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Life beyond Earth: THE RINGS OF THE EARTH

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JM de Prada Poole's (1) Orbital Megalopolis envisions 5 concentric rings of circular cross-section, in orbit at an average height of 35.750 km above the Earth's crust (like the rings around Saturn, but with different dimensions and a different objective). Each of these rings functions in the same way as a 84.330 km diameter torus, hosting a population of 2,500 million people and providing for all their needs in its interior. The main aim of the project is to empty planet Earth of most of its human population, and thus allow the biosphere to continue its natural evolution without having to bear the harmful interference and burden of humankind. This article describes the composition and size of one of these rings, and compares its parts with other similar ones already built by the human species. It begins with a brief explanation of the historical background and an introduction discussing demographic development over the last two centuries and its most immediate consequences.

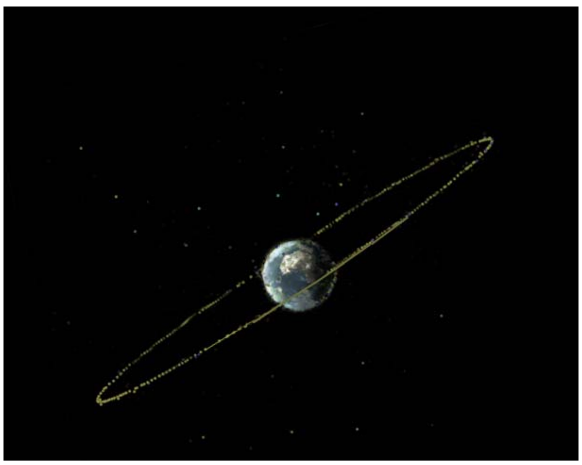

Fig.I. "The Rings of the Earth" at 35.750 km above the surface of the planet

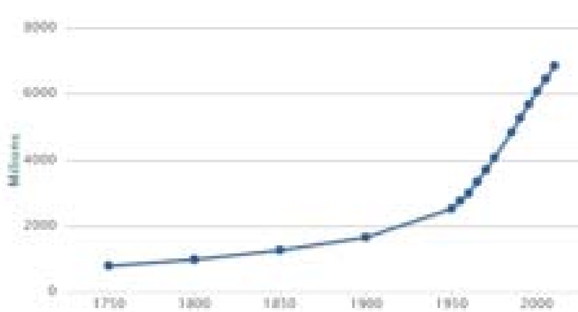

Fig.II. Exponential increase in human population

I. ZERO PEOPLE

Air pollution, the hole in the ozone layer, degraded soil, deforestation, marine pollution, rising temperatures, drought, biodiversity loss …. 25 years after the Rio-92 2nd "Earth Summit" and its "declaration on environment and development", governments and the governed have hardly progressed at all. After Kyoto Conference many of the signatories have yet to fulfil the Protocol (USA did not ratify it, and Canada withdrew). Currently, Paris Climate Conference (COP) achieved 195 countries according to reduce C02 emissions all possible to limit increase temperature of biosphere only 2º. But this agreement is not binding until the 55 countries that produce more than 55% of C02 have not yet ratified. The Treaty under these conditions is too weak, compliance is only voluntary, and only serves to point those who fail to meet the deadlines set themselves

It seems that Human Beings all prey on nature in their own way, depending on geographical area and culture (1,100 million inhabitants in developed countries produce the same "ecological footprint" as 17,000 million in India or China), but violations in one area of the planet have an impact on the rest. One of the keys for regulating these actions would be to achieve "sustainable growth"; but neither population growth nor economic growth seems to tend towards this goal.

Furthermore, the limit to the planet's "load bearing capacity" is calculated in different ways. The UN (organiser of the "Earth Summit") estimates it at 12,300 million people, Harvard at 97,000, and FAO at 50,000 million. However, for each estimate it is clear that as the population explosion progresses social structures and cultural patterns change (energy consumption, food, …) becoming increasingly restrictive, while the world's population continues to grow exponentially (fig. II).

Until the Industrial Revolution the world's population took 300 years or more to double, since then, the number of years has fallen to the current 45. That is, while the current "compound annual growth rate" (CAGR) is maintained at between 15 and 20% (according to forecasts), in 2060 the Earth would have to accommodate 14,000 million people:

Year 1800 =1,000 million + (130 years) >1930 = 2,000 mill + (55) > 1975 = 4,000 + (45) > 2020 = 8,000 million (the planet's current population is 7,000 million).

So, even if the conditions are met to avoid an increase in this rate, or to achieve a decrease (low birth rates, increased life expectancy, …) the 12,000 million envisaged as the limit by the UN will soon be with us, resources will begin to be short and, worst of all, if the Kyoto agreement commitments are still not fulfilled: immediate environmental catastrophe is ensured.

Among all the possible remedies, and in view of the fact that the planet's "sustainable growth" is quite difficult to control, J. Miguel de Prada Poole (1) dares to suggest the possible depopulation of the planet as the most reliable and efficient way for Gaia to regenerate by herself, and thus ensure that the terrestrial biosphere and all its biodiversity continues to evolve under its own steam, and without having to bear human overexploitation. How? : By manufacturing 8 orbital rings like the ones round Saturn, but around the planet Earth, which will accommodate 1,000 million people each, while a small human reserve would stay on the planet's surface to maintain and monitor it. Is it possible to construct these rings? What would they have to be like? How long would it take to develop such a project? ….

