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DIGITAL PRODUCTION

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## Challenges in planning and managing the production of a 3D city

As computer graphics technologies evolve, stories being told become visually more and more complex. A picture tells more than a thousand words – this still holds true today. The bar is continuously raised, and CG production processes of full-CG 3D cities are becoming increasingly more complex and technical. But if you want to do it, here are a few ideas to start.

by Matthias Bühler

In this article, we are looking at some managerial and technical aspects to consider when planning the production of a 3D city – and how third-party tools like Aixterior (see page 60) or vrbn studios assets can help you. Every story is different. Every budget is different. Let's have a look at a few points why 3D cities are notoriously complex to plan, and a few markers how you can leverage modern technology in an efficient way.

- ▷ **Historically grown city fabric:** A factor that is often underdeveloped is that cities grow organically. Even though some cities may have been planned as ideal cities (utopias), life continually adds layers of history to a city's fabric. Transposing the story into a 3D city is key.
- ▷ **Believable building forms and typologies:** Buildings are not sculptures!

They provide a multi-functional space, designed based on a concise inner organizational structure. More often than not, this structure is readable in the façade or shape of the roof. How people live, work, their social and political circumstances can always be derived from the story to be told. Furthermore, a city always consists of multiple building archetypes, not only one. Examples: The typical residential, commercial, administrative, or religious building. The more realistic the conglomerate or different types of architectures are tied into the urban fabric, the more believable a 3D city becomes.

- ▷ **Architectural knowledge:** One of the key components of believable architecture is its constructive consistency. The devil's in the detail: Historically accurate styles, façade patterns, choice of materials. But most of all: Dimensions. Nothing is killing the believability faster than wrong proportions, thickness, or constructions that defy given constraints like, e.g., gravity. Of course, not every 3D artist can be trained in architecture, but there are plenty of fantastic books to consult.
- ▷ **Design statistics:** Statistical analysis of the city is crucial. A few aspects for your consideration when planning your digital city are the ratio between built space and open space, the urban densities of

certain areas and quarters (including the influence of the landscape and its topology). On a more granular level, the building types with their façade types / patterns / color and material charts. Those evolve into the necessary assets and their distribution patterns. The final finishing parts are infrastructure elements (bridges, walls, airports). There are plenty more types of similar statistics that allow one to track down the essence. There is no magic behind this, but it's essential to train the eye and dive deeply into reference imagery.

### Large amounts of consistent assets and materials

A city typically consists of many hundred to many thousand buildings and countless other objects. It's unnecessary to explain that there is a myriad of different materials and assets that need to be created – all of them obeying the same quality standards. Especially assets with multiple levels of detail have to be planned carefully.

### Balancing the core factors

Balancing these points is of utmost importance and is an administrative/managerial challenge, with the final goal to produce the best possible results on a given budget. The following five factors are the key:

1. **Art directability:** What is the granularity of control the art director needs?
2. **Modeling efficiency:** What is the sweet-spot between artistic control and automation (e.g., procedural modeling)?
3. **Costs:** What is the budget? Minimal deliverable? Buffers?
4. **Architectural consistency:** What is the expected level?
5. **Data consistency:** How is the data structured across the board so everything is consistent and conform to the pipeline?

### Technical challenges

There are many different approaches to how 3D cities can be tackled, but two main flavours dictate a lot of the strategy: Approach A is the locked/limited viewpoint freedom – for example VFX shots, or nested panoramas. You can look around a little bit, but your viewpoint is fixed and controlled by the artist. Approach B is the unlimited viewpoint freedom, which we know from 3D games or interactive 3D experiences.

The advantage of a locked viewpoint is that the camera view is always known, for example, in a movie. The audience cannot alter the motion of the camera path. Using this fact allows for all sorts of commonly used shortcuts, like using projection techniques, like Matte Painting, to imply 3D detail that is not actually fully 3D. But you don't see it, because the artist does not give you the opportunity to get close.

In real-world production, the techniques are often freely mixed to leverage the best of both worlds for the situation. B is usually more labour-intensive and technically more challenging than A, as everything needs to be created in full-3D. This article's focus is on the unlimited viewpoint, as stated in the

title's part full-CG. Let's consider a few technical aspects.

### Modeling approach

A city contains a lot of variation of most objects, and for each type, there are methods of obtaining that variation. How far you go is mostly limited by the budget. Using so-called procedural methods is one of the most common approaches: For individual 3D assets, buildings, and entire cityscapes. SideFX Houdini is heavily used for general procedural content, while Esri's ArcGIS CityEngine is the industry standard for creating procedural 3D architecture. But even if it creates variation faster, the goal with a procedural system is always to balance a) the emerging quality, b) the art-directability, and c) the overall efforts to set up the procedural system in the first place. This means it's crucial to evaluate the break-even-point of setting up a procedural framework. When dealing with 3D architecture, it's essential to understand that each building type follows its own architectural rules and patterns, which may not be encoded in just one single procedural system.

