DESIGN BASIS
TO
QUALITY
URBAN LIGHTING MASTERPLAN

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The interest in the subject of urban lighting was inspired through my previous practice, the acclaimed lighting company, Lighting Planners Associates Inc (LPA), headed by Mr Kaoru Mende. Although I did not receive any formal academic training in artificial lighting, I was taught many in lighting, aiding me in the production of this thesis and the germination of this thesis subject. During my stint at LPA, I was introduced to urban lighting masterplanning, which I was keen to derive many other manners of which concepts can be derived and how different manners of lighting and urban studies can be combined and merged to form new theories in the realm of qualitative lighting.

I would like to express my heartfelt appreciation for those who stood by me and tolerate my temper during these stressful times, particularly my family and boyfriend. Also, I would like extend my gratitude to internationally acclaimed lighting designers, like Speirs and Majors Associates and Professor Lucy Hao from Tongji University, who introduced different concepts to urban lighting master planning to me. Lastly, my supervisor, Assistant Professor Dr, Stephen K. Wittkopf, who gave me much insight into the world of research, and enabling a smooth transition from practice to academia.

This condensed version of this thesis was submitted and chosen for both publication and presentation at the Urban Nightscape 2006, hosted in Athens and co-supported by CIE, Commission Internationale de l'Eclairage, while awareness in this subject was noted in the latest annual MAAN conference hosted by University of Tokyo in Japan. This signalled academic interest in this subject, whilst acknowledging that this subject, which examined quality lit environment in the perspective of environmental perception.

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SUMMARY

Quality lighting environment was defined as the lit space that supports human behavioural needs, with considerations for architectural and economical aspects of the installation. (Veitch, 2001) Although there are many codes, design guidelines and measurable indices to describe quality of the luminous environment, no research had addressed to the impact of urban lighting on human psychology and basic mechanics of visual perception. In this thesis, a new set of design basis, which addressed to the neglected human perception needs in environment, would be proposed for future Urban Lighting Master planning. Since this component of Urban Lighting is lacking in current design practices, the new proposed design basis should complement the current Codes and Regulations to derive a more holistic approach towards the formulation of quality lit urban environment.

Due to the novelty of this subject, to highlight the neglected component of Human-Environment relationship, the current design basis (Codes of Practices and selected realized lighting masterplanning projects) were analyzed. Thereafter, the proposed basis would be derived by integrating theories proposed in Environmental Perception researches and potential noted to incorporate these theories into urban lighting masterplanning. The reviews of selected realized projects and Codes of Practices had highlighted recent popularity in urban lighting masterplanning, especially in this region. Yet, it was noted that current design basis still stagnated on the quantifiable aspect of lighting, neglecting important human visual needs of his environment. Although the realized projects of lighting masterplanning indicated that there were some generic design parameters that were common, these were proposed without concrete studies and the effects on human perception were not researched upon. These prompted the research hypothesis that the current basis was not sufficient for design of a quality urban nightscape. Studies on Environmental Perception and visual urban design concluded that legible environment was necessary to construct a positive living environment,

particularly for the urban spaces. (Kaplan, 1983; Nasar, 1998; Rapoport, 1977; Lynch, 1960) In these studies, it was noted that there were common design parameters to the construction of quality environment. (See Table 10.0) Since these studies demonstrated possibilities to quantify design parameters that were preferred by human and the importance in visual design of an environment, the proposed set of design basis (See Chapter 4.0) to quality urban lighting masterplanning were then validated through surveys.

Research methodologies of both surveys were adopted after detailed studies on similar experiments. (See Chapter 3.1.4 and Chapter 5.0) Preliminary results of the questionnaires indicated that although Urban Lighting Master planning was a new subject, all test subjects are receptive towards new design techniques which would enable greater legibility of the existing urban fabric. Also, several important points which would validate the proposed basis were noted, suggesting future research opportunities. However, it must be noted that these preliminary results should serve as a reference for potential future research directions and to elevate design of urban lighting masterplanning to one that would take human perception needs into considerations. In conclusion, the next step in research on urban nightscape would be the re-evaluation of current design and design of visually well-structured urban nightscape.

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1.0 INTRODUCTION

1.1 Urban Lighting and its Main Objectives

As its name suggested, Urban Lighting, referred to the design of artificial lighting for all elements in the urban environment. Formerly, Urban Lighting was primarily provided for 4 main purposes, namely, safety of residents, security of the belongings of the city's residents, for the aesthetics of night-time environment and the economy of the country, which implied the ability of lighting to support night activities both functionally and aesthetically. (IESNA, 1975) From the 4 above mentioned aspects, lighting for safety "involves ensuring proper level of illumination to provide safe working conditions, safe passage and the identification of any hazards indoors and outdoors" (IESNA, 1999), while lighting for security is defined as "exterior lighting installed solely to enhance the security of people and property" (IESNA, 1999). With 2 main factors that related mainly to the provision of sufficient luminance level for the ability of residents to supervise their belonging and psychologically perceived security, good urban lighting was often mistaken with high luminance.

One of the misconceptions in urban lighting was to equate the level of brightness to aesthetics of a space, thus resulting in micro-scaled problems like, glaring urban spaces that was impossible to enjoy or light spillage to the macro-scale negative impact on the ecological system. Studies (Cabello, 2001; Li, 2006) had also pointed out that over-lighting was a main cause to "sky glow", which was interpreted as a "brilliant hemisphere surrounding the city sky". (Cabello, 2001) Often, the main cause to 'Sky glow' is the mismanagement of urban lighting, and would contribute to "energy waste, but also pollution that can affect the visibility of roads and sky, the appearance of outdoor spaces and can generate disturbances into private houses." (Cabello, 2001) Also, the directionality of the emitted rays in relation to the lit objects and the luminance of the lit surfaces could worsen this problem. Therefore, to minimize over-lighting, upward light output ratio must be reduced and lighting designers should utilize luminaries of better output control, while reducing in excessive surface luminance of the floodlight buildings, as depicted in Table 1.0, which categorized the intensity in the luminance of façade lighting to type of illuminated building. Moreover, the background luminance of objects in the urban environment should relate to the character of the area, in accordance to the recommendations stated in the International Codes of Practices. (See Chapter 2.0 for details on Codes of Practices)

Brightness	Luminance of building Level I (cd/m^2)	Luminance of building Level II (cd/m^2)
Dark (0.2)	20 ~ 32	12 ~ 20
Moderate (2)	45 ~ 70	25 ~ 45
Bright (12)	80 ~ 130	50 ~ 80

Table 1.0 *Recommended luminance of floodlit buildings (Li, 2006)*

Lighting is much required for the functionality of spaces in the dark, yet efforts must be undertaken to minimize the problem of over illumination, as research in ecological impact of artificial lighting in cities had pointed out how excessive lighting had disturbed the wellbeing of the animals, insects or nature within or over the skies of the cities. (Rich and Longcore, 2006; Li, 2006) In addition, the application and appropriateness of artificial lighting is correlated to various human biological needs or could affect mood and visual performance. (Bommel, 2004; See Chapter 3.1.4) Since a main cause to the problem of "sky glow" or wrong application of artificial lighting is due to mismanagement in urban lighting, the conceptualization of urban lighting masterplans would aid in corrections for wrong perception in lighting applications, while providing guidelines on sufficient luminance for urban spaces with corresponding lighting technologies recommended towards the fulfilment of design aims.

In recent years, technological advancement in development of lamp source and luminaries had seen the realization of a kaleidoscopic range of lighting concepts, which could be seemingly impossible more than 30 years ago. Also, the widespread usage of other High-Pressure lamps, like Metal Halide lamps for urban lighting, in place of High-Pressure Sodium lamps, indicated an improvement in the economic value of such lamps and efficacy of these lamps, as compared to the past. This further suggested gradual acceptance of good urban lighting, that was not restricted to its functional needs but placing equal importance on the achievement of an aesthetically pleasing skyline. (See Appendix II for detailed range of lamp properties for use in urban lighting) Hence, through the availability of this wide range of lamps and advancing luminarie technology, particularly with rising popularity of LEDs (Light Emitting Diodes) for urban lighting, many countries were inclined to utilize these technologies to aid in the exhibition of their urban fabric and evoking dynamicism in the cities at night. Principally, this trend is predominantly evident in Asian cities, with increasing number of Asian cities committing themselves to the LUCI (Light for Urban Community International), established by Lyon in 2002. Currently, LUCI had more than 60 member cities and 5 Asian cities, committing them to support of excellence in urban lighting and provided a platform for member cities to exchange information and experiences towards the provision for a better lit environment. One of the moves towards providing for a distinctive nightscape was the conceptualization of urban lighting masterplans, to educate the building professionals and public on the importance of good nightscapes and how to achieve it. This is echoed recently in Singapore, when the URA (Urban Redevelopment Authority) had announced its new lighting plan in November 2006, together with the introduction of incentives for developers who integrate façade lighting to their original architectural design and a public exhibition on the new Lighting Master plan for Marina, Bras Basah, Orchard and CBD areas. Besides this new Singapore Urban Lighting Master plan, that updated the previous lighting masterplan designed by Louie Clair in the 1996, some new urban spaces (One-North) in Singapore had invited Lighting Designers to draft and implement Urban Lighting Masterplans. Furthermore, the annual Fête des Lumières (Festival of Lights) hosted in Lyon had successfully integrate cultural event with promotion of global awareness towards urban lighting. These examples illustrated the awareness towards quality nightscape either locally, regionally or globally, thus indicating that the pursuit of a well-lit urban environment is a new urban movement that should integrate professional expertise from both Urban Planners and Lighting Designers.

However, without proper understanding of the technicalities offered by current luminarie and lamp developments, design of quality illuminated environment would not be possible. Moreover, as noted through reviews of current practice, there is still a gap between the technical knowledge developed for luminaries and lamps, and the understanding of what constitutes good lighting environment. Urban Lighting Design is still primarily the engineering of the illuminated environment to suit recommendations of Codes and subjected to individual designer's perceived effects of the resultant illuminated space. The absence of studies on the interaction of the lit environment and human perception resulted in a lit environment that did not address to the primary perception needs of human, nor the intricate human-environment relationship. Therefore, this paper aimed to directly address to what defines the needed design basis to the formulation of a good urban lighting master plan. This new proposed basis would relate urban lighting master planning to aspects of human perception and visual basis in urban planning, offering an alternative perspective to the subject of quality urban lighting masterplans, which current design basis still centered on the quantitative aspects of lighting. Till now, the approach towards the formulation of the Urban Lighting Master plan had been consistent and a few main design parameters noted as important in the design of a good illuminated environment (See Chapter 2.0), yet the steps of implementation, the underlying fundamentals and perceived effects on human perception, behind all these design parameters should be investigated further. The research hypothesis was derived through the various parallelism between the theories proposed in environmental perception studies; propositions presented through urban visual design and their potential in translating into Urban Lighting Master planning concepts. Therefore, an alternative design basis would be proposed, which translated the various proposals in Environmental Perception theories or Urban Visual Design, into possible lighting design strategies. This new-found basis would be subjected to validation through a survey on the public's perception of the nighttime environment and the responses towards these proposed bases.

Although the concept of qualitative lighting seemed novel in Urban Lighting, it had been developed and studied for interior lighting. Qualitative lighting design had been introduced after the Second World War by Richard Kelly, which structured the visual environment using artificial lighting. (ERCO, 1992) In the initiation of artificial lighting design, 3 concepts of lighting were introduced, namely, *general lighting, focal glow* and *play of brilliance.* These 3 concepts summarized the importance of artificial lighting in the structuring of the visual environment. "General Lighting" was understood as the provision of sufficient lighting for general purposes, which was also termed as "ambient lighting". "Focal Glow", however, introduced concept of visual hierarchy into lighting, by the highlighting of "relevant visual information" (ERCO, 1992, p.24) using higher intensity lighting, or differed lighting technique, for the intended object to be brought into focus amid the generally lit environment. "Play of Brilliance" meant that artificial lighting could enable the conveyance of visual information and evoking intended spatial mood. Therefore, these basic concepts behind qualitative lighting had detailed how artificial lighting could visually structure space, offering a kaleidoscopic range of possibilities on how lighting could relate to architecture and space, while addressing to the "perceptual needs of the users of the space" (ERCO, 1992, p.24) This also initiated the evolution of artificial lighting from a discipline that promoted the engineering of sufficiently, functionally-lit spaces, to the introduction of artificial lighting to create desired mood and atmosphere. Since Flynn's studies in the 1970s on the effects of various illumination techniques and their correlated effect on human psychological behavior (Flynn, 1988), many subsequent studies aimed to uncover the underlying pattern behind perception and artificial illumination of interior spaces. (See Chapter 3.1.4) This is exceptionally important, as human were highly dependent on sight in the perception of his environment, and the appearance of the illuminated space would affect the resultant psychological comfort within the space. Results had indicated that through the variation of the illumination techniques or lamps within the space, human reaction towards the same space changed (See Chapter 3.1.4), demonstrating the ability of artificial lighting in the alteration of spatial appearance.

1.2 Artificial Lighting: Technical Specifications and Impact on Perception

Therefore, lighting could influence our spatial perception, resulting in different appearance of a single space through its permutation on various light-object interactions within the same environment, or the applied luminaries' inherent technical properties. Good lighting should facilitate the use of the space, while allowing ease in the movement through space. Also, quality lighting should aim to promote "a feeling of well-being in a particular environment and at the same time enhancing that environment in an aesthetics sense." (ERCO, 1992, p.28) Therefore, good lighting design is a combination of the manipulation and application of appropriate luminaries in the illumination of the space, yet taking the human perception needs into priority. (Veitch, 2001) Therefore, to understand good lighting, it is crucial to know the technical differences between various available lamps or luminaries and how they would achieve different effects, which would alter spatial appearance. This knowledge is central in understanding how lighting could potentially affect appearance and, thus, composition of the lit urban environment.

Although it would be possible to manipulate the appearance of the illuminated space through the various permutations of the utilized lamps or luminaries, the specifics on how and what is affected in the appearance of the lit space remained unknown. It was only recent that artificial lighting had advanced beyond the engineering aspects, towards the achievement of aesthetically pleasing spaces. Therefore to clarify some misconceptions and to provide better background knowledge, this sub-chapter would briefly introduce on how the utilization of different lamps into the lighting environment could affect the perception of space and the variety of lamps available for urban lighting.

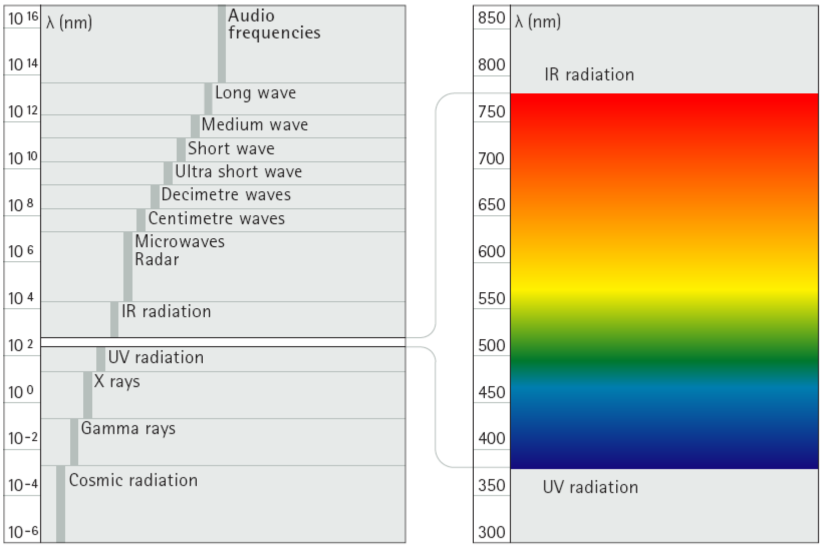

***Figure 1.0** Ranges of electromagnetic radiation. The spectrum of visible radiation comprises the narrow band between 380 and 780 nm. (Source: ERCO, 1992)*

The lamp sources available for urban lighting can be categorized into 2 main types, the Thermal Radiators and the Discharge lamps (ERCO, 1992, p.24), in accordance to the manner light is being produced from the source. Under the Thermal Radiators, it comprised of mainly the Halogen and Incandescent lamps (See Appendix II for more details), while Discharge lamps can be further classified into either high-pressure or low-pressure types. The high-pressure Discharge lamps are the Metal Halide lamps, Mercury lamps and the High-Pressure Sodium lamps and Fluorescent lamps, Low-Pressure Sodium lamps formed the group of Low-Pressure lamps. All these lamps could be used for urban lighting design and since the technical properties, like Lumen output, Colour Rendering or Colour Temperature for each lamp type differed from each other (See Appendix II), one must select the appropriate lamp for its proposed usage to achieve the desired effects. Figure 1.0 illustrated the spectrum of visible radiation, of which the emitted light from each of the lamp source were positioned at different parts of this spectrum, with Thermal Radiators having a higher percentage of the Infra-red radiation, while Metal Halide lamps had higher percentage of Ultra-violet rays.

Hence, the composition of emitted rays, in terms of the Ultra-violet or Infra-red rays, would determine the Colour Temperature of emitted light.

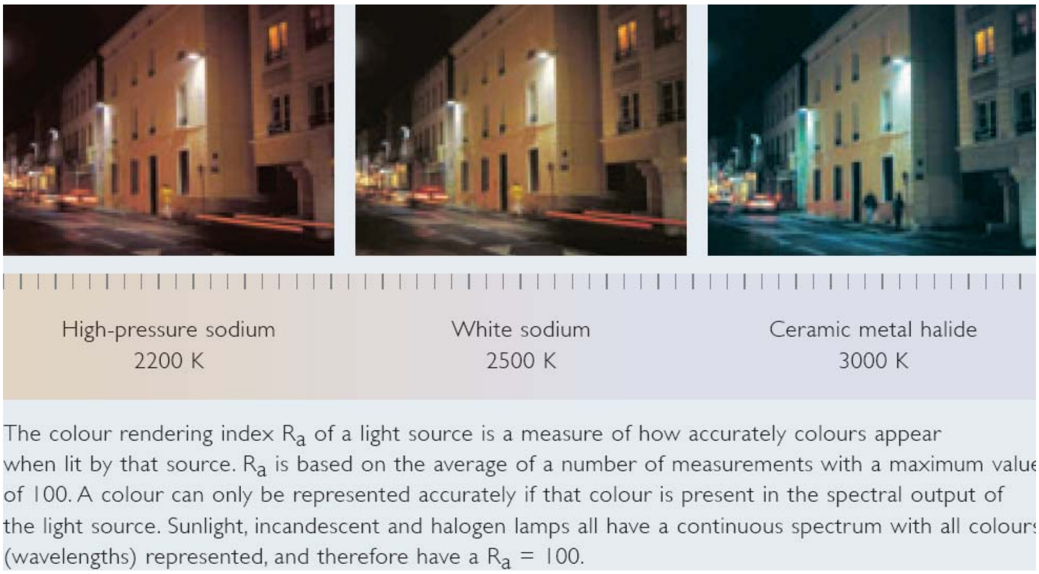

Figure 2.0: *Different effects of lamps used for outdoor lighting (Source: Philips Outdoor Lighting)*

Each lamp source has its unique properties and the design of the luminarie in which these sources were housed would further manipulate the distribution of the emitted rays, thus allowing for design of different illumination techniques. Figure 2.0 demonstrated 3 different appearances of the same streetscape, where the appearance of the street was “modified” through the choice of lamps, so demonstrating that besides the illumination technique, appropriate choice of lamp is essential in presentation of the imagery to its most desirable form possible. But, in summary, there are 4 main design parameters for artificial lighting design, which would result in different appearance of the lit environment and any misapplications might affect the quality of the lit environment. These features are namely Glare, Distribution, Colour Temperature and Colour Rendering index. (ERCO, 1992) Glare existed in 2 forms, discomfort and disability glare, which the latter would pose to impede on visual judgment. More often, glare would occur if the contrast between the bright area and the surrounding were higher than the threshold of tolerance. Since glare would affect our visual comfort in space, lighting designers should avoid having high level of Illuminance ratio between the illuminated and its surrounding to decrease the source of glare. (IESNA, 1975; IESNA, 1989; IESNA, 1999 et al.)

Since the relationship between light and the illuminated object would affect the appearance of the lit environment, distribution of luminarie or direction of its emitted rays in relation to the object should be considered during design to illuminate the object to achieve the desired visual effect. To simplify the different design techniques employed in lighting, there are basically 2 types, direct lighting and diffused. Direct lighting could be translated as the highlighting of chosen object in space, structuring the visual environment, resulting in focal points and sharp shadows. On the other hand, Diffused Lighting is used for general lighting of the environment, with even Illuminance. Since there would not be any visual structuring of the illuminated objects, diffused lighting would therefore result in poor recognition of geometrical forms and details, without interplay of shadows and light, which is unfavourable for perception. (See Chapter 3.1.4 for Lighting and effect on spatial perception) Figure 3.0 illustrated the different lighting technique and the appearance of the same object in various techniques.

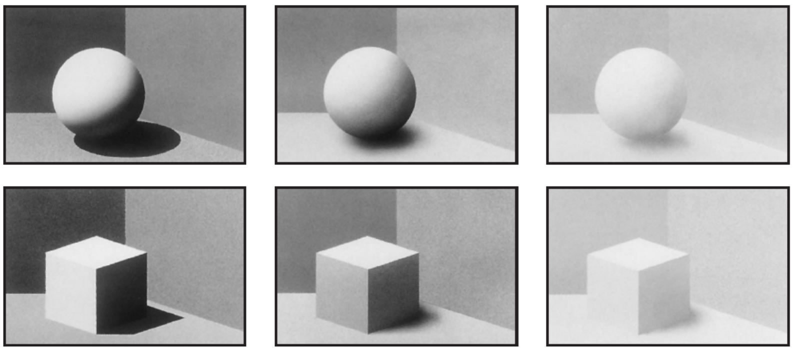

Figure 3.0: *Pictures showing the different effect of lighting techniques illustrated. Direct Lighting; Direct and Diffused Lighting and Diffused Lighting (from left to right) (ERCO, 1992, p.77)*

Since the "colour of the illuminated object is the result of the spectral composition of the light falling on a body and the ability of the body to absorb or transmit certain components of this light and only reflect or absorb the remaining frequency ranges" (ERCO, 1992, p.84), the use of lamp source and whether coloured lighting is being used, would eventually influence the appearance of the illuminated object. Since the Colour Rendering index detailed the comparison of the accuracy of colour of perceived object to the reference light source (See Appendix I for technical definition), different lamps would result in different perceived colour rendition of the illuminated object.

Table 2.0 detailed the different colour rendition categories, which is equated to their recommended usage and task, for example, for lighting which required high colour fidelity to the original object's appearance, lamps of Category 1A would be preferred. On the other hand, Colour Temperature of lamps would influence on the choice of the lamp, if illumination of specific colours is required. For example, blue and green objects should not be illuminated with thermal radiator lamps, as the reddish inclination of the emitted light rays would subdued the actual colour of the object, rendering it grayish. However, if these colours were being illuminated with daylight white fluorescent lamps, it would appear better, despite the fact that the colour rendition of fluorescent is lower than incandescent lamps.

Light source	T (K)
Candle	1900–1950
Carbon filament lamp	2100
Incandescent lamp	2700–2900
Fluorescent lamps	2800–7500
Moonlight	4100
Sunlight	5000–6000
Daylight (sunshine, blue sky)	5800–6500
Overcast sky	6400–6900
Clear blue sky	10000–26000

Colour rendering	
Category	R_a index
1 A	$R_a > 90$
1 B	$80 \leq R_a \leq 90$
2 A	$70 \leq R_a < 80$
2 B	$60 \leq R_a < 70$
3	$40 \leq R_a < 60$
4	$20 \leq R_a < 40$

Table 2.0: *Table illustrating Colour Rendering and Colour Temperature of Different Lamps. (Source: ERCO, 1992, p.84)*

To recapitulate, all the above illustrated that there are factors which would influence the eventual appearance of the illuminated in the design of the illuminated environment. Moreover, researches had demonstrated that these factors would also affect the psychological responses in relation to different usage of Colour Temperature or Lamp Sources. (See Chapter 3.1.4) Therefore, a quality lit space is not a result of correct or appropriate manipulation of lighting fixtures and sources, but to involve consideration for visual comfort in human perspective as well. Moreover, it is noted that the brightness level of am illuminated environment is resultant from the subjective appreciation of space that relates to the totality of the illuminated space, which ranged from Lumen Output of utilized lamp sources to Colour of the surfaces within the visual range. Hence, there is no direct relationship between the luminance level and brightness level. (IESNA, 1975, p. 7) These further demonstrate that there are many intricate details which involved human appreciation and judgment in lighting, which could not be quantified, and researches should be done to address the impact human preferences and visual judgment on the design of the illuminated environment.

1.3 Lack of Knowledge Transfer: Between Studies on Human-Orientated Urban Environment and Lighting Master plan Design Basis

> "To heighten the imageability of the urban environment is to facilitate its visual identification and structuring. The elements isolated above- the paths, edges, landmarks, nodes and regions – are the building blocks in the process of making fun, differentiated structures at the urban scale.'" (Lynch, 1960, p. 95)

Researches (Rapoport, 1977; Kaplan, 1998; Kaplan, 1983) in human perception of his environment had established that human had the innate need to establish their location relative to their surroundings and structure their environment into coherent forms they could identify with, which is related to the primitive need for comprehension of his environment for survival. Lee had identified 3 ways information available in the world would control our locomotive abilities, namely Exteroceptive, Proprioceptive, and Exproprioceptive, (Bruce, 1990; See Appendix) and these information are mainly obtained through sight. Exteroceptive information is particularly relevant in terms of human's position in relation to the world, where it relates to the "layout of surfaces in the environment, and the position of objects or course of events within the environment are needed to guide action in the world". (Kaplan, 1983) Indeed, there are many ways at which the environment could be interpreted, through one's imposed meaning, or the recognition of the physical elements themselves. J.J. Gibson had analysed the ecological approach to visual perception, which emphasized on the "information which may be available in extended spatial and temporal pattern in the optical array, to guide the actions of animals and people, and to specify events of importance or interest''. (Bruce, 1990) However, Gibson had structured his theories on perception that is based on direct perception, which excluded mental associations of perceived object from the initial impression from mere perception. (Nasar, 1988) However, critics of Gibson's theories had indicated that perception does not only involve the direct visual component but the cognitive component as well. (Rapoport, 1977)

> "Perception involves information in the environment picked up by the observer. Cognition involves some internal processing of the information picked up through perception. Perception and cognition, in turn, have probabilistic relationships to one another and to the physical character of the built environment." (Nasar, 1998)

Rapoport had clarified that in perception, 3 processes of Direct Perception, Evaluation and Cognition were involved. (Rapoport, 1977) This difference between the all components involved in environmental perception, were presented in detail through the following explanation, "perception deals with how information is gathered and obtained, cognition with how it is organized (although the two are closely related) and preference deals with how it is ranked and evaluated." (Rapoport, 1977) Therefore, from the above explanation, it is evident that perception, in comparison to cognition, is more direct and dependent much on the sensorial experience[1]. Moreover, the latter referred to an inferred relationship, which is not a direct resultant of perception, with intellectual references. These studies and differences between various aspects of perception shall be elaborated in Chapter 3.0, which detailed the studies on environmental perception and how they could be applied in the formulation of design basis for urban lighting master plan. However, in our area of research, it is the direct visual component of perception that is of importance, despite the acknowledgement that the evaluative aspects of perception do affect the perceivable appearance of the space. The importance of the physical structure of the environment was further supported by Lynch and emphasized through his revolutionary work in *Image of the City.* Lynch had clearly stated in the following statement that "there are other influences on imageability, such as the social meaning of an area, its function, its history, or even its name. These will be glossed over, since the objective here is to uncover the role of the form itself.

"It is taken for granted that in actual design form should be used to reinforce meaning, and not to negate it." (Lynch, 1960) Therefore, the forms that constitute the environment should be the main body of question as they would form the eventual human response to space. He, like many researches after him, had recognized the importance of cognition in perception, yet he concluded that cognition is not as relevant as perception in the initial grasp of the structure of the environment. (Lynch, 1960; Rapoport, 1977) Furthermore, his theories in visual design of the urban environment had been researched and tested upon, with concluding findings had further proved the validity of Lynch's theories on the importance of physical aspects of space. (Nasar, 1988)

Footnote:

1*. It is evident that there existed an extremely intrinsic relationship between perception and cognition. While many of the researches on environmental perception seek to define the difference between the two. Rapoport had clearly defined the difference through the following paragraph extracted from his book, " While there is evidence that higher cognitive processes affect perception through mental set, available categories and coding (Bruner,1968) there is also evidence that infants perceive objects before they know what they are, so that while they register most of the information adults do, they are able to handle less of this information, so that difference may be due to ways of handling information. Since there is more agreement about what is perceived than about how it is structured or evaluated, perception is more nearly specified by stimulus information from the environment than is cognition or, even more, evaluation. Stated differently, the degree of abstractness or concreteness varies, with perceptual processes being more concrete than cognitive and the evaluative being the most abstract. (Rapoport, 1977, p. 36)*

Therefore, to structure an illuminated environment that would best relate to human perception needs, it would be of importance to understand how human perceived his environment and parameters that would best facilitate perception. Lynch's pioneering studies on visual qualities of urban environment had highlighted the importance of visual design of the environment to enhance the experience of one's environment, enabling better identification of one's location and spatial qualities. In his revolutionary publication on the importance of primary building blocks of urban environment, he advocated that "structuring and identifying the environment is a vital ability among all mobile animals. Many kinds of cues are used: the visual sensation of colour, shape, motion or polarization of light, as well as other senses such as smell, sound, touch, kinaesthesia, sense of gravity, and perhaps of electric or magnetic fields." (Lynch, 1960) Hence, environmental perception is a complex process that involved the participation of all senses, particularly our sight. Therefore, the composition of the environment would influence the way we perceive our surroundings and lighting is one of the main factors which would alter the appearance of our space. (See Chapter 3.1.4) Lynch had also pointed out this importance of lighting, yet no researches had yet to verify the extent of which relationship between the external environment and urban lighting would affect human perception. Also, to maintain human interest in his visual environment and stimulate sensorial experiences, variety and complexity should be introduced. (Kaplan, 1983; Kaplan, 1988; Kaplan, 1998) Yet care must be taken that overly stimulated senses would result in sensory overloading, which is undesirable. (Rapoport, 1977) On contrary, Rapoport had noted that "at the perceptual level, inadequate information can be equated with deprivation while excessive information is equivalent to overload." (Rapoport, 1977) Thus, with no notable visual anchors and clarity in the environment, the correlated preference for the same space would decrease. Furthermore, upon contact with his environment, human would definitely impart a meaning to the perceived object, which would be related to his background. (Nasar, 1998; Kaplan and Kaplan, 1983) However, although perception and the derived mental image is unique to individuals, there is often a pattern observed in the appraisal of subjective quality of aesthetics, which is rather consistent for the masses, who were generally from similar cultural and social background. (Nasar, 1998) There was a general inclination of preference towards notable patterns, like the main “likable features” of “Naturalness, Upkeep, Openness, Historical Significance and Order”. (Nasar, 1998p; Rapoport, 1977) These noted features in the environment are similar to theories put forth by Lynch or Kaplan, who dealt closely with the impact of visual elements in the environment. Also, Nasar had pointed out the generic components for an appealing urban space, and this parallelism in tastes indicated that the aesthetics quality of the city form is “less qualitative and subjective than many people think it is”. (Nasar, 1998) Therefore, prior to the introduction of artificial lighting and the various techniques to illumination, one must first consider the impact of these installations on human perception and whether they would support perceptual needs.

In this analysis of Human perception of his environment, the relation of light in space is also evaluated for the potential effect of how light would affect the way spaces were perceived. In Gibson’s theories of “affordance”, he hypothesized that with the different textural compositions of different object, the amount of information extracted from the surfaces of objects and the way light interacts with the surfaces would amount to the presence of different visual information. In many studies on interior lighting, it is proven that lighting, either artificial or natural, affects perception. (See Chapter 3.1.4 for studies done on Lighting and Human Perception).Therefore, these studies had presented much concrete evidence on studies of how some perceived effects could results in uniformed human responses, suggesting that through manipulation of the illuminated and non-illuminated, or interaction of lighting on surfaces, appearances of the objects would be “modified”, hence resulting in different human responses to the same object. Furthermore, the conclusion from some of the researches had indicated the validity of such tests on human responses to his environment. In all, these researches had demonstrated the importance of lighting in environmental perception and the need for further studies to be done on the design basis to quality illuminated nightscape.

Figure 4.0 is a simplified diagram illustrating the relationships and characteristics for each area of namely, Individual well-being; Architecture and Economics that composed the overall attributes to lighting quality. (Veitch, 2001) This further emphasized that quality lit environment is not a simplistic model of providing for sufficient lighting level for functionality of space, but one that composed from the micro scale of well-being of individuals to the macro dimension of environmental impact. This model is exceptionally pertinent for quality in urban lighting, which addressed to the marriage of environmental perception, urban planning and exterior lighting concepts. Thus, a quality lit environment is simply summarized by Pellegrino as, "Good lighting designed to meet its users' comfort requirements should consider various aspects. It should, in fact, both enable people to perform their task quickly, accurately and safely, and also contribute towards the establishment of a pleasant and satisfactory environment." (Pellegrino, 1999) Although quantitative parameters were commonly utilized in the assessment of the lit spaces, they addressed to the measurable terms like the luminance or Illuminance, but factors that comprised the aesthetics of lit spaces extends beyond these benchmarks. These could only be referred to as guidelines to an *efficient* lit environment, but more design basis to *quality* lit spaces should be addressed.

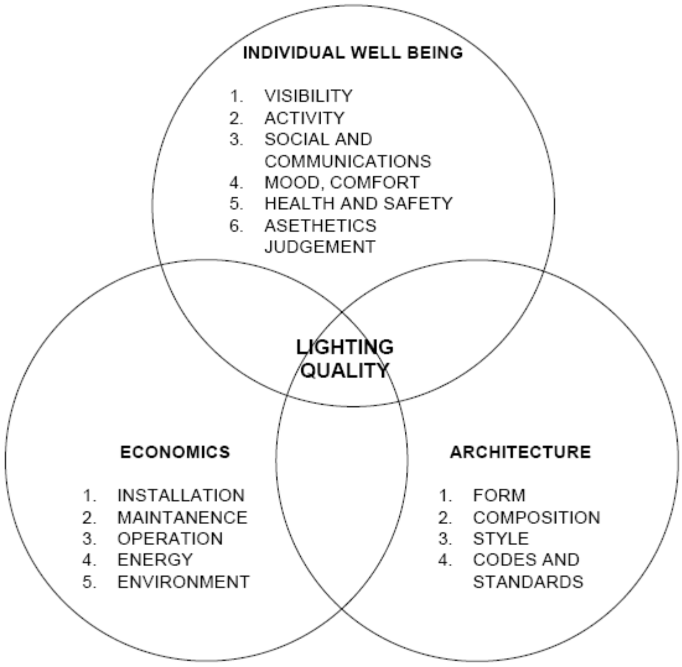

Figure 4.0: *Lighting Quality: The integration of individual well being, architecture and economics. (Source: Veitch, 2001)*

Since there is no current research that pointed to the design basis to quality urban lighting master plan, which analyzed the fundamentals to lighting masterplans that relates to the visual "requirements" of the general public, this research shall form the basis of academic knowledge and research through three main subjects,

1. Current Design Practices of Urban Lighting Master planning
    a. Realized examples
    b. Codes of Practices and Guidelines
2. Environmental Perception Theories
3. Visual Basis in Urban Design

Review of the current design practice to urban lighting master planning would allow one to gain an insight into the current design practice, through the wide genre of realized examples and Codes of Practices. On the other hand, theories to Environmental Perception and Visual basis in Urban Design would provide the required insight on how human perceived his environment and the visual structure he derived from the urban mass. The limited time does not permit deeper research onto the cognitive aspects of perception in nature, while the author acknowledged that perception and cognition co-existed in perception, and its importance in the formulation of images of the urban form. Hence, this research paper intended to evaluate what constitutes the design basis to good urban lighting masterplans, which indicated the evaluation of urban lighting principles with visual design principles from environmental perception theories and urban planning principles, based on human responses. This exposed the research studies towards how general public deemed most visually important for urban lighting masterplans and not merely from the design professionals, for a more community responsive lit environment. Computation tools would be utilized as the main tools for evaluation of various light environments. The diagram below summarized the approach to this research and the field of knowledge that were elaborated in this paper's contents. Together with the identification of this research niche, this paper aimed to address to the definition of good lighting and how the current design practice could be strengthened to achieve a better illuminated environment.

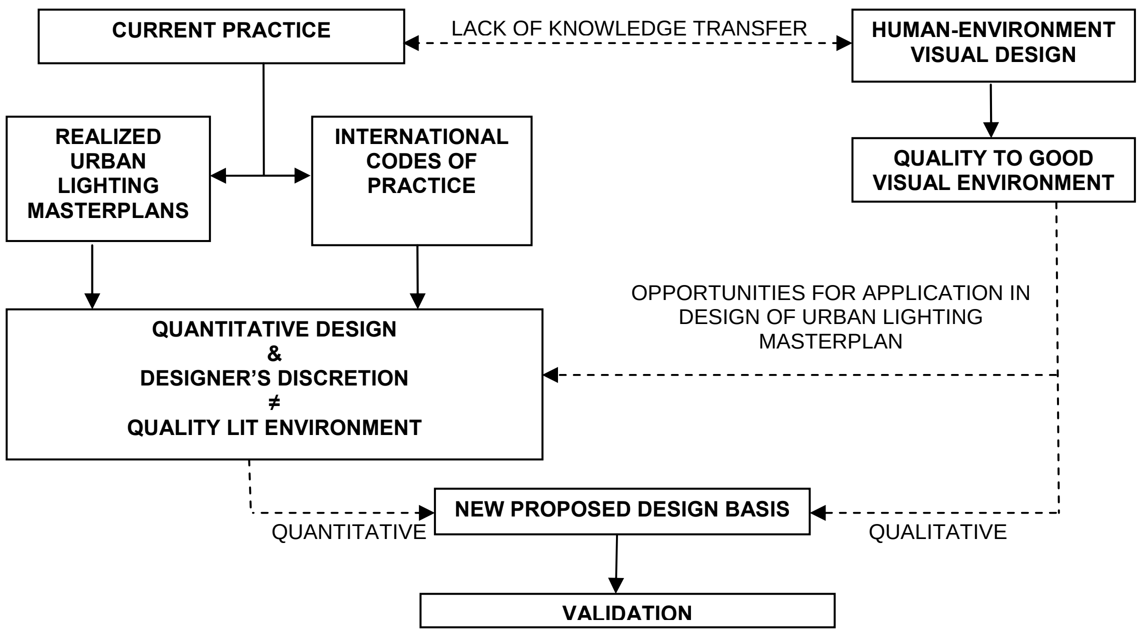

Figure 5.0: Research Framework (Source: author's own)

2.0 Review of Current Planning Basis

2.1 Introduction on Recent Trends and Technological Advancement

Exterior lighting fixture technology had advanced tremendously in the past decade, through improving the efficiency of existing lamps and fixtures and introducing new lighting technology. Previously, Low-Pressure Sodium Lamps were extensively used for Urban Lighting, due to the high lamp efficacy and lamp life. However, due to the low colour rendering abilities of these lamps, the resultant nightscapes were rendered in a greyish hue and the originally vibrant colours were subdued in the night. But recent development resulted in greater efficiency of Metal Halide Lamps and introduction of new lamps, like the LED (Light Emitting Diode). LED fixtures allowed longer lamp life, ease in control and the size of the fixtures allowed easy incorporation and minimal intrusion into the architectural details. Furthermore, the ability to program these systems, with interchanging RGB (Red-Green-Blue) interface enabled integrated colour changing ability and the generation of a wider spectrum of colours, in comparison to the former available lighting systems. Therefore, the further developments into how the output from LED could be increased and expansion of the existing technical abilities of such lighting systems would be the current technological focus in urban lighting developments. With improved technical properties of lamps for urban lighting, it was noted that there existed a need for good urban lighting. Furthermore, with current surge in international lighting conferences and subject matters that relate to the provision of good urban lighting (the condensed version of this thesis was presented at the Urban Nightscape Conference in Athens, September 2006), these signified the need in search for the improvement of current urban illumination.

Figure 6.0 Pictures of 2 products from Colour Kinetics Inc, products developed from LED technology, which allowed the control of the lighting distribution of LED (which is otherwise even) (Source: http://www.colorkinetics.com/)

Figure 7.0 Example of installation of Colour kinetic fixture, Berkeley Homes Tower at Tabard Square London, UK (Source: http://www.colorkinetics.com/)

Therefore, one of the movements as a result of lamp and luminarie development was the popularity of Urban Lighting Master planning, which is a recent movement to revitalize the city's existing fabric and renew the appearance of nightscape, while improving of the quality of the lit environment. Often, these masterplans were commissioned by Urban Planning Authorities to Lighting Designers for recommendations on the various requirements for unique cities. Therefore, during the design of these plans, Lighting Designers referred to Codes of Practices for the lighting requirements for various pockets of spaces, while integrating their formulated lighting concepts into the existing urban fabric. Since most of these urban lighting designs were perceived effect of the illuminated space on the general public and the quality of the illuminated environment was measured through quantifiable aspects of lighting, the definition towards good urban lighting remained blurred. Yet it must be noted that Urban Lighting should not be as simplistic as the mere applications of technically correct luminaries or lamps, but the analysis of the resultant composition or the appearance of the lit environment based on lamp sources of different colour temperature, should be performed. Also, it should not only restrict to the application of appropriate lighting systems for individual spaces, yet as the experience through the urban area is continuous, with greater field of vision, so the holistic approach to the design of the entire urban lighting master plan should be considered. Also, it was noted through researches in road lighting that the field of vision for human travelling through vehicles or walking pedestrians, would require different level of sensitivity and analysis in application of Urban Lighting. (See BSI 5489 for details)

Since urban lighting master planning is a novel discipline, many had proposed their own design philosophies and recommendations. (IESNA, 1999; IESNA, 1975; CIBSE, 1995) However, it was through a recent seminar conducted by Philips Lighting (a strong supporter in quality lighting master plans and the main supporting company that collaborated seamlessly with Lyon in the recommendation of the most appropriate lamps and luminarie designs), that the several basic steps in the planning of urban lighting master plan had been most appropriately summarized. The following points had presented the summary of Philips' steps to urban lighting master planning design, which had also categorized the process into 3 main steps: analysis, design and implementation.

Step 1: Analysis

1. Mapping the existing (traffic networks, major traffic routes)
2. Opportunities (to recognize visual opportunities in daytime urbanscape)

→

Step 2: Design

1. Rendering of the routes in accordance to usable lamps' colour temperature
2. Sketches of chosen sections to measure the scale of the fixtures in relation to the spaces
3. Analysis of existing condition and computer montage of proposed lighting concepts.
4. Division of the cities into areas and regions as recommended in Codes of Practices

→

Step 3: Implementation

1. Application of the proposal
2. Detailed analysis of parts through sketches of sections
3. Application of suitable lighting systems to fulfil concept requirements

To simplify, there are 3 fundamental steps to the design of the urban lighting master plan. Firstly, would be the analysis of the existing conditions. This analysis of the daytime condition of the city would allow the designers to recognize prominent existing problems at the site or the areas which were below the prescribed lighting level as noted by the International Codes and Practices. Secondly, the designer would start the master planning of the site's lighting requirements by portioning the areas into segments of zones in accordance to the zonal divisions as noted in the Codes of Practices, for reference on the lighting requirements of the area. Also, the major traffic routes would be highlighted in accordance to the Colour Temperature of the proposed luminaries. Sketches of chosen sections would be done to illustrate the interface between the physicals dimensions of proposed luminarie in relation to the scale of the street and how the lighting strategy would interact with the urban elements. Lastly, after the completion of the draft for the area, the application of the suitable lighting technology to realize the proposed lighting concepts illustrated in stage 2 of the design process. During this application of the suitable lighting technology, there must be further analysis done on selected sections of the urban spaces, of which detailed lighting interaction with the surfaces would be analyzed. Also, lighting calculations on the resultant lighting level through use of certain chosen luminaries would be done to anticipate the achievable and to compare against the required as illustrated through the Codes of Practices.

With recent departure of urban lighting from the engineering of the illuminated environment, to one that considered the total imagery of the illuminated nightscape, the definition of good urban lighting would be of utmost importance. Veitch defined a quality lit environment into a lit space which embodied the synthesis of 3 main components, as shown in Figure 4.0, the human well-being, relevancy to architectural language and economics of the lighting system. Thus, the approach to quality lighting should not be concentrated on the provision of quantitative component of lighting, but include analysis of human perception needs in his environment. (Jay, 2002; Veitch, 2001) Recent studies in the appearance of lit spaces verified and suggested that variations in artificial lighting of spaces, through the usage of lamp sources of different colour temperature or illumination technique, would ignite different human responses to spaces. (See Chapter 3.1.4) However, few of such studies existed and they were mainly for interior spaces and none existed for urban lighting. Since there is an increase in architectural interest in urban lighting, an alternative view towards the illuminated environment should be proposed to address the current lack in design. Thus, analysis of the existing site conditions should be extended to the consideration of how human would perceive the illuminated urban spaces. The new proposed basis should complement the analytic aspects in the design process of the urban lighting master plan, providing a basis for analysis of the illuminated environment towards better constructed visual space. (See Chapter 4.0 for the proposed basis) Therefore, the review of the current design basis should be approached from two main sources, the analysis of the realized projects and the Codes of Practices utilized for

Urban Lighting. This analysis would reveal the current design practices and parameters to define the illuminated environment, using the current luminarie technology. Also, through the reviews, the lack in current practice would be highlighted and if they would suffice in the construction of a well-lit environment.

2.2 Introduction of Realized Lighting Master planning Projects

With 5 Asian Cities in LUCI and many examples of realized Urban Lighting Master planning projects in this region, it is evident that Asian cities were gradually aware of the need for quality lit urban spaces. While cities involved in LUCI not only have a permanent lighting installation to qualify as a member of the association, they would have to actively sought excellence in lighting and aid in the association's aim in design excellence in urban lighting, together with complementing the urban strategies, environmental aspects, cultural aspects of lighting and lastly, for lighting to be coherent with the latest trends and technology. Despite Urban Lighting Master planning being a novel subject in Asia, there is an increase in public awareness on good lighting and various possibilities of urban illumination. Through the success of Hong Kong's Victoria Harbour Lighting Master planning in the dramatization of the existing skyline, it demonstrated that lighting master planning could help boost tourism, while differentiating the appearance of the city in the day and night. In recent years, the need for urbanization and urban renewal in China had sparked the formulation of lighting master plans for major cities like Shanghai and Hang Zhou, which were two of many cities selected for case-study reviews. Shanghai implemented the city light-up project in 1989, illuminating the breathtaking skyline along the Pearl River, and enhancing the historic character of the architectural jewels. (Li, 2006) While, Singapore had unravelled the new Singapore Marine Waterfront Lighting Master plan in November 2006, a close collaboration between URA (Urban Re-development Authority) and engaged lighting designer of which the author was extremely honoured to be part of the team, demonstrating how the new urban lighting master planning and objectives can be integrated into the existing urban fabric. (URA, 2006)

Therefore, the review of these realized examples would illustrate how urban lighting would relate to different urban context and the design process to the achievement of its design objectives. Also, the current design basis to Urban Lighting would be evident through analysis of these realized projects and Codes of Practices. Therefore, criteria of choice for these projects for analysis would be the ability in these projects to address to the site context, the variety in execution techniques and the availability of sufficient information that would contribute towards their evaluation. Of all chosen projects for analysis, most were mainly located in Asia, reflecting how Asian cities had formulate lighting masterplans and its increasing popularity as a tool to complement urban planning strategies. Furthermore, to enable better understanding on the current design strategies, some of the projects (like One-North Urban Lighting Masterplans) would be studied but not elaborated in this thesis, due to its similarity with example of Roppongi Hills. Hence, the wide polarity the chosen projects would help represent the current design practice and enable the extraction of potential patterns that might exist through the wide project genre. Table 3.0 summarized the different project characteristics and key Urban Lighting Master planning objectives. However, further details of each project would be elaborated in the subsequent chapters of the analysis of each project listed below.

