

## **Measuring Station Design Quality for Personal Safety – Preliminary Results (21)**

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### **Abstract**

Crime on public transport is a major concern for society and authorities; and many security measures have been adopted in public transport facilities like stations to reduce crime and improve the perception of safety of passengers. However a scale to measure the design quality of the public transport facilities using Crime Prevention Through Environmental Design (CPTED) principles has not yet been developed. This paper presents preliminary results of a research program to develop a unified measure of the overall design quality of train stations in terms of surveillance, access control/target hardening, maintenance, territoriality and activity support, which are the main underlying elements of CPTED. In this study a preliminary scale has been developed and applied to 4 stations in suburban Melbourne. The scores illustrate the overall station design quality and highlight elements of the stations to address to enhancing safety in future. Areas for future research and implications for practice are explored.

### **1. Introduction**

The perception of personal safety is one of the most important factors influencing the ridership and overall quality of public transport (Brantingham et al. 1991, Cozens et al. 2004). A substantial number of studies explore factors influencing safety perceptions and fear of crime of commuters on public transport. Fear of crime and perception of safety are correlated with actual crime, overall design quality, surrounding environment and situational crime prevention features of the facilities in numerous studies (Gaylord and Galliher 1991b, Ingalls et al. 1994, La Vigne 1996b, La Vigne 1996a, Loukaitou-Sideris et al. 2000, Lashmar 2001, Liggett et al. 2001). Various strategies e.g. altering design of the transit facilities, improving surveillance, adopting situational crime prevention and target hardening measures are adopted. These have been successful in reducing crime on public transport. However a small amount of research focuses on CPTED, which underpins these approaches. Measures of Crime Prevention Through Environmental Design (CPTED) have been implemented in other fields of research e.g., in the housing developments to measure design quality of respective sites. However, a measure of the design quality of train stations has not been attempted to date.

This paper develops a new scale measuring the overall design quality of train stations from the perspective of CPTED. Five principals; surveillance, access control /target hardening, territoriality, maintenance and activity support which underpin the CPTED (Crime Prevention Through Environmental Design) concept, are considered in developing the scale. Aspects such as the architectural and security features, situational crime prevention measures and surrounding areas of the station are quantified to provide a benchmark of the overall design quality of train stations in relation to personal safety.

This paper is organised as follows. The next section describes the background of the studies related to the developed scale framework. Then the proposed scale framework is presented in detail and finally results are described and conclusions drawn.

## **2. Background**

A range of factors have been identified and included in the proposed scale. These factors are explored from the context of existing research related to CPTED, crime and factors affecting crime on the public transport system. A synthesized review of CPTED, influential factors and measures found effective in previous studies to deter and prevent crime on public transport, are presented.

### **2.1 Crime Prevention Through Environmental Design (CPTED)**

CPTED stands for Crime Prevention Through Environmental Design, based on the proposition that proper design and effective use of the built and surrounding environment are effective in deterring crime. It can be defined as “the proper design and effective use of the built environment and can lead to a reduction in the fear and incidence of crime, and an improvement in the quality of life” (Crowe 2000,p46).

There are several elements of CPTED which support the concept namely surveillance, territoriality, access control/ target hardening, maintenance and activity support. Surveillance refers to improving visibility and observation (Moffatt 1983). Territoriality is a design concept that produces a sense of ownership and proprietary concerns for a territory (Moffatt 1983, Cozens et al. 2005). Access Control and Target Hardening focuses on reducing crime opportunities by deterring access to the potential targets and places. It assists to heighten risk perception in offenders and thus deters them (Brantingham 1993, Cozens et al. 2005). Routine maintenance of the dwelling area and built environment improves the perception of users regarding safety and reduces crime. Activity support encourages intended use of the public place through the aid of design and signage (Cozens et al. 2005).

