.
- Equivalent to B-R for rectangular pulses.
- Verified with vision experiments using 7 non-rectangular pulses.
- Requires only the integral and the peak of the pulse. (Waveform not needed. An analog, portable instrument is possible.)

Adopted in ECE Regulation No. 65 Uniform Provisions Concerning the Approval of Special Warning Lights for Motor Vehicles

Allard method



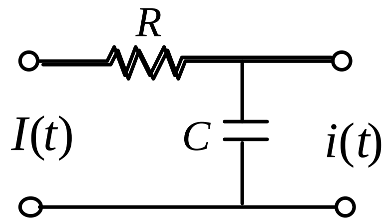
q(*t*): **visual impulse response function.**

Effective intensity is given as the maximum value of the convolution:

$$i(t) = I(t) * q(t)$$

where $q(t) = \frac{1}{a} e^{-\frac{t}{a}}$

- Physiological model : the eye is an integrator (low-pass filter).
- Requires only the peak of the convolution. (Waveform not needed)
- The convolution can be achieved with a simple R-C filter circuit.

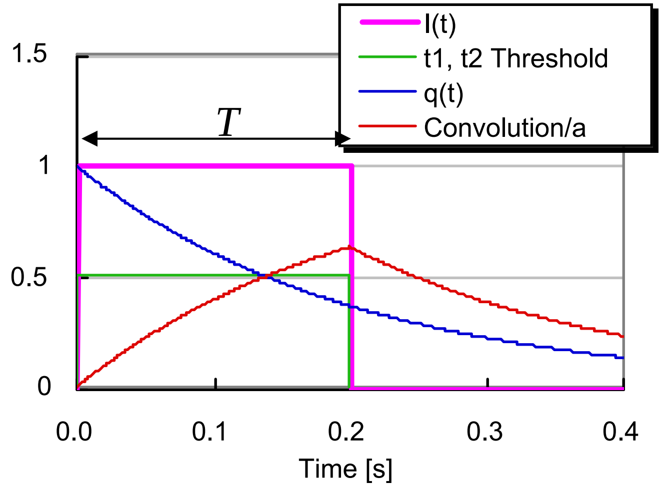


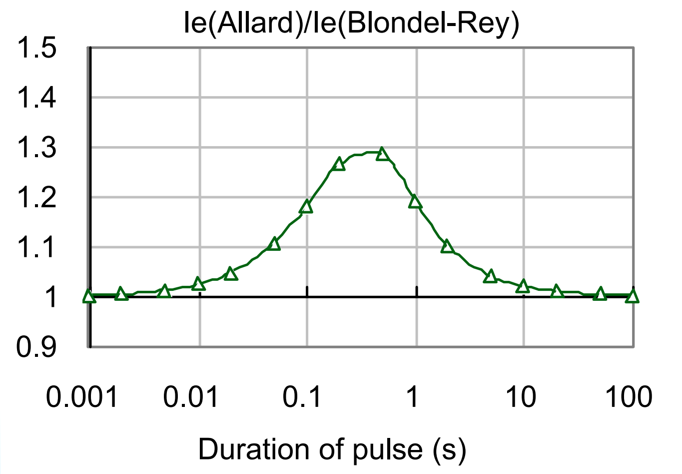
$a = R\,C$

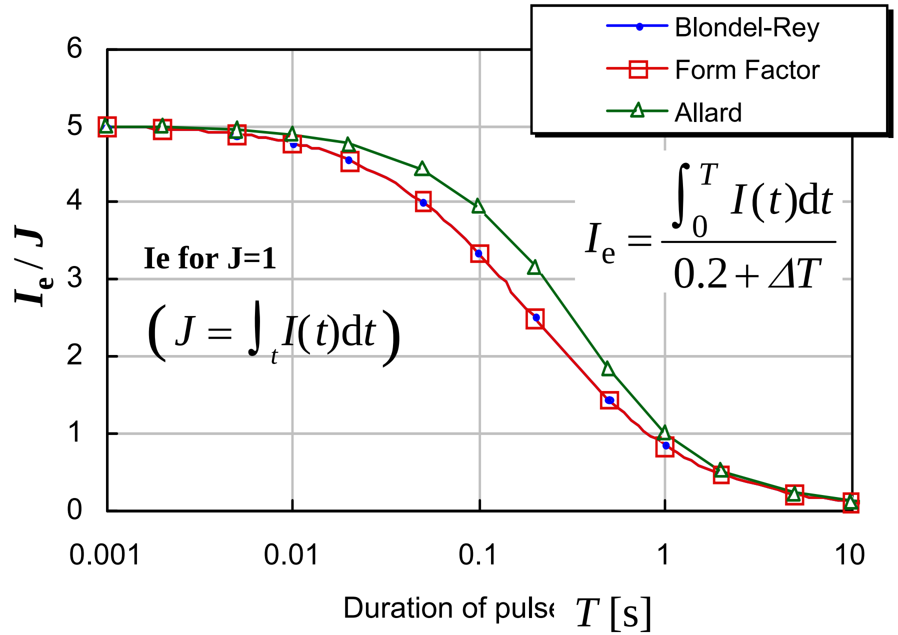
- Rarely used.

Computational Analysis

Rectangular pulse



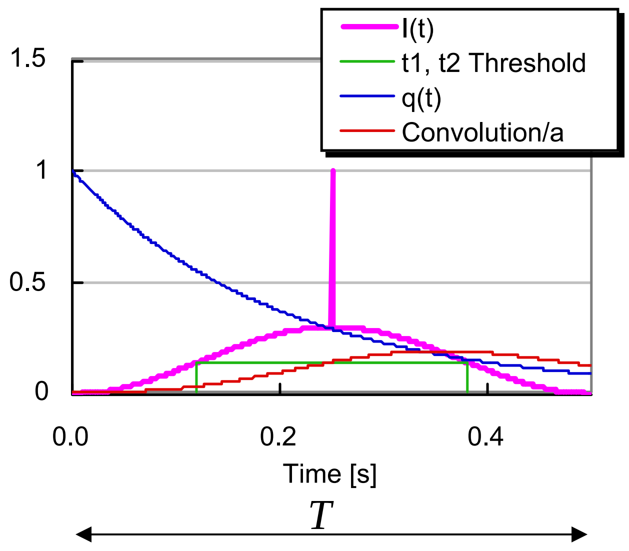


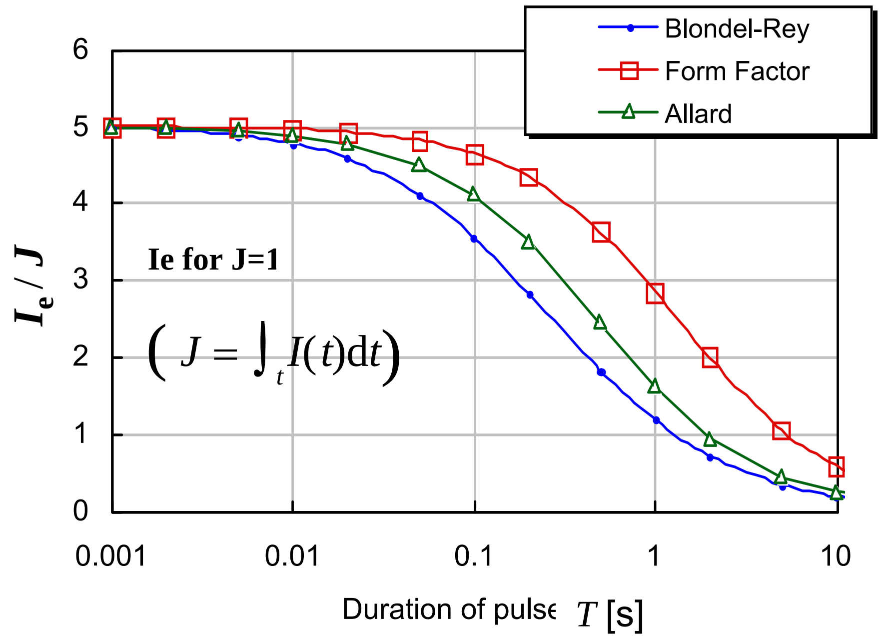


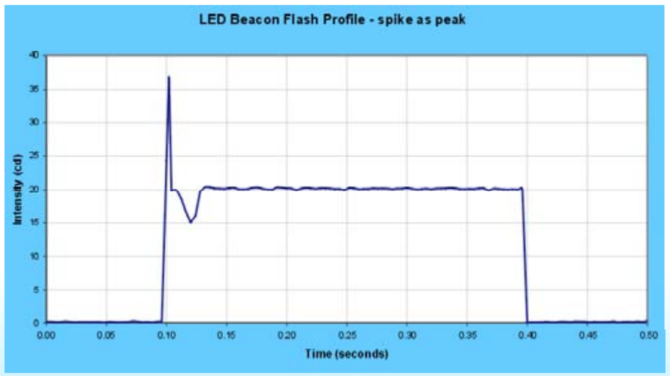
Allard gives 20~30 % higher results than B-R at T= 0.1 to 1 s.

