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Changing the Way South Africa Think about Parking Provision at Tertiary Institutions

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***Abstract*—**For decades, South Africa has been planning transportation systems from a supply, rather than a demand side, perspective. In terms of parking, this relates to requiring the minimum parking provision that is enforced by city officials. Newer insight is starting to indicate that South Africa needs to re-think this philosophy in light of a new policy environment that desires a different outcome. Urban policies have shifted from reliance on the private car for access, to employing a wide range of alternative modes. Car dominated travel is influenced by various parameters, of which the availability and location of parking plays a significant role. The question is therefore, what is the right strategy to achieve the desired transport outcomes for SA. The focus of this paper is used to assess this issue with regard to parking provision, and specifically at a tertiary institution. A parking audit was conducted at the Stellenbosch campus of Stellenbosch University, monitoring occupancy at all 60 parking areas, every hour during business hours over a five-day period. The data from this survey was compared with the prescribed number of parking bays according to the Stellenbosch Municipality zoning scheme (requiring a minimum of 0.4 bays per student). The analysis shows that by providing 0.09 bays per student, the maximum total daily occupation of all the parking areas did not exceed an 80% occupation rate. It is concluded that the prevailing parking standards are not supportive of the new urban and transport policy environment, but that it is extremely conservative from a practical demand point of view.

***Keywords*—**Parking provision, parking requirements, travel behaviour, travel demand management.

I. Introduction

AS a country, South Africa has been targeting the provision of an integrated transport system for more than 20 years. The philosophy is already widely adopted in policy documents and even legislation in all spheres of government [1]-[3], and has even found its way into some spatial and transport plans in recent years [4], [5]. In addition, funding streams now also follow the new policy direction through programmes like the National Treasury's Cities Support Programme [6]. Despite this, regulations still lag behind in many jurisdictions, making implementation of new policies problematic for officials in these areas.

South Africa is at a stage where critical decisions should be taken to ensure that the desired policy outcomes are achieved in the years to come. These depend on the difference between living in a car-dominated society or a landscape designed according to human scale. 'A city can be friendly to people or it can be friendly to cars, but it can't be both' [7]. By segregating land uses, limiting density and applying minimum parking requirements, American cities progressed towards requiring cars for 87% of all their daily trips [7].

In recent decades, public transport provision in South African cities was not comprehensive enough to facilitate all desired movements, but was largely designed to get people to work. E.g., public transport in South Africa is largely only provided during peak hours, making travel virtually impossible during off-peak periods. The Moving SA document [8], divided citizens into the following categories:

- Stubborn – only uses car.
- Selective – can afford a car, but willing to use public transport.
- Sensitive – captive to best public transport mode.
- Survival – captive to cheapest public transport mode.
- Stranded – no affordable public transport available.
- Strider – prefers to walk/cycle.

Citizens in the Sensitive and Survival categories have to use public transport and can only select destinations that are served by public transport. This environment compelled many public transport users to shift to cars as soon as it became financially possible. This shift was accelerated when many households became economically emancipated in the post-apartheid years. This contributed to car ownership levels in South Africa rising from 136 in 2004 to 165 motor vehicles per 1000 people in 2014 [9]. The urgency to obtain a car often results in the purchase of un-roadworthy vehicles. That car affordability is marginal is further demonstrated by the fact that only 35% [10] of vehicles registered in SA have any type of insurance. Trip purposes like those to the clinic, or for recreational, shopping and visiting friends and relatives can generally not be undertaken, marginalizing the poorer communities even further and fuelling the ambition of car ownership.

As the years went by, road space occupation increased more and more with the major metropolitan areas (metros) currently being grid-locked during peak times. Historically, South Africa provided infrastructure from a supply side, so the cars followed inevitably. All municipal regulations also followed a supply-side approach, including the provision of roads and parking. An example of the National Department of Transport's standards for minimum parking provision is shown in Table I [11].

Students, in particular, are at a life-changing stage where exposure and experience with different modes could drive

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travel behaviour change, which could result in a delay in the purchase of a private car.

