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On Metaverse & Geospatial Digital Twinning:

Techno-Strategic Opportunities for India

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Abstract

With the advent of satellite imagery and smartphone sensors, cartographic expertise has reached everyone's pocket and we're witnessing a software-isation of maps that will underlie a symbiotic relationship between our physical spaces and virtual environments. This extended reality comes with enormous economic, military, and technological potential. While there exist a range of technical, social and ethical issues still to be worked out – time and tide wait for no one is a metaphor well applied to the Metaverse and its development. This article briefly introduces the technological landscape, and then moves over to a discussion of Geospatial Digital Twinning and its techno-strategic utility and implications. We suggest that India should, continuing on the existing dichotomy of Open Series and Defence Series Maps, initiate Geospatial Digital Twins of specific areas of interest as a pilot for the development, testing, and integration of national metaverse standards and rules. Further, a working group in collaboration with a body like NASSCOM needs to be formed to develop the architecture and norms that facilitate Indian economic and strategic interests through the Metaverse and other extended reality solutions.

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Introduction

Cartographers argue that maps are value-laden images, which do not just represent a geographical reality but also become an essential tool for political discourse and military planning. Not surprisingly then, early scholars had termed cartography as a science of the princes. In fact, the history of maps is deeply intertwined with the emergence of the Westphalian nation-state itself, with the states being the primary sponsors of any cartographic activity in and around their territories[1]. Earlier the outcome of such activities even constituted secret knowledge, for example, it was the British Military Intelligence HQ in Shimla which ran and coordinated many of the cartographic activities for the British in the subcontinent[2]. Thus, given our post-independence love for Victorian institutions, until 2021 even Google Maps had remained an illegal service in India[3].

One of the key stressors which brought this long-awaited change in policy was the increased availability of relatively low-cost but high-resolution satellite imagery in open online markets. But this remote sensing is only one of the developments impacting modern mapmaking. A host of varied but converging technologies - particularly Artificial Intelligence, advanced sensors, Virtual and Augmented Reality, and the increasing bandwidth for data transmission - are enabling a new kind of map. This new kind of map will not just be a model of reality, but rather a live and immersive simulation of reality. We can call it a Geospatial Digital Twin (GDT) - and it will be a 4D artefact, i.e. given its predictive component and temporal data assimilation, a user could also explore the hologram/VR through time and evaluate possible what-if scenarios.

This is a natural progression when the trend of ‘software-isation of everything’ is extended to maps. To better understand the difference between the present and the next generation of maps, and the utility of GDTs, consider the case of GPS. The GPS is quite accurate in getting users within a few meters of a location, which is fine if you're driving a car to that location but not so much if a drone has to autonomously make an urgent delivery in skyscraper urban landscapes. Contrast this with many experimental 3D maps, such as the city of Helsinki's 3D point cloud[4], which are accurate about locations down to the very centimetre. And most importantly, it did not take any advanced military-grade sensors and satellites to prepare Helsinki’s 3D map, instead, the entire mapping project was

executed by integrating data from sensors in portable scanners, small drones, and volunteers' smartphones.

With Google about to start testing more immersive maps in select cities by the end of this year[5], and 6G communication networks are projected to be ready for early deployment by 2028[6] - it is necessary for policymakers in India to shun any static view of technology and instead frame policies keeping in mind the future trajectory of today's technologies. And organisations which have released their 6G strategies, have leaned very heavily on the applications of digital replicas enabled by high-fidelity holographic transmission.

Our interest here only lies in the cartographic state and the utility of GDTs in India's strategic, technological, and economic environment. We will first briefly introduce the trajectory and maturity of the technology, and then move over to a discussion of digital twinning from the point of view of the cartographic state. Subsequently, we'll touch upon the techno-strategic opportunities that underlie this emergent dimension of human activity and the need to create adaptable standards before the invisible hand takes over the domain. The article will end with some concluding remarks on the implications of this new spatial reality.

