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Spatial Computing and the Phygital City: Towards Digital Habitation

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Abstract

Spatial computing is reshaping the relationship between cities and digital technology, yet planning and governance frameworks have not kept pace with the transition now underway. This article proposes a three-stage model of urban digital transition: from the Smart City, in which sensor networks and real-time analytics form the digital nervous system of urban life; through the Phygital City, in which physical and digital layers are experienced simultaneously and inseparably within the lived urban environment; and towards "digital habitation," a condition in which physical geography ceases to be the primary frame of reference, and work, socialising, commerce, and leisure occur in immersive digital environments. Existing frameworks, including code/space (Dodge & Kitchin, 2005), hybrid space (de Souza e Silva, 2006), and platform capitalism (Srnicek, 2017), have captured aspects of this transformation, but we argue that the intermediate Phygital City phase represents a qualitatively distinct planning condition that these frameworks have not adequately named or addressed. Naming it matters: Planners cannot effectively govern a condition for which they lack adequate conceptual vocabulary, and the governance instruments of the smart city are insufficient for the experiential, spatial, and ethical complexities of phygital urbanism. Drawing on emerging empirical cases, including urban digital twins and spatial computing platforms, the article develops the Phygital City concept across three registers—interface design, domestic space, and urban form—and situates the framework within established urban theory. We treat the three-stage transition as a planning horizon requiring anticipatory governance rather than a technological inevitability, and identify the Phygital City as the most tractable site for immediate policy and design intervention.

Keywords

digital habitation; digital twins; metacities; phygital city; spatial computing; urban informatics; virtual environments

1. Introduction

The physical city has always been more than bricks and asphalt; it is a repository of information, a vast hardware system of roads, buildings, and services activated by the people who move through it. That fabric of interaction, the way we use, interpret, and experience urban space, is now approaching what we argue is a three-phase transition: from the Smart City, through an emerging Phygital City, towards a future of predominantly digital occupation we term "digital habitation." Batty (1997), in "*The Computable City*," argued that computers becoming embedded in urban life would change the structure and dynamics of the city itself, transforming every urban function from transport to utilities into digitally driven processes. To date that influence has been felt mainly through computing used to understand the city, rather than through a shift in the cityscape itself. Predating Batty, Gelernter (1991) fashioned the concept of "mirror worlds," envisaging cities as the prototypical digital replicas: software models sustaining a million views and remembering their own history in perfect detail. These were early visions of the now-emerging 3D modelling of cities and the collection of data via the Internet of Things, which Hudson-Smith et al. (2021) identify as the current driving force in the built environment. We argue that the shift goes beyond the current state of digital and urban form into a change in how we not only interact with but occupy the city itself, arriving not precisely as either Batty or Gelernter envisaged, but as a merging of their two visions.

These are valuable lenses, but each was built around a condition in which physical and digital remain separable registers, linked through software dependency, mobile social practice, or the geography of online content, rather than experienced as a single layer. What the Phygital City points to, which we define fully in the next section, is the moment at which that separability becomes hard to sustain: The augmented reality (AR) overlay is not consulted; it is simply there, woven into the visual field rather than held alongside it. As such, the Phygital City is not a fourth item to add to an existing list of frameworks, but a claim about when and how the boundary those frameworks all assume starts to break down, and a view that this breakdown carries planning consequences that the existing vocabulary of the city does not, on its own, surface.

It is necessary to acknowledge the substantial theoretical work already grappling with the relationship between physical urban space and digital technology. Dodge and Kitchin's (2005) code/space named the constitutive role of software-mediated processes in producing urban experience; de Souza e Silva's (2006) hybrid space described physical and digital merged through mobile social practice; and Zook and Graham's (2007) digiplace drew attention to the uneven, geographically structured way digital representations overlay physical space and reproduce spatial inequalities. More recently, Kitchin et al. (2015), Graham (2004), and Helbing and Argota Sanchez-Vaquerizo (2022) have further developed this terrain. The question is what the Phygital City adds to a conversation already theoretically rich.

While the term "phygital" has gained traction in urban design, placemaking, and architectural practice applied to public space (Bazzanella et al., 2014), to designed artefacts within it (Cevallos Andrade & del Blanco García, 2025), and to individual spatial behaviour (Mieli et al., 2024), these applications remain largely descriptive or design-oriented, they qualify a site, an object, or a practice. None names the city itself as phygital. They typically address discrete sites or events rather than the systemic urban condition that emerges when persistent, spatially coincident digital layers become part of everyday public experience.

Similarly, recent proposals for augmented urban planning focus on the socio-technical integration of urban digital twins to improve the planning process itself, enhancing interdisciplinary collaboration, stakeholder engagement, and operational decision-making (Azadi et al., 2025). In contrast, the Phygital City framework advanced here names a distinct planning threshold: the moment at which spatial computing renders the digital layer experientially inseparable from physical urban space for citizens, not merely for planners. This generates governance demands, zoning of digital objects in public space, regulation of persistent AR content, procurement of public AR services, and management of differential access to the lived city, that existing smart-city instruments and design approaches do not address. Naming this intermediate condition supplies the vocabulary required for anticipatory spatial planning.

The first of the two conditions this article names is the more imminent, arriving within about five years, as the physical and digital aspects of the city overlap spatially into a new information scape. We formally define this as the Phygital City: an urban environment in which physical and digital layers are experienced simultaneously, interactively, and increasingly inseparably, with spatial computing, AR, and layers of data experienced directly on top of physical space and the bodies that move through it. The term "phygital" is generally attributed to Chris Weil of Momentum Worldwide, who is said to have coined it around 2007 to describe strategies for blending in-store and online retail, although the attribution is contested and later origins have also been claimed; its subsequent adoption across cultural heritage, education, and urban studies (Del Vecchio et al., 2023) reflects the breadth of the phenomenon it names. Its marketing origins are, arguably, a liability. We use it because its foregrounding of the simultaneous physical–digital condition, rather than the transition between or interaction of the two, most precisely captures the planning threshold we seek to name. The premise is that spatial computing, encompassing AR, virtual reality (VR), and mixed reality (MR), is fundamentally altering urban function, creating a continuous, layered experience of the city from the public realm to the interior of the home. The article explores the coming decade and speculates, with caution, on the next fifty years, taking a three-stage model, which we introduce, as its conceptual spine.