TABLE I
EXTRACT FROM SA MINIMUM PARKING STANDARDS

Land Use	Land Use-subcategory	Standard
Office	General offices	2.5 spaces / 100m^2 GLA
	Banks, building societies and other public trading offices	4 spaces / 100m^2 GLA
Educational	Universities	0.4 spaces per student

With new developments, road space was thus provided according to traffic analyses accompanied by the provision of a minimum number of parking bays beforehand. The infrastructure was therefore supplied without taking either the behaviour of the future users into account, or the changing urban and transport context. The provision of this infrastructure was therefore provided without taking the vital land use-transport connection into account. To illustrate – with higher densities, travel by public transport would be more feasible and private car travel should be discouraged by providing an alternative to the existing minimum parking requirements. Higher densities and a greater mix in land use also reduce trip lengths that make the use of walking and cycling more attractive. In addition, the revolution in car-sharing technology is likely to result in a reduction in parking demand.

Rail services in South Africa are deteriorating, bus and minibus-taxis are transporting quite a significant share of the public transport users. Bus Rapid Transit (BRT) services are being implemented in metros like Cape Town. Initial feedback is that the cost of providing and operating these prove to be extremely costly and the sustainability of the funding is questionable. South Africa is therefore forced to look at managing their travel demand as efficiently as possible, specifically towards reducing single occupant vehicle travel, discouraging it as far as possible and encouraging all modes of transport besides it. Specific attention should be given to context including type of user, geographical limitations, available infrastructure and socio-economic conditions.

The particular circumstances applicable to this article includes handling transport to and from to the University of Stellenbosch's Stellenbosch campus. The town of Stellenbosch is battling with rising congestion levels threatening to destroy the quaint nature of the town and enjoyable quality of life. Congestion is driven by employees struggling to get to work, scholars to school and students to classes. From a total of 26,441 students registered at Stellenbosch University in 2017, 6,638 students are accommodated on campus in University residences, leaving the remaining 19,803 students to live in private accommodation. At first glance, it would appear that a significant cause of the town's traffic problems, stem from the movements of students and staff to and from the University.

The Stellenbosch University was also in the process of investigating the densification of certain areas on campuses. With limited land available and a shortage of lecturing venues and latest technology required, the University is forced to construct additional learning spaces with integrated, cutting-edge technology.

A need has been identified to increase the number of available space for students to live in University residences on campus, as research has proven that students perform better whilst living on campus. An obvious benefit of this objective is that fewer trips have to be made to the campus.

Following conventional municipal regulations, the provision of additional parking is required. The Stellenbosch University, however, suspected that they had sufficient capacity in its parking areas to accommodate additional lecture space, which gave rise to questions about parking utilization on Stellenbosch campus. The University undertook a study to prove their suspicion to the Stellenbosch Municipality. This article explains the methodology that was followed, describes and discusses the results obtained, and provides conclusions from the analysis.

II. CONTEXT

Stellenbosch town is located in the Western Cape Province of South Africa, about 60 km due east of central Cape Town. The 2015 population of the town was 167,572, living in 48,008 households [12], of which 43% had access to a car.

Some Stellenbosch figures:

- Economic growth in Stellenbosch town is the highest in the region at 3.7% per annum (2010 – 2013) [12].
- Stellenbosch has the highest matric pass rate in the region, at 87.2% in 2014 [12].

Stellenbosch is therefore a relatively affluent town with high literacy and car ownership rates.

Transportation planning is addressed within the municipality's Integrated Development Plan (IDP), in the Spatial Development Framework (SDF) Sector Plan. The SDF Sector Plan provides a number of strategic perspectives to support the aim of improving sustainability by minimizing the town's ecological footprint [12]:

- "Strategic Perspective 1: Interconnected Nodes. This perspective suggests that higher density developments be allowed within town limits, and that a strict urban edge be defined and enforced to put an end to low density urban sprawl".
- "Strategic Perspective 2: Car Free Living. A combination of non-motorised transport and public transport facilities is suggested. Adequate pedestrian and cycling infrastructure and appropriate development policies should ensure that at least 50% of activities found in an urban area are within 1 km of residential areas, making it easier for people to live without the need to own a private car".
- "Strategic Perspective 4: Optimal Land Use. The concept of infill and redevelopment with higher densification is promoted".

Although only Strategic Perspective 2 refers to transport directly, Strategic Perspective 1 and Strategic Perspective 4 are closely linked. Without higher densities and interconnectedness, quality public transport is not financially viable and it would be difficult to encourage a shift away from

the ever-increasing dependence on private cars.

