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Game Based Worldbuilding: Planning, Models, Simulations and Digital Twins

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Professor Paul Coulton is Chair of Speculative and Game Design within Lancaster University's open and exploratory, design-led research lab, Imagination Lancaster. His research can more generally be considered as Speculative Design which combines real and/or hypothetical extrapolations of the development of emerging technologies with a consideration of the cultural landscape into which they may be deployed. This activity is embodied as 'research through design' and, in particular, to the design of speculative physical/digital interactive games, playful experiences, and artefacts. He is internationally recognised for his work by not only academia but also industry and was the first academic invited to speak at the Game Developers Conference. Increasingly, his work encompasses a particular form of Speculative Design; Design Fiction, which is a way of exploring futures for areas such as the Internet of Things and Artificial Intelligence. Design Fictions are collections of artefacts, that, when viewed together build a fictional world. The artificially built world is a prototyping platform for the very designs that define it, meanwhile those designs reciprocate in kind and prototype the world.

ABSTRACT:
Urban planning has been simulated through various city-building games such as *The Sumerian Game* (1964), *SimCity* (1989), and *Cities: Skylines* (2015), amongst many others. Gaming technology has been utilized in 3D GIS, City Information Models (CIMs), and Urban Digital Twins (UDTs) to enhance public participation and engagement in the planning process. This article studies the overlap and 'game-like' qualities of these systems and presents an Urban Game Continuum. This interactive tool works in tandem with a taxonomy of city-building games and existing UDTs in order to assist with the design of future systems. A case study imported GeoData from Lancaster, UK, into a games platform. The continuum tool and case study offer new insights into opportunities for the utilisation of game design and gaming technology in urban planning and digital transformation. The article argues that the current use of gaming technology for real-world applications is one-directional and misses opportunities to include digital game design and research, such as mechanics, dynamics, flow, and public participatory world-building for future scenarios. By incorporating these elements, UDT systems could offer higher levels of citizen engagement.

KEY WORDS:
city-buiding games, digital games, future scenarios, urban digital twins, urban models.

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Introduction

Digital games have a long tradition of providing abstracted simulations of various systems of human activities, such as politics, culture, society, environment, and conflict (Bogost, 2011). While some of these games were merely representations of systems, such as war in chess or the exploitation of renters in Lizzie Magie's *Landlord Game* (1904), others were used in relation to scenario planning for plausible futures. A notable example was the RAND Corporation's Mathematical Analytics Division's (MAD) development of physical games for social science to test military activity, design variables, play assumptions, and anticipate effects (Daye, 2020). Scenario techniques and forecasting developed by Herman Kahn at RAND, and later when he started the Hudson Institute in 1961, were used to create systematic conjectures of the future. A 'multi-fold trend' of some of these future scenarios was urbanisation and the growth of megalopolises (Kahn, 1967). A range of scenario techniques were developed by a number of researchers and applied to many areas, but urbanisation was featured throughout (Bradfield et al., 2005). Thus, even prior to the inception of digital games, the relationship between games , urbanisation and planning had been linked as an area of critical interaction.

These interactions between games and planning could arguably be called a 'matter of concern' in Bruno Latour's terms, which consists of the study of entanglements, complexity, and the socio-technical relations between humans and objects. What can digital games add to the urban planning space in terms of game systems, the simulation of complex urban issues, and how can game mechanics be deployed? We hypothesise that while

a range of future urban planning scenarios utilise gaming technology, they do not necessarily incorporate digital game mechanics and dynamics (Hunicke, et al., 2004), levels, progress, flows and feedback as part of worldbuilding, and this needs to be more fully understood if such systems are to yield potential benefits in terms of citizen engagement. This article develops an understanding of the role of worldbuilding digital games in urban planning, architecture, and design, through the development of a playable urban game continuum to illuminate the various nuances of a range of precedents and scaffold future applications. This interactive urban game continuum is intended for developers of future city models and urban digital twins (UDTs). It is supported via a taxonomic reference of games, city models, 3D geographic information systems and urban digital twin cases. Following this continuum, an applied case study of imported GeoData into the digital game *Cities: Skylines* (Colossal Order, 2015) creating a range of urban analyses, is then compared to real-world strategic plans in order to explore and locate usage of the urban game continuum interactive tool and explore 'game-like' aspects of planning simulation.

Worldbuilding Games and Simulation Tools

A range of terms revolves around the utilisation of digital or analogue games concerning the built environment. Terms such as 'serious games' were conceptualised as a way to describe games aimed at simulating aspects of life in procedural and rationalised manners for education and professional training whilst engaging in the aspects of 'play', with the term emerging from Abt (1970). 'Serious' games have emerged as an approach often utilised for urban planning (Djaouti, 2011). An example of an early serious game related to urbanisation is Buckminster-Fuller's *World Game* (1961), which went through a number of iterations and allowed players to cooperate on population dynamics and resource allocation issues using his Dymaxion Map ("World Game", n.d.).

Digital city planning/creation games emerged from the work of Mabel Addis Mergardt and William McKay's *The Sumerian Game (Addis, 1964), an* IBM mainframe planning game written in Fortan, designed for economic instruction for school children, which was set in Lagash in Sumer circa 3500 BC. It was a text-based game in which players managed various rounds (seasons) of land management with projections and an audio guide for each round, giving procedural choices for players. Doug Dyment later recreated the digital game (in 1968) under the name *Hamurabi* (Dyment, 1968) (earlier titled *King of Sumeria* or *The Sumer Game*). The game inspired various other versions, including George Bank, *Santa Paravia en Fiumaccio* (Blank, 1978) in which a player ruled an Italian city-state in 1400 through turn-based moves and city-building capability. These early examples helped create a trajectory for city-building games, which have emerged as a creative tool for exploring urban governance, city simulation, and planning. A two-player game by Don Daglow, *Utopia* (Daglow, 1982), featured various construction options as a precursor to real-time strategy games (Daglow, 2018). *Arguably, the most famous city building game* is *SimCity* (Maxis, 1989), also known as *Micropolis*. Will Wright formed Maxis with businessman Jeff Braun to self-publish *SimCity* in 1989. *Micropolis* allows the players to inhabit the character of the city mayor and develop various planning models, particularly through the use of zoning (Terzano & Morckel, 2017). The digital game was targeted at an educational market with a dashboard interface displaying variables and oblique and isometric virtualisation of city worlds (Gaber, 2007).

