

The plan is an inadequate tool for planning.

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1 Abstract:

The term *town planning* implies a planar – two dimensional – method of analysis and design. For most of the 20th Century, two dimensional analysis was seen as adequate as it could deal with the planning issues of the time. With increasing density and populations, more complex land uses, as well as a desire to improve public spaces and the growing concerns for environmentally sustainable development, it is felt that 2D planning methods are no longer adequate and that 3D & 4D analysis and design tools must be adopted.

This paper focuses on the development of a suite of 3D & 4D digital tools geared towards urban design. The tools have been developed either through customization (scripting) or through taking advantage of under-utilized parametric features within industry standard CAD and 3D animation software. This has been done with the intention of beginning to address planning issues which are difficult to solve using conventional 2D planning techniques. The toolkit also avoids the great expense of additional specialised software, additional hardware or the appointment of additional consultants.

The suite of digital tools is currently being developed and tested on urban design case studies within an architectural practice in Melbourne, Australia. The tools discussed in this paper are: wheelchair access gradient analysis, agent-based pedestrian connectivity analysis, radiance-based daylight analysis, visual impact analysis and urban form generation. The tools are proving to be used quickly and concurrently 'in house', early in the urban design process. This suits both the limited fees and the compressed time frame of sketch design and design development within architectural Practice.

With careful research and reassessment of the way we use existing software for analysis and design, this paper highlights an opportunity for architects to not only address planning issues that have hitherto been beyond the reach of designers, but also increase the contribution architects can make in the generation of planning policy.

2 Keywords:

Customisation, Urban-analysis, Agents, Connectivity, Daylight-hours, Parametric, Scripting, Plug-in

3 Introduction: Adequacy of plans – ‘modelling’ in 2 dimensions

By its very name, the term planning implies a planar - two dimensional - method of analysis and design. *Planning* can be taken to be ‘the process of deciding how land in a particular area will be used and designing *plans* for it’¹ and a *plan* a ‘representation of a thing drawn on a plane, as a map or diagram’² and ‘a scale drawing of a horizontal section of a building’³.

A *model* can be defined as a ‘simplified version of reality, built in order to demonstrate certain of the properties of reality’, (Haggett, 1965)⁴. So *Planning* using *plans* is essentially a kind of model that simplifies the infinitely complex reality of urbanism to a two dimensional abstraction, in order to analyse and design key elements. (Antoni 2002)⁵. The term *inadequate* means ‘insufficient for a purpose, unable to deal with a situation’⁶. Adequacy is subjective and perceived by the observer, and this perception may change over time. Planning in two dimensions is no longer adequate for today's society. For a model to be adequate, it must limit the level of abstraction whilst retaining a sufficient level of reality to successfully test of the key elements in question.

Throughout the history of urban design the level of abstraction in the city modelling for analysis and design has varied. Pre renaissance cities generally either grew organically in ‘the pack donkey’s way’ (Le Corbusier 1924)⁷ or were derived from a two dimensional grid in plan.

*The pack-donkey meanders along, mediates a little in his scatter-brained and distracted fashion, he zigzags in order to avoid larger stones, or ease the climb, or gain a little shade; he takes the line of least resistance.*⁸

Le Corbusier’s concept of civilised humans planning cities with a 2D orthogonal grid in contrast to the unplanned, pack-donkey-organic echoed the thoughts of Haverfield (1913)⁹ who suggested the orthogonally planned grid distinguished the civilized from the *moral inconsistency* of the barbarian (Kostof)¹⁰.

Through the late medieval period pseudo perspective – ‘bird’s eye view’ drawings of cities (somewhere between 2D and 3D) allowed for an overview of the relationships of key buildings. Along with the discovery of perspective, this led to application of the technique as an urban design tool through the renaissance, baroque and picturesque. Urban designers composed perspective images or scenes of spaces that were projected back to 2D plans for construction.

With the rise of commerce such noble aesthetic pursuits gave way to the reversion to 2D grid plans due the ease in which real-estate could be divided up and sold. Real-estate generally being sold by square metres (2D) calculated with Length times Width equals area, not by computer measured polyline areas, or by cubic metres. The 2D grid method of planning has been adopted all over the world and is seen as the norm. It is sometimes applied over areas regardless of topography resulting in areas of Street grid

that is too steep for even a car to drive directly up. Notable examples are San Francisco California, (the home of the movie car chase) and Wellington New Zealand which was designed in England using 2D site plans with no topographical information and the designer never having visited the site.

In the current situation, *efficiency* is the catch cry, though as I will discuss, this is beginning to change. There is now an opportunity to change the way in which we work to include the noble pursuits of amenity and artistic planning of the past (Sitte 1889)¹¹, without sacrificing efficiency.

4 The problem:

4.1 Environmental Awareness > Increased Density > Diminished Amenity

Over the past decade an increased cultural awareness of environmental issues has forced governments to re-assess planning policies with regard to increased density of inner suburbs. This is often in direct opposition to local residents' desire to maintain if not improve local amenity by retaining lower density. This may be due to the fact that density has an historical stigma to overcome. High density has been problematic even in pre industrial cities, where increased density of people led to famine and high levels of disease. The problem worsened as cities became industrialized with the addition of smog etc. Attempts to address the issue of public health with planning have been investigated in various forms. Haussmann's Paris¹²(1850's) and the Garden City Movement (Howard 1898) both used 2D planning methods to address this problem, either with great boulevards or land use zoning.