Computational Analysis

Pulse with a spike







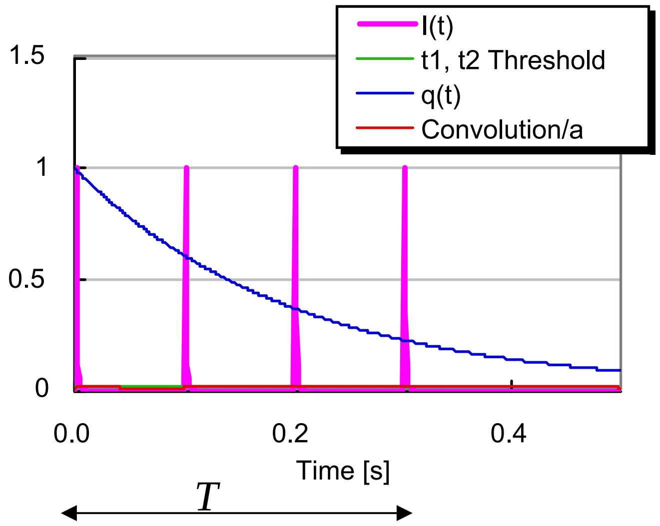
$$I_e = \frac{\int_0^T I(t)\mathrm{d}t}{a + \Delta T};$$

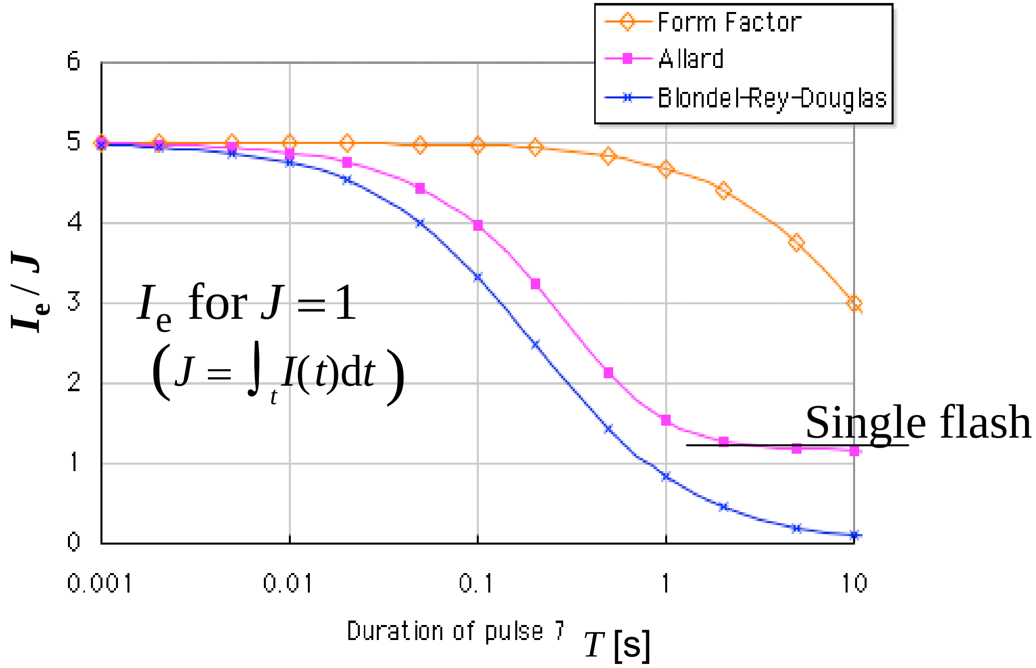
$$\Delta T = \frac{\int_0^T I(t)\mathrm{d}t}{I_{max}}$$

A problem of Form Factor Method!

Computational Analysis

Train of pulses





Form-Factor method

$$I_e = \frac{\int_0^T I(t)\mathrm{d}t}{a + \Delta T}; \quad \Delta T = \frac{\int_0^T I(t)\mathrm{d}t}{I_{max}}$$

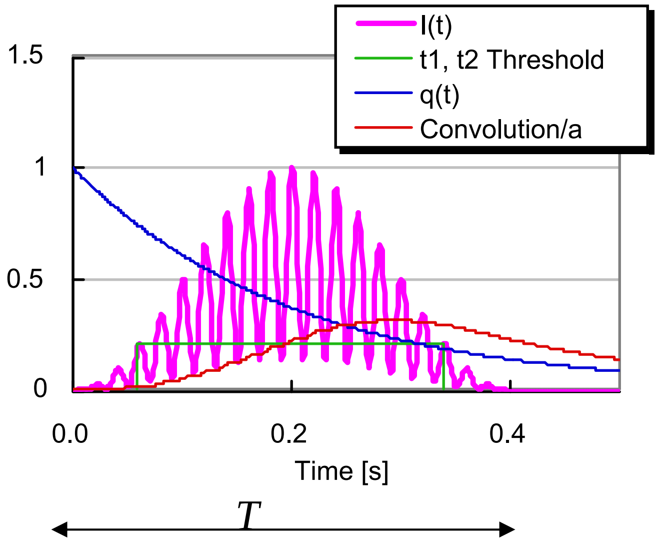
Pulse interval is ignored!

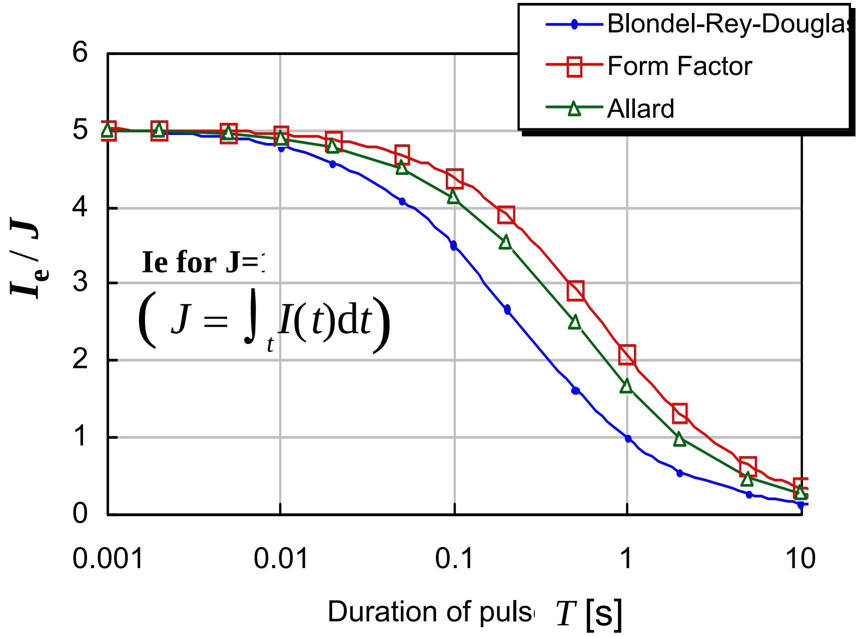
A fundamental problem of Form Factor Method.

B-R-D also has a problem.

Computational Analysis

Modulated pulse





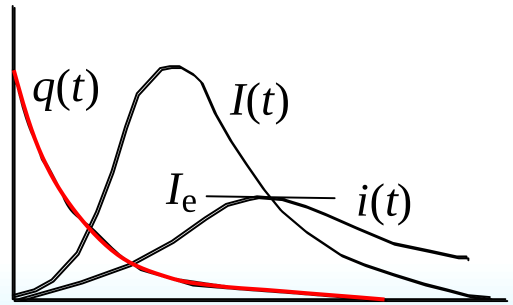
Larger differences between different methods.

Modification of Allard Method

Observation:

- Allard method seems to work well for all pulses, but there is a deviation from B-R for rectangular pulses.
- Assuming that B-R is accurate for rectangular pulses, if we modify Allard method to match B-R for rectangular pulses, all the problems will be solved!!

Approach: Modify the $q(t)$ function of Allard so that the results match B-R for rectangular pulses.

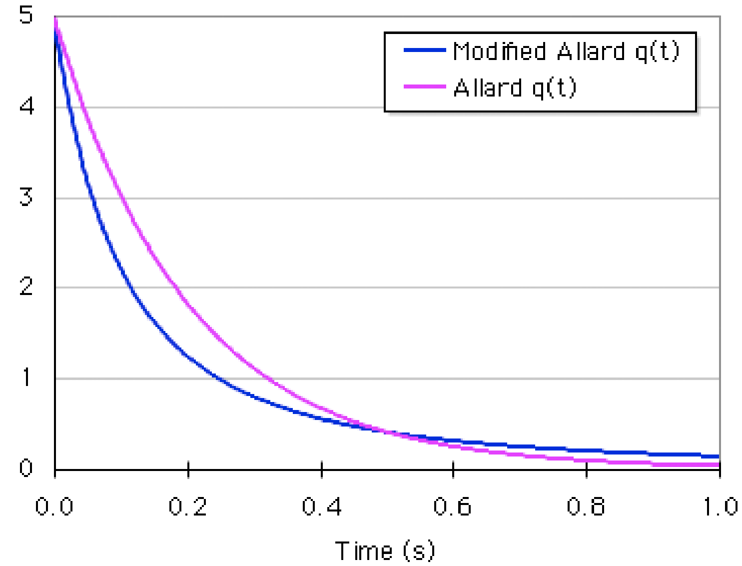


Modified Allard Method (Ohno-Couzin 2002)

q(*t*) that perfectly matches Blondel-Rey for rectangular pulses:

$$q(t) = a/(a+t)^2 \quad ;$$

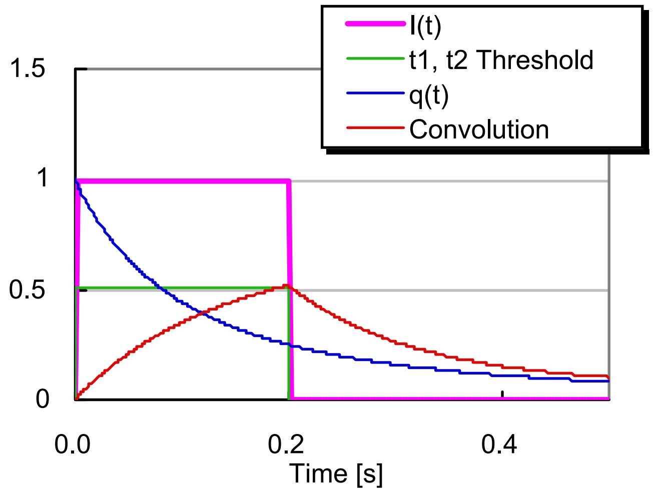
$$q(t) = 0 \text{ when } t < 0$$

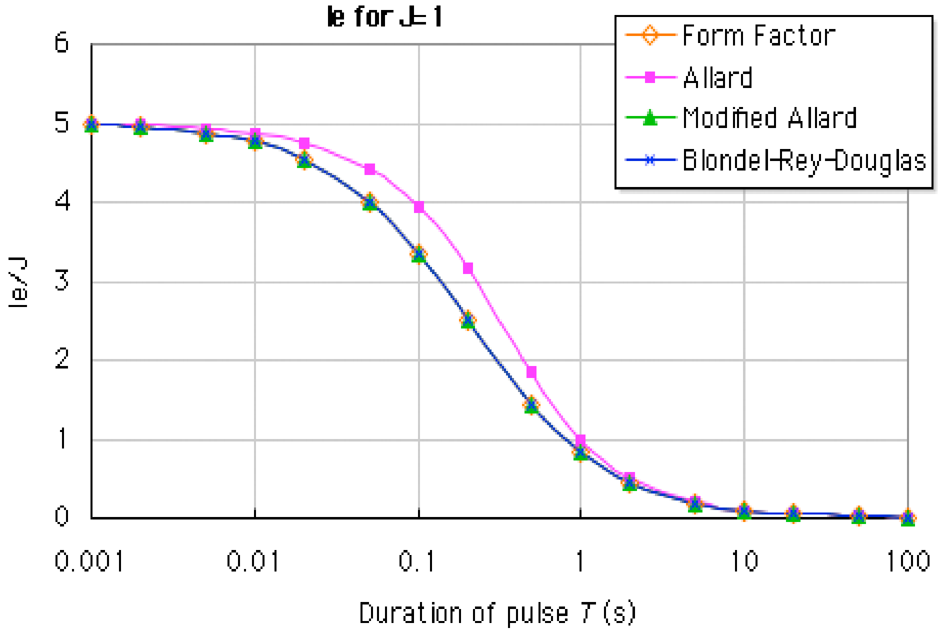


Y. Ohno and D. Couzin, Modified Allard Method for Effective Intensity of Flashing Lights (913 kB) , Proc. CIE SymposiumÕ02,Veszprem, Hungary, CIE x025:2003, 23-28 (2003).