2. Foundations of the Phygital City

The Computable City has arguably become the Smart City, which has its origins in the late 1990s as part of the broader "smart growth" movement in the United States (Harrison & Donnelly, 2011). Bowerman et al. (2000) provided some of the earliest technical frameworks for infrastructure efficiency, and IBM's Smarter Planet initiative propelled the concept into mainstream urban policy. As Hollands (2008) noted in an early and influential critique, the label was often self-congratulatory and lacked definitional precision, masking assumptions about the role of corporate technology in shaping urban futures. Hudson-Smith et al. (2020) offered a clarification, defining SMART as self-monitoring, analysis and reporting technologies, grounding the concept in sensor networks. Kitchin (2014) and Kitchin et al. (2015) refocused the concept around real-time data streams and urban dashboards, converting computational analytics into actionable intelligence. Smart traffic management, environmental monitoring, energy optimisation, and data-driven public health interventions are now routine worldwide, and the computer has become the gatherer and processor of urban information. The smart city is not an era we are leaving behind but an ongoing condition of contemporary urbanism, the digital nervous system upon which the next layer of innovation is being built.

Where the smart city focused on optimising urban flows through data collected and processed at a distance, the Phygital City concerns the experience of occupying partial digital space within the physical environment.

This transition is bolstered by the maturation of urban digital twins. Established in manufacturing by Grieves (2014) and later applied at urban scales by Shao and Helu (2020), the digital twin is starting to ground data in the real world. The Phygital City, we suggest, is reached when spatial computing, living digital twins, and AR systems are sufficiently mature to layer digital experience directly and continuously onto the physical environment. Del Vecchio et al. (2023) identify citizen experience as underexplored relative to the consumer and marketing literature; the Phygital City reframes phygital as an urban planning challenge rather than a commercial design problem. It is not a replacement for the smart city but the stage that follows provides the data infrastructure, the Phygital City the immersive layer through which citizens interact with urban environments. Digital habitation, the sustained occupation of digital space for activities currently associated with the physical city, lies beyond.

This is no longer wholly speculative. The Virtual London (ViLO) model, developed at the Centre for Advanced Spatial Analysis, overlays real-time transport and environmental data onto a detailed three-dimensional model of the city, while the commercial VU.CITY platform, used by numerous London boroughs and other UK and Irish cities, integrates a city-wide 3D model with planning data and regulation, letting stakeholders assess the visual, physical, and regulatory impact of proposals from a shared baseline. These remain planning and visualisation tools rather than spatially coincident AR experiences in the fuller sense developed below, but they show that the data infrastructure the Phygital City depends on is already operational in several major cities.

2.1. A Three-Stage Model: Smart City, Phygital City, Digital Habitation

The Smart City is characterised by observation and response: The city collects data about itself, analyses it, and adjusts accordingly, with the citizen largely a subject of measurement rather than a participant. The Phygital City moves from observation to participation: The citizen interacts with a digital layer spatially coincident with the physical environment, through devices that dissolve the boundary between screen and world. AR overlays in public spaces, haptic wayfinding systems, and mixed-reality planning consultations are all Phygital City phenomena. Digital habitation, by contrast, moves beyond the physical city as its frame of reference entirely, describing a condition in which a substantial portion of what we currently associate with urban life—work, socialising, commerce, and entertainment—occurs in immersive digital environments that need not bear any relation to physical geography. As noted in the introduction, the argument concerns the transition between these stages; Figure 1 sets out the three phases.

The Phygital City is the bridge between them: The condition in which physical and digital are simultaneously present and mutually constitutive, rather than one being a representation of the other. This has practical implications for planning, not merely for taxonomy. Smart city governance centres on data infrastructure: sensor networks, procurement, data-sharing agreements, and oversight of automated systems. These instruments are silent on questions of spatial experience: Who may place a digital object at a specific location, how conflicting AR overlays are arbitrated, what obligations attach to digital-layer content in public space, and how access is governed when that layer is produced by transnational platforms rather than public bodies. A planning authority equipped only with smart city tools confronting the arrival of persistent AR infrastructure would have no legal mechanism to zone the digital layer, no procurement process for AR public services, no design standards for spatial interfaces in public space, and no equity framework for managing differential access. These are not trivial administrative gaps: They are the phygital equivalents of the 20th-century planning failures that occurred when cities lacked frameworks for managing private