SimCity used a form of Agent-Based Modelling (ABM), cellular automata (CA) modelling, which involves 'agents' and interactions between things in order to model complexity, sometimes through the use of infinite cell structures and relationships. This has subsequently been used for real-world urban development scenarios and dynamics, such as populations or transportation modelling combined with remotely sensed data and Geographic Information Systems (GIS) (Yeh, 2021). In addition, ABM has been used to model individual behaviours and associations, such as crowd behaviour simulated in a virtual real-world space (Crooks et al., 2021). ABM and CA are processes that share system rules similar to those of city-building games. *SimCity* is CA with agents, though the design motivation is very different. The differences raise questions about the black-box nature of the city-building games and underlying parameters compared to the motivation for creating digital games such as *Micropolis* (*SimCity*), as expanded by Wright, which is firmly focused on the fiction of a city for play.

> ... you give the player a tool so that they can create things. And then you give them some context for that creation. You know, what is it, what kind of kind of world does it live in, what's its purpose? What are you trying to do with this thing that you're creating? To really put the player in the design role. And the actual world is reactive to their design. ... Giving them a pretty large solution space to solve the problem within the game. So the game represents this problem landscape. (Pearce, 2022, para. 4)

Cities and urban areas are complex systems, and games allow a player to explore the complexities of such systems, to which Wright is referring, and simulate and model behaviour and realise scenarios. However, the relationship to real-world planning should not be overstated as *SimCity* is not designed to be a planning simulation model but a game designed to create a pleasurable experience that addresses aspects of planning (Devisch, 2008). This can be juxtaposed with the game *SimNimby* (Nass & Weeks, 2022) which is a subversion of *Micropolis*, whereby players progress through futile planning experiences encompassing fifty-four different development objections, which eventually end the game and is based on the real-life experiences of game designers working in San Francisco and Brooklyn, USA. This satire highlights some of the complexities experienced in real-world planning consultations. The benefit of games such as *SimCity* is that the platform introduces players to a simplified representation of complex urban systems with little adherence to real-world planning rules and procedures, whereas *SimNimby* is a representation of a real-world planning system, which is presented as a parody to highlight frustration that often occurs when engaging with such technocratic schemes.

Players should also be aware that this introduction to planning via gaming found in *SimCity* still follows particular aspects of the real-world models, which Bereitschaft (2016) defines as 'gentrification' and represents preferential futures dominated by the motor car. The 'black box' of the Sim games rests on various designer's understanding of urban processes. The release of *SimHealth* (Thinking Tools, 1994) sought to simulate and game American healthcare during the Clinton healthcare plan reforms, juxtaposing the simulation with real-world health politics. The Markle Foundation commissioned Maxis Business Solutions to create *SimHealth* in order to provide a game experience of complex policy and health care. This was released on Capitol Hill, and copies were provided to lobbyists and the White House (Salvador, 2020). A spin-off of Maxis, Maxius Business Simulations created various corporate SIMs, including *SimRefinery* (Maxis, 1992) for Chevron, in order to simulate the complex oil industry.

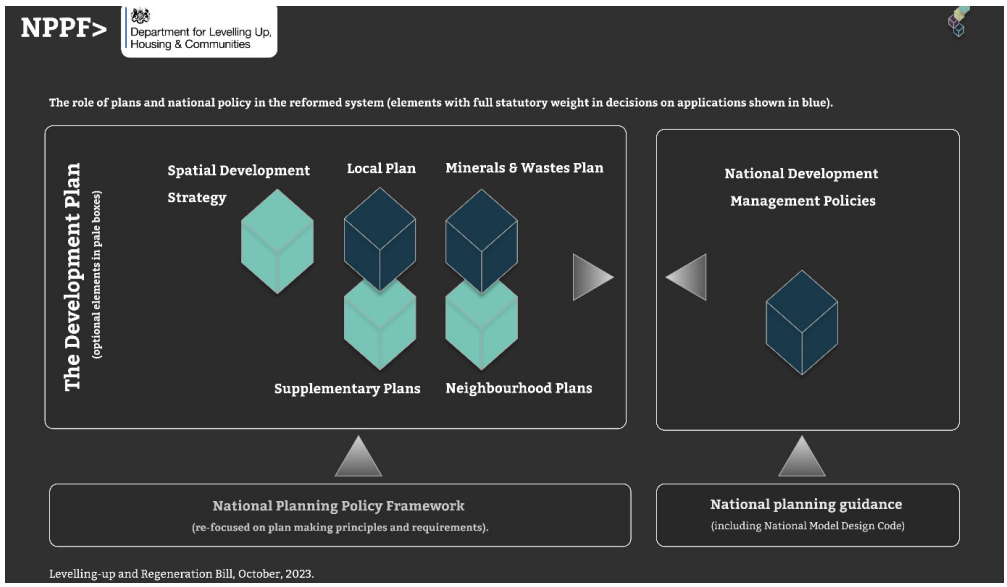
This highlights that worldbuilding and strategy games have been developed with great emphasis on particular geographic imaginaries. For instance, *Utopia: The Creation of a Nation* (Celestial Software, 1991), is a micromanagement simulation game on an off-world colony inspired by *SimCity*. The subsequent development of *SimCity 2000* (Maxis,

1993) introduced several new features, such as query tools, urban decay, and more detailed game variables. Additionally, it included a disaster scenario expansion pack with various porting options *Cities XL* (Focus Entertainment, 2013), and *Cities: Skylines* (2015, 2023) are some of the most recent city-building games to be released, which expand on the *SimCity* CBG genre.