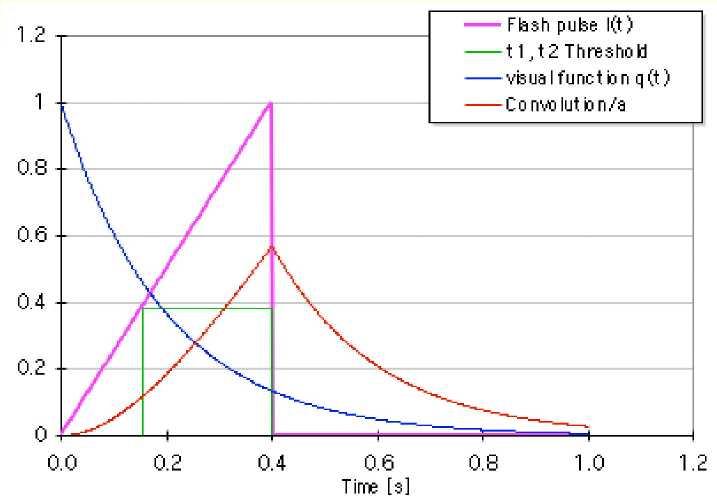
Results with Modified Allard Method

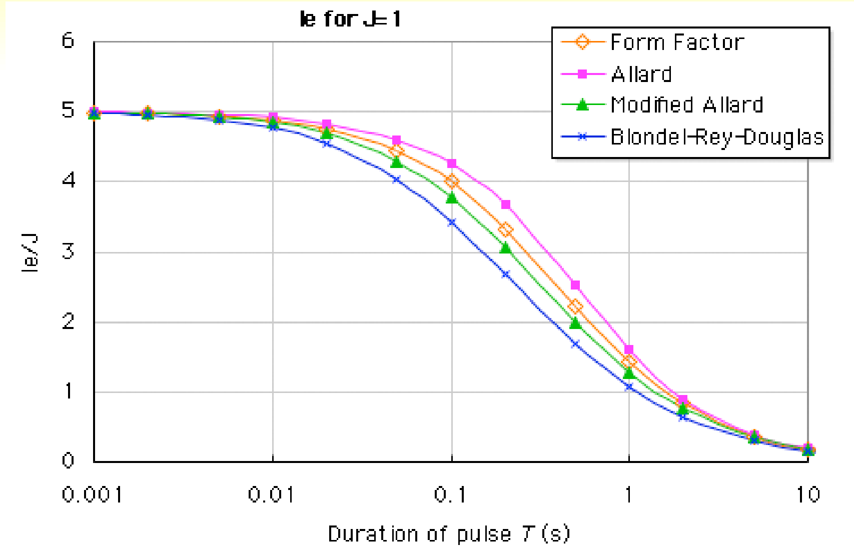
For rectangular pulses

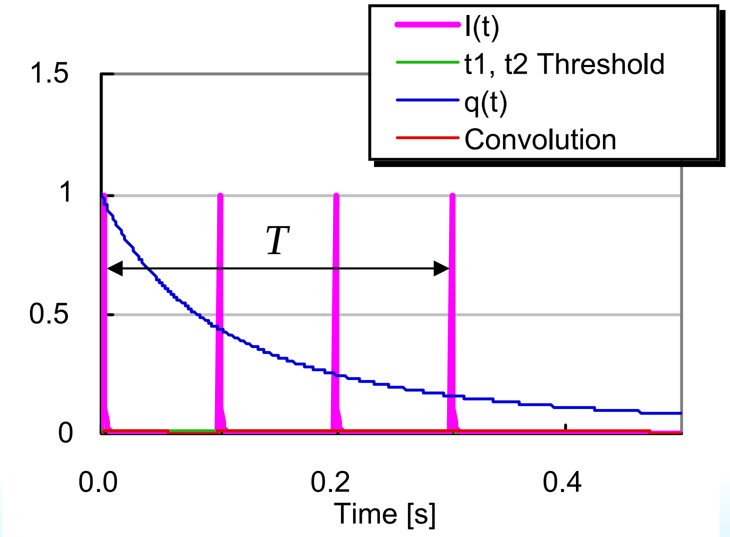


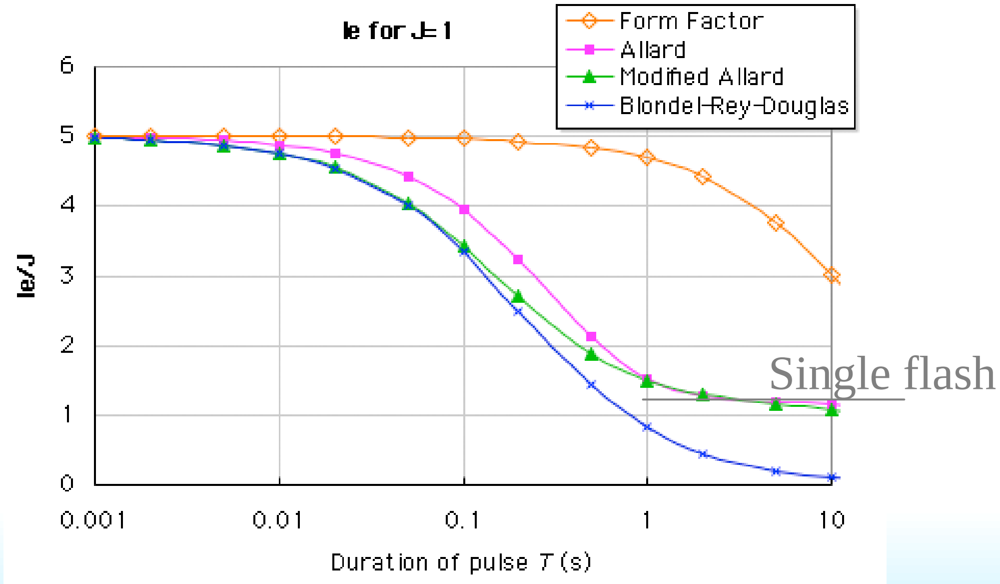


Comparison of four methods



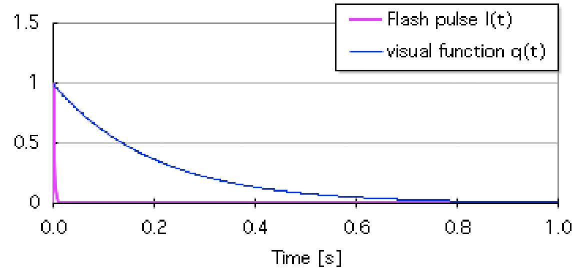




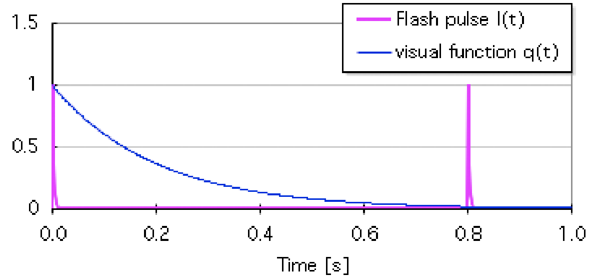


Repetition rate of flash

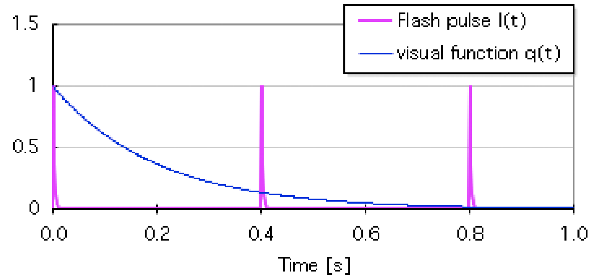
MAM calculation with T=1 s



I_e= 4.51 cd



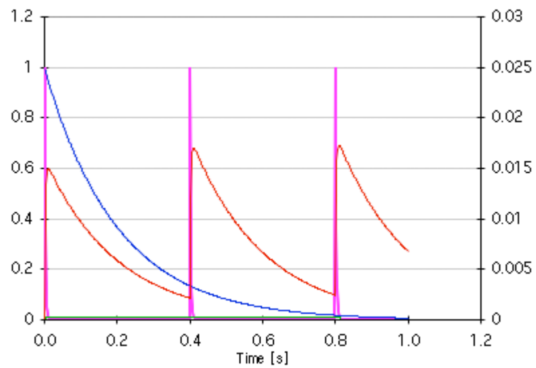
I_e= 4.70 cd



I_e= 5.24 cd

T=1 s

Assuming a single pulse calculation represent 1 Hz rhythmic light.



Not verified experimentally.