### **2.3 Preventing and Deterring Crime on Public Transport**

There have been a substantial number of research projects focusing on preventing and deterring crime on the public transport system. Research has explored that various forms of intervention techniques like altering design of the transit facilities, improving policy and adopting situational crime prevention measures e.g. natural and formal surveillance, target hardening strategies are efficacious (VAN ANDEL 1989, Smith and Clarke 2000, Newton 2014). Installation of CCTV at the stations and car parks, observation of the waiting area by the station staff, placing back exits, mirrors for drivers and changing in the seating arrangements were found effective to deter crime and improve the perception of safety of the transit users in several studies (Levine and Wachs 1986, VAN ANDEL 1989, Gaylord and Galliher 1991, Webb and Laycock 1992, Tilley and Britain 1993, Levy 1994, Lashmar 2001, Winge and Knutsson 2003, Cozens et al. 2005). Target Hardening measures e.g. alarm systems and alarm buttons, protective enclosure for bus driver, bulletproof screen for taxis, formal police checking, electronic locators or radio codes etc. reduced significance number of robberies and abuses to bus and taxi drivers. Introducing target hardening strategies like (Gray 1971, Chaiken et al. 1974, Joyner 1980, Eastal and Wilson 1991, Newman 1998). In addition, designing out opportunities for crime and controlling crime through "order maintenance" policing for transit system has been considered by the respective authorities. For example, the designer of the Washington D.C. Metro incorporated a range of preventive measures against crime opportunities like designing spacious platforms, open escalators and passageways between platforms, usage of CCTV with attendants in kiosks near entrances (La Vigne 1996b, La Vigne 1996a, La Vigne 1997). In the design of the train station various types of design consideration have been suggested by a number of studies. These include reducing the number of entrances and exits, widening staircases, closing off areas behind staircases and passageways, locating surveillance booths to overlook fare entry points and the platform level, increase surveillance by other passengers or passers-by, allowing passengers wider lines of sight, wide platforms, surveillance booth, installing see-through fencing on the periphery of the station, locating waiting room closer to retailers, attendants

and putting corner mirrors, eliminating nooks, and improving lighting etc. (Falanga 1989, Felson et al. 1990, Felson et al. 1996).

Based on the foregoing discussion, preventive measures, altered design of the station/stop and improvement and maintenance schemes undertaken and suggested by the operating body and researchers has been summarized in Table 1.

**Table 1 : Summary of the Various Elements Considered to Reduce Crime on Public Transport**

<b>Measures</b>	<b>Forms of measures</b>
Surveillance	CCTV, video camera, observation by staff and police
Target hardening	Alarm, protective enclosure, police patron, safe box for fare collection, turnstiles at entrance and exit, lighting, reduces escape routes, mirrors for drivers, automatic fare collection.
Design Management	Spacious platforms, wide staircases, open escalators and passageways between platforms, lower number of columns to prevent hiding, location and design of the waiting room, lower number of entrance and exit, see-through fences, improve lighting arrangement, card system to pay fare.
Maintenance	Cleaning graffiti and litter, repair the vandalised features of the station.

## **2.4 Measuring CPTED indicators**

### **2.4.1 Measuring CPTED in Housing**

In the context of the housing there are several studies focused on measuring and validating the components of CPTED and finding the impact of CPTED elements on fear of crime and victimization (Minnery and Lim 2005, Abdullah et al. 2012, Hedayati Marzbali et al. 2012a, Hedayati Marzbali et al. 2012b, Sakip et al. 2012). They measured the level of CPTED of the dwellings, streets and neighbourhood. For example, Hedayati Marzbali et al. (2012b) validated a CPTED construct for a residential area in Malaysia. The CPTED construct was measured considering four main dimensions namely natural surveillance, access control, territoriality and exterior maintenance using a prepared checklist. For each construct, several indicators were considered and scores were considered for each of the indicators based on the characteristics. An on-foot assessment of the 164 dwellings and their surroundings in a typical residential area in Penang, Malaysia, was undertaken. The validation was carried out by employing the Confirmatory Factor Analysis (CFA). Hedayati Marzbali et al. (2012a) used the same aforementioned scale to measure the indicators of each construct. While comparing actual level of CPTED measures with victimization and fear of crime, Minnery and Lim (2005) developed a scale to measure CPTED components. The scale was used to measure the actual level of incidental CPTED of two private housing areas of the Gold Coast in Australia. The scale considered four CPTED principals; access control, surveillance, activity support and motivation reinforcement. Each of the CPTED principals was explained with some performance measures and they were scored on a scale of one to five based on their characteristics. The scores were accumulated and represented aggregated CPTED measures for each of the measurement areas. Perkins et al. (1992) assessed the physical environment to attain an objective measure the physical elements at individual and block level for a housing development with trained raters. They counted the physical features by an on-foot assessment of selected sites.

### **2.4.2 Measuring CPTED for Public Transport Facilities**

Very little research measures CPTED principals on public transport. Cozens et al. (2003) measured the situational safety measures at 15 stations along the valley line, UK, using a

dichotomous scale (yes=1/no=0). At the stations under consideration, the presence of a staffed ticket office, CCTV, help point, public access, real-time/ electronic information, high throughput level, lack of visual obstruction etc. were scored either zero or one depending on their presence or absence. An accumulated score was termed the situational index (SI). Liggett et al. (2001) measured the surrounding physical environment for the most crime ridden bus stops in Chicago. They counted the presence of negative environmental features like the presence of bars, liquor shops etc., bus stop characteristics e.g. the existence of bus shelters, visibility, and lighting; and street characteristics; such as street and sidewalk width, on-street parking, and traffic levels etc.

