

# Developing a City Skyline for Hong Kong Using GIS and Urban Design Guidelines

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**Abstract:** *Hong Kong is a metropolis with a dense population. The need to cope with rapid population growth under the constraint of limited amounts of developable lands has resulted in a concentrated development of high-rises. Enterprising developers have clearly exploited such behaviors in the urban development of Hong Kong. Buildings have been constructed to maximum heights whenever a height restriction was not specified in the authorization to build, or stretched to their limits sideways if given a height restriction. Both of these situations have given rise to either repetitive and monotonous roofscapes or walls of regimental building flanking the harbor front. The objective of this research is to evaluate and redesign the city skyline of Hong Kong based on Urban Design Guidelines established by the Planning Department. The study makes use of the Geographic Information System (GIS) technology and its 3-dimensional (3D) modeling functions to construct, assess, and analyze the city skyline.*

## Introduction

The term “city skyline” refers to a profile of buildings that forms the cityscape in daytime and the silhouette at night (Lim and Heath 1993). It comprises a group of tall buildings against the undulating backdrop of mountains enwrapping in a natural setting. City skyline registers unique characteristics of a city’s landscape shaped by planning controls, topographical conditions, commercial considerations, building design parameters, and environmental concerns. The cities of New York, San Francisco, Sydney, Shanghai, and Toronto are among major metropolitan cities in the world with uniquely identifiable skylines.

Cities today are much more concerned about their images because a good impression is key to tourist attraction. Local governments of major cities have tried various means to enhance the visual quality of their city skylines by exerting more control over building heights and design parameters, as well as by constructing more green corridors (Council of the City Vancouver 1997; Lower Manhattan Development Corporation 2002; United Kingdom Parliament 2003). The question is whether there are any standards to form judgment in our assessment of a city skyline. What criteria or factors are used to form an opinion about a city skyline? Are there objective methodologies to define these criteria?

Aesthetic value has emerged as an important criterion for evaluating the quality of a city skyline (Delafons 1990; Habe 1989; Preiser and Rohane 1988). A great deal of focus in aesthetic interests concerns the height or the design quality of a building. Some writers have attempted to quantify the design quality of buildings with associated preferences. Stamps (1991) investigated the influence of height, complexity, and style on the preference of individual buildings, and concluded that relative complexity is a predictor of preference for individual high-rise buildings. Heath, Smith, and Lim (2000) investigated the effects of the silhouette and façade complexity of tall buildings on visual preferences of skylines. They found that a higher level of preference, arousal, and

pleasure usually is associated with a higher silhouette complexity and façade intricacy.

There is general agreement that buildings should not be considered in isolation but in reference to their unique topographical and landscape setting (Planning Department HKSAR 2001; Yu 2000; Bishop and Karadaglis 1997). Both man-made (including cultural and socioeconomic aspects) and natural (embracing mountains and waterbodies) contexts should exist coherently and in harmony with each another (Planning Department 2001). For instance, the skyline should preserve some view corridors or breezeways to mountain backdrops or natural landscapes. Open spaces or green corridors between buildings should be protected to yield a cityscape of characteristic traits and visual aesthetics.

This article outlines the criteria for skyline development and assessment in Hong Kong. It illustrates the use of 3D and viewshed analytical techniques of a GIS to visualize and practice Urban Design Guidelines. The study also proposes further recommendations to enhance the skyline of the Victoria Harbor along the waterfronts of the Hong Kong Island.

## The Skyline of Hong Kong

Hong Kong is blessed with a picturesque image along high hills overlooking the Victoria Harbor. This stretch of urban landscape is characterized with interestingly shaped high-rises set against a mountainous backdrop. Such a unique urban montage has become the image and identity of Hong Kong. Unfortunately, this beautiful vista has gradually been breached by uncontrolled high-rise developments along the harbor front (Figure 1). Many concerned citizens have protested that exceptionally tall buildings have blocked views of inland sceneries and landscapes. Planners have criticized that views from the harbor to the ridgeline and the Peak have not been duly protected (Yu 1999; Tam and Hai 2001). Buildings in districts where height controls are enforced exhibit a uniform but monotonous roofscape, reflecting the widespread practice in urban construction that observes the maxi-



**Figure 1.** The Two IFC (International Finance Centre) Building

The Two IFC is an immensely tall tower standing at the waterfront, overpowers the surrounding townscape. Its presence conflicts not only with the character and scale of the surrounding structures but also the height limitation of city skyline given its frontage position.

mum height as the literal cutoff. Tsim Sha Tsui East (Figure 2) serves as a regrettable example that should be avoided at all cost. Sideward expansion of buildings in these areas to compensate for reduced profits due to lower heights is extensive. This inclination has resulted in walls of building forming unattractive “canyons” flanking the waterfront.