Practical MAM Photometer

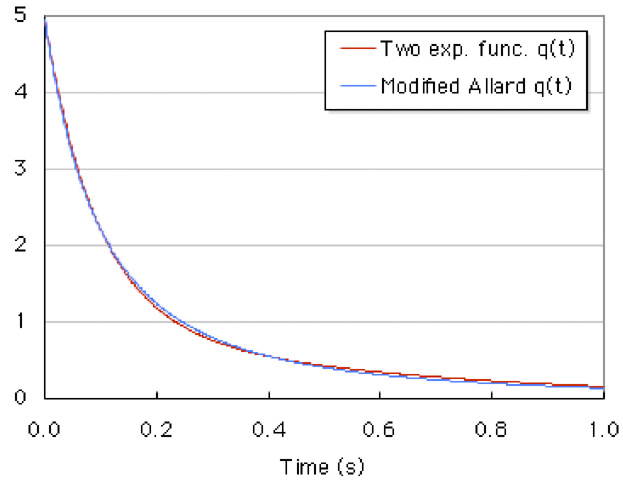
For practical measurement, q(t) can be approximated by <u>two exponential functions</u>:

$$q(t) = a/(a+t)^2 \approx \frac{w_1}{a_1} e^{-\frac{t}{a_1}} + \frac{w_2}{a_2} e^{-\frac{t}{a_2}}$$

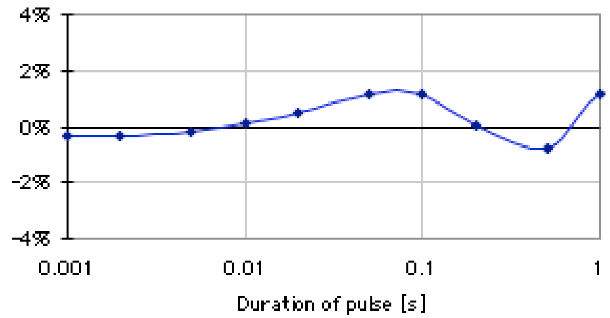
where

$$\frac{w_1}{a_1} + \frac{w_2}{a_2} = \frac{1}{a} \quad \text{and} \quad w_1 + w_2 \approx 1; \quad a = 0.2 \ s$$

Example: a_1=0.093, w_1=0.363
a_2=0.519, w_2=0.562

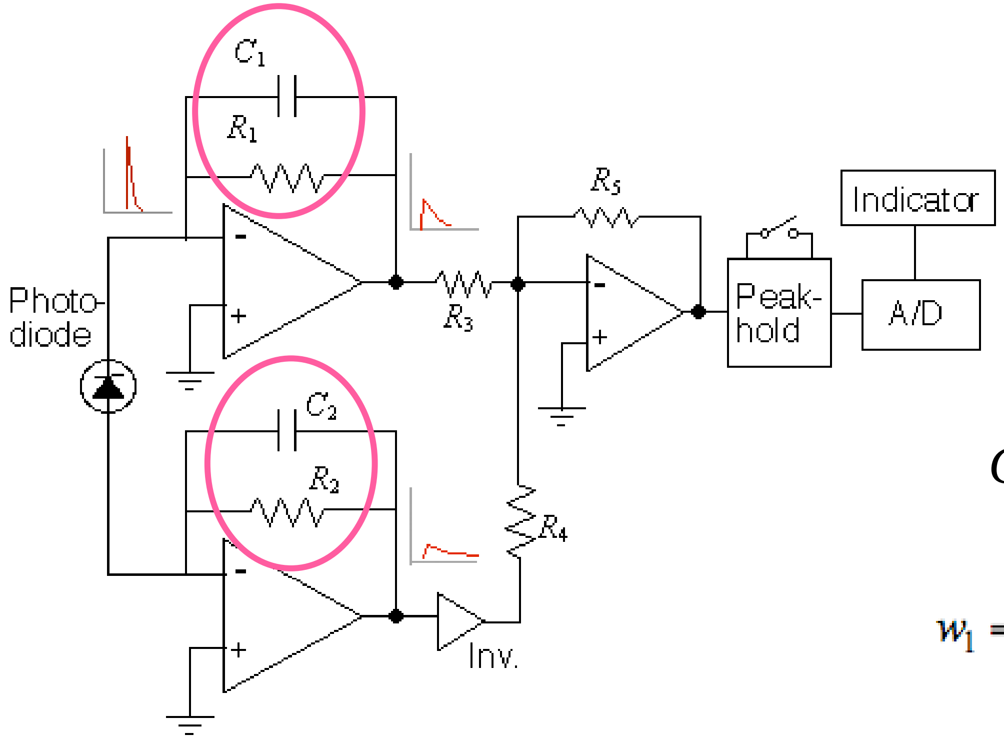


The approximated visual impulse response function



Measurement error in I_e (for rectangular pulses)

Practical MAM Photometer



$$C_1 R_1 = a_1, \quad C_2 R_2 = a_2$$

$$w_1 = k \cdot \frac{R_1 \cdot R_5}{R_3}, \quad w_2 = k \cdot \frac{R_2 \cdot R_5}{R_4}$$

An example of a configuration of an effective intensity photometer using the analog method

Modified Allard Method

- Mathematically Equivalent to B-R for rectangular pulses.
- No problem with train of pulses.
- No problem with spiky pulses.
- Considered accurate for all forms of pulses.
- Calculation not difficult (using computer)
- Practical hand-held photometer is possible.

But, experimental verification was missing!

1986 US Coast Guard paper

A METHOD OF CALCULATING THE EFFECTIVE INTENSITY OF MULTIPLE-FLICK FLASHTUBE SIGNALS

MARC B. MANDLER

AND

JOHN R. THACKER

U.S. COAST GUARD RESEARCH AND DEVELOPMENT CENTER
AVERY POINT, GROTON, CONNECTICUT 06340-6096

FINAL REPORT
APRIL 1986

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National Technical Information Service, Springfield, Virginia 22161

Prepared for:

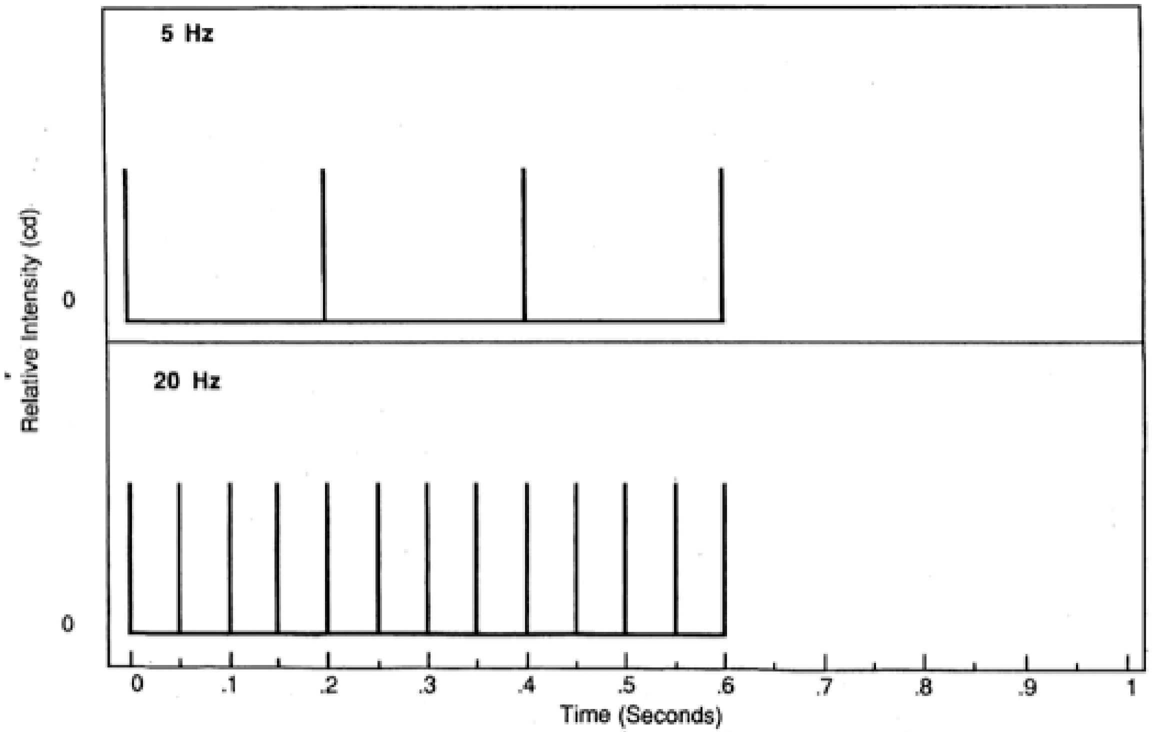
U.S. Department Of Transportation
United States Coast Guard
Office of Research and Development
Washington, DC 20593