II. EXTRATERRESTRIAL LIFE (background)

Before A. C. Clark published his "Wireless World" in 1945 in which he suggested the possibility of using geostationary Earth orbits for telecommunication satellites for the incipient consumer society, H. Potočnik had already published his "The problem of space travel - The Rocket Motor", in 1929, with the drawings, weights and dimensions of Noordung's orbital station. The initial purpose of this station was to be an "Earth observatory for peaceful purposes"; the energy required came from a solar collector (concave mirror), and communication with Earth was via radio waves. Potočnik was a young, ex-Austrian army captain and also held a PhD in electronic engineering, specialising in ballistics and rocket science. His book, published in Berlin, was well received by the German "Society for space travel" (VFR) of which a 17-year old von Braun was a member. His book was translated into Russian in 1935, and partially into English for the American magazine

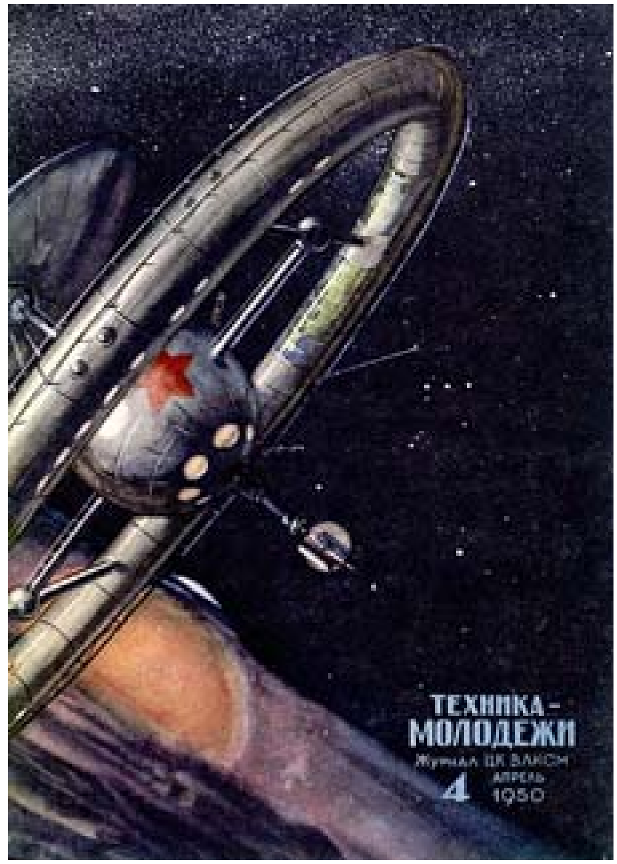

Fig.III. Russian orbiting space station project in 1950

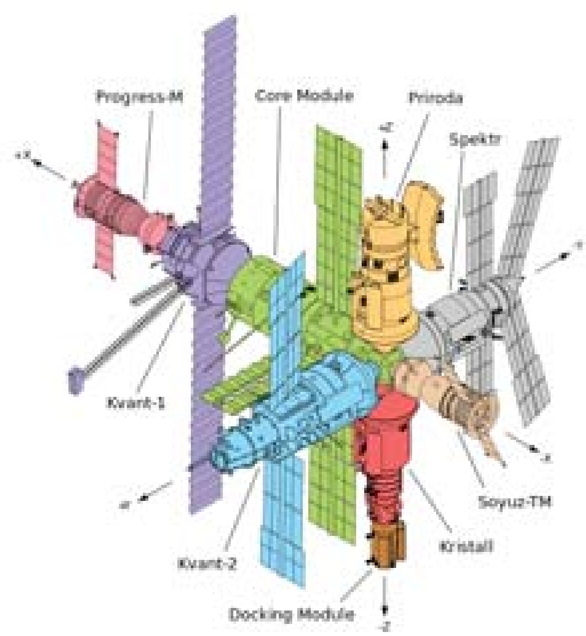

Fig.IV. MIR space station I 1986-2001

"Science Wonder Stories", and was already announcing the same possibility that A. C. Clarke was to communicate 15 years later (K. Tsiolkovsky -1857, 1935- in Russia, and Goddard -1882, 1945- in USA, are the pioneers in aerospace theory and calculations).

What happened with Clarke's theory also happened to Laika the dog and her Sputnik-2 in 1957. In 1950 the USSR had already proposed a project for an orbital station that appeared on the cover of "Texhnka Molodezhi" (fig. III).

At that time science fiction comics were beginning to appear, and these toroidal models were the first to be considered to be the most likely to reproduce certain gravitational conditions around their axis of rotation. When Kubrick filmed 2oo1 Space Odyssey in 1968, this was the influence he had received in his youth. But until then, all these sizes and uses were only designed as geostationary satellites equipped for scientific work or transhipment. It was the Irish physicist J. D. Bernal who in 1929 suggested a spherical colony 16 km in diameter for 20,000 or 30.000 inhabitants.

Later, the cold war and the results of the apollo project inspired g. k. o'neill (1927-92), together with his students at princeton university, to develop different kinds of space colonies as course work, and in 1976 "the high frontier" was published with the results found. first, the 3 kinds of geometry possible for this type of colony were identified: spherical (or bernal), cylindrical (or k. o'neill), toroidal (or stanford). the physical calculations required to make them possible were performed, based on population, orbital distance, weight, assembly, …(o'neill was then a first year professor of physics, and in 1965 after several years of research he discovered and tested the first high energy ring accelerator) (2).

The three types were illustrated and developed with the help of artists such as D. Davis, but O'Neill focused on the cylindrical type which he called "ISLAND 1", and which increased in size depending on the number of inhabitants: (Island 1 = 1km long x 200 m diam. for 10,000 inhabitants); (Island 2 = 3.2 km long x 640 m diam. for 100,000 inhabitants) fig.V; (Island 3 = 10 km long x 2 km diam. for 1,000,000 inhabitants); (Island 4 = 32 long x 6.4 km diam. for 20 million inhabitants). Island 4 was the limit using the same technology (the majority of the material comes from the Moon and the asteroid belt). The curved surface of the cylinder was divided into 6 strips parallel to the generatrix, and these sectors were alternately either 3 valleys, or 3 large transparent domes through which directed and controlled sunlight was allowed to enter. A large ring was assembled concentric to one of the bases of the cylinder where all the farming and agricultural activity for the survival of the colony was located. Water courses and cloud formations inside the valleys reproduce the Earth's atmosphere.