While vertical development is unavoidable in Hong Kong, it has been agreed generally that ridgelines are valuable tourist and visual assets, and their preservation should be given special consideration in the process of urban development. Moreover, one of many recommendations is to encourage height variation within the same area such that buildings along the coastlines should get progressively higher inland to produce a more interesting cityscape (Tam and Hai 2001). The terrace-like profile often produces magnificent skyline effect (Tam and Hai 2001). The Manhattan skyline in New York, for example, is regulated from two scenic viewpoints, located respectively at the Brooklyn Heights Promenade and the Victory Boulevard on the Staten Island, where buildings are arranged in stepped-like profiles with taller developments located inland and lower structures along the waterfront. Another example is Shanghai, where buildings alongside the Huangpu River have undulating building heights that get progressively taller from the river. These city skylines exemplify that diversity in building heights adds variety and visual stimulus for the viewers. Serious consideration should be given to designating coastal sites for low-density developments. Sadly and contrary to sensible practices, the coastal strips of Hong Kong are packed with mega-towers obstructing the views of lower buildings located inland and behind them.



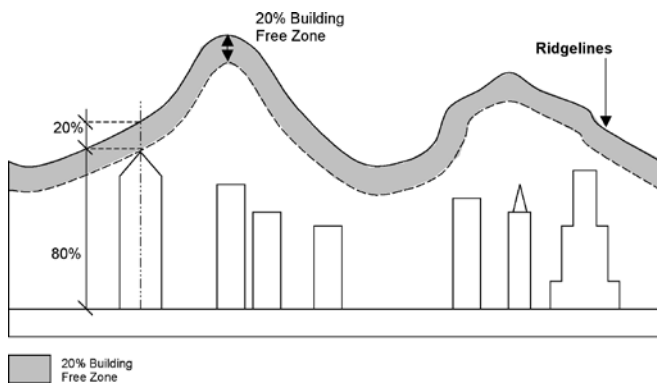
**Figure 2.** Buildings in Tsim Sha Tsui East

Height controls that were strictly enforced at one time exhibit a uniform but monotonous roofscape. Sideward expansion of buildings to maximize floor space in compensation for reduced profit margins due to lower heights is evident in this area.

## Urban Design Guidelines

Barnett (1982, p. 12) defined urban design as “*the process of giving physical design direction to urban growth, conservation and change. It sits at the interface between architecture and planning, and its emphasis on physical attributes usually restricts its scale of operation to arrangements of streets, buildings, and landscapes.*” Urban Design Guidelines have been articulated at both regional and local levels and published documents have extended the main ideas on city skyline and predominant built characters (Planning Committee 2002). In the United States, Hamilton County and City of Cincinnati collaborated to develop an overall urban design framework for the central riverfront (Urban Design Associates 2000). The guidelines regulated heights of buildings to preserve views from the downtown to the river and vice versa. Specifically, buildings were seen stepping down from Fort Washington Way to Mehring Way, with stadiums pushing as far eastward or westward as possible. This approach has guaranteed that existing and future developments can enjoy the most prestigious positions along the riverfront. Similar guidelines were applied in Lower Manhattan to embrace a diversity of mass, building heights and configuration, and a variety of architectural styles (Lower Manhattan Development Corporation 2002). New buildings were carefully planned in consideration of view corridors and access to the waterfront (Bell et al. 2002). In the United Kingdom, city development guidelines for London were adopted as a framework to ensure that tall buildings are designed as part of a coherent whole informed by clear visions as opposed to ad hoc, piecemeal, and reactive measures (Evans 2002). Tall buildings deemed detracting to the views, skyline, and townscape were encouraged to move and would be replaced by lower rise and contextual development compatible with the wider areas.

The Planning Department initiated a study on “Urban Design Guidelines for Hong Kong” with the first round of public consultation to collect opinions in February and March 2000. A second public consultation was arranged in 2002 to present

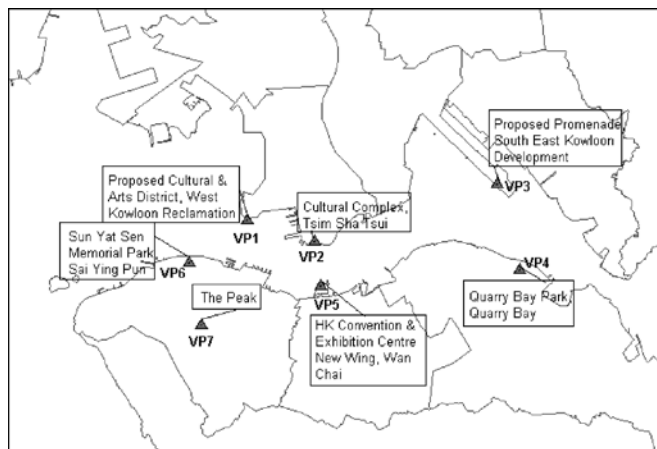


**Figure 3.** Ridgeline Protection (Adapted from Planning Department HKSAR, 2002)

the consultants' findings and to seek public views on the recommendations (Planning Department HKSAR 2002). Clearly-defined guidelines would help promote public awareness on design considerations besides providing a broad framework for urban design assessments. The study has provided many ideas on how to structure or improve the city skyline. It suggests that a good city skyline should exhibit the following qualities:

- Considers the relationships amongst buildings and between buildings and open space
- Takes into account the overall design of a city as a whole and its harmony with surrounding natural features such as ridgelines and peaks
- Enhances townscapes and local environments of quality character and interest
- Preserves the centrality of some buildings as the city's landmarks

The proposed guidelines also outline criteria and parameters deemed essential in augmenting the visual quality of a city's skyline. These include ridgeline protection, vantage positions, landmarks at strategic locations, and variation in building heights as discussed below.