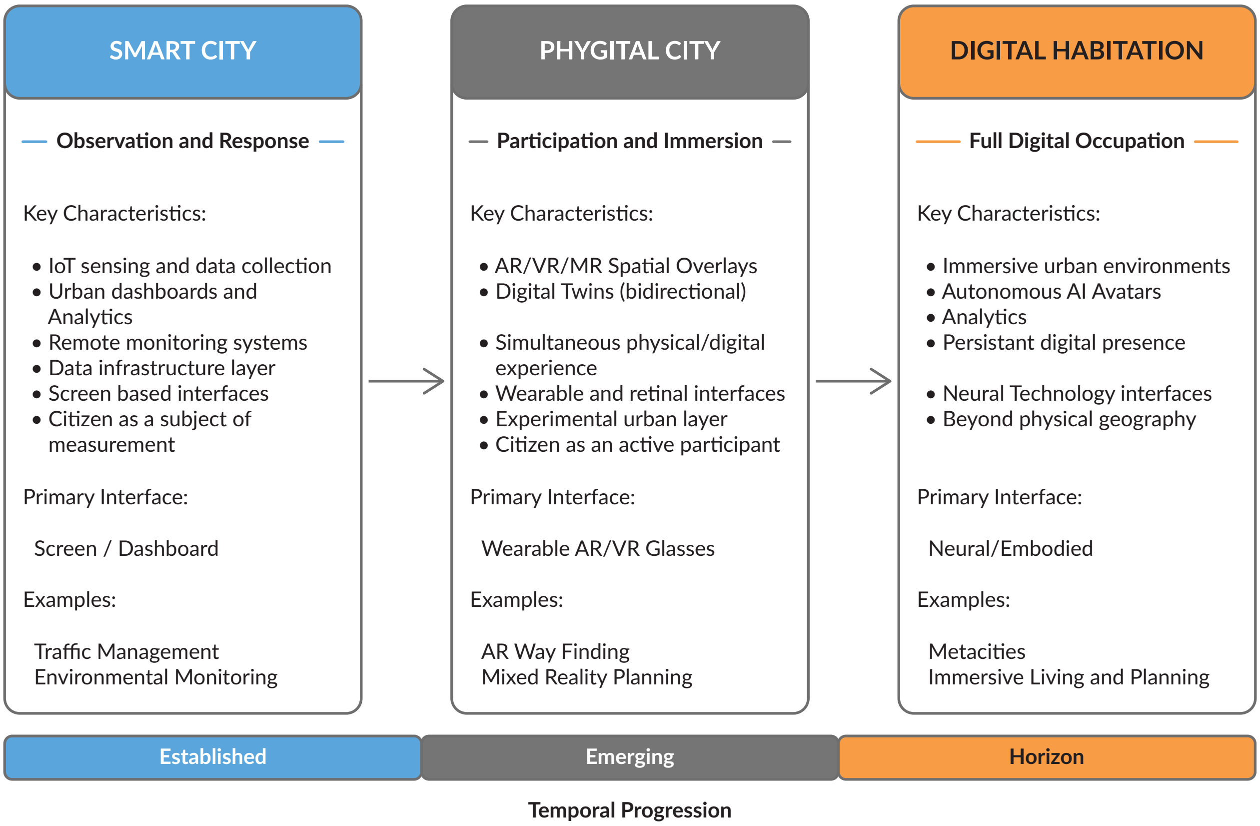

Figure 1. The three-stage transition from Smart City to digital habitation.

automobile infrastructure or regulating industrial land use. Identifying the Phygital City as a distinct phase is the first step towards building the instruments it requires. Allam, Sharifi, et al. (2022) note that the transition carries implications for sustainability and social equity that existing frameworks have not addressed; the Phygital City provides the staging post at which those can be identified before the full transition to digital habitation occurs.

2.2. On Interaction, Habitation, and the Digital Threshold

A substantial tradition in phenomenology and humanistic geography, running from Heidegger's (1971, pp. 141–160) concept of dwelling as a mode of being-in-the-world to Tuan's (1977) account of topophilia, argues that the distinction between "interacting with" and "dwelling in" a space is less clear than it appears. Arguably, with this view we already inhabit our digital environments: The hours spent in online social networks, gaming worlds, and video-call routines constitute a form of spatial occupation that perhaps deserves to be called habitation rather than interaction.

Yet this seems too limited a view, the domestic digital spaces produced by television, the internet, and social media already constitute genuine forms of extended spatial practice, what we are suggesting is a level beyond this. From Meyrowitz (1985) on the geography of television to Wellman and Haythornthwaite (2002) on the internet in everyday life, researchers have documented how successive communication technologies restructure the spatial boundaries of home and community, not by replacing the physical but by layering new presence and practice on top of it.

The Phygital City framework does not contradict this continuity; it identifies a threshold within it. What distinguishes the phygital condition from earlier forms of partial digital habitation is not the fact of digital–physical co-presence, which is, as noted, already established, but its spatial specificity and embodied simultaneity. Previous digital technologies mediated between physical and digital through screens that maintained a visible frame. The telephone extended voice but not vision; television brought remote events into the living room but not the street; the smartphone placed a digital layer in the pocket but preserved the distinction between looking at the screen and looking at the world. Spatial computing removes that frame: The AR layer is not accessed through a device held at a distance from the body but experienced as spatially coincident with physical reality. This is not a difference in degree but a difference in the governance and planning implications: When the digital layer is spatially coincident, it, we argue, should become subject to spatial planning in a way that mediated-screen technologies are not.

Three properties distinguish the phygital condition, and each is a planning property rather than a technological one. The first is persistence: a digital object anchored to a location remains there independently of any individual's session, in contrast to the transient, practice-produced hybridity that mobile devices generate. The second is inter-subjectivity: the same anchored object is encountered by multiple users at the same coordinates, which makes it less like content and more like street furniture. The third, and the most consequential for planning, is its effects on non-users. Code/space, hybrid space, and digiplace all describe conditions experienced by the person holding the device, whereas a persistent overlay produces effects for those not using it at all, including the resident whose shopfront carries an anchor they cannot see and the passer-by recorded by another's glasses. Planning has always concerned itself with precisely such third-party effects, from rights to light to amenity and signage control. This is the sense in which the difference is qualitative rather than one of degree.

2.3. Current Precursors and Early Experiments

Although full phygital urbanism with continuous, city-wide AR overlays remains emergent, several platforms and municipal initiatives already demonstrate the technical and experiential precursors of spatially coincident digital layers.

One prominent case is the inCitu AR platform, deployed across cities including New York, Phoenix, and Columbus, which allows residents and planners to view proposed developments at full scale in their actual context via smartphone, scanning a QR code to see how a transit corridor or housing development would appear in situ (Lincoln Institute of Land Policy, 2025). This moves beyond screen-based visualisation towards an embodied, location-anchored digital layer experienced at the site itself, spatially coincident with physical reality in the sense the Phygital City framework describes.

A more systemic example is Rotterdam's Citiverse initiative, an integrated urban digital twin linked to extended reality tools supporting citizen co-design of public space, allowing residents and planners to manipulate street furniture, green infrastructure, or climate-adaptive features within the model and view the results overlaid on the physical location through AR (Rotterdam Citiverse, 2025; RSM, 2025). The approach is framed as human-centred and inclusive, combining real-time data with immersive visualisation to democratise development decisions. These projects show that the spatial mapping, real-time data integration, and AR delivery mechanisms required for phygital experience are already operational in at least some major cities, well ahead of the governance frameworks needed to manage them at scale.

Together, these precursors demonstrate that the transition is not purely speculative: the technical substrate exists and is being tested in participatory contexts. They also surface the questions of access equity, content control, and public-space governance that the remainder of this article argues must now be brought into planning discourse.