The State of the Technology

First making an appearance in 1992 in a sci-fi dystopian novel called 'Snow Crash', the term 'Metaverse' referred to a computer-generated 3D environment where Hiro Protagonist (lead character's actual name) could go for sword fighting whenever he needed an escape from his pizza-delivering job in a libertarian America where the government had been entirely subsumed by corporations and private interests. Since then the term has evolved to mean a unified and seamless virtual reality that extends from and into our physical spaces. While we're still far from that, the recent developments in gaming and mixed reality applications are taking the traditional internet in the same direction[7]. The GDTs form the intermediate layer between the physical world and the metaverse by providing a geographic organisation to the virtual reality assets in mirror worlds.

The peak data rate of 5G is 20 Gb/S. High-definition holograms and virtual reality cannot get completely real-time with this transmission rate, but it's a good beginning. To completely replicate 1 square meter area digitally in a perfect real-time fashion, a throughput of 0.8 Tb/S is required assuming[6] periodic synchronisation in 100 ms and a compression ratio of 1/300, which will become a commercial reality within this decade with the next generation of communication networks. That

said, the visualisation of data is not the data, the code is not the law, and the map, as Prof. Korzybski put it, is not the territory. It is only information.

And in one of the most well-known applications of digital twinning, F1 engineers famously embed 150-200 sensors in their cars just to collect and feed live data every 0.001 seconds from racing circuits back to their control rooms, and over 750 million data points are transmitted in just a single race[8]. Thus, it can be said that the present-day latency between the object and its digital twin is fairly acceptable, and shouldn't stop anyone from trying to twin desolate mountains rivers or urban infrastructures for that matter.

Figure 1: GDTs are essential to creating mirror virtual realities which can be accessed using Augmented Reality devices in the real world, thus forming a key intermediate layer between the physical world and the Metaverse.

Most leading game engines today allow for rendering realistic 3D environments which can be extended to an immersive stereoscopic perspective instead of the usual screen-based perception of 3D environments. This spatial perception, when combined with extensive geospatial information such as vegetation, noise from various sources, elevation, pollution, population, infrastructure characteristics, LIDAR mapping of water bodies etc - produces an information-rich virtual replica of that environment. Further, each class and subclass of objects in that environment could be trained as an AI model that behaves autonomously but interdependently with the other objects. For the cartographic state, such immersive spatial awareness inside AI-based self-adjusting 3D maps can be very useful for a host of things such as tracking specific natural and ecological resources, creating hyper-realistic live replicas of objects and infrastructures of interests, and low-cost military training (especially for operations behind enemy lines) to name a few. This is only a natural step now since augmented reality tools are already making their way into the standard gear of military personnel across the world.

To quell any anxieties about the regulation of these GDTs, it must be noted that the Survey of India already produces two kinds of maps[9] – a publicly available Open Series Map (OSM) and a restricted Defence Series Map (DSM). Consequently, the dichotomy of OSM/DSM can be extended to cover any concerns about regulating GDTs as well. This is particularly important since some areas

in India's sphere of interest have a cultural and religious significance of proportions that postulates that their GDTs be available for public exploration. This can be done under an OSM framework while the more information-rich restricted layers can develop under the DSM framework.

Geospatial Digital Twinning in India's Strategic Environment

Recently in Gilgit-Baltistan, glacial floods swept away two hydroelectric projects, residences, agricultural land and water supply routes, along with a strategic bridge that China had constructed for Pakistan[10]. How such infrastructures would fare against nature and other forces can be predicted by properly digital twinning these areas. Moving over to the other side, with the Tibetan plateau the climatic and cultural stakes are much more intricate since it contains objects of ecological as well as religious significance - India's rivers and Mount Kailash. Thus there is a clear necessity to prepare an intelligent software representation of India's key areas of strategic interest to understand and predict the developments affecting transboundary water flows, populations as well as infrastructures. It would also serve as a pilot for a scalable nationwide GDT and a testbed for the development of technology standards for diffusion into the wider commercial VR market.

One of the key reasons, other than military planning and cartographic politics, that digital twinning makes sense in India's surroundings is the climate and natural resources. Most climate models today are based on a resolution of 10 to 100 KMs, while one needs a meter-scale resolution to accurately predict our changing physical surroundings, again bringing GDTs into the picture. Because of this, the European Union has already planned a complete digital replica of the entire Earth itself to be developed by 2030[11]. This digital twin of Earth will be using Omniverse, Nvidia's multi-GPU platform for 3D simulations, to predict climate change at a much more granular level than the present climate models do. In the case of India, modelling the hydrological and ecological ecosystem of the Himalayas as an immersive digital twin has benefits that far outweigh the costs.