Name of Project		**Project type and main design objective**
1.	France, Lyon	Historical city with significant cultural artefacts. First European city to establish its lighting master plan and had committed to the introduction of excellence in urban lighting through the pioneering of LUCI. **Key objective:** Heritage preservation. To highlight the former urban fabric, respecting the original city fabric and minimizing damage to the existing artefacts.
2.	Tokyo, Roppongi Hills	Development of a new mixed-use area. **Key objective:** to enhance the new development through use of latest lighting technology, to be consistent with the urban planning and architectural vision of a futuristic city
3.	Hong Kong Victoria Harbour	Urban revitalization of water edge architectural structures and appearance of city across the bay at night.

		Key objective: To highlight the existing impressive architectural gems along the waterfront, creating a dynamic skyline.
Name of Project		**Project type and main design objective**
4.	Alingsås , Sweden	Urban revitalization of existing city structure. **Key objective:** To highlight the original city fabric in another manner and innovate the appearance of these ordinary urban elements, into something of visual interest.
5.	Coventry, UK	Urban revitalization of existing city structure. Extremely successful scheme which were awarded with excellence by lighting authorities. **Key objective:** To use lighting as a tool to revitalize the formerly "abandoned" city area, and enhance the existing urban elements through use of artificial lighting.
6.	Hang Zhou, China	Historical city with significant cultural artefacts. **Key objective:** To highlight the former urban fabric, respecting the original city fabric and minimizing damage to the existing artefacts.
7.	Xi Tian Di, Shanghai, China	Urban revitalization of existing city structure. **Key objective:** The existing city fabric was reconstructed, while injecting newly introduced use of spatial programs.
8.	Civic District Lighting Masterplan, Singapore	Urban revitalization of existing city structure. **Key objective:** To use lighting as a tool to revitalize central civic district and enhance the existing urban elements through use of artificial lighting.
9.	One North Lighting Master plan, Singapore	Development of a new mixed-use area. **Key objective:** to enhance the new development through use of latest lighting technology, to be consistent with the urban planning and architectural vision of a futuristic city
10	New Singapore Lighting Master plan (Orchard, Marina, Bugis and Bras Basah, Singapore River) *Formally announced by URA on the 22nd of November, 2006.*	Urban revitalization of existing city structure. In comparison to the previous lighting plan (Noted above as no.8), the current lighting plan introduced the concept of colour lighting, visuals and lighting installations, to increase the dynamism and interactivity of the space. **Key objective:** To use lighting as a tool to revitalize and enhance the dynamicism of the existing urban elements, whilst identifying opportunities for integration of lighting together with the existing.

Table 3.0 *Summary of various urban lighting masterplanning projects and their planning objectives (Author's own)*

Generally, these lighting masterplans demonstrate clear integration Codes of Practice for Urban Lighting, with design intentions of the lighting designers for individual spaces, for a visually comfortable illuminated environment. Although most projects presented interesting lighting concepts in the integration of artificial lighting with urban planning, some of these projects presented some potential problems. These arose from overly zealous application of latest luminarie technology without sensitivity to the site, or a visually monolithic environment, where visual cues were unrecognizable. Thus, these neglected the primary human visual needs when one navigates through his environment. In the following sub-chapter, each of the realized lighting masterplans would be presented alongside with lighting recommendations in the International Codes of Practices, to analyze the current design basis and how it could be further improved.

2.2.1 Lyon – Lighting and Heritage Preservation

2.2.1.1 Introduction

Figure 8.0 Daytime image of Lyon
(Source: http://www.lyon.fr/vdl/sections/en/)

Figure 9.0 *Night time image of Lyon*
(Source: http://www.lyon.fr/vdl/sections/en/)

Lyon is situated in the centre of Rhône-Alpes region, fringed by the Alps to its East and the Massif Central to its West, while Saône-Rhône river valley divided it in the middle. Due to its prominent geographical location, it served as a major cultural and architectural hub bridging the Mediterranean and Europe. Hence, it preserved many architectural jewels and ancient town configuration, making it one of many unique cities in the world. To celebrate its efforts in preservation of its richness in architecture, it was awarded the UNESCO World Heritage site in 1998. A Lighting Master plan was thus formulated to complement the existing ancient structures, while maintaining a safe and well-lit night environment for the security of its residents, as well as to identify its unique skyline for civic pride. Lyon's pursuit for excellence in its design of public spaces in the improvement of the locals' standard of living was well known internationally. Large public squares and public parks, like Place de la Bourse and Place des Terreaux, are centrally located in Lyon, promoting community interaction and indulging in beauty of nature. The Public Parks, like Place Croix Paquet, Parc de Gerland and Sutter Park, were delightful collaboration between the artists, landscape architects and lighting designers in the creation of an enjoyable public space that is utilized fully by locals at all time of the day.

Lyon was the first European city to implement a lighting masterplan, and the resultant master plan was a by-product from close collaboration between the city council, lighting professionals and manufacturers. Since 1989, Lyon had targeted on the provision of a pleasant, yet functional public lighting scheme that allowed the enhancement of its original heritage. In Lyon Lighting Master plan, besides adhering to the standards recommended by its authorities, development of individual pocket of spaces and to celebrate their unique character was possible. Visual contrast between ancient town character and modern technology was introduced in parts and small pockets, for visual interests as one navigate through the old town. In addition, the authorities allowed for pockets of spaces to deviate from the main lighting plan for visual variety and sensorial stimulation, as evident from the example of Parc de Gerland. (See point 3 of Chapter 2.2.1.2) This close collaboration between the government authorities and private sectors was a main reason for success in the design of Lyon's public spaces and application of its Lighting Master plan. This master plan had undergone its third revision since its implementation, highlighting the maturity of the master plan and vigour in pursuit of good urban lighting.

Lyon's drive in good urban lighting was not only restricted to the authorities but the various bodies which promoted public interest in city illumination. During the annual Festival of

Lights, known as the Fête des Lumières (popular festive event that celebrate light and life), lighting event was not only celebrated through scenography, illuminated sculptures, integrating art and lights, the display of latest lighting technology and academic seminars aid in the reaching of this event to the masses. It was not merely an annual tourist attraction, but one event that celebrates Lyon's efforts in the promotion of public lighting. Furthermore, Lyon extended its enthusiasm in good urban lighting through the establishment of the LUCI (Lighting Urban Community International).

From 1995 through to 1998, success in Lyon's lighting masterplan had been studied and applied in cities like St Petersburg, Havana and Ho Chin Minh City simultaneously. In the latest press release, the mayor of Lyon had proclaimed new improvements to the public spaces, and new plans to adhere for planning, namely the revision of lighting plan, "Green Plan", "Blue Plan" and "Colour Plan". The Green Plan targets the protection of nature, Blue Plan relates to the revitalization of the area around the confluences and Colour Plan referred to the application of colours to large structures and along the riversides. The revised lighting plan should support and complement the three other mentioned plans. Also, since Lyon Lighting Master plan had undergone the 3rd revision since its initial implementation in 1998, the new lighting master plan aimed to improve the efficiency of the existing systems, by proposing the change of the existing conventional ballast to electronic ones, and the revision of all T8 Fluorescent lamps to the more energy efficient T5 Fluorescent lamps. This move coincided with the new European Union's new commitment in reduction of energy wastage.

2.2.1.2 Lighting Master plan Objectives and Design Principles

The main objective of the Lyon Lighting Masterplan was the development of a set of guidelines that would highlight the historical character of Lyon, while maintaining appropriate lighting level for safety, security and usability of all exterior spaces. Hence, to integrate professional expertise from private and public sector, lighting designers and manufacturers were involved in the development of the Lyon Lighting Master plan, resulting in the development of customized lighting technology for Lyon's streets and well synchronized lit environment. Philips Lighting Manufacturer was one manufacturer which worked extremely closely with the Lyon authorities in the recommendation of appropriate lighting technology and new product development targeted specially for Lyon.

Lyon Lighting Master plan is centered on some important lighting strategies listed as following:

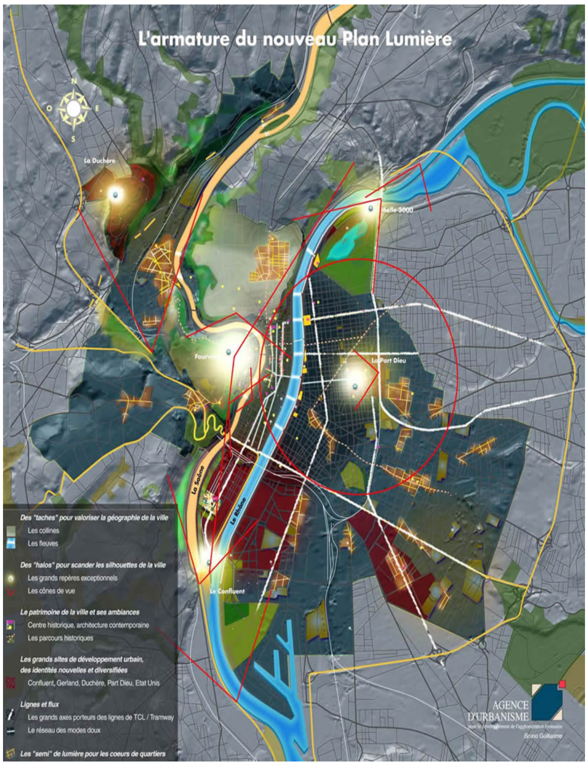

Figure 10.0. *New Lyon Lighting Plan*
(Source: http://www.lyon.fr/vdl/sections/en/)

1. Spatial division and Clarity
2. Urban elements and their forms
3. Individual designs and development of a holistic image
4. Relation of Lighting and time
5. Quality Lighting fixtures, utilization of advanced technology and researches
6. Annual festivals and public education on lighting master plan

1. Spatial division and Clarity

Lyon was analyzed on the whole and divided into different zones to highlight their individual character, as well as for lighting be "personalized" for each zone. The identified zones are the Confluences, Public spaces and Parks, the uniquely Lyon's network of "Traboule", architectural monuments and landmarks. The lighting strategy aimed to differentiate the buildings on either sides of the river, while maintaining serenity through maintaining lower illumination on nature along the waterfront. Since bridges played a significant part in the history of Lyon, care is taken to illuminate each of them to their architectural feature. Parks and garden should be maintained at an appropriate level of illumination to allow their use even when night falls.

2. Urban elements and their forms

Lyon masterplan had expressed clarity in its lighting of urban elements and express each in its own definitive styles. The categorization of urban elements is:

1. Historical monuments
2. Parks and landscaping
3. Bridges
4. Buildings along River Saône

Figure 11.0. *Bridge Lighting in Lyon*
(Source: http://www.lyon.fr/vdl/sections/en/)

Figure 12.0. *Landscape lighting in Lyon*
(Source: http://www.lyon.fr/vdl/sections/en/)

Figure 13.0. *Part-Dieu in Lyon*
(Source: http://www.lyon.fr/vdl/sections/en/)

Quality fixtures, with high Colour Rendering index and utilized in suitable lighting methods adopted for the particular element to be lit. Following the internationally recommended Codes of Practice for Urban Lighting, the Illuminance level of each element is at its suitable functional level, while highlighting the architectural character of individual elements. For example, special parts were drafted in their unique character of each independent parcel, namely the Part-Dieu, Fourviere Basilica and La Duchère towers, while maintaining coherence with the rest of the lit environment. Warmer coloured lamps would be used to achieve the "olden atmosphere" simulating the atmosphere of ancient Lyon city.

3. Individual designs and development of a holistic image

Figure 14.0. *Lighting Concept for Parc de Gerland (Source: PLD magazine no.25)*

Figure 15.0. *Parc de Gerland in the day (Source: PLD magazine no.25)*

The lighting plan identified several key areas for development of specific lighting schemes, like Lyon-Confluence. Vaise Industrie, the Major City Project Lyon-La Duchère. One example that illustrates this departure from the norm is the Parc de Gerland, which implemented a totally different manner in the illumination of greenery. In order to minimize distortion and familiarity of the illuminated object from its usually perceived image, public's opinion would be sought after the conceptualization of each design scheme.

Parc de Gerland in Lyon was one unique pocket of public space that was allowed to be different from the main lighting masterplan. After careful analysis of the quality of proposed lit environment and the design intentions behind the lighting designer's idea of accentuation of landscaping within the park, the authorities approved its design. Lighting within the Park had revolutionized the manner vegetation should interact with lights, at which the designers' main concept is that of an "impressionistic park", when lighting would interact actively with the landscaping elements. Lighting designer masterminding this project had drafted several design criteria and objectives and they are listed as following:

1. Use of saturated colours for sensorial impact
2. Entrances as visual gateways
3. High mounted lamps for minimizing glare
4. High quality lamp sources used

5. Zonal division of spaces that is linked through a succession of continued experiences
6. Rhythmic blend of light and shadows

Use of saturated colours for sensorial impact

The lighting concept of Parc de Gerland aimed to project the mystic characteristic of nature, “unusual nocturnal world” (PLD, 2002) to create a different visual experience that differed from its daytime image. Nature is illuminated, not in their true form, but saturated colours are projected and blended with the original hue of the flora, creating dramatic visual experience. Together with the effect colours have on our psychological experience of spaces and use of appropriate lamp technology, this installation allowed this space to be enjoyed differently from the usual display of natural colours.

Figure 16.0 *Use of saturated coloured lighting on meadows (Source: PLD magazine no.25)*

Figure 17.0 *Use of saturated coloured lighting on vegetation (Source: PLD magazine no.25)*

Figure 18.0 *Contrast of coloured lighting (Source: PLD magazine no.25)*

Entrances as visual gateways

To enhance the entry experience, the three different entrances, the river side, the large meadow and Allee P. de Courbertin, are flanked by 2 3.5m pole mounted luminaries, which illuminated different entrances in different colours. Each of the avenues was lit by pole top mounted luminaries that were spaced about 14m apart, and in a spectrum of hues ranging from violet of the New Avenue to the Yellow of J.P.Chevrot Avenue and Blue of Broussas Avenue. The highlighting of circulation in a variety of colours not only specifically separate each pocket from another, but enable the park to be legible and promotes the ease in navigation

.

Illustration 1.0 *Computational rendering of lighting concept and fixture locations (Source: PLD magazine no.25)*

High mounted lamps for minimizing glare

Most of the luminaries used are mounted from poles that ranged from 3.5 to 15m in height. This minimized direct eye contact with the lamp sources, yet increasing the spread of the emitted beams. The even spacing of poles and care taken into their daytime appearance, helped in the integration of these structural elements into the park.

High quality lamp sources used

Most of the sources used were metal halide, which boost of a high Colour Rendering index of 90 and high burning hours of about 9000 hours, to minimize distortion of appearance of the illuminated object. Hence, the only effect achieved is the blend of the coloured light and the original colour of the lit objects. Colours are projected via integrating colour filters with chosen luminaries. 16 Lighting Control units are installed to provide 2 different scenarios in accordance to the activities that would be taking place, fully illuminated space from dusk to 1am and the basic lighting required for safety and security from 1am to dawn.

Zonal division of spaces that is linked through a succession of continued experiences

Each of the zones within the park is delegated with their own colour schemes, which the choice of colours is based on the manner they complemented or contrasted with each other.

1. Gateways and 'thresholds' are in mixture of yellow and mauve
2. Avenues and paths are in mauve, red, orange, yellow, green, blue and violet

3. Large meadow in blue, flowerbeds in static interplay of red, green and blue, with their contrasting colours
4. Skaters area, dynamic display of colours
5. Large trees, in Blue and Green
6. Coloured Fog

These schemes are coherent to their illuminated spaces and once read in conjunction with the whole landscape, the resultant composed visual image that could be likened to an impressionist painting.

Rhythmic blend of light and shadows

Despite the wide use of colours on designated objects within Par de Gerland, a visual rhythm is maintained through the insertion of areas that is lower in illumination between those that were lit. This maintained a subtle level of blend of lit and shadowed spaces, to avoid over stimulation of senses and sensory fatigue.

4. Relation of Lighting and time

Lyon's Lighting Master plan aimed to conceive some lighting schemes that changed with time provides a dynamic visual environment for the urban dwellers, yet allowing the city to evolve with its changes. These smaller scaled installations could be provided in the city as forms of artistic installation or street furniture. These would be provided periodically and their lighting level should respond to the time of day to provide a lit space of appropriate brightness. Through these lighting installations, the streetscape of Lyon would vary with time and promote visual variety and interest that were different from what the city dwellers perceived on their daily routine.

5. Quality Lighting fixtures, utilization of advanced technology and researches

Lyon is committed to the use of up-to-date technology and using its spaces as experimental grounds for urban lighting ideas and technology. Collaborated with research institutes, universities, manufacturers, it aimed to be the showcase of Europe and experimental grounds for urban lighting. In the new Lyon Lighting Masterplan, it would review all existing public lighting luminaries and replace with luminaries that more ecologically sound, to reduce effects on Sky Glow. The new fixtures utilized for roadway lighting should minimized unwanted lighting spillage, while lighting for landscaping and pedestrian malls would minimize on utilization of upwards lighting. That would minimize undesired energy lost to the atmosphere and re-directing light beams to where they should. Fixtures that were of low performance, low efficacy should be replaced with those of better performance. For example, all T8 Fluorescent tubes with ferromagnetic ballast would be replaced with T5 of electronic ballast for their lower energy consumption level. Also, there should also be a minimization on use of lead and mercury lamps, which would pose pollution problems upon their disposal, and all unwanted lamps should be recycled upon their maintenance routine.

With close collaboration with the lighting manufacturers, Lyon would develop fixtures that are more targeted for urban lighting. Lyon authorities would support more researches on urban lighting, like the development of impact of lamps of different Colour Temperature on residents and detailed analysis of luminaries' geometrical criteria for better integration into their illuminated spaces. Since Lyon had established the Lighting for Urban Community International (LUCI), it would utilize its resources and members of LUCI to participate in excellence in their implementation of urban lighting. In addition, Lyon would see itself as a database for urban lighting technology and host more researches and exchanges in urban lighting to increase public awareness.

6. Annual Fête des Lumières and public education on lighting master plan

As the founder city of Light Urban Community International, Lyon committed itself in the development of excellence in urban lighting, through the use of advanced technology and efficient luminaries. In addition, it is the test bed for new urban lighting fixtures to evaluate their performance. Also, the annual Light festival and conducting of reviews and seminars, kept Lyon as the forth runner in urban lighting.

Fête des Lumières (Festival of Lights), Lyon

This event, which is hosted on the 8th of December annually, had history intricately entwined with the culture and history of Lyon, since nearly 150 years ago. The Festivals of Lights was originally for the inauguration of statue of Virgin Mary, of which residents of Lyon lit up their homes as a form of celebration. It was in the last 4 years that Lyon authorities had decided to integrate this annual celebration with their Lyon Lighting Masterplan. During the 4 days when the festival would be held, the whole Lyon city would participate on a wide scale and when spectacular lighting displays and new temporary lighting installations would be distributed in different parts of the city. Moreover, the main heritage sites, landmarks and nodal points within the city would be highlighted and identified through more unique lighting strategies.

Figure 19.0. *Publication of Fête des Lumières 2005 (Source: http://www.lyon.fr)*

Throughout the years of its celebration, it had seen the participation of people from all sectors, the manufactures, institutions, locals and tourists alike. After the first conceptualization of the lighting master plan and it being the predecessor

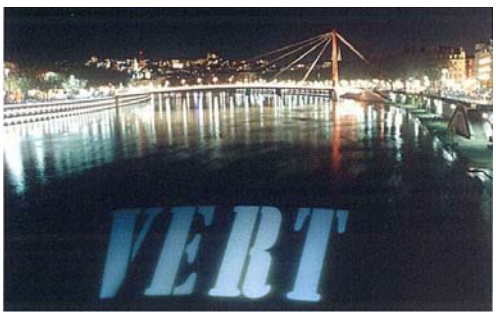

Figure 20.0. *One of Lighting installations at the Fête des Lumières (Source: PLD Magazine no.25)*

in pursuit of excellence in urban lighting, Lyon had been renowned as the “City of Lights”, and the Fête des Lumières is a time when lighting designers showcase their use of latest lighting technology to render their ideas, through a series of temporary installations. This festival attracted millions of visitors to Lyon Of which, 2 methods in lighting had been exceptionally welcomed by all.

1. Projection of over dimensioned images on the main façades of significant buildings, like Basilica Norte Dame de Fourviere, the Town Hall, St Nizier’s Church,
2. Coloured modifications of existing lighting installations, such as the sloping streets in Croic Rousse and the Façade of Cite Internationale de Lyon on the Rhone side.

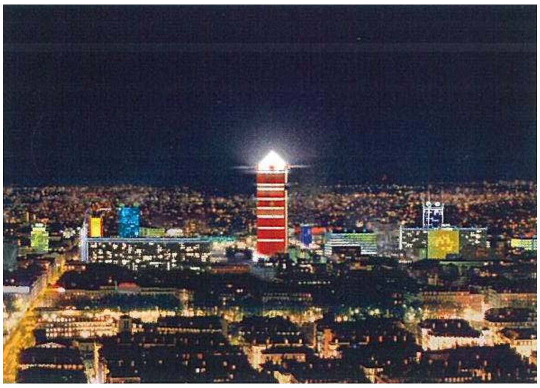

Figure 21.0. *Use of Colour Lighting during the Festival of Lights (Source: PLD Magazine no.25)*

Figure 22.0. *Lighting landmarks during the Festival of Lights (Source: PLD Magazine no.25)*

These attempts, although not particularly coherent to the traditional architectural style of the structure being illuminated, was a welcome contrast from the existing way to highlight the historical character of the buildings. These are temporary installations to create visual interest. Wide use of colours and lighting control systems meant an increase in the visual imageries that would result from the lighting installations.

2.2.2 Tokyo, Roppongi – Lighting and City's Dynamicism

2.2.2.1 Introduction

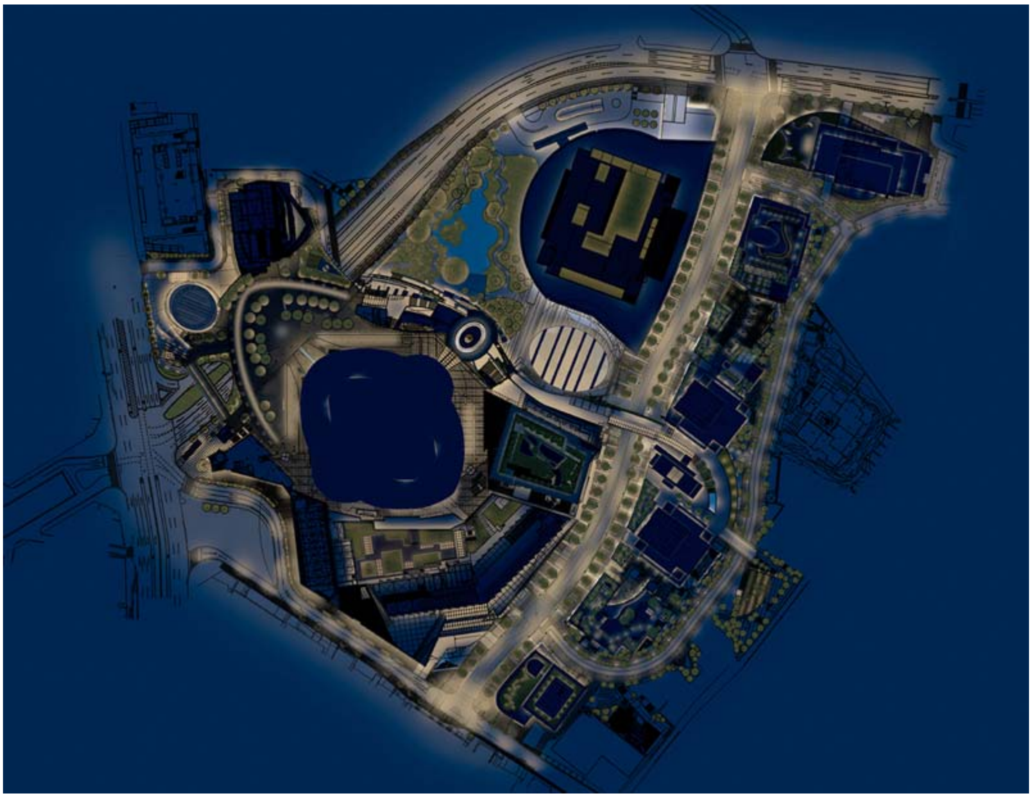

Illustration 2.0 *Overall lighting masterplan of Roppongi Hills*
(Source: PLD Magazine no.33)

Roppongi Hills, situated in Minato Ward in Tokyo, is fringed by the symbolic 54^{th} skyscraper and large architectural structures that composed the mix-used area, which comprised of a museum, residential and commercial facilities. The outdoor spaces and gardens were connected through a succession of levels that bridged the entire site. It was envisioned as the city of the future, where the lighting masterplan should embody usage of quality luminaries and of latest technology, utilized in cutting edge lighting design methodology. With the intention of experimenting revolutionary ideas on the future of urban lighting design, several groups of lighting designers, architects and urban planners collaborated to present their foremost ideas in this parcel. Several of internationally renowned lighting designers like Motoko Ishii Lighting Design from Tokyo, Kaplan Partners Architectural Lighting from Los Angeles and Isometrix from London, were responsible for the design of their designated areas, while Lighting Planners Associate Inc. (LPA) were to provide the basic specifications of which the individual firms were to conform and coordinate the potential impact each lighting schemes would have on another.

2.2.2.2 Lighting Master plan Objectives and Design Principles

Since Roppongi Hill Lighting Masterplan should be targeted for a futuristic city, technology was excessively used in this project. In addition, the chief lighting consultant employed, Lighting Planners Associates, LPA, coordinated with other lighting designs of individual developments within the Roppongi Hills, in the achievement of a coherent lit environment. The whole Roppongi Hills was analysed in detail and appropriate lighting strategy was conceptualized. LPA had benchmarked their lighting design for Roppongi Hills on several aspects, which are the viewpoints, changing scenarios with time, adhering to the architectural character of the space and employing the most appropriate lighting technology. Of these design criteria, viewpoint relates to the manner people perceive and navigate through space. Primarily, viewpoint represents the distance and points at which the designated parcel might be viewed from. Hence, lighting design had considered visual priority of every urban feature viewed and the distance from which they would be seen. Due to the complexity of functions and programs the site embodied, the following are the main lighting master plan objectives and design criteria for the whole Roppongi Hills area.

1. Zonal division
2. Time, space and vista
3. Quality lighting environment
4. Establishment of Visual Points

1. Zonal division

The seamless integration of outdoor and indoor spaces is a main planning objective behind this project, with the main circulatory route of Keyaki Zaka Street cutting through the entire Roppongi Hills, separating the site into two man portions. This became a main manner of zonal division, where the commercial spaces are distinctively separated from residential. Moreover, within each parcel, the landscaping in the outdoor spaces was lit differently from each other, dependent on their adjacent surroundings. For example, low Colour Temperature and low level lighting was utilized for landscape lighting in the Japanese Garden that is next to the residential area, but Fiberoptics wrapped trees are the highlight of the surreal garden of Roku Roku Plaza. Hence, lighting had respond to the different functions each area embodied, like the use of low level lighting for the vegetation and parks, outdoor plaza and high technology utilized for façade illumination. Together, the Colour Temperature of chosen lamps different to highlight the character of the lit space, low Colour Temperature lamps for intimate spaces and cooler Colour Temperature for areas of higher pedestrian traffic flow. The difference in lighting strategy allowed non-uniformity for visual interest and clarity in navigation.

Figure 23.0 *Outdoor Lighting in Roku Roku Plaza*
(Source: Author's own)

2. Time, space and vista

Since the advancement of technology, the operation of a city is no longer constrained by time but often a round-the-clock functioning system. The lighting system would adhere not only to the change from dusk to night but varied during the night. This is a metaphoric symbol of linking the city into a living organism that response actively with time. In addition, 3 different visual environments were considered, as Roppongi Hills could be visible from many surrounding points. First of which, the view from 1to 10km was best represented as the façade appearance of each structure, medium tier represented the visual experience of from 1km to 0.5km and the range of less than 0.5km represented how the element would appear at close range to each viewers. The setting up of visual hierarchy signified the importance of how the city would appear from a macro scale to the micro.

Figure 24.0 *Lighting Control of Mori Building (Source: Lighting Planners Associates Inc.)*

3. Quality lighting environment

Quality fixtures that were glare-free, with high Colour Rendering index and integral technology that enabled colour changing, like the Fiberoptics system and Light emitting diode (LED) system were used intensively for the comfortable visual environment. This resulted in vegetation that were entwined with illuminated Fiberoptics system, LED that changed colours on a rhythmic and time-based routine, creating outdoor spaces that are both mystical and enjoyable for all. Street lighting not only provided the basic illumination to the pedestrian pathways and roadways, but spotlights were integrated with each street lamp to highlight entrances to shops along the major Keyaki Zaka Street. Since this traffic node was characterized by 2 rows of trees flanking each side, the illumination of these trees would change together with the festivals or events that were ongoing.

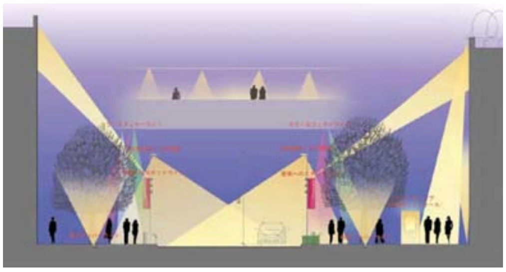

Illustration 3.0 *Lighting along Keyaki Zaka Street (Source: Lighting Planners Associates Inc)*

Illustration 4.0 *Festive Lighting along Keyaki Zaka Street (Source: Lighting Planners Associates Inc)*

Also, to increase the interactivity of the space, lighting installations like the screen wall, which occurred at junctions, lighting of the street furniture along the Keyaki Zaka Street were proposed. Temporary lighting installations were proposed during festive times, along the Keyaki Zaka Street, to highlight this main arterial road.

4. Establishment of Visual Points

Since Roppongi Hills development was a condensed parcel of new development area, the approach to the site was crucial to the developers, to distinguish this area from the surroundings prominently. The lighting master plan had identified a few view points from which the site would be approached, and how different visual hierarchy could be established in accordance to the distance from the site.

2.2.3 Hong Kong Victoria Harbour Lighting Plan – Lighting and Tourism

2.2.3.1 Introduction

Figure 25.0 *Hong Kong Island Skyline from Tsim Sha Tsui promenade*
(Source: Colour Kinetics Lighting)

The Victoria Harbour Lighting Plan is commissioned by the Hong Kong Tourism Commission and had seen a permanent display of light and laser show based on the illumination of the prominent buildings that fronted both Hong Kong and Kowloon, overlooking Victoria Harbour. This scenic spot is extremely popular with locals and the 18milion tourists that visited Hong Kong annually, hence to illuminate it as a background for lighting display would complement the existing skyline in the night, yet lent a different look to the normally dull display of skyline during the night. The formulation of this lighting plan signified the first attempt to translate such an asset in such highly visible and coordinated manner.

2.2.3.2 Lighting Master plan Objectives and Design Principles

Prior to the development of the Lighting Plan, each building was lit in accordance to their unique strategy and the relation of each to its surroundings was not considered. This resulted in a skyline that was chaotic and at times, excessive lighting worsened the problem of light pollution. Therefore, this plan had related each element to another and minimized the wrong use of lighting strategy, which reduced the effect excessive lighting had. The Victoria Harbour Lighting plan, also a scheme for urban revitalization, seek to highlight this excellent skyline that was not brought to its best at night, to create a vibrant nightscape that would be enjoyed by all across the Tsim Sha Tsui Promenade Since this stretch of skyline extends across the whole Hong Kong Island, the mirrored image of this lit environment on the Victoria Harbour would intensify the experience. After careful analysis of the site, the Victoria Harbour Lighting Masterplan was formulated with the following lighting design basis.

Figure 26.0 City Hall in the Day
(Source: Source: Colour Kinetics Lighting)

Figure 27.0 *City Hall after implementation of Lighting Masterplan(Source: Colour Kinetics Lighting)*

1. Selected Viewpoints and illuminated landmarks
2. Automated lighting control system
3. Vertical extension and Light shows

Figure 28.0 HSBC Building in the day
(Source: Source: PLD magazine no.38)

***Figure 29.0** HSBC Building after implementation of Lighting Masterplan(Source: PLD magazine no.38)*

1. Selected Viewpoints and illuminated landmarks

The formation of “Harbour Lighting Plan” was divided into a few stages, of which energy efficiency and potential problem like lighting pollution was initially analysed of each chosen architectural element. The choice of illuminated structure was based on their visibility from chosen viewpoint and also the angles at which each would be viewed. Then the list was analysed with the lighting technique that would be utilized in the lighting of each structure and on the pretext that the applied lighting strategy would be coherent to the original architectural integrity of the chosen building. This resulted in a list of significant landmarks, like the Hong Kong Shanghai Bank, Central Barracks, Jardine House and the Hong Kong Convention and Exhibition Centre.

Although all the chosen architectural landmarks had their individual characteristic, it was still complemented and analysed on the way each character would complement on the whole for a visually balanced image of the skyline. The chosen buildings, which incorporated many of Hong Kong’s prominent landmarks, were well spaced in relation to each other, so areas of unlit spaces between the illuminated structure aid in the contrast and enhancement of the overall composition. Together with the vast body of water that separated the prominent viewpoint of Tsim Sha Tsui Promenade from the stretch of coordinated lit structure, there is an appropriate distance to perceive the skyline as a whole and the reflection in the water further enhanced the aesthetics of the lighting display. The further use of search lights on most lit structures had visually extends the illumination display skywards and dramatized the whole visual experience.

2. Automated lighting control system

Light emitting diodes, LED, on automated lighting control system was extensively used for façade lighting for the creation of a dynamic skyline, which varied from the monotony of its daytime image. To increase the vibrancy and heightening of sensorial stimulation, coloured lighting was used extensively. The combination of coloured lighting and changing modes that is synchronized across the skyline inject a festive mood to the whole waterfront and heightened the experience as one moved through the Tsim Sha Tsui Promenade, or viewed the whole skyline from The Peak.

Figure 30.0. *Use of coloured lighting and Pyrotechnics on buildings (Source: Colour Kinetics Lighting)*

3. Vertical extension and Light shows

Pyrotechnics were not utilized on a major scale in Hong Kong as a result of stringent regulations, as compared to Sydney. Hence, approvals from major government bodies, like the Fire Department, Leisure and Cultural Services Department, The Hong Kong Police and Marine Department etc, was required before the execution of pyrotechnics display. The vast body of water of Victoria Harbour also meant that the distance of fireworks to the view point is greater as compared to other places with similar displays like Sydney and London. This problem had been overcome with the increase of buildings that would incorporate fireworks.

Integrating use of lasers into the overall lighting plan, using High Powered Stella Ray projectors installed into a few chosen buildings, like the International Finance Centre and Central Plaza, to enhance the whole experience. Its use would depend on the extend of air pollution for each day, as the higher the content of air particles in the skies, the greater is the visibility of the beams, hence the more effective is the display. Laser would also allow active interaction of the audience at Tsim Sha Tsui to the display on opposite banks, through animated beams of lasers that span across the Victoria Harbour. In order to minimize impact of the use of lasers on the marine and aircrafts navigation, approvals would be required from relevant authorities. Furthermore, the type of lasers used would need to have high beam divergence.

2.2.4 Alingsås Lighting masterplan, Sweden – Lighting and Functionality

2.2.4.1 Introduction

Situated in the arterial traffic route between Stockholm and Gothenburg, Alingsås is a typical small European town with a small population of about 35,000 inhabitants. Although it was made a municipality in 1690, historical records had its history dating back to the 1357. Its urban fabric is mainly composed from historical wooden architecture, which some had histories dating back 350 years from now. Due to this richness and variety in its urban fabric, Alingsås was awarded a prize in Sweden as one of its best kept historical centre. All these favourable opportunities had definitely opened the option of expending tourism industry in Alingsås, of which the town would envision itself increasing the number of inhabitants, while increasing its cultural significance and civic pride during the process. The lighting master planning did not merely serve as a platform to boost the tourism industry but resulted in a visually pleasing and functionally illuminated townscape. It was through a series of lighting workshops that was hosted in Alingsås that the town became aware of the beauty of space created by lighting and how lighting can supplement or complement the existing, to provide for sufficient lighting at night. Temporary lighting installations as a result of those lighting events were very welcomed by the residents, who expressed disappointment when the installations were removed after the events. However, the milestone for application of urban lighting master planning was the ELDA lighting event in October 2000, when many internationally renowned lighting designers were invited to host workshops and design lighting for urban elements that was distributed around the town. The elements being considered were bridges of the town that cross a river that divided the town, an old water mill and a small park, St Christine's Church and an old Italian-style villa etc. Since the theme was the event was "what is lighting masterplan? Do towns need them?", the conferences and installations were aimed at expressing the potentials in urban lighting, while educating the public on urban lighting. The discussions revealed a series of idea exchanges among many international lighting designers, manufacturers and experts in the area, which would suggest a rapid development of ideas in urban lighting and the demand for lighting master planning as the trend now. The scale of that event had not only indicated the trend in lighting towards master planning lighting for townscapes, it had lead to public interest in lighting and had brought over many innovative changes in the appearance of the town at night, when the residents had voluntarily placed their own lighting fixtures in courtyards and gardens.

2.2.4.2 Lighting Master plan Objectives and Design Principles

Figure 31.0. *Exterior of houses (Source: PLD magazine no.18)*

Figure 32.0. *Effects of fireflies on roofs (Source: PLD magazine no.18)*

Figure 33.0. *Highlighting elements in the landscape (Source: PLD magazine no.18)*

The main objective of Alingsås Lighting Masterplan was to enhance the old European small town image this town uniquely possessed in the day, but the spirit of place diminished with darkness. In addition, the introduction of points of visual interest as one moved through the town was another highlight of this masterplan, while maintaining sufficient lighting level for the functionality of exterior spaces at night. Also, the formulation of Alingsås Lighting masterplan should also embody the important aspects of security, safety for the residents. Hence, with adhering to international codes and standards, the basic lighting requirement is fulfilled, while aesthetics in lit environment was expressed as a combination of the use of appropriate lighting technique and expressing the architectural form in the most innovative manner possible. Alingsås Lighting Masterplan was structured about this design basis that was fundamental to the development of the overall lit environment.

1. Sensitivity to the Architectural Programme and Designed Atmosphere
2. Functionality and Complementing the Existing Landscaping
3. Complementing the Architectural elements
4. Using Lighting Technology in Realization of Design Concepts

1. Sensitivity to the Architectural Programme and Designed Atmosphere

One of the lighting masterplan formulated involved the existing Alingsås Mill, which was separated from the main town from a railway that was constructed in the 1900s and a bridge. The objective of lighting was to re-establish this visual link between the main town and the Mill, as well as to revive the romantic atmosphere this Mill uniquely possessed, what was fondly remembered by the residents of Alingsås. The park that fringed the mill was also separated from the main town development, with only a small portion of it near the road in use, which was partly due to the low provision of existing lighting. Lighting would revive the Mill to its intended atmosphere, while connecting it with the park and the town visually and sensitively. Lamps of warm Colour Temperature were utilized for the interior lighting of the Mill, while the connection to the main town was via the roads that was symbolized the original river. To convey the feeling of olden countryside, “Fireflies” was introduced as part of the scheme to remind the residents of the Mill being a romantic place that was subtly lit by fireflies at night. They were improvised through the use of 3M materials and lighting technology.

2. Functionality and Complementing the Existing Landscaping

The Avenue that borders Alingsås was a stretch that is situated next to home of elderly and the cemetery and hence lighting should complement the existing serene atmosphere. Since this avenue was fringed by trees, functional lighting should integrate well with the nature, as not to be visually obtrusive amongst the nature in the day, yet highlight the greenery at night.

Figure 34.0 *The avenue after implementation of masterplan (Source: PLD magazine no.18)*

Figure 35.0 *Moonlight effects on the grounds (Source: PLD magazine no.18)*

Since the main users were the residents who would utilize this as a footpath or cycling route, lighting level designed must be sufficient for them to recognize the surroundings, as well as to allow people to move through this well-used route at different speeds, while enjoying the serenity of the surroundings. Lamps of cooler Colour Temperature was used to simulate the moonlight by fixing them on the crowns of the trees and aiming them onto the route, while warmer Colour Temperature lamps was used to up-light the trees. This created s series of lighting patterns onto the route, wile providing with sufficient lighting level for the route to still be utilized at an optimum level.

3. Complementing the Architectural elements

The illumination of the church, situated in the main square of Alingsås, would complement the original pristine character of the church, while highlighting its unique architectural features. Prior to the implementation of lighting masterplanning to the town, Low-Pressure Sodium lamps were utilized to illuminate the church, which rendered it in an orangey glow and had suppressed the colours into greyish tones. New lighting plan would enhance the architectural character, while introducing blue lights to façade lighting for an appropriate contrast.

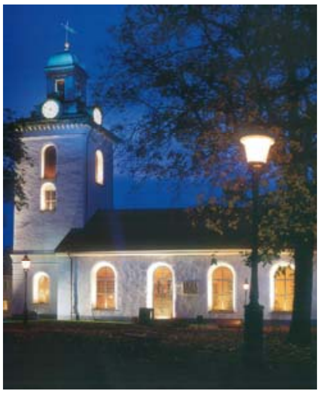

Figure 36.0 *Blue lighting contrasted with warm lighting at base (Source: PLD magazine no.18)*

Figure 37.0 *Bridge lighting (Source: PLD magazine no.18)*

4. Using Lighting Technology in Realization of Design Concepts

The use of lighting technology in the realization of various lighting design would not be possible without the advancement in research on lamps and control systems. These enabled lighting to appropriately complement the architectural intend, while creating a lit environment that is different from the daytime image. These subtle differences would increase one's enjoyment of space, as Kaplan had equated aesthetics with variety and balance. Bridges in Alingsås had been an important transportation element that linked both sides of the town across a river that divided the town into two. Designers had conceptualized their design intend of how the bridge should be expressed and lighting would fulfil this design intention. The use of coloured lighting, with good Colour Rendering index and glare-free fixtures would allow the nightscape to be more interesting and visually intriguing. Some of the bridges' illumination was controlled by control system that allowed programming of lighting scenes. Hence, the designer could vary how the bridge would be illuminated, the change in colour in an automated manner.

2.2.5 Coventry Lighting Masterplan – Lighting and City Planning

2.2.5.1 Introduction

The City of Coventry was believed to be established in the year 1043, with founding of the Benedictine Abbey by Leofric, Earl of Mercia and his wife Lady Godiva. It was situated in the West Midlands of England and spanned an area of approximately 98.64 square kilometres. It flourished in the middles ages and was one of the main trading centers for cloth in the 14^{th} century. Hence, many historical relics that were distributed about the city have history that could be traced back to a few centuries. However, during the Second World War, many of the historical landmarks and monuments, like the famous Coventry Historic Cathedral and City walls, were damaged from a massive German air raid (the 'Coventry Blitz') on the 14th November 1940.

Figure 38.0. *Coventry Cathedral*
(Source : Coventry City Council)

Figure 39.0. *Historical Spon Street*
(Source : Coventry City Council)

Coventry had engaged in rigorous Post-war restoration of its damaged city fabric but the resultant architectural style of that era was monotonous and unappealing, as concrete was used as the main construction material. In the period from 1970s to 1980s, a decline in the British motor industry had a huge economic impact on Coventry, as it was the main source of economic development of the town. This resulted in urban degeneration and abandonment of local workforce from the town to look for better prospects in other Neighbouring cities. However, Coventry City Council had committed themselves in a series of extensive urban generation projects to revitalize the city centre and landmarks the city was once famous for. In order to revitalize the degenerating urban fabric and to integrate the newer developments with the existing, architects MacCormac Jamieson Prichard and lighting designers Speirs and Major Associates, were invited to conceptualize the whole urban planning masterplan for Coventry, that involved a detail section on formulating a new set of urban lighting master plan, with the main objective, as highlighted by the architect, “a commitment to integrating the refurbished historic and new urban spaces”. Of all, the Phoenix Incentive was the most successful project as a result of the execution of these urban planning programs. It was intended to be the new focal point within the city center, introducing new public spaces and landscaping that would interlink the existing Basil Spence's Cathedral to the Coventry Transport Museum. These linkages of heritage sites through a series of public spaces with art installation provided visual variety and community interaction.

The Coventry Lighting Master plan was also a result of this urban revitalization move, with the main lighting objective as to highlight the existing monuments, while implementing innovative designs for public spaces. The formulation of a lighting master plan should provide “sufficient guidance and control whilst remaining flexible enough for those devising lighting solutions to be provided with a range of options.” (Power, 2001) The Coventry Lighting master plan was conceptualized primarily as an urban revitalization program, to enhance the existing urban fabric, while maintaining a functional, yet aesthetically pleasing night time environment for its citizens. Since Coventry is composed of unique buildings that are distinctive of their architectural styles and typology, lighting

Illustration 5.0 *Phoenix Incentive design concept*
(Source : http://www.mjparchitects.co.uk)

would need to highlight this difference between the zones within Coventry, while relating to the architectural context. After the completion of the lighting masterplan, there was a special demonstration, ‘City Lights, illustrating various lighting techniques to the public, at the end of October 1997. This involved use of colour changing luminaries on a larger scale and projections to create a vibrant city center and increase public awareness of how lighting can affect mood and drama within the space. This approach set the pace for the first phrase of the masterplan’s development and generation of general public interest’s in urban lighting.
The efforts of Coventry City Council were recognized and Phoenix Incentive was awarded the prestigious RIBA Award in 2004 and the success in urban regeneration of Coventry was awarded locally and internationally.

2.2.5.2 Lighting Master plan Objectives and Design Principles

In the Coventry Lighting Master plan, Spires and Major Associates recommended technical guidelines for lighting of architecture, structures and spaces, whilst highlighting projects that were culturally significant to Coventry, namely Council House, Coventry's three famous spires of Christchurch Spire, Holy Trinity Church and old Cathedral, three post war tower blocks (Coventry Point, Hillman House and Mercia House) and Spon Street. The formulated lighting guideline would have to fulfil the functionality requirements of lit spaces, while recognizing the original richness in Coventry’s urbanscape. Since Coventry is composed of several districts that had their own character and boundaries, lighting design should allow this distinction to be noted yet providing a coherent visual environment from one area to another. The various districts are as following:

1. Cathedral district
2. University district
3. Shopping district
4. Civic district
5. Financial/ Commercial District

Out of these districts, the Cathedral district is most culturally and significantly to Coventry. It is a unique historical site that contains the ruins of Coventry's second cathedral, the St Micheal's. The division of these zones facilitate in the formulation of Basic lighting design concepts for the Coventry Lighting Masterplan. The design principles to Coventry Lighting Masterplan are as listed:

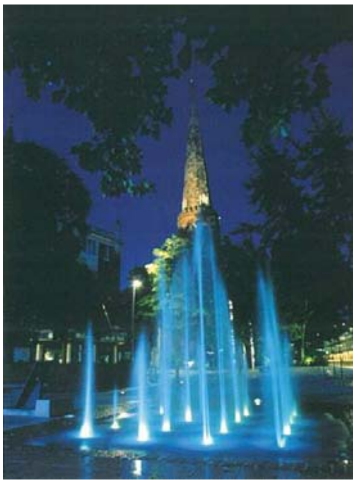

Figure 40.0 *Pield Bull Yard*
(Source :Speirs and Major Lighting)

1. Zonal clarity
2. Preserving original architectural character
3. Visual interest and sequencing
4. Quality lighting environment and luminaries utilized
5.