**Figure 4.** Proposed Vantage Points for Preserving View Corridors to Ridgelines (Adapted from Planning Department HKSAR, 2002)

**Viewing from Kowloon toward ridgelines on the Hong Kong side:**

- VP1 Proposed Cultural and Art District, West Kowloon Reclamation
- VP2 Cultural Complex, Tsim Sha Tsui
- VP3 Proposed Promenade, South East Kowloon Development

**Viewing from Hong Kong toward ridgelines on the Kowloon side:**

- VP4 Quarry Bay Park, Quarry Bay
- VP5 Hong Kong Convention and Exhibition Centre New Wing, Wan Chai
- VP6 Sun Yat Sen Memorial Park, Sai Ying Pun

**Preservation of views of the Victoria Harbor:**

- VP7 Lion Pavilion, The Peak

**Ridgeline Protection**

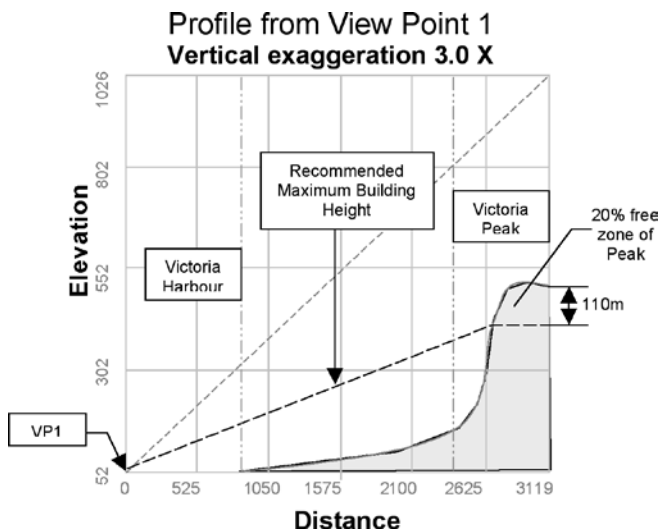
Urban Design Guidelines of Hong Kong recommend that at least 20% of building free zone must be sustained against the backdrop of ridgelines from various viewing points (Figure 3). In effect, the contour of maximum building heights can be plotted against the ridgelines to ascertain compliance with this recommendation. New buildings, and particularly the mega-towers, are advised not to intrude upon the 20% building free zone.

**Vantage Positions**

The Urban Design Guidelines also recommend seven vantage points surrounding the Victoria Harbor that form the bases of preservation of views to ridgelines and peaks (Figure 4). Visual access from these vantage positions to the waterfront must be maintained at status quo or enhanced by providing additional view corridors. The aim is to allow visual permeability from the waterfront into the inner areas. This guideline would help develop a better microclimate of the inner areas by facilitating air movement through breezeways.

**Landmarks at Strategic Locations**

The most recognizable cities in the world are often characterized by a number of towers rising from the ground. Mega-towers often have been selected as landmarks of a city, and they should be given special attention. These landmarks of certain heights should be introduced at suitable locations, such as at the harbor entrance or to mark a district. The threshold height at which a building is deemed a mega-tower is suggested at 300 meters or above from the ground level. The provision of mega-towers allows



**Figure 5.** A Profile Analysis for Recommending Maximum Building Heights

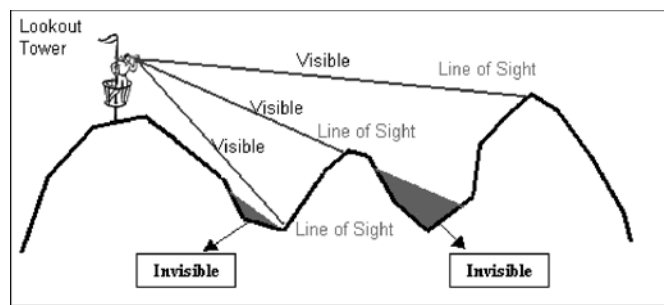
for special consideration of new structures so that their proposed locations must be evaluated against existing setting and their ultimate presence regarded not overly intrusive to maintain the visual coherence of the city.