A range of contemporary game releases in this genre created meaningful game experiences, such as *Block'hood* (Plethora Project, 2016), in which players must envision a neighbourhood and maintain ecological balance; *Constructor* (System 3, 1997) in which players inhabitant a commercial construction company and undermine its rivals, and *Little Cities* (Purple Yonder, 2022), in which players develop on grid forms on an island and the prosperity is measured through the immersive design choices. Finally, *The Architect: Paris* (5PM Studio, 2021), is a high-realism city planning sandbox based in Paris with extensive detailing features in which players can realise designs in developed construction phases.

Planning Systems

If a games designer were to create a simulation game of a national planning framework, the complexity of this world-building exercise would be highly challenging. For example, in the United Kingdom, The National Planning Policy Framework (NPPF) is the government's view of the planning system in England that must operate in accordance with primary and secondary legislation with sixteen categories under the framework provision (Picture 1). The NPPF provisions are supported by further detail in the National Planning Practice Guidance (NPPG). Aligned with the NPPF, 317 Local Planning Authorities (LPAs) develop local plans and neighbourhood plans. Updates to the NPPF are frequent, often yearly. Thus, creating a simulation of the NPPF and NPPG is not conducive to game design principles, nor can the nuances and translation of a framework, primary and secondary legislation, and a range of local plans into game rules be properly enacted in totality.



Picture 1: National Planning Policy Framework (NPPF) in the United Kingdom
Source: own processing based on "Levelling-up and Regeneration" (2023)

However, with the rise of City Information Models (CIMs), a term coined by Lachmi Khemlani in 2005 (see Khemlani, 2023), 3D Geospatial data, cloud-based services for the web and urban digital twins (UDTs) (cyber-physical systems that provide virtual replicas of real-world aspects and indicators), developers have started to incorporate various game technologies and design patterns to create interactive systems around particular aspects of the planning system. In particular, the use of game engines provides 3D experiences, interactive dashboards or game UI, interactive modelling, and immersive visualisation. Currently, digital twins of urban environments are informed through various fields as part of urban informatics, urban analytics, geographic data science and geo-computation – making geographical decisions about how best to tackle a real-world problem (Brunsdon & Singleton, 2015). In essence, urban informatics, urban analytics and geo-computation are terms with overlapping research communities across a variety of disciplines applied in the real world using a variety of approaches and methods for sensing, working with big spatial data, and the modes in which people utilise data, plus the communication of findings, models and predictions. However, there are opportunities for game design to make an integral contribution in these multi-disciplinary teams, especially in the areas of interaction. We are in a period of large volumes of ubiquitous 4D urban data (3D and time-based) captured from embedded, connected and remote sensors. The ability of participants to engage in various forms of immersion and interaction with this data has developed through cloud-based GIS platforms, yet these areas are often unconnected, fragmented and unequal (Souza & Bueno, 2022).

There is an opportunity to define the gamified and game-like systems being developed in relation to actual city-building games and game design principles in order to both understand current practices and open up the opportunity to playfully engage the general population in the complexities affecting decision-making in urban planning. Currently, many of the UDTs seek participation using gaming technology for aspects of their systems, yet miss the game's design elements, which could provide much more positive experiences. For example, Markus Persson, Jens Bergensten's *Cave Game*, subsequently *Minecraft* (Mojang Studios, 2011), is an open-world explorative free block creation game, has been translated into the UN-Habitat *Block by Block* methodology from 2012, increasing participation in a range of urban design and planning projects across the world, with a replicable workshop 'playbook' (Imam & Lahoud, 2021). Communities use *Minecraft* to plan, design and test proposals for public spaces using the game. This example is an outlier compared to current systems and cases focused on the exploitation of gaming technology only.

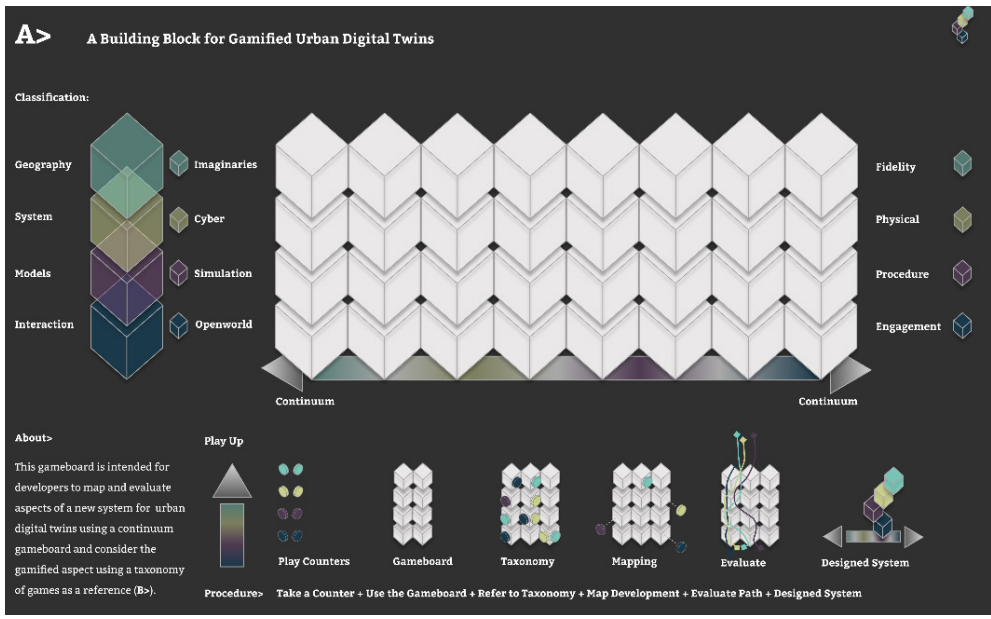
Arguably, there is a restrictive incorporation of gaming technologies *for* real-world planning that misses opportunities to engage players in changing the rules of the system being replicated. This is much needed as governments such as the UK argue that urgent change is required in planning if we address the chronic shortfall in housing and stimulate economic growth. Gaming technology and gamified Geodata are intended for citizen participation and access, yet fundamental challenges remain unaddressed. The Royal Town Planning Institute (RTPI) in the UK stated that "response rates to a typical pre-planning consultation are around 3% of those directly made aware of it. In Local Plan consultations, this figure can fall to less than 1% of the population of a district" (Manns, 2017, para. 3). The RTPI paper of 2020 also evidenced that only 11% of young people have been engaged in a local plan consultation (Butler et al., 2020). However, what if games research and ludic interactions are introduced, and gaming technology in which the planning system is played and redesigned? This creates alternative ways of working and new possibilities for worldbuilding and developing fundamental changes to the planning system. Games should not be vehicles in which real-world planning systems are simulated but a platform