Consider the following general aspects of such intelligent and immersive software maps:

- ***Enhanced 4D Perception:***

  Other than uncanny physical realism and granularity, a user will also be able to scroll through time in a GDT. Thus monitoring, predicting, and analysing possible scenarios pertaining to food security, water, infrastructure, geopolitics etc will become far more optimised and informed.

- ***The Military Utility:***

In 2018, the Pentagon offered Microsoft $22 Billion to develop an augmented reality system based on HoloLens[12]. A virtual reality ecosystem can solve a lot of problems militaries face, including immersive training and the integration of autonomous systems.

To supplement the metaverse, current mixed reality devices are already extending the immersion to omnidirectional treadmills and wearable sensors, i.e. with haptic wear a user could feel the rain, flowing water, or even the recoil of a gun being fired inside the virtual reality. That sort of mind-tricking immersion, when coupled with geospatially accurate simulation of an area or facility, can be extremely valuable in training personnel for special military operations.

Notwithstanding, geospatial digital twinning will be very useful for training physical robots as well, and a lot of scientific effort in AI is going into "closing the reality gap" between simulation and reality[13]. Having been trained over GDT-based simulations will not just make autonomous robots better navigators of conflict zones but also much more attuned to the spaces that human societies inhabit.

- ***The Economic Utility***

  GDTs would simplify the creation of a photorealistic imitation of reality and open up the massive potential for commercial activities within the metaverse. This potential for economic activities, the need for regulating misbehaviour, and the requirement of security and interoperability of virtual assets bring us to another opportunity – which is creating national technical standards for the metaverse.

  We could let the global market dictate this matter as happening presently. But considering that we're the second-largest internet consumers and one of the largest mobile gaming markets for global firms, it is not advisable. We also have software trade bodies like NASSCOM which have previously excellently defended and lobbied Indian business interests internationally. Our gaming industry is also soaring in comparison to others[14]. This is a great opportunity to make up for the lost ground in shaping the networked digital economy and its governance.

An Optimistic Note on Approaching Standardisation

Just a week before this writing, a large set of leading technology companies came together and announced the launch of a Metaverse Standards Forum[15]. Since this comes while projects like the IEEE Metaverse standards group exist too, and considering that a few major companies like Google

and Apple haven't joined the effort, it can be argued that we're in for a lengthy contest over the technical standardisation and architecture of the Metaverse.

These technical standards are necessary for building interoperability between systems. Technical standards are also active grounds for international politics. Because digital twinning requires a wide set of rather independent technologies, attempts are being made to shape the domain as a unified field - through standardisation. Since the rules of the game have not yet been written, there exists a small window of opportunity for states like India to leap forward with globally relevant projects in order to develop and promote their own national technical standards in this extended immersive reality. As a lot of future activities, from everyday commerce to social communications, are expected to be facilitated in "metaverse" like environments where physical reality merges with digital virtuality - taking a lead in setting technical standards, protocols, and performance benchmarks could give India the much-touted early mover advantage in technology. And developing GDTs of specific areas of interest, which is basically the intermediate layer between the real world and the metaverse, is an excellent way to pilot this in a manner which would bring environmental, political, as well as military benefits to the table.

Previous research has suggested a strong connection between economic growth and national standards strategy[16]. It is only natural that in future there will be many metaverse platforms - and it is important that information could be exchanged among these "metaverses". The mistake of today's messaging services should not be repeated here. For example, a WhatsApp user cannot send a message to a telegram user from WhatsApp, but a Gmail user can send an email to a user of another email client and vice versa. Because virtual realities contain elements such as digital real estate and digital currencies – an early standardisation of protocols and interfaces is required to ensure a unified and interoperable experience in the VR economy. Since India already has world-class remote sensing capacity and has only recently deregulated the geospatial data for industry, there is a good case for plunging into the metaverse by developing the middle layer that enables a geographic symbiosis of the physical and the virtual. This is also a sound and safe way to develop and test VR standards before promoting those in commercial markets.