Analysis of 1986 Coast Guard paper

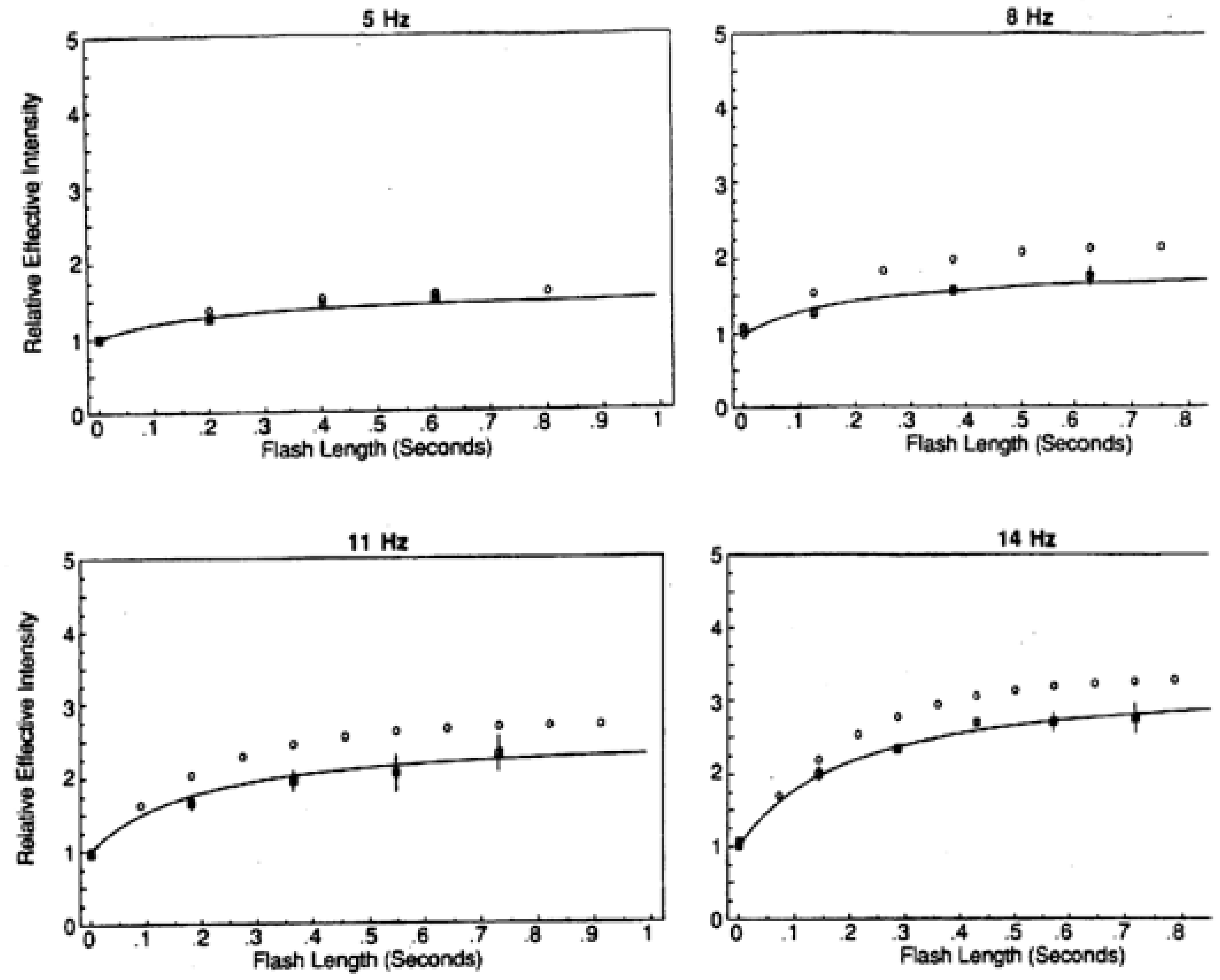
Yoshi Ohno
April 28, 2007

Summary of 1986 U.S. Coast Guard paper

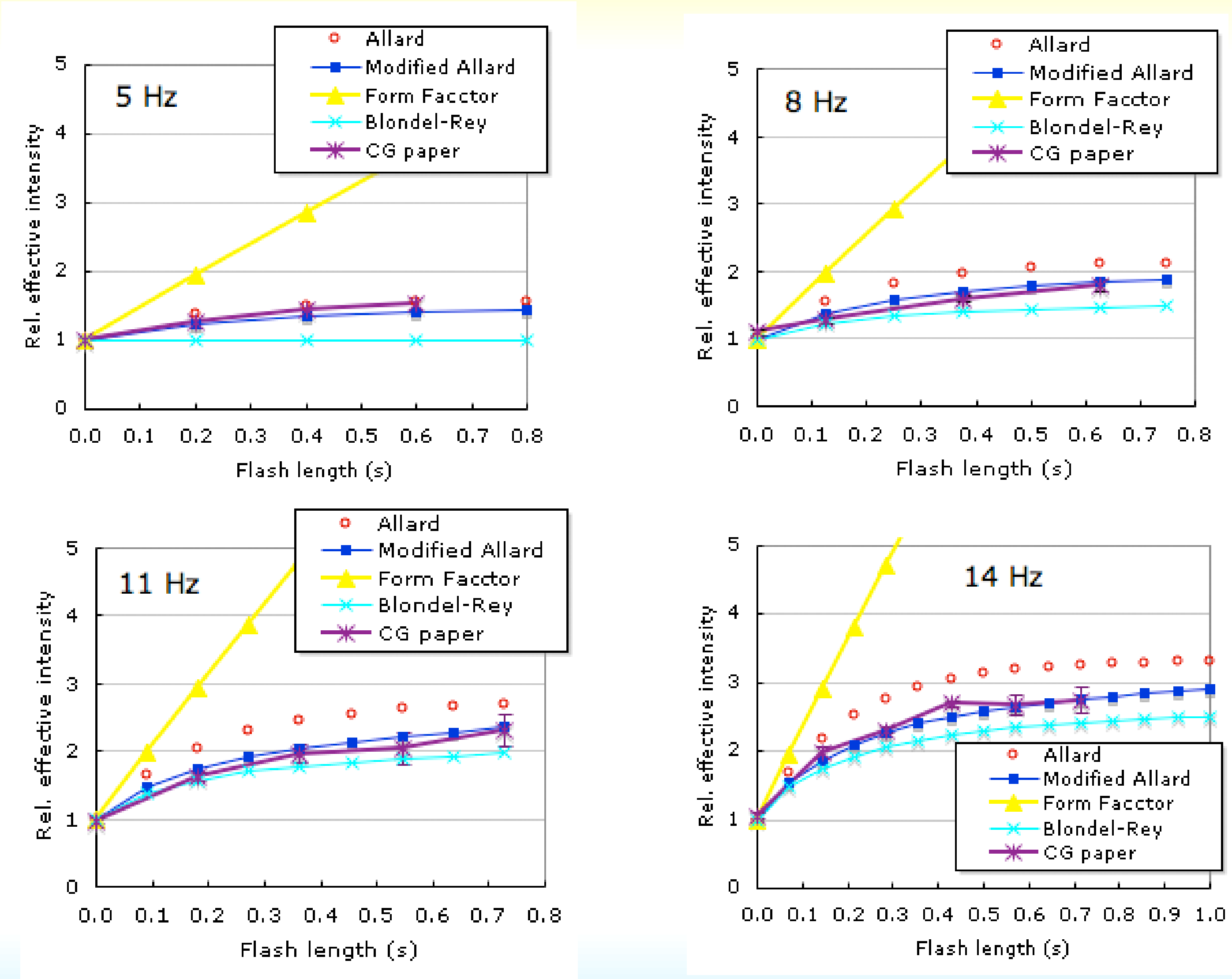
The paper [1] describes the results of comprehensive experiments conducted on detection of a train of pulses at different intervals and different number of pulses. Figure below shows an example of pulses (called "signal" in the paper). The interval of each flash pulses is expressed by "Flick frequency" [Hz]. Different number of pulses are presented at each different frequency, and intensity for threshold detection was measured.



Results


5 Hz
8 Hz
11 Hz
14 Hz
Relative Effective Intensity
Flash Length (Seconds)
0
1
2
3
4
5
.1
.2
.3
.4
.5
.6
.7
.8
.9

Comparison with the four methods



CIE TC2-49

Photometry of Flashing Lights

Chair: Y. Ohno (USA)

TR: Produce a technical report on CIE recommendation for measurement of effective intensity of flashing lights. (modified, July 2008)

At TC meeting in July 2007, the TC decided to adopt MAM as a standardized method for effective intensity recommended by the CIE.

Current draft: Draft 4.1 (July 22, 2008)

4.3 Limitations of the recommended method

The Modified Allard method is made equivalent to the Blondel-Rey equation for rectangular pulses. Therefore its application conditions are considered the same as those for Blondel-Rey equation:

- threshold of detection
- white light
- dark background
- foveal vision
- angular size should be visually zero.

Thus, the effective intensity formula recommended in this document will not be applicable to a supra-threshold condition, in peripheral vision condition, nor when lights are observed with a significantly bright background or with many other lights in the background.

Thank you for your attention !

Contact:

Yoshi Ohno
ohno@nist.gov

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Annex 5

Presentation of Mr. Omar-Frits ERIKSSON

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INTERNATIONAL EXPERT MEETING ON
STANDARDIZATION OF NEW LIGHTING METHOD
FOR MARINE AIDS TO NAVIGATION

TOKYO – 25th to 28th November 2008

On the Use of Flicker in Maritime Signalling Applications

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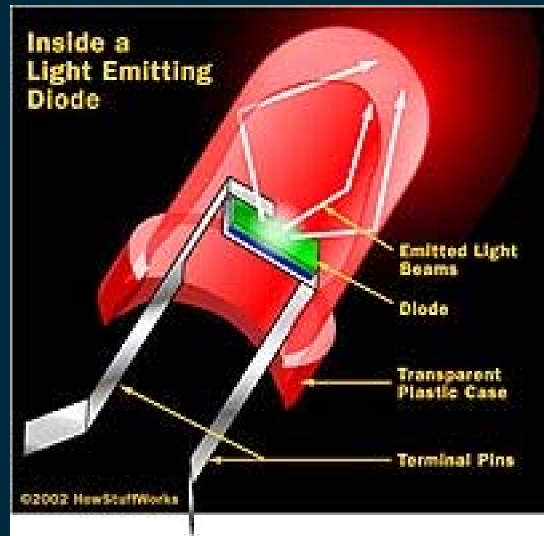
IALA AISM

FARVANDSVÆSENET
Danish Maritime Safety Administration

Light Emitting Diodes



Broca-Sulzer Effect (1902)

(Birghtness Matching)

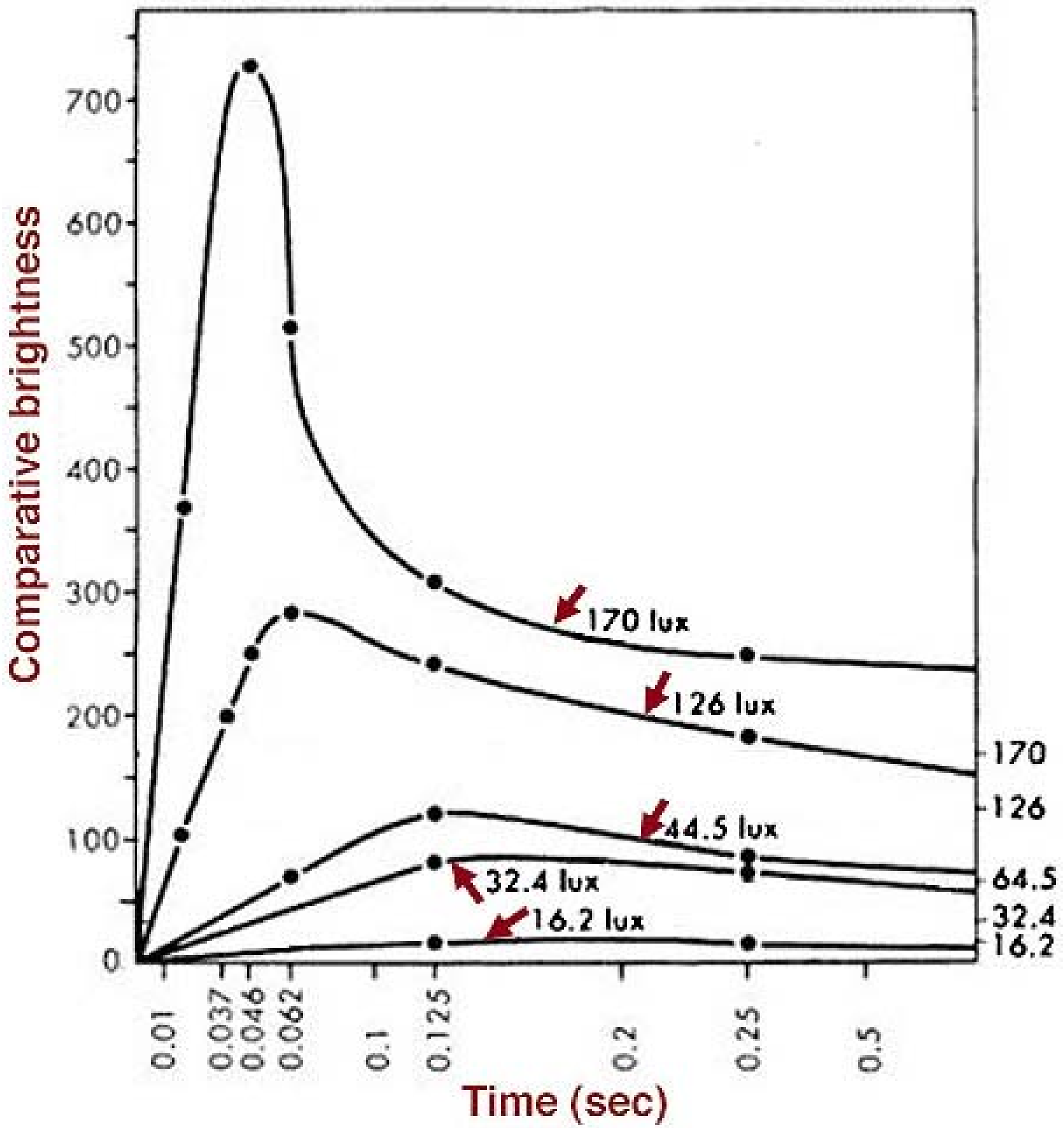


Fig. 6. Apparent brightness of flashes with various luminances, as a function of flash duration. Broca and Sulzer data from Hart Jr, W. M., The temporal responsiveness of vision. In: Moses, R. A. and Hart, W. M. (ed) Adler's Physiology of the eye, Clinical Application. St. Louis: The C. V. Mosby Company, 1987.