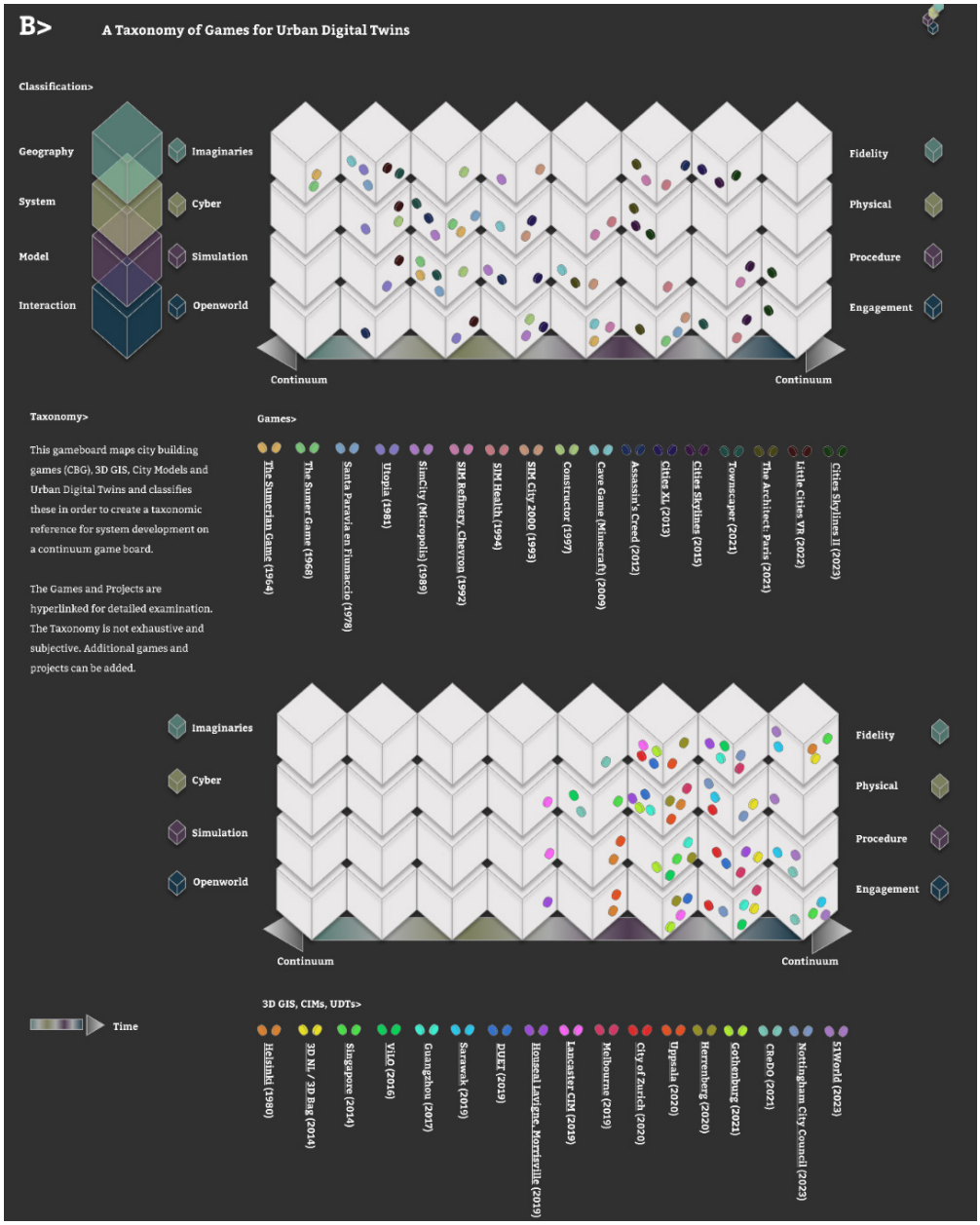
in which alternative worlds are imagined in order to change the limitations of that very real-world system. Would this worldbuilding approach and result increase citizen participation, and what would this game system for planning look like?

Urban Game Continuum

By referencing the aforementioned range of city-building game precedents, an urban game continuum is presented in Pictures 2, isolating four major factors in this paper's range of precedents. The continuum has four level blocks. The continuum operates left to right in a similar way to the virtuality continuum created by Paul Milgram and Fumio Kishino, often used as an initial basis to discuss extended reality (XR) and the metaverse (Milgram et al., 1995). The interactive tool contains four classifications in the coloured level blocks – Geography, System, Models and Interactions common attributes of digital games, 3D GIS, CIMs and UDTs. Players map from the bottom upwards, plotting and mapping the aspects of the system for future development using coloured counters. The resultant map thus informs the system design. The four classifications are devised on these terms:

1. Interactions: Acts of open-world gaming (Left), single-player, ludic and games technology for citizen engagement (Right).
2. In terms of Models and Urban simulations, the continuum maps simulations of implausible acts and environments (Left) and augmentation of real-world urban planning (Right).
3. In system terms, a continuum for cyber networks, game systems (Black Box), data and models (Left) and their relationship with the physical (Cyber-physical) is created (Right).
4. In geographic terms, a classification and continuum are created to map pure imaginaries (Left) games and adopt high realism and fidelity (Right).