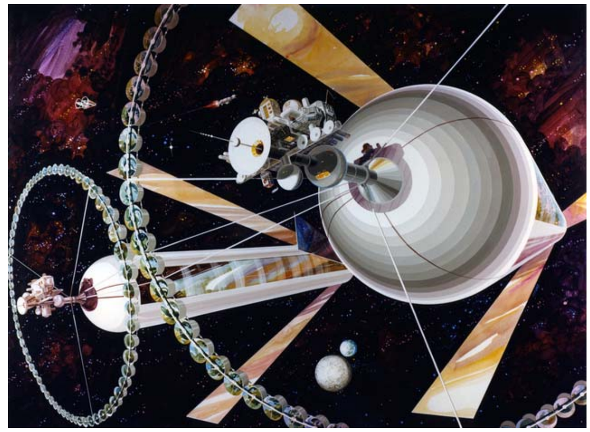
Fig.V. O'Neill's Island 2, 1974

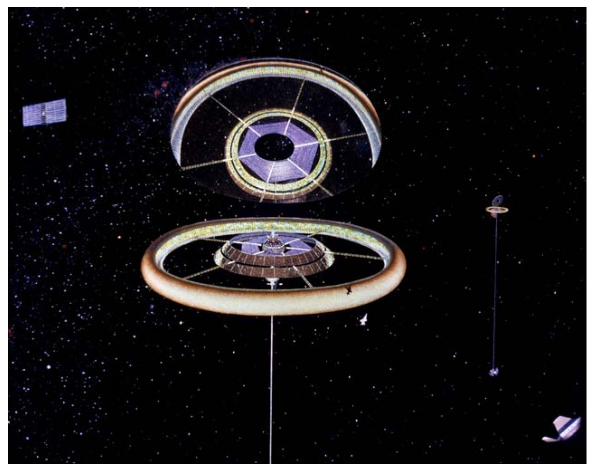
Fig.VI. Stanford torus, 1975

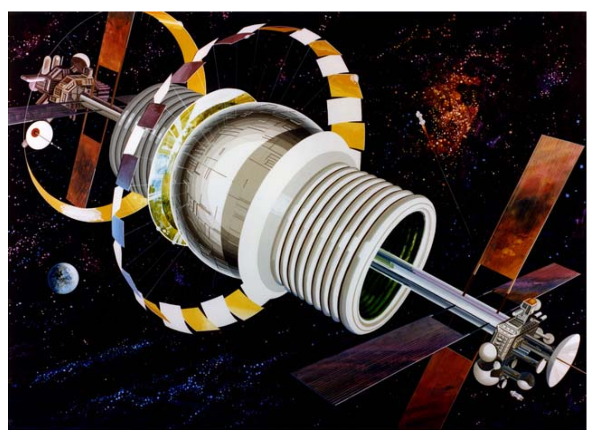
Fig.VII. Bernal sphere, 1977

The Stanford torus was designed in 1975 in the NASA Summer Study at Stanford, led by A. Russell together with a few more students. Its diameter was 1,795 m, it turned 1 rpm on its main axis, and the 130 - m diameter tube accommodated a population of 10,000 inhabitants. (fig. VI),

The Bernal sphere was designed in 1977 (also under NASA's supervision) inspired by the original 1929 proposal, but with the further addition of all kinds of accessories to make it viable: toroidal rings for the farms, solar collection instruments at the ends of the rotation axis (fig.VII).

After all this euphoria, inspired above all by the possibility of creating orbital solar stations to combat the first energy crisis, the serious Challenger accident in 1986 slowed down all manned flights considerably; but, in spite of this, in 1993 another orbital station was proposed, a hybrid of the previous ones with the same name as the crew member who disappeared in the accident: Kalpana. It was a short cylinder for only 3,000 inhabitants, with a diameter of 500 m, to avoid problems generated by the Coriolis effect when rotating, but the interior layout was like the Stanford torus.

Moving on, and to compensate for all these designs with something practical, we must not forget 2 projects developed in the last 2 decades that simulate conditions of isolation and partial sizes similar to those described above, and whose conditions, linked to ecosystems and related to the sizes of the parts, are similar to those we have been looking at.

In 1990 the Biosphere 2 project in the Arizona desert was completed. The proposal originated from the U.K. "Institute of Ecotechnics" and reproduced up to 7 terrestrial ecosystems producing fresh and salt water and more than 3,800 species of plants and animals, all contained in complete isolation from the outside world for 2 years. Eight scientists lived in isolation from the outside with only electronic communication. The enclosed volume was 2,300,000 m3 (which is the minimum volume to ensure human survival). Pearce Space Frames built it (fig 5.1) (VIII). In addition, the design included: an observatory, a library, gym, office, communications room, games room, and 8 apartments (the project could not be concluded because one of the scientists had to leave the confined space due to an incurable and contagious illness).

In 2001, T. Smith inaugurated the Eden Project - two large greenhouses in St. Blazey (Cornwall-UK) designed by N. Grimshaw. Both are installed under a series of multiple domes supported on each other and covering 50 ha. creating an interior height of up to 52 m (fig IX). One is the largest tropical greenhouse in the world (reproducing a humid tropical climate), and the other is a Mediterranean ecosystem (reproducing a hot and dry climate). It was built to reuse an old quarry and promote sustainability by recycling water and organic

Fig.VIII Biosphere 2. Arizona, 1990

Fig.IX Eden Project, Cornwall 2001

Fig.X Halley VI Research Station. 2012

material. The roof uses R.B. Fuller's geodetic approach (4), but combines several domes at the same time (something that Fuller never formulated) = more surface area covered: more domes, instead of building one larger dome. The intersections of the domes and their structure thus generate critically precise and stable metal arches and joints. In addition, the design uses faceted surfaces with large hexagonal shaped pneumatic scales that make the structure lighter, provide insulation and let solar radiation in.