The initial uptake of the car led to the spread of the city – suburban sprawl, which meant that residential, could be located far away from the industrial areas. This would have initially had a positive effect on health, but as numbers grew, roads have become more and more congested (Davison, Yelland 2004)¹³. The effect of pollution from cars is now seen as a major contributor to global warming, a phenomenon even the largest sceptics such as the current President of USA and Prime Minister of Australia are beginning to recognize (Darby 2006)¹⁴. This has led to the desire by governments in Australia to contain the sprawl by putting development boundaries around cities and encouraging higher density development in *transport hubs* near existing public transport to lessen reliance on cars. By encouraging a higher population density, the old fears of public health, access to daylight, fresh air etc. once again move to the fore. In 2002 the Victorian State Government released the planning document 'Melbourne 2030 Planning for sustainable growth', with nine objectives to promote urban consolidation and the containment of suburban sprawl.

Figure 1

Melbourne 2030 – Planning for sustainable growth -- Key aspirations / objectives.

Direction 1: A more compact city Direction 2: Better management of metropolitan growth Direction 3: Networks with the regional cities Direction 4: A more prosperous city Direction 5: A great place to be Direction 6: A fairer city	Direction 7: A greener city Direction 8: Better transport links Direction 9: Better planning decisions, careful management
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Local councils are responding to the *Melbourne 2030* report in the form of ‘Urban Design Frameworks’ and ‘Structure Plan’ documents, which set up the planning rules within which new construction must abide. These documents are produced by planners, stake holders, user groups, traffic engineers, landscape architects and architects. They set out zoning plans for future development allocating programs eg. ‘Retail Zone’ or ‘Entertainment Precinct’, suggest preferred visual character, suggested urban interventions, set height limits for different areas with the intention of addressing each of the nine objectives of *Melbourne 2030*, achieving both an increased density and retaining amenity despite generally being limited to written instructions or that which can be drawn in 2D plans or sections.

4.2 Do we have the tools?

Existing tools / Available tools

The general aims of *Melbourne 2030* have been widely accepted, even by the Leader of the State Opposition¹⁵, though the implementation has been widely criticized. Resident groups complain that the report does not protect ‘local character’ from ‘inappropriate development’. They believe height limits should be in line with the Residential Code of Victoria - *ResCode* (Kirby 2003)¹⁶. They also have problems with the ‘selection techniques for determining which are the best areas to direct higher density development’¹⁷. An independent study produced by Monash University on *Melbourne 2030* concluded that there are ‘too few tools to ensure that the strategy is implemented’ (Birrell 2005)¹⁸. This is in line with the view shared by focus group discussions held with various municipal planning departments - neither architects, nor planners currently possess the tools to deal adequately with the 2030 directives within the time and fee constraints¹⁹.

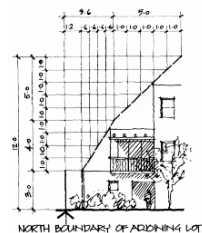


Figure 2

ResCode - Residential setbacks - ‘Setback from boundary for building height at any point - more than 3.6m but not more than 6.9m must be: 1m plus an additional distance calculated at the rate of .3m for every metre of height over 3.6m.’²⁰



Figure 3

Planning zones illustrated in 2D plan for South Melbourne Central Urban Design Framework (Port Phillip 2005) relating to use and height limits.

The industry predominantly uses Autodesk's AutoCAD™ software. Some architects are slowly including Building Information Modelling (BIM) software in addition to AutoCAD (such as Revit™, or ArchiCAD™). And an increasing number of enlightened councils are moving to GIS (Geographic Information System) systems (Yigitcanlar 2005)²¹. GIS software is very strong on data/statistical analysis but has traditionally been 2D, and relatively weak on 3D. Even with the extended packages offered by software developers ESRI and MapInfo™ that allow 3D modelling there is resistance to the uptake of the 3D capabilities (Pietsch 2005)²². Despite the efforts by ESRI to produce the *all-in-one out-of-the-box* planning program, they have opened the program up to 3rd party 'add-ons'. Google's Sketchup™ has recently released a plug-in for ESRI - GIS which theoretically allows information transfer between the two programs. This is an acknowledgement that both programs individually are insufficient to deal with planning issues - ESRI's 3D modeller is 'too clunky', and Sketchup's 'user friendly' polygon meshes don't store the required attribute information, but the two programs combined move closer to what is needed by planners. This synergy of software seems to have many advantages; if the planners/architects already possess the GIS software, the very cheap Sketchup can be added on with minimal cost and training. Unfortunately the majority of planners in Victoria do not use the ESRI software, opting for the slightly cheaper Map Info (Yigitcanlar 2005)²³, for which no plug-in for information transfer with Sketchup currently exists. In the case of architects any form of GIS is extremely rare, (see table 1).