**3. Framework of the Proposed Scale**

This study develops a measurement instrument that aims to provide an objective measure of CPTED present in stations. Based on the literature and existing guidelines of CPTED for transit facilities, the scale has considered surveillance, motivation reinforcement / access control, maintenance and territoriality/ activity support dimensions of CPTED strategies (Justice et al. 1976, American Public Transportation Association 2010).

The proposed index has been developed using a weighted multi-criteria scorecard approach. The scale has several dimensions and each of the dimensions in the scale was divided into several relevant criterions. Criteria are further subdivided into several component indicators which have a score set and relative significance weighting. Individual scores are usually 0 to 10. The weighting of the dimensions are based on existing published research evidence as well as author’s subjective view of importance. Depending on the ranking of the safety measures of the public transport facilities cited in the existing research, the main dimensions namely surveillance, access control, motivation reinforcement, maintenance and territoriality/activity support have been prioritized (Morgan 1996, Hamilton 2003, Stafford and Pettersson 2004, Hamilton 2007).

Several component indicators of each the key dimensions are measured by onsite observation of the stations. The next section provides a description of the measurement scale for each of the component indicators.

**3.1 Surveillance**

As the literature suggests, both natural and formal surveillance are effective in reducing crime and fear of crime (Shellow et al. 1974, Smith and Clarke 2000). Based on the ranking of the security measures in the existing research (Morgan 1996, Hamilton 2007) and from the viewpoint of the authors, formal surveillance of the platforms and waiting area have been provided with the highest weight followed by the ticketing area, entrance /exit route to the station and entrance /exit route point to the platforms. For the platforms, ticketing areas, entrance and exit points and routes a score from 1-10 will be provided based on their proportion and length under CCTV surveillance according to the following equation:

$$\text{Score} = \frac{\text{number/area of X location having CCTV}}{\text{total number/area of X location}} * 10 \dots \dots \dots (a)$$

While measuring natural surveillance of the rail station, visibility of the platforms was given highest importance followed by the car park, waiting and ticketing areas, entrance/exit to the platforms and station area. Detailed scoring approaches are shown in Table 2.

**Table 2: Scale To Assess Surveillance Dimension of the Train Stations**

<b>Surveillance</b>					
<b>Type: Formal</b>					
<i>Criteria: CCTV</i>					
No	Locations	Scale	Score	Weight	Max Score
1	Platforms	Not present	0	2	20
		No of Platforms covered	1-10		
		Area covered	1-10		
		Maximum weighted score for platforms			
2	Ticketing area	Not present	0	1.5	15
		No of ticketing area covered	1-10		
	Entrance and exit point to the station	Not present	0	1	10
		Area covered	1-10		
3	Entrance and exit point to the platform	Not present	0	1	10
		No of Platforms covered	1-10		
4	Waiting area	Not present	0	2	20
		Area covered	1-10		
Maximum total weighted score for CCTV					95
<i>Criteria : Station office</i>					
5	Platforms	Length visible	1-10	1	
6	Car Park	Proportion Visible	1-10	0.5	
7	Waiting Area	Proportion Visible	1-10	1	
Maximum total weighted score for <i>Station office</i>					25
<i>Maximum possible score for formal surveillance</i>					120
<b>Surveillance</b>					
<b>Type: Natural</b>					
<i>Location: Car park</i>					
No	Criteria	Scale	Weight	Max Score	
1	Type	0=Not surface parking; 10= Surface parking	0.5	5	
2	Business development (Within 20m radius)	0=Absent; 5=Facing at 1 side; 7.5= Facing 2 sides 10= Facing more than 2 sides	0.5	5	
3	Residential development (Within 20m radius)	0=Absent; 5=Facing at 1 side; 7.5= Facing 2 sides 10= Facing more than 2 sides	0.5	5	
4	Visibility from Platforms	0=not visible; 2.5=More than 25 % ; 5=About 50 % 7.5=About 80 % ; 10=Entirely Visible	0.5	5	
5	Visibility from waiting area	0=not visible; 2.5=More than 25 % ; 5=About 50 % 7.5=About 80 % ; 10=Entirely Visible	0.5	5	
6	Visibility from entrance points	0=not visible; 2.5=More than 25 % ; 5=About 50 % 7.5=About 80 % ; 10=Entirely Visible	0.5	5	
Maximum weighted score for Car park					30
<i>Location: Platforms</i>					
No	Criteria	Scale	Weight	Max Score	
	Visibility from car park	0=not visible; 2.5=More than 25 % ; 5=About 50 % 7.5=About 80 % ; 10=Entirely Visible	1.5	15	
8	Visibility from outside	0=not visible; 2.5=More than 25 % ; 5=About 50 % 7.5=About 80 % ; 10=Entirely Visible	1.5	15	
9	Visibility from other platform	0=not visible; 2.5=More than 25 % ; 5=About 50 % 7.5=About 80 % ; 10=Entirely Visible	2	20	
Maximum weighted score for Platforms					50
<i>Location: Entrance and exit point to the circulation/station area</i>					
No	Criteria	Scale	Weight	Max Score	
10	Visibility from waiting area	0=not visible; 2.5=More than 25 % ; 5=About 50 % 7.5=About 80 % ; 10=Entirely Visible	0.5	5	
11	Visibility from station office/staff	0=not visible; 2.5=More than 25 % ; 5=About 50 % 7.5=About 80 % ; 10=Entirely Visible	0.5	5	
12	Visibility from nearby street	0=not visible; 2.5=More than 25 % ; 5=About 50 % 7.5=About 80 % ; 10=Entirely Visible	0.5	5	
13	Visibility from Platform	0=Not visible; 5=From some parts; 10=From any location	0.5	5	