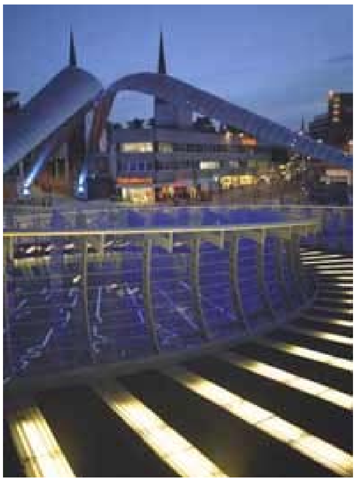

Figure 41.0 *Phoenix Incentive – Millennium Place*
(Source :Speirs and Major Lighting)

1. Zonal clarity

The cathedral district is extremely important culturally and historically to Coventry. Hence the lighting of these historical landmarks is one of the primary considerations in the master plan. Since the 3 churches of St Micheal's, Christ chuch and Holy Trinity are symbolic of close relationship between the development of churches and history of Coventry, the illumination of these churches is centred on the highlighting of the 3 spires and visually connecting the 3 churches at night. Although there is a need to bridge these three churches together visually, each of the churches' spires were lit in accordance to their own theme of namely, Regeneration and Communication for Christchurch, Religion and Industry for Holy Trinity church and Conflict

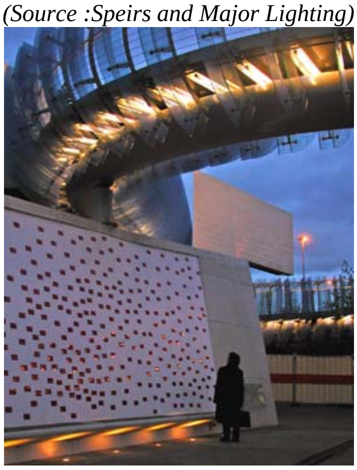

Figure 42.0*.Phoenix Incentive – Millennium Place*
(Source :Speirs and Major Lighting)

and Reconciliation for the church of St Micheal's. The other zones are the Spon Street, where traditional wooden architecture of Middle Ages styles lined the streets on either side. Warm lighting would be used for this area for the preservation of the traditional atmosphere desired. Phoenix Incentive was seen as separated and should be highlighted from the rest of the city centre.

Figure 43.0.*Old cathedral at night (Source: Coventry City Council)*

2. Preserving original architectural character

The cathedrals were illuminated in warm coloured lighting fixtures to highlight the materials used and the spatial patterns. In addition, the fixtures were well integrated into the architectural form, to minimise its visual obtrusiveness in the day. With lighting visually connecting the 3 spires of Coventry, this would enhance the importance of these cathedrals to the development of this modern city, while extending the image of the cathedrals vertically.

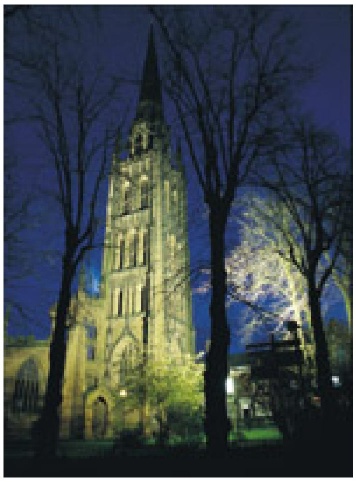

Figure 44.0. *Old cathedral at night (Source :Speirs and Major Lighting)*

Coventry Council House was also one of the landmarks of the area, which the lighting master plan would utilize warm white remote lighting sources to subtly light the architectural features. Through this lighting technique, the distinctive bay windows along the façade are lit by highlighting the underside of the bays, or lighting these windows from the sills. To create visual hierarchy and to highlight the entrance, customized column fixtures were tailor made based on the original lanterns that were hung along the central bay of the Council House. Also, some

Figure 45.0 *Coventry Council House (Source : PLD Magazine no.18)*

low voltage spotlights were concealed on the columns to highlight the assortment of architectural elements noted along the central bay. Moreover, the slate roof was illuminated through a combination of using lamp sources of cool Colour Temperature and spill lights from the lit turrets, to highlight the architectural form and line of the roofs. In addition, spotlights were utilized to highlight the “Peeping Tom” statue located at the base of the clock tower.

3. Visual interest and sequencing

Since the Phoenix Incentive project denotes a series of pockets of spaces were linked together via a path that connected two landmarks of Coventry City, lighting would have to create a sense of visual rhythm as one moved along the pathway. Innovative lighting techniques were used along this path to introduce visual variety and heighten our sensorial experience of the space. Warm lighting was used for intimate pockets of spaces and coloured lighting introduced at random for visual variety. In addition, the mounting level of fixtures was kept low to minimise direct eye contact and maintain a comfortable visual environment.

4. Quality lighting environment and luminaries utilized

Since urban centre are built around the concepts of nodes, landmarks and pathways and the identifications of these elements for the ease of orientation in the urbanscape, lighting should highlight the landmarks for ease in moving around the city. The lighting guideline is conceptualized around the ease of identification of these elements and highlighting the landmarks like churches in their best true form. The traffic circle that extremely prominent in the city centre was character as a divided body, and lighting as a boundary as well as an integrated body.

2.2.6 Hang Zhou（杭州）, China – Lighting for a Famed City

2.2.6.1 Introduction

"A Heaven on Earth", a phrase coined by ancient Chinese, best summarized the experience of all who had been to Hang Zhou. The city is the political, economical and cultural capital of Zhejiang (浙江) province and located along the South-eastern coast of China, only 180 kilometres from Shanghai. Its unique water system was a result of its geographical position, where it is located in the lower reaches of Qiantang River（钱塘江） and on a superior location in Yangtze Delta and adjacent to the East China Sea. Hang Zhou was made capital during the 5 Dynasty and Southern Song Dynasty, thus, its richness in historically significant relics. Although much were destroyed during the Taiping revolution in the mid nineteen century, it was still recognized as one of the most prominent historical heritage sites, amongst other historically significant cities, like Xi'an, Beijing and Chengdu, in China. Some of these relics remained from past are the landscaping elements along the West Lake, the Six Harmonies Pagoda and Lin Yin Temple, just to name a few. The "Ten West Lake Prospects" (西湖十景) along the West Lake offered a series of viewpoints that is the choice of Hang Zhou's natural scenic surroundings, with its ancient monuments, and their names were further inscribed with Qing Emperor Qian Long's calligraphy. The names of these scenic attractions are as follow:

- Spring Dawn on the Su Causeway (苏堤春晓)
- Listening Orioles Singing in the Willows (柳浪闻莺)
- View Fish in the Flower Harbour (花港观鱼)
- Lotus in the Breeze at the Winding Courtyard (曲苑风荷)
- Evening Bells at the Nanping Mountain (南屏晚钟)
- Autumn Moon over a Calm Lake (平湖秋月)
- Evening Sunshine over Leifeng Pagoda (雷峰夕照)

- Three Pools Mirroring the Moon (三潭印月)
- Melting Snow on Broken Bridge (断桥残雪)
- Twin Peaks Piercing the Clouds (双峰插云)

The beauty of Hang Zhou, particularly West Lake, is well known in China and had been celebrated since the ancient times by poets like Su Dong Po and Bai Ju Yi. From Hang Zhou Tourism Committee's Statistics, it attracted about 26 million domestic and 1.05 million international visitors in 2002, while the West Lake was again awarded the National Civilized Tourist Scenic Spot by the Central Government Bureau in Beijing in January 2006. To re-vitalize the original urban fabric and preserve the historical relics, Hang Zhou's municipal government undertook a series of urban re-development projects to maintain the intricate balance between the historical and modern, nature and man-made, and to retain the character of ancient Chinese city Hang Zhou had always been known for. The Hang Zhou Lighting Masterplan was formulated as part of this urban redevelopment exercise, to re-create the charming ancient Chinese city at night, highlighting main scenic spots in Hang Zhou, while maintaining a visually comfortable and well-lit environment for both locals and tourists.

2.2.6.2 Lighting Master plan Objectives and Design Principles

The Hang Zhou Lighting master plan was conceptualized for 'the lighting to present the soul of Chinese traditional scene that is the aim of our plan' (Hao, 2003) There are 3 main parts to the formulation of the Hang Zhou Lighting Master plan, namely,

1. Adopting appropriate lighting strategy for elements along the West Lake
2. Lighting the nature in Hang Zhou, which the city is famed for
3. Skyline and architectural lighting along the east side of Westlake
4. Circulatory lighting in relation to landscaping

It is evident from the directions of this Lighting Master plan that its focal area is the Westlake and how to highlight it in the best possible manner. The desired lighting level would be very subtle and just sufficient for the functional aspect of space, to preserve the serenity of the space and maintain appropriate balance of bright and shadowed spaces. While the main lighting design objectives were drafted, recommendations on lighting environment was made based on the usage of lighting fixtures of appropriate output and lamp source of suitable properties to illuminate and render the target object in the internationally recommended lighting level, with apt designed lighting atmosphere.

Figure 46.0 *Su Dong Po Memorial*
(Source: http://www.xihu-photo.com)

Figure 47.0 *Along the West Lake at night*
(Source: http://www.xihu-photo.com)

1. Adopting appropriate lighting strategy for elements along the West Lake （西湖）

The West Lake is well known both within China and internationally as a top notch scenic spot. The wondrous sights around West Lake not only been celebrated in ancient Chinese literature, poems but myths and paintings as well. The famous Chinese poet, Bai Ju Yi had managed sort out 10 most magnificent sights around the West Lake, known as to the" Ten Scenic Sights", with the name of each site originated from a series of paintings on West Lake done by a painter from the Southern Song Dynasty (1127~1279A.D.). These names not only symbolized the enchanting beauty of flora and fauna in West Lake, but also how visually intriguing, mesmerising West Lake was to the visitors since the ancient times.

The Lighting Masterplan had highlighted parts of the West Lake and implemented most fitting lighting strategy for the area, by analysing the location in detail and choice of lighting design strategy in the creation of a visually comfortable environment. The chosen areas to highlight along the west lake river are listed as following,

1. The Su Dam (苏堤) and Bai Dam (白堤)

In the Su Dam and Bai Dam area, the main elements to consider for lighting were the dams, bridges and the vegetation. Due to the proximity the visitors is with the vegetation around the dams, human factors in lighting were of primary consideration, for example, if fixtures were considered as glaring, choice of lamp source, choice of colour lighting. Roadway luminaries and lighting for vegetation along the periphery of Su Dam should provide sufficient lighting level for pedestrian safety and movement.. Also, lighting for vegetation would highlight the existing visual richness of the site, while creating "visual layers", through the simultaneous lighting of architecture and vegetations. This combination of two different lighting strategies for basic lighting level would also illuminate the profile of the Dam which can be easily perceived at all corners of the West Lake.

Figure 48.0 *Nature and heritage sites along West Lake (Source: http://www.gakei.com)*

The bridges spanned from the dams across the West Lake should maintain the continuity in lighting level across its opposing ends, with required lighting level for safety of the pedestrians and drivers. Lighting should also highlight the architectural feature and character of these bridges, to maintain visual relation with its daytime image. Also, lighting should highlight the physical continuity Gu Hill had with Bai Dam. Since these historical elements on Gu Hill were visible across the West Lake, their lighting should consider the highlighting of their original character and their visibility. Spatial rhythm was created through the appropriate introduction of shadowed and illuminated spaces.

2. Moon in Three Pools (三潭印月)

Figure 49.0 *Island in Moon in Three Pools (Source : http://en.wikipedia.org)*

For Moon in Three Pools, the main elements for lighting were the architecture, furniture, bridges and vegetations. Due to the variety and richness of elements this area present, lighting strategy should allow for visual coherence and continuity from one element to another, while ensuring the overall visual composition of the lit environment is comfortable and suitable for the desired image. Lighting would need to emphasize the outlines of roofs of architectural structures in this area, for reflection in the lake, as well as to enhance the scenery when viewed from top of the hills. To continue with the subtle lighting level used for lighting of this area, the illumination level was kept at near to the internationally recommended standard, and the luminaries to be mounted at low position, to avoid eye contact. Vegetation on the island is analysed according to the shape, types and species of the plants, while their scales, heights and positions, together with the textures of their leaves. There should not be excessive lighting on the water surface to leave it undisturbed; re-creating the serene atmosphere when ancient Chinese lingered along the banks of West Lake.

3. Ruangong Island

The main illuminated elements were the architecture, furniture, bridges and vegetations, similar to the previous focal points. Lighting for architecture should emphasize their uniqueness and illuminated in warm lighting level , creating a warm ambience in creating the appropriate setting for social events.

4. Huxin Pavilion

In the area of Huxin Pavilion, the main highlights are the buildings and vegetations. Due to its small scale and area, a cohesive composition of illuminated vegetation and ambience should be achieved.

Figure 50.0 *Huxin Pavilion (Source:http://www.gaikei.com)*

2. Lighting the nature in Hang Zhou, which the city is famed for

Figure 51.0 *Characteristic scenic pots in West Lake (Source : http://en.wikipedia.org)*

Figure 52.0 *Overview of West Lake (Source : http://en.wikipedia.org)*

Since the West Lake was fringed by only Willow and Peach trees, rendering its distinctive image, the illumination technique should be carefully integrated to highlight this uniqueness. All the vegetation types were studied in detail for the formulation of their appropriate lighting design method, with that their individual position in relation to the adjacent surroundings. This analysis would enable the choice of correct luminarie, lighting design method, the demarcation of lighting zones and the focal of the lighting masterplan. These would integrate to form a harmonious overall lit space and the lighting design of each vegetation type would be dealt with an ecologically appropriate lighting technique.

From the review of all the plant types in West Lake Scenic Region, the types of plants can be divided into 4 main types, according to their crowns and overall shape:

1 Ball shaped

2 Cone or column shaped

3 Vases, umbrella or fountain shaped

4 “Weeping” or Stringy type

Due to the variety of tree types and the difference in colours and textures of their leaves, the lighting technique should showcase each tree in its truest form by rendering it in its natural colour. Since visual variety and visual depth is very important for lighting an area of such scale, trees of different zones were lit using lamps of different colours and highlighting a variety of their detail.. This would present a kaleidoscopic view of nature’s beauty to visitors walking along the banks of West Lake at night.

3. Skyline and architectural lighting along the east side of Westlake

The east side of West Lake is the only part that is urbanized. Hence, this urban skyline forms a contrasting view when compared against the serene beauty of nature that is abundant along the banks of West Lake. Hang Zhou lighting master plan aimed to contrast the night-time view of West Lake Scenic Region to the vibrancy of developed urban nightscape. Yet harmonious blend between these two entities should be achieved, for them to complement each other. The lighting of urbanized skyline is based on the following considerations:

1 Height

Heights of the buildings within the urbanized area would determine how the skyline would present itself; hence the study had resulted in the division of the skyline into 2 layers parts, with the Lake Centre Pavilion as the epicentre of this zoning. These layers existed within a radius of 2km from the Lake Centre Pavilion and another layer spans from 2km to 4km away from the centre of the Pavilion. After the establishment of these 2 layering of skylines, the visual hierarchy and impact of architecture that resided within the demarcated zones is determined. Since the buildings that are within 2km radius from the Lake Centre Pavilion are in proximity to the West Lake and are very significant in the formation of skyline that could be viewed from all sides along the West Lake, these would need to adhere to strict lighting design guidelines. Hence, exterior Lighting of Buildings that are within 2km radius from the Lake Centre Pavilion would need to be planned in accordance to the design principles set forth and should be coherent with the total image of the nightscape.

2 Architectural forms

The geometrical form, especially the roofs, of architecture within the two demarcated zones, is exceptionally significant in their impact on the appearance of skylines. Hence, the elevation of buildings fronting the West Lake and the design of roof structure should be considered in detail for suitable lighting strategy individually.

3 Focal / Controlling Points

Figure 53.0 *Wuling Square in the day*
(Source : http://www.xihu-photo.com)

Figure 54.0 *Wuling Square at night*
(Source : http://www.xihu-photo.com)

Several points are set up within the stretch of skyline for visual variety and highlights. They are namely the, Wulin Square region (武林广场), Qingchun Road region (庆春路), Jiefang Road region (解放路), Train Station Region and Chenghuang Ge. These are known locally as landmarks, nodes and architecturally different sites. Lighting with these noted points would be considered independently from the main Hang Zhou Lighting Masterplan, due to their prominence and urban importance in the formation of skyline. Also, the taller structures within these focal points would be the most important element for exterior lighting design, to highlight and strengthen the character of these points. Lighting of roofing elements of buildings within the focal points should be carefully planned and synchronized with the surroundings. In addition, the primary architectural forms within the focal points should be considered in detail to formulate an appropriate façade lighting technique.

4 Choice of Luminaries for Quality-lit Visual Environment

The illumination strategy of the urban are should be different from the West Lake Scenic Region. Hence, the lamps chosen should be of a higher Colour Temperature, in comparison to those used in Scenic Region. Colour lighting should not excessively used, as it would have impact on the skyline and the reflection upon the West Lake. Moreover, coloured lighting of high saturation is only restricted to the roof components of buildings. Also, illuminated signboards on the top of architectural structures should be coordinated with the overall lighting of the architectural form to present a synchronized lit environment. The lighting design strategy each architectural element would implement should be considered together during its design for a seamless integrate with the architectural form, as well as appropriately highlight its architectural character.

4. Circulatory lighting in relation to landscaping

Illuminance level and choice of lighting types for both roadway and pathway lighting is extremely vital in the creation of a safe, yet visually comfortable night-time environment for the enjoyment of outdoor spaces. The Hang Zhou Lighting Master plan had proposed a special plan for road lighting, which introduced the road lighting principles, criteria for classification of roads in Hang Zhou, industry standards to roadway lighting, Design for some standard sections of the roadways and selection of appropriate luminaries. Since proximity to nature and need for integration of man-made with the natural surroundings is fundamental to the Hang Zhou Lighting Masterplan, certain sections of landscaping should contribute to lighting on its adjacent pathways. This would provide the basic lighting level for functional aspects, yet fulfil the aesthetic requirement in landscape lighting.

2.2.7 Xin Tian Di（新天地）, Shanghai, China – Lighting and Heritage Conservation

2.2.7.1 Introduction

Illustration 6.0 *Map of Xin Tian Di*
(Source : http://www.xintiandi.com)

Figure 55.0 *Overview of Xin Tian Di*
(Source : http://www.shuion.com)

Xin Tian Di (新天地) located in central Shanghai City and south of Huai Hai Zhong Lu (淮海中路), covered an area of approximately 30,000 square meters. The unique original Shanghai architecture of Shikumen (石库门) was extensively conserved to preserve the original character of the space, yet the interior spaces were readapted to modern uses. Hence, the exterior of Shikumen housing was preserved in its original appearance and the interior was re-furnished for modern usage like international gallery, bars and cafes, boutiques and theme restaurants. This extensive effort had been internationally acclaimed and recognized by a series of awards, like the national “Innovation China 2001 – Architecture Award”, “AIA Hong Kong Citation 2002” and the 2003 Award for Excellence from United States based Urban Land Institute.

To introduce architectural variety and support appropriate level of contrast, Xin Tian Di was developed in two separate parts, where the North and South blocks were composed of different architectural character, yet complementing each other experientially. The North block was retained the original Shikumen architecture style, whereas the South block introduced modern architecture, with preserved Shikumen architecture as a contrast to these new forms.. The dividing line between the two blocks is the Xin Ye Lu, which was the site of the first Congress Hall of Communist Party of China. Since Shikumen architecture was greatly influenced by the French and Dutch developers, in both 1926 and 1933 respectively, one distinctive characteristic that differentiate them is in their finishing. Those of French influence could be identified by their "charcoal-grey coloured walls", while those Of Dutch influence was identifiable by their "red-coloured brick wall". (Steiber, 2003)

Figure 56.0 *Xin Tian Di's Shi Ku Men (Source : http://www.gluckman.com/XinTianDi.html*)

Taipingqiao Lake, largest man-made lake in Shanghai city, and Park（太平桥公园绿地和人工湖）were introduced to the development of Xin Tian Di for urban variety and different spatial experience. This Park was connected to the main development of Xin Tian Di by a path that spanned 1.2 km in length and it traced along the periphery of the man-made lake. This path allowed the visitors to experience spaces of different scales and textures, as they moved from the historically rich Xin Tian Di main development, whilst experiencing the intimately-scaled Soft-scapes. In

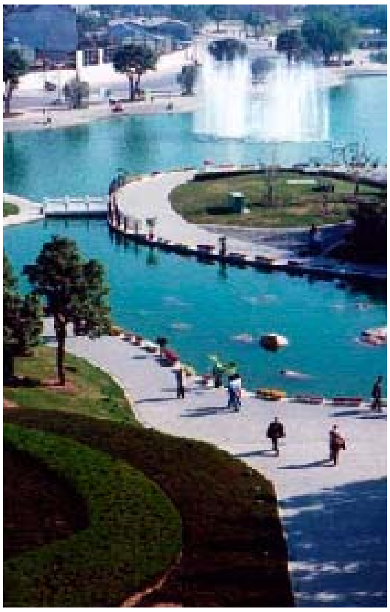

Figure 57.0 *Taipingqiao Lake and Park (Source : http://www.xintiandi.com)*

addition, 2 little islands, Magnolia (玉兰岛) and Unison (合欢岛), were created in the middle of this 12,000 square meters Lake.

2.2.7.2 Lighting Master plan Objectives and Design Principles

Figure 58.0 *Xin Tian Di Mall*
(Source: Author's own)

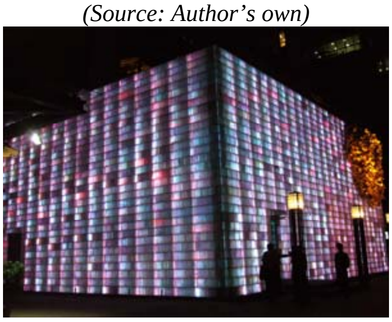

Figure 59.0 *Liu Li Gong Fang (琉璃工坊) Museum*
(Source: Author's own)

Since the main objective behind the development of Xin Tian Di was the preservation of the Shikunmen architectural style and the urban character of olden Shanghai, while maintaining this contrast of modernity with the past, the lighting master plan was to recreate this desired atmosphere and highlight the original architectural character of Shikunmen architecture, which Shanghai was uniquely known for. The lighting master plan would improve the "night ambience and image of the city for visitors and residents". (Steiber, 2003) The analysis of Xin Tian Di had resulted in the following lighting design basis:

1 Zonal clarity
2 Visual hierarchy
3 Spatial Interactivity
4 Relation of Light to Architectural Form

1 Zonal clarity

Since Xin Tian Di is a mix-used development, the division of site into different zones, to tailor-make lighting design for individual zones for ease of identification for separate spaces. The entire development had been stratified into, Commercial, Residential, Conservation and Landscaping. Automated colour changing lighting technology had been integrated into the commercial areas, to liven up the space to create suitable atmosphere. In addition, different lighting techniques, from "theatrical lighting, architectural lighting and accent lighting" were utilized in Xin Tian Di Commercial Development for visual variety. Warm coloured lighting was utilized in Residential area, like Lakeville, to create an inviting atmosphere, while an appropriate balance of lit and shadowed spaces was noted in the rest of the residential development, for a comfortable and relaxing night-time environment. Decorative pole lights, coherent to the architectural style in "Li Long" the alley between each of the Shikumen architecture, was used to provide for the appropriate lighting level in the spaces, while minimizing visual obtrusiveness and glare on the passers-by.

Within the landscaping area, highlights were made on the specific features like the water sprouts and selected spots. To achieve the sense of serenity in the Taipingqiao Lake and Park, contrast between the lit and shadowed spaces was well distributed, with path lighting to highlight orientation, while ensuring ease in navigation during night-time.

2 Visual Hierarchy

Since the pole lights and wall mounted customized fixtures are either positioned along the main pathways or mounted on the walls of the restored Shikumen structures, they aid in the provision of visual focal points for users navigating in the dark, differentiation of structures and the circulation zones from retail areas. The vibrancy created by the use of coloured lighting in the South block, in contrast the warm coloured temperature lighting used in the North block, distinctively created the different atmosphere from one block to another. LED in-ground indicator lights were used along the main circulation path between the North and South Block, leading to the mall's main entrance.

3 Spatial Interactivity


Figure 60.0 *Shikumen lighting in Xin Tian Di*
(Source: Author's own)

Although the North block is characterized by the use of warm coloured temperature light source, which subtly provided sufficient level of luminance to support functionality within the spaces, the South block was approached with an opposite design intention. The introduction of the Xin Tian Di Mall and modern structures within this block encouraged the use of automated colour changing lighting highlighting the underside of the Mall's roof structure. Coloured lighting is introduced in some of the structures in the South Block. One notable example is the Liu Li Gong Fang (琉璃工坊) Museum, where coloured lighting is used to illuminate the glass block structure, creating a kaleidoscopic image and intensifying interactivity of the space.

4 Relation of Light to Architectural Form

The luminaries are positioned aligned to the main entrances to each of the Shikumen structures, also the Structures are also illuminated at the roof tops, highlighting the pitched profile of the roof structures.

2.2.8 Singapore Civic District Lighting Masterplan - Lighting and Civic Pride

2.2.8.1 Introduction

A site that is central to the development of Singapore, the Civic District is located within the Downtown Core planning zone and consisted of the Museum Planning zone. Bras Basah Road, Marina Bay, the Singapore River and the Istana Park via Clemenceau Avenue constitute the periphery of the 105 hectares site. In the 1988, revitalization for the Civic District was extensively executed, from the "coordinated pedestrian and vehicular network and the improvement of parks and open spaces" (URA, 1996) to the conservation of several noted historical architectural landmarks. These were done for the Civic District "to revitalize and promote this area as Singapore's Civic and cultural hub." (URA, 1996) Architectural diversity and variety of urban spaces present within the Civic District characterized the uniqueness of this planning zone. The lighting master plan would provide for a nightscape that highlights this diversity in architectural qualities of urban elements within this zone, while providing for sufficient and appropriate lighting level for safe navigation through the city. The site was divided into several districts, in coherence to the distinctive identity of each area, namely, the Celebration Route, Heritage Link and Historical Link. (See URA 1996). These areas should be characterized by the differences in their circulatory routes, with each route having their distinctive visual image.

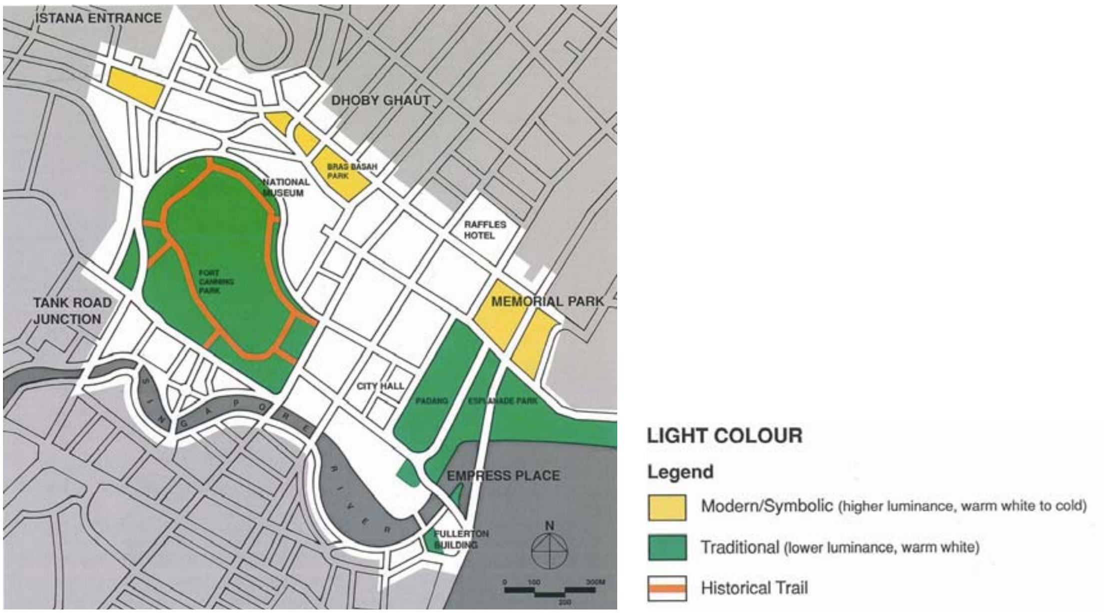

Illustration 7.0 *Conceptual demarcations of different lighting utilized (Source: URA ,1996)*

2.2.8.2 Lighting Master plan Objectives and Design Principles

In order to "reinforce the Civic District's night identity; encourage strolling at night; enhance the architectural wealth of the District and highlight the parks and open spaces" (URA, 1996), the Urban Redevelopment Authority of Singapore (URA) commissioned French Lighting designers from Light Cibles to conceptualize the lighting master plan for Civic District. Hence, in 1992, the Civic District Steering Committee, a body comprising of several government departments and statutory boards, did a detailed analysis on the existing site conditions prior to the conceptualization of the lighting master plan. In addition, together with URA's planning objectives for the Civic District, the lighting master plan would, "reinforce the identity of Civic District; reinstate pedestrian in the Civic District at night by strengthening the prominence of the Celebration Route and Heritage Link; enhance the architectural wealth of the Civic District and Highlight the green foliage, parks and open spaces" (URA, 1996).

After a detailed analysis of the architectural forms and recognition for the variety of urban elements within the Civic District, the lighting master plan had the following lighting objectives:

1. Zonal Clarity
2. Linkage Networks (Roads and Walkways)
3. Highlight Architectural Features
4. Open Spaces
5. Quality Lighting Environment

1. Zonal Clarity

In order to illustrate the differences in the different zones set up in the Civic District, different lamps were used, which also correspond to the existing character of each zone. The following are the categories of proposed lighting types:

- Modern, high rise, active and fast.

  Lamps of cold white and white intense output would be used.

- Traditional, historic, low rise.

  Lamps of warm white, gold orange lighting would be used

- Greenery

  Lamps of cold white output would be used to "render the actual colours".

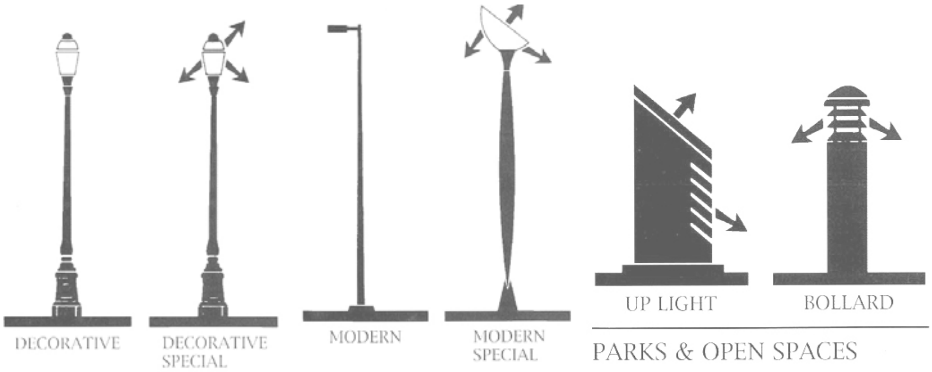

Illustration 8.0 *Lighting fixtures recommended for Parks and Open Spaces (Source: URA ,1996)*

2. Linkage Networks (Roads and Walkways)

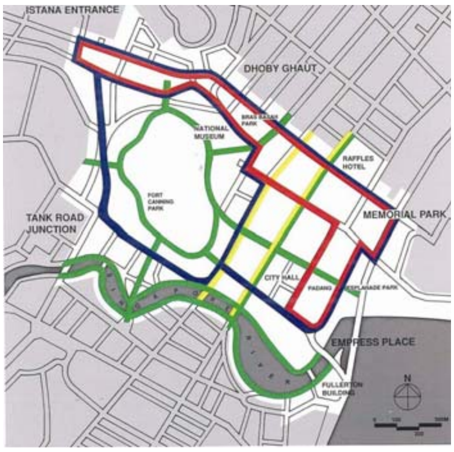

Illustration 9.0 *Map demarcating the 4 different routes in the site (Source: URA ,1996)*

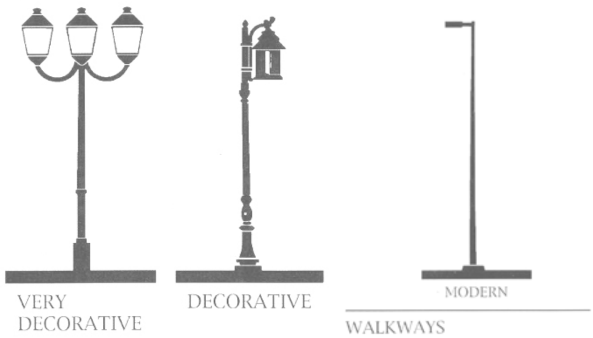

Illustration 10.0 *Lighting fixtures recommended for Walkways(Source: URA ,1996)*

Although to provide for sufficient level of lighting that would render these circulatory routes usable, differences between the Celebration Route, Heritage Link, Historical Trails and Retail Corridor should be highlighted. The main differences should be through the colour of the lamp sources used and the aesthetics of the pole lights to be used, which would relate to the character of the route. However, for visual consistency, the colour of these luminaries would be the same, but the detailing on the poles would be proportionate to the importance of the route they are located. Also, the lighting level along Celebration Route and Heritage Link would be higher than the others.

Since the Celebration Route spans from the Istana Park to the City Hall, the Colour Rendering of lights used along this route would be comparatively better, with a more even lighting distribution. On the other hand, the Heritage Link, which is of second importance to the

Celebration Route, would have lamps of different Colour Rendering and lower uniformity in lighting distribution for differentiation from the former.

3. Highlight Architectural Features

Since the Civic District comprised of architecture of various architectural typologies and characteristics, the proposed lighting strategies would be divided into,

- Historic Buildings

Generally, lamp sources of warm white light would be used to highlight architectural forms, by lighting the roofs. This would enhance the architectural character and highlight the "majesty of these buildings" (URA, 1996)

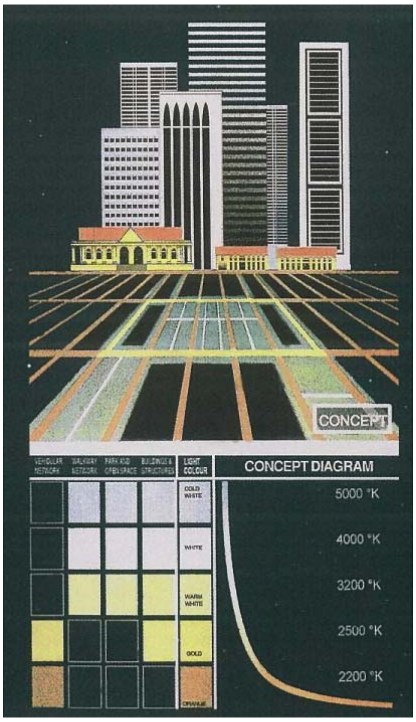

Illustration 11.0 *Concept rendering of lighting for various buildings (Source: URA ,1996)*

- Modern Buildings

Either Warm-white or Cool-white Colour Temperature lamps would be used for illumination, which is also dependent on the architectural style and details of these buildings. Also, in lighting these buildings, its relation with its lit environment would be considered for a coherent visual composition.

- Symbolic and Historic Structures

The Istana Arch, located in the Istana Park and the War Memorial, were the two symbolic features in the Civic Districts. To highlight their importance and contrast with their surroundings, "powerful cold light" (URA, 1996) would be used.

4. Open Spaces

To preserve the landscaping elements in their actual colours, lamps of cool Colour Temperature would be used. Also, the lighting level would be maintained at a low level to minimize glare of these fixtures in the generally dim surroundings in the park. The scale and relation of these landscaping elements would be considered and the big trees would be placed on a higher visual hierarchy for appropriate contrasts. To further enhance the overall character of the parks, namely a modern outlook for the Istana Park and Bras Basah Park versus the Traditional concept used for the Esplanade Park, Fort Canning Park and Empress Place, the appearance and the emitted Colour Temperature would be differentiated.

5. Quality Lighting Environment

Due to the variety in available lighting techniques and lamp sources, the choice of luminaries and lamp source should correspond to the desired atmosphere to be created and to render the urban environment in the suitable technique and colours. Generally, the Colour Temperature of utilized lamps should relate to the lit object, where warm Colour Temperature is used for the historical monuments, to highlight the materials and mood appropriately. On contrary, cooler colour temperature lamps is used for illumination of greenery or for larger scale lighting. Also, using lamps of good Colour Rendering would result in the lit objects being closer to their actual colours. Moreover, uniformity in the lighting distribution is important in the perception of spaces, hence should be observed whenever possible.

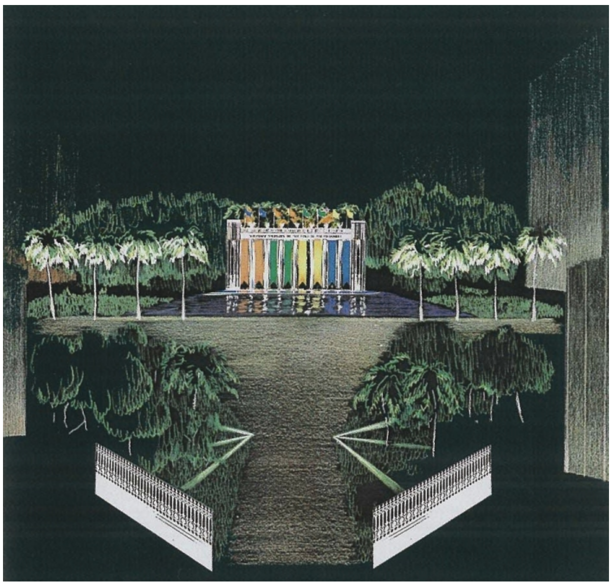

Figure 61.0 *Conceptual design for Istana gates (Source: URA ,1996)*

Figure 62.0 *Conceptual design for War memorial (Source: URA ,1996)*

2.3 Studies on International Codes of Practices for Urban Lighting

2.3.1 Introduction on Codes of Practices for Urban Lighting

As highlighted earlier, the design of Urban Lighting Master plan is still dependent on the choices made by the lighting designers, while implementing the recommended lighting requirements from Codes of Practices, to ensure an aesthetically pleasing, yet functional, illuminated environment. Despite the existence of design handbooks published by some individuals (See Philips, 2002; Lumsden, 1974), the Codes of Practices were still the main reference material, when the designers draft lighting requirements for each individual spaces. There are four main lighting authorities, from which lighting designers would refer to, namely, CIE (Commission Internationale de l'Eclairage), the IESNA (Illuminating Engineering Society of North America), BSI (British Standards Institute) and the CIBSE (Chartered Institute of Building Service Engineers). The following sub-chapters shall briefly individually introduce these publications and their recommended design basis to exterior lighting or, particularly, urban lighting.

In summary, of these guidelines, the lighting guide published by IESNA is the most comprehensive in terms of urban lighting, through dealing with the different areas of the town, with their own design needs and criteria. In this Code, the city is divided into various zones, in accordance to their architectural programme, while the appropriate lighting method and type of luminaries or lamps were stated for their advantages and recommended usage. On the contrary, the British Standards seemed to address to the techniques and appropriateness in designing for road lighting, while the other exterior spaces, like the parks and squares, were being treated as secondary spaces that was adjacent to the roadways. However, both Codes had dealt with urban lighting in an overly simplistic manner, while the list of recommended luminaries and lamps was not as extensive to those current available.

2.3.1.1 IESNA – Lighting Guide for Outdoor Environment

The Illuminating Engineering Society of North America (IESNA) is a professional body which commit itself to the provision of good lighting. They had established many publications on design standards and Codes of Practice for lighting of interior or exterior spaces, which had been frequently referred to during the design of lit environment. The *Lighting Guide for Outdoor Environment* was meant as a generic guide to good exterior lighting, with introduction on the constituents to quality lit environment, with main objectives as to "assist all who take or influence decisions that affect the safety, security and pleasantness of urban and rural districts." (IESNA, 1975, page 6). This guideline had been re-edited from the previous edition published in the 1975 (see IESNA, 1975) to the recent edition as published in the 1999. (See IESNA, 1999) From the comparison of these publications, it is noted that the guidelines had inclined towards the provision of a lit environment that facilitates visual comfort instead of the stringent implementation of lighting levels and engineering values. Therefore, the author had noted that the second edition of the Code of Practice is more comprehensive in the recommendation of good urban lighting practice, thus would be reviewed in this subchapter.

Outdoor or exterior lighting should allow promoting safety and security at night, enhancing appreciation and enjoyment of the surroundings and by giving a sense of belonging, assisting people to relax."(IESNA, 1975, page 7). This IESNA guideline for outdoor lighting is divided into the following components,

1. Aesthetics and Impact on Visual Perception
2. Environmental Issue of Urban Lighting
3. Technical Aspects to a Well Lit Environment
4. Lighting for different urban elements
5. Economical Issues that Arise from Urban Lighting

1. Aesthetics and Impact on Visual Perception

Visual comfort and the aesthetics of the lit environment are two main attributes to good lighting. Vision is categorized into 3 aspects, Photopic, Scotopic and Mesopic Vision. (See IESNA, 1999 and Appendix for more details) Therefore, in the early part of this Code of Practice, several basic knowledge to good lighting were introduced, namely, brightness versus Illuminance, reflectance, Illuminance, glare, Colour Rendering and colour appearance. Therefore, good lighting should consider these points raised, alongside with the various lighting technique introduced in this guideline, such as area lighting, flood lighting, accent lighting, covered area lighting and emergency lighting. To complement the previous edition of urban lighting guideline, the edition published in 1999 introduced the concept of quality urban lighting, which "helps define a positive urban character and image." (IESNA, 1999, p. 3) Therefore, the composition of the illuminated environment is extremely important, whilst one must relate to the community established lighting theme. Also, visual hierarchy must be established to allow clarity in the structuring of the nightscape.

2. Environmental Issue of Urban Lighting

On contrary to the previous edition of the urban lighting guideline, this version published in 1999 introduced the concept of "light pollution" and "light trespass", which were two problems that arose from the mismanagement of the illumination techniques. Hence, to minimize these problems, designers should limit the use of lighting that is directed towards the hemisphere. Also, for directional light should be focused on the object and not aimed elsewhere to minimise the "stray" light that might result in an uncomfortable visual environment. The fixtures should be programmed that they would be switched off in periods of non-use. Furthermore, to reduce the impact of light trespass, the exterior environment is divided into 4 different zones (See IESNA, 1999, page 11 to 12), where the division is related to the activities that would occur within the zone and its correlated lighting requirements. This would also determine the brightness level of the luminarie used within each of the mentioned zones. (IESNA, 1999)

Zone and Description	Recommended Maximum Illuminance Level
Zone E1: Areas with intrinsically dark landscapes – examples are national parks, areas with outstanding natural beauty, or residential areas where inhabitants have expressed a strong desire that all light trespass be strictly limited.	1 lux (0.1 fc)
Zone E2: Areas of low ambient brightness – these may be outer urban and rural residential areas	3 lux (0.3 fc)
Zone E3: Areas of medium ambient brightness – these will generally be urban residential areas.	8 lux (0.8 fc)
Zone E4: Areas of high ambient brightness – normally these are urban areas having both residential and commercial use and experience high levels of night-time activity.	15 lux (1.5 fc)

Table 4.0 *IESNA Definition of Environmental Zones(RP-33-99) (IESNA, 1999,p.12)*

3. *Technical Aspects to a Well Lit Environment*

In the composition of a well lit environment, the choice of appropriate lamps is especially important. Both Colour Rendering and Colour Temperature are some characteristics of the sources that might alter the visual appearance of the perceived objects to its actual form. In addition, since the lamp life and efficacy of lamps differ from one to another, one would need to take into the consideration of the characteristics of each lamp types, together with their advantage and disadvantages, for their appropriate use. (See Appendix II for more information on different lamps)

Area Description	Average Target Illuminance (vertical) (lux/footcandles)
Bright Surroundings and Light Surfaces	50/5
Bright Surroundings and Medium Light Surfaces	70/7
Bright Surroundings and Dark Surfaces	100/10
Bright Surroundings and Light Surfaces	20/2
Dark Surroundings and Medium Light Surfaces	30/3
Dark Surroundings and Medium Dark Surfaces	40/4
Dark Surroundings and Dark Surfaces	50/5

Table 5.0 *Illuminance level for floodlighting buildings and monuments (IESNA, 1999,p.27)*

Recommended Colour Temperature (K)	Illuminated objects
2100 – 3500 (Warm)	When a warmer setting is required or in lighting of specific type of architecture like the Brick or Sandstone
4000 – 5000 (Cool)	Green Landscape

Table 6.0 *Recommended Colour Temperature table for illumination (IESNA, 1999)*

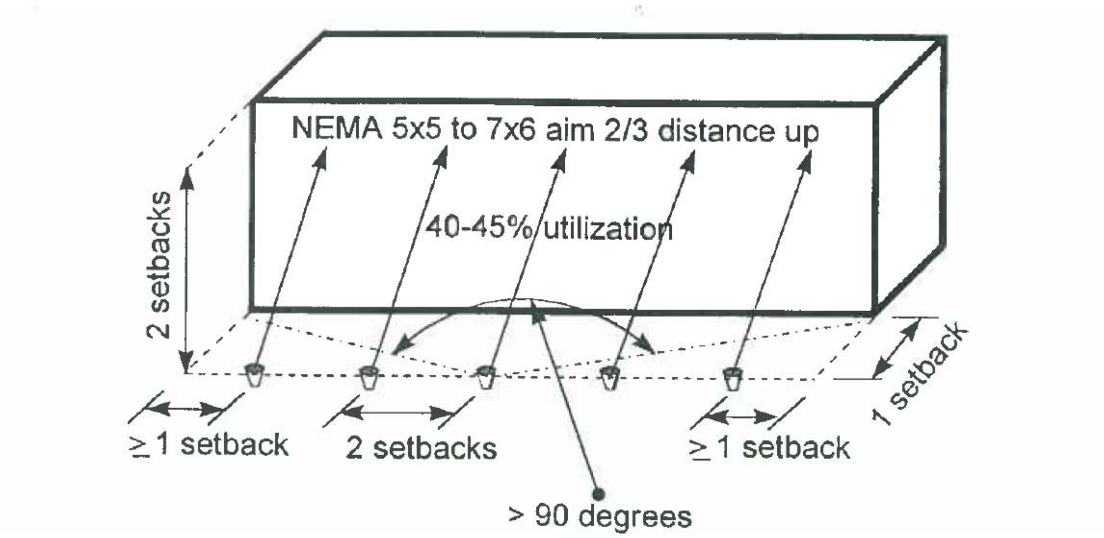

Illustration13.0 *Recommended floodlighting geometry(IESNA, 1999,p.27)*

Together with the specifications of the lamps, all luminaries and their operating accessories should comply with the recommendations of relevant British Standards, while understanding the conditions under which the luminarie would operate and provide for appropriate maintainability of the luminaries. Also, each of the exterior lighting schemes should address to these technical requirements, Illuminance suggestions; Illuminance uniformity; Addressing to glare, Light pollution, Light Trespass; Glare control; Equipment types; Lamp recommendations and Controls; Selection of Luminaries and Ballast. (IESNA, 1999, p. 14)

4. Lighting for different urban elements

Due to the existence of a variety of urban elements, one of the main objectives in lighting would be to suitably highlight the different textures of these elements and to enhance the skyline. IESNA had recommended lighting design practice for both architecture and landscaping elements. A properly composed well-lit environment would definitely contribute to the overall urban planning strategy of the city, by creating focal points and “circulation patterns can be reinforced and the entire area unified with street lighting and landscape lighting”. (IESNA, 1999) This guideline had streamlined the various urban elements by their types, whilst addressing to the appropriate lighting systems and methods to be used for illumination. The guideline had separated the whole area of exterior lighting into the illumination requirements of separate spaces and these are divided into, Town and City centre, urban residential districts and rural districts. Besides elaborating on the general lighting requirements in terms of the measurable luminance level and composition of the lit environment, the guideline address to the lighting of selected urban elements, as mentioned in the following,

1 Buildings

2 Bridges and Viaducts

3 Individual features

4 Leisure and entertainment areas

Typology of space	**Illumination technique**
Architectural structure	Floodlighting technique, when employed in different methods: 1. Positioning in illuminating direction can create different effects on illuminated surfaces, either the diffused shadows from direct aiming of light on surface or the modelling of the details from sharper shadows. 2. Floodlighting when directed in various methods can strengthen the dimensional qualities of the element, like the construction details (finish, textures, shape of surface material) 3. Nature of finishing would determine whether floodlighting would be utilized. It is not recommended for highly reflective surfaces. 4. Application of highlighting of discrete architectural details. Architectural character of the illuminated structure should be considered in whether floodlighting would be used. In the event of buildings with strong verticality or distinctive architectural features, accent lighting would be more appropriately used. It is important to minimize instances when floodlighting is directed upwards, to reduce lighting pollution. Hence, choice of correct beam spread, external and internal shielding and careful field aiming would aid in the reduction of light pollution.
Landscaping (Soft-scape)	Primary lighting objectives: 1. controlling glare

***Table 7.0** Extracts of Lighting Recommendations (IESNA, 1999*)

The above extract of the guideline clearly proposed the ideal situation in the application of floodlighting technique to either the illumination of architecture or Soft-scapes. The guideline also recommends certain manner to manipulate the floodlight to better highlight the urban elements for designated visual effects.