III. Other Parking Study in SA

To address the parking provision dilemma at Stellenbosch University, a study at a knowledge-based professional institution in the City of Tshwane was reviewed [13], employing 3,751 people with office as land use. A total number of 3,817 parking spaces were available on the site. The maximum utilization of parking spaces was 63% over a full day period (from 06:15 – 18:00). Tshwane exhibits similar levels of car ownership and travel behaviour as Stellenbosch. This empirical observation further motivates the purpose of this article, illustrating the need to reconsider minimum parking provision requirements, as required by the respective authorities in line with the South African Parking Standards [11]. As a contributing measure to TDM, parking should be managed effectively. By manipulating parking costs successfully, the number of single-occupant-vehicle (SOV) users might be impacted and hopefully decrease. Further studies could be considered to investigate this aspect.

IV. Stellenbosch University – Case Study

Stellenbosch University also has a campus in Bellville to which this study is relevant. In total in 2016, there were 30,854 students enrolled at Stellenbosch University, of which, 26,441 were affiliated with the Stellenbosch campus, representing 85.7% of the total number of students at Stellenbosch University. From a town perspective, the Stellenbosch campus occupies a significant proportion of the town's development footprint.

Originally, every re-development of Stellenbosch University had to follow the municipal regulations, stipulating the minimum number of parking to be provided accompanying the re-development. The Stellenbosch University re-developed open areas into residences, changed offices into lecturing halls and vice versa, and plan to further intensify its activities on the campus. This densification is directly in line with Strategic Perspective 4 which is concerned with Optimal Land Use.

The University questions the fact that the Municipal regulations still demand parking in areas where land could be better utilized. On a campus with apparently sufficient parking capacity, the question is raised whether it is not time for a change in the way parking requirements are viewed?

As part of the planning for Stellenbosch University, the residential addresses for all staff and students were extracted from the University's staff and student databases. Since the identity of individuals was removed from the data, the analysts could not differentiate between different types of staff. The number of records (8,834) therefore included permanent staff, as well as temporary staff. Of all these records, 92% could be mapped geographically. Addresses outside an 80 km radius from Stellenbosch were excluded in the final mapping. This resulted in a 78% mapping for Stellenbosch staff.

For students on Stellenbosch campus, 87% of the records could be mapped geographically. The general patterns are as follows:

Stellenbosch students:

- Of the 87% that were mapped, about 66.8% (13,031) live within a radius of 1.2 km from the centre of campus, with another 6.8% within 2.5 km. Thus, 73.6% (14,360) of students live within 2.5 km from the centre of campus.
- 6,638 of these students (4%) live in University housing.
- 4.3% live up to 10 km from campus, with 19.1% between 20 km and 40 km away.

Stellenbosch staff:

- Only 19.6% live within a 1.2 km radius from the centre of campus. This includes residence heads in Stellenbosch University housing.
- About two thirds of staff live within a radius of 20 km from the centre of campus, with almost 92% within a 40 km radius.

V. Methodology

As a start to address the parking provision dilemma at Stellenbosch University, the University's mobility manager started to monitor the allocation of parking bays in combination with the utilization. For clarity, staff and students can apply for parking, as follows:

- Students in university residences can apply for parking at the particular residence, where the total number is capped by the availability – therefore the assignment of parking spaces are contained.
- Students in private housing apply for parking in general parking areas.
- Staff members apply for parking according to a set of criteria in the allocated parking areas.

Parking is then assigned according to availability and the set of criteria. The students in private housing can apply for the general parking areas which are distributed across the campus. Staff members generally apply for parking close to their offices in the allocated parking areas, in cases where this is not possible, staff can also be accommodated in the general parking areas.

In terms of assigning parking to the students in private housing, the process was simple, because there are ample bays available and everyone applying could be accommodated.

The difficult step was to assign parking to the staff, as bays are limited close to the main campus buildings. The mobility manager realized that the utilization of the 60 parking areas differed, each faculty seemed to have different parking utilization behaviour, and therefore he had to develop a method in order to allocate the parking appropriately. At some of the 60 parking areas, parking could be allocated at 100%, therefore each person applying for a parking bay could receive one parking bay at his/her disposal. This was only necessary if all the users are present simultaneously. In most instances, the mobility manager could "over"-allocate the available parking bays while users still did not struggle to find an open bay.

The step that remained as part of the parking management system was to conduct an audit at all the parking areas on the Stellenbosch campus and then compare the utilization in order to determine whether the Stellenbosch University could facilitate all the demand. A parking audit was then conducted

from Monday 25 July to Friday 29 July 2016 during business hours. The results are indicated in the next section.

