

From Literature to Image—Aesthetic Features of Space Megastructure Cities in American Sci-Fi Movies

Zhi Li

Abstract—The concept of Space megastructures is originated from science fiction novels. They symbolize the material landscape form of a comprehensive advancement of intelligent civilization after the continuous development of technology. Space megacity is actually an expansion process of human development in the future. It is not only a transformation of space colonization but also a mapping of self-help homeland. Therefore, it is a symbol of technological optimism and a future utopia in the context of technology. In contemporary times, sci-fi movies use digital technology to translate the giant imagination in literature into richer digital image landscapes. Space giant cities are one of the most typical digital images with spectacle view, which reflects the impact of American sci-fi movie scene design on the landscape and preference that human will be living in the future. The aesthetic preferences and design principles of the future picture, and the aesthetic value of science fiction as a medium of imagination are revealed. The aim of this article is to explore the digital design style of space megastructure with utopia sense in science fiction movies, and analyzes its aesthetic connotation.

Index Terms—Megastructure, science fiction movie, design style, aesthetics.

I. INTRODUCTION

Space megastructure cities is an important scene that reflects the imagination of sci-fi city form and the degree of civilization evolution. With the development of digital technology, the imagination of megastructure in literature is presented by more colorful and rich digital image landscapes through sci-fi movies. Space megastructure Cities is one of the most typical digital images with spectacle view, which reflects the impact of American sci-fi movie scene design. The aesthetic preferences and design principles of the human future picture, and the aesthetic value of science fiction as a medium of imagination are clearly revealed. Therefore, this article, taking space megastructure cities as the object, to studies the rules of American science fiction movie scene design, reveals its aesthetic characteristics, and hopes to provide reference for the aesthetic expression of Chinese science fiction cities.

II. IMAGINATION OF SPACE MEGASTRUCTURE IN SCIENCE FICTION LITERATURE

A. Space Megastructure in Science Fiction Literature

Megastructure is not only a special term for science fiction, but also has appeared early in the history of

architecture. From the perspective of a single giant volume, ancient buildings such as pyramids, Roman roads & aqueducts, and early Gothic cathedrals are all in the category of megastructure form. Comparing the modern giant projects, the classic megastructures are not a large-scale industrial project, but a non-utilitarian and non-targeted large-scale architecture [1]. The megastructure architectural genre in the 1960s was an imagination of future existence based on limited resources after the war, which conceiving a human society in a closed, multi-layered permanent building structure. Space megastructure is a very large artificial object. John W. Cook and Heinrich Klotz define a megastructure as an oversized, huge, multi-unit building quality. Some scholars consider that megastructures create a new world that the level of this world should be above the size of the moon [2]. The concept of megastructure can be found in science fiction novels back to the 1920s and 1930s, and it became a popular science fiction concept the 1970s to the 1990s. The megastructures may be man-made large-scale constructs, or may be the huge remains of a living things.

It is the overall feature of the megastructure story which constructs a giant living environment with unconventional experience based on huge geometric volume and the mass quality. The classic megastructures is Ringworld published by Larry Niven in 1970. The Ringworld is a solid ring connected end to end around a planet with a diameter of about 2au and a habitable surface. There are some architectures in it. The novel creates a mysterious world through the huge circular megastructure and the city built on it together. After RingWorld, Rama in Clark Asimov's Rendezvous with Rama is another famous example. Rama is a cylindrical alien spacecraft 50 kilometers long which has a very smooth appearance to show its identity of the creation of the intelligent civilization. Rama is like a cylindrical ark with a rich ecosystem in, and the ice layer melts as Rama's distance from the sun gets closer to causes change on climate and environment. The variety climatic environment brings the waterfalls and natural phenomena and also the life is appeared in the ocean. It is seemingly staged in a short time on the biological evolution process and environmental change laws on the earth. The other giant space megastructures are the Dyson Sphere in Bob Shaw's Orbitville published in 1974 is, and The interstellar ship in Gomship in 1973 which is a Dyson field. The space megastructures in Jonh Varley's Tatan is relatively smaller scale which is similar to the size of the moon. It is a living "planet" and human can use the language to communicate with it. After the 1980s, stories related to space megastructure cities include Kapp's 1982 Search for the Sun!, James White's 1988 Federation World, Banks' Orbitals and Shellworlds, Baxter's Ring and etc. [2].