### Variation in Building Heights

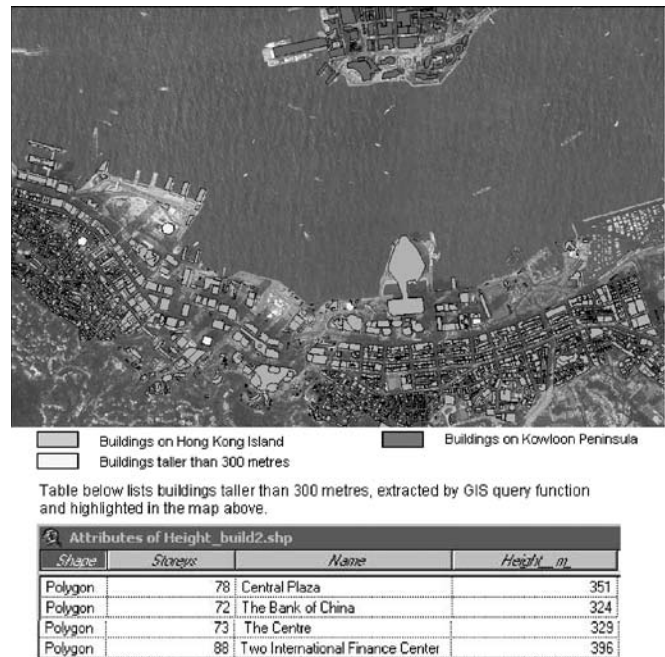
Variations in relief and building height will introduce a more vibrant and dynamic cityscape. The Urban Design Guidelines recommend that terraced-like arrangement of buildings be encouraged where appropriate. Taller developments should be located inland with lower structures closer to the waterfront. The recommendation illustrates with an example of a vertical profile between viewpoint VP1 and the Victoria Peak (as shown in Figure 5). The height of the Victoria Peak is around 545 meters, so that the 20% building free zone is approximately 110 meters below the Peak. The mark for the 20% building free zone is linked with VP1 to yield a line of maximum building heights that increases progressively from the waterfront.

### Visualising Urban Design Guidelines In A GIS

GIS has been used extensively in many 3D applications (He and Tsou 2001; Zhang et al. 2000; Batty et al. 2000). It has been shown a practical means to aid decision making and terrain modeling. The 3D-Analyst extension of ArcView (ESRI 1997) was employed here to convert a portion of the Hong Kong maps in 2D representation into 3D models. Two functions were particularly helpful in this regard: (1) 3D visualization functions and (2) 3D analytical tools. The former permits integration of an orthophoto image and a 2D map to construct a more intuitive model of the same area in 3D perspective. 3D representation, as illustrated by the cross-sectional profile in Figure 5, enables graphic presentation of the 20% building free zone against the



**Figure 6.** Line-of-Sight and Viewshed Analyses from a Vantage Point

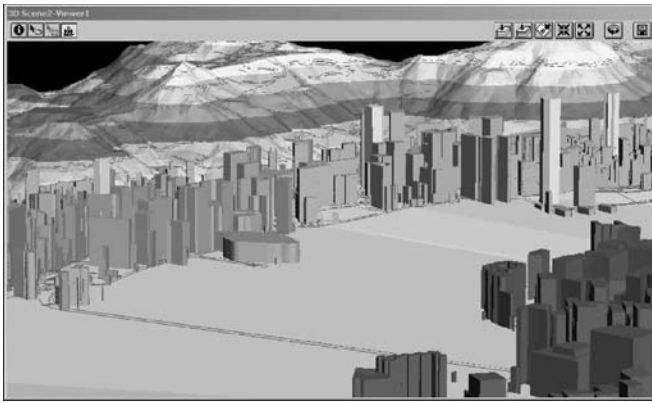


**Figure 7.** The Victoria Harbor in Hong Kong with Landmark Buildings Highlighted

ridgelines such that buildings in violation can be manifested. The 3D analytical tools, on the other hand, support visibility analyses (Figure 6) to examine if a given target is viewable from a point of observation (i.e., the line-of-sight check) and to determine the extent of visible areas from an observation point (i.e., the viewshed inspection).

Both non-spatial and spatial data were used in the 3D modeling and design of the Hong Kong skyline. The Lands and Planning Departments of Hong Kong provided spatial/map data for this study. Building or storey heights were gathered from various sources and incorporated with the spatial data. Orthophotos were also acquired from the Lands Department to provide a realistic backdrop for our skyline profiles.

The following is an account of our attempts to incorporate Urban Design Guidelines with GIS functions to examine skyline development of Hong Kong at the Victoria Harbor. Specifically, we demonstrated how GIS modeling capabilities have enabled the visualization and understanding of Urban Design Guidelines.