Picture 2: Urban game continuum
Source: Cureton, 2024b

In order to map a new system onto the continuum and on the four classifications, a supporting taxonomy, which is hyperlinked to the original game, case, or dataset, is developed from city building games, 3D GIS, CIMs and UDTs to support this exercise. These two components allow users/players to reference and benchmark the games and cases against their development needs. For example, a player may design a system on the continuum from left to right and benchmark from the taxonomy. For example, a user/player mapping a new system may plot their design by comparative values such as one more block face for Open-world exploration compared to the *SimCity 2000* game, two more

block faces towards Procedure nearer the game *Cities: Skylines*, and one more block face towards Physical, and three more block faces across to Fidelity.

Establishing such a continuum is essential as there is a rich territory and crossover with the increasing urbanisation and large-scale investments in smart cities. Developers can use this interactive tool to develop new systems and make reference to game titles and existing 3D GIS, CIMs and UDTs. The taxonomic reference is subjective, not exhaustive, and expandable from the seventeen Games and seventeen UDTs plotted in the first instance. However, through juxtapositions and comparative benchmarking, users can map the new system using the game board to evaluate its aspects.

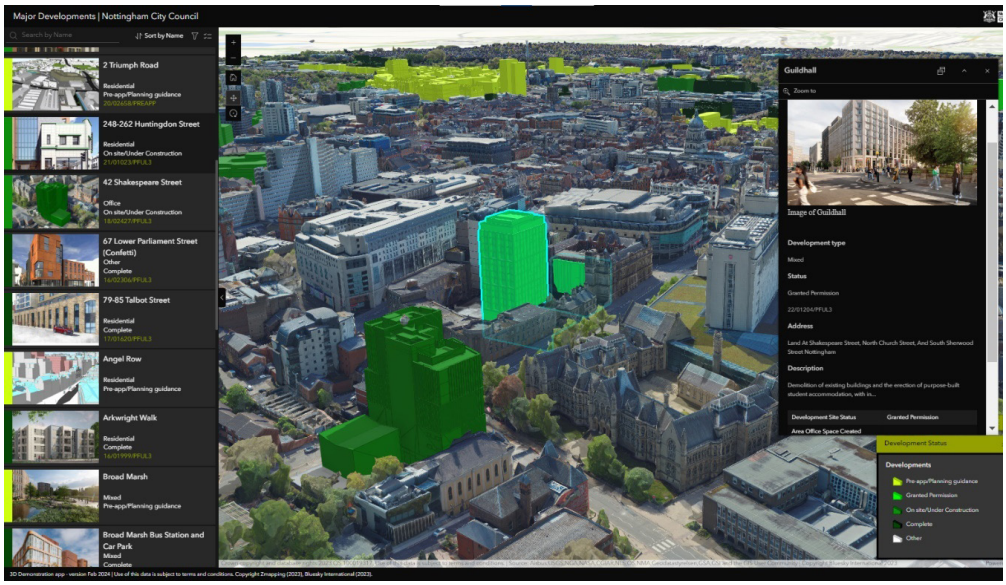
In order to create this continuum, distinctions need to be made between the use of games for planning education and game technology for planning processes. For example, 'game-like' platforms, such as Cesium plugins for Unreal Engine and ESRI ArcGIS, provide 'real world' geo-located information. In another example, Houseal Lavigne used a procedural modelling program and a games engine as part of public consultation for Morrisville, North Carolina, USA (2019) and its land use plan, in which two scenarios were created for its town centre with different build-outs including a dashboard that adopted the zoning code ("Mapping Morrisville", 2021). Hence, it is relatively central on the gameboard, leaning towards Fidelity and Engagement.

Game Engines are utilised for a range of activities and simulations, including geolocated weather and 3rd-person open-world exploration, amongst other operations. GIS and game engine integration is, of course, reliant on streaming architecture. The gamification of GIS systems, availability of photogrammetry data, satellite imagery and open street map, provide environments long sought in early city-building games. Gaming technology enables fidelity and urban planning simulations to a higher degree (Poplin et al., 2020). Thus, in the seventeen cases, the majority are mapped toward the right-hand side of the continuum and support the hypothesis of the one directionality of games technology applied towards urban planning, but lacking game design principles.

The role of digital games is critical; for example, a range of planning platforms utilising 3D GIS and data dashboards to simulate future scenarios and describe developments in the current planning process. There is a user interface crossover from some of the game precedents already described, such as *Cities: Skylines II*, with a clear relationship between a computer game and a real-world dashboard of various urban indicators. In both cases, there is a need for navigable, understandable and progressive information in order to explore the various parameters of the fictional or real-world 'gamified' space (Young & Kitchin, 2020). In *Cities: Skylines*, residential development suitability is presented on a colour ramp. For Nottingham City Council, colour systems indicate the current real-world planning application and status, including public consultation (Picture 4). In both cases, the importance of game research interaction and mechanics is at a critical juncture with urban informatics and urban planning. Questions arise on the nature of interactions for citizen engagement and how decisions are formed from the basis of governance. For Nottingham City Council, applications will be assessed based on the adopted local plan by planning officers, but what role does the GIS model play in informing this assessment? Line of site studies, energy efficiencies, and environmental effects are all parameters the model can assist, and the role of 3D urban models has many benefits, such as Helsinki's energy and solar atlas and the possibilities for energy renovations throughout the Helsinki region. Building-specific information features include water consumption, district heating and electricity comparable to the indicators created in *Cities: Skylines* game ("Energia- ja ilmastoatlas", n.d.). The four sections of the data model include energy data on buildings, simulated heating demand, solar energy potential, and geothermal potential, and it is intended to be used by a variety of actors. However, unlike city-building games with

pre-defined missions, progression and open-world creativity, this 'gamified' content has profound implications. Reflecting on *SimHealth* at the time of release, and his role as a policy maker, Paul Starr, states,