Maximum weighted score for Entrance and exit point to the circulation area				20
<i>Location: Entrance and exit point to the platforms</i>				
No	Criteria	Scale	Weight	Max Score
14	Visibility from waiting area	0=Not visible; 5=From some parts; 10=From any location	0.5	5
15	Visibility from station office	0=Not visible; 5=From some parts; 10=From any location	0.5	5
16	Visibility from nearby street/outside	0=Not visible; 5=From some parts; 10=From any location	0.5	5
17	Visibility from Platform	0=Not visible; 5=From some parts; 10=From any location	0.5	5
Maximum weighted score for Entrance and exit point to the platforms				20
<i>Location: Ticketing area</i>				
No	Criteria	Scale	Weight	Max Score
18	Visibility from station office	0=Not visible; 5=From some parts; 10=From any location	1.5	20
19	Visibility from Platform safety zone	0=Not visible; 5=From some parts; 10=From any location	1	10
20	Visibility from outside (Car park/street)	0=No 10=Yes	0.5	5
Maximum weighted score for Ticketing area				30
<i>Location: Waiting area</i>				
No	Criteria	Scale	Weight	Max Score
21	Visibility from station office	0=Not visible; 5=From some parts; 10=From any location	1.5	15
22	Visibility from platforms	0=Not visible; 5=From some parts; 10=From any location	1	10
23	Transparent Materials	0=No; 5=Yes	0.5	5
Maximum weighted score for Waiting area				30
<i>Maximum total weighted score for natural Surveillance</i>				300

### 3.2 Access Control and Motivation Reinforcement

In the proposed scale, the access control measures for the stations are benchmarked considering the features controlling illegitimate access to the platforms and station area. Several features in this context e.g. presence of turnstiles materials at entrance and exit, presence of the railway staff, control of access point to the stations etc. are considered to benchmarks as detailed in Table 3.

**Table 3: Scale to Measure Access Control and Motivation Reinforcement Dimension**

Access Control				
<i>Location: Platforms</i>				
No	Criteria	Scale	Weight	Max Score
1	Turnstiles	0=Not at entry; 10=Present at entry	2.5	25
2	Staff	0=Not at entry;5=Present at office; 10=Present at entry	4	40
3	Entrance/Exit	0=More than 3 points; 5=2 points; 10=One point	1	10
Maximum weighted score for Platforms				75
<i>Location: Station area</i>				
4	Entrance/Exit at each side	0=More than 3 points; 5=2 points; 10=One point	.5	5
5	Fencing	0=Not present; 10=Present	2	20
Maximum weighted score for Station area				25
Maximum total weighted score for Access Control				100

Motivation reinforcement influences the willingness of committing offences. Based on the existing research (Hamilton 2003, Stafford and Petterson 2004, Currie et al. 2010, Delbosc

and Currie 2012) several factors like presence of the staff ,proper lighting, provision of PSO<sup>1</sup>, CCTV, alarm button and presence of police booth at or outside the station premises are considered. Table 4 outlines the detailed measurement scales for motivation reinforcement.