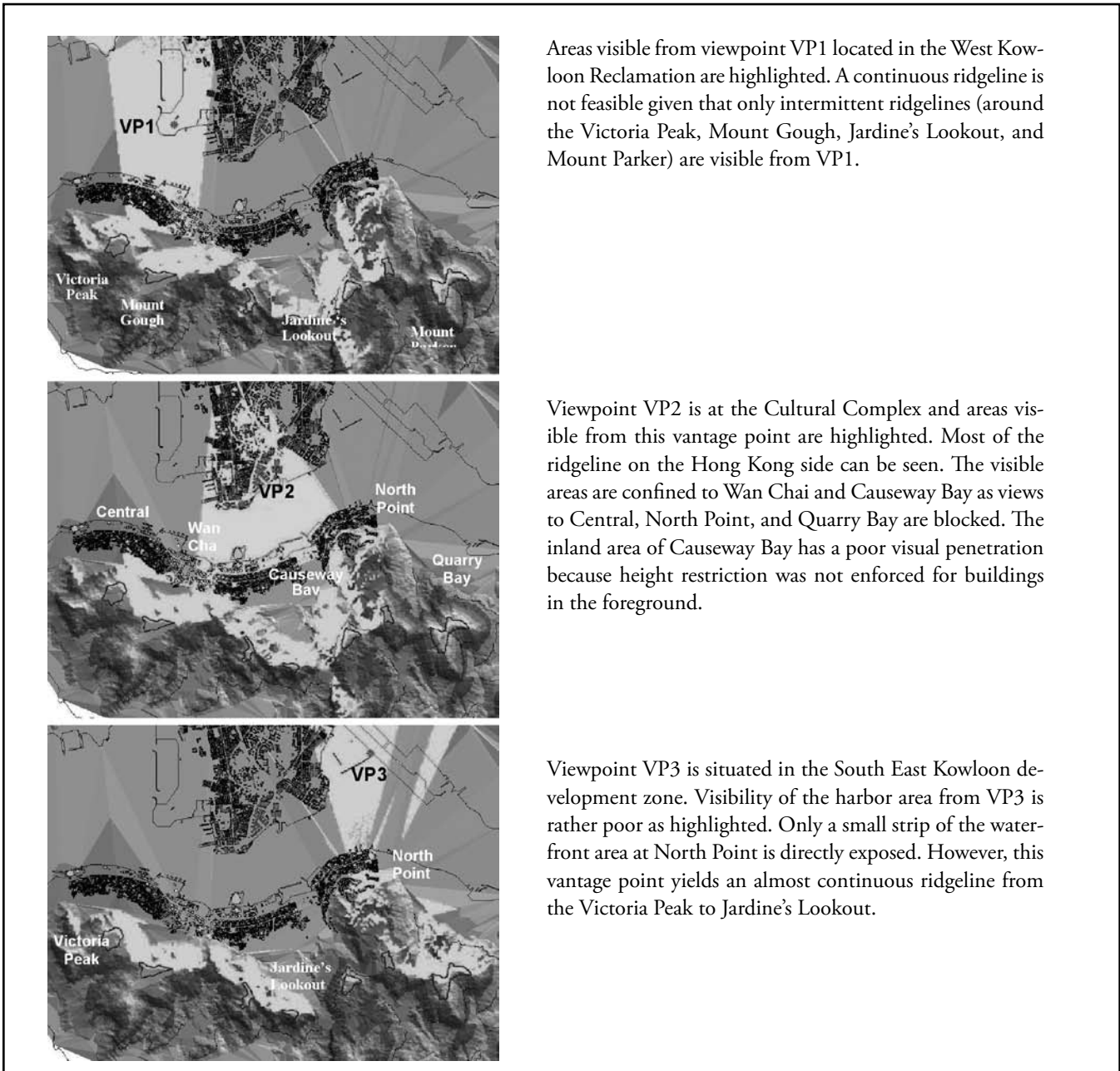
**Figure 8.** A 3D Representation of the Victoria Harbor on the Hong Kong Side

### Procedure 1: 2D Data Compilation and Selection of Landmarks

We began by superimposing a layer of building polygons over an orthophoto image of the Victoria Harbor (Figure 7). We then identified prominent landmarks or mega-towers exceeding 300 meters in heights, as specified in the proposed Urban Design Guidelines of Hong Kong. The recognition of these mega-towers is fundamental to assessing their visual prominence and impacts on the urban scenes.

### Procedure 2: 3D Representation of a Cityscape

A 3D illustration bears a closer resemblance of the location it



**Figure 9.** Viewshed Analyses from Three Vantage Points in Kowloon Overlooking the Hong Kong Side

represents and enhances visualization of the landscape and its associated features. GIS modeling functions were used to create a 3D urban scene of the Victoria Harbor (Figure 8). The 3D urban scene shows the Victoria Harbor front overlooking the Hong Kong Island, with landmark buildings highlighted in yellow. The natural topography is shown as a backdrop to offer contrast in the elevation and enhance realism of the display. The procedure started off by erecting buildings over a terrain. These vertical structures were then shaded in different colors to mark their geographic subdivisions (whether located in Kowloon or Hong Kong Island) and unique characteristics (whether or not a landmark building). While Figure 6 is a static manifestation of a screen shot, the GIS platform actually supports an interactive operational setting to