> ... when policymakers depend on simulations to guide present choices--especially when legislators put government on "automatic pilot," binding policy to numerical indicators of projected trends-- they cede power to those who define the models that generate the forecasts. (Starr, 1994, p. 20)



Picture 3: Major Developments portal, Nottingham City Council
Source: Nottingham City Council, 2024

Starr highlights an important research space for using gaming technology and mechanics in urban planning platforms and systems. Does the black box space of the game-like platform and model dictate decisions, and how does this change the dynamic of the planning process and judgements for progression? The social-technical relations between systems and interaction are thus a critically underexplored research space pertinent to high-level investment in UDTs, as recognised in the WEF Global Practices report on City Digital Twins in which 55.6% of DT use in public service management and 44.4% of digital twin application uses are reported in community development (World Economic Forum, 2022). Thus, games and the range of real-world planning systems using game technology is a critical research area.

Modifying Cities: Skylines with GeoData, Lancaster City, UK

Considering the Urban Game Continuum and taxonomy, a digital game *Cities: Skylines*, modification and map builder are utilised to import real-world geodata to examine the game's simulative and reductive qualities and consider real-world planning issues

in relation (Khan & Zhao, 2021). The purpose of the task is not to critique current local plans but to simulate some of the policy principles and explore options for worldbuilding outside of the NPPF system constraints. For the game *Cities: Skylines*, players can import geodata height maps (Digital Terrain Model) and export fictional cities and models to real-world digital Open Street Maps (OSM) via modifications or import real-world maps.[1] The modifications to do this in *Cities: Skylines II* (Colossal Order, 2023) were not yet available at the time of writing. Simple terraform tools of DTMs can be used to create a baseline from which to build out, and this aspect is an established workflow, though there are opportunities to demonstrate the bi-directionality of the gaming platform itself (Wicaksana & Darmawan, 2021). The game has been used to simulate Norra Djurgardstaden, Stockholm, Sweden (2017), the role of industrial zones and factories in Braunschweig, Germany (2017) (Juraschek et al., 2017), Żuromin, Central Poland (Olszewski et al., 2020) and Denpasar City, Indonesia (2021), amongst many others. Historical plans, such as Ebenezer Howard's layout for Letchworth Garden City, have also been recreated (2022) ("Recreating the first", 2022). This translatory aspect of the game towards real-world planning issues has also been applied to the player's understanding of sustainable development goals (SDGs) in their game worldbuilding (Jolly & Budke, 2023). The extent and limitations of the game can be mapped to the fidelity, physical replica, procedures, and engagement values from the Urban Game Continuum and are mapped based on the game mechanics.

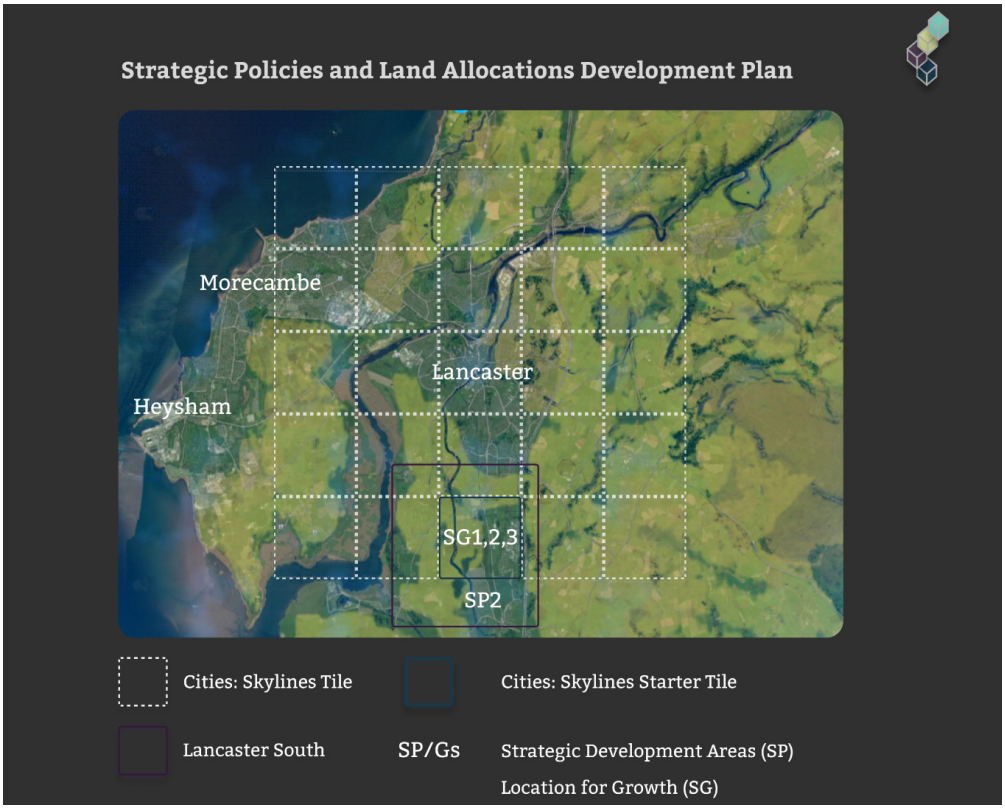
This case is mapped against the degrees of imaginaries and fidelity of the game in terms of managing health, employment, traffic, and pollution levels compared to the real-world strategic plans of Lancaster City Council. The degree to which *Cities: Skylines* can relay the cyber or physical aspect of the city, the capacity of the game 'black box' to mimic planning procedures and the engagement potential and playful experience of the game for real-world issues. Indeed, much of the focus of explorations has concentrated on one aspect of the game, real-world planning issues, rather than the possibilities of new modifications via gaming and redesign of the existing real-world planning system.