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Zhi Li is the Communication University of China, China (e-mail: 463951237@qq.com).

Megastructure mobilizes a creative and optimistic future architectural language, which integrates the concepts of machine, replaceable and prefabricated parts into the architectural design [3]. Megastructures achieve the imagination of human being's conquest of limited resources and the extraction of energy from stars in space through the huge man-made systems and the ultra-conventional bulks. Megastructure itself is a form of challenge for mankind to extend the hope of civilization and celebrate self-evolution through technology.

B. The Structure and Visual Performance of the Space Megastructure

The interest of Megastructure in space and desire to conquer outer space in science fiction literature influenced the future imagination of astronomy for space habitats. Different types of space habitats such as cosmic spaghetti, Generation Ship, Artificial Asteroids, etc. in space megastructures are real habitat structures for astronomical research. On the one hand, these megastructural habitats are inspired by various novel concepts in science fiction literature, and on the other hand they strictly follow the rules of actual astronomy and science in terms of shape and structure. These space mega-habitats are conceived on the basis of technology and the basic conditions of human existence, and they integrate energy, gravity, habitation, survival and other indicators for habitat design and planning. They are one of the best symbols of mankind's attempt to create the miracle of a complete ecosystem in the future. Thus, the visual form of space megastructure is influenced by both literature and astronomical science together.

1) Cosmic spaghetti

The cosmic spaghetti is a circular tube shaped space megastructure habitat that rotates around an inner circular axis to generate centrifugal force instead of artificial gravity. The cosmic spaghetti includes some structures such as Stanford torus, topopolis, Bernal sphere, O'Neill cylinder, and O'Neill colony. These circular pipes are all expanded versions of the rotating wheel space station. They are cosmic colony concepts that provide permanent human habitation to accommodate entire cities with gravity system..

2) Generation ship

Generation ship is usually the spacecraft that travel at speeds below the speed of light, and need to navigate through space for several generations to complete a predetermined light-year interstellar journey. Therefore, generation ships often contain a complete complex ecosystem including habitation, living, air circulation and natural metabolism for human survival, with sufficient fuel reserves and strong power systems.

3) Artificial asteroid

Artificial asteroids are usually hollow asteroids with inhabited areas inside the planet. The city of Trantor in Asimov's science fiction novel Foundation series can be seen as a typical analogue of a giant artificial asteroid: the entire surface of the planet, except for the Imperial Palace, is covered by an artificial shell. Trantor inspired Coruscant in Star Wars, forming one of the models for an ecumenopolis

4) Dyson sphere system

The Dyson Sphere is a product of an intelligent

civilization that has reached level 2: once an intelligent civilization is able to harness stellar-level energy, the corresponding technological industry will also require stellar-level energy, which will then require the orbital structure wrapped around the parent star to collect stellar energy. As depicted in "Ringworld", the Dyson Sphere system wraps the star in a huge material and collects its energy into a megastructure to feed the continuation of the intelligent civilization that made it.