**Table 4: Scale to Benchmark Motivation Reinforcement Dimension**

Motivation reinforcement					
<i>Criteria :CCTV</i>					
No	Location	Scale		Weight	Max Score
1	Notification	0=Not present	10=Present	1	5
2	Platforms	0=Not present	10=Present	1.5	15
3	Waiting area	0=Not present	10=Present	1.5	15
4	Circulation area	0=Not present	10=Present	0.5	10
5	Entry/Exit to the station area	0=Not present	10=Present	0.5	5
Maximum weighted score for CCTV					50
<i>Criteria: PSO</i>					
No	Location	Scale		Weight	Max Score
6	Station	0=Not appointed 5=Appointed on Weekdays/Weekends	10=Appointed 7 days	5	50
<i>Criteria: Police booth/Station</i>					
No	Location	Scale		Weight	Max Score
7	at station	0=Not within .5 km radius 5= Within .5 km radius	7.5=Visible platforms 10=Located just outside	1.5	15
<i>Criteria: Railway Staff</i>					
No	Location	Scale		Weight	Max Score
8	at station	0=Not appointed 10= Appointed 7 days 5=Appointed on weekdays		4	40
		5=During office hours 10= Until last train		4	40
Maximum weighted score for Railway Staff					80
<i>Criteria : Alarm button</i>					
No	Location	Scale		Weight	Max Score
9	At platform	0=Not present 10=Present		1.5	15
		5=Not near entrance; 10=Located near entrance		.25	2.5
10	At waiting area	0=Not present 10=Present		.75	5
Maximum weighted score for Alarm button					25
<i>Criteria : Lighting</i>					
No	Location	Scale		Weight	Max Score
12	at Platforms	0=Dark places( >9 spots);		2	20
14	at Car park	2.5= Dark places (7-9 spots);			20
16	at Circulation area	5= Dark places (3-6 spots);			20
18	Access/egress routes	10= Dark Places(0-2 spots)			20
Maximum weighted score for Lighting					80
<i>Maximum total weighted score for Motivation Reinforcement</i>					300

### 3.3 Maintenance and Design Considerations

Maintenance of transit facilities is found to be effective in both reducing perpetration of crime and addressing safety concerns (VAN ANDEL 1989, Carr and Spring 1993, Wilson 2003). Graffiti, vandalism can invite crime by suggesting less policing (Glazer 1979, Castleman 1982). For Graffiti, if at the location considered had graffiti present in all of the surrounding walls was then given zero, otherwise five. If no graffiti was present at any side then the score was ten. Details of the measures are shown in Table 5.

### 3.4 Territoriality and Activity Support

Public transport facilities are public property. The specific boundary of the station, signboard and markings will clarify the territory of the station and activity supported. It is assumed here

<sup>1</sup> Protective Service Officer (PSO). They are appointed at the selected stations in Melbourne from 6 pm until midnight.

**Table 5: Scale To Measure the Maintenance Dimension**

<b>Maintenance</b>				
<b>Locations</b>	<b>Indicators</b>	<b>Scale of measure</b>	<b>Weight</b>	<b>Max Score</b>
Platforms	Seats(nos)	0=Discoloured ; 10=Not Discolour	.25	10
		0=Scratches ; 10= No Scratch		
		0=Damaged ; 10= No damage		
		0=Graffiti present 10=No graffiti		
	Floor	0=Graffiti present; 10=No graffiti	0.5	10
	0=Garbage/left over; 10= No Garbage/left over	0.5		
Walls	0=Graffiti present; 10=No graffiti	1	10	
<i>Maximum weighted score for Platforms</i>				<b>30</b>
Around station	Trees	0= height exceeds platform; 10=Not exceed	1	<b>10</b>
Car park	Walls	0=Graffiti on all sides; 5=Graffiti at least 1 side 10=No graffiti	1	<b>20</b>
	Floors	0=Garbage; (>70% area); 5=Garbage (15-69 % area); 10= No Garbage	0.5	
	Signs	0= not intact 10=Intact	0.5	
Waiting area	Seats(nos)	0=Discoloured ; 10=Not Discolour	0.25	10
		0=Scratches ; 10= No Scratch		
		0=Damaged ; 10= No damage		
		0=Graffiti present 10=No graffiti		
	Floor	0=Graffiti present; 10=No graffiti	0.5	10
	0=Garbage/left over; 10= No Garbage/left over	0.5		
Walls	0=Graffiti present; 10=No graffiti	1	10	
<i>Maximum weighted score for Waiting area</i>				<b>30</b>
Entrance to the platforms	Graffiti/Garbage	0=Yes 10= No	1	<b>10</b>
Circulation Area/lobby	Graffiti	0=Graffiti present 10=No graffiti	0.75	<b>10</b>
	Garbage	0=Garbage/left over; 10= No Garbage/left over	0.25	
Amenities	Bathrooms/lifts	0=Doors have graffiti 10=Does not have	0.25	<b>10</b>
		0=Walls have graffiti 10=No graffiti		
		0=Fittings are intact 10=Damaged		
		0=Not clean 10=Clean		
Station outside wall	Graffiti	0=A lot; Moderate=5; 10=Absent	1.5	<b>30</b>
Surrounding walls/buildings	Graffiti	0=A lot; Moderate=5; 10=Absent		
Miscellaneous	Garbage bins	0= absent 10= present at the station	0.5	<b>10</b>
		0= not cleaned daily 10= cleaned daily		
Platforms	Lighting	Proportion working (Score=1-10)	1	<b>40</b>
Car park	Lighting	Proportion working (Score=1-10)	1	
Circulation area	Lighting	Proportion working (Score=1-10)	1	
Access/egress routes	Lighting	Proportion working (Score=1-10)	1	
<i>Maximum total weighted score for Maintenance</i>				<b>200</b>

that encouraging or discouraging particular behaviour at specific spaces of the station through signs and markings may help to reduce disorder and anti-social behaviour at stations. That is why signs and markings at and around the train station are assessed in the scale as shown in the Table 6.