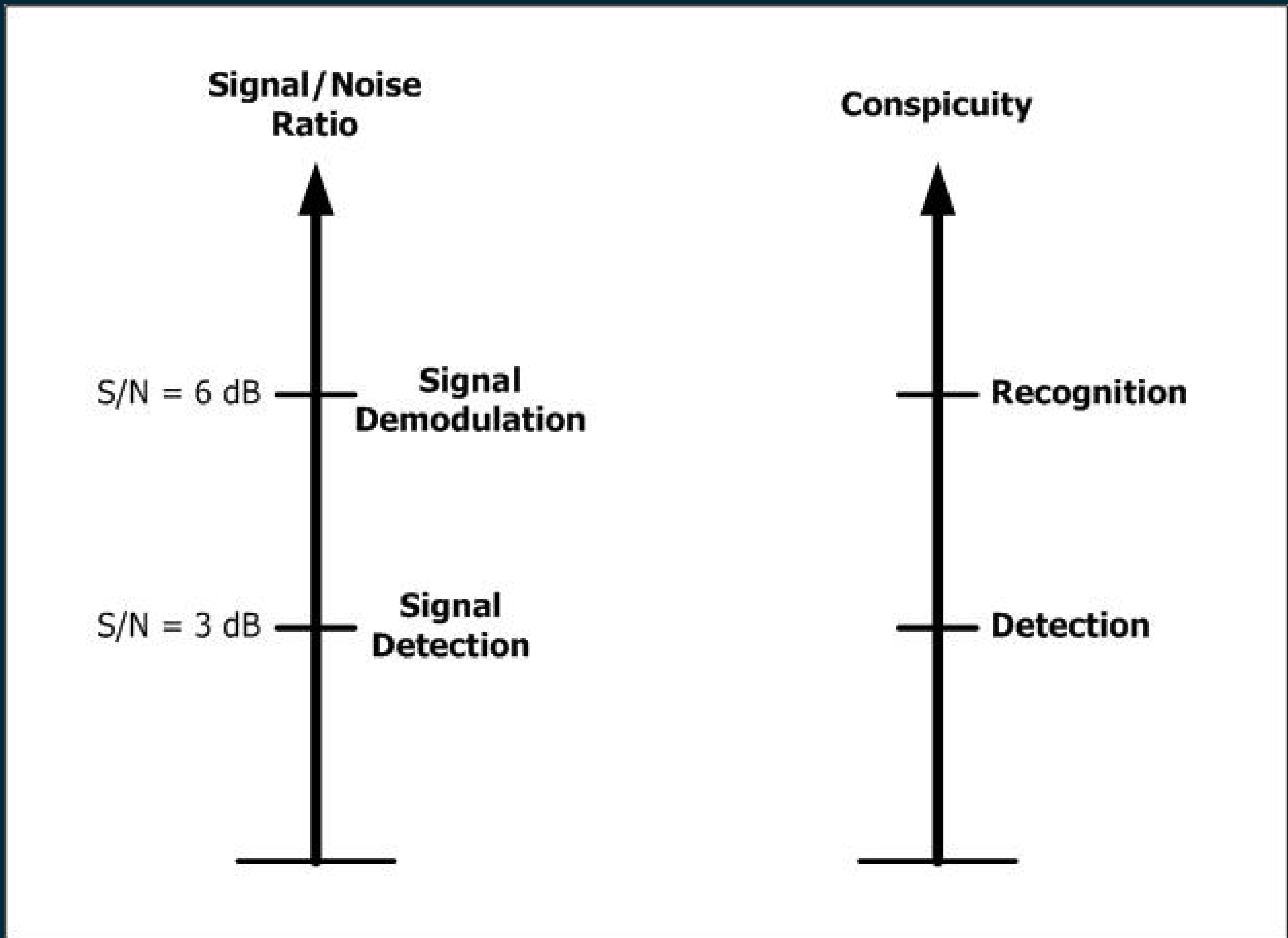
Farvandsvæsenet
Danish Maritime Safety Administration

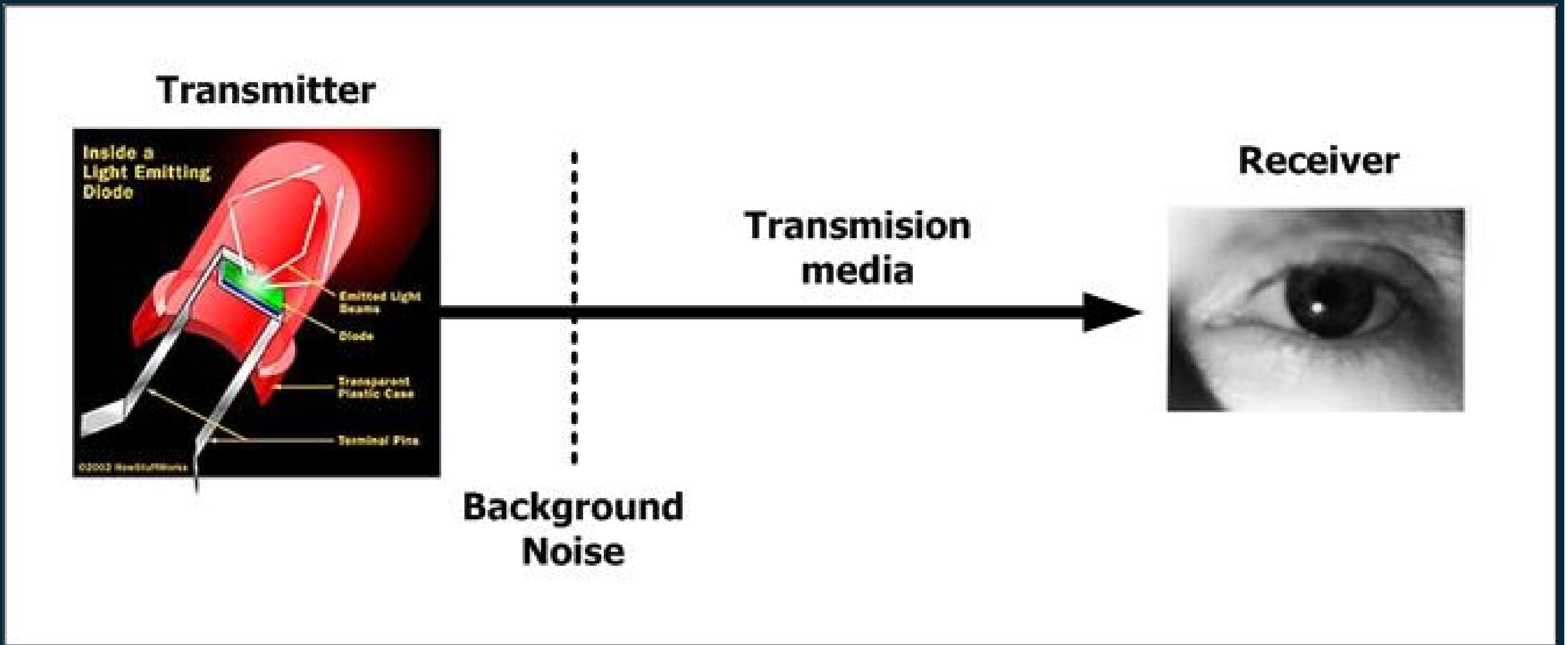
Copenhagen Flicker Experiment

- Little difference between pulses at distance (1,5 Nautical Miles)
- Sensation of flicker varies with distance
- One or two observers did not see any flicker at distance
- Flicker was found to be useful in relation to conspicuity and identification

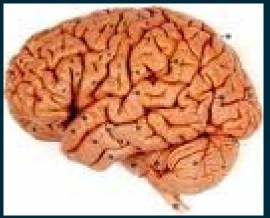
(Steady intensity was about 80 Cd)

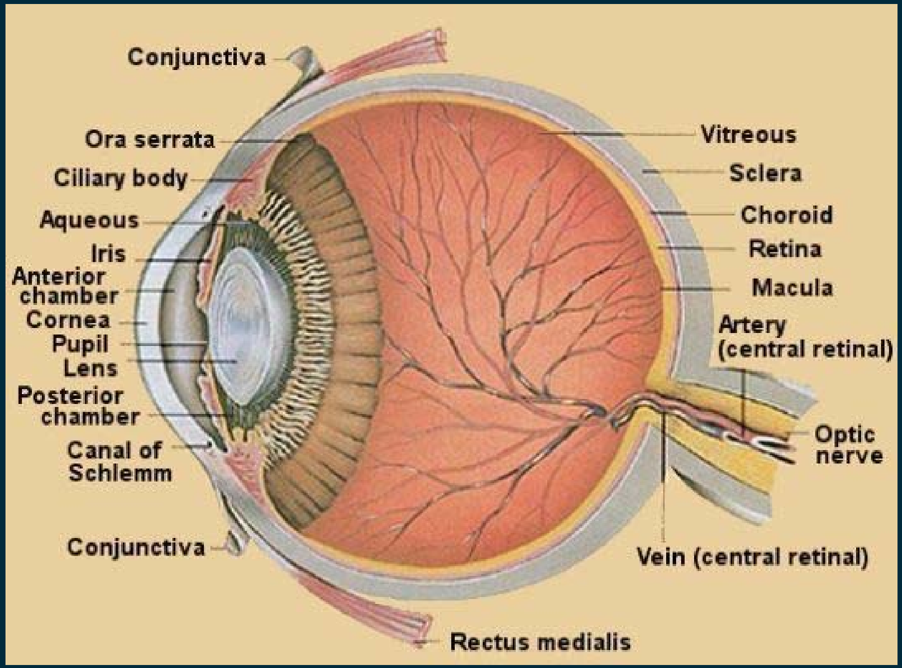
Conspicuity – S/N Ratio Analogy




Transmitter
Inside a Light Emitting Diode
Emitted Light Beams
Diode
Transparent Plastic Case
Terminal Pins
Transmision media
Background Noise
Receiver