III. THE DESIGN FEATURES OF THE SPACE MEGASTRUCTURE HABITATS IN AMERICAN SCIENCE FICTION MOVIES

A. Space Civilization Habitats that Subverts the Form of Space

It can be said that the various space docks in Star Trek are typical representatives of space megastructure habitats, such as K-7, Regula I, Starbases 74, Lya Station Alpha and the famous Deep Space 9. Starbase Yorktown in Star Trek Beyond is recognized as a miracle in the visual and sci-fi world. Starbase Yorktown is a huge transparent sphere built in deep space, 40 miles in diameter [4], and this megastructure can accommodate millions of people. To emphasize the unbiased Federation position, Starbase Yorktown was designed to be constructed entirely of artificial materials rather than built on a planet. The most distinctive feature of this megastructure is not only that the cities are built in giant spheres encased in transparent aluminum, but also that there are arms inside the sphere that extend from the center of the sphere. Arm is the basis for the existence of each alien race city in Starbase Yorktown, and the city is built on arms. Each arm is 17.5 miles long [5], and the arm itself is a huge space that is planned for offices, residences, and important transit hubs. Another impressive feature of Starbase Yorktown is the huge water system within it. Each arm has a river-like water system, and these huge in-town water systems are controlled by a gravity system and exist alongside the buildings on top of the huge arms. The containers that carries these waters are also transparent. It also means that while flying through the different arms, people can see various architectural landscapes above and below the river through the transparent containers and transparent waters (Fig. 1). These massive transparent water systems contrast with the opaque variety of transportation systems and structures, highlighting the unique qualities of Starbase Yorktown's combination of massive and permeable.



Fig. 1. Yorktown in Star Trek beyond.

Starbase Yorktown presents the artificial asteroid in the megastructural space habitat in another form. The megastructures, such as Death Star and Borg Sphere, are all hollow spheres, with the entire megastructural space

consisting of a steel shell and a gravity system inside the sphere providing a single direction of gravity. The novelty of megastructures comes from the giant sphere itself, as well as the abyssal spaces, artificial pipes and mechanical structures created in space due to the hollow core. However, Starbase Yorktown turns the artificial shell transparent and subverts the conventional gravity experience by replacing the upside-down air trains that usually exist in science fiction with entire city systems intact.

Cooper Station in “Interstellar” is a typical Stanford Torus, with the houses of the residents on the other side of the sky overhead. The Torus in Elysium is also a large Stanford Torus, which resembles the wheel of a bicycle and is made up of three layers of giant hollow rings and five cantilevers. The outer ring of The Torus is a giant space with a diameter of 40 km and a width of 2 km (Fig. 2). In the city, people can see the entire arc-shaped ground and the arc-shaped living space extending to the distance. The initial design of the Elysium habitat was much more massive to set at 160 km in diameter. In the actual movie, however, it was reduced in size to allow the “arc” to appear in the sky at the front of the vision.

The white exterior of The Torus alludes to the status of the City of Light, while its complex external support structures form a compelling design that embodies a modern technological style that defines form by function. The Torus in Elysium is designed in the form of an actual NASA space station. Different shapes of panels, windows, and mesh structures are stitched together like “decorative” textures to form the outer surface of a giant circle. The film do using various modules and different shapes of components to enrich the visual image of a huge structure that combines credibility and complexity. The digital technology in Elysium was mainly used for the rendering of the space habitat and the construction of the interior environment of Elysium. The digital technology in Elysium was mainly used for the rendering of the space habitat and the construction of the interior environment of Elysium. The difficulty of the CG production in Elysium is the complex structure of the outer ring itself and the lush landscape within it. The entire space needed to deal with nearly 3 trillion polygons on screen and the complex geometry of the many leaves [6]. Finally, the rendering technique successfully rendered the numerous interior buildings, facilities, and tropical vegetation environment in The Torus realistically, while allowing the wide water system that acts as a counterbalance when rotating to be seamlessly integrated into the entire virtual landscape and live close-up shots.

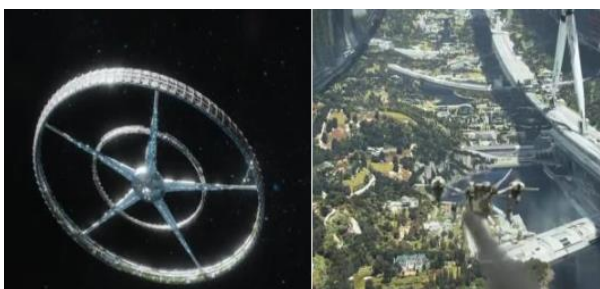


Fig. 2. The torus of elysium.