The Lunox lunar base was to be a hybrid between these terrestrial spaces and space colonies, designed in 1993 by NASA in cooperation with the Russian Space Agency. In the drawings of the settlement there are hangars for vehicle and goods storage, storage tanks, storage batteries, dish telescopes, but all tabulated and weighed to ensure all the merchandise is properly packaged and ready for the 6 journeys required to make the base fully functional in 2005 by working in phases. One of the important developments of the mission is the removal of O2 from lunar soil to combine it with H brought from Earth, making the return fuel load much lighter. This material was also used to operate a small nuclear reactor to power the base. Another important development was the use of 2 robotic vehicles capable of storing and transporting the material extracted and which also served as pressurized living units for 4 people after they were joined to another support-unit brought in the 5th flight, which generated supplementary power, H2O, common spaces and spaces for physiological needs. These rovers can explore within a radius of hundreds of kilometres for up to 14 days.

The Halley VI Research Station (fig.X) should also be mentioned among these achievements since it works along the same lines. In an extreme climate, and under difficult assembly conditions, the British Antarctic Survey transported the 6 units required to complete the mission by sea and the station was operating in 2012 after 6 months. The largest 3D-unit hosts common spaces (dining room, games, sport, conversation, observatory), and two other smaller ones have cabins for 16 winter maintenance technicians. The rest (up to 4 more) are used for laboratories and observation machinery. Like the Lunox rovers, these wagons can also move on mechanical legs, which, this time, are like skis. And, in both cases, as in the case of MIR as well, the habitat is made up of different 3D units that finally complete a system that is easy to expand and where components can easily be replaced.

Returning to space, now on a smaller scale with regard to the beginning of the article, the first orbital station, launched by the USSR, MIR, weighed 100 tonnes. It accommodated a crew of 3 astronauts (sometimes up to 6) plus all the control, experimentation, and observation instruments (fig.IV). The station was assembled in several phases from 1986 until it was completed in 1996 and destroyed in 2001. It comprised six 3D-units which accommodated two docking ports at the ends of an axis plus another for the shuttle in one of the four side arms. The main axis comprised: Kvant 1 + the base unit + 1 core with 6 ports that join the side arms to each other and to the main axis.

The core module contained 3 compartments: Work (cockpit and control) / living space (kitchen, bathroom, gymnastics, and sleeping bags, seating, TV and bookshelves) / propulsion (control, fuel tanks, antennas, sensors); in 1987 Kvant-1 was added aft (for astrophysical and biotechnological research with gyroscopes and radio telescopes), and subsequently the 4 remaining 3D-units were attached to the docking module; in 1989 Kvant-2 with 3 compartments (biological research, Earth observation / outlet sluice, toilet and shower with water recycling / control and energy distribution) 14 m long x 4 m ext diameter; in 1990, Kristal (for biological production technologies and space environment materials); in 1995 Spektr (living and working quarters for the 3 USA astronauts complemented with the Kvant-2); and in 1996 Priroda (nature) carried the Earth remote sensor as well as adding docking unit 3 for the Kristal shuttle.

The last three examples, for stations on the moon, water and in space, show how the base station always comprised a concatenation of 3D-units ranging between 15 and 30 m long x 4 to 9 m wide. Units fully loaded with artefacts, with certain specialised uses, which can be transported with relative ease to the assembly point, and which are manufactured entirely elsewhere. Units that, initially, are assembled in a linear configuration, but that are also able to generate reticular structures in space based on their docking nodes.

Structures that, given their size and use, generate fully compressed spaces, completely separated from the outside, and without the ability to generate controlled gravity conditions (claustrophobic spaces, and habitable only for short periods of time). However, what will we find if we apply these same manufacturing and assembly concepts to larger units? (Also to be sent into orbit). What if we also changed the scale of the Stanford torus? Could a torus with a diameter larger than the Earth's be built and also sent into geostationary orbit? Could O'Neil's cylinders work as 3D-units? Let's see what J.M Prada Poole can teach us.