The Eye is a Complex Sensor

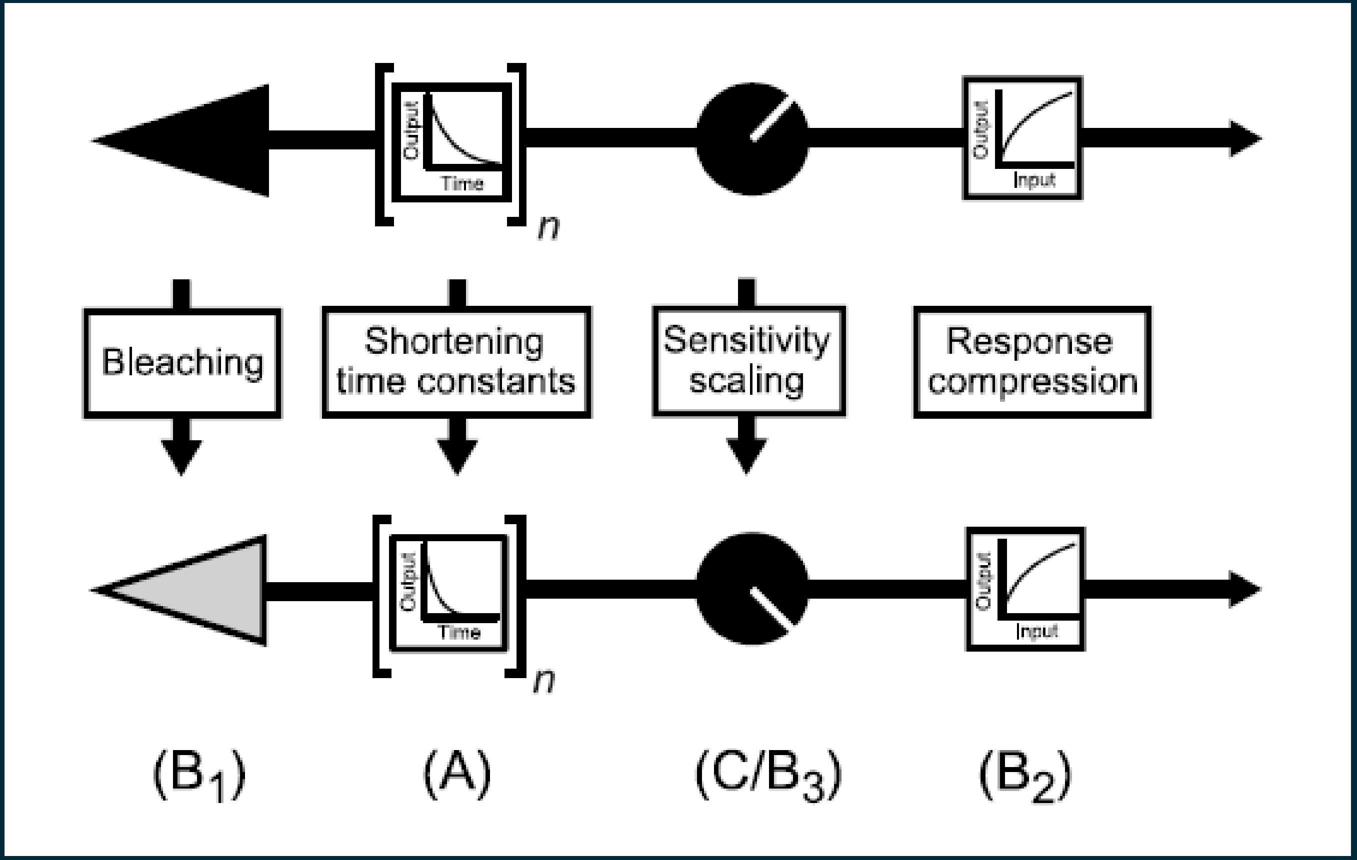




Perception depends on:

- Spectral Content
- Temporal Content
- Background Luminance
- Observer Fatigue
- .....?

Modelling the Human Visual System



Human Cone Light Adaption,
Stockman et al, 2006

Standard Observer

Mr. Yoshio Yamakoshi

Mr. Omar Frits Eriksson

IALA Activities on Flicker

- EEP Committee has flickering lights on its Work Program
- The Ad-Hoc Light Specialist group is looking into flickering lights
- ANM Committee is reviewing the IALA MBS

Use of Flickering Lights

- Use flicker only when needed for conspicuity or identification.

- Make part of the signal character flickering (beginning)

Conclusions

1. Flicker should be mentioned in the revised IALA MBS

2. We should consider developing more complex models of the human Visual System and then define a standard observer in order to create a common reference point

3. We should express ourselves in probabilistic terms when we talk about detection and recognition etc.

4. We should all continue to carry out Visual Experiments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Annex 6

Presentation of Mr. Xavier KERGADALLAN

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RÉPUBLIQUE FRANÇAISE

Ministère de l'Écologie, du Développement et de l'Aménagement durables

Cetmef
Centre d'Études Techniques Maritimes Et Fluviales

EFFECT OF DISTANCE OF OBSERVATION ABOUT FLICKERING LIGHTS

INTERNATIONAL EXPERT MEETING ON STANDARDIZATION OF NEW LIGHTING METHOD FOR MARINE AIDS TO NAVIGATION

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JCG

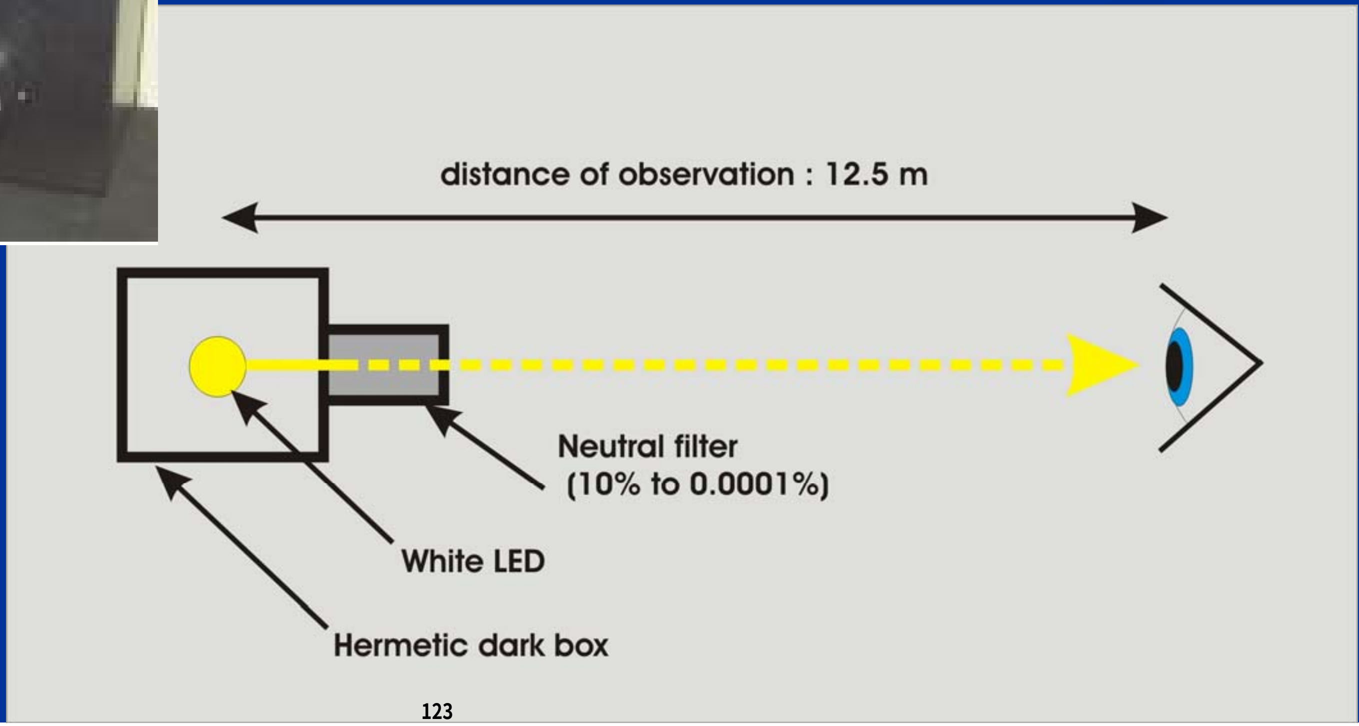
QUESTIONS ?

- Research has showed that LED light with flicker increases AtoN conspicuity against background lights

- Perception of flickering effect depends :
  - on distance of observation ?
  - on direction of observation (direct or lateral vision) ?