B. The Conservative Architectural Form in the Crazy Megastructure

In American sci-fi movies, although the design of space megastructures are crazy and unprecedented, the city aesthetics and architecture design within it are usually conservative and regular. For example, the architectural forms in Starbase Yorktown are not as spectacular and exaggerated as the arm rail systems. The buildings are like cells in a giant arm systems, Most of the vertical buildings on arms are predominantly white tall buildings, and the iconic architecture is used to build the visual focal point of the city on different arms. Starbase Yorktown's architectural design is not only focused on how cool the building forms look, but also on designing the entire city system to meet the different functions required by the city. In the pre-design stage, the film considered the history of the city and how it would develop in the future, and then determined the architectural style and transportation form of the city. Therefore, in the early stage, concept designer Sean Hargreaves focused on designing one of the Starbase Yorktown arms, presenting the transportation system, building style, space layout, greenery, exhaust system, etc. in detail in the final rendering. The architectural form of the city reflects the style of Dubai architecture to match the image of the city taken from Dubai. The buildings are set at a 45-degree angle to give a more artistic image of the city and to make the film more visually appealing [7]. At the same time, the maximum height of the buildings on the arms barely exceeds the diameter of the arms, and the density of the buildings is restrained, with the buildings mostly distributed in a linear structure on the arms. These restrained city spaces are surrounded by appropriate greenery and arranged in an orderly manner along the surface lake system. The more orderly urban planning and restrained building forms are in contrast to the crazy size and structure of Starbase Yorktown itself. The more orderly urban planning and restrained building forms are in contrast to the crazy size and structure of Starbase Yorktown itself.

In Starbase Yorktown, architectural spaces are distributed on the arms in a linear structure. At the same time, the building exists in a restrained manner in terms of height and density, which surround by appropriate greenery, and arrange in an orderly manner along the ground lake water system. All of these show the conservative principles of architectural design in the space megastuctrues in American sci-fi movies.

The buildings of The Torus in Elysium are also a conservative and low-key design. When the director Neill Blomkamp “filled” the giant space of “Elysium”, he made it clear that architectural forms need to be from the real world and the designers should avoid pursue overly the futuristic design — such a design has no trace and continuity of human civilization. Expression focus of the architectural aesthetics in Elgsium lies in manifestation of wealth, as well as restrained technological design. Wealth is mainly represented by modern high class residences, while technology is mostly expressed by government public buildings, amenities and facilities in all architectures. The city of The Torus in Elysium is a space that resembles a combination of suburb and beach town, while the high class residences reference the mansions of the Los Angeles coast.

The film fits the modern, minimalist villas in the Waratah with the arched, curved city made of CG to create a futuristic style with a sense of familiarity. Beverly Hills also inspired the architectural style of The Torus residences [8]. And the environmental atmosphere of the Beverly Hills which is built by woods, streams, rivers and birds, has become the basic urban space character of The Torus inner city. The technology government buildings are also small, low—key structures (Fig. 3).



Fig. 3. The conservative architectural forms in YorkTown and Elysium

There are two reasons for the conservative and relatively conventional architectural aesthetic principles on the American sci-fi megastructure. The first reason is for the control of the movie budget. The close-up shooting of a movie requires framing in the corresponding building, and realistic scenes can be produced with bit effects to save movie expenses. The second reason is to highlight the core of science fiction scene performance. Restrained architectural aesthetic is the good way to balance the aesthetic performance of different scenes in American sci-fi movies: the conventional interior architectures make the crazy megastructures more stand out. This design principle fully shows the excellent control over the aesthetic tension on virtual landscapes.

In addition, we can find that whether the director's demands or the designers' create on sci-fi scenes shows that the architectural aesthetics follows the principles of modern design. The restrained building also reveals this pursue and perform the designer's understanding about modernity and technology. From the perspective of architectural aesthetics, from the Art Deco style that began in 1910, the Googie style and space age architecture after 1950, to the neo-futuristic architectural style from 1980 to the present, real-world architectural genres have clearly express technology and modernity. In a sense, contemporary architecture has embodied a certain degree of science fiction landscape. Digital aesthetics, parametric design and virtual reality all blur the boundary between reality and virtuality. The real world itself can also be said to be a space with future aesthetic features.