A large section of the Lancashire district region has been used in the game (Picture 4), North-West UK (Lng/ -2.7984740523877747 Lat/ 54.044485589053494). The district has a population of 144,246 and area coverage of 576.2 Km² / 57,620 ha. The area was chosen for its spatial complexity, the non-metropolitan district is defined through UK Governmental Boundaries, its legislative framework and the Office for National Statistics ONS ("Adopted policies", n.d.). The district is a two-tier non-metropolitan area of high-grade agricultural land that has extensive rural coverage and mixes small towns, coastal communities, post-industrial ports and a primary 'arc-like' urban area and urban extensions. The primary urban area is an arc stretching from the coast at Heysham, upwards to Morecambe Bay and southeast to Lancaster. The study area contains the Forest of Bowland, an Area of Outstanding Natural Beauty (AONB), Arnside & Silverdale (AONB), military sites, and a nuclear power plant. The current Local Plan for Lancaster District was adopted for 2011 – 2031 and contains the policies for sustainable settlements, rural villages and future growth development areas ("Local plan", 2020).

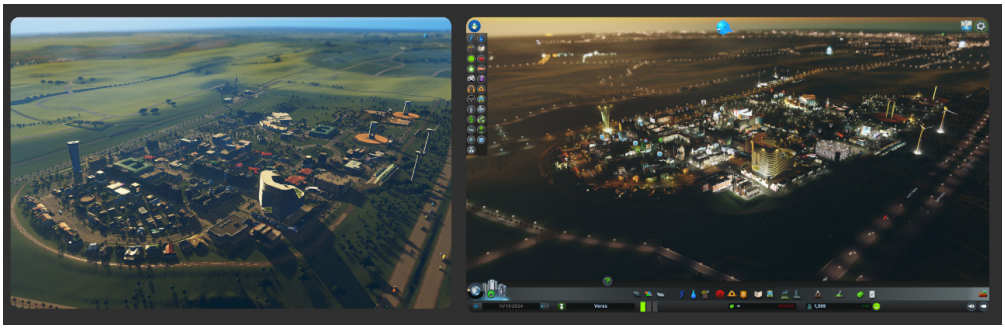
Major motorways, local routes, railways and natural environments were mapped using the game map editor, which consists of asset paintbrushes. Manual editing is required to reference satellite images and OSM layers. The standard game checklist added Resource allocation for the game parameters and mobility requirements (Picture 5). Additional building of assets is also possible in a range of 3D procedural modelling programs, which can be imported into the game using community resources or expansion pack materials. Realistic cities, such as Rochester and Pittsburgh, USA, have been realised,

1 See: https://heightmap.skydark.pl/

demonstrating possibilities with additional build hours and skills ("Pittsburgh 1:1", 2022). In another project, 3D Level of Detail (LOD, 2.5) buildings were created for the district, which could be imported and developed with textures for higher levels of realism but outside of the remit of study due to time constraints (Cureton & Hartley, 2023). Additional British modifications and housing typologies could also be utilised to increase degrees of realism and suitability ("Biffa's British", 2022).



Picture 4: Lancaster strategic policies and land allocation development plan and Cities: Skylines map tiles
Source: Cureton, 2024a



Picture 5: Lancaster South Map & Cities: Skylines in-game play
Source: authors' screenshots from the game Cities: Skylines (Colossal Order, 2015)

The start game area of the map was chosen as Lancaster University, which is nestled between the M6 and West Coast mainline railway and Lancaster Canal, which is central in the 'Lancaster South Development Area' ("Local plan", 2020). Skylines requires the starting tile area, which was used for the detailed build-out south of the University, which is a sustainable settlement policy growth and employment area (SP2, SG2) in the adopted local plan at Galgate ("Local plan", 2020). A planned broad settlement called Bailrigg Garden Village (SG1, SG3), delivered by Homes England to the west of the campus, has had outline planning for around 5,000 homes and a junction link to the M6 road, which has been put on hold. The policy for the garden village seeks community involvement in the development, of which *Cities: Skylines* could play a role ("Bailrigg Garden Village", n.d.). The authors used the policy principles and made reference to them during gameplay, as well as tested deviations from the policy. For example, for policy SG1, the following principles were considered a gameplay guide:

- The delivery of access into the Strategic Highways Network via a reconfiguration of Junction 33 of the M6 to the satisfaction of the strategic and local highways authority.
- Improvements to the local road network as appropriate to address recognised capacity issues and issues of highway safety to the satisfaction of the local highways authority.
- Improvements to the public transport network, specifically the creation of a Bus Rapid Transit System linking South Lancaster to Lancaster City Centre, Morecambe and the Employment areas on the Heysham Peninsula to provide genuinely realistic alternatives to private vehicle use.
- Improved cycling and walking linkages from South Lancaster to the north, towards Lancaster City Centre and to the south, towards Galgate. This will be through the creation of a Cycling and Walking Superhighway which will provide a safe and attractive route for pedestrians and cyclists. Improvements will also be sought for improvements to walking and cycling links along the Lancaster Canal.
- The delivery of sufficient education places at both a primary and secondary school level to the satisfaction of the local education authority.
- The delivery of new local centre(s) provision, which will include a range of local services and community facilities in an accessible location for both new and existing residents in South Lancaster.
- The provision of sufficient public open space to fully meet the amenity and recreational needs of the residents in the Garden Village ("Local plan", 2020).