Table 1 : Primary CAD system survey of architects (2004)²⁴

Product	Percent
Architectural Desktop	14.1%
ArchiCAD	1.0%
AutoCAD	54.3%
AutoCAD LT	1.8%
AutoCAD Map	1.2%
Inventor	2.1%
Mechanical Desktop	2.1%
MicroStation	4.2%
Land Development Desktop	9.1%
Solid Edge	1.2%
SolidWorks	3.3%
All Other (ESRI, Revit, Map Info etc)	5.6%

4.3 What is needed?

Customisable software - building upon industry standard software (old dogs really can learn new tricks)

It is essential for any software used by planners and architects to be customisable (Burry 1997)²⁵, and for the digital information to be transferable to a range of other programs. It is inevitable that any software package will be good for some discipline-specific tasks, but poor at other tasks, illustrated in the ESRI GIS and Sketchup example. This should not be considered a bad thing; with this combination of software the best of both worlds begins to be possible. If the *all-in-one out-of-the-box* planning program is recognised as an unachievable aim, energy can be put into development of innovative 3rd party add-ons.

Like most architectural offices, the office in which this research has been conducted does not possess GIS software. It does however possess the usual AutoCAD, 3D Studio Max, (normally used for rendering presentation models), and a copy of Revit (BIM). None of these programs by themselves are adequate, but AutoCAD and Max are open to customisation with basic 'user programming' (Autolisp or scripting), meaning there is the opportunity to improve the programs and produce tools which fill the gaps identified above.

Increase speed of analysis and reduce work done in isolation.

There is great cost associated with the engagement of additional specialist consultants to do 3D and 4D analysis for lighting, wind, pedestrian connectivity analysis etc. as well as the time lost as information is sent out, with feedback coming days and sometimes weeks later, (McGauran 2006)²⁶. This limits the number of design iterations possible, but also means the analysis happens in isolation – the person carrying out solar access doesn't see the results of traffic studies. Or, just as problematic, the traffic analysis has to be done first with no chance to revisit decisions made. In this sequential scenario, the traffic consultant does traffic flow analysis and proposes road layout, which is then 'locked in', the next consultant does their analysis and then the next. This is problematic for a number of reasons, not least of which is it produces 'a system that, relentlessly condemning all artistic traditions, has restricted itself exclusively to questions of traffic', (Sitte 1889)²⁷. Whilst there might be some artistic traffic engineers out there somewhere, traffic engineers are also less likely to consider pedestrian movement (Desyllas et al. 2003)²⁸, just as lighting engineers are unlikely to be concerned with traffic flow, and – dare I say it – architects could be accused of considering aesthetics of designs and not much else. The suite of add-on tools being developed enable the architect to take on some of this work currently done in isolation by others, by reducing the level of abstraction in the modelling, without sacrificing speed or flexibility. As the one consultant can manipulate the model and instantly see perspective views for visual assessment as well as pedestrian, solar access etc. concurrently, a more synergistic planning response can be made.

5 The Digital Tools:

5.1 'The Gradiator' - Access for all

The planning aspiration

Improving wheel chair access²⁹ and catering for a rapidly aging demographic (Murray 2006)³⁰ have both been stated within the objectives of *Melbourne 2030*. In the case of residential developments catering for the elderly, it is desirable that these projects be located close to public transport and for topography be considered during initial siting. Topography is also important when considering upgrading transport facilities – the introduction of wheelchair friendly train & bus stops etc.

Existing method and their shortcomings

Within traditional drafting packages, 2D sections of contour drawings can be produced and used to analyse gradients along the section cut line. However, this traditional manual 2D section is time consuming and only allows assessment of that which is actually cut by the section plane.

There is a plug-in available for the 3D add-on for ESRI GIS, which allows contours lines with height attributes to be used for gradient analysis. McNeil's Rhinoceros 3D program has change of gradient analysis capability with the *Draft Angle* command which can be used on topographic 3D meshes, although Rhino itself does not have terrain mesh creation capabilities. Landscape architecture programs such as the 'vertical application' (discipline specific add-on package) Land-CAD (add-on for AutoCAD) can be added to with the purchase of 'Eagle Point'.

These methods are far more useful than a simple section, but require a topographic mesh to be created from 3D contour lines using one program, then imported, converted into an appropriate format and then analysed, which takes time. Also, once the surface is analysed, changes to the topography must come from the original source, re-imported, re-converted then re-analysed.

Constraints

The speed of analysis is seen to be a key constraint in this process. The 3D terrain creation and manipulation as well as slope analysis must be fast enough to analyse existing topography, but in the case of new developments also be quick to test alternate topographic manipulations.

The digital tool

The 'Gradiator' tool can be applied on any size topography, even large scale areas as big as whole cities and done in seconds. There are two steps to this process for using the Gradiator, firstly 3D contours lines are turned into a surface using 3D Studio Max's inbuilt 'Terrain' 'compound object' command. This is followed by running the Gradiator script, which assesses each polygon's *normal* in relation to the Z axis and applies a material colour (fall off map) according to the user-defined key. The

key by default is set to show equal access areas (relatively flat areas accessible by an unassisted wheelchair) as blue, fading from blue to red as the gradient gets steeper.