5. Economical Issues that Arise from Urban Lighting

"Lighting system conditions should be considered in realistic rather than optimistic terms when establishing such maintenance factors, as lamp lumen depreciation, luminarie dirt depreciation and ballast factor." (IESNA, 1999, p. 22) Besides the need to create an aesthetically pleasing night-time environment, the proposed lighting system should be examined in terms of their practicality. Hence, in the drafting of the urban lighting masterplans, the lighting designers should also consider the maintainability of the proposed system, together with the most suitable luminarie or lamp source in relation to the site condition.

2.3.1.2 British Standards Institute – Outdoor Lighting Guide

The British Standards is National Standards Body of the UK and develops standards and standardization solutions to meet the needs of business and society, whereby they had drafted a set of lighting codes for outdoor lighting, which lighting designers utilized in their design of the lit environment. This publication was divided into a series of 9 different parts which addressed to different exterior lighting environment and their needs. (See BSI, 1992) Of the 9 parts of the guidelines to road and urban centre lighting, only the part 9 is of relevance in urban lighting. Although majority of this Code of Practice had related to the need for road lighting to be sensitive to the various types of vehicular or pedestrian circulation, whilst creating the optimal illuminated environment for their usage, the last part addressed to the other areas of the urban centre, dividing the area into parts which relate to their functionality. Primarily, besides the primary requirements of fulfilment for sufficient lighting level for prevention of crimes and safety in vehicular movement, lighting could "bring a sense of order to a space where it is lacking and enhance those building of significant architectural merit." (BSI, 1992), so achieving balance between the different urban elements and various visual hierarchies of the different objects that required illumination. Furthermore, it is noted that the lighting master plan should also address to the following, as indicated in BS 489, page 5. (BSI, 1992)

1. Lighting design and choice of equipment in relation to the architectural scene and urban landscape
2. Lighting to provide for safety for pedestrians from moving vehicles and to deter antisocial behaviour
3. Lighting commensurate with the character and volume of vehicular traffic (including cyclist)
4. Control of illuminated advertisements in the interest of the amenity.
5. Control and integration of permanent floodlighting installations into the visual master plan
6. Control of temporary special lighting effects such as floodlighting, festive decorations;
7. Control of road and direction signs and their relationship with other illuminated material
8. Control and blending of lighting from both public and private sources, eg bus shelters and telephone kiosks.
9. Protection of residential development from light pollution
10. Protection of installation from accidental or deliberate damage
11. Maintenance of installations.

Since the subject for study in this sub-chapter is the current practice for Urban Lighting as highlighted in Codes of Practices, the ninth part of this Code would be studied in detail, of which several urban spaces were addressed, namely the circulation areas, car parks, service areas, conservation area, parks and landscapes, landmarks, decorative or festive lighting and fountain lighting. Following the categorization of all the different urban areas that would require illumination, the recommended lighting level and other technical recommendations such as the lamp properties were listed for each of the elaborated areas. However, the various elements listed in this Code would not be elaborated as the lighting recommendations and objectives are highly similar to those stated in the IESNA Code.

2.3.1.3 CIBSE & ILE – A Guide to Good Urban Environment

The main objective of this lighting guideline was to reconcile all the various lighting Codes of Practices for various areas in the urban centres to derive a coordinated nightscape. It recognized that currently, the cover of exterior lighting in existing Codes and Guidelines was not sufficient and greater control should be executed. Hence, this guideline aimed to "form a basis for future controls." (ILE & CIBSE, 1995, p.1) It is recognized that lighting the exterior environment would derive the following benefits,

1. Ambience — Using lighting to create desired atmosphere and mood
2. Identity — Using lighting to emphasize the area's unique character
3. Safety — Creating a night-time environment of sufficient lighting level for safety of the residents
4. Security — Lighting could aid in reduction of night time crime, while protecting individual's belongings and properties
5. .Orientation — Illumination of roads and landmarks would aid in the recognition of an unfamiliar night-time environment and would help in orientation in the environment
6. Promotion — Aid in the promotion of the town or city for boosting tourism, while increasing civic pride
7. Spectacle — Lighting would aid in the utilization of the outdoors for leisure and the extension of the usage of these spaces in the dark.

This guideline had addressed to the lighting requirements of various outdoor spaces, namely the Urban fringes, Towns and Cities.

1. Urban Fringes

This area is recognized as the transition zone which is located between the built-up city area and the countryside, which is particularly sensitive to the effects brought about by artificial lighting, as the level of brightness is significantly lower compared to the concentrated city area. Hence, there should be consistency in the lighting level, without any “sudden or frequent variations in lighting levels”. (ILE & CIBSE, 1995, p.10) Also, the appropriate choice of lamps should be executed and one should consider the utilization of the Colour Temperature and rendering of the lamp sources, whilst minimizing the contrast between the illuminated spaces to their darker adjacent spaces. Also, due to the high difference between the illuminated spaces and their adjacent zones, care must be taken to minimize intrusion of light into the darker areas. This can be carried out by limiting the use of luminaries that were equipped with accessories to reduce glare and directing the light throw downwards or onto the desired illuminated areas.

2. Towns

In comparison to the Cities, Towns are of smaller scaled and lower human activities, with mainly residential spaces. Therefore, lighting level should be kept lower in comparison to the city centres, while maintaining a visually comfortable space for the residents. Also, the fringe areas between towns should be treated similarly to fringe areas. In addition, the town centres should be highlighted appropriately, to enhance the public amenities and creating an aesthetically pleasing nightscape.

3. Cities

The city embodied the concentrate of human activities and often, within the same area, there would be a greater variety of lighting systems and requirement, in comparison to the towns or the fringes. Hence, the planning of lighting within the city should address to different concerns and prioritizing them despite the variety of lighting concerns in the city, the design of lighting should also address to the appearance of the lit environment upon its approach, creating the feeling of anticipation. The lighting concept should also address to the planning of the whole environment, taking into the consideration of how the skyline and composition of the lit objects. Moreover, different lighting methods could be adapted to highlight the differences between the different districts within the city area, to create visual variety, while using lighting to evoke the various moods desired. Besides addressing to the created lighting effect, the physical dimensions of the luminaries should be coherent to the illuminated object and should maintain visually coherent. This lighting master plan also addressed to the igniting of interest as one navigates through the city, which could be achieved through the "variation in lighting pattern, colour and Illuminance from one area to the next." (ILE & CIBSE, 1995, p.17) In all, the lighting of the city should consider the 4 following points, in the fulfilment of the lighting needs of the environment,

- Functional needs
- Architectural
- Amenity
- Promotional

These 4 points should be considered prior to the classification of an area's lighting requirements. This would allow the identification of the designed area's illumination needs, which would facilitate the choice of the appropriate lamp source and to prioritize the lighting level of the designed area in comparison to the adjacent area's. To ensure a well-composed illuminated nightscape, it is necessary to identify the overall visual hierarchy of the composed nightscape, while ensuring that the highlighted area is within the visual range along the main viewing direction. The design of the urban nightscape can be identified in the following steps,

Step 1:	Identification of the overall composition of the illuminated urbanscape
Step 2:	The assignment of the relative brightness of the individual building elements, on a logarithmic scale, for example, 1 : 3 : 5 : 10 : 30 : 50 : 100 but the increment of this ratio should be kept manageable, to reduce the incurrence of overly varied lighting environment of varied intensity. For example, If our structure is in the urban fringe, then the ratio would translate into $5cd/m^2$: $15cd/m^2$: $25cd/m^2$ With these ratios in mind, these could be translated into the designed Illuminance with knowledge of the surface reflectance.
Step 3:	After the establishment of the basic requirements, the designer would need to choose the mounting position for the luminaries, to allow the appropriate light modelling of the illuminated element.
Step 4:	Finally, one would need to select the appropriate luminarie and the lamp with desired lighting distribution.

Table 8.0 *Table illustrating steps to designing of the urban lighting master plan (Source: ILE & CIBSE, 1995)*

Besides referring to the above steps in the planning of the urban lighting master plan, there is a need to cross reference to the official publications on “Sport Floodlighting”, “New Residential, Commercial and Miscellaneous developments”, “Advertisements” and “Listed Buildings”, for more in-depth lighting requirements of these areas in details, in terms of the lighting intensity required.

2.4 Analysis of Current Design Practices

2.4.1 Analysis of Current Design Criteria and Approach

Urban Lighting was a discipline that was highly inclined towards the engineering aspects, but it is only recent that more efforts were taken in the awareness towards provision of quality urban lighting. Currently there are 2 main approaches to the design of lighting masterplans, namely through lighting designers’ analysis and personal aesthetics judgement to derive lighting concept that best address the urban master plan, or referring to International Codes of Practices for appropriate application of lighting level and Illuminance ratio for a visually comfortable space.

Current design practice

Realized Lighting Masterplans	**Codes of Practices**
1. Lyon, France	1. IESNA (Illuminating Engineering Society of North America)
2. Coventry, UK	2. BSI (British Standards Institute)
3. Tokyo Roppongi hills, Japan	3. CIE (International Commission on Illumination)
4. Singapore Civic District	4. CIBSE (Chartered Institution of Building Services Engineers)
5. Singapore One-North	5. ILE (Institute of Lighting Engineers)
6. Hong Kong, China	6. Singapore Standards
7. Hangzhou, China	
8. Shanghai Xintiandi, China	
9. Alingsas, Sweden	

The above diagram illustrated the 2 components of current design basis which were being analyzed in this paper for the derivation of current design basis. The previous subchapter had elaborated on the choice of these selected realized examples of lighting masterplans, while listing the various international lighting guidelines that were being utilized by professionals. In these instances, publications by IESNA, CIE and BSI were often extensively referred to in the design of lit environment. Generally, these standards had extensively reviewed the lighting level, types of lamp sources and lighting design strategy recommended for mentioned urban elements, together with the different lighting treatment for urban zones, from countryside to the city centres. These International Codes of Practices had listed a comprehensive table of quantifiable lighting levels and recommended lamps with appropriate distribution level, intended for different urban areas in the books. In summary, these standards are benchmarked on these main points,

1. Definitions to several visual issues, like Glare, Luminance, Visual Acuity and Illuminance.
2. Selection of appropriate luminaries
3. Different types of luminaries and illumination levels

4. Luminaries' maintainability and economics of the lighting systems
5. Illumination of different urban structures
    a. Architecture
    b. Soft-scape Landscaping
    c. Hard-scape Landscaping
    d. Roadways and walkways
    e. Pedestrian Mall
    f. Parking lot
    g. Outdoor retail
6. The provision of ordinances and involvement of community in design process

However, it must be noted that these lighting guidelines had addressed to the generic pocket of spaces that existed in all urban environment, like Parks, Architecture, Historic Structures, and Roadways etc. Current practice had terminated at the fulfilment of requirements for individual spaces, but neglected the composition and relationships between these illuminated elements within the larger urban environment. Although these stipulated lighting requirements might provide for a visually comfortable environment, one would question on whether they would suffice towards the construction of a *quality lit environment.* Urban Lighting Master planning should not be simplistically translated into an exercise of application of measurable illumination requirements for individual pockets of space, but human's perception needs of his environment and considerations on how all these installations would affect psychological comfort within the environment. Hence, the current design practice as noted from the recommendations in the Codes of Practice is not sufficient towards the construction of a quality lit environment.

On contrary, these realized projects demonstrate the complexity involved in urban lighting master planning, with some pertinence to urban planning ideologies, yet the analysis had concluded that further improvements to the planning basis could be made. Although the cities chosen for review is not the exhaustive list of all recent realized urban lighting master plan established in the world, they represented the generic form of urban lighting master planning for their individual category, with design criteria based on objectives set up jointly by Lighting Professionals and Urban Planners. Moreover, the wide range of design objectives and types of urban spaces, allowed the analysis if there existed an underlying pattern beneath each unique master plan. In summary, these examples highlighted the urgency and potential in the need for a *quality* lit environment, a departure from the conventional street lighting which focused on the maintainability and sustainability of the urban lighting proposals. Since all these projects, despite their commissioning from official local planning authorities, they were all drafted by lighting designers; the analysis of these chosen lighting masterplans would enable better understanding into the current practice in the design of urban lighting masterplans and the methodology adopted by lighting designers. The study of these projects revealed that there is a certain consistency maintained, despite the different genre and types of projects, in the generic design approach to urban lighting master planning. Therefore, in the analysis of these realized case-studies, the following research question would be asked,

1. Does a generic pattern exist in all current practices? Or does themes governed the appearance of the lit environment?
2. Is the human-environment relationship neglected in the current design practice?

Generally, all realized projects had utilized advanced lighting technology, to highlight the distinctive urban element or to re-create the required lighting atmosphere. However, during the introduction of new lighting technology, care should be taken to reduce visual discomfort from the use of wrong or badly engineered luminaries, exposed lamp sources or fixtures mounted at the wrong location. It is also noted that most lighting masterplans had begun to introduce colour lighting to urban spaces, or lighting with pre-programmed scene changing modes, to promote dynamicism and interactivity of users with their spaces. Also, the changing scenes would introduce the element of ‘time” and the manner at which the city changed with different period of the day, for visual variety, as noted from the example of Roppongi Hills, where the appearance of the entire city changes in accordance to time, in terms of the intensity of the lighting level and the total lighting level for the spaces. Also, all these case-studies had revealed a strong intricate link between the architectural character, desired spatial atmosphere and the lighting methods. Often, these cities had utilized good and appropriate lamp sources in the lighting of architecture, so the imagery of the city would not be distorted and the colours subdued, often a result when Low-Pressure Sodium lamps were used. Cities like Alingsås had tried to envision a different and more innovative method to illuminate some functional spaces, like their periphery pathway or the bridges that linked the town at various parts. This is contrary to Lyon, which lighting was not done driven by such innovative intent but more of to highlight the historical feature of its architectural element in their full glory. Furthermore, these master planning not only complemented the daytime imagery of the city (Lyon, Singapore Civic District), or to re-create a new image of the city in the night (Hong Kong or Roppongi Hills).

Besides adhering to the recommended technical requirements for the individual pockets of space, it is noted that most the case-studies demonstrate general sensitivity to the general composition and the need to evoking the correct atmosphere for the area. However, it is still noted in all the case-studies that due to the overly enthusiastic incorporation of latest lighting systems and unrestricted use of automated colour changing lighting systems, the resultant nightscape often appeared to be visually chaotic, like the example of Hong Kong, where colour changing lighting system were used for the major buildings.

The reviews of all these projects had indicated the essential knowledge of technical aspects of lighting that must be accompanied with need to create required lighting ambience. Without clear understanding of the specification of each lamp, the uninformed would associate the Low-Pressure Sodium lamps the creation of olden world atmosphere, examples as noted in

Singapore Civic District, Shanghai Bund area and Xin Tian Di. Although these lamps have extremely low Colour Temperature, their Colour Rendering abilities is extremely low. This would distort the appearance of the actual colour illuminated object, rendering the building in the orangey-greyish hue. Also, in China the misconception of using green filters with luminaries in the lighting of Soft-scapes resulted in their use in illumination of parks and landscaping spaces. Although no studies were done on the effect of using green coloured lighting on perception of these soft-scapes, it is noted that colours would have certain psychological effects which would affect perception. (Mahnke, 1987) Care must to choose the correct complementary colours for the illumination of objects, as green lighting should not be use for illumination of red objects, as the resultant appearance of the object would be altered and subdued. (ERCO, 1992) Moreover, overly use of coloured lighting, which is evident from the streets of Shanghai and Hong Kong, might result in sensory fatigue and visual chaos, due to overly stimulated senses.

In summary, the approach towards *quality lit environment* should be examined further, as most of current design basis, noted from the realized examples, were based on perceived effects of lighting on urban environment. The Codes of Practices addressed to the needs in the basic construction of a functionally lit urban environment, yet good lighting should not be merely quantifiable through mathematical analysis, as these guidelines addresses to the specific areas individually and not the whole urban environment as a composite body of varied spaces. However, from a comparison of the different editions of the IESNA Lighting Code for Exterior Environment, there was a gradual shift of urban lighting from the engineering of individual pockets of space to the orchestrating of the whole illuminated environment. It is evident from the revised outdoor lighting guideline drafted by IESNA (See IESNA 1977 and IESNA 1999). Furthermore, the comparison of these two editions had revealed a shift from provision of sufficient lighting level as per specified in the tables and calculations, to the details that lighting designers should take note in the design of the illuminated urban space. However, we can already note that some of these generic design tools had paralleled to some of the fundamental design basis illustrated in environmental perception theories. (See Chapter 3.0 on existing studies on human perception needs in environment)Despite addressing to the composition of a nightscape that better relate to the enhancement of the individual elements within the urban form, it must be noted that since the perception is a continuous process, the design of the urban lighting master plan should be dealt in totality, in the appearance of the composed space. Hence, the design basis of lighting master plan should relate to the visual design of the urban environment, a subject that had been extensively researched upon yet not linked to the formulation of urban lighting masterplans. This visual design of the environment relates to the fundamental process of human perception and how the environment should be designed to better relate to the human perception needs. In all, this component of visual design had been neglected from the current design practice and should be included for a better design nightscape.

2.4.2 Generic Lighting Themes or Patterns in Current Urban Lighting?

Due to the variation in physical form, local culture, the geographical position etc, no cities in the world have totally identical character. Yet through review of all realized projects of urban lighting masterplans, it was noted that although all the lighting masterplans possessed some generic design qualities that paralleled across all the projects, but differentiated through their execution, some of the lighting masterplans were shaped by the primary design objectives which it was modelled after. With a strong design objective in mind, the resultant nightscape often appeared synchronized, with a prevalent illumination strategy or created ambience, like the case in Hong Kong Victoria Harbour lighting or Shanghai Light-up program implemented in the 1998. The following provides a detail analysis of the role of urban lighting and the generic design basis that governed the drafting of these lighting masterplans.

Figure 63.0 *Illumination of façade along Hong Kong Island, Victoria Harbour Lighting Masterplan (Source: Author's own)*

Figure 64.0 *Illumination of façade along The Pearl River. Shanghai, China (Source: Author's own*

In some of the lighting masterplans, the primary objective was to highlight and dramatize the exiting architectural skyline, like the case of Hong Kong Victoria Lighting Master plan and Shanghai Light-up program. Often, in these masterplans, the one of the key features was the large amount of coloured lighting and automated colour systems, creating the desired festive atmosphere, resulting in a nightscape of strong visual impact and overall identity. However, over-utilization of automated scenario changing luminaries, or too much concurrent ongoing effects might result in sensory fatigue. (Kaplan, 1983) The mismanagement of these nightscapes might result in either visual monotony or clutter, which is especially true when coloured lighting were proposed, coupled with use of low quality lamp sources. This is evident from the example of Shanghai Lighting Master plan, when the illumination of the historical buildings utilized Low-Pressure Sodium Lamps, to evoke the Old-World charm one would normally associate with olden shanghai. However, the low Colour Rendering abilities of Low-Pressure Sodium lamps resulted in subdued appearance of the materials and uncoordinated use of lamps resulted in a visually cluttered illuminated façade. Therefore, the formulation of urban lighting master plan is not a simplistic task of utilization of the latest luminarie technology and implementing it on the urban scale. Since lighting design is a visual "exercise", one must consider the composition of the resultant appearance of the lit environment, yet more studies on quality illuminated nightscape should address to the primary human visual needs in his urban environment.

Lynch's advocate of "Sense" as one of potential dimensions in city planning, defined by the ability of the city's structure in relation to its implied functionality and the ease at which the urban elements could relate to one another in a series of coherent linkages. (Lynch, 1960) This clearly defined that visual master planning of the urban space should be ordered in the form of a complete experience, with care taken in the planning of the visual composition, as perception is a dynamic and continuous process. Besides fulfilling the minimal recommendations designated for individual spaces, as noted in the Codes of Practices, the following urban lighting master planning design basis were also noted,

1. Recognition of Geometrical Forms

Modelling of urban structures is extremely important in maintaining consistency of the elements to its daytime appearance, which is especially true for Lyon, a UNESCO heritage site. Choice of lamps differed in accordance to its architectural character, with warmer Colour Temperature commonly used in the illumination of historical structures and cooler ones for lighting modern forms or landscaping. Therefore, lighting for the buildings within the master planning should allow for appropriate modelling of the façade, taking into consideration the architectural form, colours and material. Thus, to accurately display the richness in architecture, there are 2 main points to take note,

- The chosen lighting technique
- Choice of correct lamps and luminarie

Firstly, the lighting technique would determine how the emitted light would interact with the architectural form. The placement of fixtures in relation to the buildings should be analyzed to avoid the creation of image distorting shadows, while highlights should be created along the focal point of the façade. The following pictures demonstrate the visual appearance of 2 historical buildings, under different lighting condition and choice of lamps. The façade of Montréal City Hall was illuminated with low temperature Metal Halide lamps, while highlights were created using higher intensity lamps, at the bay of each window. This created rhythm and visual focal along the monotonous façade. In contrast, the Singapore City Hall was illuminated using Low-Pressure Sodium lamps, which masked the original appearance of the architectural materials. Moreover, the form and details of the architecture was not clearly visible due to the placement of these luminaries. These 2 pictures clearly demonstrate the ability of lighting to shape the appearance of the building, differentiating it from its daytime appearance.

Figure 65.0 *Montréal City Hall, Éclairage public Inc (Source: http://www.vieux.montreal.qc.ca)*

Figure 66.0 *Singapore City Hall (Source Author's own)*

2. Spatial Typologies

Generally, all the realized lighting master plan had divided the urban spaces through, the type of luminarie chosen for the type of urban spaces to be illuminated and the required lighting level, which often complement the spatial typology. For example, Metal Halide lamps were often used for illumination of vegetation and façade, while lower Colour Temperature lamps were utilized in the lighting of historical monuments. Automated colour changing or programmable luminarie are often used to light public spaces, to inject vibrancy or complementing the required spatial atmosphere. This was most apparent in the example of Lyon, Coventry and Roppongi Hills, where different spatial typologies required varied lighting treatment. In the lighting of Victoria Harbour, coloured lighting with automated changing scenes were utilized to enhance the festive mood and complement the famous skyline of Hong Kong Island. On the other hand, the historical fabric of Lyon was illuminated using lamps of low Colour Temperature, while coloured lighting were utilized for the illumination for small pocket of spaces, like Parc de Gerland, injecting visual variety. Moreover, it must be noted that in the selection of lamp sources, the increase in Colour Rendering of the lamp is correlated to the accuracy in the rendering of object's colours to actual appearance. Low Colour Rendering would render the space monotonous, without highlighting the natural vibrancy of the urban structure, creating a stark contrast to its daytime vibrancy. The lighting of Singapore Civic District is one example where the wrong use of lamps had resulted in a monotonous nightscape. The choice of lighting had subdued the original richness in colour and texture, which is apparent in the day. The clear application of lighting to each pocket of spaces within the master plan would enhance the legibility of the urban structure, defining the structures of the environment. In the process of illuminating the landscaped using lamps of cool temperature and warmer tones for historical areas, it would in turn accentuate the "edges" between different materials and ability in visual perception of these differences, aiding in the legibility of the urban structure. With clarity in urban structure, it would enhance the human ability to navigate through the urban fabric even in the dark, facilitating perception.

3. Functional Requirements of Space

Since the Codes of Practices were still utilized as the basis in the determination of appropriate luminance level for different space, they were often referred to on the luminance requirement to support different spatial requirements during drafting of lighting masterplans. Often, these Codes provided the basis for recommended lighting level for different spaces. Due to the different spatial requirements, the level of brightness could contrast across different spaces, creating visual hierarchy. Also, the required luminance levels for different urban spaces were tabulated, with difference in accordance to their frequency of use, typology of space or the anticipated human traffic. The table below illustrates the recommendations of lamps, with their inherent properties, in relation to a variety of urban spaces they were recommended to be used for.(See Appendix II for more details on lamps for urban lighting)

Lamp Type	Color Rendition	Energy Efficiency (lumens/watt)	Life (hours)	Recommended Uses
Incandescent	renders colors well with emphasis on warmer tones	10-20	750-2,000	pedestrian areas, where natural color rendition is important
Mercury Vapor	green to blue-green; cannot render reds and yellows well	30-65	24,000	residential street lighting and accent lighting for planting material
Metal Halide	white light; renders colors well	75-125	15,000	general area lighting in public areas
High-Pressure Sodium	golden cast	75-130	20,000	primary and secondary roadway and parking lot lighting

Table 9.0 *Lamp characteristics (Source: USAF exterior lighting guide)*

From the table, it is clear that the use of lamps is paralleled to typology of spatial programme, with the relation of the spectrum of emitted light correlated to the colour of illuminated object, for example, incandescent lamps were recommended for use of lighting of spaces, where there is higher human traffic, due to its good Colour Rendering properties. (IESNA, 1999; IESNA, 1975; ILE, 1995) Since these sources were radiators, with the higher component of Infra-red rays from their emitted light, they would better complement human skin colour, in comparison to Low Pressure Sodium Lamps. Therefore, it is noted that there existed an intricate relationship between the choice of appropriate lamps and the spatial programme. The relation of lighting requirements to different urban spaces is particularly evident in master planning of Roppongi Hills and Hang Zhou, where the choice of lamps and lighting levels varied in accordance to the spaces, with landscaped areas designed with lower lighting level as compared to the main arterial traffic route that divided the site. Also, in Alingsås and Coventry lighting master plan, both lighting requirements and innovative lighting techniques complemented each other perfectly, demonstrating that Codes does not impede creativity.

4. Visual Variety

Although the International Codes of Practices had categorized spaces in accordance to their function, it would be overly monotonous if similar spaces were designed in the same fashion. Hence, variety should be introduced in the master planning for visual interest. Differentiation can be sought by a variety of lighting strategies for different elements, from architectural structures of varied materials to the soft-scapes. This not only highlight the different materials and details in their most suitable form, but also creating a sense of variety that is most welcomed in perception of one's environment, eliciting one's desire for exploration. Visual variety in urban lighting masterplans can be achieved through the following techniques,

1. Coloured lighting (Automated Colour-changing system, LED lighting, Neon)
2. Choice of luminaries (In-ground recessed, Floodlight, Linear Fluorescent etc)
3. Choice of lamps (Metal Halide, Low-Pressure Sodium, LED, Mercury vapor etc)
4. Choice of lighting technique (Floodlighting, Indication Lighting, Spotlighting)

Due to the extremely wide range of fixtures and lighting technique available, it would be impossible to illustrate all within the range of this thesis. However, examples would be provided in the form of this paper to illustrate the various visual effects that would be achieved with the different choice of source and techniques. The diagram below illustrates the various typical lighting techniques that could be implemented for illumination of vegetation. Therefore, it is evident that within the park spaces, different placement and choice of luminaries would result in a varied appearance of the landscaping as one moved through the space. Yet, coloured lighting could be manipulated with skill to create a mystic natural setting, which was different from the conventional landscape illumination, as evident in Parc de Garland.

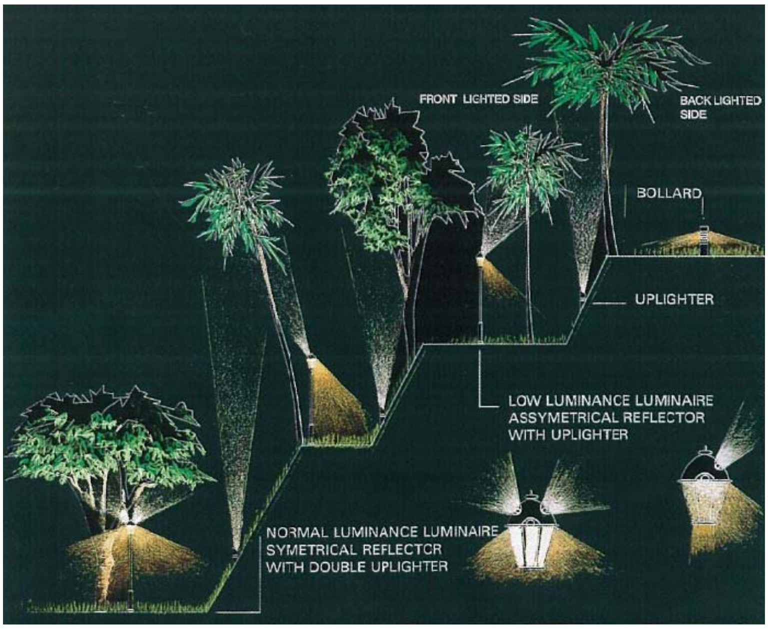

Illustration 14.0 *Different lighting techniques for landscaping areas*
(Source: Singapore Civic District Lighting Plan)

Although urban lighting master planning often vary one space from another, for spatial differentiation, the extent of which variety is introduced should be examined in detail. It is noted that too much variety would result in visual clutter, while a monotonous space would result from little variation between the spaces. Moreover, the use of coloured lighting should be carefully evaluated and balance should be sought to avoid sensory fatigue, a problem derived from too much sensory stimulation in one's environment. (Nasar, 1988; See results on colour lighting derived from survey conducted in Chapter 5.2.2) Also, automated colour-changing lighting system had gained popularity recently as a technique for urban lighting master planning, as a result from the advanced technological development of LED lighting systems, evident from the reviewed projects, namely Roppongi Hills, Hong Kong Victoria Harbour, and Coventry Urban Lighting. Therefore, it is evident that these advancements in lighting technology had brought about new potential areas of research into their effect on human perception and psychological comfort of his environment.

5. Visual Hierarchy

Visual Hierarchy is persistently consistent across all the lighting masterplans, which differentiate different areas through the intensity of lighting, which coincides with the hierarchy of the urban elements. In all reviewed lighting masterplans, visual hierarchy was addressed to in the following manners,

1. Relationship between the illuminated and its adjacent elements
2. Contrast between the illuminated and shadowed
3. Creation of "layers" of illuminated space

Figure 67.0 *Alcazaba, Malaga, Spain(Source: Philips Lighting)*

Figure 67.0 illustrated how visual hierarchy could be achieved, through the use of lamps of different Colour Temperature. It is clear that the façade is categorized into the visual foreground, background and mid-ground. Lamps of different Colour Temperature were used in the illumination of each of the identified planes, with the higher Colour Temperature lamps chosen for illumination of the planes that were the furthest from point of perception. This resulted in a subtle visual contrast with the lower Colour Temperature that was utilized for the illumination of the foreground objects. The resultant composition appeared to be highly structured, three-dimensional and dramatic.

In the highlighting of the landmarks, most lighting masterplans were designed with the deliberate lowering of the Illuminance level of the elements in proximity to the highlighted object. This would create an intentional contrast, bringing immediate attention to the illuminated object, as evident in the example of Hang Zhou Urban Lighting Master plan, along the famous scenic West Lake, as pictured. Although the rhythmic patterns of alternating illuminated and shadowed spaces should be well composed to allow appropriate contrast between these areas, the shadowed pockets should be maintained at an appropriate level that functionality within space should still be permitted, and avoiding psychological insecurity. Despite the popularity of these perceived effects in the design of Urban Lighting Masterplans, academic researches had yet to investigate the level of contrast that is most comfortable for perception, other method at which hierarchy can be enhanced.

6. Landmarks

Landmarks could be defined as one of physical prominence or of cultural or historical significance, often the main visual element in aid of navigation and orientation in the larger urban environment. Lynch had advocated Landmarks as one of the main elements which should be made obvious in the visual design of the urbanscape, as they facilitate in way-finding and imageability of the space (See Chapter 3.1.2). Hence, in the design of the Urban Lighting masterplans, all reviewed examples had clearly highlighted the landmarks through distinctive lighting techniques, to differentiate the appearance of these prominent elements from the rest of the urban fabric. In the illumination of the Hong Kong Victoria Harbour, identification of the landmarks were done prior to the design of the lighting master plan, and of which, coloured lighting were used on the façade of these landmarks. Coventry Lighting Master plan had set the landmarks apart from the rest of the urban fabric through usage of specially orchestrated lighting effect, at the Trinity of three Spires, recognized by the locals and visitors as the main cultural landmarks. However, considerations should extend towards the identification of cultural and social landmarks, identified by the locals, instead of focusing on the physical landmarks. Studies had indicated that landmarks should not be limited to their physical prominence but the local's familiarity of these elements does render them as important nodes in establishment of locality. (See Results from survey 2, Chapter 5.2.2)

7. Time-based or Scenario-driven Lighting Controls

Originally, urban lighting techniques were restricted by the programmability of the lamps, of which dimming control system was used to decrease the lighting intensity of the selected areas according to the time of the day. However, due to the increase in incurred costs, coupled with the inability of some lamps (namely, the standard High Intensity Discharge lamps like, Metal Halide or Low-Pressure Sodium Lamps) to be dimmed unless fitted with special ballast or control systems[2], these control systems were only used for a handful of projects or areas.

Recent development in LED lighting technology had seen development of LED as a main system for façade lighting or implementation of automated time based control. Extremely high life span of LED allowed them to be extensively used for installation in spaces of low maintainability. Also, flexibility in control and ability to integrate computational programming of these LED fixtures allowed them to be integrated better in façade lighting for a more dynamic lighting environment. Together with the development of these lighting systems, urban lighting master planning had slowly introduced the concept of time-based lighting control systems, as illustrated through the dynamic lighting display composed from the illumination of façade along the Hong Kong Victoria Harbour. In addition, colour changing LED fixtures were introduced in the illumination of leisure spaces, with the subtle alternating of colours increasing interactivity between the users and his space. Due to the unique operating technique and manner of which light energy was generated, enabled better control of the Light Emitting Diode, especially when computers were integrated as a form of

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Footnote:

2. *In the dimming of HID lamps, there are a few technical issues which concerned the light output, efficacy, lumen depreciation, service life and color. During dimming, HID lamps can experience a color shift and correlated reduction in its color rendering ability, of which the Metal Halide lamps are most susceptible to changes in lamp color characteristics. According to the Rensselaer Polytechnic Institute, Lighting Research Center, clear Metal Halide lamps, for example, will shift to a higher color temperature or cooler appearance during dimming, from white to blue-green. When a clear Metal Halide lamp is dimmed to 50% of rated power, color temperature can increase 1500. In addition, Color rendering may also be affected; when a clear Metal Halide lamp is dimmed to 50% of rated power, the Color Rendering Index (CRI) value may decline from 65 to 45. However, in comparison, coated Metal Halide lamps would experience a smaller reduction in CRI or alteration in the Colour Temperature.*
(Source: Craig DiLouie, Lighting Controls Association,
http://www.aboutlightingcontrols.org/education/papers/hiddimming.shtml)

control system, with the development of its unique operating systems for programmable controlling system on the LED systems. In contrast, those achievable by LED systems were difficult to realize with the previous range of lamp sources, as limited control of the fixture's output is permitted.

Although LED is being introduced as an innovative expression of urban lighting design, its usage is not explored in the Codes of Practices. Due to the flexibility of this lighting system, it is foreseen that this lighting system would have significant effect on perception of space. Hence, further researches would be required to explore the different effects colour changing or scene changing lighting would have on human perception.

8. Clarity in movements

Orientation in dark is extremely important, as limit in visibility would render dependency on visual guides based on the level of their illumination and the contrast of these illuminated objects against backgrounds. Since "path" is one of the main urban elements which would contribute to the construction of a legible environment (Lynch, 1960), it is essential that pathway lighting to be one of the main design basis for lighting masterplans. Although all Codes of Practices had recommended a minimal of 50 lux for the illumination of the pathways, it must be judged that this is basically a rough figure for reference, while the actual lighting level should vary in accordance to the site context. In the analysis of all the lighting masterplans, all had structured the environment by highlighting the landmarks, but none had identified how pathways should be addressed. Roppongi Hills had utilized specially designed streetlamps to illuminate the main arterial traffic route that spilt the site into halves, while the Singapore Civic District Lighting master plan utilized lower Colour Temperatures to visually divide between the pathways that linked the historical monuments and the normal pedestrian walkways. However, it must be noted that there existed many methods in terms of pathway illumination, as illustrated in the pictures below.

Figure 68.0 *Frederikshavn, Denmark*
(Source: Philips lighting)

Figure 69.0 *Kastrup Søbad bathing platform*
(Source: ERCO lighting)

Figure 70.0 *Axis Lighting*
(Source: ERCO lighting)

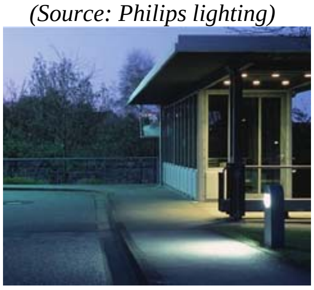

Figure 71.0 *Bollard lighting*
(Source: ERCO lighting)

Figure 72.0 *In-ground recessed up-lighter*
(Source: ERCO lighting)

Figure 73.0 *Continuous linear lighting*
(Source: ERCO lighting)

The above only illustrated some of the common pathway lighting techniques, ranging from the indirect lighting of the elements adjacent to the path, to the direct illumination of pathways or integrating indicator lighting, serving as visual guides along the pathways. Although there are many techniques in the illumination of pathways, indirect and indirect, horizontal or vertical lighting, studies should be done on which of the technique would be most effective and preferred by human in orientation, especially when the surrounding elements offered little or high contrast to the Illuminance level to the pathways.

2.4.3 Limitations of Current Planning Basis

Originally, the main focus of urban lighting was the provision of sufficient lighting level for safety of the residents, security of individual's possessions (IESNA, 1975), while aesthetics of the illuminated environment was one of the last considerations. With the advancement in lighting technologies and increase in possibilities in fulfilment of different lighting design concepts, urban lighting had transcended the engineering aspects of providing for the functional aspects of urban spaces, to the orchestration of an aesthetically pleasing nightscape. Through the review of the realized examples, it was noted that aesthetics should co-exist with the fulfilment of the requirements as in the Codes of Practice. Furthermore, these Codes should not be the main design basis, but to complement the design strategy towards achieving well-illuminated environment. Although awareness in quality lit urban environment had increased, there is a lack in detailed academic research on how these basis could better construct and define *quality* urban lighting master plan. Furthermore, it is apparent from the above analysis that the current design practice would not suffice, as the relationship between human and his visual needs in environment remained unexplored. Furthermore, without better understanding on the applications of these lighting installations on human perception, some lighting designers would be inclined to utilize the latest available luminarie technology, instead of prioritizing the construction of an illuminated environment that best relate to human perception needs.

Since urban lighting master plan is akin to the visual design of one's urban environment, while using artificial lighting to complement the illuminated object, the impact of the various illumination techniques, the utilization of the appropriate lamps or luminaries and the effect it had on human should be studied in detail. Furthermore, despite the expense of studies done on the visual design aspects in urban planning theories (See Chapter 3.0), the potential on how these theories could contribute to the examination of quality urban lighting masterplans remained unexplored. A research in these would definitely be advantageous in,

1. Reducing unnecessary lighting level and implementation
2. Minimization of light pollution
3. Well-structured nightscape
4. Educating the public on the meaning of good urban lighting and its constituents
5. Better utilize the existing lighting techniques and luminaries
6. Exploring on the effects of current lighting technologies on human psychological comfort and perception.

7. To better improve illuminated environment for safety and security and reduction in crimes after dark.

Frequent occurrences of over-illuminated, yet chaotic urban lit environment, are noted in some cities without proper urban lighting knowledge. Since one of the frequent misconceptions in artificial lighting is equating high achieved lighting level to good lighting, neglecting the composition of the illuminated space and examining the type of utilized lamps or luminaries or how light interacts with the objects, through deepening the understanding of the fundamental requirements to quality urban lighting would certainly enable better understanding on how current design basis could be improved. This would further provide an insight if current popular use of coloured lighting (as noted in the highlighted examples, or even cities like Shibuya in Tokyo or Las Vegas, where the colourful illuminated nightscape had became an urban feature) would impede visual qualities of a space. Hence, correct perception on how lighting would better complement urban elements would definitely aid in eliminating occurrence of discomfort glare, while providing an appropriately composed nightscape, which facilitate human perception and easing the problem of light pollution, through directing lighting to the illuminated objects, instead of causing visually uncomfortable light spillage. Also, development in the understanding of the relation of different lighting effects to impact on perception would suggest better implementation of the existing luminarie technology in relation to the urban elements or the composition of the lit environment.

In the perception of his environment, human depended on cues in navigation and obtaining necessary information which is innately related to survival. Hence, ease in obtaining necessary information is highly important in designing for visual perception. This is an extremely intricate subject where detailed and rigorous studies had been undertaken since Lynch highlighted this forgotten aspect of urban planning in his revolutionary book, *The Image of the City*, in the 1960. Although the content of the book had been challenged by some critics on its validity and ability to represent some of the key concepts proposed, the book had initiated the importance in awareness in visual design of the urban environment. The subsequent chapters would provide an introduction on the existing studies that had been done on the visual qualities in the urban environment, which are highly preferred by human in the perception of his environment. The cross-analysis would then establish the key points that future urban lighting master planning could explore and validate in the design of a better lit environment. Reviews on the visual perception of spaces, that involved direct perception and "meaning" of the perceived object to the viewer, had derived several important basis of which lighting design can be developed and studied upon for a better lit environment that is pertinent to the manner human perceives his spaces. Kaplan theorized that human prefer environment where information is offered easily, as the speed of extraction of relevant information is correlated to the ability to survive in the environment. (Kaplan 1983). Further Rapoport and Nasar had emphasized on the importance of an *imageable* environment and how the environment would support human visual needs. (Rapoport, 1977; Nasar, 1988; Nasar, 1998)

The subsequent reviews had highlighted that although recognition for quality lit environment had recently gained popularity in many countries, the knowledge in how various illumination techniques and tools affect human perception and appearance of the lit indoor environment were still stagnant in interior lighting, while the same area in urban lighting remained undeveloped. It is only in the recent years that lighting research had strived to establish design criteria for quality in provision of lighting, beyond the mere provision of required quantity for the space to function. Visual and psychology impact of lighting had been research extensively, since the revolutionary work done by John Flynn in 1960, establishing correlations between the appraisal of space from its lighting design and choice of lamp sources. Despite the urge in quest for quality lit interior spaces, through research of appearance of various lighting scenes, in relation to human perception or comfort, no researches on quality urban lighting or basis to which a better urban lighting master plan could be drafted, was executed. The following intangible variables would affect human comfort in space and thus, preventing generation of a stable and constant environment for experiment.

1. *Site related issues:*

- Scale of the actual test site
- Environmental changes – seasonal changes
- Existing lighting – street lamps, architectural lighting, landscape
- Types of urban elements and the complexity existing in lighting requirements for each elements
- Variety of materials in the urban environment
- Difficulty in coordination for relevant test environment (Required co-operation from different parties, building authorities, passer-bys and survey subjects to maintain consistency in test environment.; Obtaining of approval of different building management authorities)
- Glare from unanticipated sources (traffic, streetlamps etc)
- Presence of uncontrollable variables at site, which would potentially affect survey of comfort at actual site. (Heat, Noise, Air Pollution etc)
- Need for additional installations which might be time-consuming
- Time for test to be conducted.

2. *Luminaries used:*

- Luminaries' distribution and output
- Range of lamp sources (High-Pressure and Low-Pressure lamps)
- Quality of fixtures
- Mounting distance and height, which is a potential factor for glare

3. *Experiment audience*

- Choice of sample group (Different Race, Gender, Age and Professional versus the General Public.)
- Size of Sample Group
- Perceivable objects

- Extent of vision
- Time in viewing
- Initial psychological comfort level of participants (as affected by dark), which might affect their response.

The above list is not an exhaustive list which listed all the potential reasons which would hinder the conducting of tests on quality urban lighting, but provided a proposed outlook on why such tests were not realized, which an alternative test environment should be proposed to overcome such problems. Since Urban Lighting involved many factors and considerations for a successful experiment to be performed, the scale of site might mean that the users' perception is not easily controlled and fixed on what was required to be tested. Therefore, in study of quality urban lighting, actual conducting of experiment on-site would not be recommended for a sound experiment. However, computational tools and virtual environment had been introduced into the realm of test in artificial lighting (Mahdavi, 2002; Eissa, 2001; Wittkopf, 2000) indicated the validity of use of computational tools and the effectiveness of such tools in test for lighting design. The author had integrated the use of computationally generated test environment for both surveys and the results achieved had indicated similar findings as those proposed through prominent studies done in artificial lighting, also correlations could be observed between the findings and the theories in visual design of the environment. (See Chapter 5.0) These implied the effectiveness of such test environments as surrogates of the actual environment for experiments in urban lighting, as the stimulated space can be defined in accordance to all the lighting types and design, with photo-realistic quality that would generate scenarios that is similar to the actual derived effects. Also, such test environment would enable full-manipulation of the environment, while achieving the test objectives designated for the experiments. Furthermore, reviews of literature on human perception studies and tests for such studies had revealed that photographs or models, or even interviews with support of relevant graphic materials were sufficient for the conducting of such experiments. (Nasar, 1988; Nasar, 1998; Lynch 1960; Rapoport, 1977)

To re-evaluate the current basis of urban lighting master planning through an alternative perspective, the subsequent chapters proposed to improve upon the current limitations as observed through the current design basis, whilst highlighting the importance of other areas of investigations in urban lighting.