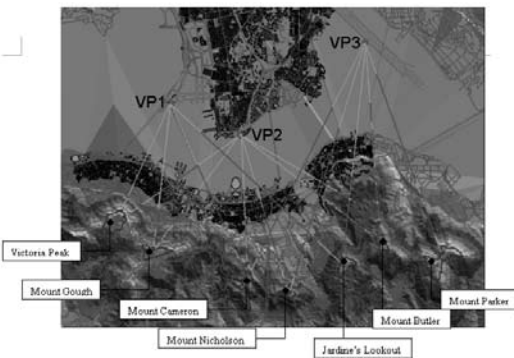
maneuver the 3D urban model from any direction, angle, or zoom level. Such flexibilities heighten exploration and review of Urban Design Guidelines from various perspectives, as exemplified in the discussions that follow.

### Procedure 3: Visibility and Viewshed Analyses

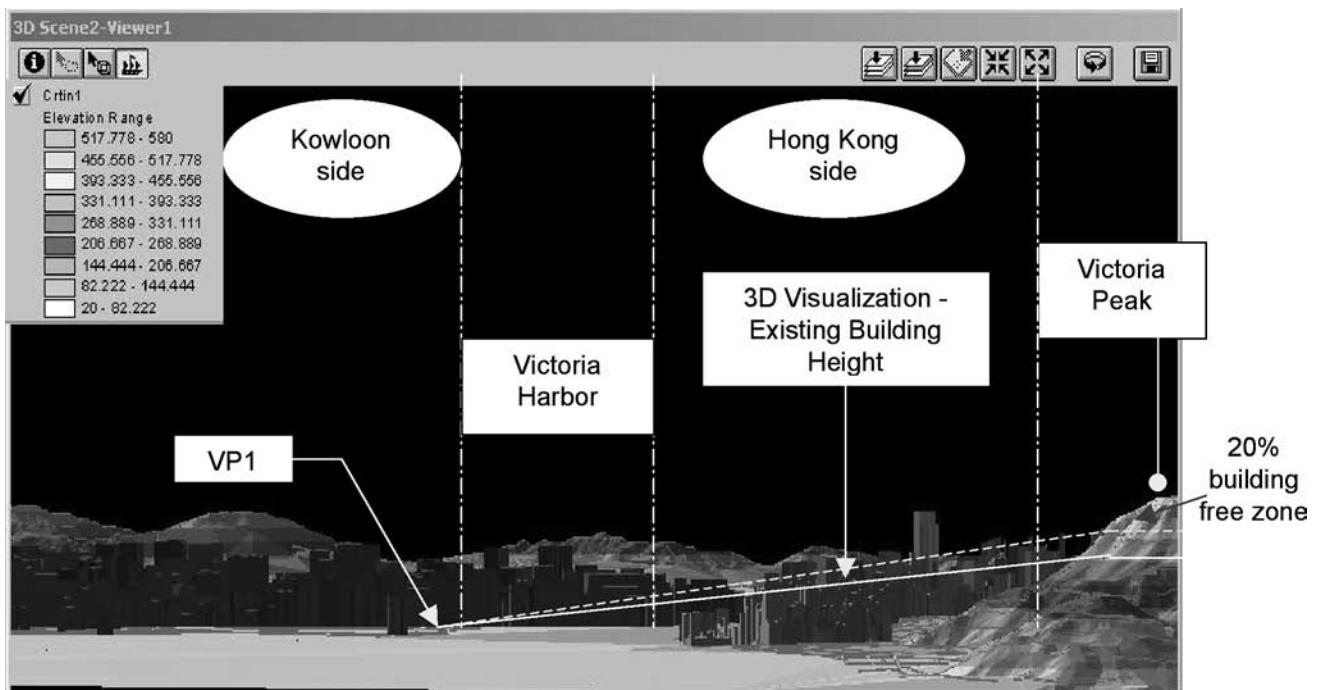
Visibility and viewshed analyses are perhaps the most significant functions of GIS modeling in this study. The procedure allows the specification of a vantage point whereupon an examination of its view corridors to the ridgelines as stipulated in the Urban Design Guidelines can be conducted. Figure 9 shows the results of the viewshed analysis from three vantage points located in Kowloon (VP1, VP2, and VP3). The visible areas were derived with the assumption that the observer was 1.6 meters above sea level (i.e., the average height of a person). These visibility results indicate clearly whether the selected vantage points provide sufficient coverage of Hong Kong's scenery at the harbor front, as well as the extent of visual penetration into the inland areas. They also highlight major viewing obstacles from individual vantage points. Alternative vantage points at more strategic locations may emerge from repeated modeling and visibility analyses.