IV. THE AESTHETIC CONNOTATION OF THE SPACE MEGACITIES IN AMERICAN SCIENCE FICTION MOVIES

A. Amusement-Park Like Urban Space Experiment

The spherical aesthetics of Starbase Yorktown updated the universe of Star Trek, and take the concept of amusement-park into the aesthetics of spatial habitats. The director commented that this bold megastructure is as novel and exciting as a roller coaster. The aesthetic characteristics

of Starbase Yorktown and Tomorrowland (2015) are similar: exaggeration, smoothness and traffic surroundings.

The exaggeration of Starbase Yorktown lies in the different directions of the sky-spanning arms that make up the city's massive structures. These structures and the vertical orientation of the buildings on the arms, which can be easily changed by flipping gravity, combine to create the spectacular style of the film.

The smoothness of Starbase Yorktown is expressed in the combination of urban space and the huge track: the urban details are like vines spreading along the direction of the track, forming a pyramid-shaped core gathering area on the outer plane of the track. Starbase Yorktown is a "homeworld", where each arm is the home of a race/alien species with an independent gravity system that supports the normal functioning of the city on both sides of the arm. The multiple arms in Starbase Yorktown form a cityscape where different civilizations exist independently and harmoniously, and this cityscape accommodates different living customs with different architectural forms. In other words, Starbase Yorktown is a giant multicultural container. This container allows for multiple degrees of freedom in terms of architectural direction and human experience due to the design of arms. Through this way, the film constructs amusement-park features visually and psychologically. The city in Tomorrowland (2015) is similar to Starbase Yorktown that itself is also like an amusement park, and the buildings are the same as plant with a variety of twisted forms, surrounded by hovering air highways, air tracks, so that the city is similar to a large toy.

The anti-gravity design is one of the features of the living space of "amusement-park like". The Ring of Kafrene in Rogue One: A Star Wars Story (2016) is similar to Yorktown, and the city is an "upside down city system": The Ring of Kafrene is built between two meteorites, and the gap between the meteorites is connected by architectures. The interior of the city presents a new world with a lot of architectures in the sky and on the ground. The design of the "upside down city system" is the way to update the aesthetics of American sci-fi movies through filling the space of the building in the visual space of the movie lens (Fig. 4).



Fig. 4. Urban space experiment in Yorktown, Tomortowland and Ring of Kafrene.

Starbase Yorktown uses spatial inversions and spatial surrounds to create a visual landscape, constructing the city in a process of folding, restructuring and re-expanding. In a sense, this is the combination of the objective entity of the city with the complex content in it , and then conduct visual spatial experiments on the cores of race symbiosis, cultural collision and mutual respect in the city. Deleuze proposes in topological terms that the relationship between the virtual and the real is like a kind of folding of the plane. This folding complicates the plane. Understanding, thinking and

experiencing are opening and refolding of the real materiality and thus revealing the plurality of the virtual object [9]. They represent a multitude of unformed and unfinished functions, as well as relationships of forces. This metaphor visualizes the relationship between urban entities (architecture, layout, transportation, etc.) and urban culture, politics and urban consciousness. The arms-structured city in Starbase Yorktown is a different spatial form that reorganizes the complex relationships of the contemporary city/future industrial city after being deconstructed in an anti-vertical way. The urban hierarchy and cultural diversity of Yorktown are unified in a way that intersects with multiple linear structures. The transportation system in Starbase Yorktown Station, with its different directions and gravity, is a metaphor for the different directions of life in the city of the future, just like the buildings on arms.

B. Closed Isolation Metaphor of Escape from Earth Ruins

From an ecological point of view, the space habitat actually provides a future refuge from the destruction of the earth. The Cooper Station in *Interstellar* is a typical space for human migration. The film uses black holes and high-dimensional space to make it possible for human to escape from the ruins, and humans can eventually survive in a Stanford Torus. The Stanford Torus itself is a metaphor for the destroyed ecological balance, energy pollution, resource degradation and the disorder of the human environment in the earth ruins. The Mars journey of the space station in *Mr. Nobody* (2009) is also a herald of the junction between the improved future of mankind and the end of natural human history. The space megastructure habitat for human being by itself has the functions for isolation and escape. The ruins of the earth represent various original sins and terrible destruction of the future earth. American sci-fi movies present a huge classes conflict and showing dramatic tension by comparing the the megastructure and earth ruins.