3.0 Neglected Component of Human-Environment Interaction

3.1 Introduction on Environmental Perception

Human always receiving and analyzing information he extracted from his surroundings. The study of environmental perception addressed the various manners human derived information from his environment, of which human perception comprised of the following three main areas, as extracted from Rapoport (Rapoport, 1977),

1. *Environmental Evaluation and Preference - involving perceiving, knowing and thinking, the basic processes whereby the individual knows his environment.*
2. *Environmental Cognition – the way in which people understand, structure and learn the environment and use mental maps to negotiate it.*
3. *Environmental Perception – referring to the direct sensory experience one would have the environment*

As seen from these three highlighted processes, it is evident that perception is affected by "nature of the stimuli, the physiology of perception and the state of the organism – expectation, attention, motivation, selectivity or adaptation." (Rapoport, 1977, page 178) These processes do not occur independently, but interact during perception, forming the total derived experience of one's environment. Since human is constantly in search of information from the environment and some researches had theorised this need to the primitive instinct for survival (Kaplan, 1983; Nasar, 1988), the manner from which human extracted information from the environment could be interpreted in 2 forms, where direct information defines the sensory experience of the environment, and inferred information referred to the processed image of the environment, with relation to one's mental processing of the extracted information, Undeniably, human's experience of the environment is initially affected by the direct sensory experience, and it is often the most analysed form of environmental perception in researches. The significance of designing for human visual needs and mental mapping of one's environment is pioneered by Kevin Lynch, in the revolutionary works in *The Image of* *the City* (Lynch, 1960) His work had spurred many subsequent researches in the importance of visual design in urban planning and how visual structure could facilitate in the ease of formulation of mental structure. Although environmental perception does not constitute of only the visual aspects of the environment, and perception is often a result of multi-sensorial experience, it is important to note that the visual experience of one's environment is often the most consistent amongst the other sensorial experience of environment. (Lynch, 1960; Rapoport, 1977) Cognition is often the derived experience of the environment, and often "static", as opposed to the dynamic nature of perceptual experience, this is extremely relevant for large scale environmental perception, which involved "exploration, movement, inference, experience and memory" (Rapoport, 1977, page 184).

Various academic studies proved the importance of visual design of the environment and how it is correlated to the quality of the environment. Moreover, the extent of which these processes differ from one individual to another is also dependent on the social and cultural differences, objectives for perception. (Rapoport, 1977; Nasar 1998; et al.) Of which, cognition would be a resultant of analysis and experience of individual. Although perception might be highly subjective, similarities in the responses to one's environment is noted for people with similar background and of similar geographical positions. This is noted from the study of definition of a quality environment across different literature and researches (Rapoport, 1977), which derived some main criteria to the definition of a quality space. Table 9.0 summarized several academic findings consolidated by Rapoport (Rapoport, 1977), to define the parameters that human would perceive as elemental to the design of quality public spaces. Since this research would address the better illumination of the physical elements in the environment, to compose quality lit urban environment, only the physical aspects would be focused in this table. The understanding of generic qualities that would formulate quality environment would constitute background knowledge for the establishment of required physical characteristic for urban lighting.

Reference	Setting	Physical components
USA		
Wiggins (1973)	Urban Spaces	1. Degree of enclosure 2. Size of space 3. Character of space 4. Nature of enclosing elements 5. Amount of greenery
UCLA (1972)	Small town in a recreational area	1. Scenic beauty 2. Small town atmosphere 3. Visual quality – signs, distinct districts, orientation 4. Air quality and weather 5. Transportation
Appleyard and Lintell (1972)	City blocks and streets	1. Traffic hazard 2. Noise, vibration, pollution, trash 3. Maintenance 4. Privacy 5. Greenery 6. Complexity and Variety
Lowenthal (1967)	Parts of town	1. Natural preferred to artificial 2. Variety and contrast
Lynch and Rivkin (1970)	Urban streets, downtown	1. Spatial quality (interest, contrast, greenery liked) 2. Intrinsic interest of features 3. Specific buildings 4. Nature of traffic and parking
Van der Ryn and Boie (1963)	Part of city	1. Natural character 2. Views without obstruction 3. Special dislike – utility poles
Van der Ryn and Boie (1964)	Part of city	1. Maintenance level 2. Low pollution 3. Noise at night 4. Traffic dislike 5. Ownership and identity of house 6. Detached houses 7. Low density 8. Openness, spaciousness 9. Greenery 10. Hilliness and views
Kaplan and Wendt (1972)	General visual character of scenes	1. Natural greatly preferred to urban 2. Within any class – complexity, legibility, identifiability, coherence, interestingness, mystery
Carr (1973)	Urban streets	1. Signs recognized hence important – not seen as a problem 2. Legibility and orientation
Other countries		
De Lauwe (1965 (a)) FRANCE	City	1. Lively exciting cities – shops and street life 2. Those elements furthest away from rural life 3. Symbolic aspects – cultural symbols
King (1971) AUSTRALIA	Various urban areas in large city	1. General appearance of area 2. Elevations or apparent elevation 3. Extensive views of water or trees but no industry 4. Detached houses 5. Newness 6. Greenery 7. Spaciousness 8. Individuality
Barrett (1971)	Urban areas	1. High status area (good scenery, topography, hills and views etc)

Young and Wilmott (1973)	City and parts of the city	1. Spaciousness – the more space the better 2. Detached houses with gardens 3. Views – specially over large commons 4. Rural character or desirable older central areas (historical snobbery) 5. Topography – height and hills preferred to flatness 6. Proximity to water, if no industry along it
Johnston (1971) comparing different counties	Urban areas	1. Proximity to recreation, water 2. Views 3. Microclimate 4. Proximity o open country 5. Low density and space 6. Greenery

Table 10.0 *Summary of important components of environmental quality from selected studies (Rapoport, 1977, page 65 to 80)*

Generally, there existed general preference for visual variety and interest in one's environment. This might be explained through Kaplan's works, where he had pointed out that complexity and legibility is correlated to quality visual environment, yet the extent of complexity and variety should be controlled. Thus, an increase in complexity beyond the tolerable threshold would result in the reverse scenario of decrease in likeability of environment. (Kaplan, 1983) Kaplan further proposed that 2 different manner from which environment were perceived, with the process separated into the extraction of information from two dimensional planes (two-dimensional spatial qualities), and the depth in the environment is correlated to the mystery and the need to explore (three-dimensional spatial qualities).(Kaplan, 1983; Kaplan, 1988) On the other hand, Lynch proposed that in experience of the larger environment, one constructed mental maps of the space, which is aided by certain urban elements that would enhance the ease in which these mental structures were constructed. (Lynch, 1960) Nasar had proposed a theory which is an extension of Lynch's idea of *legibility* of the city. He referred to the "city appearance as evaluated by the public who experiences it" (Nasar, 1998, page 3), of which he proposed on how the city's visual structure could better enhance the *likeability* of the structure. Therefore, these studies implied that human decision in environment is a reflection of the perception of the environment and the ability to extract information from the environment. Generally, many consistencies noted through the review of these environmental perception theories revealed similar, generic design criteria towards quality visual environment, suggesting potential of extending this research on how the visual environment could be further developed into design basis for urban lighting masterplans.

The following sub-chapters detailed the various prominent studies on environmental perception and visual design in urban planning, which could be the fundamental design basis in urban lighting master plan. The possibilities in the integration of these neglected components into existing design practices of urban lighting master plan, where emphasis is placed on the quantifiable, indicated the potential of future studies in this novel subject.

3.1.1 Basis to a *Legible* Urban Space

> "There is sheer delight in sensing the world: the play of light, the feel and smell of the wind, touches, sounds, colours, forms. A good place is accessible to all the senses, makes visible the currents of the air, engages the perceptions of its inhabitants." (Lynch, 1981, p. 132)

Of the 5 dimensions Lynch proposed as the various dimensions that composed the legible city form, namely "Vitality", "Sense", "Fit", "Access" and "Control" (Lynch, 1981), Sense is especially pertinent to the clarity of city's visual form. Sense is defined as "the clarity with which it (the city) can be perceived and identified, and the ease with which its elements can be linked with other events and places in a coherent mental representation of time and space and that representation can be connected with non- spatial concepts and values." (Lynch, 1981 page 131) Lynch was one of the earliest and most prominent pioneers who highlighted the importance in the visual structure of the city, for ease in navigation and perception. Although the perceivable structure of the city might be a subjective experience unique for each individual, generally people of similar cultural background would enjoy similar experience of the city and extract similar visual information. Researches by Lynch, Nasar and

Kaplan had consistently noted patterns in individual's responses to their visual experience within the city. Furthermore, in his revolutionary book, *Image of the City*, analyzing urban planning through the visual qualities of the environment and addressing the vital building blocks of the city, he demonstrated that the character of each city would be illustrated from the mental maps people formed of the place, using case studies of 3 cities, Boston, Los Angeles and Jersey City. The validity of the 5 building blocks to the city, namely the path, landmarks, nodes, districts and edges, were tested upon and their significance illustrated through the interview session conducted with the surveyed subjects. It was noted that the *paths* embodied the highest significance to the subjects and the definition of the path could be anticipated through the concentration of details, patterns and consistencies, noted as one navigated along the paths. In his demonstration, he had proved that despite the similarities noted in the perceptions of people within the same city, differences in what are noted and the manner at which the mental map is constructed. For example, some might amplify the physical proportion of the landmarks, symbolizing their significance in navigation, while others might emphasize on the presence of pathways in orientation. However, the definition of these 5 elements had proven to enhance the structuring of the urban environment, making navigation a much enjoyable experience.

From the studies of the visual patterns people derived from their urban environment, Lynch surmised the existence of 5 main urban elements that would construct the *imageable* urban space, namely, landmarks, nodes, districts, paths and edges. (Lynch, 1960) *Landmarks* are visual anchor points, which might imply its huge physical presence, or the high significance of the object to the viewer, making it a visual anchor point in orientation. *Paths* are primary routes in navigation through the urban spaces and their recognition can be enhanced by the definition of its edges, the materials that fringed the paths, the patterns and consistencies that enhanced the prominence of these paths. *Districts* are areas of which distinctive character is noted throughout the area that segregates it from the other parts of the city. *Edges* denote the separation between different materials or surfaces, which can further enhance the presence of its separating objects. *Nodes* are focal areas where high human traffic is noted, traffic junction, the traffic connector to other cities or a popular activity spot amongst the community. Lynch noted that the city is constructed with these 5 primary building blocks of which the presence of all would result in a more legible city structure, yet the interrelations between each element should complement and enhance the overall experience. Following his research, subsequent studies confirmed the existence of these generic building blocks of a legible city. (Nasar, 1981; Kaplan & Kaplan 1998; Kaplan 1983) The development of these design attributes of the larger metropolis is indicative of how dependent human is on the visual impact of his surrounding and his imposed meanings and self-identification of his environment. Human perception is further aided when he is able to 'make sense' of his spaces, to visually and mentally organize his surroundings into forms which he could identify with. (Kaplan, 1983) This mental construction is derived from the innate human need to navigate in space and desire to orientate in the larger environment, particularly when one is within an unfamiliar environment. This need is justified by many studies in environmental perception, while discomfort is commonly noted in instances when one is unable to comprehend his surroundings. Hence, Lynch noted that a highly legible environment is most enjoyed and one that would best supports human activities. However, the legibility of the environment is often coloured by personal experiences and rendered meaning, due to the major role cognition had in perception. Therefore, Lynch did not refer to his 5 major elements as fixed physical form with definitive geometrical forms, but also for urban forms that fulfilled those symbolic meanings. These 5 points were not of single dimensional meanings but possessed many layers of embodied meanings that would further aid in the formulation of mental images of the city form for each individual.

> "Given the general view and the task of constructing a limited set of performance dimensions for the spatial form of cities, I suggest the

following ones. None are single dimensions; all refer to a cluster of qualities. Yet each cluster has a common basis and may be measured in some common way." (Lynch, 1981, page 117)

Hence, the *dimensions* and qualities to the design of a legible city are not single dimensional descriptive terms, but embodied meanings that pointed to generic characteristics of those descriptions. In *Image of the City,* Lynch had also deduced the existence of some design qualities to a legible city, summarized in the following table.

No.	Design Qualities	Characteristic
1	Singularity or figure background clarity	1. Sharpness of boundary 2. closure 3. contrast of surface, form, intensity, complexity, size, use, spatial location. To the immediate surroundings or viewer's experience. Qualities that make it identifiable or remarkable, usable and vivid.
2	Form simplicity	Clarity and simplicity of visible form in the geometrical form, limitation of parts (clarity of the system) Forms of this nature are much more easily incorporated in the image, and there is evidence that observers will distort complex facts to simple forms.
3	Continuity	Continuance of an edge or surface; nearness of parts; repetition of rhythmic intervals. Qualities that facilitate the perception of a complex physical reality as one or as interrelated, the qualities that facilitate the perception of a complex physical reality as one or as interrelated, the qualities that suggest the bestowing of single identity.
No.	**Design Qualities**	**Characteristic**
4	Dominance	Size, intensity, or interest, resulting in the reading of the whole as a principle feature with associated cluster. 1. Allows the necessary simplification of the image by omission and subsumption. 2. Physical characteristic that is over the threshold of attention 3. Radiation of their concept to some degree
5	Clarity of joints	High visibility of joints and seams Clear relation and interconnections. Strategic moments of structure and should be highly perceptible

6	Direction differentiation	1. Asymmetries 2. Gradients 3. Radial differences 4. differentiate one end from another 5. heavily used in structuring on a differentiate scale
7	Visual scope	Qualities which increase the range and penetration of vision, actually or symbolically 1. Transparencies 2. Overlaps 3. vistas and panorama (increase the depth of vision) 4. Articulating elements 5. concavity Relates to the facilitation in grasping of a vast and complex whole by increasing the efficiency of vision
8	Motion awareness	1. The qualities which make sensible to the observer, through both visual and the kinesthetic sense, his own actual and potential motion. 2. A city is sensed in motion, so these qualities are fundamental and they are used to structure and even to identify, wherever they are coherent enough to make it possible. 3. Qualities reinforce and develop what an observer can do to interpret direction or distance and to sense form in motion itself.
9	Time series	1. Sensed over time, including both simple item by item linkages, where one item is simply knitted to the two element before and behind it (in a casual sequence of detailed landmarks) 2. Truly structured in time 3. Melodic in nature

Table 11.0 *Design criteria for a legible urban environment (Source: Lynch, 1960, p. 105 to 108)*

Since the studies are often focused on the "generalizable connections between human values and settle forms or how to know a good city when you see one", the attributes above are guidelines to which the legible city structure can be achieved, but the construction o the city form is not as simplified as illustrated. Lynch had pointed out that in the explanation of how the city form is made, three different theories would result in separate planning tools. The first was the "planning theory", which dealt with the "public decisions about city development are or should be made" (Lynch, 1981, p 37), while the second theory of "functional theory", which address to how the city took a certain form and "how it functions". (Lynch, 1981, p 37). In the final theory of "normative theory", it is concerned mainly with the interactions between individuals and the city forms, which addressed to the basic human needs in the visualization of the city form. This is more on a personal level, and is or a more micro-scale compared to the earlier theories where the policies and stringent rules were dogmas.

Lynch presented 3 different constituents to the construction of environment image, “identity, structure and meaning”. (Nasar, 1998, p 6) and presented the 5 different elements that would form the urban structure. Although researches that further analysed his theories subsequently had proven the validity of his researches and the importance of the 5 elements, landmarks, nodes, edges, districts and paths, some studies refuted his theories based on the overly simplification of perception. However, his research had revealed that there are fundamental requirements or basis to which individual’s directly experienced his space without the involvement of cognition or evaluation, which would involved another realm of knowledge into psychological influences on perception.

> “The paths, the network of habitual or potential lines of movement through the urban complex, are the most potent means by which the whole can be ordered. The key lines should have some singular quality which marks them off from the surrounding channels: a concentration of some special use, or activity along their margins, a characteristic spatial quality, a special texture of floor or façade, a particular lighting pattern, a unique set of smells or sounds, a typical detail or mode of planning.” (Lynch, 1981, page 96)

It is noted through the analysis of Lynch’s research that he made a constant reference to light as a prominence form shaper, to increase the distinctive quality to space. (Lynch, 1960) Indeed, as how Le Corbusier had illustrated through his famous quote in *Vers une architecture*, “Architecture is the masterly, correct and magnificent play of masses brought together in light. Our eyes are made to see forms in light; light and shade reveal these forms; cubes, cones, spheres, cylinders or pyramids are the great primary forms which light reveals to advantage; the image of these is distinct and tangible within us without ambiguity. It is for this reason that these are *beautiful forms, the most beautiful forms.*" The interaction between light and the elements would result in a kaleidoscopic experience as one moved through the city, which is extremely valid in today's instances when the development of the artificial lighting technology had the ability to render singular forms into a variety of appearances. The city is an ever-changing conglomerate of human activities and physical elements, hence the appearance of city in varied time of the day, season, distance, "static and moving" and the state of mind should be considered in conjunction to maintain consistency. Lynch maintained that the physical form of the basic 5 constituent elements to the city form should be recognizable despite the changing form of the city. Lynch had executed his studies of the urban form during the day, where visibility was only affected by the physical placement of the objects or presence of obstacles but in the analysis of the appearance of the urban form during the night, the lighting master plan would be the primary tool to enhance the prominence of these elements, in the determination of their illumination level or lighting design strategy. Hence, to employ this into the design of the urban lighting masterplan, the current practice does not address to the concerns of appearance of the individual elements in day or how the illumination would alter its appearance. Also, Lynch had also pointed out the importance in the recognition of basic urban elements, which would be critical in the formation of the urban lighting master plan, in the denotation of design hierarchy and interrelations between the various illuminated forms.

3.1.2 "Being Involved" and "Making Sense"

> "As pervasive and far-reaching human needs, making sense and involvement are important components in preference. These needs profoundly influence human preference for patterns of information. These preferences express themselves not only in relatively abstract situations (as, for example, people's reactions to written or oral messages), but in people's reaction to

the physical environment as well. People prefer, in other words, both landscape and books, interiors and organizations, that offer promise of being involving and of making sense." (Kaplan, 1983)

Kaplan and Kaplan (Kaplan & Kaplan, 1998) focused on the specific human characteristics that are central to the design and management of general settings, mainly addressing to human's basic needs of *Understanding* and *Exploration.*" Understanding provides a sense of security. When people cannot understand a situation, they can become distressed." (Kaplan, 1998) Understanding can be interpreted as the comprehension of one's surroundings for psychological comfort and security. Hence, environment that supports the extraction of necessary information for survival and clarity in navigation would be more preferred than those which are visually cluttered. However, this extraction of information and how the environment would support human interest depends on the manner at which human perceived his environment.

	UNDERSTANDING	EXPLORATION
Immediate	**Coherence** Organization – Ease in which the environment can be read or understood	**Complexity** Richness – Variety of objects [*rather than the number of objects*]
Inferred	**Legibility** Wayfinding – Ease of understanding orientation	**Mystery**[5] Sustained interest – Potential for more information

Table 12.0. *Preference matrix*
(Source: Kaplan, 1998 Page 13)

The basis behind Kaplan and Kaplan's preference matrix is from the formation of flat retinal images to the ability to extract depth from these two dimensional mental images. From the matrix, "Coherence" and "Complexity" are two environment components, which are directly derived from object's geometrical forms or their layout in relation to each other. However, the information from the third dimension, like "Legibility" and "Mystery", "require the inference of the third dimension" (Kaplan & Kaplan, 1998, page 13). Furthermore, Coherence and Legibility are correlated in their aid in understanding the environment, yet Mystery and Complexity would prompt further exploration of the environment.

Visual attributes	Characteristics
Coherence	Organized into clear areas ; Few distinct regions Repeating themes and unifying textures Limited number of contrasting textures
Complexity	Richness of elements ; Different visual components Greater richness or variety would encourage exploration However, increase in complexity might not suggest a decrease in coherence, as long as the different groups are distinctive
Legibility	Distinctiveness Memorable components that help with orientation Legible space would allow ease in navigation
Mystery	Desire to explore a place would be enhanced if there were promise of more offerings in the visual scene Studies in people's preference for different environments showed that mystery is a particularly effective factor in making some scenes highly favoured.

Table 13.0. *Extracts from Kaplan's definition of 4 environmental attributes (Source: Kaplan, 1998 Page 15 to 16)*

These environmental attributes, upon achievement, would allow the design of a preferred environment, which supports functionality. Preferred environment would not only "enhance people's effectiveness" but is "supportive of mind and body". (Kaplan & Kaplan, 1998) If the environment were designed to facilitate orientation, it would entice exploration and contribute to quality experience in that environment. Studies done on the effects of environment and orientation to its resultant impact on human had shown negative feelings from being disorientated. (Nasar, 1998; Kaplan & Kaplan, 1998; Lynch, 1960, et al.) Therefore, if the structure of the visual environment were designed to allow for easy recognition of the landmarks, the pathways, clarity in directions and minimization of visual clutter, ease in orientation would result. Moreover, visual landmarks create focal points which capture attention, which in combination of segregating the environment into regions would ease visual perception in space.

"When local needs and understanding are routinely incorporated in design and management the resulting solutions can be, and have been, far more satisfying for all concerned." (Kaplan & Kaplan, 1998, page 123) Kaplan had also recommended the public to be engaged in the design process, for the design of an environment that better supports the public interest. Nasar's study earlier demonstrated the differences between design connotations between design professionals and general public. (Nasar, 1998) Kaplan had advocated the importance of visual forms in the appreciation of the environment. However, the derived effects from an improvement of the visual space is not only localized on the city's visual form, but the "community's meaning and appearance for the many people who experienced it" (Nasar, 1998) Studies had demonstrated and proved the impact of the city on one's experience and pleasure derived from the environment. (Kaplan, 1983; Nasar, 1998). Since people's participation in the design process of their space would result in better appreciation of their environment, prior to the derivation of such guideline, the public's evaluation and opinion should be sought.

3.1.3 *Evaluative Image* of the City

> "Likeability refers to the probability that an environment will evoke a strong and favourable evaluative response among the group or the public experiencing it. Inhabitants of a city with a good evaluative image find pleasure in the appearance in the appearance of its memorable and visible parts." (Nasar, 1998, page 3)

Human's experience of the city is not merely defined by the physical structure of the city and the ease of which the identity could be perceived. Nasar proposed that the relation of the city to ignite positive emotional associations in perception and these emotional meanings one developed for the environment would "define the evaluative image of a city." (Nasar, 1998, p. 8) From researches on human response to environment, it is concluded that "evaluation and appearance to be primary dimension of the environmental experience'. (Nasar, 1998, p. 8) Therefore, the greater the amount of these imageable elements in the environment, the more *likeable* would be the environment. Three factors which Nasar had identified to "affect the imageability of elements: distinctiveness of form, visibility and use/symbolic significance" (Nasar, 1998, p. 61) From his experiment conducted in Knoxville and Chattanooga on the evaluative map of these two cities, he concluded that “the evaluative image relates to distinctiveness of form, visibility and use significance, or the convergence of these factors” (Nasar, 1998, p. 61), of which he proposed a series of “likeable features” in the construction of an *imageable* city.

Nasar analysed the outlook of the city according to the manner at which public response could aid in the shaping of the urban form for spaces which are more conducive for activities. Since he had analysed the common benchmark for visual appraisal of urban forms from the aesthetic value to the “evaluative response”, which would minimize the subjective connotation paralleled to beauty. In the idea of “evaluative response”, the appeal of the object is not judged by its mere appearance but “refers to favourable emotions and meanings experienced in relation to the environment.” It explored the meaning of attributes that could contribute to the visual appeal of the space, for example in the extensive researches done by psychologists James Russell and Larry Ward, there existed 4 dimensions to the space that relates to its appeal in environmental appraisal, stated as *Pleasantness, Arousing, Exciting* and *Relaxing.*

Amongst the 4 presented cases of emotive quality of the environment, pleasure is the one which is independent and possessed evaluative quality. It is of an opposing spectrum to Arousal, while the other 2 qualities of Excitement and Relaxation are both sensations to one’s environment that stemmed from a mixture of arousal and evaluation of one’s surroundings, which can perhaps be related to as an indirect or derived response to one’s environment. However, beyond these potential emotive qualities of spaces, human also imposed inferred meanings to reviewed places and often link images of places to their “connotative meanings.”(Nasar, 1998) These meanings would affect potential actions and psychological responses within the spaces, for example a place which appeared to be unsafe might ignite fear and insecurity of one’s safety. Hence, these qualities that might attribute to inferred meanings about a place would eventually affect the evaluative image of the place to its users. Although qualities of a place might present themselves as subjective and individual, studies and researches in the area of visual appraisal of environment and environmental perception had presented consistencies in one's responses to the generic definition of a pleasing space. (See Appendix study on environmental perception)

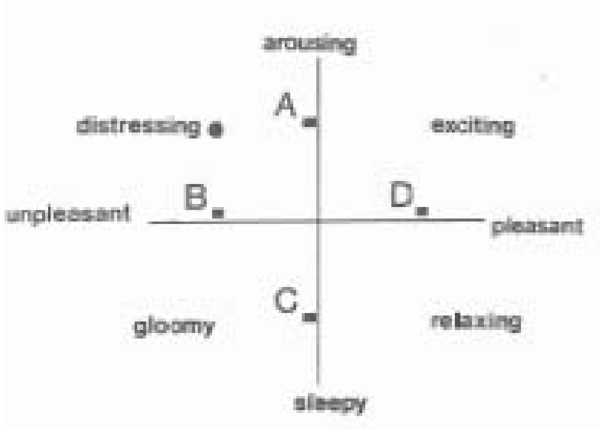

Illustration15.0 *Dimensions of affective appraisals*
(Source: Nasar, 1998 extracted from Russell & Snodgrass 1989)

Nasar's concept of human's perception of his environment involved the evaluative component, which he would add upon Lynch's proposal of the city's legibility with recognition of the city's "identity, structure and meaning" (Nasar, 1998). Nasar had expanded the meaning of evaluative city to encompass the emotional component of one to his environment. His researches had pointed to the existence of a common benchmark to the widely perceived generic aesthetics quality of the environment. He quantified it as the likeability of the environment, which he sought through the "evaluative quality of the environment", which is a benchmark extracted from public's opinion, instead of the professionals who are closely involved in the mentioned area. He referred this quality of likeability to "the probability that an environment will evoke a strong and favourable evaluative response among the groups or the public experiencing it." (Nasar, 1998, page 3)

His research had advocated 5 environmental attributes as being enjoyable and rated as appealing, existing in the urban fabric. The 5 attributes are "Naturalness, Upkeep, Openness, Historical Significance and Order." (Nasar, 1998 page 62) These attributes are not single dimensional, but is correlated to the cognitive images of these attributes to certain positive image in the perceivers' minds.

No.	Positive Environment Attributes	Definition
1	Naturalness	The presence of vegetation, water or mountains. Typically involves the users' perception of an area as natural or predominance of natural over built environment.
2	Upkeep/Civilities	Maintenance of areas. Untidiness of urban spaces is referred as physical incivilities, pointing to cues of social disorder.
3	Openness	Vistas.
4	Historical significance	Places having historical significance.
5	Order	Degree at which an area looks organized, visual order, meaning the area's order, cohesiveness and compatibility.

Table 14.0 *Positive Attributes for Visual Environment (Source: Nasar, 1998, p 62)*

Table 14.0 illustrated the positive attributes to environments and the existence of these attributes would render the visual environment pleasant. Various studies had demonstrated the validity of Nasar's claims. "Naturalness" had been studied to be a predominant feature in the environment during visually appraisal and it had always been distinguished from the built. (Kaplan & Kaplan, 1998; Nasar, 1998) Reviews had also demonstrated the consistencies at which natural had been preferred over the built environment, and regardless of the age of the respondents. Also, the reviews had proven that the increase of vegetation in the scene is highly correlated to an increase in the preference for it. This is highly related to Lynch's report of utilizing vegetation to heighten the imageability of the space, and studies on the features associated with buildings that would reinforce its image in the users had shown that vegetations contribute and enhance its impression on the people for navigation. (Nasar, 1998) Also, the restorative and connotative image that is closely related to nature is perhaps one of many factors that rendered "Naturalness" as being a positive attribute in the visual appraisal of environment. "Upkeep or civility" is one environmental attribute that possessed strong connotative meanings, which is evident in the studies done on the users judging their environment based on the appearance of environment and increase in visual clutter in form of overhead wires, billboards or poor maintenance of building façades result in low preference. Responses derived from such studies also relate these visual clutters to “old”, “dirty” and “drab” (Lynch 1960; Nasar, 1998). However, their removal would result in a higher preference for the same environment, implying that upkeep of visual order had not only served as an indicator to the connotative image of such spaces in the users’ mind, but also affecting their enjoyment of spaces. Presence of “Openness” is closely related to an increase in the preference, is perhaps attributed to the ability to seek for visual coherence, and for the ability to perceive one’s potential threats in the environment. Also, Kaplan had related open vistas to “mystery” offered in the scene, for one to acknowledge the depth in space and the ability to venture further. Studies by Lynch and Kaplan had also reflected that open vistas and panoramas is equated to enjoyment of space. (Kaplan & Kaplan, 1998; Kaplan 1983; Lynch, 1960) It is also pointed out in Nasar’s studies that the existence of deflected vistas after dark would give pedestrians psychological comfort. (Nasar, 1998) Historical significance of the building is highly associated with its potential as a landmark and hence complemented the building’s *imageability* in the overall surroundings. Lastly, “Order has also emerged as a prominent dimension of human response to the surroundings.” (Nasar, 1998, page 72) Order in the visual environment had implied image on the civility of the space, and increases the coherence of the units within the space, easing perception. Although order could aid in the ease of recognition of forms and reduce visual clutter, complete order would render the space boring and characterless. Hence for variety, complexity should be moderately present to prevent visual clutter, yet present for visual interest. Hence, the figure below reflects on the relationship of complexity in space with the correlated responses reflected in affective appraisal. It showed that the increase in complexity would reflect on low preference and stagnant interest from users’ responses.

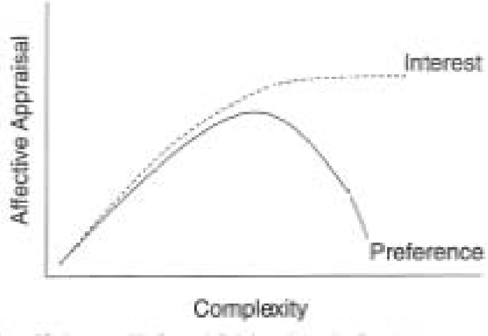

Figure 74.0 *Interest and preference in relation to increasing complexity (Source: Nasar, 1998)*

Guidelines for environment		
Exciting appearance	Relaxing appearance	High-status appearance
Built element to dominate	Natural element to dominate	Large open space
High complexity	High coherence	Well-kept and organized elements
Low coherence and compatibility, bright colours and high contrast between elements	Built elements, where they occur, to look 1. Fitting or compatible with one another and nature 2. Familiar and historical	Large, free standing Tudor and Colonial style buildings
High levels of movement and activity		Ornamentation

Table 15.0 *Design guidelines for 3 spatial typologies (Source: Nasar, 1998)*

Nasar derived the set of design guidelines for 3 different spatial requirements and had tested with the subjects, further proving the existence of the five environmental attributes he had pointed out earlier. These illustrated that although preference and aesthetic value of general public might differ due to different cognitive associations formed for individual forms. However, these general characteristics had repeatedly surfaced from interviews and various studies demonstrated that there are indeed design guidelines for different spaces to evoke the character it is required for functional purposes. These revealed the potential to expand the study of extracting environmental qualities into aid in formulation of design policies and spaces for clearer and more enjoyable spaces for the general public.

3.1.4 Light and its Effects on Spatial Perception

> "The resultant structures of the urban community were seen as being identifiable only when temporal aspects were considered coincidentally with the spatial aspects." (Parkes, 1980, p. 322)

Light, as the form giver, is exceptionally central to the basis at which lighting influences perception and appearance of the object visually. Urban lighting would shape the visible environment and create different images of the same city, rendering the visually monotonous concrete jungle to a kaleidoscopic array of colours at night. Initially, the concept of artificial lighting of spaces was to provide for sufficient Illuminance to suffice for the basic functionality of space (IESNA, 1975) and effects brought upon by these illumination techniques, were *perceived* and not proven. The effects of different lighting techniques and how these lamps interact with objects for the eventual appearance of spaces were not researched upon, until John Flynn's revolutionary works in the 1970s. He was keen to establish concrete findings on the appearance of lit indoor spaces and established a series of tests, using actual constructed spaces and achieving statistically justified results gathered from a number of respondents through questionnaires. (Murdoch, 2004; Flynn, 1998) His proposal was extremely revolutionary at that time, when artificial lighting was equated to the quantitative level of luminance or the measurable qualities. However, Flynn had proposed that lighting is not only constituted by these measurable qualities bit its potential effect on the intangible qualities that encompassed human perception, which he termed this potential quality of space as "spatial illumination". (Flynn, 1998) Since different lighting methods, namely direct or indirect lighting, could shape the spatial appearance, while the illumination level would limit one's visibility, the presence of these effect of lighting on spatial perception is highly anticipated. Hence, Flynn hypothesized that "lighting, in addition to providing task visibility, also influences motivation, orientation, mood, social interaction and well-being" (Murdoch, 2004). From his studies, he had noted several consistencies in the responses of the perceivers to the varied lit environments. In actual experiment site constructed, the environment is varied accordance to the Colour Temperature, the intensity of lighting and uniformity. (Flynn, 1998) Flynn proposed that lighting would have potential effects on the behaviour of users in space, which takes lighting to the level beyond the provision of appropriate lighting level, but the overall synchronization of the lit environment.

Also, Flynn proposed that lighting patterns would result in correlated responses, which would potentially "affect personal orientation and user understanding of the room and its artefacts" (Flynn, 1988, page 156). His studies concluded with high statistical correlations on the effects of lighting on the users' psychology comfort, derived through semantic differentiate scales and aesthetics appraisal. Flynn proposed that in the design of a quality lit environment, lighting would need to fulfil the following design criteria,

1. Create focal centers
2. Outline the space
3. Be un-cluttering
4. Create patterns of light and shade
5. Provide orientation
6. Present the space without distortion
7. Be stimulating without being overpowering
8. Be glare-free
9. Provide balanced luminance ratios.

In Flynn's studies, it is noted that he had integrated some of the design criteria for legible spaces, proposed by Lynch, Nasar and Kaplan, into his proposed lighting design criteria. For example the need of spaces to be legible and structuring spaces to allow for ease in orientation were similarly proposed by Nasar, Lynch, Kaplan and realized in form of concepts for illumination by Flynn. The creation of focal centre would allow distinguish of different zones and clarity of different areas, for formation of visual hierarchy. Also, minimization of visual clutter allowed visual order to be established and clarity in perception. These similarities justified that attributed that were defined as facilitating to human perception could be realized through artificial lighting, making spaces legible and enabling better orientation during the dark. This is most appropriately emphasized by Veitch, who clarified the intricate link between the disciplines of artificial lighting and human perception as, “intervening psychological processes believed to underlie the lighting-behaviour relationship: perceived control, attention, environmental appraisal and affect”. (Veitch, 2001, p125) Veitch, like the other researchers who followed up on Flynn’s research on effect of illuminated environment, hypothesized that there were effects on human perception, as a result from employment of various lighting design techniques. The parameters presented by Flynn were further supported by subsequent studies done on quality of illuminated space. Recent studies on effect of lighting to visual perception had demonstrated statistical correlations between light source types on visual comfort appraisal. (Laurentin, 2000) Mansfield had presented in his paper, where he had concluded that in the quantification of the acceptability of the appearance of the illuminated space, it would be possible to derive such description through the definition of the light pattern “using the average luminance and the luminance distribution standard deviation” within the horizontal 40° band (within the human’s normal field of vision). (Mansfield, 2000) To extend Flynn’s research findings, Loe tried to examine the “relationship between a subjective response to a lit environment, and its luminance distribution as a contribution to improving lighting design.” (Loe, 1994), through the construction of mock-up space which is to be illuminated in 18 varied manners and the analysis of these spaces were done through questionnaires and the results analyzed through factor analysis. He concluded that the tests he had done proved that it would be possible to measure human attitude to different illuminated spaces, yet there should be a more extensive method done in the quantification in appearance of illuminated spaces, instead of reliance on the existing codes of practices as they do not addressed to the human aspects in lighting and perception of illuminated spaces. His results indicated that the two factors that would contribute to good interior lighting, “visual lightness" and "visual interest" were essential in the composition of the illuminated space[3], but the exact ratio between interest and contrast would differ based on the context on which they were applied. Lighting needs to be a composition of light and shade put together in such a way that it complements architecture in a holist way, and in doing this, provides a lit environment that is both light and interesting." (Loe, 1994) The above only characterized few of many milestones that were obtained through research on appearance of lit indoor environment, which the author saw a potential and need in the extension of such studies for urban lighting, to derive a better urban environment that were orientated towards addressing the Human-Environment needs.

However, due to the "poor quality of existing research" (Veitch, 2001, p.126), opportunities should be given for future research to ponder upon this intricate link between human and his illuminated environment, for the creation of quality environment which would facilitate human presence. Regardless, the existing body of research on quality illuminated space, on human-environment relationship, had been restricted to studies for indoor lighting, but no studies were done for urban lighting. The study done by Li and his team had concluded that the current recommendations as reflected in the Codes by CIE did not appropriately address to the manner the buildings could be better lit, in accordance to their architectural significance and human subjective appraisal. (Li, 2006) This signalled that human perception is extremely important in urban lighting, yet neglected in the current design basis. Hence, these tests signalled the ability to emulate the earlier tests procedures done for interior lighting, for quantification of appearance of illuminated urban environment.

Footnote:

3. *The results derived by Loe was similar to another research on appearance of illuminated space, using different lighting techniques (indirect lighting, direct lighting and combination system) done by the author. The author had performed the test with aid from computational tools and modelling of the various required scenes using AutoDesk Lightscape 3.0, with radiosity options, and the survey of the various scenes was done on a sample group of approximately 40 students through display on slides. The results indicated that there were clear dislike of spaces with high or extremely low contrast and there were no direct correlation between bright space and visually aesthetic. This clarified the misconception that bright spaces were normally associated with preferred spaces or aesthetically pleasing spaces by designers on users. (Ong 2005)*

3.2 Effect and Importance of a *Well-structured* Visual Environment

> "Environmental evaluation, then, is more than a matter of overall affective response than of a detailed analysis of specific aspects, it is more than a matter of latent than of manifest function, and it is largely affected by images and ideals. It can, however, be clarified by identifying some of its constituent elements." (Rapoport, 1977, p. 60)

Human depended highly on sight, of the five senses in the perception of his environment. Yet studies indicated that with the complementing of other sensorial experiences, it would heighten one's spatial experience. (Rapoport, 1977) J.J Gibson proposed human perception is a process that involved the extraction of relevant information in the "stimulus array", rather than affected by personal mental evaluation of the space and cognitive processing. Hence, he named these visual cues that human extracted from his environment as "affordance", which implied that the amount of information present for individual objects is to amount is central to perception. Hence, the "additional information, such as textures, shadows, colour, convergence, symmetry and layout are all central to their effect on the appearance of the object to our eye. (Nasar, 1988) This theory solely address to the physical information that is present for all objects, whilst excluding the mental associations one would from these objects, as these information were often subjective and intangible. Gibson is revolutionary in his proposal of human perception as the by-product of his direct perception of the environment, which is exclusive of further mental processing. (Nasar, 1988) However, this theory assumed that perception is an active process between the environment and the perceiver, with the perceptions made in reference to human bodily position or functions in relation to his environment. This opposed to the traditional Gestalt theories[4], which emphasized on the importance of the stimulus organization and relationship between the perceiver and his objects. Although there were debates on Gibson's exclusion of cognition in perception, it is undeniable that cognition and evaluation, as pointed out by Rapoport, would affect human judgement. (Rapoport, 1997) However, the extent of such impact of these named mental processes, as opposed to the direct process of perception would differ in their intensity across different individuals, and often dependent on the influences from other social, geographical backgrounds. In Lynch's research on the importance of physical cues on the urban environment, he had based his research primarily on the physical components of the urban space, and justifying that the design form should be of priority in the structuring of the urban space, to complement the meaning of the spaces.[5] (Lynch, 1960) This implied that there remained measurable direct responses on perception, which is still untainted by evaluative responses, which are the main objective for research in the quantification of subjective responses to the aesthetics quality of spaces.

As mentioned previously, human perception involved the total system comprising of direct component of sensorial perception, with the processed component of the environment, through individual cognition and evaluation, with these three processes "mutually supporting" each other (Rapoport, 1977). Although perception might be a subjective process, various academic papers and studies indicated the existence of environmental design parameters to, which is correlated to spatial quality and would improve spatial experience. (Lynch, 1960; Nasar, 1998; Rapoport, 1977) The above review summarized that human had certain concepts towards definition of quality environment design and clear preferences were noted for most of

***Footnote**:*

4. *Gestalt theories stressed on the effect of the perceived forms on human perception psychology, and at few instances, the "perceptual mechanism is stronger than our conscious reasoning"(ERCO, p.33) A few basic laws of Gestalt involved the "interpretation of closed forms as a figure", "preference to perceive lines as steady continuous curves or straight lines, and to avoid bends and deviation", arrangement of objects into groups using the element of "symmetry" or" movement". (See ERCO, 1992 for more details)The understanding and application of Gestalt theories is extremely fundamental for lighting designers in the modelling of the appearance of the objects or space.*

5. *Lynch limited his research on the 5 main constituents to the structure of the urban form, to the physical elements, which he justified as "This analysis limits itself to the effects of physical, perceptible objects. There are other influences on imageability, such as the social meaning of an area, its function, its history, or even its name. These will be glossed over, since the objective here is to uncover the role of form itself. It is taken for granted that in actual design form should be used to reinforce meaning and not to negate it. " (Lynch, 1960, p.46)* the environmental attributes being rated. (See Lynch, 1960; Nasar 1998) In addition, these tests had proven that it is possible to perform well-structured surveys or questionnaires to derive measurements to defined environmental attributes that contribute to quality space. (Lynch, 1960; Rapoport, 1977; Nasar, 1998), indicating possibilities of measurement of proposed design basis to quality lighting masterplans, through validation from well-tailored questionnaires with appropriate sample size to the minimization of statistical errors.

Human have the innate need to orientate in the larger environment and easily extracting relevant information for survival (Kaplan, 1983; Kaplan, 1976; Kaplan, 1998).Since Urban Lighting Master planning is a process in visual design of one's environment, the composition of the illuminated nightscape should complement these needs. The above subchapters had reviewed and highlight several key points to the design of a legible environment, and psychological effect artificial lighting had on spaces. Hence, to increase the imageability of an environment, there must be visual clarity in structuring of the environment and the identification of its individual parts, to form a holist image. (Lynch, 1960) Beside the differentiation of the parts through contrast and prominence of physical forms, the continuity of the imageable environment must be made visible in both day and night. Researches by Lynch, Nasar and Rapoport had revealed that the quality of lighting on space would influence the eventual appearance of the space, while lighting patterns can be utilized as a form of spatial differentiation. This is most appropriately summarized by Lynch in the following statement, "the key line should have some singular quality which marks them off from the surrounding channels: a concentration of some special use or activity along their margins, a characteristic spatial quality, a special texture of floor or façade, a particular lighting pattern, a unique set of smells or sounds, a typical detail or mode of planting." (Lynch, 1960, p.96) These strategies that were proposed by Lynch, which characterized a certain area with its unique spatial qualities, rendered the distinctive quality of space tangible via evoking of the senses in its perception, while differentiating various parts of the urban environment. In these, Lynch had highlighted the potential of light in urban spaces in the formulation of spatial patterns.

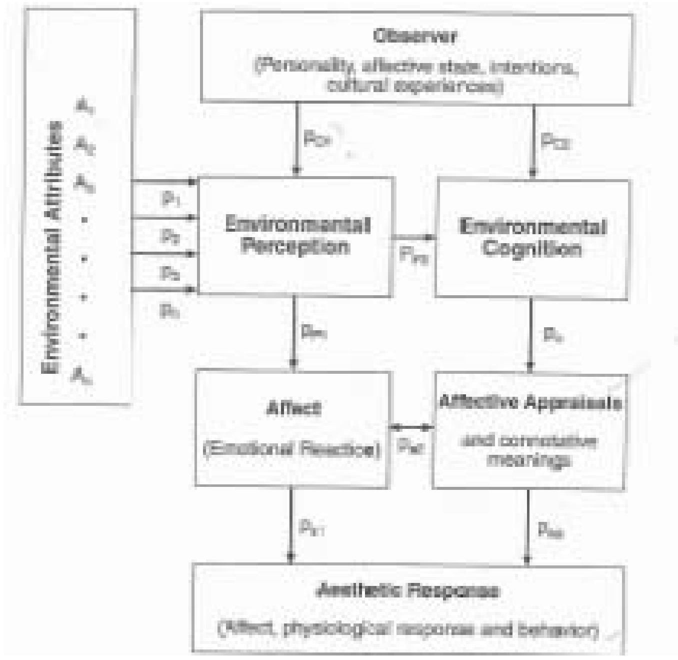

Illustration16.0 *A model of evaluative response to the environment (Source: Nasar, 1998)*

Kaplan and Nasar had researched and complemented the information that was pioneered by Lynch. Both proved and supported the claims of Lynch in the design of a legible city. Their studies had further demonstrated that the lack of a legible environment would result in negative psychological effects among the perceivers. (Nasar, 1988; Nasar, 1998; Kaplan, 1983; Kaplan, 1998) Kaplan had addressed to how human perception would be supported by the provisions of information that would support natural perceptions, like the ability to judge distance and directions for navigation and intrigue in visual space to encourage explorations. (Kaplan, 1983; Kaplan, 1988)On the other hand, Nasar theorized that perception is an evaluative process, when perception is coloured by meanings and personal experiences. Spaces with implied connotative meanings, like open spaces or ordered spaces, would relate to positive responses in the surveyed subjects, as they often relate to the high-class districts. (Nasar, 1998) Therefore, Nasar proposed that perception embodied the evaluation component, which would affect judgement. Although the theories differs from the manner at which perception interacts with cognition and environment, they all proved that perception can be affected by the design of the visual environment, and resultant discomfort when perception is not supported by the visual environment. (Nasar, 1998) This significant relationship between perception and visual design of environment is closely related to urban lighting masterplans, when the subject of perception and design of the visual environment is extremely relevant and pertinent. These design qualities pointed out the potential of integrating visual design basis in urban planning ideologies to the foundations that constitutes the urban lighting master plan.

John Flynn's pioneering studies in effects on lighting on spatial perception had demonstrated the potential impact of light on psychological comfort, explored through tests via varying lamp's Colour Temperature, lighting intensity and distributions. The potential effects highlighted by Flynn had been researched and proven by many others, who constructed real experimental spaces, and the patterns noted are distinctive and consistent. However, Flynn's tests are restricted to indoor lighting, where the actual experimental space is easier to control and there are lesser independent variables which might affect the results of the tests. These highlighted potential effects would be greater and extensive in urban lighting, where a greater variety of lamps and luminaries are used in comparison to indoor lighting. (See Appendix II) Therefore, this highlighted the fundamental question of what would be the basis to urban lighting and how lighting could address to the quality of lit environment. Many consistencies and parallels noted between the visual perception theories and urban lighting design fundamental concepts provided the impetus to study whether these principles to design of a legible city would form the basis to design basis of a legible nightscape.

> "Meier has observed that Singapore is becoming an intensive 24-hour city, with expansion into time well advanced. It is perhaps the best model for distributing activities round the clock, and it will become even more efficient when it is able to make full use of world market situations transmitted to it through communications satellites." (Parkes, 1980, p. 327)

Due to no studies in the design basis that constitute the quality lit environment, the establishment of these preliminary design basis would aid in the understanding of how different lighting strategies would have varied effects on the perceivers. Also, amidst the advanced technology and the ability of luminaries to fulfil different lighting design concepts, lighting designers would need to understand urban lighting design from what would be the basis to design to provide for a more legible nightscape, while minimizing visual chaos, a lit environment that would be more coherent to human perception. Lynch had addressed to the importance of the consistency in the maintenance of the image of the city through different time of the day and importance in using lighting as a form of spatial differentiation strategy. (Lynch, 1960) Although studies on perception of city had been extensively researched upon, few had addressed to the change of visual perception and how one perceived his surroundings at night. A city's rhythm is not constrained within the day but night is proven to alter the behaviour perspective of human. (Parkes, 1980) Majority of the studies on environmental perception had not demonstrated clarity in the differences between perception at varied times of the day, or "time has tended to be absent as an integral factor in the study of the structuring of urban images." (Parkes, 1980, p. 323) In the series of studies which relates changes in visual perception of same spaces to different times of the day, results had showed significance deviation of the responses of the same spaces in the day from at night. It is extremely evident in the responses derived from a study on 120 test subjects in evaluation of urban spaces in Newcastle, Australia. The study indicated that same spaces that were rated as safe or familiar in daytime, would be rated as unsafe or "feel strange to be in" at night. (Parkes, 1980) This might be attributed to the cognitive meanings of these same places at different times of the day, the lack of sufficient luminance level for the subjects to feel psychologically safe or individual meanings of time etc. However, these studies had successfully demonstrated that perception of urban spaces varied with time; hence, the visual perception of city spaces at night should be treated with more sensitivity to the correlated effects on human psychological or visual comfort. The basis of how visual basis to quality lit urban environment is further justified by the psychological effects artificial lighting had on perception.