### Procedure 4: Line-of-Sight Analysis

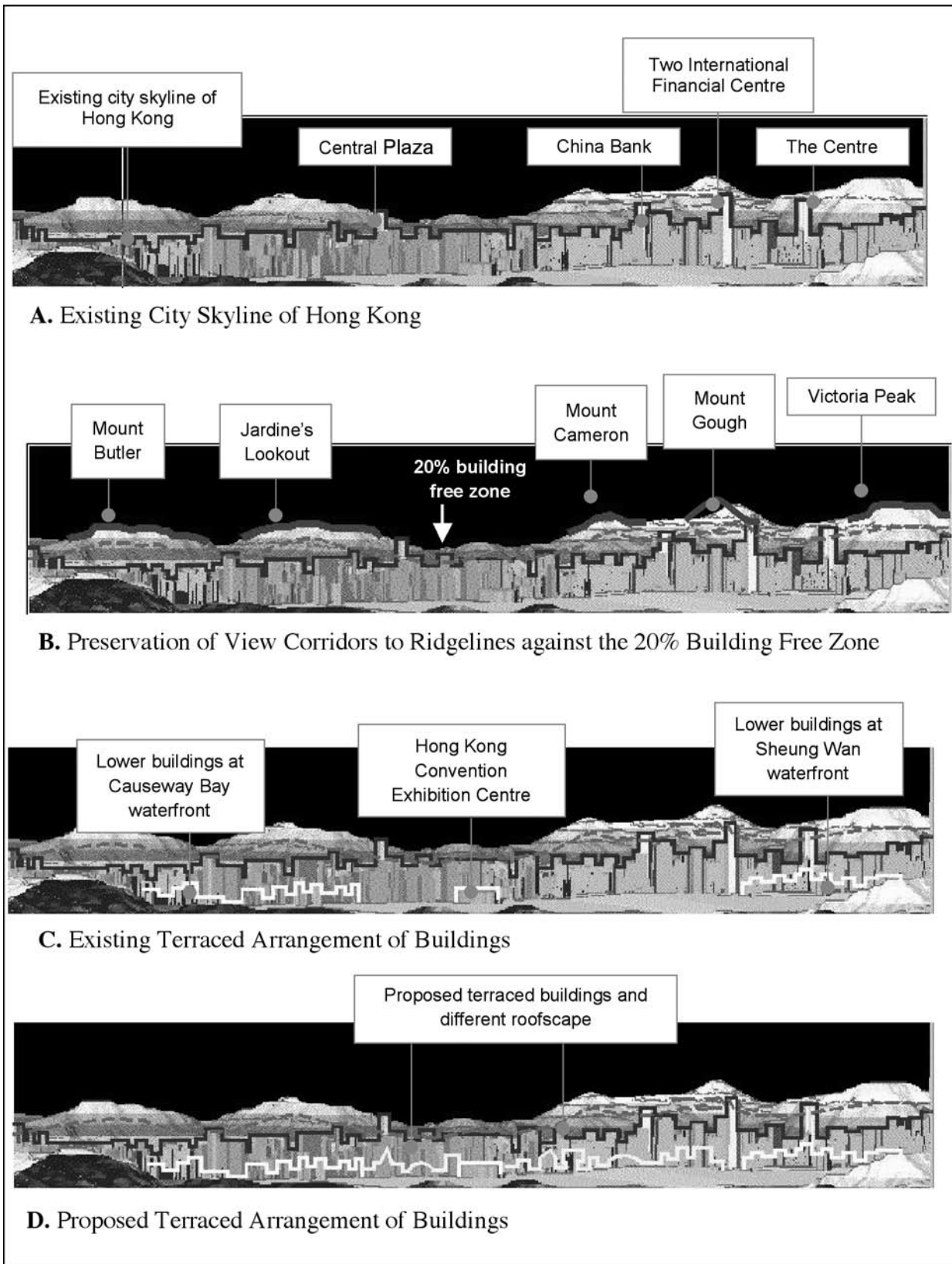
The line-of-sight tool permits a test of visibility between a pair of pre-set points representing a viewing position and a target object. This GIS function augments visibility analysis in situations where specific target objects for viewing have been identified. A line is drawn to link the pair of points and visibility between them is not established if one or more obstacles (usually tall buildings)



**Figure 10.** The Line-of-Sight Analyses from Three Vantage Points in Kowloon to Strategic Points Along the Ridgeline of the Hong Kong Island



**Figure 11.** A 3D Visualization of Line-of-Sight Analysis from VP1 to the Victoria Peak



**Figure 12.** Cross-sectional Representations of the Development of City Skyline at the Hong Kong Island

exist along the line of sight. Figure 10 shows that Mount Parker is not visible to observers at VP2 while Victoria Peak and Mount Cameron are not visible to observers at both VP1 and VP2. However, VP3 maintains an episodic line of sight to Mount Parker, Mount Butler, and Jardine's Lookout.