3. The Interface of the Phygital City

The primary interface for the smart city was the screen: mobile phones, control room dashboards, and public displays. These provide access to the digital layer of the city while maintaining a deliberate and visible separation between the user and the data. Spatial computing removes that frame entirely. As Kitchin et al. (2015) have shown, urban dashboards reify particular ways of knowing the city; immersive spatial computing disrupts this, placing the user inside the data environment rather than before it. The city is no longer something you read off a screen; it is something you walk through, layered and augmented, simultaneously physical and digital. Hudson-Smith et al. (2025) provided a view of what the user would see, although they did not use this term, treating it merely as an AR overlay (see Figure 2).

Figure 2. Concept image of data in the Phygital City.

Google Glass, launched as a development build in 2013, is usually filed away as a hardware failure, but its more durable lesson concerns timing. Its technical constraints, a small display, short battery life, limited rendering power, mattered less than a social one: It let people record their surroundings with only a minimal visible signal, and no regulator, platform policy, or social convention yet existed to govern ambient recording in public space (Bilton, 2015). The lesson is not that the technology is doomed to fail again, since sensor and display hardware has moved on, but that whoever builds the governance layer after the hardware ships rather than alongside it risks repeating that mistake at a larger scale.

There are several reasons why platform governance is insufficient. First, the spatial specificity of AR overlays makes them analogous to physical infrastructure in a way social-media content is not: A digital object anchored to a street corner or building façade occupies that space, so governing what may be placed where, by whom, and on what terms is functionally equivalent to zoning and signage regulation, and there is no reason private platforms should make those determinations unilaterally for public space. Second, the public-interest dimension is high: AR layers will shape wayfinding, access to public services, political advertising, emergency communications, and the lived experience of public space for all users, including those without AR devices who are nonetheless surveilled by those who have them. Third, jurisdictional authority already exists in nascent form: local authorities regulate signage, hoardings, street furniture, and public-realm design, and extending that authority to digital equivalents is legally coherent even if it requires new instruments. Srnicek (2017) argues that platform capitalism externalises costs onto the public while privatising network effects; in AR urbanism those costs include the erosion of visual public space, the normalisation of ubiquitous surveillance, and access hierarchies that deepen existing inequalities. Just as twentieth-century planning confronted who the physical city was built for, twenty-first-century planning must confront who the Phygital City is rendered for, a new form of zoning that planners have not yet begun to theorise.

This necessitates a new urban interface ethics: a framework for asking who determines the content of the AR layer, who bears the cost of access, and who arbitrates when the digital shadow of the city systematically misrepresents, excludes, or surveils particular communities. The case for public intervention requires careful argument, since the obvious response is that these questions will be resolved by platform governance: Meta, Apple, and Google are already developing AR infrastructure and will presumably develop terms of service to govern it.

Indeed, at the time of writing, March 2026, Google has pre-launched Android XR, an AI-powered operating system for headsets and glasses that brings digital information together with the real world (Android, 2026). Others will follow: wearables closer in form to ordinary spectacles, capable of beaming information directly onto the retina while allowing physical reality to show through. This is “true AR,” and with it the prospect of genuine phygital urbanism, a continuous overlay of digital information on physical space, experienced not through a held device but through the act of simply looking at the city. This resonates with Castell’s (1996) “space of flows,” but adds a spatial dimension: the flows are not merely informational but experiential, sensory, and immersive. As Graham and Marvin (2001) argued, the uneven distribution of digital infrastructures risks producing “splintered” urban experience; in the Phygital City that splintering acquires new depth, since those without access to the AR layer inhabit a literally different version of the same physical space.

A degree of precision about timing matters, since the governance argument depends on it. Over roughly the next five years the more probable development is not full sensory AR but a lighter step: glasses-format devices carrying persistent, location-anchored information. A genuinely continuous AR overlay across public space, with the spatial mapping infrastructure it would require, sits further out, plausibly into the 2030s, contingent on battery and optics improvements not yet realised. The governance case rests on both horizons, close enough to warrant a proactive rather than reactive planning response.

4. Digital Habitation: Redefining Domestic and Urban Space

It is worth pausing on how unoriginal the claim of domestic rupture actually is. Each prior communications technology, the telephone, broadcast television, the home computer, the smartphone, arrived with similarly dramatic forecasts: that distance would cease to matter, that offices would empty out, that private and public life would no longer hold apart. None proved entirely wrong; none proved straightforwardly right. The domestication of technology literature (Haddon, 2004; Silverstone & Hirsch, 1992) describes a more modest pattern: New technologies are folded into existing household routines rather than overturning them. Two things follow. First, expect a similar pattern of partial, socially mediated adoption here, which should temper some of the broader suggestions below. Second, the home was already some distance towards being a hybrid space before spatial computing arrived; what is new is not hybridity but its form, digital content seemingly untethering from the screen and distributing itself across the physical surfaces of the room.

The Phygital City is the transitional condition; digital habitation is, arguably, its destination. Where domestic space was traditionally defined by walls and a roof, it comes to be defined by bandwidth and immersion. The physical home becomes a portal: through MR the walls of a small urban apartment can dissolve to reveal a virtual vista, or expand to host friends present only as high-fidelity avatars. The transition is one of degree rather than kind, but the urban consequences are substantial.

4.1. The Evolution of the Frontier

Visions of future cities have always blended utopia and dystopia. From the neon-lit megastructures of *Blade Runner* to the haptic metaverse of *Ready Player One*, these imagined worlds are mirrors of societal aspiration and anxiety. Stephenson's (1992) coining of "metaverse" in *Snow Crash* gave a name to a concept circulating since the earliest experiments in collaborative virtual environments. The significance of that lineage lies not in terminology but in framing: the metaverse as a virtual space conceived as an urban phenomenon, a city at the scale of digital space. Hudson-Smith et al. (2025), in their book *Cities in the Metaverse*, building on Radoff (2021), define five layers required to form the frontier cityscape: connectivity infrastructure, the human interface of headsets and glasses, a decentralisation layer underpinning the exchange of digital assets, spatial computing itself, and the experiences layer of metaverse workplaces, venues, and shops.

Early experiments demonstrated both the potential and the constraints of the technology: cities mirrored in the computer and occupied by avatars, unrestrained by geography and physics. As Benedikt (1991) argued in one of the earliest explorations of the then called "cyberspace," virtual worlds are not real in any conventional sense; the laws of physics can be violated, suspended, or reinvented. What has changed is that the tools are now consumer-grade, the environments spatially coincident with the physical world, and the distinction between model and modelled philosophically untenable.