VI. Results

By means of an empirical assessment, the utilization of all 60 parking areas was observed over a five-day period during business hours. The following outcomes were desired:

- The utilization of the parking areas in total – Fig. 1.
- The utilization of the parking areas per type (general/ allocated) – Fig. 2.
- The utilization of the parking areas per geographical area (central/south/north) – Fig. 3.

To determine whether the mobility manager allocated (over/ under) the parking demand efficiently.

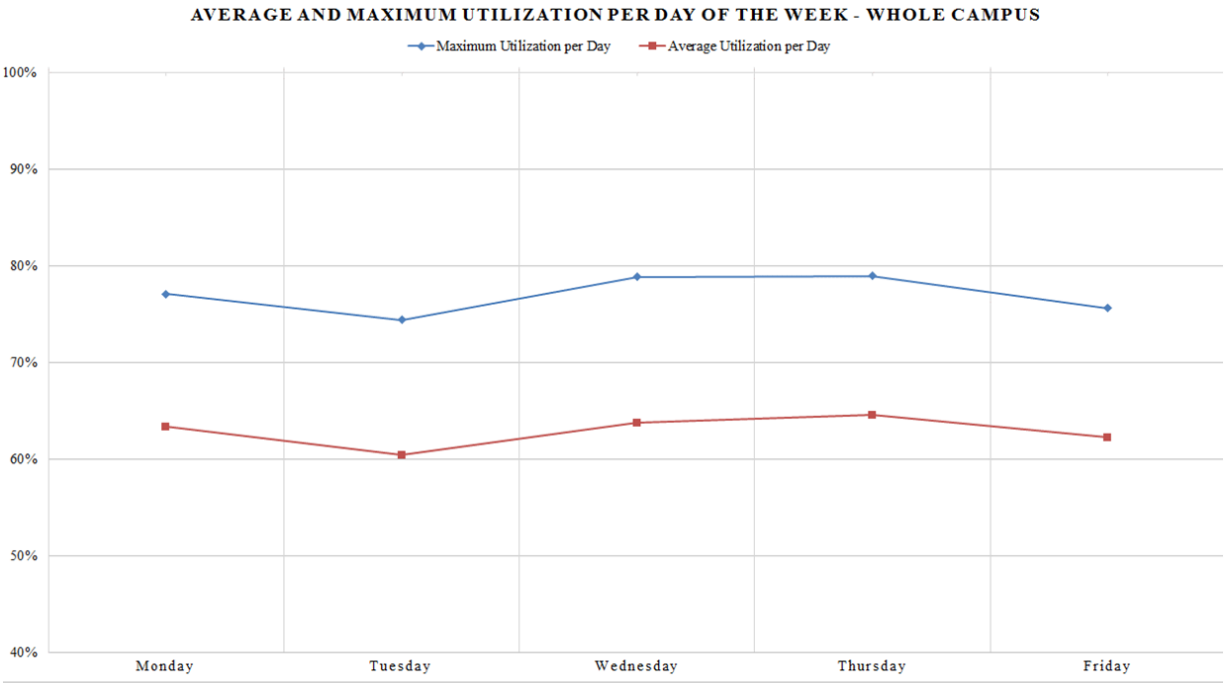

Fig. 1 Utilization Entire Campus

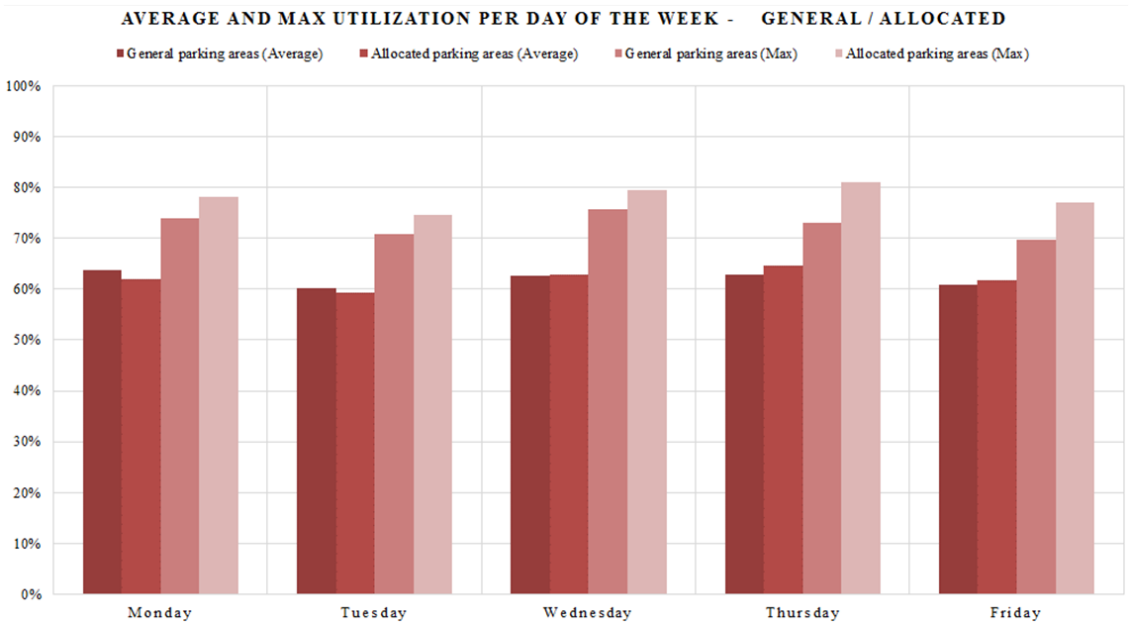

Fig. 2 Utilization per Type Parking Area

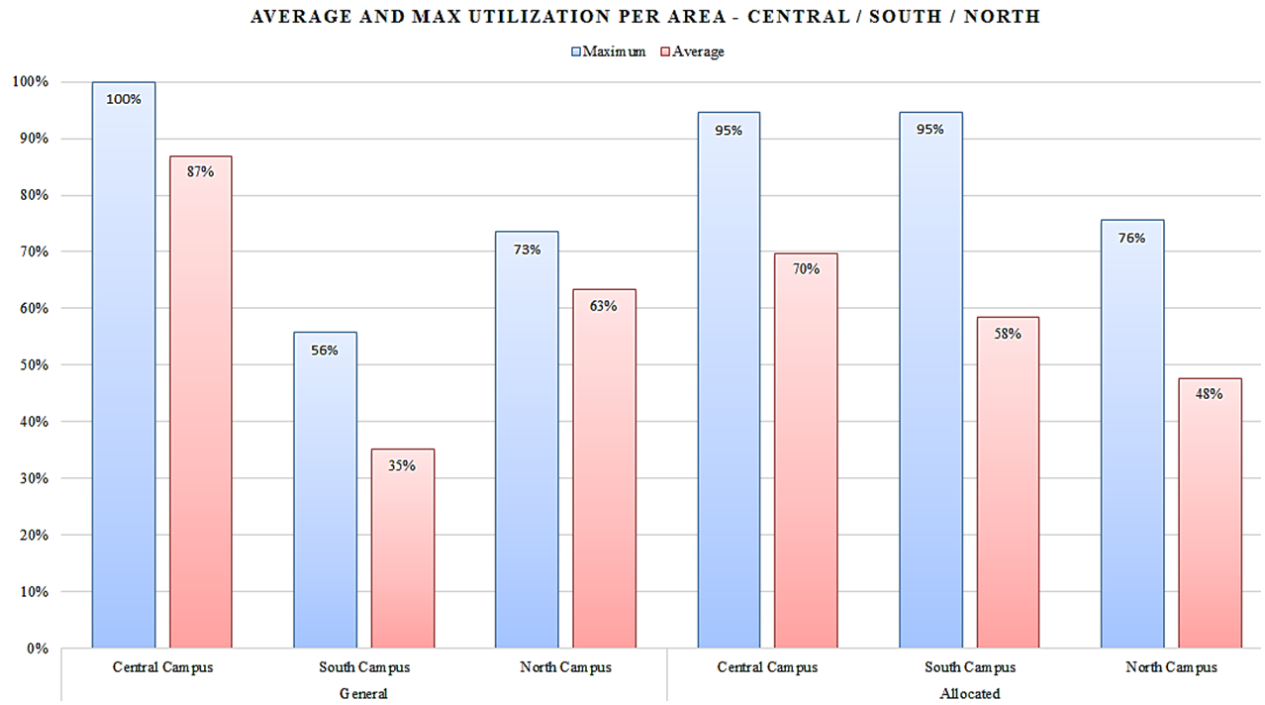

Fig. 3 Utilization per Geographical Area

Fig. 1 presents the parking utilization of the entire campus, indicating that the maximum utilization never exceeded 80%.