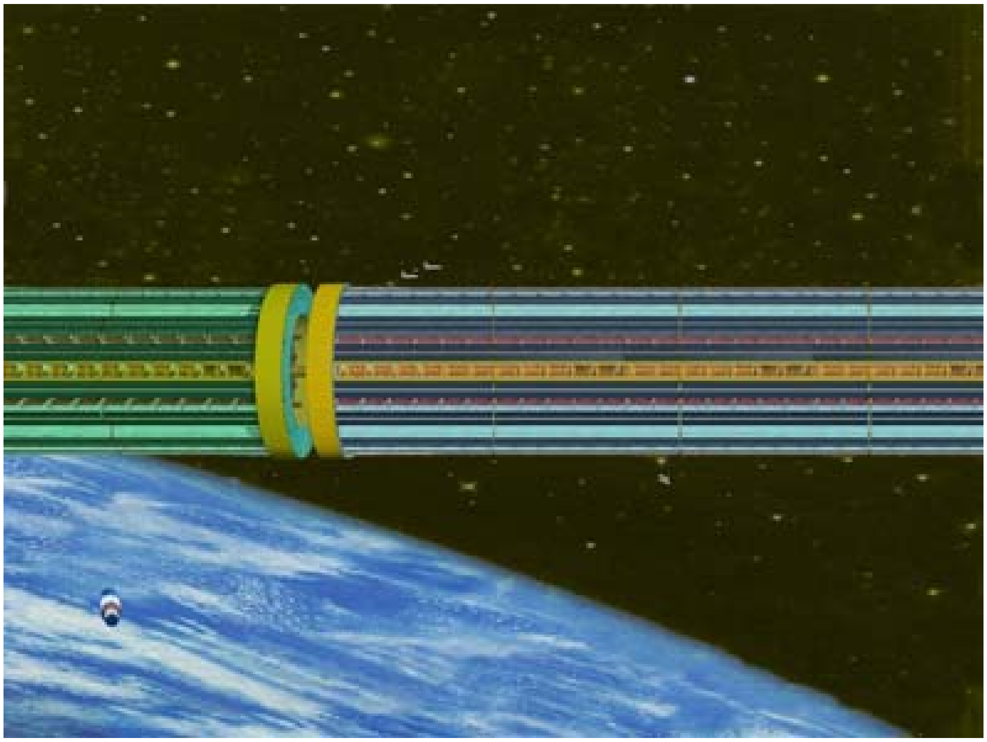

Fig.XI
two segments of
"The Rings of
the Earth"

Fig.XII. View from the RC gap toward the inside of the torus.

III. THE RINGS OF THE EARTH (new milky way)

JM Prada's orbital megalopolis envisions 5 concentric rings of circular cross-section in orbit at an average height of 35.750 km from the Earth's crust, separated from each other by 1,800 m (fig I). Each of these rings behaves like a 84.330 km diameter (average) torus that accommodates a population of 2.500 million people in its interior, providing for all their needs. The project aims to empty planet Earth of most of its human population, and thus allow the biosphere to continue its natural evolution without having to bear the harmful interference and the burden of humankind. Below is a description of the composition and size of one of these rings, with some examples of large-scale constructions with comparable methods of assembly and stages of manufacture.

The middle ring is 265.000 km long, and consists of 53,000 circular cross-section segments. Each of these segments is a 5 km long cylinder with a 510 m outer diameter, (in its second version) (5), which is a very similar size to O'Neill's *Island 2*. Each cylinder has a mixed design brief, and may vary depending on the percentage of its volume dedicated to social, tertiary, or residential uses (the latter being predominant), but its overall structure is always the same and by describing its general cross section (fig XIII) it is easy to understand both its structure and the way it works.

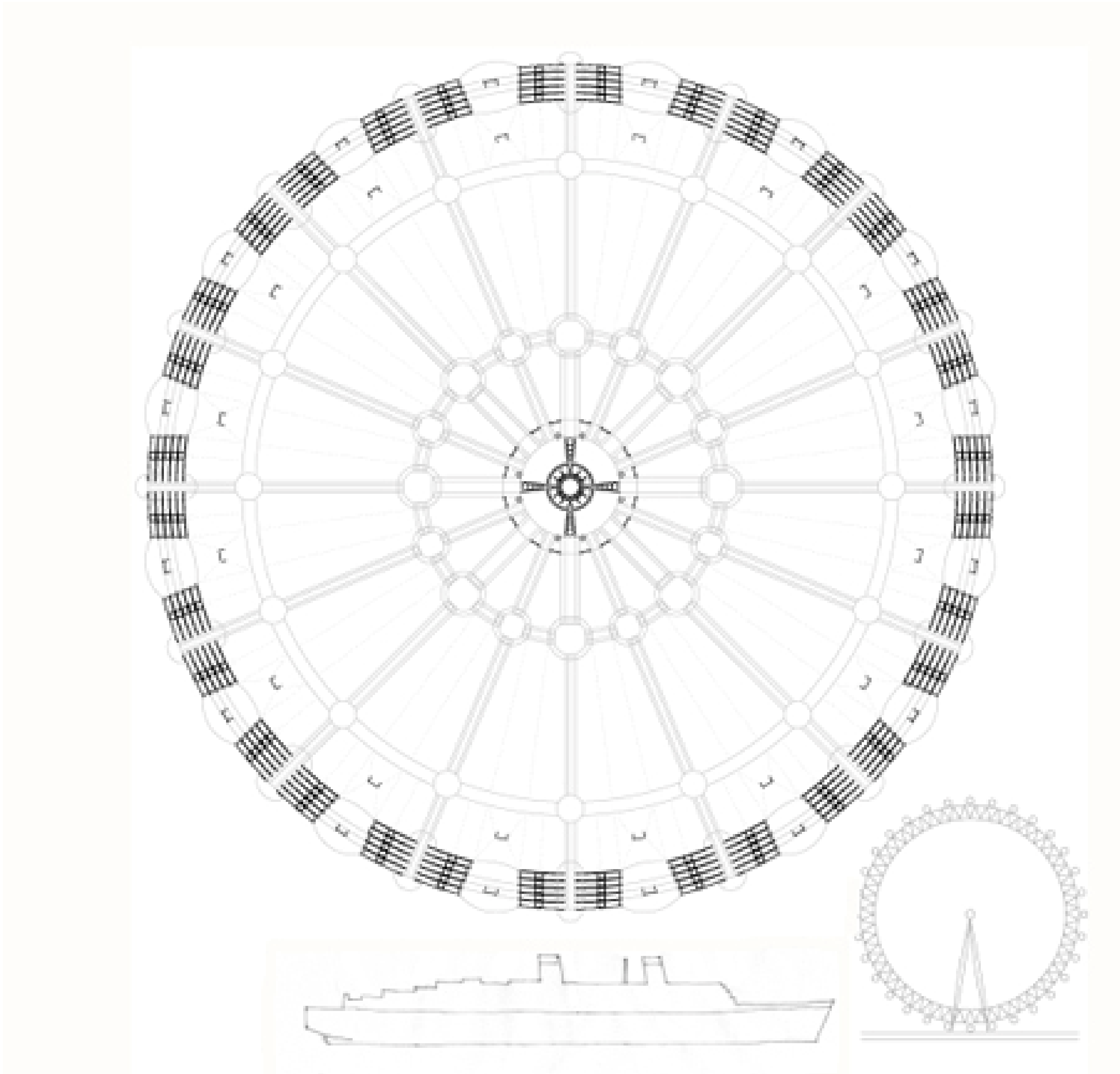

Fig.XIII.: General section of version 2 of a ring 510 m in diameter ; 314 m. length Queen Elisabeth.