Case study

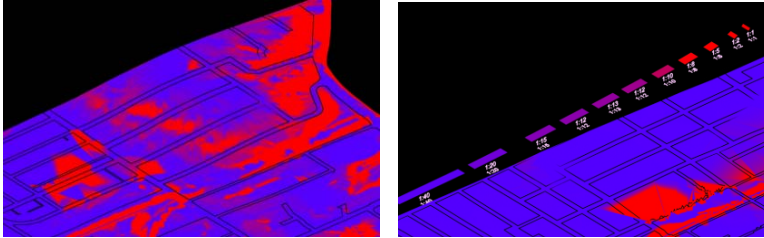


Figure 4 Gradiator applied to an area in Prahran in Melbourne. Analysis of non-accessible areas of suburb made in 140 seconds.

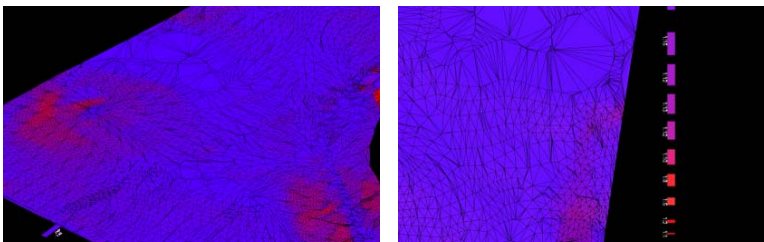


Figure 5 Gradiator applied the town of Hamilton in rural Victoria for Oculus Landscape Architects. Analysis of non accessible areas of town performed and emailed back to consultant within 45 minutes.

Results – speed, accuracy, level of abstraction

The Gradiator can be applied to a terrain mesh in seconds. The level of accuracy is as high as the topographic information input into the terrain model. The model can be progressively refined as more data is gathered and these updates are reflected live in the analysis.

This tool allows an architect to know where a retirement village should (or shouldn't) be located and where special wheelchair friendly bus or tram stops may be ineffective due to surrounding topography. It can also be used in pedestrian catchment analysis in cases which may be greatly influenced by steep terrain.

5.2 'Ped Catch' - Pedestrian connectivity

The planning aspiration

An over arching theme of *Melbourne 2030* is urban consolidation through improved access to public transport. It is believed this can be achieved by increasing density within existing transport node catchments (walking distance from railway stations etc).

Existing methods and their shortcomings

This idea of catchment has been considered important by planners since the 1930's and particularly after the housing shortage at the end of the Second World War (Barnett, Burt, Heath 1944)³¹. The technique for establishing this catchment has remained unchanged.

The Circular catchment method: The analysis technique adopted for assessing transport catchments uses a 2D plan and simplifies pedestrian movement from a central node (eg a railway station) to an 'as the crow flies' radial catchment, (see Figure 7). Radii commonly used are 400m and 800m, which represent five and ten minutes walking distance at average walking speed of 1.33 meters per second, the amounts of time people are willing to walk to shops and transport respectively (Pushkarev 1975)³².

Shortcomings: This modelling technique is very quick but has very low accuracy. It fails to allow for discrepancies in street grid layout, busy roads and crossings, as well as ignoring 'aspects of the physical environment that may influence walking distances, such as gradient, perceptions of safety, destination type and climate'³³ (Pikora 2001). This is a 2D abstraction of what is essentially a 4D problem. Consequentially the technique is only accurate when the topography is flat, the street grid is radial and no time is spent waiting at lights.

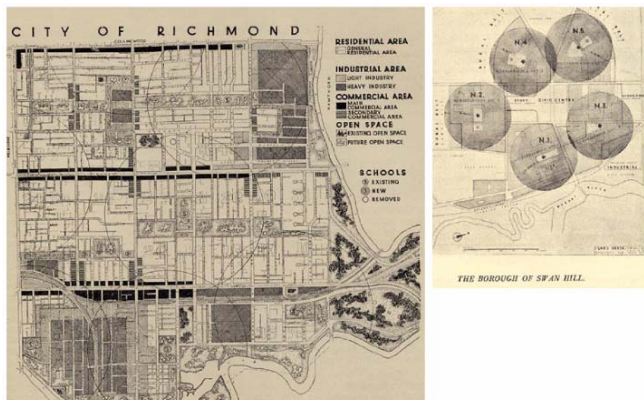


Figure 6 Diagram from We Must Go On (1944) showing five minutes walking distance catchment measured from centre of transport interchanges.



Figure 7,
Diagram from Melbourne 2030 (2003) showing five minutes walking distance catchment measured from centre of transport interchanges.

Pedestrian Route Directness: Research by Dr Jennifer Dill at Portland State University, into other GIS based methods of measuring pedestrian connectivity compared methods such as Block length Ratio,

Block Density, Street density, Pedestrian Route Directness (PRD) and Link Node Ratio concluded that by far the most effective method of measurement is PRD. (Dill, 2004)³⁴. PRD measures the distance between two nodes and expresses this as the 'ratio of route distance to straight-line distance for two selected points', eg. the distance between railway station and a supermarket are measured both 'as the crow flies' and also by navigating through the block layout and these distances are expressed as a ratio.

Shortcomings: Although accurate, PRD is the most difficult to calculate and most time consuming method, and its computational complexity renders it difficult to use for policy making and consequently it is rarely employed by planners. (Dill, 2004)³⁵. Also, PRD doesn't consider aspects of 3 and 4 dimensional environment, such as topography, busy roads, and daylight.