Fig. 2 indicates the parking utilization separately for general parking areas (mostly used by private students) and allocated parking areas (allocated to personnel). The maximum utilization for allocated parking areas is just above 80% at 81% whereas the maximum utilization for general parking areas peaks at 76%. Both these maximum values are still reasonably below the 100% mark.

Fig. 3 breaks the study down geographically, into central campus, south campus and north campus. Fig. 3 indicates some pressure is experienced on the Central campus for the general parking areas, sitting at 100% utilization (maximum). The utilization for general parking areas on the South and North campuses are operating at lower levels (73% maximum for North campus and 56% maximum for South campus). In terms of the allocated parking areas, higher utilization levels are experienced, 95% maximum for Central campus, also 95% maximum for South campus and 76% maximum for North campus.

In terms of the provision for staff (allocated parking areas), staff numbers do not change significantly from year to year. It is therefore just a matter of meeting the existing demand, allocating as efficiently as possible and have some spare capacity available, which could be used to alleviate the pressure experienced on the Central campus (spare capacity is still available on the North campus).

In terms of the provision for private students, the Central campus is experiencing some pressure. It will be considered by Stellenbosch University to balance the utilization of the different areas better. Currently all parking areas have the same cost structure. The Stellenbosch University will begin to implement differential pricing in the next few years to address the pressure on the Central campus. This TDM measure will assist with levelling the demand across campus. Even with the pressure experienced on the Central campus by private students, it should be emphasized that according to Fig. 2, the combined maximum utilization for general parking areas still have significant spare capacity at 76%. The North and South campuses are connected to the Central campus by a shuttle bus operating at regular intervals; the distance is about 1 km from North to Central campus and 1km from South to Central campus. Thus, some private students can rather be accommodated on the North and South campuses.

The total number of private students in 2016 for the Stellenbosch campus was 19,803 students. The total number of general parking bays is 1,691 bays. Therefore, currently parking is provided at a rate of 0.09 bays per student. The important conclusion from this data is that by supplying at a rate of 0.09 bays per student, the utilization of the general parking areas is 76% at the most. By comparing the rate of 0.09 with the required parking provision rate in

TABLE I

of 0.4 bays per student, there is a significant difference, with 4.7 times more parking bays being required according to the regulations. Should Stellenbosch University have provided parking bays according to the regulations, it would have been a fruitless and wasteful expenditure. It is due to this outcome that it is suggested to rather treat parking provision from a demand side than from a supply side. It could also be reasoned that the minimum parking standards are outdated and require updated surveys. But still it is difficult to apply a blanket approach and treat all tertiary institutions similarly. Each institution will have a unique context in terms of land use, road network, public transport provision, NMT

infrastructure and surrounding town/city structure. The optimal solution therefore entails planning each institution's requirements based on its own individual set of characteristics. The Stellenbosch University in collaboration with the Stellenbosch Municipality is aiming to prepare an Overlay Zoning Scheme to include all the University areas. As part of this Overlay Zoning Scheme, it is proposed to amend the parking requirement by decreasing these requirements according to the findings of this parking audit. This Overlay Zoning Scheme will then be presented to the Stellenbosch City Council for approval.

VII. Discussion and Conclusion

"The past teaches us that minimum parking requirements lower site density, increase land consumption, oversupply parking and reduce profits per unit of covered land" [14].

Zhan Guo and Shuai Ren at New York University [15] studied the results of London's shift from minimum parking requirements with no maximum, to maximum parking limits with no minimum. "Using a sample of developments completed before and after the reform, they found that the supply of parking after the reform was only 68% of the maximum allowed, and only 52% of the previous minimum required. If, after the reform, developers provided only 52% of the parking spaces previously required, and rarely provided as many parking spaces as allowed, the result implies that the previous minimum parking requirement almost doubled the number of parking spaces that developers would have voluntarily provided on their own. They concluded that removing the minimum parking requirement caused 98% of the reduction in parking spaces, while imposing the maximum standard caused only 2%" [15]. According to these studies, the following steps can be considered for Stellenbosch University:

a. Reduce the minimum parking requirements
b. Remove the minimum parking requirements
c. Impose a maximum parking requirement