The main axis of the cylinder
is used as the main communication corridor for local travel. Capsules for 2 or 4 people can dock anywhere on the network via a 30 m diameter tube and the "transfer system" then automatically takes them to the central hub, at 600 km/h if necessary. The rest of the cylindrical volume is separated into 5 concentric crowns. **The outer crown** (RC) is **20 m** thick, g = 9.8; and it accommodates the 5 floors of residential space (or other uses where applicable); the other 4 crowns are defined by a system of intermediate rings, 2 of which form part of the transportation network and are used for the transfer capsules to move from a point on the RC to any of its adjacent or radially opposite points, while the area in the centre houses pipelines and services.

16 spokes (fig XIII).
connect these 4 bodies to each other (main hub, intermediate communication rings, and residential crown RC), and ensure they form part of a total stable structure. In turn, the spokes divide the 360º cylinder into 16 equal parts (each 22.5 º). These 5 m diameter spokes act as transfer conduits and their structure relies on cables that spread like a fan between the different rings. Each one of these spokes connects to the outer RC crown where access galleries lead to the residential floors. The spokes act as elevators between these different levels and lead up to the cylinder axis where they reach maximum speed. Where these spokes intersect with the intermediary communication ring there are other conduits parallel to the cylinder axis, which drive the transfer capsules at intermediate speeds.

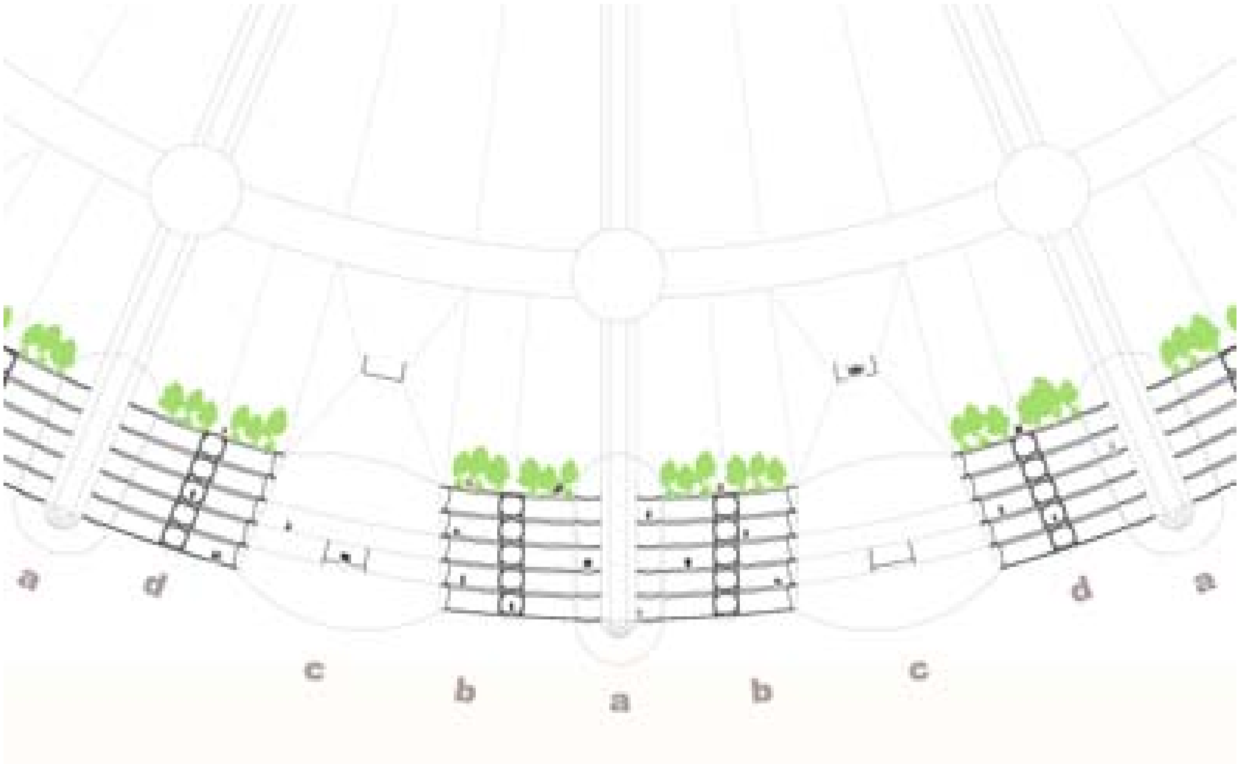

Fig.XIV Partial section of a ring through the RC crown

The residential crown RC (fig.XIV)
comprises the following parts every 22.5 º: **a/** 8 access galleries from the transfer area; **b/** 2 symmetrically built bodies on each side of this gallery; **c/** a large intermediary gap between the 2 aforementioned wings corresponding to each spoke; **d/** a corridor for pedestrian access to the apartments of the RC located at the mid-point between the two wings [b] of the building). That is to say, in principle there are 2 kinds of dwelling on each side of the elevator: some that overlook the galleries [a], and others overlooking the gap [c]. Transparent domes (reinforced polycarbonate) cover all these intermediate spaces both on the outside and on the inside (facing inward and outward from the master cylinder). These 2 separate skins ensure the RC crown are airtight should an outside dome suffer damage. In addition, screens made of the same material protect the envelope of the rooms that overlook the gaps [c].