That philosophical challenge is what makes the Phygital City so significant. As Batty (2018a) observes, as models approach greater fidelity they begin to converge with the system they represent, raising the question of whether a complete digital twin running in real time remains separate from that system or becomes it. Goodchild et al. (2024) complicate this further, arguing that all digital twins are characterised by inherent uncertainty, while Lei et al. (2023) confirm that technical sophistication has outpaced the governance frameworks available to manage them. The Phygital City and beyond is the moment at which the convergence between model and modelled becomes experientially real.

4.2. The State of the Metaverse

The metaverse is best described as frontier territory under mixed development, with an expanding ecosystem of platforms, developers, and investors across the gaming, social, and enterprise sectors (Park &

Kim, 2022). It has moved in boom-and-bust cycles: abandoned worlds have grown steadily in number, and platforms that once seemed dominant, most notably Active Worlds and Second Life, are now shells of their former selves. Meta's Horizon has joined them: the tens of billions invested in Reality Labs since 2021, alongside the renaming from Facebook, came full circle when Meta announced in March 2026 that Horizon Worlds would be withdrawn from VR and continue as mobile-only, only to reverse that decision some 48 hours later after user outcry. Despite this outcry, the system and with it the current state of the Metaverse, is what could be described as underwhelming, especially compared to its previous highs. Park and Kim (2022) identify premature platform death as a structural feature of the space, linked to the difficulty of sustaining network effects at scale. These abandoned worlds are not merely failures; they are the digital city's archaeological layer. Despite this, platforms on the edge of the metaverse, Roblox, Fortnite, and similar, continue to attract huge audiences: Roblox averaged 85.3 million daily active users in the final quarter of 2024 (Roblox Corporation, 2025), perhaps offering a glimpse of the next hype cycle.

This merits examination beyond simple product failure. The social dimension of digital space is not reducible to rendering quality: Users did not find Horizon Worlds meaningful as a place, and better graphics did not resolve that. The threshold for digital habitation is therefore cultural and social as much as technological, involving spatial attachment, social practice, and economic activity built up over time. The Phygital City may in fact be a necessary cultural precondition for full digital habitation rather than simply a technical stepping stone, and the failure of attempts to "skip" straight to it is consistent with this.

Central to all these devices is a screen. The Phygital City is based around spatially aware AR glasses worn in the city itself; digital habitation is anchored in the home, where MR headsets such as Apple's Vision Pro and Meta's Quest track walls, windows, and furniture in order to augment new scenes onto them. This creates the illusion of extended space, and with it the central context for digital habitation: the view from a window overlooking a main road could instead present a live stream from Times Square, the ocean, or a chosen metaverse. We illustrate the concept in Figure 3, where the view is of a city but could in reality be anywhere.

Figure 3. An illustration of future digital habitation.

The domestic implications are profound and not without dystopian potential. Urban living could become increasingly dense, fitting more people per square metre into our cities; windows may become virtual, and spaces that are physically small experientially infinite. This "TARDIS effect," infinite digital space nested within physical boundaries, is the domestic expression of the broader Phygital City logic: The physical is the container; the digital is what is experienced within it. Mitchell (1995) anticipated that digital technologies would alter the relationship between physical space and functional capacity. As Bibri and Allam (2022) have argued, the hyper-connectivity and datafication inherent in these systems raise acute concerns about privacy, surveillance, and the algorithmisation of urban society that existing regulatory frameworks are poorly equipped to address.

4.3. The Locomotion Problem

The translation of physical movement into virtual space remains one of the key problems in the field: If you put on a headset and walk across a street in the metaverse, you run out of room in your living room. Current workarounds, teleportation, flying, controller-based navigation, are functional but non-immersive, and the first home-based platforms enabling continuous full-body movement remain niche and far from mass adoption.

The importance of this barrier extends well beyond convenience. As Lefebvre (1974/1991) argued, space is produced through bodily practice; the capacity to walk, to navigate, to encounter others in motion is constitutive of the urban experience. A metaverse in which one can only teleport offers a fundamentally different spatial experience from one in which one can walk continuously. The Phygital City, where physical walking activates digital overlays, preserves that bodily relationship to space; digital habitation, with full locomotion, would extend it into environments unconstrained by physical geography. It is once this barrier has been crossed that digital habitation becomes a possibility, and with it the implications for the physical city.

4.4. AI and Digital Habitation

AI is central to digital habitation and thus to the future city. It matters first through avatars, the representation of the self. Where the avatars of Active Worlds and Second Life could merely wave or perform a limited set of dances, current systems track facial expression and full-body movement, and a photorealistic digital twin of yourself, at least from the neck up, is now a practical reality rather than a research prototype. In the Phygital City, the avatar is not merely seen; it is the instrument through which the citizen navigates between the physical and digital layers of the urban environment. In digital habitation, the avatar becomes the primary up-front social presence.

Avatars will soon be indistinguishable from human beings in visual fidelity. More significantly, your avatar may be able to act in the metaverse on your behalf while you are offline, eating, sleeping, or engaged in the physical world. In effect, these are AI agents working across environments on your behalf, looking like you but purely artificial, akin to the emerging AI desktop agents but operating in the metaverse. Handling routine social and commercial transactions autonomously, they would create a "persistently inhabited" digital city that never sleeps, not because its human population is perpetually awake but because their digital proxies maintain continuous presence. This blurs the boundary between human and artificial urban populations in ways that extend Graham's (2004) account of the remediation of urban life, and raises legal, ethical, and philosophical questions that current urban theory is only beginning to frame.

Secondly, AI is central to the creation of world scenes. Persistent, AI-driven gaming worlds are not merely entertainment; they are the environments in which the norms, economies, and social contracts of the future city are being developed and tested. As Fraser (2023) argues in her geographical analysis of gaming, VR, and metaversal thinking, gaming environments are not neutral spaces of play but active sites of spatial knowledge production whose conventions will shape how people expect to inhabit digital cities. Games already create whole universes: *No Man's Sky* is effectively infinite, generating novel planets through procedural algorithms, while AI can populate such landscapes with plausible vegetation, weather, and self-sustaining ecosystems. This allows for "metacities": not static backdrops but evolving entities, complex systems exhibiting emergent properties irreducible to their components, a characteristic Batty (2005) identified as definitional to real cities. The procedural metacity is, in this sense, more like a city than any conventional urban model has ever been. As the metaverse provides an expanding digital habitat for AI, the question arises: Could AI, within the metacity, be said in some meaningful sense to inhabit it? Recent AI modifications of games such as *The Elder Scrolls V: Skyrim*, giving non-player characters memory, lore, and voice conversation, offer a glimpse of a future in which digital cities are populated by AI avatars living alongside digital representations of actual people. The question, as Floridi (2014) has framed it, is whether we are entering an age of "onlife," a condition in which the distinction between online and offline is no longer meaningful.