Comparing the Elysium constructed by The Torus which is the spatial habitat of the Stanford Torus structure with the ruined world of slums on the earth, this film shows the huge contrast. The first is the contrast between form and volume. The earth is a huge sphere, and the habitat is a ring-shaped megastructure. Its white appearance makes it look like an artificial moon if you watch it from the earth. In terms of volume, this megastructure is a metaphor for the pyramid-like class population ratio of human society. This metaphor about proportion of the social population by The Torus is reflect in the film plots. There is no middle class in "Elysium". The ratio of the poor population to billionaires seems to reach 9:1, which obviously shows the huge classes conflict with the reversed "T-shaped" social structure. The entire planet has been destroyed into global ruins, and those who live in the ruins of the planet have lost their right to a good living condition, working environment and medical system. In the film, the landscapes of earth's ruins combine the Spanish-style super slums and the city ruins of Los Angeles together as well as refer to the slums of Rio de Janeiro and Mexico City [10]. This huge mixed global slum is in stark contrast to the Elysium with the rich, upscale, futuristic style. From the perspective of the earth, the "moon" Elysium habitat, which symbolizes the back garden

of the earth, carries the beautiful imagination of human beings of space colonies, and space city is an utopian for human being.

The second is the comparison of urban conditions between the Turos and the Earth. Elysium City is actually an ultimate gated community in Bel-Air, Los Angeles. In the Turos, the urban environment is also dominated by tropical environments like Malibu, California. So the city has sufficient green environment as well as good transportation. This city is a "ribbon city" built by the river, and the water area replaces the highway as the main element that runs through the city. The well-organized urban planning and reasonable building height allow the buildings in the city to have good lighting. In the displayed image, Elysium is like a holiday resort, with neatly manicured green lawns, and the river in the city forms a private area like a private pool.

The third is the contrast of political metaphors. Elysium's main conflicts focus on command center and the struggle for immigration status. Elysium's command center is a small space compare to command center and global ruins structured by smooth materials. Contrary to the leisurely and spacious settings in residential spaces, the spaces related to the command center are designed with the materials implying sense of rationality. These small spaces are designed in such a way indicating authority spaces, which not only imply the right to manage the Elysium habitat, but also a metaphor for the Elysium government's serve the residents of the habitat. This is in line with the contemporary topics discussed in the immigration issues and segregation governance. From the other senses of the movie can be found the same implication. The Turos where rich people live is built not for the ruling of the ruin but for the isolation and separation of the classes. The indifference of residents and authority of the Turos to the destruction of the earth, insensitivity and disrespect to the poor people, indicating the evil force behind the Elysium is the technological advancement.

V. CONCLUSION

With the support of digital technology, the space megastructure in science fiction literature is transformed into a richer digital image through science fiction movies. Space megastructure cities have become prominent representatives in several typical digital spectacle landscapes. Space megacities use a creative language of future architecture to vividly present the vision of human beings to conquer space, looking for new resources and supply, and use technology to conduct space experiments. It is a symbol of technological optimism and a future utopia in the context of technology. From the design point of view, the space megacities in the American science fiction movies are the represents of the habitats of space megastructures. They not only symbolize the habitat of space civilization that subverts the form of space, but also reflect the conservative architectures in the crazy megastructures. Its design style is distinct and unique. Aesthetically, the space megastructure cities not only symbolizes amusement-park like urban space experiment, but also reflects the isolation metaphor of escape from ruins. Its aesthetic connotation is rich and profound.

CONFLICT OF INTEREST

The author declares no conflict of interest.

AUTHOR CONTRIBUTIONS

Zhi Li conducted the research and wrote the paper.

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Zhi Li is a Ph.D. candidate in College of Animation and Digital Arts, Communication University of China, Beijing, China, majoring in media arts. She has got her master of arts, majoring in animation and new media (new media direction), Beijing Institute of Fashion, Beijing. She obtained the bachelor of engineering, majoring in industrial design (product design direction), Beijing Institute of Fashion, Beijing. Her research fields includes science fiction city design, science fiction film, digital aesthetics, new media stage.