The inverted balconies in the gaps are the result of the staggered walls [c] which in turn create irregular intermediate spaces in the corridors [d]. Therefore as we look out onto the spatial gaps [c] and "look down" (depending on the corresponding g), the viewing angle is wide and either space or the Earth can be seen (fig 9) ; and if we look up, the viewing angle becomes narrower and some of the transfer conduits in the interior of the torus can be seen: this means that the surface of the inward facing RC envelope forms a deck over the building layers [b], used for plants (fig XVI). Walking along this deck, the whole inner enclosing surface of the RC is perceived as a continuous green tapestry with its streams and canals, only interrupted by gaps [c] and galleries [a], that let filtered sunlight in. Farms and crops will be located according to regulations in order to accommodate them without encroaching on the public enjoyment of this great common space.

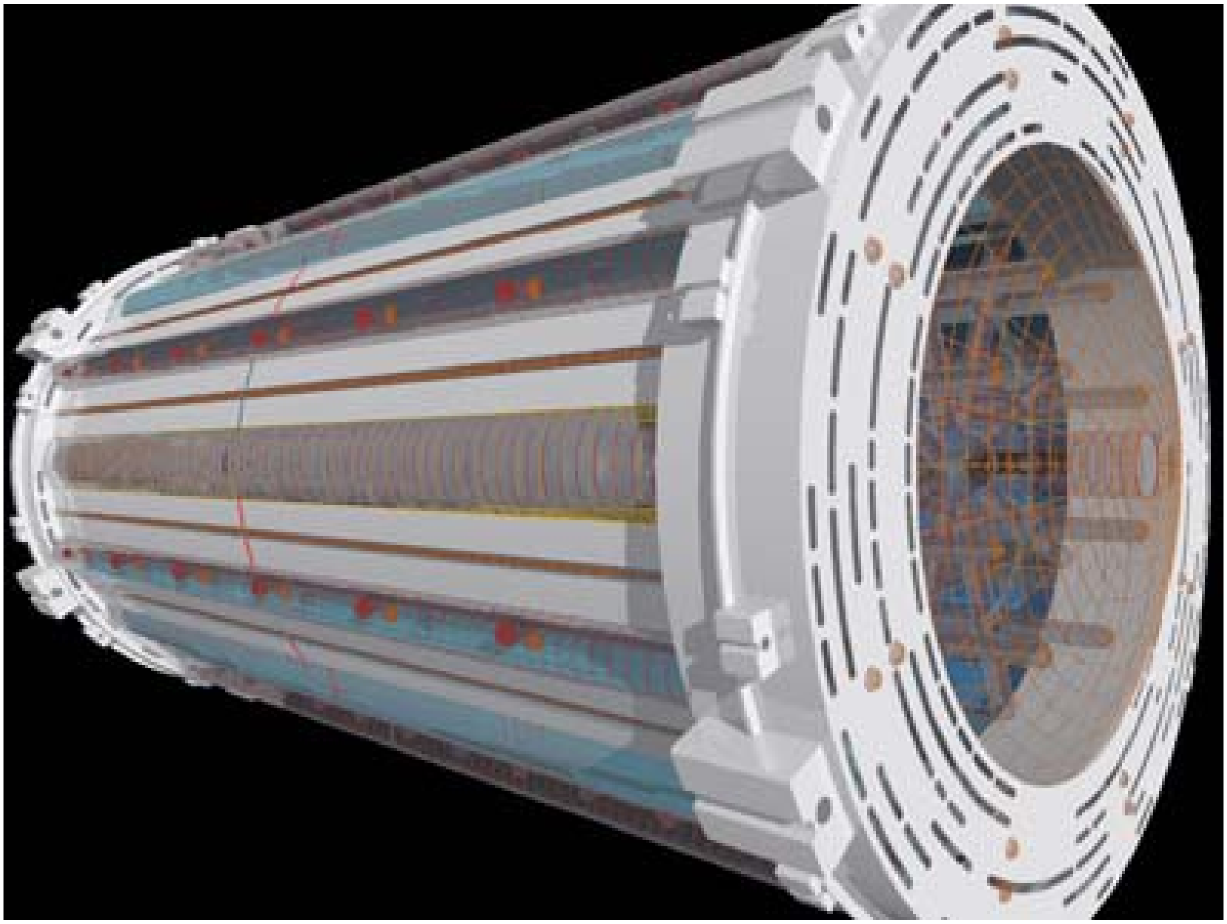

Fig.XV View of one of the bases at the end of segment

This general cross-section
is repeated 60 times throughout the main hub up to the bases of each cylinder segment of the ring. There is 120 m between each group of 16 spokes.

The bases of the cylinder
of each segment are capped by an opaque crown at each end that fits perfectly on the RC (fig XV). This opaque crown houses the power stations and air conditioning, the arrival and departure ports between the 8 main rings and the Earth, and the thrusters that make the cylinder rotate properly on its axis (which must be = 2 rpm to achieve 1g in the middle of the RC). The centre of the crown at The bases of each cylinder segment are covered by a transparent dome (cap) reinforced with titanium ribs.

The central transfer conduit TC
crosses through the middle, being the only tangible component that puts one cylindrical segment into contact with its neighbour. A large elastic joint is used to articulate the segments where they meet and absorb deviations and reciprocal movements. A system of springs holds them together in pairs.

Each of these cylindrical segments
can accommodate up to 150,000 people if its use is entirely residential, but since there is a hybrid of uses an average of 90,000 is estimated, reaching 2,500 million inhabitants per orbital ring. In other words, the equivalent of a city of 100,000 inhabitants as in the case of O'Neill's Island 2.

