ANNEX B

KEY BUILDING DESIGN CONSIDERATIONS

1 Introduction

1.1 The concept design as well as the detailed planning and design stages of the building's development are key milestones to incorporate security considerations into the architectural layout, the structural design as well as the mechanical and electrical systems of the building development. During the concept design stage, key issues to be considered include, but not limited to, site selection, building type, dimensions, positioning and orientation within the lot, landscaping as well as parking and vehicle flow. At the design and planning stage, important deliberations include, but not limited, to the structural scheme, characteristics of the envelop walls and facades, location of car parks and access roads, crowd flow, locations of critical assets and mass congregation areas.

1.2 Incorporating physical security concepts into the initial architectural design of a project is the most efficient and cost-effective way to achieve the required security level. Apart from the financial benefits of early planning for protection of the building, by considering the security aspects from the onset, early planning also allows architects and planners to work with security consultants and blend the required protection elements into the design of the building to achieve both security and aesthetic requirements. The following sections relate to general design, structural and system issues which should be considered.

2 General Architectural Considerations

2.1 Security considerations should be deliberated during the initial stages of a development project such that cost effective protective solutions could be incorporated into the structural, layout and system designs, thereby reducing the need for hardening measures. Security measures can be integrated into the overall architectural design concept of the development in a seamless and unobtrusive manner. These can be designed such that they do not impede pedestrian movement and negatively impact the enjoyment of public spaces within the development.

2.2 <u>Creating Stand-off Distance</u>

2.2.1 Stand-off distance is defined as the distance between the detonation point and the target building. Stand-off distance is the single most important factor when considering the mitigation of the effects of an explosive attack. By increasing the stand-off distance, the resultant blast loads would be reduced, therefore saving significant effort and capital costs that would otherwise be needed to deal with the attack consequences. Therefore, the distance between a building and any road (or drop-off point, car park or loading/unloading bay with vehicular access) should be maximised, where feasible.

2.2.2 However, given the scarcity of land in Singapore and the need to optimise land, large stand-off distance may not be feasible. Nevertheless, if adequate stand-off distance cannot be achieved, critical assets should be located away from the facade and towards the centre of the building.

2.3 Building Orientation

2.3.1 The orientation of the building may influence its vulnerability against threats such as firearms that require direct line-of-sight to be effective. By taking advantage of the horizontal and vertical angles and obscuring the lines of sight from a potential threat, the requirements for window protection against firearms may be reduced significantly. Locating critical assets as high as possible and away from public areas will serve to reduce their vulnerabilities against explosive threats.

2.4 Vehicle Anti-Ram Perimeter Line

2.4.1 The perimeter line should prevent unauthorised entry or the ingress of hostile vehicles through the use of crash rated fencing, barriers and bollards etc. Anti-ram perimeter lines can be integrated into the overall architectural design concept of the building or within the design of the public spaces at grade with the road level. For example, where necessary, instead of crash-rated bollards, these structures can be integrated as part of the landscape features or streetscape infrastructure, such as public seating and planters. A detailed vehicle approach analysis, which identifies possible unobstructed vehicle paths towards the building, can be carried out to determine the effectiveness of such anti-ram measures.

2.5 Traffic Flow, Access Roads and Parking

2.5.1 Traffic is a challenging issue when planning a new building as vehicle access control and screening measures must be carefully planned such that it does not excessively impede the movements of vehicles into/in the premises. A smooth flow of traffic allows the security officers manning the checkpoint to focus on their checks and not get distracted by the congestion. The flow of traffic must also complement, and not compromise, security of the premises.

2.5.2 As part of the Traffic Impact Assessment required for the development, additional security requirements could be considered and incorporated as part of the overall design for the building. For example, this should take into account the vehicle screening requirements such as the number of screening bays, the type of screening measures and the average time taken to screen each vehicle.

2.5.3 At an early stage, efforts should be taken to balance vehicle access control and screening requirements with having an efficient flow of traffic and people. Once the building has been constructed, it is extremely difficult to change the design and allocate space for such requirements. Hence, making sure that physical measures at access points are weaved into the overall traffic management of the premises (i.e. covering access roads, driveway, drop-off points, entrances to the building, and parking areas), will ensure proper functionality when the site is operational.

2.6 Mass Congregation and Critical Assets

2.6.1 Some areas in a building are characterised by the presence of large crowds. These areas of mass congregation are considered highly attractive for terrorists and therefore should be given special consideration during the design stage. Areas of mass congregation should be housed away from glass facades, main entrances or lower levels, where there could be direct impact from possible threats.

2.6.2 Critical assets (e.g. Security Control Room, Operations Command Centre, Building Maintenance Room, Fire Control Room, Data Centre, Server Room etc.) or essential personnel, should also be housed at the core of the building or in specially protected areas.

2.7 Materials and Façade Systems

2.7.1 The choice of building materials has a direct impact to the physical integrity of the building. Each type of material offers a different level of protection due to its differing hazard levels, for instance, cast in-situ reinforced concrete usually offer the best protection, whilst glass is inherently weak against blast. Special consideration must be taken when choosing the type of building materials, especially for the façade.