5. The Changing Role of the Physical Centre

If work, socialising, and entertainment can occur in high-fidelity phygital and digital environments, the necessity of the physical centre as a place of transaction diminishes. This does not diminish the city but elevates its role as a place of experience, of the sensory, embodied, and serendipitous encounter that remains, for now, irreducibly physical. The Phygital City is not the end of the physical city but the beginning of a new relationship between the two: landmarks such as the Eiffel Tower or Times Square will persist as physical objects and simultaneously as anchoring points in phygital space.

The prediction that digital communication would render cities obsolete has been made repeatedly and proved wrong repeatedly. When the internet went mainstream in the early 1990s the expected dispersal of offices did not occur; cities became technology hubs. As Glaeser (2011) argues, physical proximity enables the informal exchanges that drive creativity and economic growth, and Batty (2018b) makes a similar point. Yet the current transition is qualitatively different: it is not about shopping on a screen or meeting via webcam but the recreation of place and space online, and with it the experience of the city itself.

5.1. The Fifteen-Minute City and the Logic of Digital Proximity

The "fifteen-minute city," advanced by Moreno et al. (2021) and adopted as policy in Paris and elsewhere, proposes that essential urban services be accessible within a fifteen-minute walk or cycle from home. The Phygital City and digital habitation together strengthen rather than undermine this case. If substantial portions of work, education, entertainment, and social interaction migrate to digital environments, the remaining physical functions become overwhelmingly local and service-oriented: food provision, healthcare, exercise, maintenance of the built environment, and forms of sensory and social experience that cannot yet be replicated digitally. Digital habitation thus strengthens the fifteen-minute foundation by displacing non-local functions into digital space, freeing the physical city to concentrate on hyper-local services and embodied experience. As Allam, Bibri, et al. (2022) argue, the fifteen-minute framework offers a foundation for sustainability, liveability, and health that the digital transition may reinforce rather than erode.

5.2. The Service Hub and the Hyper-Local City

Physical cities may therefore evolve into service hubs: less oriented towards mass transport and commercial office space, more focused on food, local amenities, healthcare, and experiential offerings that remain irreducibly physical. Perry's (1929) neighbourhood unit, the self-contained residential community with schools, shops, and amenities within walking distance, was once a planning ideal. The Phygital City and digital habitation may, in effect, return us to a modernised version of that ideal, embedded within a global digital infrastructure that handles everything else. Rather than Ebenezer Howard's (1898) town–country magnet, the vision presented here is a town–digital, where the pull is not green space but the digital spaces of mixed reality and digital habitation.

6. Towards a Research Agenda

It is worth recalling the terminological boundaries established earlier: AR is an interface technology, not the Phygital City itself; a digital twin is a representational tool within the infrastructure of both; the Phygital City is the planning condition of simultaneous, spatially coincident physical–digital habitation; and digital habitation is the further condition in which immersive environments become the primary frame of reference for activities previously associated with the physical city.

The arguments advanced here suggest a research agenda organised around the three-stage model itself, since each stage names a distinct planning condition and generates distinct questions. The priority is not to study digital urbanism in general but to distinguish what the Smart City to Phygital City transition requires, what challenges define the Phygital City in its own right, and what the trajectory towards digital habitation raises. The model allows planning institutions to sequence their responses rather than treating the digital transition as a single undifferentiated challenge.

At the transition from smart city to Phygital City, the most pressing questions concern the readiness of existing data infrastructure and governance frameworks for the shift from observation to participation. Digital twins are evolving from static visualisation tools towards inhabited, real-time environments; research is needed on the point at which a twin becomes a phygital environment in the planning sense, and on the regulatory relationships this creates between planning authorities, platform operators, and citizens (Batty, 2018a; Lei et al., 2023). The methodological toolkit of urban studies (Batty, 2013) must be adapted for environments in which physical and digital data are simultaneously generated and experienced. The inCitu and Rotterdam Citiverse deployments are early instances of this transition; systematic comparative research across such initiatives would build the evidence base anticipatory governance requires.

Within the Phygital City itself, the most urgent priorities concern governance, equity, and ethics. The governance gap identified here, the absence of planning instruments for the digital layer of public space, requires both conceptual development and empirical investigation: who determines the content of persistent AR overlays, by what mechanisms, by what democratic processes, and with what regulatory instruments, analogous to planning law or public utility regulation, to ensure the Phygital City serves all its inhabitants. Equity must be designed in from inception rather than retrofitted once exclusions become visible, a lesson the smart city era has already taught. Graham and Marvin's (2001) concept of splintered urbanism acquires a new dimension when the splintering occurs between residents experiencing different spatial realities simultaneously. Research on the distributional profile of phygital access, on the implications of differential access to AR-mediated public services for civic participation, and on accessible interface design for those with sensory and cognitive disabilities or without high-cost devices should be central to this agenda rather than supplementary.

Looking towards digital habitation, priorities become longer-horizon but no less consequential. The difficulties encountered by Horizon Worlds (Section 4.2) suggest that social and cultural conditions for sustained digital habitation are as significant as technical ones; research on meaningful place-attachment in digital environments, and on the cultural preconditions under which immersive space generates the social capital associated with physical urban life, would substantially advance understanding. Questions of jurisdiction, labour rights, taxation, and social exclusion in virtual environments are not merely future concerns; the gaming and platform economies in which the norms of digital habitation are being formed already raise them at scale (Fraser, 2023; Park & Kim, 2022). Environmental implications also require attention: reduced commuting could yield carbon benefits, but the energy demands of cloud computing, AI training, and the manufacture and disposal of spatial computing devices present counter costs that must be modelled alongside any transition scenario. Although, the drive towards increasing consumerism and the pace of technology development and uptake may well simply override this. Together, these three tiers of the agenda, transition readiness, phygital condition, and digital habitation horizon, map directly onto the three-stage model and provide the structured basis for the interdisciplinary collaboration between urban planners, geographers, computer scientists, legal scholars, and ethicists that the Phygital City will require.