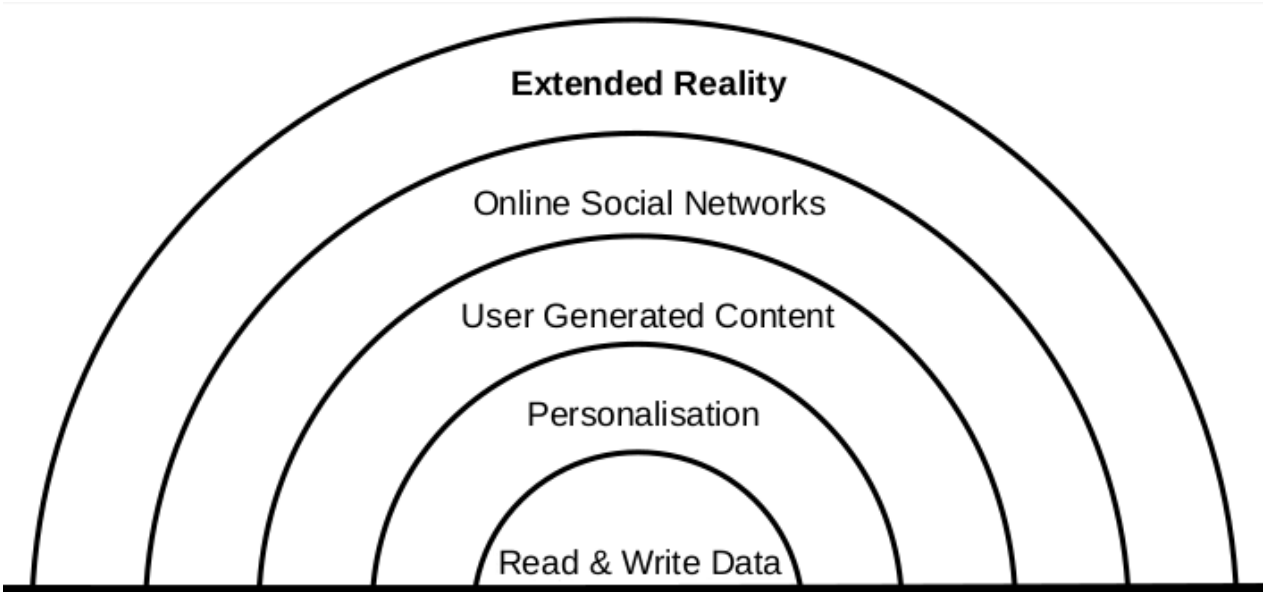

Figure 2: From the intangible realm of 0s and 1s away from the physical world, the Cyberspace is now merging with our physical realities and creating a mixed or extended reality that subsumes previous iterations of the internet, i.e. personalisation, social networks etc. This new form of internet will be experiential and geospatial digital twins will have a huge role to play in this 3D virtual reality. Given our existing vast gaming market and a skilled IT workforce, India is well placed to seize the opportunity of shaping the future of the internet.

Lack of early technical standardisation efforts often also means that a successful product itself, owing to positive network externalities, might become sort of an industry-standard in itself. This creates technology monocultures, and monocultures create over-reliance on proprietary platforms and tend to massively scale information security threats. A regulatory approach to standardisation, however, will be rife with issues at such an early stage. As Dewang Mehta used to say, a state-led regulation often leans towards controlling and not towards facilitating. Observing standard neutrality means losing the advantage of having a dominant standard and giving away a possible competitive edge. And given the extremely dynamic nature of the technology landscape, rigid standards must also be avoided at all costs.

Basically, the government has to tread a middle way that is neither regulatory nor completely market-driven. The first task to do to catalyse and become part of the metaverse standard development process is initiating the GDTs which are extracted from the real world and serve as the base layer and testbed for the metaverse. The goal of any subsequent standardisation in the metaverse should be thus not to regulate at present but to increase technology diffusion and adoption by incentivising interoperable development of virtual and mixed reality solutions and safeguarding the interests and economic potential of Indian industry in the metaverse. This brings us to the second task, that a central working group with a body like NASSCOM needs to be formed to iron out any competing internal interests and implementation mechanisms. Having bought the Information Technology enabled

Services (ITeS) into India's national policy agenda, initiating the annual Game Developer Conference, practically steering the national IT policy and successfully lobbied for tax exemptions and high-speed transmission links for Indian software exports that formed the backbone of offshore software development in India[17] - NASSCOM brings in a high level of in-house expertise, experience, and industry networks to tackle the challenge of enabling national economic competitiveness and constitutional norms within the Metaverse.