3 General Structural Considerations

Any type of building collapse must be avoided, but the most critical category to be avoided is progressive collapse. Past incidents have demonstrated that progressive collapse results in very high fatality rates and will cause significant collateral damage to humans, buildings and other structures in the surrounding area. In order to mitigate progressive collapse, protective measures should be directed towards strengthening primary structural elements.

3.1 Progressive Collapse Mitigation

3.1.1 Progressive collapse is defined as the spread of an initial local failure from element to element, eventually resulting in the collapse of an entire structure or a disproportionately large part of it. Progressive collapse occurs in most cases, due to the loss of one or more critical column supporting the building.

3.1.2 The primary structural elements are the essential parts of the building, which support the building and provide the resilience against progressive collapse, in the event of a blast.

3.1.3 Typically, adopting a straightforward approach which involves design of primary structural elements against local failure for the given threat and stand-off distance suffices.

3.2 Capacity for Resisting Shear Failure

3.2.1 It is essential that the primary structural elements maintain sufficient strength and ductility when undergoing flexural response so as to preclude a shear failure. When the shear capacity is reached before the flexural capacity, the possibility of a sudden, non-ductile failure of the element exists, which could potentially lead to a progressive collapse of the structure.

3.3 Multi-Storey and Underground Car Parks

3.3.1 During an explosion in an underground car park or enclosed area, the forces acting on the structure are different from those in an open location. Hence, it is essential to study the integrity of the structural system of the underground car park during the design and planning stage.

3.3.2 A blast in an underground car park is subject to many reflections, where the impulse it creates is much higher compared to an explosion in the open air. The lifting forces are therefore expected to be very high and a breach of floors and ceilings must be considered and studied. It is recommended that the underground car parks be segregated into public and private car parks, with the public car parks placed outside the main building's footprint to prevent progressive collapse from unscreened Vehicle Borne Improvised Explosive Devices (VBIEDs).

3.4 Blast Resistance

3.4.1 The ability of the structure or façade to resist blast pressure is a function of (i) the material composition of the structure and (ii) the section properties of the main structural elements, including the structural spans and the connection details. Selection of suitable resilient structural designs should be considered during the initial structural design phase to minimise the impact on the building's final design.

3.4.2 During the design and planning stage, a simple structural scheme consisting of a beam/column system should be adopted. Arising from the studies of the Oklahoma City attack, it is recommended that the use of large transfer beams be avoided at public areas that are accessible by vehicles.

3.5 Safe Spaces[1]

3.5.1 Safe spaces are to be provided for Critical Infrastructures which require essential personnel to be stationed in-situ to ensure the continued delivery of an essential service. Safe spaces are to be sited at a location that is in close proximity to where the essential personnel are expected to be stationed.

4 Mechanical and Electrical System Considerations

4.1 The general design and security considerations for mechanical and electrical systems should also be considered at an early stage. Compatibility and integration with the general design in the initial stage will help achieve an effective assimilation of systems into the overall building. Such consideration will also prevent conflict between the system requirements and other factors such as the urban planning, landscaping, lighting and fire safety.

4.2 The solutions should take into consideration the capacity for future upgrades, expansion and replacements. Any software and hardware used should therefore be modular and upgradeable with adequate physical space catered for future replacement.

4.3 Typically, many systems are either shared by security, safety and administration or at least must take into account the requirements and environment of each other. This has to be considered at an early stage to ensure that the requirements of all parties are met and that there is adequate integration between them.

[1] Safe spaces are hardened spaces for short-term, small group protection.

4.4 Power Supply

4.4.1 As a practice, providing redundancies and backups to the power supply should be adopted. Firstly, multiple feeds from the public utility should be provided to enhance diversity and ensure no single point of failure. Secondly, an Uninterruptible Power Supply (UPS) service to provide a minimum period of backup power should be installed to ensure continuity of services at the initial stage; and thirdly, provision of on-site standby diesel generators to sustain power for longer-term outages. The electrical power system should be designed to support continuity of vital functions in the aftermath of an attack i.e. a smooth cut over to emergency electrical power supply.

4.4.2 The UPS and the backup diesel-powered generators are crucial in maintaining a constant flow of power in the event of a power failure from the public utility. The UPS should be adequately sized to support the power demand of all vital functions e.g. all computer and data centre equipment, mechanical and ventilation systems, fire safety systems and electrical devices (such as emergency lighting and security equipment), minimally for the time taken to switch over to the emergency power supply or the standby generators. In addition, it must take into consideration the “peak” load or fault overload conditions i.e. the surge in power demand when the equipment is first energized. As a rule of thumb, the UPS should be sized for 150 percent of the operating demand and be continuously operational to filter and condition the power supply.

4.4.3 Diesel generators should be provided to generate power for longer-term outages, if the UPS is not sustainable for long term provision of emergency power supply. The generators should be maintained and tested periodically to ensure their operational integrity at all times. Sufficient fuel supply should also be catered to sustain the generators during the outage duration.