Visual Graph Analysis (VGA): The Space Syntax method of analysis developed at UCL can be used for pedestrian connectivity using Visual Graph Analysis (VGA). This method has shown to have a direct link to pedestrian movement (Hillier 1996)³⁶ in studies conducted in London. The work of Dr. Jake Desyllas from Intelligent Space London also uses VGA as well as many other factors such as footpath width, along with empirical studies of an area, with the use of multi regression analysis (MRA).

Shortcomings: Whilst the VGA method has been shown to be a successful method of analysis in London (Desyllas et al)³⁷, London is a very particular form of urban fabric. For those people having walked around Brasilia, (a city with very high levels of VGA), few would argue that the city has high levels of pedestrian connectivity. There are many other factors that must come into account such as street program (retail, blank carpark walls etc), shade etc. These factors are taken into account with the MRA method, but the method requires a great deal of data collection, and, to have the analysis performed, one must appoint Intelligent Space (London based spatial consultants).

Agent based analysis: The use of Artificial Intelligence (AI) for an agent-based pedestrian analysis technique utilises advancements in crowd animation (examples include Peter Jackson's Lord of the Rings and any advertisement with a crowd). These use large numbers of 'agents' that are capable of being programmed to make basic decisions, move at human walking speeds³⁸, be attracted or repelled by other elements within a 3D model, slow down as they travel uphill etc.

Shortcomings: The main pitfalls of Agent based analysis are the prohibitive cost and the fact that the programs used are specialised and require training to use. Though originally designed for crowds escaping from burning buildings, Agent based evacuation software such as Legion and Ped-Sim could be reconfigured and used to determine pedestrian catchment, but these programs are quite specialist and expensive and require the translation of all data into another program.

What is needed

A tool is needed which allows analysis of a single destination – such as a railway station – and all destinations within ten minutes walking distance. A 4D analysis should use CAD with a 3D animation software package commonly used within architectural practice to not only compare agent’s walking distances versus the ‘as the crow flies’ distance, but also allow the comparisons of various proposed urban interventions whilst still managing to meet the architectural office’s deadlines.

The digital tool

A simplified version of the Artificial Intelligence (AI) in the form of *Crowds* and *Particle Flow* has been built into even cheaper animation programs such as 3D Studio and Maya, with 3D Studio being the most commonly used in architectural practices (Hobbs 2006)³⁹.

These new software capabilities can be used to simulate crowds of pedestrians capable of ‘seeking’ goal destinations such as libraries or railway stations and being ‘repelled’ by destinations/objects, eg. move as far as that can away from a particular destination and avoid bumping into each other. To calculate transport interchange catchments, we run the agent process in reverse, with agents which begin at the transport node programmed to move as far away from the node as possible in ten minutes.

Case study

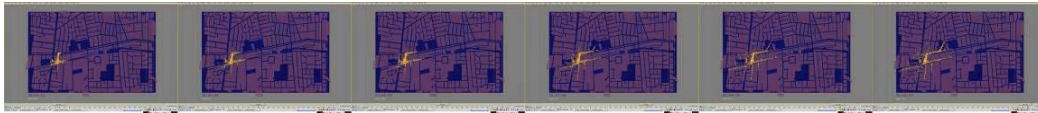


Figure 8 Frames from Ped-Catch pedestrian animation for 10 minutes walking distance - existing street layout for the Nunawading railway station precinct.

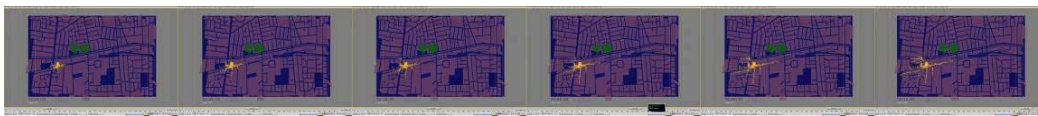


Figure 9 Frames from Ped-Catch pedestrian animation for 10 minutes walking distance - proposed street layout for the Nunawading railway station precinct.

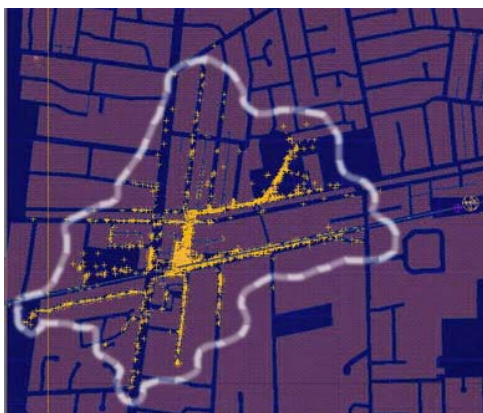


Figure 10 Catchment shape for 10 minutes walking distance - proposed street layout (note: not a circle)

Results – speed, accuracy, level of abstraction

In the case of Ped-Catch, the speed of use failed to match existing 2D method of analysis. To draw the 800m radius in plan takes approximately seven seconds compared with Ped-Catch method, which takes approximately seven hours although this includes modelling of the site.