### Camera proximity and perceived realism

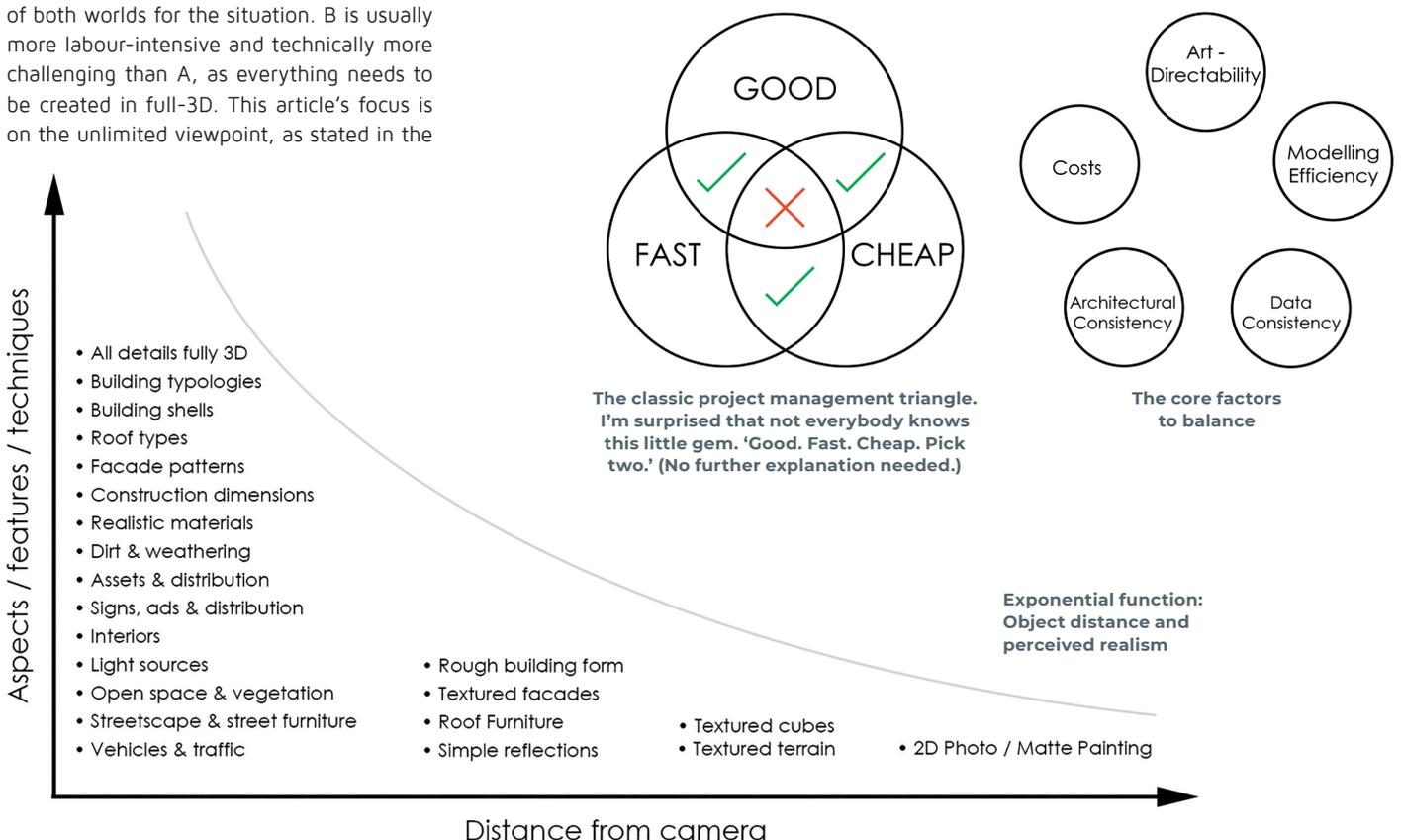
Things that are far away from the camera are quite forgiving to the human eye in appearing believable or photo-realistic. Atmospheric effects like fog or haze, depth of

field, motion blur, or other similar effects help massively in this regard. When creating artificial cities, the closer we get to a building, the exponentially more details need to be right to make a genuinely believable city. An example: Imagine how complex a system is, based on which billboards are distributed in a city.