As the experience of technology giants suggests - highly successful software products generally are also enabling the development of a large number of third-party solutions based on them. This should be kept in mind so that the standardisation efforts lay the foundation for market creation i.e. economic activities within and using VR environments, and not otherwise. Further, an early specification of protocols and interfaces for the industry and government is also necessary for embedding these technologies into the physical world, as well as for ensuring technological sovereignty in the new cyberspace.

A Word of Caution

While there exist wide economic and military utilities of GDT-based extended realities, a symbiotic environment merging the physical and the computational universe also expands the surface of social and security concerns. It is nothing that cannot be handled but making those issues visible is essential in tackling them appropriately.

Chief among those are the moral differences in how people act in real life and how they might want to act in virtual realities. The governance of 3D virtual realities must take this into account as well. There will be moral, philosophical, as well as some social and legal issues pertaining to such ambiguities. The protagonist in the motion picture 'V for Vendetta' puts it rather succinctly, that when you give people a mask, they'll show you their true face. One way to go around this is to have some kind of online-offline identity binding mechanism, although such a thing would come with its privacy issues and at some point, the policymakers and the civil society will have to make a trade-off on this.

Given the involvement of economic assets and digital currencies, the development of a governable mixed reality would also require that there is not only interoperability between metaverse platforms but also that these metaverse solutions interoperate with the physical world's financial, legal, and asset management ethos. People who have trouble coming to terms with AI doing face recognition are going to have a hard time ingesting GDT, which happens to be a data assimilation exercise at its core and would ideally mean sensing everything from every possible angle. This brings us to another

issue of Metaverse, its energy-intensive nature. For example, the EU's proposed Deep Learning for granular digital earth is expected to require 20,000 GPUs[18], running which will be equivalent to running extremely large cryptocurrency mining operations. While most GDTs wouldn't require such supercomputing granular simulations, far from it, collectively the energy footprint of Metaverse computing would be hard to ignore.

Further, the existing threats of phishing and disinformation will also be further complicated in the metaverse and one should expect to see new kinds of attacks and fraudulent behaviour in virtual realities. Given its data-intensive nature and dependence on advanced communication networks for a high-fidelity seamless immersive experience, the metaverse would also expand the purview of present discourse on data privacy and data access rights. Unfortunately, the experience of today's social networks suggests that most people will be willing to, knowingly or unknowingly, happily part with their personal data in exchange for a little convenience, economic incentives, or even social and psychological validation.

Concluding Remarks

With the advent of satellite imagery and smartphone sensors, cartographic expertise has reached everyone's pocket and we're witnessing a software-isation of maps that will underlie a symbiotic relationship between our physical spaces and virtual environments. This extended reality comes with enormous economic, military, and technological potential – and is bound to alter the traditional practices and notions of establishing a society's spatial reality.

Since it is only the application of cartography which had made territory the defining characteristic of the state[19], scholars like Paul Virilio always considered cyberspace to be having a deterritorializing effect over states[20]. But the way territory is defined is conditioned by the way space is presented, and as the space of cyberspace evolves to entangle with the physical space itself, how the relationship between territory, the space and the state evolves could present profound consequences for nations, their social contracts, and the spatial identity of the state as well. Notwithstanding the philosophical considerations, given her gaming industry and software expertise, India is well placed to begin formulating the intermediate layer between reality and virtual reality by initiating GDTs of specific areas of interest as a pilot for the development, testing, and integration of national metaverse standards. The existing dichotomy of Open Series/Defence Series maps is well suited to produce these in developmental as well as military contexts. The rest must be left over to the visible hand of a

consensus-based govt-industry working group focusing on interoperability, security, and national economic interests in the provision of extended computational realities.

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