In order to contextualize these steps for the Stellenbosch campus of Stellenbosch University, some parking requirements must still be included as part of the Overlay Zoning Scheme which needs to be accepted by the Stellenbosch City Council. The previous graphs only illustrate the maximum and average utilizations, in order to determine some form of benchmark, it is necessary to determine the time duration during which the parking areas are under pressure. In order to explain, should a parking area have a maximum utilization of 100% and it is only fully utilized for 10% of the time, it is different from a parking area having a maximum utilization of 100% which is fully occupied for 90% of the time. To illustrate these aspects, heat "figures" were drawn of the five general parking areas having a maximum utilization of over 90%.

For each of these five parking areas, the time duration was calculated during which these areas experienced utilization above 90%. The results obtained were as follows:

- For Smuts Street (Fig. 4) – 80%
- For Ou Bloemhof (Fig. 5) – 71%
- For Engineering North (Fig. 6) – 53%
- For Skuilhoek Students (Fig. 7) – 16%
- For Coetzenburg (Fig. 8) – 2%

Smuts Street	Monday	Tuesday	Wednesday	Thursday	Friday
7:45	100%	59%	100%	100%	83%
8:45	100%	40%	100%	100%	89%
9:45	100%	100%	100%	100%	95%
10:45	100%	98%	100%	100%	99%
11:45	100%	100%	99%	100%	99%
12:45	100%	67%	100%	100%	100%
13:45	100%	61%	100%	100%	97%
14:45	100%	103%	100%	100%	83%
15:45	91%	46%	100%	100%	87%

Fig. 4 Smuts Street Parking Area

Ou Bloemhof	Monday	Tuesday	Wednesday	Thursday	Friday
7:45	100%	100%	81%	86%	100%
8:45	100%	100%	85%	89%	100%
9:45	100%	100%	100%	92%	100%
10:45	100%	100%	100%	100%	100%
11:45	100%	100%	100%	100%	100%
12:45	97%	99%	100%	100%	92%
13:45	96%	99%	100%	97%	88%
14:45	89%	100%	88%	89%	82%
15:45	81%	100%	76%	80%	55%

Fig. 5 Ou Bloemhof Parking Area

Engineering North	Monday	Tuesday	Wednesday	Thursday	Friday
7:45	58%	93%	91%	85%	85%
8:45	59%	95%	87%	82%	85%
9:45	98%	87%	95%	90%	92%
10:45	100%	89%	94%	92%	93%
11:45	99%	88%	95%	94%	92%
12:45	98%	88%	91%	98%	95%
13:45	98%	86%	95%	92%	95%
14:45	100%	86%	87%	87%	89%
15:45	98%	90%	83%	89%	90%

Fig. 6 Engineering North Parking Area

Skuilhoek Students	Monday	Tuesday	Wednesday	Thursday	Friday
7:45	53%	52%	66%	66%	61%
8:45	50%	56%	73%	73%	58%
9:45	68%	97%	81%	90%	63%
10:45	66%	65%	100%	61%	69%
11:45	74%	48%	90%	90%	58%
12:45	60%	69%	65%	97%	77%
13:45	55%	79%	52%	60%	69%
14:45	95%	81%	84%	42%	63%
15:45	65%	65%	44%	23%	48%

Fig. 7 Skuilhoek Students Parking Area

Coetzenburg	Monday	Tuesday	Wednesday	Thursday	Friday
7:45	41%	55%	40%	43%	48%
8:45	80%	58%	42%	48%	53%
9:45	80%	66%	66%	71%	56%
10:45	85%	78%	72%	74%	58%
11:45	91%	85%	77%	81%	60%
12:45	71%	77%	84%	87%	61%
13:45	75%	75%	39%	46%	67%
14:45	68%	71%	35%	43%	64%
15:45	50%	62%	31%	45%	49%

Fig. 8 Coetzenburg Parking Area

A proposed benchmark can contain a reduced minimum parking requirement in combination with a percentage utilization that should not be exceeded more than a specified

time threshold (the parking audit will be repeated annually to review the usage). For example, it can be requested that Stellenbosch University should provide parking for private students at a rate of 0.07 bays (decreasing the 0.09 rate by 80% due to campus maximum not exceeding 80%) per private student, with utilization of the general parking areas not exceeding 90% utilization for more than 85% of the time.

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