In the graphic, you see a simplified breakdown of the problem. It becomes clear that for example modeling a detailed 3D city cannot simply be done with a procedural system. Such a system would have to be incredibly complex and would, therefore, not be financially feasible. There are always smart trade-offs needed – the art is to figure out which ones for a given project.

### Building up a library of assets and materials

3D libraries are a huge commitment. For a detailed 3D city, the asset count can easily go into the hundreds. Everything needs to follow the same material convention and the same quality standards. In the case of most game titles, it means that you need to have multiple levels of detail for every single asset. The same consistency also applies to a material library. It becomes clear that building up a library, especially for procedural systems, needs absolute meticulous file management. Some projects profit from using GIS data, either for mapping out realistic layouts or for inspiration. Importers for open data like OSM exist for all 3D tools



nowadays. CityEngine – being developed by the world’s leading GIS technology developer, Esri – has native support for additional file formats such as SHP or GDB. However, data in these formats are a bit harder to come by or process without specific GIS tools.

### Levels of detail (LODs)

As modern graphics cards can fluidly display only about 5 million triangles (polygons) simultaneously (in a game or real-time demo), scenes with large amounts of complex objects need to be optimized. For example, if a scene had 1.000 trees, with each tree having 15.000 triangles, that would be 15.000.000 triangles – way too many to run fluidly. The go-to solution to tackle this is LODs.

### Differences between offline and real-time rendering

Let’s address some key technical differences between the two visualization technologies.

Offline (classic) rendering is mostly CPU-based, and takes

minutes or hours per frame – for that disadvantage you get virtually unlimited possible complexity. Which means that LODs are rarely needed to deliver a static image or video.

If we look at real-time rendering on the other hand, it is graphics card (GPU) based, and you get 30 frames each second, if it is working correctly (VR needs at least 90). But, as a surprise to exactly no one who ever saw a video game, there is strong optimization needed (polygons, textures, and so on). One of the most efficient optimizations are LODs, which are used and needed all the time. This effort affords you something that offline rendering can’t provide – a free 3D navigation and interaction with your scene.

### Conclusion and learnings

Most stories told play in an urban context. Therefore, a 3D city is a type of container in which a story unfolds – and that 3D city



## Levels of Detail (LODs)



LODs are common in games and real-time applications. The challenge in their creation is the visual continuity between them, so that the LOD pop, when the models are swapped, is minimal. To reduce this pop, most game engines offer a dithering effect that blends between the LODs. Technically, any 3D mesh can have LODs – from a simple asset like an AC-unit up to a complex structure like a building.

We have invested a lot of time internally to develop an LOD system, which consistently combines a building with individual assets into a building with its own combined LODs. Creating assets with consistent LODs is a significant investment that needs meticulous planning and execution.



itself is a silent but important actor. As we have seen, developing a 3D city system that “automagically” solves everything is impossible. Therefore, every project must mix-and-match techniques to reach a (hopefully) happy compromise. As there are so many factors to consider, the managing team must carefully define the goals to reach in an open dialog. Usually, budget or time available dictate the quality that can be achieved, so transparent communication of constraints and expectations is always crucial.

### Our work at vrbn studios

Many of the things described above are daily challenges in our studio, but also a personal passion of our staff. Our work is artistic

and architectural, but also very technical and involving precise planning. Next to being involved in different types of 3D environment creation and consultancy services, our primary focus over the last 1,5 years has been developing our proprietary tools and an ever-growing library for the production of our high-quality off-the-shelf buildings. As not every studio has the resources to build up its own 3D environment production pipeline, it is our goal to provide high-quality content that is drag-and-drop ready. The unique challenge we set ourselves was to create a workflow that would produce buildings that are compatible with both VFX and game engines at the same time. We invest a lot of time to optimize our importers for look parity between the tools. The results allow very effi-

cient workflows in hybrid pipelines that leverage both offline and real-time rendering, for example, in virtual production. By the way: A real-time demo (for PC) that showcases some buildings (including 5 LODs) is available at [bit.ly/vrbn\\_demo\\_buildings](http://bit.ly/vrbn_demo_buildings) > ei

Matthias Buehler is the founder and CTO of Switzerland based vrbn studios. His background is in architecture. Over the last ten years, he's become a specialist in procedural city modeling: For real world architectural and urban planning uses, but also for entertainment. vrbn studios specializes in creating large scale 3D urban environments and supports clients with consulting and custom 3D content production. Further, vrbn studios offers off-the-shelf 3D buildings. For general info or questions, please contact [info@vrbn.io](mailto:info@vrbn.io).