This article has argued that the transition from the Smart City to full digital habitation is not a single step but a structured progression, and that the intermediate phase, the Phygital City, is the crucial and under-theorised stage at which physical and digital realities become simultaneously and continuously present in the lived urban experience. That progression is the urban expression of what the World Economic Forum has characterised as a fourth industrial revolution of "cyber-physical systems," a fusion of technologies blurring the lines between the physical, digital, and biological spheres (Schwab, 2016); but the form it takes in the city is specific to the city, and it requires a vocabulary of its own.

The smart city has given us dashboards and sensing infrastructure. The Phygital City will give us layered, immersive, spatially coincident digital experience embedded in the physical environment. Digital habitation will take us beyond the physical city as a frame of reference entirely. Each stage requires different governance frameworks, different design principles, and different conversations about equity, access, and what cities are for. Planners must become system architects, designing not only for the physical body but for the digital presence; geographers must extend their frameworks to hybrid physical-digital territories; economists must model value creation in virtual layers. The challenge for urban scholarship and practice is to ensure that this digital habitation is shaped not by technological determinism or corporate capture, but by the same values of access, inclusion, and democratic participation that have animated the best traditions of urban planning.

For three decades, Batty's computable city and Gelernter's mirror world stood as two separate propositions: computation embedded within urban function on the one hand, and a parallel software model of the city on the other. The Phygital City is the condition in which they converge into a single visual field. The city is no longer computable, the city of the future is a computer, and we are beginning to live inside it.

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LLMs were used to produce Figures 2 and 3 due to the nature of the subjects not yet being a reality.

References

Allam, Z., Bibri, S. E., Chabaud, D., & Moreno, C. (2022). The 15-minute city offers a new framework for sustainability, liveability, and health. *The Lancet Planetary Health*, *6*(3), e181–e183. https://doi.org/10.1016/S2542-5196(22)00014-6

Allam, Z., Sharifi, A., Bibri, S. E., Jones, D. S., & Krogstie, J. (2022). The metaverse as a virtual form of smart cities: Opportunities and challenges for environmental, economic, and social sustainability in urban futures. *Smart Cities*, *5*(3), 771–801. https://doi.org/10.3390/smartcities5030040

Android. (2026). *Android XR: AI-powered operating system for headsets and glasses*. https://android.com/xr

Azadi, S., Kasraian, D., Nourian, P., & van Wesemael, P. (2025). What have urban digital twins contributed to urban planning and decision making? A systematic literature review and a socio-technical research and development agenda. *Smart Cities*, *8*(1), Article 32. https://doi.org/10.3390/smartcities8010032

Batty, M. (1997). The computable city. *International Planning Studies*, *2*(2), 155–173. https://doi.org/10.1080/13563479708721676

Batty, M. (2005). *Cities and complexity: Understanding cities with cellular automata, agent-based models, and fractals*. MIT Press.

Batty, M. (2013). *The new science of cities*. MIT Press.

Batty, M. (2018a). Digital twins. *Environment and Planning B: Urban Analytics and City Science*, *45*(5), 817–820. https://doi.org/10.1177/2399808318796416

Batty, M. (2018b). *Inventing future cities*. MIT Press.

Bazzanella, L., Roccasalva, G., & Valenti, S. (2014). Phygital public space approach: A case study in Volpiano. *IxD&A: Interaction Design & Architecture(s)*, *20*, 23–32.

Benedikt, M. (1991). *Cyberspace: First steps*. MIT Press.

Bibri, S. E., & Allam, Z. (2022). The metaverse as a virtual form of data-driven smart cities: The ethics of the hyper-connectivity, datafication, algorithmization, and platformization of urban society. *Computational Urban Science*, *2*, Article 22. https://doi.org/10.1007/s43762-022-00050-1

Bilton, N. (2015, February 4). Why Google Glass broke. *The New York Times*. https://www.nytimes.com/2015/02/05/style/why-google-glass-broke.html

Bowerman, B., Braverman, J., Taylor, J., Todosow, H., & Von Wimmersperg, U. (2000). *The vision of a smart city* [Paper presentation]. 2nd International Life Extension Technology Workshop, Paris, France.

Castells, M. (1996). *The rise of the network society*. Blackwell.

Cevallos Andrade, D., & del Blanco García, F. L. (2025). Designing a phygital prosthesis for urban spaces: Merging digital and physical realities. *Street Art & Urban Creativity*, *11*(1), 163–178. https://doi.org/10.62161/sauc.v11.5684

de Souza e Silva, A. (2006). From cyber to hybrid: Mobile technologies as interfaces of hybrid spaces. *Space and Culture*, *9*(3), 261–278. https://doi.org/10.1177/1206331206289022

Del Vecchio, P., Secundo, G., & Garzoni, A. (2023). Phygital technologies and environments for breakthrough innovation in customers' and citizens' journey. A critical literature review and future agenda. *Technological Forecasting and Social Change*, *189*, Article 122342. https://doi.org/10.1016/j.techfore.2023.122342

Dodge, M., & Kitchin, R. (2005). Code and the transduction of space. *Annals of the Association of American Geographers*, *95*(1), 162–180. https://doi.org/10.1111/j.1467-8306.2005.00454.x

Floridi, L. (2014). *The fourth revolution: How the infosphere is reshaping human reality*. Oxford University Press.

Fraser, E. (2023). The future of digital space: Gaming, virtual reality, and metaversal thinking. *Dialogues in Human Geography*, *14*(2), 347–351. https://doi.org/10.1177/20438206231189586

Gelernter, D. (1991). *Mirror worlds: Or the day software puts the universe in a shoebox…How it will happen and what it will mean*. Oxford University Press.

Glaeser, E. (2011). *Triumph of the city: How our greatest invention makes us richer, smarter, greener, healthier, and happier*. Penguin.