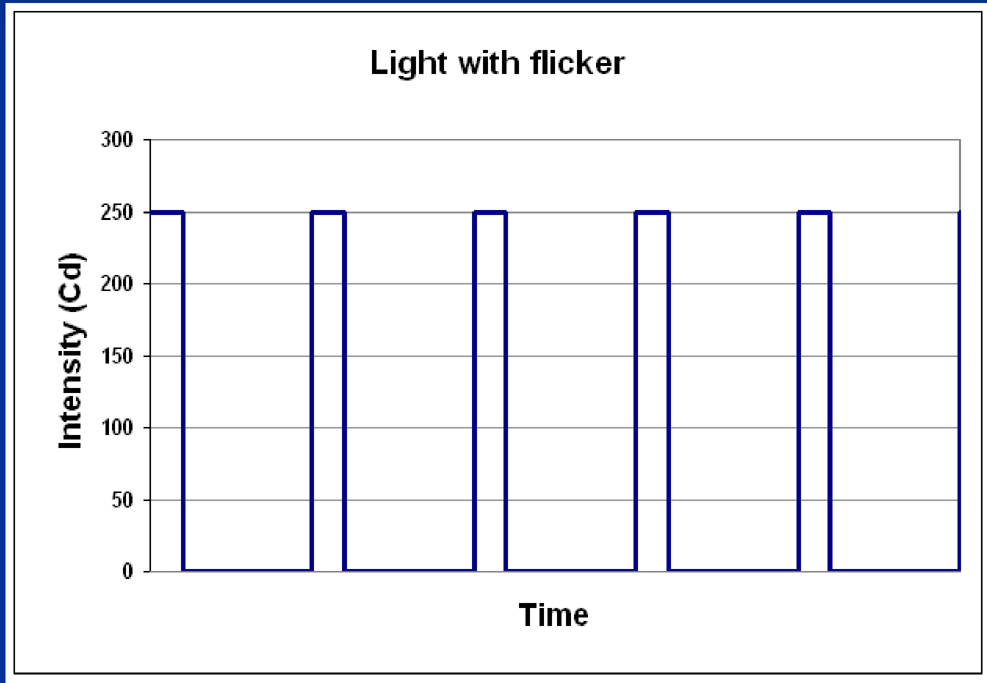
APPARATUS OF MEASUREMENT

- 1 light LED with flicker seen in the dark
- Illuminance control with neutral filters
- 5 observers



LIGHT CHARACTERISTICS

- Frequency :
  - 5Hz, 10Hz and 20Hz
- Duty ratio :
  - 20%
- Equivalent intensity :
  - Max : 250 Cd
  - Average : 50 Cd



- Equivalent distance of observation (visibility 10M) :
  - 235m, 715m, 2035m and 5035m

EVALUATION OF PERCEPTION

- 5 observers
- Mark from 0 to 3 to quantify perception
  - 0 : flickering effect is not visible
  - 1 : flickering effect is difficult to see, it can be confused with atmospheric flickering effect
  - 2 : flickering effect is visible
  - 3 : flickering effect is clearly visible
- Average of marks for each configuration

RESULTS OF OBSERVATIONS

Duty ratio : 20%		Frequency					
		5 Hz		10 Hz		20 Hz	
		direct	lateral	direct	lateral	direct	lateral
Distance of observation	235 m	3	3	3	3	2.6	0.2
	715 m	3	3	2.6	0.6	1.2	0
	2035 m	3	2.4	1.6	0	0.2	0
	5035 m	1.4	0	1	0	0	0

- Range : 4,4M (8 149 m)
- Lateral observation at 45°

- 0 : not visible
- 1 : not really visible
- 2 : visible
- 3 : clearly visible

RECOMMANDATION 1

- Use of ultra quick rhythmic characters of lights
  - Because flickering effect at 5Hz is more conspicuous
  - From 240 to 300 flashes par minute

RECOMMANDATION 2

- Introduction of “flickering range”
  - Because flicker effect is more difficult to see to when distance of observation increases
  - Modification of eye illuminance level in Allard's Law
    - Not theoretical level of perception 0,2 µLux but new level which depends on frequency
  - Example for light with flicker at 10 Hz and average intensity at 50Cd :
    - Nominal range : 4,4 M (eye illuminance at 0,2 µLux)
    - Direct flickering range : 1 M (eye illuminance at 10µLux)
    - Lateral flickering range : 0,2 M (eye illuminance at 350 µLux)

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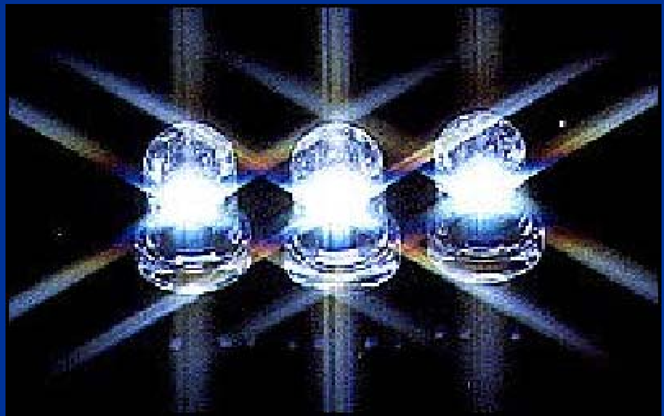

Thank you

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Annex 7

Presentation of Mr. Yoshiyasu FUKUSUMI

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Origin ～ The origin of this study was that for aids to navigation using natural energy such as lighted buoy, by using flicker light, if it is possible to operate the aids under less energy consumption as keeping the same effect of the aids.

Result of Experiment until 2007 (1)

- An experiment in visibility of red LED by comparison of combination of frequency from 5 to 25Hz by 1hz and duty ration from 10 to 90% by 10% was conducted.
  - Flashing time was 0.4 seconds as same as the conventional flash.
  - The comparison was conducted by two LED lanterns.
  - Total luminous energy was set to constant.

Result of Experiment until 2007 (2)

- All flicker lights were conspicuous compared with the conventional lights.
- The best combination was frequency of 5Hz and duty ratio of 20% chosen from the tournament of the 96 combinations.
  - However, since Ultra Quick Light of the IALA Recommendation E-110 for the Rhythmic Characters of Light used the frequency of 4 to 5Hz, it was decided to use the higher frequency.

Result of Experiment until 2007 (3)

- The interval between pulses of the flash that is recognized as one flash without mis-recongnized for other character was 100 ms or less.
- The best three combinations of conspicuity were 10Hz and 10%, 8Hz and 30%, and 9Hz and 20%.
- There was no constant law for conspicuity of the combinations of frequency and duty ratio.
  - The result of the experiment and the Modified Allard Method were not completely accordant however mostly accordant.
- From a cost performance of a lantern on the assumption of practical application, the combination of 10Hz and 30% was decided to use for the present.

Result of Experiment in 2008 (1)

- The following experiments on green and white LED were conducted.
  - Comparison between the conventional flash and the flickering flash of 10Hz and 9 duty ratios from 10 to 90%.
  - Since the experiment of red LED had been already conducted, only the confirmation by color difference was made.
- Fixing duty ratio as 30%, comparison of all combinations that was made from 9 frequencies from 6 to 14Hz by 1Hz was conducted.
  - Compare 2 flashing lights using 1 lantern by 0.5 seconds interval.
  - Total luminous energy of 1 flashing (0.4 seconds) was set to constant.

Result of Experiment in 2008 (2)

The condition and method of the experiment：

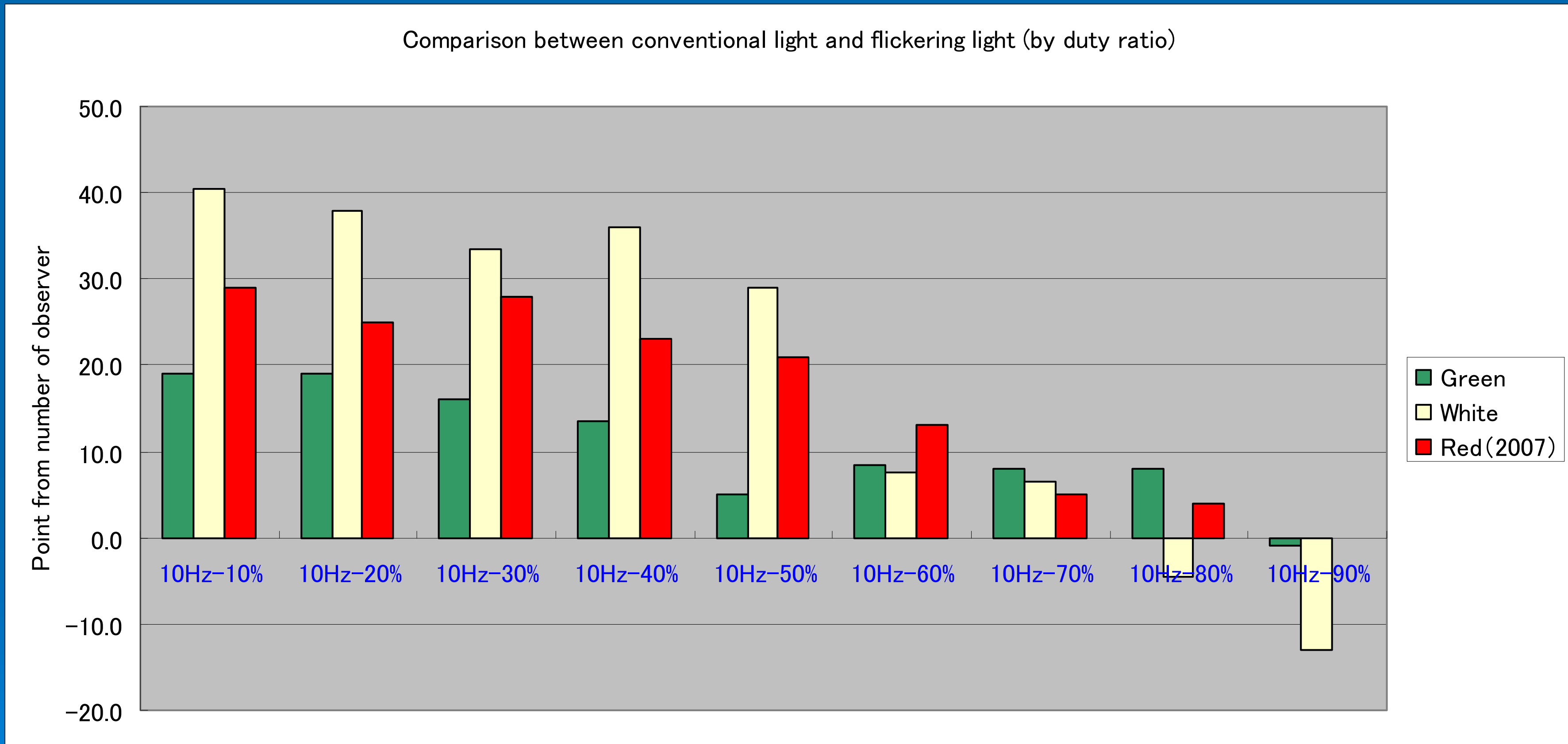
- October 7, 2008 from 19:03 to 20:54 (sunset 17:15, age of moon 7.3)
- The background brightness above the lantern was 0.011 [cd/m^2]。
    - 0.0131 at start → 0.0102 at end, almost constant
- The distance from the lantern to the observer was 2.0 km.
- The total number of the comparisons of green and white were 180 (90 each).
- The number of the observer was 52
    - Average age: 46.3 years old
    - Average eyesight: right 1.07 and left 1.03 in Japanese scale (Japanese scale 1.0 is equal to 20/20 in English scale.)

Result of Experiment in 2008 (3)

Situation



Result of Experiment in 2008 (4)



New Lighting Method of LED Lights

Result of Experiment in 2008 (5)