#### **4. Aggregated Combined Scores**

An aggregated score to measure the quality of the train stations in terms of crime prevention and reduction measures is developed using component scores and relative weighting. The scoring method has considered CPTED factors as key dimensions. Each station can get a maximum possible weighted score of 1,000 points. The surveillance and motivation reinforcement dimensions has the highest weighted score of 300 points followed by



maintenance (score of 200 points), access control (score of 100 points) and territoriality/activity support (score of 100 points).

**Table 6: Territoriality and Activity Support Measuring Scale**

Territoriality and Activity Support					
Territoriality					
No	Criteria		Scale	Weight	Max Score
1	Control marking	Border	0=Not clear; 10=Clear(fencing)	2	20
		Station name	0=No signboard; 10=by signboard	1	10
			0=Absent at entrance; 10=Present at the entrance	2	20
		Station car parking	0= No signboard ; 5= Defined by signboard 10=At entrance +Signboard	1	10
Maximum weighted score for Control marking					60
2	Usage		0=Presence of non-passengers (homeless/young group); 10=Only passengers	2	20
Maximum weighted score for Territoriality					80
Activity Support					
No	Scale			Weight	Max Score
3	Markings and signs provide clear idea and use of 10=Restrooms; 10=Circulation area; 10=Platforms; 10=Waiting area			.5	20
Maximum total weighted score for Territoriality and Activity Support					100

## 5. Application of the Scale

The proposed scale has been applied to four stations in suburban Melbourne. The stations were broadly divided into premium station<sup>2</sup> and unstaffed stations and set of two stations in each case. The stations labelled A and B are unstaffed station, and C and D are staffed stations<sup>3</sup>. Table 7 outlines the type, passenger load and crime rate in the suburb they are located. These datasets are obtained from PTV (2015) and CSA (2015). Design features of the stations are found different which has resulted in the variation of the CPTED score. Figure 1 provides some comparative pictures of the security and design features from the case study sites explored during the onsite observation.

**Table 7 : Characteristics of the Case Study Stations**

Station	Passenger Load/weekday (2011-12)	Passenger Load/weekend (2011-12)	Passenger Load/week (2011-12)	Type
Station A	4172	2894	26455	Unstaffed
Station B	1,732	1667	10309	Unstaffed
Station C	5,358	5761	32553	Premium (Staffed)
Station D	9,233	8172	54336	Premium (staffed)

## 6. Results

### 6.1 Aggregated Scores

Table 8 summarizes the aggregated total scores for each component of the CPTED dimension along with their component indicators and Figure 2 illustrates the comparative scores.

<sup>2</sup> Stations having customer service office and staff

<sup>3</sup> We avoid naming station to avoid any stigma which may result from our research

Figure 1: (a) and (b) Compares the Entrance at the Station A and D; (c) and (d) Visibility of the Platforms From the Outside at Station A and C; (e) and (f) Characteristics of the Waiting Area at Station A and D.



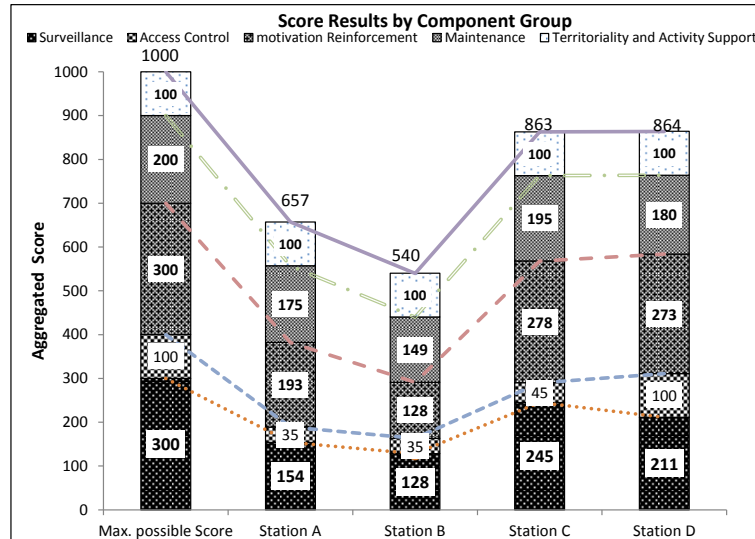
Table 8: Aggregated Weighted Score of the Proposed Measurement Scale for Each CPTED Elements