According to validation studies, the Circular Catchment method of analysis is less than 50% accurate and there is no mechanism for comparison – ‘what if’ scenarios which look at different street configurations, which Ped-Catch allows. The accuracy of this method is currently being tested through empirical evidence – running observation trials with actual students in a method similar to Daamen, W, & Hoogendoorn (2003)⁴⁰ but is estimated to be substantially higher (more than 80%).

These studies illustrate catchments more clearly than the circle technique. Ped-Catch analysis presented to community groups as animations have proved to be a powerful advocacy tool, with the proposed changes to street layout in the Mega-mile case study approved and supported by all stakeholders and community (Figure 8 & Figure 9).

Ped-Catch allows designers to make educated decisions on where density should be increased with regard to access – higher density within five minutes walking distance, tapering down to lower density at ten minutes walking distance.

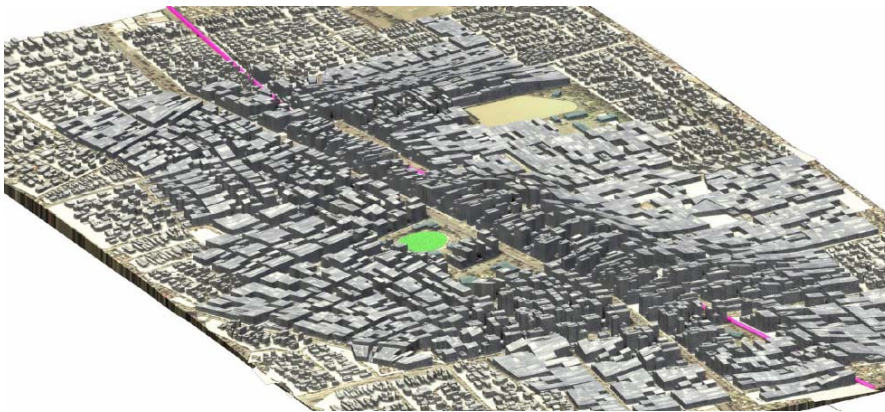


Figure 11 Pedestrian Catchment for 10 minutes represented as logarithmic density

5.3 ‘P-Radiance’ –Quick Solar Access Assessment

The planning aspiration

Equally important is the need to protect solar amenity. Increased density should not be at the expense of access to daylight and fresh air. This sentiment is reflected in the 2030 objectives of ‘a better place to be’. In response to these issues, investigation into urban form simulation as well as solar access has been conducted.

Existing method

Though it is relatively straight forward to produce shadow studies of a building using 2D plans and sections using solar tables tracing Azimuth and Altitude, complex building forms or large areas involving many buildings can be time consuming and, on undulating topography, almost impossible. Fortunately over the last ten years or so, 3D modelling packages have gained the ability to raytrace shadows, with a light rotated to match Azimuth and Altitude in the solar table. In some programs, *Solar Systems* have been included so the user can choose the location and the time of day and the system moves the light to the correct angle to cast accurate shadows. This alone is a very powerful ally for urban designers and better still, in some programs the system is parametric and animatable.

The digital tool

With some scripting, multiple sun positions and shadow positions can be shown simultaneously. This, combined with *P-Radiance* render setting, can be used to analyse the amount of daylight hitting each surface over the course of a full day and over different days of the year. This gives almost real-time feedback on different urban design proposals. (Figure 12). ‘What is the difference between two levels and four levels in an area with regard to footpath over-shadowing?’.

Case study

The P-Radiance tool has been used on a master plan proposal for the ‘Office Of Housing’ in Prahran, Melbourne. The tool was used to test 18 different options of slab block / tower configurations for daylight impact within the site as well as neighbouring sites.

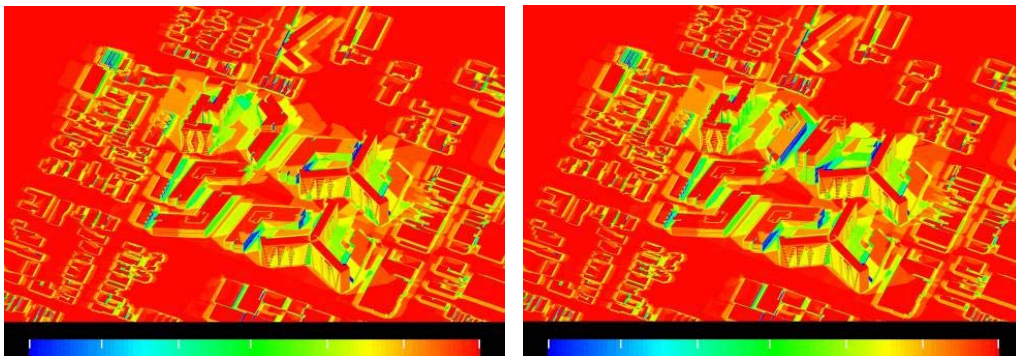


Figure 12

Case study for Prahran Office of Housing – Urban Design Framework for City of Stonington using P-Radiance

Results – speed, accuracy, level of abstraction

Speed with which comparison solar studies can be made is greatly improved. What would normally take a day can be done in a minute. The level of accuracy is also greater than existing solar table methods. Whilst a solar study might previously have taken into account two or three different time/sun positions for the year, P-Radiance can take into account 20-60 solar positions. Whilst not as accurate as a full radiance/daylight hours calculation analysis performed by specialist lighting engineers, speed is maintained and accuracy is improved to a level in which a comparative in-house form studies are

possible. This technique enhances the urban designer's ability to assess cause and effect, where a design can be proposed and the effects can be seen quickly allowing for comparison and more informed decision making.