> "Indeed, a distinctive and legible environment not only offers security but also heightens the potential depth and intensity of human experience. Although life is far from impossible in the visual chaos of the modern city, the same daily actions could take on a new meaning if carried out in a more vivid setting." (Lynch, 1960, p. 5)

An imageable city is not only clear in its structure, enabling ease in navigation and identification of its separate components; it enriches the various different districts with their individual character. Such contrast and rendering of unique meanings to different components of the urban entity, not only allow locals to characterize their personal meaning of the space to the physical components, but give rhythm to movement in space. The helpless feeling of being lost would be prevented in a legible city, where the structuring of the urban environment is further supported by its planning and visual cues. Also, the clear the urban structure, the easier people would be at ease, hence "a good environmental image gives it possessor an important sense of emotional security. He can establish a harmonious relationship between himself and the outside world." (Lynch, 1960, p. 4). This would ease in the formulation of mental maps, where certain urban elements were extracted and imprinted in individual's mapping of the urban space, with individuals residing in city with clearer urban structure, having more comprehensive mental maps. Rapoport illustrated this through the analysis in Holland (Rapoport, 1977), where the "mental maps seem easiest to form where the street pattern is regular with a single dominant path and where there are characteristic nodes and unique landmarks. Where overall structure and patterns were difficult to grasp and unclear, isolated landmarks, single buildings and individual paths became more important as did visual details." (Rapoport, 1977, p.115)This demonstrate the human need to establish certain significant referencing points in orientation which are often distinctive and contrasted with the background, so as to know his locality within the larger environment. Through the involvement of other senses, together with sight, would increase the memorable aspects of immersed space whilst intensifying spatial experience, as compared to the singular use of visual appraisal of one's environment. (Lynch, 1960; Rapoport, 1977; Lozano, 1988) The resultant experience is more informative, yet demand more attention in terms of the surge in amount of information the environment conveyed to the perceiver. Therefore, it is necessary to identify the primary sense of sight, and allowing other senses to complement it, to prevent over-whelming the senses within the time-frame of perception.

Despite all needs to relate one's presence in space through the involvement of all senses in perception, care must be taken against over-stimulation of the senses, that beyond a certain threshold, which might differ across individuals, the experience derived from his environment would gradually deteriorate. (Nasar, 1998) Although human perception might be subjective, it was commonly recognized that one could not over stimulate the senses in perception nor the absence of a varied environment be preferred. Lozano had elaborated on the subject of visual variety and visual interest, of which he observed that the existence of these two named character of urban space would increase human preference for the space, and these design characteristics were present in urban design since the period of medieval towns. However the concepts of visual design did not materialize till Lynch's revolutionary works. (Lozano, 1988) He noted that the integration of these design characteristics should be noted with sensitivity, as "monotony, then, can be considered as a sensorial deprivation, since human senses tend to reject such visual conditions." (Lozano, 1988, p.403); "If confusion is defined as the quality of environments that lack orientation, it can be said that confused environments lead to undifferentiation." (Lozano, 1988, p. 404) Thus, as illustrated by Lozano through the above statement, a urban environment that support human perception would certainly mark the synthesis of both visual variety and ability to support human orientation.

As evident from the analysis of the current practice and the reviews of literature on environmental perception, there is a strong linkage between these two disciplines that is still ignored. Lighting researches on quality of lit environment and appearance of lit spaces, in relation to human perception and visual design parameters to urban environment, had always pointed out how each discipline could complement the other, yet no researches had proposed the linkage between the two. (Veitch, 2001; Lynch 1960, et al.)The design of the Urban Lighting Master plan should extend beyond the application of the quantifiable; instead, it should be an exercise of visual design, where the relationships of various lit elements, the composition of the nightscape, should be of priority too. Therefore, this neglect of Human-Environment relation inspired the establishment of a new set of visual planning basis for urban lighting master plan, in design of a more coherent illuminated environment, while providing new basis for design. From the analysis of the needs and parameters to visual design of the urban environment, the author would extract the essential design basis which could be realized through the implementation of appropriate lighting design techniques. These would then formulate a new set of design basis for future urban lighting master planning and enabling better understanding of how human would navigate through the complexities in his urban environment. The subsequent chapter would elaborate on the extraction of these design bases, and the formulation of the final concluded set of parameters which would constituent the proposed design basis.

4.0 New Proposed Planning Basis

4.1 Human-Environment Interaction: Lighting to Structure the *Imageable* City

> "The shaping or-reshaping should be guided by what might be called a "visual plan" for the city or metropolitan region: a set of recommendations and controls which would be concerned with visual form on the urban scale." (Lynch, 1960, p.116)

As pointed out from the earlier subchapters that there were many factors that could contribute to a more wholesome visual environment which would much facilitates the extraction of relevant visual information. As opposed to the current practice which focused on the achievement of measurable quantity designated for each element, the proposed design basis served to answer to various considerations in the formulation of the urban lighting master plan. The proposed design basis should be a combination of the proposed basis with application of the lighting level as recommended to fulfil the usability of the space.

Firstly, the illuminated nightscape should be considered as a whole, the composition and interrelationship between each element, as contrary to what was highlighted in the Codes of Practices, as identified parts of the environment. Lynch mentioned about the imageability of the urban environment was derived as a result of the composition of various forms with hierarchy and clear structure to aid in the imageability of the space. (Lynch, 1960) Moreover, from the extractions of ideas presented by Kaplan and Nasar, it is clear that human perceive their environment as a general experience, and do not experience only in parts and the enhancement of the constituents of the urban forms would increase the preference of the environment. (Kaplan, 1998; Kaplan, 1983; Nasar, 1998; Nasar, 1988) Currently, although it is noted that the lighting masterplans focused on the highlighting of landmarks, but they are restricted to the physical or historical landmarks and circulations were stratified in accordance to the applications of the varied Colour Temperature for identifications. Although the master planning strategically identified the varied lit elements and opportunities for applications, the underlying concepts that governed these concepts were mainly subjective and pivoted about the Lighting Designer's personal preferences. This thesis would offer another perspective into the formulation and application of design basis for urban lighting master planning, focusing on the human perceptual needs and the better synchrony of the illuminated elements, whilst proposing a hierarchy for illumination based on the environmental perception theories. Lynch had identified lighting as a prominent tool in the distinguishing of areas from another, whilst creating patterns which would ease movement in space. (Lynch, 1960) Therefore, these new proposed basis would be formulated after analysis of the design basis and key design points proposed in Lynch and other visual design elements identified by Nasar and Kaplan, and realized these through application of lighting design. Therefore, these proposed basis would not be mere theoretical but they could be realized with sensible lighting applications. Therefore, the definition of the 5 elements and key design strategies to quality environment that was mentioned by Lynch (See Table 10.0) should be examined and of relevance to the formulation of the lighting master plan.

Secondly, the overall composition of the illuminated space should retain the daytime character of the environment even at night, or even to complement the existing daytime urban elements and select the elements to highlight to promote ease in navigation of the space. Therefore, careful analysis of the daytime character of the urban spaces should be done, not only physically, but also through interviews with locals to identify the key points for illumination. "Forms should be manipulated so that there us a strand of continuity between the multiple images of a big city: day and night, winter and summer, near and far, static and moving, attentive and absent-minded. Major landmarks, regions, nodes or paths should be recognizable under diverse conditions and yet in a concrete rather than an abstract way." (Lynch, 1960, p. 109) Lynch pointed out the need to maintain the visual distinctiveness of the key elements, during daytime or when dark falls. Hence, urban lighting master plan should recognize this important maintaining of continuity of the city image and identify these.

Thirdly, visual variety and visual interest are instrumental in the design of a quality urban environment, however their application should be executed with care to maintain coherence with site context, taking care not to overly stimulate or deprived one's sensory perception, as pointed out by Kaplan and Lozano. (Kaplan, 1983; Lozano, 1988) Therefore, this need to include items of interest and contrast for variation of spatial experience should be considered in the formulation of lighting masterplans. Thus, creating spatial rhythm through varying lighting intensity would create variety in the visual environment, promoting interest in the space. (Kaplan, 1983) Also, the much enjoyed complexity could be achieved by the variation of lighting strategy in the environment, and the introduction of coloured lighting or automated lighting scene changing fixture and lighting control, which would be analyzed in detail in the later chapter.

Fourthly, from the reviews of the various literatures, on elements that were highly preferred by human in the visual environment, the ability to recognize the "naturalness" of the place is one important aspect in perception. (Rapoport, 1977; Nasar, 1998; Kaplan, 1983; Kaplan, 1998) Therefore, lighting masterplans should emphasize in highlighting the original nature of the vegetation, whilst retaining the texture and characteristics of the plants being highlighted. Therefore, the lighting of the vegetation should not be restricted, as of current practice, to certain designated lighting level for basic functionality, but advance towards the visual construction of the greenery to retain the daytime character even at night.

Lastly, Gibson highlighted that human perception is dependent on the information provided by the environment, which can be derived from the textures of objects, details in the environment etc. The greater the presence of these visual "information", the better would be the ability to extract the information of which objects were being perceived or the spaces one is located at the point of time in perception. Therefore, lighting master plan must also consider the ability of human to extract information through the illumination of the relevant façade and revealing of the architectural details and the illumination of urban elements, to allow recognition of these elements after dark. The perception of details and texture would allow better structuring of the perceived object and to allow the individual in the obtaining of more information from the object. Therefore, lighting should not concentrate on the even illumination of the object but highlight any unique details or texture to enable ease in perception and recognition of the object to its daytime appearance. Furthermore, future research could consider if the increase in amount of illumination of details, in comparison to illumination of the building's geometrical form, would result in a more preferred lit environment.

The above illustrated the links between the visual design parameters to design of a legible city form and the translation of these concepts into urban lighting master planning design basis. These would definitely require understanding of the existing urban structure, together with analysis of the local requirements and understanding of general public's attitude to the urban spaces. This would then clarify the relationships between the illuminated and thereby, visual hierarchy of the composed lit environment would enhance the clarity of the existing urban structure. Therefore, this new proposed urban lighting master plan design basis would renew the current practice of urban lighting master plan design, providing another outlook into this subject, which was formerly centred on the application of the quantifiable and latest luminarie technology. Lynch's statement had encapsulated the quintessence objective that underlying this quest for new design basis of urban lighting master planning, as "the conception of the city as a total visible form." (Lynch, 1960, p.116)

From the studies on theories proposed by academics on environmental perception and the practice standards and design basis, this subchapter shall reunion these named disciplines and draft a new set of proposed design basis for the drafting of future lighting masterplans. However, it must be noted that these proposal basis should serve as the initiating basis to this novel research subject and not as the definitive list of all visual basis that should address to all the human-lit urban environment concerns. Furthermore, future research into this subject should be supported and the extension of research into this list of basis should be analyzed into how these could be translated into future research opportunities and objectives. These concerns would be addressed at the end of this chapter.

4.2 Designing Lit Urban Spaces for Human: Proposed Design Basis

The following list of design basis proposed would unite the theories proposed in visual design towards an *Imageable* environment and how lighting could achieve these proposed strategies. These proposed design bases should complement the existing Codes of Practices which were used in the determination of appropriate lighting level to achieve the functionality of the space. However, it must be noted that there were no existing researches on the quality of appearance of lit urban environment and the human-lit environment relationship is still ambiguous and highly speculated. Therefore, this paper would initiate the study in this area, via the proposal of these set of design basis which would perhaps aid the design of future lighting master plan, through addressing to the design using another approach by adopting similar strategy as visual design of the urban environment. Also, the set of drafted parameters would caution against some of the current practice of over-zealous application of colour changing lighting systems or use of lamps of low Colour Renderings. These would result in a visual environment that would not be constructive for human perception, and perhaps even neglecting some of the fundamental human perceptual needs. This list was derived after the understanding and analysis of the human perceptual needs, after the review of the literature on the environmental perception and visual design theories. They comprised of the following,

1. Clarity in Urban Structure
2. Highlighting Textures and Details
3. Naturalness" and Variety
4. Coloured Lighting
5. Differentiation between Elements
6. Historic Significance
7. Visual Hierarchy
8. Perceivable Background and Foreground
9. Psychological Comfort
10. Context and Culture

Lighting had the potential in "pattern-making" in the urban environment and distinguishing between the various elements in the urban environment. (Lynch, 1960) Each of the factors was extracted from the studies and was also ranked as parameters in urban design that were preferred by human. (See Rapoport, 1977, Table 8.0) It must be noted that each of the noted parameters are not singular in their implied meaning but could be expanded to accommodate different strategy which brought abut its realization. Although this list is not an exhaustive one, detailing all the necessary design basis that would contribute to a highly legible visual nightscape, it provide a starting point into the analysis of human perception and urban lighting, whilst addressing potential future research topics.

4.2.1 Clarity in Urban Structure

Lynch had established that clarity in the urban structure is extremely important in perception and the enhancement of the differences between different urban elements within the larger environment. "Identification with place is also related to uses, perceptual differences, affect, social identity and status." (Rapoport 1977, page 114) The ability to recognize the various elements which constitute the urban environment is related to the ability to form image of the environment, while promoting the ease in navigation. Researches after Lynch had followed up on his theories on the 5 urban elements which were to be highlighted and concluded that the enhancement of these elements would allow the ease in formulation of the mental map. (Nasar, 1998) However, Lynch had pointed out that these 5 elements were not single-dimensional, and they might represent a range of meaning dependent on the local urban context. This implied that "landmark" should not be taken as physical landmarks, which extremely visible against other urban elements, but "landmark" might implied an object of historical or cultural significance, which might be familiar to the locals. Therefore, in the formulation of the masterplans, lighting designers had often restricted themselves to the highlighting of the physical landmarks, but more information should be obtained through interviews with the locals in the recognition of the cultural landmarks. This would minimize the distortion of the daytime versus the night time image of the urban environment and avoid the highlighting certain urban objects which were highly recognizable in the local context.

4.2.1.1 Landmarks

Landmarks do not implied to the physical landmark but cultural or historical, as well. Therefore the lighting master plan should highlight all these landmarks, and recognition of these could be verified through interview with the local or observation of the site context. Moreover, the lighting master plan should illuminate these landmarks in their "true form", to prevent the distortion of the daytime image in comparison to that at night. Good Colour Rendering fixtures should be utilized in the lighting of the landmarks, to preserve their actual appearance at night, with choice of appropriate lamp sources' Colour Temperature or illumination strategy.

4.2.1.2 Pathways

The distinction of pathway from the surroundings would facilitate movement and orientation. Previous lighting strategy had failed to recognize the importance of pathways in terms of relation to human-environment relationship. Previously, in practice, pathway lighting was originally denoted with a functional purpose, with the provision of sufficient lighting level for the ability to orientate, yet due to the low lighting level usually provided for pathway lighting, they would not be obvious to people in the navigation through the urban environment. Thus future lighting masterplanning should provide for an appropriate contrast between the pathways to the immediate surroundings to maintain visual distinction of these elements. However, different illumination techniques of pathways (direct, indirect or indication lighting), spurred by development of vast variety of luminaries and lamps, brought about the study of how these different illumination techniques might affect human perception.

4.2.1.3 Nodes

Nodes can be defined as the central points of activities and they should be highlighted for locals to recognize and utilize these public facilities even at night, particularly to support their usage even after dark. Lighting should recognize these important structures within the larger environment, as these do serve as points of orientation for the locals and a space for community to congregate.

4.2.1.4 Districts

Districts signalled a grouping of the similar elements together or the separation of a distinctive parcel from the adjacent area. This might be evident from the lighting strategy adopted by Lyon, where the whole city was separate into parts, in accordance to their historical significance. In the usage of illumination to separate areas, the perceivable difference between various urban zones becomes clearer. However, care must be taken not to exaggerate the differences between the zones, as they might provide too much visual variety, resulting in over-simulation of the senses in perception, leading to fatigue.

4.2.1.5 Edges

Since the definition of edge could be multi-dimensional, it might be defined as the boundary between different objects or the definition of the structure or outline of geometrical forms. (Lynch, 1960) In the illumination of the edges of forms, the object would be more apparent against the background. In addition, the highlighting of the edges would enable better perception of the geometrical form of the object, easing perception and gaining of immediate information of the object. Edges can also de defined as the boundary between 2 different objects, which should be distinctive, for clarity of forms and visual contrast. Illumination of these objects can highlight edges by clearly highlighting the object, while maintaining an appropriate level of contrast between the object and its background. In addition, illumination of the forms can also clearly distinct the edges of the geometrical forms through using continuous lighting fixtures, like LED strip. They could outline the forms and enhancing the silhouette.

4.2.2 Highlighting Textures and Details

Gibson highlighted that in perception, the ability to perceive the textures or details of the objects is extremely important. (Nasar, 1988) While all objects' textures and details would be evenly illuminated in daylight, the illumination of these forms reminded to be explored. Illumination should take into consideration, the unique details or textures of the objects and highlight these. This would maintain consistency with its daytime appearance. In the lighting of these objects with special details, care must be taken in the placement of the objects and the relationship of the light and the angle of illumination, to avoid the undesired shadows. Studies in perception of statues at night had concluded that if the lighting fixtures were placed at the bottom of the statue (which is a common illumination technique for statue illumination), it would result in unsavoury shadows which would cause the statues to appear "frightening" and "intimidating". (Mavhik, 2000)

4.2.3 Naturalness" and Variety

> "Studies show naturalness as a powerful predictor to preference. Moreover, they show that adding vegetation to scenes increase preferences and that people prefer natural scenes to scenes perceived as having human intervention." (Nasar, 1998, p.64)

Human had this natural preference for nature and vegetation. (Kaplan, 1983, Kaplan, 1998; Nasar 1998; Rapoport, 1977 et al). Studies had pointed out that there is a correlation between nature to preference of the space and Nasar, upon evaluation of other studies and his experiment, concluded that "cities can improve their evaluative image by adding natural elements (such as trees, water and mountain) and providing views to nature." (Nasar, 1998, p. 65) Although studies had yet to verified if artificial lighting for vegetation or its absence would directly influence the preference of the space, it could be concluded that lighting for vegetation is extremely important in the formulation of the lighting masterplan. Although the Codes of Practices had placed little emphasis on lighting of parks, besides providing for the appropriate lighting level for functionality of space, illumination of nature should highlight its texture and the form of the trees. Also, lamps of correct Colour Temperature and rendering should be used, to emphasize the greenness of the flora, instead of subduing it in the grayish hue of Low-Pressure Sodium Lamp Lighting. These Sodium Lamps were often used in public area lighting for their economical lamp life and higher lamp output. However, they would not produce satisfactory rendering of colours.

Figure 75.0 *Example of good tree lighting, Beppu Park (Source: Lighting Planners Associates inc.)*

Figure 76.0 *Example of bad lighting of trees, using Low-Pressure Sodium (usual for public park lighting at night)*

> "Through the evaluative maps seem to accent order, theory and research indicate that human also prefer visual arousal and complexity. We see some indirect references to this variable in the preferences for historical areas (that tend to have more detail) and in the visual richness of the most liked areas."
> (Nasar, 1998, p. 74)

Variety is preferred for human, due to the constant seek for sensory stimulation and studies had indicated that people would prefer variety, yet there must be an order to this variety, by clustering of similar elements or the subtle formation of visual groups, as too much variety might led to complexity, which beyond a certain threshold, is not preferred. (Kaplan, 1983) Therefore, it is evident that variety in urban lighting masterplan is important in maintaining users' interest and upkeep the enthusiasm for exploration (Kaplan, 1998) Variety can be achieved by,

1. Different lighting methods
2. Introduction of coloured lighting (the following shall discuss the implications of coloured lighting)
3. Separation of the entire illuminated area into zones, by their functionality or desired atmosphere. This would create a rhythm in the urban environment, which would extend the interest to explore further. However, care must be taken in the treatment of the "edges" between these zones (See previous section on "edges".)

4.2.3.1 Coloured Lighting

Colours are integral in our environment and its potential effects in perception is widely acknowledged in many literature and researches. (Mahnke, 1987) Since colours would be rendered in materials or in form of coloured illumination, therefore, lighting could potentially alter the appearance of the objects. (See Appendix II) Studies had demonstrated that colours in both illumination or rendered onto surfaces of materials could affect one's preference for the object, as colours would evoke mental images, as studies had shown that certain colours had strong cognition meaning, dependent on cultural influences. (Mahnke, 1996) Therefore in the application of coloured lighting, care must be taken in the choice of colours in relation to the illuminated object and the context. Due to the rapid development of LED illumination technology, a wide range of automated colour changing LED lighting systems were available for exterior lighting. This increasing popularity of coloured lighting for exterior façade lighting is also attributed to the wide-spread integration of LED lighting systems into façade structures. This is notable from many of the exterior lighting projects and integration of these coloured lighting systems into urban lighting masterplans. Exterior coloured lighting had been mainly attributed from the use of either light filtered through coloured filters, or the use of coloured lamps, like Neon or Cold Cathode Lamp sources. Although coloured lighting might inject vibrancy and dynamicism into spaces, careful planning would be required to determine the extent at which coloured lighting is utilized. Research had proven that light and colour have potential impact on human, either "visual and non-visual basis" (Mahnke, 1987). Studies on colours had concluded that colours had significant psychological impact on the human within the space, as the cognitive meanings of colours would the users to initiate meaning of the space, so colours can effectively render space and potentially complement the spatial intentions. (Thompson, 1994) For example, vibrant colours had positive effects on the recovery of patients, while care had to be exercised in the combination of colours to minimize chaos and over-stimulation of senses, which would lead to sensory fatigue. However, our environmental should not be deprived of colours, as monotony in environment would decrease the motivation to explore our environment. Visual quality is of utmost importance in the appreciation of our environment. Therefore care should be undertaken to seek the balance in which colours should be introduced into the visual environment.

Figure 77.0 *Example of using lamps of different Colour Temperature in proximity (Source: author's own, of Shanghai)*

Figure 78.0 *Example of using lamps of colour lighting in proximity (Source: author's own, of Shanghai)*

Although academic researches on coloured lighting and its potential effect on spatial perception are limited, patterns could be noted on the general impact of colours on perception. Investigations on Colour Temperature from lamp sources and its correlated effects on perception had demonstrated that patterns could be noted from the preference of spaces rendered in different Colour Temperature spaces; also different Colour Temperature lamps are usually associated with different intended atmosphere.(Laurentin, 2000; McCloughan, 1999) Since all these studies had pointed out that coloured lighting should not be applied at a wide scale, and it should relate to the context of the illuminated object, to minimize visual distortion, with relation to its daytime image. Distinct differences of the daytime image in comparison to that at night would result in negative feeling and sense of disorientation. (Lynch, 1960)

4.2.3.2 Differentiation between Elements

Lynch had stated lighting should take into context the visual effect of each object in the urban environment (Lynch, 1960), so it is clear that with the wide variety of objects in the environment, care should be taken on how these individual objects should be illuminated to preserve their appearance and not to allow visual distortion. Furthermore, the appropriate choice of lighting technique and lamps should complement the context of the object and relate it to its surrounding. Although differentiate should be sought, too much contrast would also render the object separately from its setting. This would disrupt the continuity in experience through the urban spaces, so care must also be taken to visually integrate, yet characterize the uniqueness of individual elements.

4.2.4 Historic Significance

Nasar suggested that the prominence of Historical Significance as a feature for the construction of a likeable city, were attributed to that “historical content enhances building imageability”, “meaning” and “historical significance may also evoke favourable responses through favourable associations”. (Nasar, 1998, p. 72) Rapoport had also concluded that with his studies on the various literature that analyze on design features to urban planning, identification of historical landmarks is often preferred by users and therefore, suggesting that this identification of the historical landmarks would not only improve on the imageability of the environment, but might be correlated to preference. (Nasar, 1998, p. 72; Rapoport, 1977) Most of the lighting masterplans would recognize the historical forms as landmarks, yet many did not highlight them using appropriate lighting strategy. Most of the historical landmarks were illuminated using Low-pressure Sodium lamps, due to their orangey lighting output, they seemed to render these historically important building with an old world charm. However, these Low-Pressure Sodium Lamps had low Colour Rendering, which would subdue the original colour of the architecture. Also, the luminaries which housed these Low-Pressure Sodium lamps are usually bulky and would be visually obstructive in relation to these historical facades. The following are 3 items to note in lighting for historical landmarks.

1. Choice of lamp source
2. Angle of illumination
3. Creating focal points within façade (for highlighting entry and important details)
4. Securing of luminaries on façade
5. Non-obtrusive mounting on façade

As highlighted earlier, various lamp sources had their unique technical properties which rendered the lamp suitable for designated purposes.(See Appendix II for list of Lamp sources) It is preferred to highlight the historical architecture in their true form and actual colours, using lamps of appropriate Colour Rendering properties. Lower Colour Temperature lamps were often preferred for illumination of historical buildings, to highlight the historical atmosphere desired. The relation of the chosen luminarie to the illuminated façade should be considered, if diffused lighting on the façade or accent lighting to highlight certain architectural features would be required. Also, these luminaries should not be visually prominent during the day and they must be incorporated well into the details of the façade, while minimizing the physical damage on the façade. Although there is a need for the position of the luminaries to be considered in terms of their resultant appearance, the angle of their illumination should be considered to light the building in the desired effect.

4.2.5 Visual Hierarchy

Researches in quality lighting of indoor environment had concluded that human responded to an illuminated environment of varied lighting level and contrast. (See Chapter 3.1.4)In the lighting master plan, a sense of rhythm should be maintained through the movement in the larger environment, as human would prefer variety and the senses are heightened from the presence of environmental stimulants. (Lynch, 1960) In the creation of different visual hierarchical structure for the whole master planning, it would lend clarity and highlights in the urban night time environment, and orientation would be easier, while visual landmarks identifiable. Hierarchy should be identified in the order of importance in relation to the daytime image of the city, and districts can be drafted to separate the spaces of different lighting intensity or brightness level, in relation to whether special lighting effect would be utilized. This would enable the analysis of the composition of the resultant illuminated space. Lighting should not only consider the illumination of the landmarks individually, but how each landmarks should relate to another landmarks, whether in close proximity or distant.

Also, the highlighted elements should not have high contrast to the neighbouring elements, to prevent glare.

4.2.6 Perceivable Foreground and Background

In all the lighting codes and practices, many masterplans had considered the illumination of building or districts individually, without consideration of the composition of the entire illuminated nightscape, in relation to how human perceive his environment. Since the urban composition is more complex, as compared to indoor lighting environment, together with the elements which existed in different geometrical shape and height, there would be visual "layering" of these elements. This is extremely evident when panoramic views across the whole skyline were possible, with example like the Victoria Harbour Lighting Master plan. In these instances, the composition of the foreground elements to the perceivable background would be important, and whether the contrast between the foreground and background would be appropriate to highlight either of the elements. In addition, in the physical landmarks, the top of these building should be sufficiently highlighted using quality illumination, to allow visual identification of these landmarks at any point within the city, which would ease orientation.

4.2.7 Psychological Comfort

All Code of Practices proposed tables of allowable illumination for different areas in the lit environment. (See Chapter 2.3) However, these had fulfilled the functional requirement for lighting within each zones but neglected the human psychological needs. Nasar had highlighted in his case-study of the ratings derived of same spaces within the city during the day and night and concluded that the spaces which were favourably rated in the day, were rated neutral to unfavourable in the dark. (Nasar, 1998) Hence, this indicate that the lighting level is not just a quantitative requirement but is correlated to psychological comfort of the illuminated space, which is perhaps attributed to the foreboding sense of danger lurking in the corners in these areas. (Parkes and Thrift 1980; Hanyu, 1995)Studies had demonstrated that the level of brightness is not necessarily correlated to the psychological comfort it would render on the users. Another factor that should be considered is the environment which is of proximity to the illuminated space or the character of the illuminated environment. It is especially evident in areas where the crime rate is higher or if there were no clear visual access to any neighbouring inhabitants. Therefore, "guidelines sensitive to both conditions might call for a deflected vista during the daylight but the use of permeable vegetation and lighting to remove concealment after dark" (Nasar, 1998, p.124), were two design strategy to increase the psychological comfort of users in the dark.

4.2.8 Context and Culture

Nasar had elaborated on the importance of context in relation to urban design. (Nasar, 1998) In perception, there exist 3 components, namely, direct perception, evaluation and cognition. (Rapoport, 1977) From the name, we would derive that direct perception is the direct reaction to the viewed objects, while evaluation and cognition relied on the mental processing on the significance of the processed object. (Rapoport, 1977) Although cognition is often volatile and affected through a variety of personal factors, it is still clear that site context and cognition still play a role in the resultant visual imagery formed. (See Chapter 3.0 for details on perception) Lighting could consider the culture through the choice of appropriate coloured lighting, as colours would have psychological effects on human perception. For example, red might be related to good fortune for the Chinese, yet might relate to the opposing meaning in another culture. In addition, the lighting designers should have a thorough understanding of the site context before the proposal of any drastic lighting design for the area, for example, some might feel that the modern LED lighting or perhaps the concepts of illuminated flooring should not be seen together with old historical elements. Although these installations would not pose to be of any visual highlight in the day, they might appear to be jarring or disturbing at night, which demonstrate a strong contrast to the daytime image of the city.

5.0 Validation of Proposed Planning Basis

> "Although the methodology to introduce visual inputs in the design process is poor and inadequate, the visual qualities of the built environment are extremely important." (Lozano, 1988, p. 395)

The main research hypothesis of this thesis highlighted that the neglected component of human orientated design basis should be considered and is important in the future formulation of urban lighting master plan. The integration of these fundamental human visual requirements would aid in better structuring and legibility of the illuminated nightscape. Therefore, tests should be done to validate the proposed basis, as well as to establish preliminary understanding on how human perceived his night-time urban environment. Due to the novelty of this research subject, the proposed tests should also highlight if there would be potential for future tests, while ascertain new subjects for further testing. From the review of all literature on human perception of environment, or impact of lighting on appearance of indoor environment, it is noted that although preference is highly subjective, criteria that contribute to quality perceived environment could be derived through questionnaires, conducted with relevant test environment and appropriately identified test variables. (See Chapter 3.0 for studies) In order to verify the potential effect of lighting on human perception, two different experiments were carried out. These tests would aid in the verification of the possibilities of lighting affecting perception and investigate into how human perceived his night-time environment.

The first survey demonstrated if there were any correlations between the brightness of the room surfaces, with the type of lighting strategy adopted in illumination, and if the variation of either factor would result in different appearance of the space. The second survey aimed to establish understanding of current public awareness of the illuminated environment and features of the environment which would be important for human at night. Thereafter, the derived results would be compared against the proposed basis to establish their validity. In both experiments, computational stimulations were used to generate the relevant test environments to enable total control in the test variables. Tests on artificial lighting design which utilized computationally modelled spaces, indicated that computationally generated test environment or photographs could suffice as surrogates for the actual experience spaces, as human could relied on associative mental images to establish how the shown pictures could be translated into realized examples.(Nasar, 1998; Rohrmann, 2002; Newsham, 2005) However, it must be noted that the replicated test environment should be as close to the actual environment as possible, as the greater the accuracy, the more precise would be the derived responses as a mapping of the actual experiment conducted.(Eissa, 2001; Mahdavi, 2002; Wittkopf, 2000) Although human perception is a totality of personal preferences and cultural influences, together with social background of individuals (Nasar, 1998), studies had indicated that it were possible to quantify preference from the selection of statistically valid sample group, whilst taking into consideration, age, gender, social background and race of the respondents. (Nasar, 1998; Tiller, 1992) Studies on perception of lit environment further indicated through the consistency of the responses obtained, there were notable responses towards certain lighting patterns within a demarcated space. (Tural, 2005; Veitch, 2001; Shepherd, 1992, Fotiossa, 2005 et al.) However, it must be noted that the studies undertaken for this thesis were novel, and a forth runner in this subject for quantitative research. So, further investigations should be taken to establish a more concretized understanding of human perception of his exterior environment, through the design basis concluded.

In all, this chapter should detail potential experiment for the validation of this proposed design basis to lighting master plan or whether it would prove to be more efficient as compared to the current practices. Furthermore, this chapter would establish further knowledge into how lighting would affect spatial appearance, public perception of their illuminated environment and the potential of the proposed basis to be integrated into existing lighting master planning practices. Since no studies had yet to address to the structuring of the lit environment in accordance to human perception needs, the results of both surveys should not be concluding but should serve as guidelines and subjects to address towards in future researches. It must be noted that for tests on design basis, for both illuminated environment or general design of the environment, should not be easily concluded through one preliminary test, but further tests should be done to exclude the potential statistical errors and to examine the factors exclusively. Hence, the second survey would serve as an introduction for both lighting professionals and layman to understand how the nightscape could be designed towards a better-constructed legible visual environment, even at night. Therefore, the analysis of the second survey should extend towards potential directions for future researches in the last chapter.

5.1 Survey 1: Utilization of Computational Simulation for Responses on Perception of Indoor Lighting Environment

> "Although such anecdotal statements exist in abundance and there is much data on the human –engineering aspects of light in architecture, there needs to be more research on the use of light to meet the symbolic needs of people." (Lang, 1988, p. 18)

Although lighting design had been highly "speculative", where the design intentions are a result of anticipated human response to the illuminated space, yet few researches served to concretize the anticipated effects and prove if lighting does result in certain human responses to the space. (Veitch, 2001) The gap between knowledge of luminarie technology and the perceived effects is widening with the introduction of greater variety of lamp sources and improvement in research in fixture technology. Researches on effect of artificial lighting on spatial perception had demonstrated that variation in lighting patterns would evoke certain psychological responses in the definition spatial atmosphere for certain design intentions.

(See Chapter 3.1.4) John Flynn had noted that there were patterns to lighting design of interior spaces that was related generalized human responses. His experiments, conducted in real constructed space, had derived findings that "peripheral lighting" and "non-uniform lighting" would give the impression of a "relaxed space". (Flynn, 1988) Hence, his experiments established the grounds for the existence of qualitative lighting design and that artificial lighting effects on spaces could be derived through detailed experiments. This indicated a change in directions towards lighting design, which was formerly the engineering of the illuminated environment and had neglected the component on human perception. Although no researches had been done on the evaluation of quality urban lighting, that is centred upon human visual needs of his environment, researches on quality of indoor spaces had indicated the impact of lighting on spatial appearances. (See Chapter 3.1.4) Through these researches, it was also noted that computational simulation would be a potential tool to establish the test environments. These tests had indicated that the simulated test environment would be easily manipulated. Furthermore, due to the nature of the generated images, they could be easily translated into different mediums for public evaluation, through slides or worldwide web. Also, the results derived through these tests were often statistically sound, so justifying the integration of these research tools for the future of exploring lighting design using computational aids. (Eissa, 2001; Franz, 2005; Wittkopf, 2000; Mahdavi, 2002 et al)

> "Responses to photography accurately reflect on-site experiences and responses to colour photos or slides more closely reflect on-site responses than responses to other stimulations such as drawings, models or black-white photos. " (Nasar, 1998, p. 147)

The validity of using photographic representative of test environment or computationally simulated images was verified by Nasar who stated that the responses derived from using photographs as a test medium had derived similar results with the on-site responses of the same photographed site. (Nasar, 1998.) He had also concluded that "airbrushing, photomontages, photos of models or computer imaging also allow for simulation of different conditions" (Nasar, 1998, p.147) Since mental evaluation formed part of the environmental perception experience, subjects would imagine themselves "actually" experiencing what they had perceived in the photographs. (Nasar, 1998) Therefore, this verified the use of computational modelling as the test medium, as "Computer imaging allows researcher to sample a diversity of real scenes, digitize them and alter them to control extraneous variables." (Nasar, 1998, p. 147) Earlier, it was pointed out that one major factor of which hindered the research on quality of urban lighting was the inability to control the intangible or unpredictable variables that might be present during the setting of real urban lighting experiment. However, the raising popularity of using computational simulation in the test for users' responses had provided a reliable solution to simulation of the urban lighting environment for tests on responses. Studies undertaken to justify the use of computational tools had justified that simulations could effectively act as the surrogate for real experiment sites, but the quality of the modelled space must be ensured, as its accuracy to the real environment would result in more reliable results. (Eissa, 2001; Mahdavi, 2002)

5.1.1 Test Methodology

For this survey, the main research objective was to initiate the potential of lighting to affect spatial perception and to establish patterns that would contribute to perception. Furthermore, this survey would help establish the use of computational simulation and test the stability of such tools for use in survey 2. The limitations and problems encountered in the course of experiment would be reviewed and minimized for conducting of the second experiment. Reviews on researches in appearance of interior lit environment revealed that there were several key factors that would affect the appearance of the lit interior space,

1. Lighting methodology: interaction between the emitted light and the surfaces.
2. Material type: Apparent brightness of surfaces is correlated to the surface

reflectivity. Furthermore, the surface brightness or the nature of the surface (polished) would affect the intensity of reflected light. Also, distinctive textures or details of the materials would enable better recognition, due to higher amount of potential visual information one might derive. (Kaplan, 1983)

3. Chromaticity: Colours have impact on perception and so the choice of the colours of surface is related to the resultant perception one would derive of the space. (Mahnke, 1996)
4. Visual Variety: Although variety and complexity would entice exploration, studies indicated that too much sensorial stimulation would result in discomfort and sensory fatigue. (Nasar, 1988; Kaplan, 1998)
5. Field of Vision: Studies indicated that human would be primarily affected by objects within the visual range of 40
6. Geometrical shape of room

Figure 79.0 *Tree diagram illustrating attributes affecting the perception of space (Source: Author's own)*

An enclosed test environment was generated in Autodesk CAD 2004, with a visual reference object situated in the centre of the room. Two different artificial lighting strategies were utilized to vary the interaction of light with different room surfaces, and the utilized fixtures were obtained from the lighting manufacturer's website (ERCO Lighting). Together with the use of Autodesk Lightscape 3.2, as the main tool for rendering of the generated spaces, it would maximize the accuracy of the rendered images to the actual test scenario. This was made possible through the radiosity option and lighting fixtures with IES files, which would generate images that would mimic the real scenario, together with correct mapping of surfaces and construction of shadows.

The surfaces of the simulated room were divided into 3 different planes, “wall”, “floor” and “ceiling. Thereafter, different permutations of images were generated, with variation in the colour of the surface material (categorized Bright, Medium and Dark). Furthermore, to introduce tests on perception of colours, coloured surfaces were introduced into the experiment. To maintain consistency of the perceivable lighting effect, the surface reflectivity was kept constant.

Lighting fixture used	Surface definition		
	Ceiling	Wall	Floor
Erco linear up-lighter (Erco 12410.000, 2x54W) - Greyscaled	Bright (B): H: 0 Medium (M): H: 0 Dark (D): H: 0	S: 0 S: 0 S: 0	V: 0.8 V: 0.5 V: 0.2
Erco linear down-light (Erco 12410.000, 2x54W) - Greyscaled	Bright (B): H: 0 Medium (M): H: 0 Dark (D): H: 0	S: 0 S: 0 S: 0	V: 0.8 V: 0.5 V: 0.2
Erco linear down-light (Erco 12410.000, 2x54W) - Coloured	Yellow (Y): H: 60 Green (G): H: 125 Blue (Bl): H: 240	S: 1 S: 1 S: 1	V: 0.8 V: 0.5 V: 0.2

Table 17.0 *Definition of attributes for computational space (Source: Author’s own)*

The above table illustrated the different fixtures that were utilized in the study. The lumen output for all three fixtures used was calculated and maintained at consistent level to maintain same lux level across all the generated lighting scenarios. The images that were rendered were generated from a normal human viewpoint of 1.6m, with focal length of 31.18mm, field of view 60°, and at a high resolution of 1024 by 768 pixels, so as to preserve the high quality of generated images which would be presented to the surveyed subjects. Microsoft Powerpoint XP was employed as the tool to present the sets of images, to allow flexibility in randomization of the sets for tests, while limiting the exposure time to 15 seconds per set. The short exposure time would allow the derivation of direct visual responses, minimizing impact from evaluative component in human perception. (Rapoport, 1977)

These simulated images were shown to the subjects in sets of 2, for comparison between the two images and clear preference can be mapped, to reduce complexity in derived results. The sets were shown to 34 test subjects (statistically sound sample group) who were undertaking Masters in Building Science and did not receive any professional training in lighting design. Their responses would be valuable to constitute the general public's perception of their lit interior spaces. Results from the survey would be analysed using statistical software, SPSS 12.0 (Statistical Package for the Social Science) where ranking and correlation between each sets and attributes were generated. (See Appendix II (a) for results derived through SPSS)

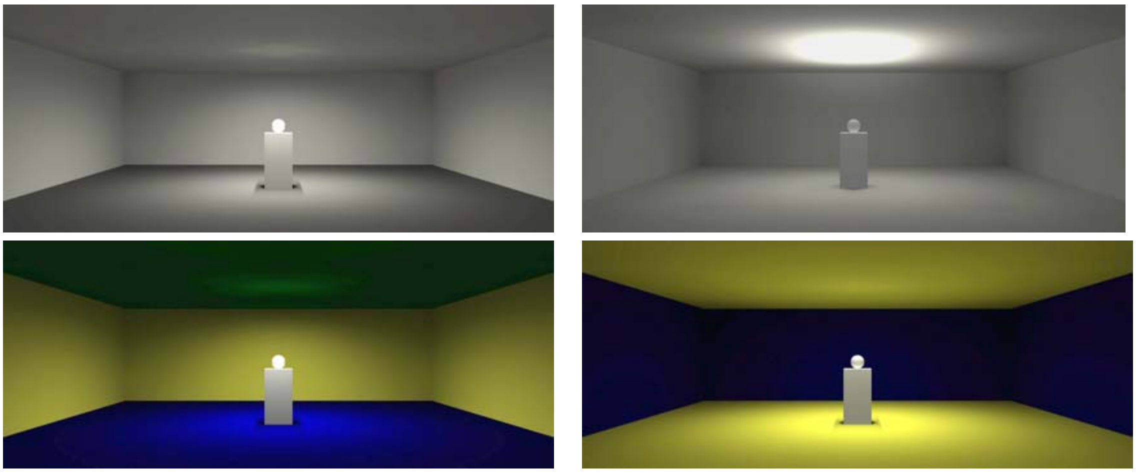

Figure 80.0 *Some images generated for the experiment – Down light, Up light and Colour Scenarios (Source: Author's own)*

The questionnaire posed to the surveyed subject consisted of 3 main sections, which addressed to the following research objectives for individual sections, as following,

1. Perceivable Brightness

The research objective for this set of images shown is to demonstrate the whether different lighting strategies adopted for interior would result in difference in perceived brightness. It is a common perception that direct lighting would appear to be comparatively brighter than indirect sources of same resultant luminance level. Also, misconceptions on luminance level is benchmarked on the surfaces of the illuminated rooms, as the rooms with brighter room surfaces would appear to be brighter than a room with darker surfaces, despite the same luminance level. Hence, for this test, a pair of images, both of grey-scaled room surfaces, with each image would be generated from different lighting types, direct and indirect sources. Of the 2 images shown, per set, subjects were asked to identify the image which illustrates the room that is comparatively brighter. Although these images were only differentiated through the lighting technique used (Direct or Indirect lighting), whilst maintaining consistency in the character and colour of the room surfaces.

2. Perception of Visual Comfort

This set of questions would target what defined visually comfortable rooms, whether the contrast of the surfaces would define the visual comfort level or which lighting technique is more preferred for visually comfortable spaces. The test procedure is the same as the earlier experiment, with a pair of images illustrating rooms with different lighting design used, while maintaining the same type of room surfaces for both images. The subjects were to identify which of the rooms they would feel most comfortable in, if they imagine themselves inside.

3. Perceived Visual Aesthetics

Researches had noted that aesthetics is not exactly a subjective quality that could not be defined as general parameters to aesthetically pleasing space could still be noted from bipolar semantic differential scales. (Kaplan, 1998; Nasar, 1988) Hence, for this set of research questions, the basic parameters to an aesthetically pleasing space is noted through mapping the responses of the users to spaces with coloured surfaces, in comparison to grey scaled surfaces. For the experiment, 2 different sets of images is shown to the subjects at each time, one illustrating the room with coloured surfaces and another for room of grey scaled surfaces. Both utilized the same lighting technique and similarities were in the same classification of the surface brightness of the coloured and the greyscale simulated rooms. Therefore, the results could demonstrate if colours were a factor in the determination of the room's aesthetics value, and whether the contrast value between the surfaces would be a factor in the appraisal of these spaces.

5.1.2 Test Results

The results had demonstrated that it was possible to derive patterns of the general aesthetics value that would be common for general public, as people would have preconceived benchmark on how certain spatial configuration would lead to the anticipated spatial atmosphere. Therefore the three main areas of investigation, namely Perceivable Brightness, Perception of Visual Comfort and Perceived Visual Aesthetics, had derived results that are somewhat consistent across the general surveyed subjects. This relatively low standard deviation achieved also suggested the reliability of the achieved results

Generally, the achieved results had pointed that Visual Comfort and Brightness is not directly correlated, which helped to clarify the misconception that equates the level of brightness within the space to comfort and aesthetics, as the results of rooms that were ranked amongst the most visually comfortable were not the visually brightest. This might be explained that most spaces that were perceived as bright were noted as glare sources, and too glaring for functionality. However, the fact that the level of brightness is psychologically comforting for users is a subject that would involve studies of greater depth and intensity to pursue the level or ratio of brightness a space would require for optimum functionality. Furthermore, the results derived for either the direct or indirect lighting scenarios present 2 different sets of ranking. This implied that the manner at which light interact with various room surfaces and the presentation of the resultant composition of the lit room, would result in different preference of the individual towards the same space.

Also, despite consistency in the same employment of lighting technique, different composition of the room, in the colour of different room surface would derive different preference rankings. The preliminary results implied that human preferred surfaces with low contrast level but appropriate enough to stimulate the senses sufficiently. This is further verified by Kaplan or Nasar's findings on the fact that human would require visual variety for sensory stimulation and to function appropriately in his environment. (Nasar, 1988; Kaplan 1983; Lozano, 1988) Lastly, the experiment focused on the difference between the responses for coloured spaces and those grey-scaled ones. The comparison between the grey-scaled spaces and the coloured ones, keeping the lighting technique consistent for each pair, had noted that there is no clear preference towards either coloured or grey-scaled ones. However, one interesting pattern was noted that the preference was for the grey-scaled spaces only when the contrast between the colours of the surfaces of the coloured spaces was too high. This usually occurred when the colours were too overpowering or when the hues that were at opposing ends on the Munsell colour wheel were used together in one enclosed area. This could perhaps be attributed to the fact that human had pre-conceived ideas on how colours would be combined and complemented in the space, or the cognitive images of colours to each individual would be too influential for its use in the space. Since the psychological impact and cognitive meanings of colours had been addressed in many studies and literature, it might be a possible reason for which coloured images were not consistently being preferred over the grey-scaled ones, even though human had clear preference for visually stimulating spaces. Hence, it might be attributed to this fact that the change of either one of the 3 values of Hue, Saturation and Value would result in greater psychological reaction from the surveyed subjects. To develop the ideas of how coloured spaces and lighting would result in certain psychological responses or patterns, more in-depth studies would be required to analyze this.