The content management system and indicators of the game provide clear progression and elements to build out the university campus; game mechanics rest on building out from road networks and parking lots, over pedestrian routes, and several city elements have to be incorporated, such as a fire station and hospital, in order simulate growth. There was often a divergence between the development plans and the gameplay. Transport networks often must be looped and do not reflect the real-world situation, which may operate on larger scales. The proposed M6 highway link in the garden village plan could be incorporated into the game, but there are limitations to the highway tools. Environmental impacts are limited and especially pertinent with a coastal habitat to the west and AONB to the east, to which the authors avoided growth. The game simulated a 'happy' campus community with distanced industrial zones and infrastructure facilities. However, development potential was limited due to the transport corridors. Some existing real-world housing remained underutilised and abandoned in the game, such as a student housing block nestled against the West Coast mainline station, and heavy traffic

and congestion were featured on the main arterial route to campus and the M6 motorway link through Galgate. Interesting scenarios could be visualised, such as connecting the canal system and River Lune and a new train station for new mobilities outside of the current real-world system and policy considerations. The map and modification require further testing with a range of players to map the various scenario options and imaginaries of players. Regional planning considerations are limited due to the game mechanics, but they could be an important area of investigation to stimulate inter-urban connectivity, growth and tourism on a larger scale as well as incorporate a broader range of actors (Harrison et al., 2022). The game is more suited to local development plans than regional ones at present. Finally, once players are satisfied with modelled scenarios, a modification allows the export of the developed model as an OSM map via CimToGrapher for use in GIS software. Thus the 'Black Box' of the game system, provided ludic experiences, but devitations to the development policies regularly occurred. The possibilities of new urban forms and transport options outside the plan, such as a new train station, helped develop unconsidered options and delivered sustainable growth in the game.

Limitations

Henri Haimakainen, the game's designer for Collosal Order, Paradox Interactive, discusses the system of *Cities: Skylines II* and states that the game has five levels of educational attainment featured and mapped to school building types. Education is linked to job progress and happiness. Citizens can become criminals depending on jobs and education in the new release; high crime probability is a featured indicator in the system design (Cities: Skylines, 2023). This reductive view of citizen agents can help with game management but is far removed from the complexities of real-world demographics, and when applied to the university campus area in this study, it is highly unrealistic. The simplified view of citizen behaviour indicates the reductive aspects of many real-world planning aspects due to the goal of playability. However, the game system management and UI of both game releases are highly intuitive, with high-level overviews using a 'chirper' bot resembling social media and expandable and collapsable dashboard indicators, utilising easily readable colour ramps and real-time situations, applied policies and governance aspects for the players. This UI and the game mechanics provide a critical pedagogical tool in the game's planning and development system, with clear targets for progress, which is nonexistent in the range of UDT cases. The citizen-focused 3D experiences of UDTs, dashboards, and interaction do not help viewers navigate and understand the range of proposals and scenarios being presented or reference existing planning documentation, which normally consists of heavy text documents and PDFs, which is often assumed apriori knowledge. To a degree, the range of UDT precedents provides some accessibility through game technology but does not explain *the system of planning* itself. Many of these planning-led UDTs could reflect *Cities: Skylines*, which is transparent in terms of the *system of the game* and contains a rich range of explanations embedded in the game mechanics through the UI and bots. There is rich potential in analysing games such as *Cities: Skylines* to visualise urban informatics and introduce progressive game mechanics and transparent explanations. Notably, the building typologies present in the game could be added in some UDT cases, with 3D reality environments to present a range of scenarios for the public to sample preferable options and schemes through future co-designed workshops. Further work in the juxtaposition of real-world and game simulations requires playtesting for a range of demographics in

terms of usability and player experience for citizen engagement. Barriers to the accessibility of the game are navigated by the extensive tutorials of the Chirper 'Bot'. Interest in the CBG genre should not be an immediate barrier for usage in workshops, given the game has an estimated 10.45m owners since release, sixty-nine extension packs, with around fifty-seven thousand peak users at a time (SteamDB, n.d.). This future work also has the potential for replicability given the computing needs for the game are not intense, given the game's release in 2015.

Conclusion

The range of 3D GIS datasets, City Information Models and UDTs utilise various aspects of gaming technology, such as game engines or game-like interfaces and require unpacking to better understand how particular design decisions change the nature and focus of the experience. The increasing number of cases and applied UDTs for urban areas globally requires a tool for understanding these systems' design and social-technical relations. The urban game continuum is a playable tool created to address this challenge with reference to a taxonomy of games and existing cases. This taxonomy is expandable and provides a benchmark for devising future systems. Games cannot replicate the complete planning system, but with low engagement in the UK's case, there is a need to consider how game design approaches could play an essential role in increasing public interaction within current planning processes through an explanation of the planning system itself.

In the case of the map for *Cities: Skylines,* the game experience contains embedded learning of the game system and its mechanics, whereas the sample of existing UDT cases in the Urban Game Continuum is a one-directional information flow. Creating playable experiences with an embedded learning and progressive UIs could provide much higher-level modes of citizen engagement, reflections, and redesigns of the real-world planning system via serious games. However, a different complex system is played over the real-world NPPF system in the *Cities: Skylines* case. Ultimately, players are still utilising a range of pre-established game rules and dynamics, and there is a lack of opportunities to design an overall system in tandem with designers.

Damjan Jovanovic's (2021) *Planet Garden*, a terraform simulation game of non-linear systems in which players build and balance various sources for 'worldmaking' tested underlying urban assumptions, allowing players to design the system for a range of future scenarios. While players cannot explore the 'black box' of *Cities: Skylines* as a system, unlike *Planet Garden*, the extensive modification possibilities are useful, as are the pedagogic benefits, including players reflecting and thinking about networks, connections and relationships with each micro city building planning decision played, especially for sustainable transit networks. The reflectivity provided via gaming is an incredibly useful device to promote discourse around future environments rather than a one-way information source communicated via gaming technologies and interfaces.

Providing opportunities and games to explore 'problem landscapes' and help players scaffold their worldbuilding is essential for planning engagement. In a period in which cyber-physical sensors and models that constitute urban digital twins are increasingly being sought to virtualise our urban environments, we must introduce the ludic and not just the games technology to simulate future space and life.

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