5.4 'Subtracto Sun' – solid negative shadow subtraction tool

The planning aspiration

Where a clearly defined outcome is given – for example 'This plaza must not be in shadow between these hours' – a kind of reverse solar modelling is required. For the St Vincent's Hospital in Melbourne, part of the Masterplan brief dictated that a particular plaza should remain unaffected by shadows during 9.30 am and 3.30 pm between March and September.

Existing method

Other than an extremely time-consuming process of trial and error, there was no existing method to perform this task within the available software.

The digital tool

This problem led to the development of a technique called *Subtracto-Sun*, a scripted tool which utilises parametric solar systems, real-time parametric Boolean operations, and Wired (linked) parameters. (Figure 13) The script creates a permissible building envelope by subtracting a solid negative 'shadow' object derived from angles of the sun during the given period. This results in a development envelope within which any building can be built without casting a shadow onto the plaza within the designated times.

Case study

This technique has since been used on other urban design projects to minimise effects of overshadowing on footpaths, plazas and existing buildings (public library).

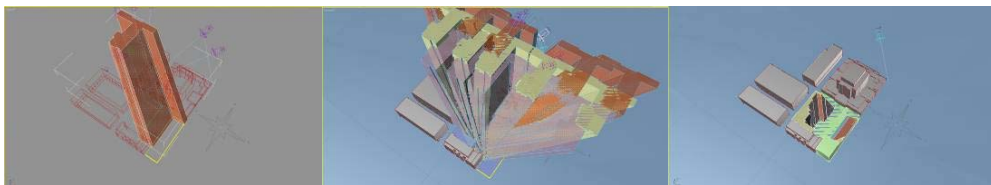


Figure 13

St Vincent's Hospital master plan using 'Subtracto-Sun' to project plaza shape as a subtractive solid of different times of day and removed from surrounding potential built form.

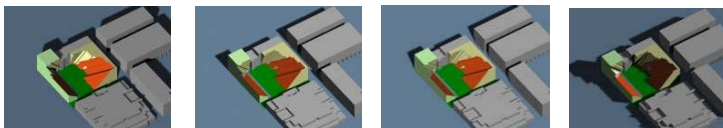


Figure 14

Permissible building volume created with Subtracto-Sun tested with raytraced solar shadows based on Melbourne Solar tables.

Conclusions – speed, accuracy, level of abstraction

In the case of Subtracto-Sun, the level of accuracy can be as high as the amount of detail in the model. This technique was both developed and used within the time allocated for the job, and so met with the client's deadlines. Subtracto-Sun has since been used on other projects where similar desires have been expressed. It has been used to provide height limits on the opposite side of a café strip footpath requires direct sunlight at lunch times throughout the year. It has also been used for a development site directly adjacent an existing high school library to ensure no overshadowing of the reading room during school hours.

5.5 Visual Impact - Urban form simulation and visualisation tools

The planning aspiration

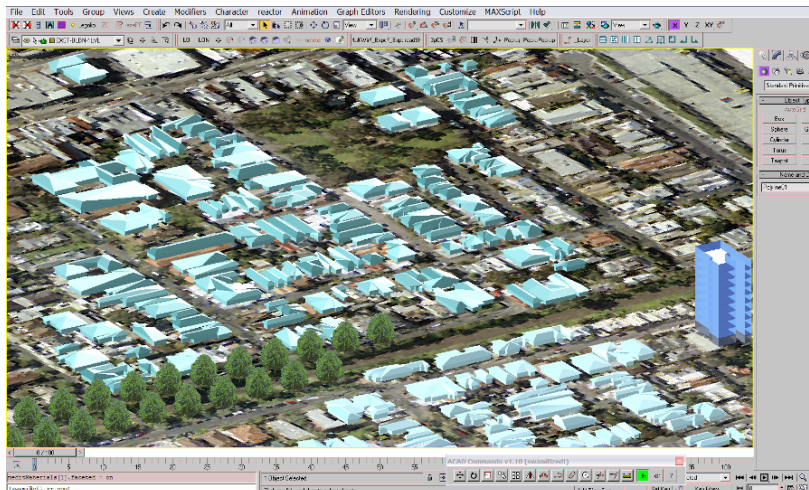
When density is increased, there is a need to protect heritage, community identity and consider the visual impact of development. There is generally a desire to keep buildings low, to 'hide' upper floors of buildings or 'reduce visual bulk'. This can be a very subjective discussion, as what is bulky to one may be elegant to another.

Existing method

Planning departments generally stipulate that plans, sections and elevations be submitted to council as part of the planning application process. These 2D drawings are then compared with the 2D legislation drawings for compliance. (see Figure 15). Perspective images are sometimes submitted, but are rarely a requirement.

The digital tool

With the adoption of 3D Studio Max™ as the program used for modelling, the recently built-in *walk-through* command can be used to test eye height perspective views. Once again scripted tools have been created to enhance the speed of creating building envelopes (Quick-House, Quick-Tower and Quick Medium Density). These envelopes can be adjusted parametrically, with changes registering in perspective views in real time.