In conclusion, it is noted that spatial perception is a complex process which is a result of the total composition of the appearance of the environment. Preference of a space might be a result from different factors that constitute the overall spatial experience, and not only restricted to lighting. Hence, lighting designers should visualize their design as the resultant composition, whilst considering all factors that reside within the space, and not only on the interaction between light and the illuminated object.

5.1.3 Survey Limitations

Despite the common notion that preference is subjective and differed across individuals, various tests on human perception of his indoor lit environment had concluded that human had generalized responses towards his lit environment and these responses had remained consistent despite differences in lighting patterns. (Pellegrino, 1999; Shepherd, 1992; Loe, 2000 et al.) Through the execution of this survey, several problems in questionnaires were noted. These problems and limitations could aid in the formulation of future surveys and minimize any potential errors in subsequent studies. Moreover, the existence of these limitations did not discount the validity of the experiment, but its indication would serve to caution future similar experiments that were to be executed, whilst indicating some of the lessons which the author had noted, which should be taken into considerations during the conducting of future similar tests.

1. Distance between the question number and answer box is too wide, so subjects would have taken extra effort to ensuring that the responses were in the correct box.
2. Coloured answering boxes were rather hard to be filled in.
3. Spacing between questions is too narrow and makes the reading of the question very difficult. Thus to rectify, the questions could be grouped into two columns and allow for bigger spacing between each question.
4. Consistency in the arrangement of both the question number and the shown images

should be observed. The images were arranged in a vertical fashion, while the questions were ordered horizontally. Thus, the subjects would have to spend more time to orientate themselves to select correct box.

5. The questions should be grouped and sectioned to avoid "breaks" between answering each question.

Furthermore, this test integrated use of computer simulated spaces for tests on artificial lighting design. One main limitation of such tests would be the accuracy of the simulated to the actual test scenario. Therefore, care must be taken to ensure that the generated images would illustrate the achieved effect. In this case, with the radiosity mapping options of Autodesk Lightscape 3.2 and the utilization of the lighting fixtures with correct IES files downloaded from the manufacturer's website, the images simulated would be close to the actual.

5.2 Survey 2: Test on Appearance of Night-Time Urban Environment

> "Can we scientifically study something as apparently subjective or qualitative as community appearance, evaluation and meaning? Yes." (Nasar J.L, p. 22)

Result from survey one demonstrate that variation in illumination techniques or difference in the colours of room's surfaces, would result in different human responses within the same space. Also, these results had shown the potential of using colours to alter the visual "appearance" of the room, while different appearance would indirectly conjured certain human psychological responses. Hence, the results from this test verified Flynn's claims that "some psychological aspects of lighted space can be recognized and perhaps documented if we are prepared to discuss and study lighting design as an exercise in visual communication." (Flynn, 1988, p. 156) Therefore, the above test encouraged the development of the second survey, which would propose deeper understanding of the illuminated urban environment[6].

The second survey conducted would, therefore, answer the following research questions on current urban lighting master planning practices,

1. Gaining further insights on how general public understands the illuminated city (people without prior architectural lighting background)
2. Introduction of new Human-centred Design Basis for Urban Lighting Master planning
3. Importance of orientation in cities at night
4. Derivation of visual hierarchical definition of existing urban elements (Understanding which were the visual anchor points individuals depended upon in navigation through the city at night)
5. Testing of some popularly utilized urban lighting concepts and their effectiveness
6. Understanding public's receptiveness of new lighting technology (Coloured lighting and automated colour changing lighting)
7. Gaining further insight on whether urban lighting would complement psychological comfort of cities at night

The results from this survey would derive the factors that are important in the structuring of the lit environment and whether the proposed basis (See Chapter 4.0) was important in the design of the urban lighting master planning and the possibilities of them aiding in the design of a legible environment. Since the previous chapters had elaborated on the lack of development of Human-orientated design basis in Urban Lighting Masterplans, whilst highlighting the potential of research on these design basis through studies on environmental perception theories, this survey would allow better establishment on whether these basis

Footnote:

6. *See Chapter 5.0 for the Proposed Design Basis which would be used for development of the test variables of Survey 2.*

would be useful in designing for a more legible nightscape, as well as to provide for validity for future studies. Previously, the new proposed design basis was extracted as the primary constituents to quality visual environment and was characteristic of the visual cues from which human extracted from his environment. This survey would, therefore, allow us to establish the validity of these proposals. Questionnaire was utilized as the main tool of test, to understand of human preference, as this is commonly utilized as a means to evaluate human responses to the environment. (Nasar, 1998; Nasar 1988; Lynch; 1960; Rapoport, 1977; Kaplan, 1983; Kaplan, 1976; Kaplan, 1998) As observed from studies on design criteria to quality environment, interviews or questionnaires (where answers given were structured in form of semantic differential scales or ratings) were the adopted test mediums to obtain responses concerning subjective design qualities that were preferred by the public. (Nasar, 1998; Pellegrino, 1999) Furthermore, predecessor studies which utilized computer generated environment for tests in lighting had indicated the validity of using such tools in the obtaining of relevant survey responses, in the achievement of test objectives, and often such generated environments were more predictable, with greater abilities to manipulate the potential variables that might be existent in actual test environment. (Mahdavi, 2002; Eissa, 2001; Newsham, 2005) All studies indicated that these surveys, with well-structured answers would enable the mapping of qualities that would contribute to a well-designed environment.

5.2.1 Test Methodology

Since we would require the understanding of the basic perception needs of general public, the questionnaire would be conducted with a group consisting of 40 architectural postgraduates and undergraduates students, without any prior knowledge of lighting master planning. Therefore, their evaluation of the nightscape would be purely instinctive and not informed,

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Footnote:

7. *The validity of photographs or computationally generated images had been verified by many literatures on the subject of evaluation of quality in environment. (Nasar, 1998)* yet the number of participants in the sample group would be sufficient for a statistically sound conclusion.

Figure 81.0 *Question 16, Picture 1*
(Source: Author's own)

Figure 82.0 *Question 16, Picture 2*
(Source: Author's own)

Figure 83.0 *Question 17, Picture 1*
(Source: Author's own)

Figure 84.0 *Question 17, Picture 2*
(Source: Author's own)

The relevant pictures that would be used in this survey would be computationally rendered, using Adobe Photoshop 7.0, replicating high accuracy of the montage images to the actual photographs[7]. The questionnaire was divided into 3 sections, with Section A requiring the respondents to fill in the ranking of the stated elements, while Section B featured a series of questions where the subjects had to choose either a 'yes' or 'no' answer. For Section C, the subjects had to compare and choose the image which they prefer. The 20 questions short questionnaire was emailed to these respondents, to be replied within 4 days, without time restriction during their answering of the survey. Also, they could retain privacy, as no direct contact would be made, except via email. Therefore, this minimized any reservations in providing true answers, while the answers derived was not affected by any professional knowledge in urban lighting (none of the subjects received professional training in urban lighting). The pictures were digitally altered to achieve the desired effects of illumination of all building's façade, as evident from the picture on the right. The picture on the left showed the unaltered image of Singapore's skyline, where the forms of each building was not clear. In contrast to picture 2, where the image was digitally enhanced to 'illuminate' the form of all buildings that construct the skyline. The second set of image would suggest the use of coloured lighting in illumination, so the respondents were to determine if they would prefer the illumination of nightscape using non-coloured lighting or coloured lighting.

5.2.2 Survey Results

The distribution of the survey via emailing had provided the opportunity to randomize the sample group, while ensuring that the educational background of the subjects remained consistently similar. A total of 40 students, a mixture of different genders and either Architectural undergraduates or post-graduates, replied to the survey with their answers. Some, however, had indicated personal responses on their emailed questionnaire (which is possible if the respondents retained privacy), which are extremely valuable for future studies. The results had indicated several interesting points, which could be followed up in formulation of future research objectives and researched in detail. Also, the responses demonstrate potential of future research into,

1. Use of Coloured Lighting and the potential impact on human perception
2. Gender influenced aspects of lighting in urban environment
3. Illumination as a means to increase psychological comfort at night
4. Colour Temperature and their relation on façade illumination
5. Value of illuminated urban elements in relation to culture

The above potential directions for future research shall be elaborated in the later chapter, where further analysis would be given to approach these research subjects from different angles. Generally, the results had indicated that 100% of respondents feel that the current illumination of Singapore's cityscape could be improved upon. For the second section, all given responses to each survey question were clearly inclined towards a unanimous answer. Also, pattern can be noted for the ranking of the various illuminated elements which human would like to see in the dark, noted clear preference which would constitute to the visual hierarchy of these elements. However, some of the responses noted indicated difference between the perceived design direction of the lighting professionals and public's perception, which would be elaborated upon in the later part of this chapter. The following points summarize the results derive from the questionnaire,

1. General Preference of Well-structured Lit Environment

As evident from the responses derived from the questionnaire, 100% of the respondents believed that further improvements could be done for the existing Singapore nightscape, while 95% of the respondents indicated that they would prefer a city which is easy to orientate at night. To verify the need for an attractive skyline, 92.5% of those surveyed indicated the appeal of these beautifully lit skylines. Also, 83% of the respondents had indicated that it is important for them to know their orientation and recognize the key urban elements at night. Therefore, these indicated the need for the urban elements to retain the key appearance at night, and focal points would need to be drafted to highlight certain elements in comparison to the others, introducing visual hierarchy into urban lighting master planning. As evident from the table below, which is the ranking derived for each of the listed elements below. It is clear that the public transport station, parks and gardens were ranked at the last and second last places respectively, at 38% and 40% of the people voting for their places each. In comparison, the public would prefer to see prominent buildings, pathways and familiar buildings they recognize in the daytime, as they have an average of 23% to 25% of the respondents placing them in the first place. In addition, landmarks are important visual features, with about 28% of the people voting for them in the second place and 18% of the surveyed subjects voting them in the first place.

	1ST CHOICE	**% OF PEOPLE**	**2ND CHOICE**	**% OF PEOPLE**	**3RD CHOICE**	**% OF PEOPLE**	**4TH CHOICE**	**% OF PEOPLE**	**5th CHOICE**	**% OF PEOPLE**	**6th CHOICE**	**% OF PEOPLE**	**7th CHOICE**	**% OF PEOPLE**
Prominent Building	9	**23**	8	**20**	6	15	4	10	9	23	3	8	1	3
Pathway / walkways	10	**25**	5	**13**	8	20	6	15	6	15	4	10	1	3
Familiar Buildings	9	**23**	9	**23**	7	18	4	10	4	10	3	8	4	10
Landmarks	7	**18**	11	**28**	7	18	6	15	4	10	5	13	0	0
Public Transport Stn	0	0	3	8	3	8	10	25	6	15	2	**5**	16	**40**
Parks / Gardens	2	5	1	3	6	15	2	5	6	15	15	**38**	8	**20**
Bridges	3	8	3	8	3	8	10	25	5	13	6	**15**	10	**25**

Table18.0 *Answers Obtained for Section A, Question 1 (Source: Author's own)*

From the analysis of the visual preference of the surveyed subjects, it is evident that human would construct their personal mental map of the environment, where they are navigating, thus validating Lynch, Nasar and Kaplan's' theories (Lynch, 1960; Nasar, 1988; Nasar 1998, Kaplan, 1983). Human would establish their points of reference in the environment and these 'landmarks' could be personal and not necessary due to the physical distinctiveness of the structure. Instead, familiar buildings or prominent buildings (with elaborate or unique architectural details) were more visually prominent in comparison to landmarks. (Lynch, 1960) Therefore, landmarks were not clearly the first choice of preference in an illuminated environment. Also, human had the primary desire to be aware of his orientation and positioning within the environment. Also, pathway allowed one to establish his bearings and know the potential of information available ahead. (Kaplan, 1983; Kaplan, 1998) Thus, pathways were amongst the important visual cues human would desire to see in the illuminated environment. On contrary, public transport station, this was noted as a node (See Lynch, 1960), was ranked at the last. This might be attributed to their usual lack of design appeal and often an object of transit, so people would utilize it at great volume, yet not wanting it to appear too prominently in the nightscape. The above result had derived a preliminary set of illuminated elements human would desire to see at night. Thus, in the drafting of the urban lighting master plan, it is primary that lighting designers understand and derive the hierarchy for illuminating, in accordance to the visual hierarchy human recognized for his urban environment.

Derivation of Visual Preference for Illumination

	1ST CHOICE	% OF PEOPLE	2ND CHOICE	% OF PEOPLE	3RD CHOICE	% OF PEOPLE	4TH CHOICE	% OF PEOPLE	5th CHOICE	% OF PEOPLE	6th CHOICE	% OF PEOPLE	7th CHOICE	% OF PEOPLE
Textures lighting (of buildings or plants)	6	**15**	11	**28**	4	10	10	26	3	8	5	13	0	0
Brightly lit areas	12	**31**	1	3	7	18	5	13	4	10	0	0	10	26
Illumination of nature	2	5	4	10	5	13	6	15	5	13	7	18	10	**26**
Colour lighting	3	8	2	5	4	10	2	5	10	26	12	**31**	6	15
Temporary Lighting installations	4	11	5	13	8	21	5	13	8	21	5	13	3	8
Dynamic-scene changing lighting	4	11	6	16	4	11	5	13	5	13	5	13	9	**24**
Lit Architectural details	5	**13**	10	**26**	5	13	7	18	6	16	5	13	0	0

Table 19.0 *Answers Obtained for Section A, Question 2 (Source: Author's own)*

Section A established the ranking of the visual elements that would construct the lighting masterplans, together with the manner of their definition of the illumination strategy. The second question established the hierarchy of ranking of the various lighting strategies in lighting master planning and the results would help lighting designers establish the visual hierarchy of the stated elements in relationship to each other. It is evident from the list that human would prefer brightly lit areas, of all the listed lighting techniques, at 31% of the surveyed placing it at the first place. In addition, the illumination of textures and lit architectural details had about 28% and 26% of the people voting for them in the second place respectively. However, it was indicated that the surveyed subjects do not prefer dynamic colour changing lighting systems, as about 24% voted it in the last place. Coloured lighting is also lowly preferred by the subjects, with 31% of the subjects voting it at the 6th position and 15% denoting it at the last place. Also, lighting of nature is ranked lowly at about 26% of the people voting it in the last place, while 18% voted for it in the second position.

Although the ranking for various lit elements varied in accordance to personal subjective preference of his visual environment, the results had indicated that there is a pattern to the preference of individuals, while suggesting the establishment of certain visual hierarchy of the illuminated details in accordance to the manner human construct his visual environment. It is noted that the preference of details and textures can be accounted for by Gibson and Kaplan's theories, which proposed the extraction of visual information in accordance to the information derived from textures and details of the object. Therefore, human would prefer the ability to perceive details and textures from his perceivable environment to understand the geometrical structure and the object he perceived. However, visual sensory stimulation in form of coloured lighting or automated scene changing lighting system is not preferred,, indicating human preference for ability to perceive objects than complexity in the environment, or information overload. Also, the low preference of illumination of nature might suggest that the in the drafting of the lighting master plan, the lighting of the parks or nature should be of lower priority in comparison to the illumination of built elements.

2. Urban Lighting on Psychological Comfort

82.5% of the respondents indicated that they would feel unsafe if they lost their way or were unfamiliar with the surroundings at night. Furthermore, 87.5% of the subjects indicated that they would derive pleasure from awareness of their orientation in the city at night. However, they did not associate brightness level with psychological comfort, as only 60% of the subjects indicated that increasing the brightness of the space would decrease their fear. This is contrary to the rationale lighting designers often depended upon in design of the illumination level of the urban spaces, where the brightness is tagged to the frequency of use of the space and functionality of the space. (See IESNA Exterior Lighting Guide) However, this finding supported another result derived by Parkes and Thrift (Parkes, 1980), who concluded that in the perception of psychological comfort, people would also depend on the appearance of the structure, or whether the existing condition of the urban space would result in any seeming danger. For example, a brightly illuminated cathedral, which appeared to be abandoned and intimidating in the day, would not decrease the perceived fear of the people who passed by it. Therefore, the relationship between brightness and psychological comfort is not direct, and other factors should be considered as well.

3. Responses versus Lighting Conventions

From the evaluation of the results, it is notable that several of the responds indicated that some of the popularly-utilized lighting techniques need to be re-evaluated in accordance to their resultant reaction on the perceivers. Furthermore, there is a difference between the opinions of the lighting designer and the general public, which was anticipated through several studies which compared the difference in opinion between the layman and the professionals.

Use of Colour Lighting or Colour Changing

In accordance to the results from the survey, although lighting designers widely perceived colour lighting as a means to inject dynamicism and life into urban environments, the public would prefer an illuminated environment where visual complexity is kept to the minimal and sensory stimulation is only timely introduced. From the results, 52.5% of the subjects expressed their dislike of using colour changing illumination for the urban spaces. However, 77.5% of the subjects express their liking of using coloured lighting to distinguish the various urban spaces (in the coding of different districts), while 77.5% expressed that they like the use of coloured lighting in illumination of urban elements. One probable translation of this result was that human prefer legible visual environment, yet too much sensory stimulation would not be preferred. This stimulation can be in the form of colour changing lighting systems, or variety in the appearance of the illuminated environment through coloured lighting. This is further complemented by the evaluation of the images in section C, where the general responses indicated that there is a preference of the illuminated nightscape, with 75 % of the people indicating that they would prefer the illumination of the nightscape using non-coloured lighting, instead of coloured lighting. But, it is rather surprising that a slight majority of the public prefer non-illuminated nightscape in comparison to the illuminated one, as 55% of the subjects indicated their preference for the non-illuminated skyline, instead of the one generated through computational manipulation.

QUESTION	OPTION 1	% OF PEOPLE	OPTION 2	% OF PEOPLE
QN 17	22	55	18	45
QN 18	10	25	30	75

Table 20.0 *Answers Obtained for Section C(Source: Author's own)*

The results indicated potential of coloured to be introduced to urban lighting master planning, yet further studies should be done to explore the relationship between coloured lighting and human perception. Preliminary studies on coloured lighting and perception had indicated that different colours might result in a variety of effects on perception. (Mahnke, 1987; Mahnke, 1996). To verify, results from Survey 1 had indicated that coloured lighting does interact with appearance of interior spaces and combination of different colours would result in psychological reactions from the surveyed subjects. Therefore this suggested that this relationship between colours and human perception is important and should be addressed through detailed and specific researches. The potential of this subject, the approaches and various potential concerns of coloured lighting in urban lighting master planning would be explored in the later chapter on future research directions.

Colour Temperature and Resultant responses

QUESTION	OPTION 1	% OF PEOPLE	OPTION 2	% OF PEOPLE
QN 19	33	83	7	17
QN 20	10	25	30	75

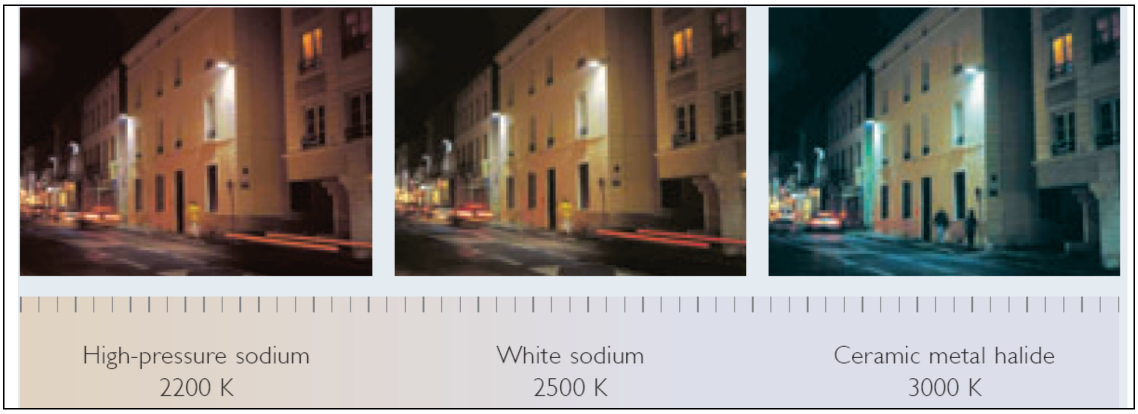


***Table 21.0** Answers Obtained for Section C (Source: Author's own)*

From responses derived from the associative image of orangey hue lighting to illumination of historic buildings, 56% of the subjects denied the association. This is contrary to the conventional lighting design basis where the lower Colour Temperature is usually designated for the illumination of historic buildings. Therefore, this suggested that the illumination of these monuments should not be merely dependent on the Colour Temperature of the selected lamps, but also on the resultant appearance of the illuminated object. Therefore, refuting the rampant use of Low-Pressure Sodium lamps for the illumination of historic monuments, where technical knowledge of different lamps were absent.[8]

Also, the above results obtained for Section C of the survey indicated that 83% of the people prefer picture 1 for questions 19, which compared the picture of the scene illuminated using White Sodium lamps of 2500K, with the Metal Halide lamps, which is about 3000K. Some of the responses had indicated that the 3000K lamps appeared to be "cold". The results indicate similar conclusions to another study done for the indoor lighting, using lamps of different Colour Temperature. (See McCloughan, 1999) Spaces illuminated by lamps of warmer Colour Temperature are noted to be more facilitating for social interactions and conducive to create a relaxing environment. However, too low Colour Temperature would not be preferred, as only 25% of the subjects indicated their preference for the scene where High-Pressure Sodium lamps of 2200K were used. This implied that there is an inclination of human preference in choice of certain Colour Temperature for illumination of the urban environment, which remained to be verified through further tests, with Colour Temperature as the main research objective.

These feedbacks would be useful in the tailoring of future surveys, particularly the potential survey for those conducted to evaluate the quality of urban lighting masterplans. However, this research for interior lighting and the preference derived from different compositions of the room surfaces and illumination techniques had demonstrated that patterns do exist in the evaluation of subjective qualities like aesthetics, which would provide the basis in the establishment of design basis and quality design that appeals to the general public. This is extremely valid when many researches had pointed out the different aesthetics value between those professionals and the general public, as the latter were not biased against stylistic design movements or trends. (Nasar, 1988)

5.2.3 Analysis of Results to New Proposed Basis

The responses from the survey indicated that several of the new proposed bases were of importance in the construction of a visually legible illuminated nightscape. However, the survey provided an insight into human perception of his illuminated environment, yet further tests should be conducted to perform detail study on each of the proposed feature in order to better understand the constituents to a quality illuminated environment.

Clarity

Clarity between the various illuminated elements was important in the visual structuring of the space and Lynch had proposed the usage of lighting to differentiate between urban spaces. (Lynch, 1960) Furthermore, the results of this survey indicated that there were certain

Footnote:

8. *It was noted that Low-Pressure Sodium Lamps were widely utilized in the illumination of Historic monuments in Shanghai and Singapore, due to their orangey hue emission. Yet the appearance of the actual architectural material is being compromised through the choice of such lamps.*

elements that were more visually important as compared to the others (See results of Section A, Question 1), and the rankings derived from the respondents were rather consistent. Therefore, the survey indicated that visual clarity and structuring of the illuminated nightscape was important in the perceiving of the nightscape, as well as to facilitate navigation through the city in the dark.

Highlighting Textures and Details

Approximately more than 25% of the respondents indicated that they would most prefer to perceive textures and architectural details in the illuminated urbancape, suggesting that these features were important and should be perceivable in the dark. These results supported Gibson's theories on perception and importance in perception of textures and details, whilst implying that Kaplan's proposal on the significance of ability in the extraction of information from the environment is extremely important in the perception of one's environment. (Kaplan, 1983; Kaplan, 1988; Kaplan, 1998) Hence, the design of future illuminated nightscape should encompass these qualities.

Naturalness and Variety

Although these two features were much highlighted in the environmental perception theories as positive visual features (Rapoport, 1977; Nasar, 1988; Nasar, 1998; Kaplan, 1983), results from this survey indicated that vegetation illumination was ranked amongst the lowest in the features which people would like to see. Moreover, about 52.5% of the subjects indicated that they would not prefer a nightscape where coloured-changing lighting was used. In contrast, about 77.5% of the subjects indicated that they would prefer the colour lighting in their environment. Thus, these results suggested a need to evaluate the effect in use of coloured lighting and the appropriateness in the extent of its use in urban lighting, for development of quality lit urban environment.

Historic Significance

One of the misconceptions in urban lighting was the association of orangey-hue lighting with historic buildings. However, the results indicated that about 55% of the subjects indicated that they do not associate orangey hue lighting with historic buildings, correcting the practice in urban lighting, where often low colour temperature lighting were to illuminate the historic buildings, to evoke the Old World feel.

Psychological Comfort

Psychological comfort is extremely important for the ease in moving through the city in the dark. Parkes studies had indicated that psychological comfort and the daytime appearance of the place do affect the desired brightness level of the space at night, as a place perceived to be unsafe in the day would require higher brightness level for its use at night, to minimize psychological discomfort. (Parkes, 1980) The results of the survey had indicated that 60% of the subjects feel that by increasing the level of brightness of the area, it would decrease their fear of the dark if they were lost at night. Hence, in the formulation of the Urban Lighting Master plan, to depend on the Codes for recommendations would not suffice, as there were other factors that would affect perception, which should be considered during the drafting of the Lighting Master plan.

Of the proposed design basis, a few of the proposed could not be accommodated within this short survey, namely Visual Hierarchy, Perceivable Foreground and Background, and Pertinence to Context and Culture. Since these would require different forms of tests and the questions to test for the validity of these would be vastly different from the genre of the survey question. Furthermore, although the results had indicated that about 80% of the subjects indicated that they prefer a different appearance of the city in the day as compared to the night-time image of the city. In addition, on the application of coloured lighting and colour changing lighting, further studies should be done to find out the extent of its recommended application and how it would affect perception, if it were applied on a large scaled basis.

5.2.4 Survey Limitations

The limitation of this survey shall be elaborated through the following sections, which divides the potential problems into categories, listed in the following paragraphs. However, the author would like to note that these limitations would be minimized through multiple experiments and the refinement of the test procedures in pilot surveys. But the time limitation in the progress of this thesis would not permit the execution of pilot surveys. Furthermore, since this survey would serve as an introduction to the understanding of how human perceive his night-time cityscape based on his perception preference, this survey would allow the establishment of the underlying patterns that would aid in understanding of the primary constituents that would aid in the structuring of human's perceivable environment, so precision of the test would not be critical. Also, problems would be unavoidable due to the novel nature of this subject for test and the non-existence of predecessor studies.

Tools generated for survey

The correct identification of the survey variables is important in the establishment of an appropriate survey in mapping users' responses. However, one must not tailor the survey to influence the subjects towards certain inclined answers. Neutrality must be preserved in the subject's stand upon the evaluation of the questions. Since computational simulations were gradually introduced in the construction of valid test environments, where the execution of the test in actual site would be extremely difficult, the digitally altered images should be as close to the actual scenario as possible. As pointed out earlier, the validity of using computational generated images for test on perception would be dependent on the accuracy of the generated images to the real examples of the same proposed scheme. The higher the realism, the better is the derived results as a representative for the general public's responses.

(Rohrmann, 2002; Eissa, 2001) Furthermore, Nasar had pointed out the effectiveness of using graphical tools in evoking public responses in evaluation of the environment. (Nasar, 1998) Therefore, the quality of the generated images would be one of the determinant factors in the derived results when the original images were compared against those digitally altered. Care should, thus, be taken in the rendering of the effects in the superimposition of the effects on the actual altered photographs in Adobe Photoshop, using colours which are visually accurate with the colour of the emitted lights from luminaries. With the correct use of adjustments for highlights and fine tuning on the effects of which lighting would create on the facades of the buildings, the images is rendered to mimic the actual effect achieved. Although limitations were noted for the usage of computationally generated images as the test environment, experiment undertaken by Mahdavi (Mahdavi, 2002) had demonstrated that the responses achieved through the comparison between actual test environment and computationally generated space revealed that achieved responses were consistent, indicating that computationally generated spaces were effective surrogates to the actual built environment. Therefore, the main limitation, as pointed out by Mahdavi, the use of computationally generated images is to the accuracy of the actual to the simulated. Yet precautions should be undertaken to minimize this limitation, whilst preserving the validity of the achieved results.

Coloured Lighting and the generation of images

It is recognized that coloured lighting for urban environment should be studied in detail on their impact on perception, but is impossible to cover within the length of this thesis. Thus the future research direction should provide detail insight on this subject. However, the stimulation of colour lighting in this survey suggested preliminary insight into human reaction towards the use of colour lighting in urban lighting. In this survey, the presentation of coloured lighting suggested the use of a single colour hue, but the achieved responses might be derived from the personal judgement of the colour used, and not to relate as a form of coloured lighting strategy, which would be applied for façade illumination. Therefore, the two questions in Section B and ranking of the various illumination techniques in Section A would provide a preliminary insight on human responses towards coloured lighting. Yet, to reduce potential statistical error through the rendering of single colour for façade illumination, a comparison of different colours should be done for further studies.

Structuring of questionnaire

The division of the questionnaire into 3 sections, with 20 questions allow the obtaining of easy and quick responses to some of the proposed design basis drafted in earlier section. Care was taken to maintain the relevancy of the questions to the objective of the survey. However, the post-survey interview revealed that some of the respondents felt that the questionnaire could be improved by adding another option of “maybe” and allow them to give their personal responses for Section B. Also, the ranking of Section A ,Question 2 was not clear, leading to one of the surveyed subjects not answering the whole question. This highlighted the need for clarity in the structuring of the questionnaire to achieve the correct results from the subjects.

5.3 Overview of Results Derived from Both Surveys

The results derived from both studies had provided interesting insights into how the general public perceived his illuminated environment, whilst offering alternative viewpoints for some of the conventions in artificial illumination. Both surveys indicated the ability of artificial lighting in the influencing on spatial perception. Furthermore, a variation in the illumination technique, from normal to coloured lighting, or the different manner lighting interact on surfaces, might result in the different human response towards the same space.

In Survey 2, the hierarchy of the illuminated elements was derived from the survey of these environmental features with the subjects, proving that human’s formulation of personal mental maps in navigation. Although clarity in the structuring of the illuminated environment is preferred by all, physical landmarks were not as important as personally familiar “landmarks”, as noted through the survey. Hence, in the drafting of the Urban Lighting Master plan, the designer should allow detailed studies on the public’s responses, while establishing clear visual hierarchy in the various identified elements.

Colours or coloured lighting have an important impact on the visual appearance of the object and resultant human response towards the choice of colours might be influenced by personal tastes or cultural background (Mahnke, 1987; Mahnke, 1996).Therefore, to tailor for a visually pleasing environment, an appropriate decision in the choice of colours or manner colours interact with materials or another hue would be recommended. However, the advancement of lighting systems or automated scene changing systems, particularly LED, had introduced various potentials in the illumination of the dynamic skyline. However, both studies had indicated the potential of coloured lighting in resulting in visual complexity and chaos. Therefore, studies on appropriateness of coloured lighting or time-based controlled lighting system should be executed towards the construction of quality illuminated environment.

Also, both studies had clarified the misconception most had on the relationship between the level of brightness, with perceived aesthetics and psychological comfort. Both demonstrated that there are no direct correlations between brightness and aesthetics and psychological comfort. Therefore, further studies should be done to clarify how illumination of space should be in relation to human preference.

6.0 Conclusion

6.1 Towards the Formulation of Quality Lit Environment

Human-orientated design basis are extremely important in the visual design of a comfortable nightscape and studies in environmental perception further justified the importance of a legible visual environment. Current advancement and development in various lighting technologies and gradual popularity for cities in formulation of their unique lighting masterplans, had indicated the need and feasibility in research on how the current design basis should be improved, beyond the quantitative aspects of urban illumination, to better understand the relation between artificial lighting and perception. Despite no researches done in appearance of illuminated urban nightscape on human, the analysis on current researches done in interior lighting revealed that artificial lighting does evoke psychological responses in human. (See Chapter 3.1.4) Furthermore, results from survey 2 had indicated many potential and feasibility in the derivation of design parameters which is aesthetically pleasing for the visual nightscape, whilst survey 1 had concluded the possibilities on how artificial lighting can modify the appearance of space. Also, results from both tests indicated clear preference that can be derived from the human responses to the illuminated environment, indicating need for future research to follow up on the how various urban lighting techniques can influence the appearance of the total urban space. Since human's visibility of his environment is mainly dependent on the interaction between artificial lighting and his environment, there exists a need in the investigation on how human-environment relationship can be enhanced through the appropriate use of artificial lighting design on the urban elements, and how lighting could be better integrated as form of visual enhancement tool for Urban Design, as proposed by Lynch. (Lynch, 1960) Although this thesis proposed an alternative view on which the subject of quality illuminated urban master planning can be dealt with, it must be noted that all that were proposed is not all, but the beginning of the study in quality urban lighting, through another perspective.

Urban Lighting had advanced from the mere provisions of sufficient illumination level for functionality of spaces, to the understanding on how lighting could affect human perception. Therefore, the complexity of urban lighting should not be underestimated, as urban lighting embodied the human-environment factors, besides the wide variety of lamps that could be utilized for illumination. Hence, there remained a need to better understand the intricate relationship on how the existing technology could enhance human perception and for the Urban Lighting design basis to complement the existing urban structure. This is especially crucial, the recent surge in lighting technological development that lighting designers might be overly eager in the employment of new technology, without careful consideration of the resultant composition of the created nightscape. Although there was awareness in the provision of quality nightscape in some cities in the review, many were still keen on the utilization of latest technology or lamp efficacy, to consider how the resultant nightscape would affect perception of one's nightscape and the definition of *quality* illuminated nightscape.

As noted from the latest Singapore Urban Lighting Master plan for Marina, Bugis, Orchard and Central Business District (See The Straits Times, 22th of November 2006), many new lighting installations and planning basis were introduced in this master plan. Furthermore, the new urban lighting master plan presented how new lighting technology could integrate into the existing urban fabric. Although this new master planning proposal appeared to be extremely rich in the aspect of visual variety, one would still question on its relevance to the context of site or if these proposed lighting installations would result in over sensory-stimulation in perception. Therefore, through this new master plan, we could note that further efforts might be required in the understanding in the appropriateness of the current design basis and better understanding should be taken into what would constitute the fundamentals in urban lighting master plan. These highlighted urgency in the design for Urban Lighting

Master plans that do not merely present a seemingly attractive illuminated nightscape, but offered visual comfort and deeper consideration into how human perceived his nightscape.

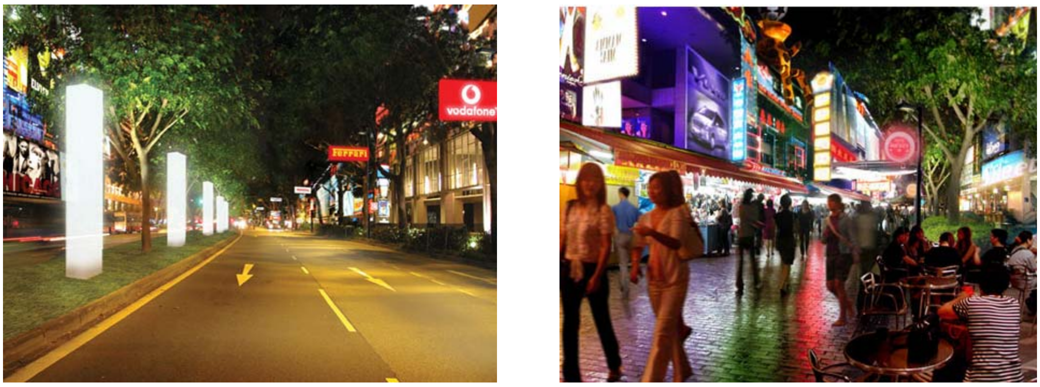


Figure 85.0 *Extracts of New Lighting Master plan for Singapore (Source: URA, 2006)*

The new proposed design basis aimed to forge a more coherent human-environment relationship, in the design of Urban Lighting Master plans, to complement the lack noted in the current design practice. (See Chapter 4.0) Since the design of the Urban Lighting Master plan should embodied the subject of Human visual needs in his environment, many new design basis were noted after the review of several prominent literature on environmental perception, to derive the final proposed basis, which pointed out the main elements which should be considered in illumination and future formulation of lighting master plan. This would aid in the derivation of a well-designed visual nightscape and the establishment of a visually coherent day and night scene. Previous tests, in environmental perception research, had indicated that the presence of these visual qualities, like historical significance, naturalness and distinctive urban forms, is correlated to the increased preference for the space and would complement human perception of his environment. Furthermore, studies had indicated that a legible visual-scape would improve preference and decrease negative feelings on his environment. (See Chapter 3.0) Therefore, the review demonstrated positive effects of a well-designed visual environment, while proving the existence of human-oriented design parameters in the visual environment, thus a potential to incorporate these parameters in the guiding fundamentals when lighting masterplans were being drafted.

6.2 Furthering Research for Urban Lighting

A legible nightscape is important to both locals and visitors, to minimize disorientation and maximize the spatial experience one would derive. The earlier questionnaires would allow better insight on the importance of the illuminated environment, how human perceived his lit city and effect of artificial lighting on spatial perception. However, it must be noted that since this subject is new and no previous researches were undertaken, the proposed basis in this thesis would serve as a starting ground for future researches to be undertaken in this area, and not as the conclusion to the research on Human-oriented design basis for Urban Lighting Master planning. Since this topic would complement the current design basis, towards the design of a legible nightscape, future development of this research topic should be detailed, for possible follow-ups in subsequent researches which would aid in the verification of the existence of such planning basis.

The analysis of both surveys, together with the reviews of the literature on Environmental Perception and current Urban Lighting Design Basis, had revealed many opportunities and potential for furthering studies on the improvement of the quality in formulation Urban Lighting Master planning. Furthermore, Survey 2 revealed some interesting findings which present contrary viewpoint to some urban lighting design convention. Therefore, the following list of questions and potential subjects were proposed to initiate further studies into the investigation of Human-orientated Urban Lighting. Design basis of urban lighting master plan, whilst proposing new research subjects for further studies.

1. Coloured Lighting and their relation with,
    a. Different materials or textures
    b. Architectural typologies
    c. Urban element type (vegetation, building etc)
    d. Zoning (Proximity to water or historic districts)

e. Extent of application (Coloured Illumination on every façade or at intervals)
f. Different attitude towards coloured lighting in relation to culture or geographical locations
g. Complementary hues or Contrasting hues

2. Urban Illumination ratio or Illuminance level, in relation to,
    a. Gender related preference
    b. Locations (Proximity to Historic areas, Entertainment)
    c. Potential danger (Abandoned buildings, Unsafe neighbourhood)
    d. Psychological comfort at night
    e. Illumination ratio between lit and shadowed for visual priority

3. Choice of Luminarie or Lamp Sources
    a. Variation of Colour Temperature on same objects
    b. Vertical illumination versus horizontal illuminated surfaces
    c. Different Illumination strategy and effect on perception
    d. Colour Rendering properties and effect on human perception
    e. Lighting Distribution patterns on perception

Figure 86.0 *Figure demonstrating the effect in variation of lamps on perceived colours of same vegetation (Source: Philips Lighting)*

Also, the following questions provides a source of evaluation into the quality of existing lighting master planning and served as a cautionary insight for the relevant parties during the formulation of lighting master plan.

1. Would discomfort be detected if the daytime image of the city were different from its appearance at night? Many urban lighting masterplans had been designed with the intention to explore different illuminated scenery which differed from the daytime appearance of the city, to inject dynamicism and variety into the urban environment. However, no study had demonstrated whether this difference would result in negative responses in terms of recognition of familiar objects or landmarks and navigation in the night. Thus, this would examine whether a difference in the daytime appearance of the urban environment would result in negative Reponses amongst the respondents, through preliminary investigation into this difference, noted in Survey 2, Question 5, had 80% of the subjects indicating their acceptance of this difference. However, Lynch maintained the importance of the appearance of the city to maintain legibility in various times of the day and at different seasons. (Lynch, 1960)

2. What is the relationship of the urban elements to each other at night, for example, the illumination of the foreground, together with the background and how would the illumination of both, or lack of either would result for perception of one's environment? This would investigate on the composition of the illuminated environment, whether a sense of depth could be created through the manipulation of foreground or background. Currently, lighting designers manipulate the perception of depth through use of different Colour Temperature lamp sources or the contrast between the shadowed and lit spaces. (See Chapter 2 on the examples of current practices)

3. What is the scale of these lighting installations in relation to the site upon which they are located? Since these installations should be classified in the same category as a statue or street furniture, so does the acceptance of their scale in relation to the street varied, in accordance to its illuminated surface area?

4. Would the ability to perceive greater details in one's space aid in the enhancement of one's visual perception and understanding of spaces? This would investigate the theories proposed by J.J. Gibson, which proposed the study of the objects through the understanding of the details and human's extraction of information through greater understanding of the object's composition. Preliminary investigations through Survey 2 had suggested that Human would prefer to perceive the illuminated textures or illuminated details. (See Chapter 5 on the results of Survey 2). Yet the understanding on the potential negative feelings evoked through the absence of these, remained not investigated.

5. Visual variety in urban environment, versus the lack of it, how would it affect perception? This is extremely important for night time environment, as a contrast to the daytime when the city is covered in darkness and the objects being illuminated are critical to our perception of the city forms at night. Visual variety can be interpreted as the ability to perceive the complexity of urban forms in their true appearance, without distortion of colours, or the use of coloured lighting, which is an increasing trend now. Results from Survey 2 indicated that variety should be "controlled" and not overwhelming, as the subjects indicated low preference for coloured lighting or automated colour changing system, perhaps suggesting that these visual stimulants could resultant in potential sensory overload or fatigue.

6. Is there any preferred lighting treatment to a space or would different lighting design concepts within a space might ignite visual chaos and how much “visual variety” would be permitted for enjoyment of night time spaces. This addressed to the application and the appropriateness of the proposed design, so serving a word of caution for the lighting designers in the development of the lighting concepts for different zones within the larger urban environment and how the various illumination techniques for different zones would relation and compose the overall illuminated nightscape.

7. Would the quality of illumination or the illumination patterns affect perception? If low Colour Rendering were used extensively, would it result in negative ratings for the environment?

The earlier chapters had pointed out that the current design basis had neglected the natural human perception of the environment and the need for visual cues. Current practice had focused on the design of a well-lit environment which addressed to the utilization of correct quality luminaries of appropriate lighting level, instead of the composition of the lit environment and how the overall appearance of the environment would facilitate perception, whilst being coherent to the daytime image. Thus, the above questions only constitute a part of many questions that quality urban lighting could relate to, but it would propose to extend the understanding of design basis for urban lighting masterplans, towards the formulation of a quality lit environment, which was beyond current quantitative lighting requirements, as well as to complement on the existing urban lighting master planning practice.

Research Limitations and Practice Exceptions

Although a legible visual environment is always preferred by human, too much predictability and no surprises would result in monotony and an un-stimulating environment that would not prompt explorations. (Kaplan, 1983; Rapoport, 1977; Lynch, 1960) Since human thrive through innate need to visually explore and extract information from his environment, variety and balanced complexity should be present, to spur interest in one's visual environment. (Lynch, 1960; Kaplan, 1983; Kaplan, 1998) Hence the design basis for quality nightscape, should allow for variety and less predictability, as too much monotony and *legibility* were still not preferred. Therefore, it is understood that a perfectly legible visual environment would be impossible to achieve, yet legibility and the extent of its introduction into the visual design of one's environment remained to be investigated further.

Through the two experiments executed by the author, using semantic differential scaling for test of human responses to lit environment, and use of computationally generated environment as surrogates of the actual test environments, several potential limitations were noted that would serve as precautionary measures for future tests. However, it must be noted that the existence of these limitations would not override the validity of potential results achieved, yet served as parameters for further studies. Furthermore, through analysis of previous researches on researches in appearance of lit environment, it is noted that in the research on appearance of quality lit environment, there were different aspects to consider, mainly, the test environment, mode of test, the formulation of questionnaires and the choice of test respondents. (See Chapter 3.1.4 and Chapter 5.0) In this case, as highlighted through both experiments carried out by the author, since computational modelling would be the main tool to investigate the validity of the implementation of these design bases, the quality of the computationally generated model is equated to the validity of the experiment results (Eissa, 2001; Wittkopf, 2000) and the quality of derived results from the research. Hence, one of the main limitations of this research would the quality of the computationally generated images or models for tests, methods of its generation and the computational tools used. Another limitation to future researches would be the chosen subject and the sample size. It was noted that responses from professionals and general public might be different, (Nasar, 1998), future tests should consider the choice of appropriate in accordance to research objective. Also, the questionnaire posed should be precise, with every question pointing to the test variable in question, while the research objective should be clear prior to the formulation of the question, to minimize statistical errors, which arises from unclear phrasing of the questions, which would not allow immediate responses. Nasar had pointed out the advantages and disadvantages between the different modes of tests, through tele-conversation, interviews or mailing. (Nasar, 1998) Since this test is utilized computational modelling, the test medium is extremely portable, and the production of photorealistic images of the different effects or real-time simulation, could be presented to the test audiences in form of photographs or ,to extent to the other countries or study on the responses from people of different geographical locations, be posted on the world wide web, to enable participants from different areas, to study whether culture would be a factor which should be considered in the design of the visual environment, since prior researches had demonstrated the different viewpoints of people from different cultural background.

With recent interest in the understanding of *quality* nightscape noted through various conferences and seminars hosted by different authorities (like the International Urban Nightscape Conference, where a condensed version of this thesis was presented, the Annual Light Fair or the Biannual Light and Building Fairs), it is noted that the interest in provision for a better illuminated environment would continue and more efforts would be taken in the understanding of *quality* nightscape. (Ong, 2006(a)) Furthermore, analysis of all the case-studies undertaken for this thesis revealed that the implementation of urban lighting masterplanning had been rampant in recent times, particularly in Asia, as author's paper on urban lighting masterplanning for Asian cities had been highlighted for presentation in the 2006 m AAN conference in Tokyo. (Ong, 2006(b)) Also, comparisons across all case-studies revealed that the design strategy and ideology conceived for each masterplan had matured in the use of lighting fittings and the relations of lighting to urban planning theories. (See

Chapter 2.0) Furthermore, the revisions in the international codes revealed a need to better design our exterior lit environment.

All these highlighted the receptiveness of new ideologies for the design basis of urban lighting masterplanning and the variety of available fittings further signalled the need for design basis to better relate to human perception needs for his visual environment. Hence, Urban Lighting Master plan should embark upon a new direction, from the quantitative aspects of lighting and measurable spatial requirements, to one that would better address to the previously neglected component of human visual needs in his environment. Therefore, with a better understanding of how human visual needs could be addressed in the formulation of future lighting masterplans, it would not be long before city dwellers would enjoy well-lit spaces, which were not only centred on their functional requirements as stated in Codes, but designed with greater sensitivity on human-environment visual needs, in mind.

APPENDIX I *(Extracts from IESNA, RP – 33-99 & RR-89)*

Since there are a lot of technical jargons that are specifically used in lighting design, choice would be made on the selected terms that are often referenced to in the thesis. The definitions for the elected terms are based on internationally recognized publications that are extensively used and often quoted in practices of lighting design.