Goodchild, M. F., Connor, D., Fotheringham, A. S., Frazier, A., Kedron, P., Li, W., & Tong, D. (2024). Digital twins in urban informatics. *Urban Informatics*, *3*, Article 16. https://doi.org/10.1007/s44212-024-00048-6

Graham, S. (2004). Beyond the "dazzling light": From dreams of transcendence to the "remediation" of urban life. *New Media & Society*, *6*(1), 16–25. https://doi.org/10.1177/1461444804039905

Graham, S., & Marvin, S. (2001). *Splintering urbanism: Networked infrastructures, technological mobilities and the urban condition*. Routledge.

Grieves, M. (2014). *Digital twin: Manufacturing excellence through virtual factory replication* (White paper). Florida Institute of Technology.

Haddon, L. (2004). *Information and communication technologies in everyday life*. Berg.

Harrison, C., & Donnelly, I. A. (2011). A theory of smart cities. *Proceedings of the 55th Annual Meeting of the International Society for the Systems Sciences*, *55*(1). https://journals.isss.org/index.php/proceedings55th/article/view/1703

Heidegger, M. (1971). *Poetry, language, thought*. Harper & Row.

Helbing, D., & Argota Sanchez-Vaquerizo, J. (2022). *Digital mirror world: Towards the next level of reality*. arXiv. https://arxiv.org/abs/2203.07890

Hollands, R. G. (2008). Will the real smart city please stand up? Intelligent, progressive or entrepreneurial? *City*, *12*(3), 303–320. https://doi.org/10.1080/13604810802479126

Howard, E. (1898). *To-morrow: A peaceful path to real reform*. Swan Sonnenschein.

Hudson-Smith, A., Hügel, S., & Roumpani, F. (2020). Self-monitoring, analysis and reporting technologies: Smart cities and real-time data. In K. S. Willis & A. Aurigi (Eds.), *The Routledge companion to smart cities* (pp. 383–394). Routledge.

Hudson-Smith, A., Signorelli, V., & Wilson, D. (2025). *Cities in the metaverse: Spatial computing, digital twins, avatars, economics and digital habitation on the new frontier*. CRC Press.

Hudson-Smith, A., Wilson, D., & Dawkins, O. (2021). Urban IoT: Advances, challenges, and opportunities for mass data collection, analysis, and visualization. In W. Shi, M. F. Goodchild, M. Batty, M.-P. Kwan, & A. Zhang (Eds.), *Urban informatics* (pp. 701–719). Springer.

Kitchin, R. (2014). The real-time city? Big data and smart urbanism. *GeoJournal*, *79*(1), 1–14. https://doi.org/10.1007/s10708-013-9516-8

Kitchin, R., Lauriault, T. P., & McArdle, G. (2015). Knowing and governing cities through urban indicators, city benchmarking and real-time dashboards. *Regional Studies, Regional Science*, *2*(1), 6–28. https://doi.org/10.1080/21681376.2014.983149

Lefebvre, H. (1991). *The production of space*. Blackwell. (Original work published 1974)

Lei, B., Janssen, P., Stoter, J., & Biljecki, F. (2023). Challenges of urban digital twins: A systematic review and a Delphi expert survey. *Automation in Construction*, *147*, Article 104716.

Lincoln Institute of Land Policy. (2025). *Augmented reality offers a new perspective on urban planning*. https://www.lincolninst.edu/publications/land-lines-magazine/articles/augmented-reality-offers-a-new-perspective-on-urban-planning

Meyrowitz, J. (1985). *No sense of place: The impact of electronic media on social behavior*. Oxford University Press.

Mieli, M., Zillinger, M., & Nilsson, J.-H. (2024). Phygital time geography, or: What about technology in tourists' space-time behaviour? *Tourism Geographies*, *26*(3), 389–406. https://doi.org/10.1080/14616688.2024.2318722

Mitchell, W. J. (1995). *City of bits: Space, place, and the infobahn*. MIT Press.

Moreno, C., Allam, Z., Chabaud, D., Gall, C., & Pratlong, F. (2021). Introducing the "15-minute city": Sustainability, resilience and place identity in future post-pandemic cities. *Smart Cities*, *4*(1), 93–111. https://doi.org/10.3390/smartcities4010006

Park, S. M., & Kim, Y. G. (2022). A metaverse: Taxonomy, components, applications, and open challenges. *IEEE Access*, *10*, 4209–4251. https://doi.org/10.1109/ACCESS.2021.3140175

Perry, C. A. (1929). The neighborhood unit, a scheme of arrangement for the family-life community. In *Neighborhood and community planning* (Vol. 7, pp. 2–140). Committee on Regional Plan of New York.

Radoff, J. (2021, April 7). The metaverse value chain. *Medium*. https://medium.com/building-the-metaverse/the-metaverse-value-chain-afcf9e09e3a7

Roblox Corporation. (2025). *Fourth quarter and full year 2024 financial results*. https://ir.roblox.com/news/news-details/2025/Roblox-Reports-Fourth-Quarter-and-Full-Year-2024-Financial-Results/default.aspx

Rotterdam Citiverse. (2025). *Rotterdam Citiverse*. https://rotterdamcitiverse.com/en

RSM. (2025). *Rotterdam's digital twin: Building a human-centred smart city*. Rotterdam School of Management. https://www.rsm.nl/discovery/2025/reimagining-the-digital-city

Schwab, K. (2016). *The fourth industrial revolution*. Crown Business.

Shao, G., & Helu, M. (2020). Framework for a digital twin in manufacturing: Scope and requirements. *Manufacturing Letters*, *24*, 105–107. https://doi.org/10.1016/j.mfglet.2020.04.004

Silverstone, R., & Hirsch, E. (Eds.). (1992). *Consuming technologies: Media and information in domestic spaces*. Routledge.

Srnicek, N. (2017). *Platform capitalism*. Polity Press.

Stephenson, N. (1992). *Snow crash*. Bantam Books.

Tuan, Y.-F. (1977). *Space and place: The perspective of experience*. University of Minnesota Press.

Wellman, B., & Haythornthwaite, C. (Eds.). (2002). *The Internet in everyday life*. Blackwell.

Zook, M., & Graham, M. (2007). Mapping digiplace: Geocoded Internet data and the representation of place. *Environment and Planning B: Planning and Design*, *34*(3), 466–482. https://doi.org/10.1068/b3311

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