	Measuring Components					Total Weighted Score
	Surveillance	Access Control	Motivation Reinforcement	Maintenance	Territoriality/ Activity Support	
Station A	154	35	300	200	100	657
Station B	128	35	193	175	100	540
Station C	245	45	128	149	100	863
Station D	211	100	278	195	100	864
Highest Possible Score	300	100	273	180	100	1000

Key Findings from Table 8 and Figure 1 are listed below

- Station D has the highest maximum aggregated weighted score followed by Station C, Station A and Station B.

**Figure 2: Comparison of the Maximum Possible Weighted Score with that of the Station A, B, C and D along with Each Component of CPTED**



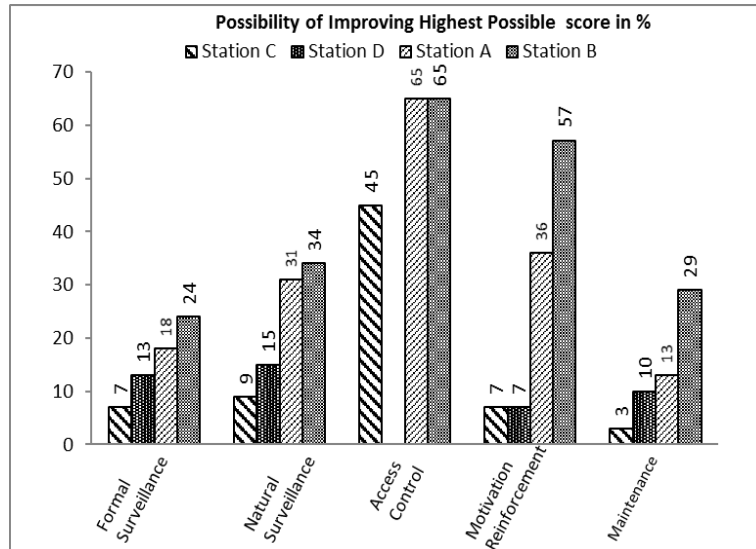
- Generally, premium or staffed stations (Station C and Station D) have the higher aggregated weighted scores than the unstaffed stations (Station A and Station B). On average unstaffed stations have a score which is 26 % lower than those of premium stations.
- The maximum aggregated weighted score is for Station D (864 points) which is 14% lower than that of the maximum possible total aggregated weighted score (1,000 points).
- For the Surveillance dimension, Station C has the highest weighted score of 245 which is the 18% lower than the total highest possible score (300 points). This is followed by Station D (211 points), Station A (154 points) and Station B (128 points). This is because, station C has higher CCTV coverage and natural surveillance compared to others.
- For the Access Control criteria, Station D achieved the highest possible aggregated score (65 out of 65 points) due to the presence of staff and turnstiles at the platform access points unlike other stations. Station C received 45 and, Station A and Station B received equal aggregated score of 35 points which is 55 % and 65% lower than the maximum possible score respectively (65 points).
- Station C and D have received the highest possible aggregated score of 278 points for the Motivation Reinforcement dimension, which is 35% less than the maximum possible weighted score ( 300 points). Station A scored 198 points followed by station B (128 points). Station B got lowest (128 points) which is 57% lower than the maximum possible weighted score due to the absence of PSOs, staff and less CCTV coverage.
- Station C has received the highest possible aggregated score 195 points out of 200 points possible for Maintenance. The score is closely followed by Station C (180 points) and station A (175 points). Station B received the lowest score (149 points), due to lack of proper management of the platforms, waiting area and trees around the station

- For the Territoriality and Activity Support dimension, all of the stations received an equal score of 100 points which is equivalent to the maximum possible score.

## 6.2 Disaggregated Analysis and Key Findings

CPTED component scores by stations are provided in Table 9. Figure 2 illustrates the likely improvement (in %) of the highest possible score at each station which would increase the CPTED value and in turn might assist to improve perception of safety.

**Figure 2: Probable improvement of the highest possible score at the case study station in Percentage**



For the Surveillance dimension, appointing station staff will improve the formal and natural surveillance both for station B and A. For Station C and D, by improving the natural surveillance, 9% (about 26 points) and 15% (about 46 points) increase in the highest possible score for station C and D is possible (as Figure 2).

Figure 2 illustrate that Station B, A and C lack access control features. For Station B, A and C, the inclusion of turnstiles and presence of staff at the entrance of the platforms can improve access control about 65%, 65% and 45% respectively (see Appendix B and Table 9).