Case study

The City of Port Phillip council’s planning code legislates a desire ‘not to see’ upper levels of buildings. This is legislated by way of a 2D sectional diagram alongside a description (Figure 15). When this is modelled in 3D and ‘walked through’ it quickly becomes apparent that though the upper level is in fact not visible in sectional viewing position, the upper levels may be clearly seen from many other viewpoints. This exposes a flaw in the legislation and highlights the need to test planning policies three and four dimensionally, by actually moving around the virtual 3D model of the proposed urban form.

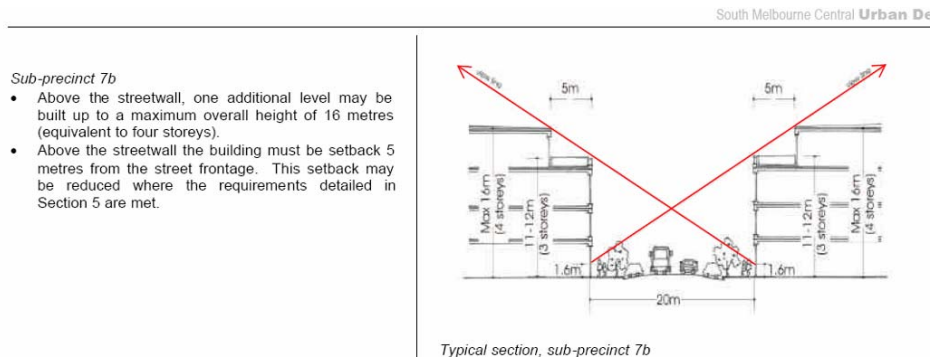


Figure 15 - 2D section of legislated height limits aiming to obscure upper level of building. (South Melbourne Central – Urban Design Framework for city of Port Phillip, by David Lock Associates (Nov 2005) PDF exhibition version)

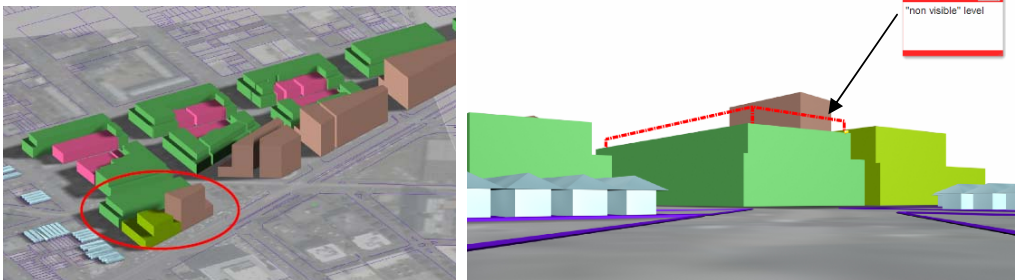


Figure 16 - 3D model of permissible form exposing the inadequacies of the legislated 2D section, as the upper level is clearly visible when viewed from numerous perspectives at eye level

Results – speed, accuracy, level of abstraction

These tools improve statutory planner's ability to generate maximum building envelopes etc that closer represent the planners' aspirations.

Real-time building envelope manipulation provides the opportunity to better ensure envelopes do what they are intended to do. There is also a possibility to revisit forgotten ideas from the Renaissance such as perspectival composition of urban form and the Picturesque.

6 Conclusion

*The pack-donkey meanders along, mediates a little in his scatter-brained and distracted fashion, he zigzags in order to avoid larger stones, or ease the climb, or gain a little shade; he takes the line of least resistance.*⁴¹

The pack-donkey considers space in 3D, assessing topography and obstacles and also considers 4D solar locations and wind. These desires are similar to those of *Melbourne 2030*. Le Corbusier dismissed this and thought that order – the architect's graphic – was of primary importance.

Is the plan an inadequate tool for planning? The plan is still a useful tool but tools are needed which work in four dimensions to create a holistic approach to planning. The aspirations of the community have changed in relation to planning; increasing density and population, more complex land uses, environmental consciousness and amenity awareness expose the inadequacies of existing planning tools. This has been shown to be the case by comparing existing 2D methods with new 3D and 4D techniques. Successes ranged from processes which were more time consuming – but gave far greater accuracy – than previously, to tasks performed in minutes which are impossible in 2D.

These tools are in no way definitive. This approach is an example of how architects might overcome the limitations of working in 2D. There are other tools that are needed and other valid platforms from which to begin. There is an opportunity to further expand the skill set and tools to further address points of *Melbourne 2030*. Future research could include simulating the effects of noise using particle flow on buildings with sound reflective and absorption properties, allowing designers to consider traffic noise and noise from music venues. With further applied research, particles could be used for a simplified computational fluid dynamics to analyse wind speeds and pressures for comparative urban design scenarios.

This is an opportunity for architects to contribute more to the planning process by skilling-up and offering more synergistic solutions. Both Le Corbusier's and the pack-donkey method of urban design have merit, and it is now possible – and desirable – to have a combination of both techniques. These tools begin to provide a 4D-digital-pack-donkey to compose cities in an artful and rigorous way.

7 Acknowledgement

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