Figure 11 illustrates with a 3D model the line of sight between VP1 and the Victoria Peak. Given the Urban Design Guidelines as explained in Figure 5, we can identify with some degree of certainty existing buildings that have violated the recommended building heights and infringed upon the 20% building free zone. As new buildings are expected to develop in this area in the future, the line-of-sight analysis is potentially useful in recommending or enforcing more flexible and dynamic building heights. In this way, progressively taller buildings can be staggered to provide more visual stimulus from the waterfront toward the ridgelines. The terraced approach should improve visual penetration into the inland areas to reveal greenery and other heritage artifacts.

### Procedure 5: Cross-Sectional Analysis

A cross-sectional display emphasizes depths such that structures/features in the foreground are clearly distinguishable from those at a distance. The 3D model supports cross-sectional drawings of the harbor front to facilitate a perspective view of interacting and counteracting elements (Figure 12).

Figure 12A is a cross-sectional view from the Harbor to ridgelines of the Hong Kong Island. Some of the mega-towers (such as the Central Plaza, China Bank, and the Centre) have been highlighted to contrast their existence against surrounding buildings. It is also evident that building profiles to the left of the Central Plaza project a relatively flat and monotonous roofscape.

Figure 12B highlights existing silhouette of the city along with the line that delineates the 20% building free zone. It is apparent that some of the mega-towers (such as the Central Plaza, China Bank, and the Centre) have obviously intruded upon the 20% building free zone. The figure also illustrates view corridors to Mount Butler, Jardine's Lookout, Mount Cameron, Mount Gough, and the Victoria Peak. These hills that overlook the Victoria harbor are said to broaden people's spatial perception and make the harbor appear perceptually larger than its physical coverage. They also promote the identity of the city by providing "visual cues" to the people. Given their significance in complementing and contributing to vistas of the Harbor, the preservation of these ridgelines should be given unique consideration in the process of skyline development.

Some lower structures along the waterfronts of Sheung Wan, Wan Chai, and Causeway Bay are discernable from Figure 12C. Urban Design Guidelines suggest more variation in building heights to yield a terraced arrangement. It can be seen here that the diversified building heights in the Causeway Bay area does heighten the perception of depths resulting in a higher silhouette complexity, marred only by the monotonous roofscape at the far end. It is also clear that there is room in developing a more spectacular and dynamic skyline of Hong Kong as illustrated in Figure 12D.

## Conclusion

This paper has demonstrated that GIS can operationalize recommendations subscribed by the Urban Design Guidelines. For example, the government of Hong Kong has identified seven viewpoints for the preservation of view corridors to important peaks given a strong appeal from the public to heighten protection of views to the ridgelines. Our study has shown that some of the designated viewpoints do not allow a deep penetration with extensive visual scopes because a few excessively tall buildings have blocked or extracted the views.

Urban Design Guidelines of Hong Kong volunteers a systematic approach to the design of its urban skyline. Some recommendations are quantitative in nature, and these can be accommodated readily in a GIS. Specifically, the 3D models constructed with a GIS can aid in the following aspects: (1) to identify violation cases, (2) to assess the preservation of views, and (3) to suggest possible areas of improvement.

The Urban Design Guidelines recommend that buildings should exist in harmony with surrounding natural features such as ridgelines and peaks. Violation cases are discernible through both visual and attribute examinations. The 3D GIS visualization affords viewing perspectives from almost every direction to determine the extent to which a built structure has infringed upon the restricted zones or the combined impact a collection of structures has on the surrounding townscape. The attribute functions can validate and pinpoint structures exceeding the 300 meter threshold in building heights or those suspected of sideway expansion. The Urban Design Guidelines also encourage the preservation of view corridors and breezeways to prominent features along the ridgelines to yield a cityscape of characteristic traits and visual aesthetics. In this regard, GIS endorses the visibility analyses along a given *line of sight* or across the entire *viewshed*. These utility functions make possible an overview of what obstructions there are and which features are visible or hidden from a given vantage point. In line with practices of cities like Manhattan, Shanghai, and London, the Urban Design Guidelines also advocate stepped-like buildings to provide visual set-backs from major parks, waterfronts, or principal roads. GIS allows the plotting of vertical or cross-sectional profiles to suggest indicator lines for controlling building heights that increase gradually from the waterfront to the city's interior. Along with violation cases and considerations in the preservation of views, elements deemed unattractive or undesirable in a townscape should be blacklisted for future replacement by more amenable structures when opportunity arises.

We believe that GIS can be an effective support tool to coordinate control measures for building heights. We further believe that GIS provides a means to engage the Government and the public in fruitful discussions toward the creation of a more spectacular and impressive skyline of Hong Kong. It is noteworthy that many recommendations of the Urban Design Guidelines (such as the introduction of more open space and greenery to the cityscape, massing the building through architectural design, and

the preservation of heritage buildings, etc.) were not examined in this paper. We hope to address these areas in future research. Our initial study has proved that GIS is an enabling technology and a support tool for better decisions and more comprehensive planning.

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