1.	**Accent lighting**	Directional lighting to emphasize a particular object or to draw attention to a part of the field of view.
2.	**Ballast**	A device used with an electric Dischargelamp to obtain the necessary circuit conditions (voltage, current, and wave form) for starting and operating.
3.	**Ambient lighting**	Lighting throughout an area that produces general illumination.
4.	**Colour Rendering**	General expression for the effect of a light source on the colour appearance of objects in conscious or subconscious comparison with their colour appearance under a reference light source.
5.	**Colour Rendering index, CRI** ***(of a light source)***	Measure of the degree of colour shift objects undergo when illuminated by the light source as compared with the colour of those same objects when illuminated by a reference source of comparable Colour Temperature.
6.	**Colour Temperature of a light source**	The absolute temperature of a blackbody radiator having a chromaticity equal to that of the light source.
7.	**Conspicuity**	The capacity of a signal to stand out in relation to its background so as to be readily discovered by the eye.
8.	**Cut-off angle** ***(of a luminaire)***	The angle, measured up from the nadir, between the vertical axis and the first line of sight at which the bare source is not visible.
9.	**Direct glare**	Glare resulting from high luminances or insufficiently shielded light source in the field of view. It usually is associated with bright areas, such as luminaries, ceilings and windows, which are outside the visual task or regions being viewed.
10.	**Direct lighting**	Lighting by luminaries distributing 90 to 100 per cent of the emitted light in the general direction of the surface to be illuminated. The term usually refers to light emitted in a downward direction.
11.	**Disability Glare** ***(veiling luminance)***	Caused by stray light scattered within the eye, which reduces the contrast of the primary image on the retina. This contrast reduction can be thought of as a "veil" of luminance over the objects, thus the term veiling luminance.
12.	**Discomfort Glare**	Does not necessarily reduce the ability to see an object (as in the case of disability glare), but it produces a sensation of discomfort. It is caused by high contrast or a non-uniform distribution of luminance in the field of view. Discomfort glare can be reduced by decreasing the luminance of the light source, or increasing the

background luminance around the object.

13. **Distal stimuli** In the physical space in front of the eye one can identify points, lines and surfaces and three dimensional arrays of scattering particles which constitute the distal physical stimuli which form optical images on the retina. Each element of a surface or volume to which an eye is exposed subtends a solid angle at the entrance pupil. Such elements of solid angle make up the field of view and each has a specifiable luminance and chromaticity. Points and lines are specific cases which have to be dealt with in terms of total candlepower and candlepower per unit length.

14. **Field of view** The field of vision is the part of the observable world that is seen at any given moment.

Different animals have different fields of view, depending on the placement of the eyes. Humans have a 180-degree forward-facing field of view, while some birds have a complete 360-degree field of view. In addition the vertical range of the field of view may vary.

15. **Lamp Efficacy** *Luminous efficacy of a radiant flux:* The quotient of the total luminous flux by the total radiant flux by the total radiant flux. It is expressed in lumens per watt.

Luminous efficacy of a source of light: The quotient of the total luminous flux emitted by the total lamp power input. It is expressed in lumens per watt. It is expressed in lumens per watt. The term luminous efficiency has in the past been extensively used for this concept.

16. **Floodlighting** A system designed for lighting a scene or object to a luminance greater than its surroundings. It may be for utility, advertising or decorative purposes.

17. **General lighting** Lighting designed to provide a substantially uniform level of illumination throughout an area, exclusive of any provision for special local requirements.

18. **Glare** The sensation produced by luminance within the visual field that is sufficiently greater than the luminance to which the eyes are adapted to cause annoyance, discomfort, or loss in visual performance and visibility. The magnitude of the sensation of glare depends upon such factors as the size , position and luminance of a source, the number of sources and the luminance to which the eyes are adjusted.
See Blinding glare, Direct glare, Disability glare and Discomfort glare.

19. **Illuminance** The density of the luminance flux incident on a surface; it is the quotient of the luminous flux by the area of the surface when the latter is uniformly illuminated. S.I unit of illuminance is *lux.*

20.	**Lamp**	A generic term for a man-made source of light. By extension, the term is also used to denote sources that radiate in regions of the spectrum adjacent to the visible.
21.	**Lamp Lumen Deprecistion factor *LLD***	The multiplier to be used in illumination calculations to relate the initial rated output of light sources to the anticipated minimum rated output based on the relamping program to be used.
22.	**Light Loss Factor *LLD***	A factor used in calculating illuminance after a given period of time and under given conditions. It takes into account temperature and voltage variations, dirt accumulations on luminaries, lamp depreciation, maintenance procedures, and atmosphere conditions.
23.	**Local lighting**	Lighting designed to provide illuminance over a relatively small area or confined space without providing any significant general surrounding lighting.
24.	**Luminaire**	A complete lighting unit consiting of a lamp or lamps together with the parts designed to distribute the light, to position and protect the lamps, to position and protect the lamps and to connect the lamps to the power supply.
25.	**Luminance**	The quotient of the luminous flux at an element of the surface surrounding the point, and propagated in directions defined by an elementary cone containing the given direction, by the product of the solid angle of the cone and the area of the orthogonal projection of the element of the surface on a plane perpendicular to the given direction. The luminous flux may be leaving, passing through and/or arriving at the surface.
26.	**Luminance contrast**	The relationship between the luminances of an object and its immediate background.
27.	**Nuisance or annoyance glare**	Can be defined as glare that causes complaints, such as the “light shining in my window” phenomenon.
28.	**Object colour**	The colour of the light reflected or transmitted by the object when illuminated by a standard light source.
29.	**Perceived object colour**	The colour perceived to belong to an object, resulting from characteristics of the object, of the incident light, and of the surround, the viewing direction and object adaptation.
30.	**Quality of lighting**	Pertains to the distribution of luminance in a visual environment. The term is used in a positive sense and implies that all luminances contribute favourably to visual performance, visual comfort, ease of seeing, safety and aesthetics for the specific visual tasks involved.
31.	**Quantity of light *(luminous energy)***	The product of the luminous flux by the time it is maintained. It is the time integral of luminous flux.
32.	**Subjective brightness**	The subjective attribute of any light sensation giving rise to the percept of luminous magnitude, including the whole scale of

qualities being bright, light brilliant, dim or dark. The term brightness often is used when referring to the measurable luminance. While the context usually makes it clear as to which meaning is intended, the preferable term for photometric quantity is luminance, thus reserving brightness for subjective sensation.

33. **Veiling luminance** A luminance superimposed on the retinal image which reduces it contrast. It is this veiling effect produced by bright sources or areas in the visual field that results in decreased visual performance and visibility.

34. **Vision** Vision is classified into 3 different types, as defined in IESNA RP 33- 99. (See IESNA, 1999 for more details), Photopic, Scotopic and Mesopic.

1. Photopic Vision – Human eye's response at high light levels whereby the cones account for the majority of vision. The cones are also responsible for foveal vision, the central area where the eye focused on objects. Color is also perceived by the cones. This vision is generally assciated with adaptation to a luminance $\geq$ 3cd/m^2 ($\leq$ 0.0001 cd/ft^2)
2. Scotopic Vision – Human eye's response at very low light levels such as moonlight. At these levels, the rods account for the majority of vision. Stimuli from the rods are also responsible for peripheral vision, with everything appearing in black, white and grey. This vision is generally associated with adaptation to a luminance $\leq$ 0.001 cd/m^2 ($\leq$ 0.0001 cd/ft^2)
3. Mesopic Vision – A combination of Scotopic and Photopic vision, occurs under the majority of exterior night lighting conditions. Both the rods and the cones contribute to the visual response. This vision is generally associated with adaptation to a luminance 3 and 0.001 cd/m^2 (0.3 and 0.0001 cd/ft^2) Exterior lighting design should take into account the prevalence of mesopic conditions. When clarity, depth-of-field and peripheral detection are important, then a light source rich in short wave length (blue and green) light should be used. Current research indicate that less light is required with a light source rich in green and blue components (metal halide, fluorescent) relative to a light source with few green and blue components, for an equivalent peripheral mesopic response.

35. **Visibility** The quality or state of being perceivable by the eye. In many outdoor applications, visibility is defined in terms of the distance at which an object can be perceived by the eye.

36. **Visual acuity** A measure of the ability to distinguish fine details. Quantitatively, it is the reciprocal of the minimum angular separation in minutes of two lines of width subtending one minute of arc when the lines are just resolvable as separate.

37. **Visual field**

The locus of objects or points in space that can be perceived when the head and eyes are kept fixed. The field may be monocular or binocular.

Binocular visual field: that portion of space where the fields of the two eyes overlap.

Central visual field: that region of the visual field corresponding to the foveal portion of the retina.

Monocular visual field: the visual field of a single eye.

Peripheral visual field: the portion of the visual field that falls outside the region corresponding to the foveal portion of the retina.

APPENDIX II

(Extracts from IESNA, *Lighting for Exterior Environment,RP-33-99, 1999)*

The below illustrates the various available lamp sources for urban lighting applications, to understanding he technical properties unique to each lamp and their applications in relation to the illumination of choice urban elements.

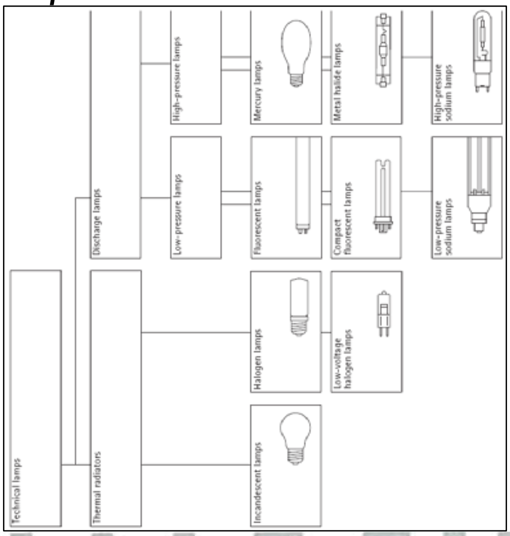


Table 1: General Characteristics of Commonly Used Light sources*
(This table shows the wide range of parameters available for lamp products. A specific example has been chosen for each source type.)

Sources Type and color Temperature	Lamp Watts	Initial Lumens	Efficacy (LPW)	Lumen Maintenance[2]	Life (Hours)	CRI
Standard Incandescent Filament, 2700 K	100	1690	17	85	750	100
Tungsten Halogen (Reflector), 2850 K	90	1300[3]	14	95	2500	100
TungstenHalogen (Low Voltage, Reflector), 3000 K - 3200 K	50	900[3]	18	95	4000	100
Fluorescent T-5 4 ft.[4], 3000 K - 4100 K	28	2900[5]	104	95	16,000	82
High Output Fluorescent T-5 4ft.[4], 3000 K - 4000 K	54	5000[5]	93	95	16,000	82
Fluorescent T-8 4 ft.[4], 3000 K - 4100 K	32	2850	89	85	20,000	75
Slimline Reduced Wattage 8 ft. 3000 K - 5000 K	60	5900	98	80	12,000	82
High Output Reduced Wattage 8 ft., 3000 K - 6700 K	95	8000	84	75	12,000	62
Compact Flourescent (Long Twin), 3000 K - 4100 K	39	3150	81	85	20,000	82
Compact Flourescent (Double), 2700 K - 6500 K	26	1800	70	85	10,000	82
Mercury Vapor, 3000 K - 5700 K	175	7950	45	60	24,000	15
Metal Halide, Low Wattage, 3000 K - 3800 K	100	9000	90	85	15,000	70
Metal Halide, High Wattage, 3000 K - 4000 K	400	36,000	90	80	20,000	65
Ceramic Metal Halide (Clear), 3000 K	100	9300	93	80[6]	10,000	85
High Pressure Sodium, Low Wattage, 1900 K[7]	70	6400	91	90	24,000	22
High Pressure Sodium, High Wattage (Diffuse), 2100 K[7]	250	26,000	104	90	24,000	22
Low Pressure Sodium, (Monochromatic), 1800 K[7]	90	12,750	140	90	16,000	<2

Representation of the different kinds of electric light sources according to the means of their light production.
(Source: ERCO, 1992, p. 44)

APPENDIX III (a)

The below is the survey used for the test where the results were analyzed in Chapter 5.1. The results derived from all the responses are attached behind this survey.

Name:	

Sex: [ ] Female [ ] Male

Age:	[ ] < 20 years old	[ ] 20 - 25 years old	[ ] 26 - 30 years old
	[ ] 31 - 35 years old	[ ] 36 - 40 years old	[ ] > 40 years old

Do you suffer from any visibility impairing problems, which affects any one of the listed:				
[ ]	Yes	[ ]	No	Difficulty in distinguishing between different colours or contrast?
[ ]	Yes	[ ]	No	Difficulty in Distinguishing shapes and brightness level even with visual aids (like spectacles)

---

1. LEVEL OF BRIGHTNESS

Part A *The Series of images generated showed a series of different scenes generated. For each of the shown set, please indicate which of the images is brighter, by ticking in the correct box.*

Qn.	Image shown:	A	B
1	SET 1		
2	SET 2		
3	SET 3		
4	SET 4		
5	SET 5		
6	SET 6		
7	SET 7		
8	SET 8		
9	SET 9		
10	SET 10		
11	SET 11		
12	SET 12		
13	SET 13		
14	SET 14		
15	SET 15		
16	SET 16		
17	SET 17		
18	SET 18		
19	SET 19		
20	SET 20		

Part B *The Series of images generated showed a series of different scenes generated. For* *each of the shown set, please indicate which of the images is brighter, by ticking in the correct box.*

	Image shown:	A	B
21	SET 1		
22	SET 2		
23	SET 3		
24	SET 4		
25	SET 5		
26	SET 6		
27	SET 7		
28	SET 8		
29	SET 9		
30	SET 10		
31	SET 11		
32	SET 12		
33	SET 13		
34	SET 14		
35	SET 15		
36	SET 16		
37	SET 17		
38	SET 18		
39	SET 19		
40	SET 20		

2. COMFORT LEVEL

Part C *Please imagine yourself in each of the rooms depicted, and choose the image that represented the room whereby you would feel more comfortable in.*

	Image shown:	A	B
41	SET 1		
42	SET 2		
43	SET 3		
44	SET 4		
45	SET 5		
46	SET 6		
47	SET 7		
48	SET 8		
49	SET 9		
50	SET 10		
51	SET 11		
52	SET 12		
53	SET 13		
54	SET 14		
55	SET 15		
56	SET 16		
57	SET 17		
58	SET 18		
59	SET 19		
60	SET 20		
51	SET 21		
52	SET 22		
53	SET 23		

54	SET 24		
55	SET 25		
56	SET 26		
57	SET 27		
58	SET 28		
59	SET 29		
60	SET 30		
61	SET 21		
62	SET 22		
63	SET 23		
64	SET 24		
65	SET 25		
66	SET 26		
67	SET 27		
68	SET 28		
69	SET 29		
70	SET 30		

Part D *Please imagine yourself in each of the rooms depicted, and choose the image that represented the room whereby you would feel more comfortable in.*

	Image shown:	**A**	**B**
71	SET 31		
72	SET 32		
73	SET 33		
74	SET 34		
75	SET 35		
76	SET 36		
77	SET 37		
78	SET 38		
79	SET 39		
80	SET 40		
81	SET 41		
82	SET 42		
83	SET 43		
84	SET 44		
85	SET 45		
86	SET 46		
87	SET 47		
88	SET 48		
89	SET 49		
90	SET 50		
91	SET 51		
92	SET 52		
93	SET 53		
94	SET 54		
95	SET 55		
96	SET 56		
97	SET 57		
98	SET 58		
99	SET 59		
100	SET 60		

3. ASETHETICS

Part E *Please imagine yourself in each of the rooms depicted, and choose the image that represented the room whereby you would feel more comfortable in.*

	Image shown:	**A**	**B**
101	SET 1		
102	SET 2		
103	SET 3		
104	SET 4		
105	SET 5		
106	SET 6		
107	SET 7		
108	SET 8		
109	SET 9		
110	SET 10		
111	SET 11		
112	SET 12		
113	SET 13		
114	SET 14		
115	SET 15		
116	SET 16		
117	SET 17		
118	SET 18		
119	SET 19		
120	SET 20		
121	SET 21		
122	SET 22		
123	SET 23		
124	SET 24		
125	SET 25		
126	SET 26		
127	SET 27		
128	SET 28		
129	SET 29		
130	SET 30		

END OF QUESTIONAIRE
THANK YOU FOR YOUR HELP.

APPENDIX III (a)

The results of the survey one, with the summary analyzed in Chapter 5.1.

Results of all tests sets

Subject analyzed: Perceivable Brightness

SET1_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBD	14	41.2	41.2	41.2
	BDD	20	58.8	58.8	100.0
	Total	34	100.0	100.0	

SET4_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DDB	20	58.8	58.8	58.8
	DDD	14	41.2	41.2	100.0
	Total	34	100.0	100.0	

SET13_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	18	52.9	52.9	52.9
	DDB	16	47.1	47.1	100.0
	Total	34	100.0	100.0	

SET15_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	14	41.2	41.2	41.2
	BBB	20	58.8	58.8	100.0
	Total	34	100.0	100.0	

SET5_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DDB	6	17.6	17.6	17.6
	DBB	28	82.4	82.4	100.0
	Total	34	100.0	100.0	

SET8_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	24	70.6	70.6	70.6
	DBD	10	29.4	29.4	100.0
	Total	34	100.0	100.0	

SET9_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DBB	24	70.6	70.6	70.6
	BDB	10	29.4	29.4	100.0
	Total	34	100.0	100.0	

SET10_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBD	11	32.4	32.4	32.4
	BDB	23	67.6	67.6	100.0
	Total	34	100.0	100.0	

SET17_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DDD	10	29.4	29.4	29.4
	DBB	24	70.6	70.6	100.0
	Total	34	100.0	100.0	

SET18_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBD	21	61.8	61.8	61.8
	DDD	13	38.2	38.2	100.0
	Total	34	100.0	100.0	

SET22_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBD	15	44.1	44.1	44.1
	DBB	19	55.9	55.9	100.0
	Total	34	100.0	100.0	

SET24_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBB	18	52.9	52.9	52.9
	DBD	16	47.1	47.1	100.0
	Total	34	100.0	100.0	

SET26_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DBD	11	32.4	32.4	32.4
	DBB	23	67.6	67.6	100.0
	Total	34	100.0	100.0	

SET27_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DDD	11	32.4	32.4	32.4
	BDB	23	67.6	67.6	100.0
	Total	34	100.0	100.0	

SET28_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBB	28	82.4	82.4	82.4
	DBB	6	17.6	17.6	100.0
	Total	34	100.0	100.0	

SET30_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBB	26	76.5	76.5	76.5
	DDD	8	23.5	23.5	100.0
	Total	34	100.0	100.0	

SET32_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DBD	10	29.4	29.4	29.4
	DDB	24	70.6	70.6	100.0
	Total	34	100.0	100.0	

SET34_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	7	20.6	20.6	20.6
	DBB	27	79.4	79.4	100.0
	Total	34	100.0	100.0	

SET35_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBB	11	32.4	32.4	32.4
	DDB	23	67.6	67.6	100.0
	Total	34	100.0	100.0	

SET37_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DDB	21	61.8	61.8	61.8
	BDB	13	38.2	38.2	100.0
	Total	34	100.0	100.0	

Results of all tests sets

Subject analyzed: Perceivable Contrast

SET100_U

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	none	1	2.9	2.9	2.9
	DBD	2	5.9	5.9	8.8
	MBM	31	91.2	91.2	100.0
	Total	34	100.0	100.0	

SET41_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	3	8.8	8.8	8.8
	BDM	31	91.2	91.2	100.0
	Total	34	100.0	100.0	

SET43_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	10	29.4	29.4	29.4
	BBB	24	70.6	70.6	100.0
	Total	34	100.0	100.0	

SET45_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MDM	5	14.7	14.7	14.7
	MBM	29	85.3	85.3	100.0
	Total	34	100.0	100.0	

SET46_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	30	88.2	88.2	88.2
	DDD	4	11.8	11.8	100.0
	Total	34	100.0	100.0	

SET62_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	5	14.7	14.7	14.7
	BMM	29	85.3	85.3	100.0
	Total	34	100.0	100.0	

SET64_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBB	31	91.2	91.2	91.2
	DDB	3	8.8	8.8	100.0
	Total	34	100.0	100.0	

SET66_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MMD	6	17.6	17.6	17.6
	MMB	28	82.4	82.4	100.0
	Total	34	100.0	100.0	

SET50_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBB	24	70.6	70.6	70.6
	BDB	10	29.4	29.4	100.0
	Total	34	100.0	100.0	

SET51_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DDB	1	2.9	2.9	2.9
	MMD	33	97.1	97.1	100.0
	Total	34	100.0	100.0	

SET53_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BMB	22	64.7	64.7	64.7
	DMD	12	35.3	35.3	100.0
	Total	34	100.0	100.0	

SET55_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DDB	3	8.8	8.8	8.8
	MMB	31	91.2	91.2	100.0
	Total	34	100.0	100.0	

SET57_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	none	2	5.9	5.9	5.9
	DMD	4	11.8	11.8	17.6
	MMM	28	82.4	82.4	100.0
	Total	34	100.0	100.0	

SET59_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBD	7	20.6	20.6	20.6
	MBD	27	79.4	79.4	100.0
	Total	34	100.0	100.0	

SET76_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DBD	23	67.6	67.6	67.6
	DDD	11	32.4	32.4	100.0
	Total	34	100.0	100.0	

SET77_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBD	12	35.3	35.3	35.3
	BBB	22	64.7	64.7	100.0
	Total	34	100.0	100.0	

SET79_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DBB	2	5.9	5.9	5.9
	BMM	32	94.1	94.1	100.0
	Total	34	100.0	100.0	

SET69_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDB	8	23.5	23.5	23.5
	MBM	26	76.5	76.5	100.0
	Total	34	100.0	100.0	

SET72_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MBB	28	82.4	82.4	82.4
	MDD	6	17.6	17.6	100.0
	Total	34	100.0	100.0	

SET74_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DBD	8	23.5	23.5	23.5
	BMB	26	76.5	76.5	100.0
	Total	34	100.0	100.0	

SET91_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDM	10	29.4	29.4	29.4
	BBM	24	70.6	70.6	100.0
	Total	34	100.0	100.0	

SET92_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	3	8.8	8.8	8.8
	MBB	31	91.2	91.2	100.0
	Total	34	100.0	100.0	

SET94_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	none	1	2.9	2.9	2.9
	BBB	28	82.4	82.4	85.3
	DBD	5	14.7	14.7	100.0
	Total	34	100.0	100.0	

SET96_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BMM	29	85.3	85.3	85.3
	DMM	5	14.7	14.7	100.0
	Total	34	100.0	100.0	

SET97_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	none	1	2.9	2.9	2.9
	DDB	28	82.4	82.4	85.3
	DDD	5	14.7	14.7	100.0
	Total	34	100.0	100.0	

SET99_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	none	1	2.9	2.9	2.9
	BBB	27	79.4	79.4	82.4
	DBB	6	17.6	17.6	100.0
	Total	34	100.0	100.0	

SET81_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBD	22	64.7	64.7	64.7
	DDM	12	35.3	35.3	100.0
	Total	34	100.0	100.0	

SET83_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBM	28	82.4	82.4	82.4
	DDM	6	17.6	17.6	100.0
	Total	34	100.0	100.0	

SET85_UL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MMM	31	91.2	91.2	91.2
	DDM	3	8.8	8.8	100.0
	Total	34	100.0	100.0	

SET42_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BMB	15	44.1	44.1	44.1
	DMD	19	55.9	55.9	100.0
	Total	34	100.0	100.0	

SET44_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBD	29	85.3	85.3	85.3
	BBB	5	14.7	14.7	100.0
	Total	34	100.0	100.0	

SET47_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBB	7	20.6	20.6	20.6
	DBB	27	79.4	79.4	100.0
	Total	34	100.0	100.0	

SET49_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	none	1	2.9	2.9	2.9
	BDB	25	73.5	73.5	76.5
	MBM	8	23.5	23.5	100.0
	Total	34	100.0	100.0	

SET52_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	4	11.8	11.8	11.8
	BDM	30	88.2	88.2	100.0
	Total	34	100.0	100.0	

SET54_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBD	20	58.8	58.8	58.8
	MBD	14	41.2	41.2	100.0
	Total	34	100.0	100.0	

SET56_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	none	1	2.9	2.9	2.9
	BBB	11	32.4	32.4	35.3
	DDB	22	64.7	64.7	100.0
	Total	34	100.0	100.0	

SET67_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DBD	24	70.6	70.6	70.6
	BMB	10	29.4	29.4	100.0
	Total	34	100.0	100.0	

SET58_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBB	8	23.5	23.5	23.5
	DBD	26	76.5	76.5	100.0
	Total	34	100.0	100.0	

SET68_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DDB	10	29.4	29.4	29.4
	MMB	24	70.6	70.6	100.0
	Total	34	100.0	100.0	

SET60_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBM	15	44.1	44.1	44.1
	DDM	19	55.9	55.9	100.0
	Total	34	100.0	100.0	

SET70_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	11	32.4	32.4	32.4
	BMM	23	67.6	67.6	100.0
	Total	34	100.0	100.0	

SET61_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MDM	29	85.3	85.3	85.3
	MBM	5	14.7	14.7	100.0
	Total	34	100.0	100.0	

SET71_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBD	20	58.8	58.8	58.8
	DDM	14	41.2	41.2	100.0
	Total	34	100.0	100.0	

SET63_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BMM	21	61.8	61.8	61.8
	DMM	13	38.2	38.2	100.0
	Total	34	100.0	100.0	

SET73_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	24	70.6	70.6	70.6
	BBB	10	29.4	29.4	100.0
	Total	34	100.0	100.0	

SET65_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	none	1	2.9	2.9	2.9
	DMD	8	23.5	23.5	26.5
	MMM	25	73.5	73.5	100.0
	Total	34	100.0	100.0	

SET75_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MBB	10	29.4	29.4	29.4
	MDD	24	70.6	70.6	100.0
	Total	34	100.0	100.0	

SET78_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DDB	28	82.4	82.4	82.4
	DDD	6	17.6	17.6	100.0
	Total	34	100.0	100.0	

SET88_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DDB	6	17.6	17.6	17.6
	MMD	28	82.4	82.4	100.0
	Total	34	100.0	100.0	

SET80_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DBD	29	85.3	85.3	85.3
	DDD	5	14.7	14.7	100.0
	Total	34	100.0	100.0	

SET89_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DBB	9	26.5	26.5	26.5
	BMM	25	73.5	73.5	100.0
	Total	34	100.0	100.0	

SET82_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	23	67.6	67.6	67.6
	DDD	11	32.4	32.4	100.0
	Total	34	100.0	100.0	

SET90_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DBD	26	76.5	76.5	76.5
	MBM	8	23.5	23.5	100.0
	Total	34	100.0	100.0	

SET84_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MMM	30	88.2	88.2	88.2
	DDM	4	11.8	11.8	100.0
	Total	34	100.0	100.0	

SET86_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MMM	27	79.4	79.4	79.4
	MDD	7	20.6	20.6	100.0
	Total	34	100.0	100.0	

SET87_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBB	9	26.5	26.5	26.5
	BDB	25	73.5	73.5	100.0
	Total	34	100.0	100.0	

SET95_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDM	27	79.4	79.4	79.4
	BBM	7	20.6	20.6	100.0
	Total	34	100.0	100.0	

SET93_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MMD	14	41.2	41.2	41.2
	MMB	20	58.8	58.8	100.0
	Total	34	100.0	100.0	

SET95_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDM	27	79.4	79.4	79.4
	BBM	7	20.6	20.6	100.0
	Total	34	100.0	100.0	

SET98_DL

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	27	79.4	79.4	79.4
	MBB	7	20.6	20.6	100.0
	Total	34	100.0	100.0	

<u>Results of all tests sets</u>

Subject analyzed: Perceptive ranking of coloured images against greyscaled images

SET101_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBM	28	82.4	82.4	82.4
	YBG	6	17.6	17.6	100.0
	Total	34	100.0	100.0	

SET102_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DDB	32	94.1	94.1	94.1
	YYY	2	5.9	5.9	100.0
	Total	34	100.0	100.0	

SET103_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	none	1	2.9	2.9	2.9
	BDD	31	91.2	91.2	94.1
	GYY	2	5.9	5.9	100.0
	Total	34	100.0	100.0	

SET107_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	18	52.9	52.9	52.9
	YBG	16	47.1	47.1	100.0
	Total	34	100.0	100.0	

SET108_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MDD	29	85.3	85.3	85.3
	GYY	5	14.7	14.7	100.0
	Total	34	100.0	100.0	

SET109_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	28	82.4	82.4	82.4
	YYY	6	17.6	17.6	100.0
	Total	34	100.0	100.0	

SET104_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBD	28	82.4	82.4	82.4
	BBG	6	17.6	17.6	100.0
	Total	34	100.0	100.0	

SET105_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MBM	20	58.8	58.8	58.8
	YBY	14	41.2	41.2	100.0
	Total	34	100.0	100.0	

SET106_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DBD	32	94.1	94.1	94.1
	YYY	2	5.9	5.9	100.0
	Total	34	100.0	100.0	

SET113_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	none	1	2.9	2.9	2.9
	MBM	23	67.6	67.6	70.6
	GBG	10	29.4	29.4	100.0
	Total	34	100.0	100.0	

SET114_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DMM	26	76.5	76.5	76.5
	YGG	8	23.5	23.5	100.0
	Total	34	100.0	100.0	

SET115_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MMD	26	76.5	76.5	76.5
	GYY	8	23.5	23.5	100.0
	Total	34	100.0	100.0	

SET116_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DDB	27	79.4	79.4	79.4
	BIBIBI	7	20.6	20.6	100.0
	Total	34	100.0	100.0	

SET117_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	none	1	2.9	2.9	2.9
	DBD	22	64.7	64.7	67.6
	BIBIBI	11	32.4	32.4	100.0
	Total	34	100.0	100.0	

SET118_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	none	1	2.9	2.9	2.9
	BDD	23	67.6	67.6	70.6
	BIBIBI	10	29.4	29.4	100.0
	Total	34	100.0	100.0	

SET110_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DDM	28	82.4	82.4	82.4
	YYG	6	17.6	17.6	100.0
	Total	34	100.0	100.0	

SET111_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBD	24	70.6	70.6	70.6
	YBG	1	2.9	2.9	73.5
	GYB	9	26.5	26.5	100.0
	Total	34	100.0	100.0	

SET112_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DMD	21	61.8	61.8	61.8
	YGY	13	38.2	38.2	100.0
	Total	34	100.0	100.0	

SET119_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DDM	27	79.4	79.4	79.4
	GGG	7	20.6	20.6	100.0
	Total	34	100.0	100.0	

SET120_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DMD	31	91.2	91.2	91.2
	GGG	3	8.8	8.8	100.0
	Total	34	100.0	100.0	

SET121_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	MDD	29	85.3	85.3	85.3
	GGG	5	14.7	14.7	100.0
	Total	34	100.0	100.0	

SET122_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BBD	30	88.2	88.2	88.2
	YYY	4	11.8	11.8	100.0
	Total	34	100.0	100.0	

SET123_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDB	25	73.5	73.5	73.5
	YYY	9	26.5	26.5	100.0
	Total	34	100.0	100.0	

SET124_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DBB	33	97.1	97.1	97.1
	YYY	1	2.9	2.9	100.0
	Total	34	100.0	100.0	

SET125_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DDB	18	52.9	52.9	52.9
	GGB	16	47.1	47.1	100.0
	Total	34	100.0	100.0	

SET126_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BMB	16	47.1	47.1	47.1
	BYB	18	52.9	52.9	100.0
	Total	34	100.0	100.0	

SET127_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DBB	29	85.3	85.3	85.3
	YGG	5	14.7	14.7	100.0
	Total	34	100.0	100.0	

SET128_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	DDB	20	58.8	58.8	58.8
	GGY	14	41.2	41.2	100.0
	Total	34	100.0	100.0	

SET129_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	1	2.9	2.9	2.9
	DBD	19	55.9	55.9	58.8
	GYG	14	41.2	41.2	100.0
	Total	34	100.0	100.0	

SET130_C

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	BDD	21	61.8	61.8	61.8
	YGG	13	38.2	38.2	100.0
	Total	34	100.0	100.0	

APPENDIX III (b)

The below is the survey used for the test on human's perception of his night-time environment, where the results were analyzed in Chapter 5.2. The results derived from all the responses is attached behind this survey.

Survey for Appearance of Night-time Environment

Name (optional) :

Age: Sex:

Please indicate if you are :

(1) Undergraduate Architectural student (2) Postgraduate Architectural student

---

Section A: Kindly indicate your choice clearly for each of the question below.

Qn 1 Picture yourself walking through the city at night.
Please rank all of the following stated urban elements you would want to see, in order of importance. (1 – most important & 7 – least important)

☐	Prominent Building (appearance – wise / physical / historic)	☐	Public Transport Stations (Bus-stops, Taxi stands)
☐	Pathway / walkways	☐	Parks / Gardens
☐	Familiar Buildings you recognized in the day.	☐	Bridges
☐	Landmarks		

Qn 2 Imagine yourself walking through the city at night.
For each urban feature, at a scale of 1-7, please rank the importance of seeing each of the following lit features in the environment (1 – most important & 7 – least important)

1. Textures lighting (of buildings or plants) ☐
2. Brightly lit areas ☐
3. Vegetation or illumination of nature ☐
4. Colour lighting ☐
5. Temporary Lighting installations (Street-art) ☐
6. Dynamic-scene changing lighting (Interactive lighting) ☐
7. Lit Architectural details ☐

SECTION B: Please indicate your choice of Yes or No clearly by underlining the selected answer for the list of questions below:

Qn 3 Do you enjoy walking in the city at night?
YES NO

Qn 4 Would you prefer a city where it would be easy to orientate yourself at night?
YES NO

Qn 5 Would you prefer a city where the daytime appearance is very different from the night-time appearance?
YES NO

Qn 6 Do you think a city with beautifully illuminated skyline would be attractive to you?
YES NO

Qn 7 Is it important for you to know your orientation and the recognition of the city's element at night?
YES NO

Qn 8 Do you feel any pleasure from knowing your orientation at night?
YES NO

Qn 9 Do you feel any unsafe if you do not recognize your surroundings or are lost, at night?
YES NO

Qn 10 Would increasing the brightness level of the surroundings help decrease your fear, if you are lost at night?
YES NO

Qn 11 Does differentiating the different areas (parks, main pedestrian walkways, and waterfront) in different lighting colours, help you in easy identification of these spaces?
YES NO

Qn 12 Do you like the use of colour lighting in lighting of urban elements?
YES NO

Qn 13 Do you like colour-changing lighting for lighting of urban spaces?
YES NO

Qn 14 Do you take note of the Singapore city lighting when you are strolling in the city at night?
YES NO

Qn 15 Do you associate orangey-hue lighting rendering with lighting of historic buildings?
YES NO

Qn 16 Do you think the lighting design of our city can be improved?
YES NO

SECTION C: For the series of pictures shown, please indicate which of the picture you would prefer, by underlining the picture annotation, below the picture.

Qn 17

(Picture 1)

(Picture 2)

Qn 18

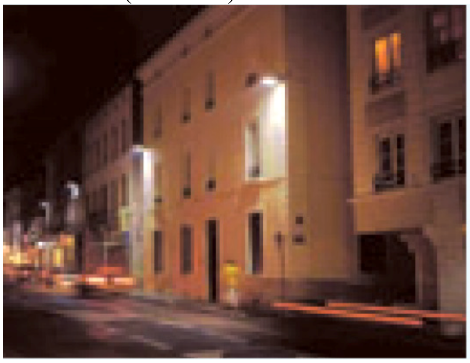
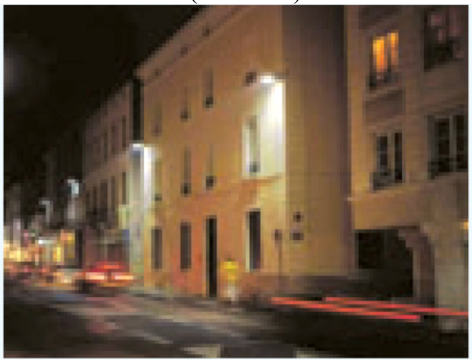
(Picture 1) (Picture 2)

Qn 19

(Picture 1) (Picture 2)

Qn 20

(Picture 1) (Picture 2)

Thank you for your participation in the above questionnaire.
Your help is greatly appreciated.

Survey analysis

Survey analysis	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Undergrad / Post grad	P	P	P	P	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
Sex:	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
Question 1																				
Prominent Building (appearance –wise / physical / historic)	3	3	4	4	3	7	5	5	5	3	4	2	1	1	3	1	1	2	3	1
Pathway / walkways	4	4	3	3	6	2	3	4	2	5	6	1	6	2	5	2	5	3	7	5
Familiar Buildings you recognized in the day.	1	2	7	2	2	5	1	1	1	1	1	7	2	3	6	3	2	7	2	3
Landmarks	2	1	1	1	1	6	6	2	6	2	2	3	4	5	1	4	3	1	5	2
Public Transport Stations	5	5	2	5	4	4	7	3	7	7	3	4	5	7	7	6	7	4	4	7
Parks / Gardens	7	6	5	6	7	1	2	7	3	6	7	6	7	6	4	7	6	5	6	6
Bridges	6	7	4	7	5	3	4	4	4	4	5	5	3	4	2	5	4	6	1	4
Question 2																				
Textures lighting (of buildings or plants)	3	1		2	2	2	2	5	6	6	3	1	4	1	4	1	3	4	6	2
Brightly lit areas	4	1		1	1	7	3	4	7	7	1	3	1	3	7	7	7	4	3	5
Vegetation or illumination of nature	1	3		5	4	1	6	7	3	4	7	7	7	2	5	3	2	5	7	4
Colour lighting	7	5		3	6	5	6	1	5	1	5	4	3	7	6	2	6	6	1	6
Temporary Lighting installations (Street-art)	5	7		6	5	3	5	3	2	2	6	6	5	4	1	4	4	3	2	3
Dynamic-scene changing lighting (Interactive lighting)	6	6		7	7	6	7	2	1	3	2	2	6	6	2	5	5	5	5	7
Lit Architectural details	2	2		4	3	4	4	6	4	5	4	5	2	5	3	6	1	5	4	1
Question 3 Do you enjoy walking in the city at night?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Question 4 Would you prefer a city where it would be easy to orientate yourself at night?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Question 5 Would you prefer a city where the daytime appearance is very different from the night-time appearance?	Y	N	N	Y	Y	Y	Y	N	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Y
Question 6 Do you think a city with beautifully illuminated skyline would be attractive to you?	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Question 7 Is it important for you to know your orientation and the recognition of the city's element at night?	Y	Y	N	Y	N	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
Question 8 Do you feel any pleasure from knowing your orientation at night?	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
Question 9 Do you feel any unsafe if you do not recognize your surroundings or are lost, at night?	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
Question 10 Would increasing the brightness level of the surroundings help decrease your fear, if you are lost at night?	Y	Y	N	Y	N	Y	N	Y	Y	N	Y	Y	Y	Y	N	N	Y	N	N	Y
Question 11 Does differentiating the different areas (parks, main pedestrian walkways, and waterfront) in different lighting colours, help you in easy identification of these spaces?	Y	Y	N	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
Question 12 Do you like the use of colour lighting in lighting of urban elements?	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N
Question 13 Do you like colour-changing lighting for lighting of urban spaces?	N	Y	N	Y	N	N	N	Y	Y	Y	N	Y	Y	N	N	N	N	N	Y	N
Question 14 Do you take note of the Singapore city lighting when you are strolling in the city at night?	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
Question 15 Do you associate orangey-hue lighting rendering with lighting of historic buildings?	Y	N	N	N	Y	Y	N	N	Y	N	N	N	N	Y	Y	Y	Y	N	N	N
Question 16 Do you think the lighting design of our city can be improved?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Question 17	1	2	2	2	1	2	2	1	1	1	1	2	2	2	1	1	1	1	2	1
Question 18	1	2	2	2	2	2	2	1	1	1	2	1	2	1	2	2	2	1	2	2
Question 19	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1
Question 20	2	2	1	2	2	1	2	2	1	2	2	2	2	2	2	2	2	2	2	2

Survey analysis	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
Undergrad / Post grad	U	U	P	U	P	U	U	U	P	U	U	P	U	U	U	U	U	U	U	U
Sex:	F	F	F	F	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M	M
Question 1																				
Prominent Building (appearance –wise / physical / historic)	1	2	5	1	2	6	2	6	5	1	1	5	2	5	4	5	1	5	2	6
Pathway / walkways	5	1	1	2	1	1	1	3	1	4	4	6	3	4	2	3	3	1	5	1
Familiar Buildings you recognized in the day.	3	3	2	5	5	4	4	7	3	2	5	1	4	3	6	1	4	6	1	2
Landmarks	2	6	3	3	4	5	3	4	4	3	2	2	6	1	3	2	2	2	4	5
Public Transport Stations	7	4	4	7	3	2	7	5	2	7	7	4	7	7	7	4	5	7	6	4
Parks / Gardens	6	5	6	4	6	7	6	1	7	5	3	3	5	6	5	6	6	3	3	3
Bridges	4	7	7	6	7	3	5	2	6	6	6	7	1	2	1	7	7	4	7	7
Question 2																				
Textures lighting (of buildings or plants)	2	6	2	1	6	4	4	4	4	5	5	3	2	4	2	1	4	2	2	4
Brightly lit areas	5	5	1	3	1	3	7	7	1	7	7	1	4	5	4	2	3	1	1	1
Vegetation or illumination of nature	4	7	3	7	2	6	5	2	5	6	6	4	7	7	6	7	6	4	6	3
Colour lighting	6	3	6	5	7	7	6	5	6	3	4	5	5	6	5	5	7	6	7	2
Temporary Lighting installations (Street-art)	3	1	4	6	5	5	3	3	2	1	1	6	2	3	7	3	5	7	4	5
Dynamic-scene changing lighting (Interactive lighting)	7	4	7	4	4	1	2	1	7	2	3	7	4	2	3	4	1	5	3	7
Lit Architectural details	1	2	5	2	3	2	1	6	3	4	2	2	2	1	1	6	2	3	5	6
Question 3 Do you enjoy walking in the city at night?	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Question 4 Would you prefer a city where it would be easy to orientate yourself at night?	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
Question 5 Would you prefer a city where the daytime appearance is very different from the night-time appearance?	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Question 6 Do you think a city with beautifully illuminated skyline would be attractive to you?	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y
Question 7 Is it important for you to know your orientation and the recognition of the city's element at night?	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y
Question 8 Do you feel any pleasure from knowing your orientation at night?	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	N	Y	Y	Y
Question 9 Do you feel any unsafe if you do not recognize your surroundings or are lost, at night?	Y	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	Y	Y	N	N	Y	Y	Y	Y
Question 10 Would increasing the brightness level of the surroundings help decrease your fear, if you are lost at night?	Y	N	Y	Y	Y	N	N	N	Y	N	Y	Y	Y	N	N	Y	Y	N	Y	Y
Question 11 Does differentiating the different areas (parks, main pedestrian walkways, and waterfront) in different lighting colours, help you in easy identification of these spaces?	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	Y	N	N	Y	Y
Question 12 Do you like the use of colour lighting in lighting of urban elements?	N	Y	Y	Y	Y	N	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
Question 13 Do you like colour-changing lighting for lighting of urban spaces?	N	N	Y	Y	N	Y	N	Y	N	Y	Y	Y	N	Y	Y	N	N	Y	Y	N
Question 14 Do you take note of the Singapore city lighting when you are strolling in the city at night?	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y
Question 15 Do you associate orangey-hue lighting rendering with lighting of historic buildings?	N	Y	Y	Y	N	N	N	N	N	Y	Y	N	N	N	Y	Y	N	Y	Y	Y
Question 16 Do you think the lighting design of our city can be improved?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Question 17	1	1	2	2	1	1	1	2	2	2	1	2	1	2	1	1	1	1	2	1
Question 18	2	2	2	2	2	1	2	2	2	2	2	1	2	2	2	2	1	2	2	2
Question 19	1	2	1	1	2	2	1	1	1	1	1	1	1	2	1	1	2	1	1	1
Question 20	2	2	2	2	2	1	1	2	2	1	2	2	2	1	2	1	1	2	2	1

Survey analysis

Undergrad / Post grad
Sex:

Question 1

	1ST CHOICE	% OF PEOPLE	2ND CHOICE	% OF PEOPLE	3RD CHOICE	% OF PEOPLE	4TH CHOICE	% OF PEOPLE	5th CHOICE	% OF PEOPLE	6th CHOICE	% OF PEOPLE	7th CHOICE	% OF PEOPLE	TOTAL PEOPLE
Prominent Building (appearance –wise / physical / historic)	9	23	8	20	6	15	4	10	9	23	3	8	1	3	40
Pathway / walkways	10	25	5	13	8	20	6	15	6	15	4	10	1	3	40
Familiar Buildings you recognized in the day.	9	23	9	23	7	18	4	10	4	10	3	8	4	10	40
Landmarks	7	18	11	28	7	18	6	15	4	10	5	13	0	0	40
Public Transport Stations	0	0	3	8	3	8	10	25	6	15	2	5	16	40	40
Parks / Gardens	2	5	1	3	6	15	2	5	6	15	15	38	8	20	40
Bridges	3	8	3	8	3	8	10	25	5	13	6	15	10	25	40

Question 2

	1ST CHOICE	% OF PEOPLE	2ND CHOICE	% OF PEOPLE	3RD CHOICE	% OF PEOPLE	4TH CHOICE	% OF PEOPLE	5th CHOICE	% OF PEOPLE	6th CHOICE	% OF PEOPLE	7th CHOICE	% OF PEOPLE	TOTAL PEOPLE
Textures lighting (of buildings or plants)	6	15	**11**	28	4	10	10	26	3	8	5	13	0	0	39
Brightly lit areas	12	31	1	3	7	18	5	13	4	10	0	0	10	26	39
Vegetation or illumination of nature	2	5	4	10	5	13	6	15	5	13	7	18	10	26	39
Colour lighting	3	8	2	5	4	10	2	5	10	26	12	31	6	15	39
Temporary Lighting installations (Street-art)	4	11	5	13	8	21	5	13	8	21	5	13	3	8	38
Dynamic-scene changing lighting (Interactive lighting)	4	11	6	16	4	11	5	13	5	13	5	13	9	24	38
Lit Architectural details	5	13	10	26	5	13	7	18	6	16	5	13	0	0	38

	Y	(%)	N	(%)	T
Question 3 Do you enjoy walking in the city at night?	38	95.0	2	5.0	40
Question 4 Would you prefer a city where it would be easy to orientate yourself at night?	38	95.0	2	5.0	40
Question 5 Would you prefer a city where the daytime appearance is very different from the night-time appearance?	32	80.0	8	20.0	40
Question 6 Do you think a city with beautifully illuminated skyline would be attractive to you?	37	92.5	3	7.5	40
Question 7 Is it important for you to know your orientation and the recognition of the city's element at night?	33	82.5	7	17.5	40
Question 8 Do you feel any pleasure from knowing your orientation at night?	35	87.5	5	12.5	40
Question 9 Do you feel any unsafe if you do not recognize your surroundings or are lost, at night?	33	82.5	7	17.5	40
Question 10 Would increasing the brightness level of the surroundings help decrease your fear, if you are lost at night?	24	60.0	16	40.0	40
Question 11 Does differentiating the different areas (parks, main pedestrian walkways, and waterfront) in different lighting colours, help you in easy identification of these spaces?	31	77.5	9	22.5	40
Question 12 Do you like the use of colour lighting in lighting of urban elements?	31	77.5	9	22.5	40
Question 13 Do you like colour-changing lighting for lighting of urban spaces?	19	47.5	21	52.5	40
Question 14 Do you take note of the Singapore city lighting when you are strolling in the city at night?	36	90.0	4	10.0	40
Question 15 Do you associate orangey-hue lighting rendering with lighting of historic buildings?	18	45.0	22	55.0	40
Question 16 Do you think the lighting design of our city can be improved?	40	100.0	0	0.0	40

	O1	(%)	O2	(%)	T
Question 17	22	55.0	18	45.0	40
Question 18	10	25.0	30	75.0	40
Question 19	33	82.5	7	17.5	40
Question 20	10	25.0	30	75.0	40

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