For the Motivation Reinforcement dimension, a significant enhancement of score is possible for the station B and A. For station B, appointment of staff and PSOs at the station will increase the scores by 43%, which is 130 points (score 128 to 258). For station A, an improvement of 27% is possible through the inclusion of staff (as PSOs are already appointed). For station C and D, installing an alarm button at the waiting area and a police booth near the station could improve the Motivation Reinforcement about 7%, which is about 22 points

For station B, a 29% improvement of the Maintenance dimension score is possible through cleaning up graffiti at platforms and waiting areas, and maintaining trees. On the other hand, maintaining trees at the station, cleaning up the car park and graffiti would have increased the score about 13% (200 out of 200 points) for station A. At Station D, cleaning up graffiti and higher maintenance of the platforms would increase the score about 10% (or 20 points).

**Table 9: Weighted Score of Each Indicators of CPTED Elements**

Measuring Components	Weighted Scores				
	Maximum Possible Score	Station A	Station B	Station C	Station D
<b><u>Surveillance</u></b>					
CCTV (Formal)	95	67	49	90	72
Station office/Staff (Formal)	25	0	0	8	10
Car park	30	17	13	22	20
Entrance/exit to Station area	20	4	8	14	16
Entrance/ exit to Platforms	20	5	5	16	16
Ticketing Area	30	15	15	26	24
Platforms	50	30	23	50	34
Waiting area	30	15	15	26	24
<b>Measured Total</b>	<b>300</b>	<b>154</b>	<b>128</b>	<b>245</b>	<b>211</b>
<b><u>Access Control</u></b>					
Turnstiles	25	0	0	0	25
Staff	40	0	0	10	40
Entrance/Exit points platforms	10	10	10	10	10
Entrance/Exit points St. area	5	5	5	5	5
Fencing	20	20	20	20	20
<b>Measured Total</b>	<b>100</b>	<b>35</b>	<b>35</b>	<b>45</b>	<b>100</b>
<b><u>Motivation Reinforcement</u></b>					
CCTV	50	45	30	50	45
PSO	50	50	0	50	50
Police	15	0	0	0	0
Staff	80	0	0	80	80
Alarm Button	25	18	18	18	18
Lighting	80	80	80	80	80
<b>Measured Total</b>	<b>300</b>	<b>193</b>	<b>128</b>	<b>278</b>	<b>273</b>
<b><u>Maintenance</u></b>					
Platforms	30	30	15	27.5	22.5
Trees	10	5	0	10	10
Car Park	20	7.5	20	18	15
Waiting Area	30	30	10	30	30
Entrance to the platforms	10	10	8	10	10
Entrance/Exit points St. area	10	10	6.25	10	10
Amenities	10	10	10	10	10
Graffiti: Miscellaneous	30	23	30	30	23
Garbage	10	10	10	10	10
Lighting	40	40	40	40	40
<b>Measured Total</b>	<b>200</b>	<b>175</b>	<b>149</b>	<b>195</b>	<b>180</b>
<b><u>Territoriality and Activity Support</u></b>					
Territoriality	80	80	80	80	80
Activity support	20	20	20	20	20
<b>Measured Total</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>
<b>Total Score</b>	<b>1000</b>	<b>657</b>	<b>540</b>	<b>862</b>	<b>864</b>

## 7. Conclusions

This paper has proposed a scale to measure the design quality of the stations considering CPTED concepts. Existing features at the station and quality of the entrance, platforms and waiting area are considered in the scale. Four suburban train stations in Melbourne are assessed onsite using the proposed scale and are scored accordingly. The case study stations are broadly divided into staffed/premium station and unstaffed station with two stations in each set. Overall comparison of the scores suggests that for unstaffed station the average score is lower than that of staffed station. Station B has the lowest overall score followed by, in order, stations A, D and C. It has been found that only appointment of staff and PSOs could improve the score significantly for Surveillance, Access Control and Motivation Reinforcement dimensions, at station B. For station A, also the presence of staff will be effective in improving Surveillance, Access Control and Motivation Reinforcement Dimensions. For unstaffed stations (A and B), the Maintenance dimension has lower scores overall. Except for station D, all other stations need to install entrance turnstiles to increase

Access Control. Graffiti is common in almost all of the stations studied, although at a moderate to low level.

Future research would explore range of areas. For example, a wide range of suburban stations in Melbourne will be assessed with the proposed scale. Also stations from underdeveloped and developing countries might be considered for comparisons. Questionnaire survey of train users regarding their perception of importance of station features to determine the weight of the components of scale would be considered. Further investigation would also consider linking CPTED scores of the stations with the perception of crime, crime rate as well as perception of safety of the passengers.

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