Fig.XVI View inside the ring from a spoke in the Middle Crown MC towards the RC vegetation

Each orbital ring

is constructed by placing the cylindrical segments described above in juxtaposition, making it possible to assemble them independently and then put them in their proper place later on. Given the high cost of transporting any heavy material from Earth another two sources of resources have been identified: lunar bases for mining and the asteroid belt itself (that orbit between Mars and Jupiter). The metal extracted is used to make resistant alloys (mainly of titanium + aluminium for the structures), and the ready-made components can be manufactured either on the moon, or in independent orbital bases assembled for this purpose and also brought from the moon. Sandwich panels manufactured from synthetic polymers (inorganic) can be used for the remaining envelopes and interior divisions. With these resources the weight/m2 of the RC crown should not exceed 50 kg/m2.

The solar energy-capturing stations

are also bases outside the rings and are plugged into the rings at the base of each segment (fig XX).

The shuttle ports

for arrivals and departures from Earth are also located at the ends of each segment. These same ports serve to communicate the 8 main rings, or travel long distances within the same ring (beyond 45º within the torus), using the same vehicles.

Fig.XVII Beijing Capital International Airport (Foster Associates 2004-08)

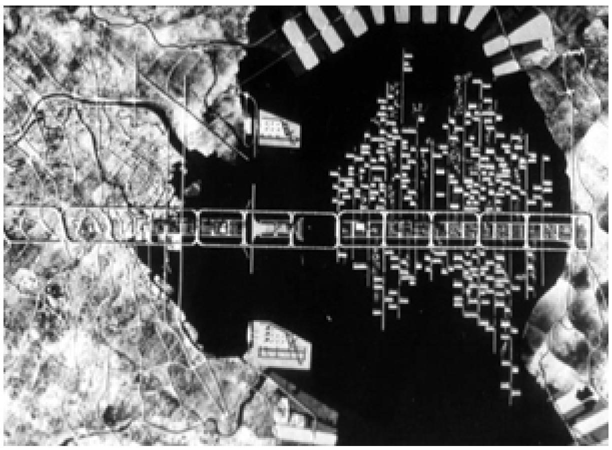

Fig.XVIII Project for Tokyo Bay. K. Tange 1961

IV. PHASES of CONSTRUCCTION and TIMING

The construction phases of this “linear city” with a total of 1,324 millions km (in addition to the length of the 5 rings) require a long period of time to be completed, anything up to 1 or 2 centuries. The collaboration of the most advanced nations on the planet would be essential, but the planet might be practically depopulated after this period of time.

Initially, the standardized, industrial production of each segment will be slower during the early years of construction, but once the processes and their routines are mastered (mostly automatic and robotised) the time it takes for each one to be up and running will increase exponentially. Below are some examples of large, inhabitable human constructions, which can serve as a benchmark for the duration and organization of these processes:

- Queen Elizabeth (1936-38) 314 m in length x 30 beam and 2,283 passengers.
- Torre Repsol (Madrid 2004-08) 250 m long x 42 m beam and 6.000 jobs
- T4 Barajas (Madrid 2002-06) 1.2 km-long x 130 m beam (S=1.15 million m2)
- Beijing Capital International Airport (2004-08) 3.5 km long x 120 m beam. (S= 1.3 million m2) (fig XVII)

We cannot omit the "*Russian linear city* " projects proposed by Leonidov or Miljiutin between 1922-27 which are a clear conceptual background to what P. Poole proposes almost 100 years later, without forgetting K. Tange's Tokyo Bay project (1961) 18 km long x 300 beam (its central axis) that is divided into 10 sectors housing the tertiary uses of the entire project (fig. XVIII).

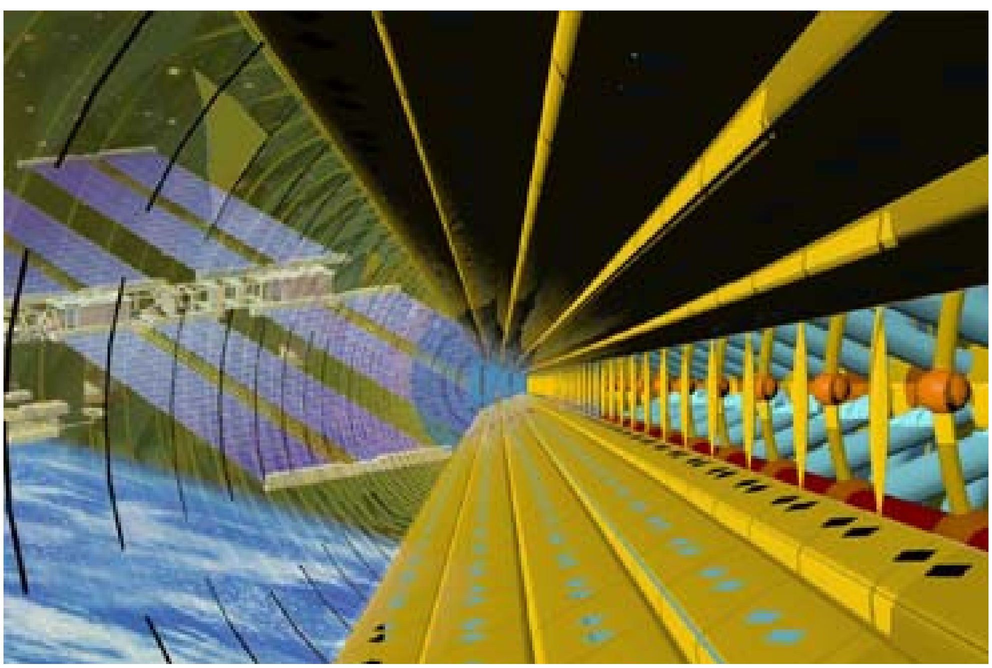

Fig.XIX
View from the RC gap toward the outside of the torus

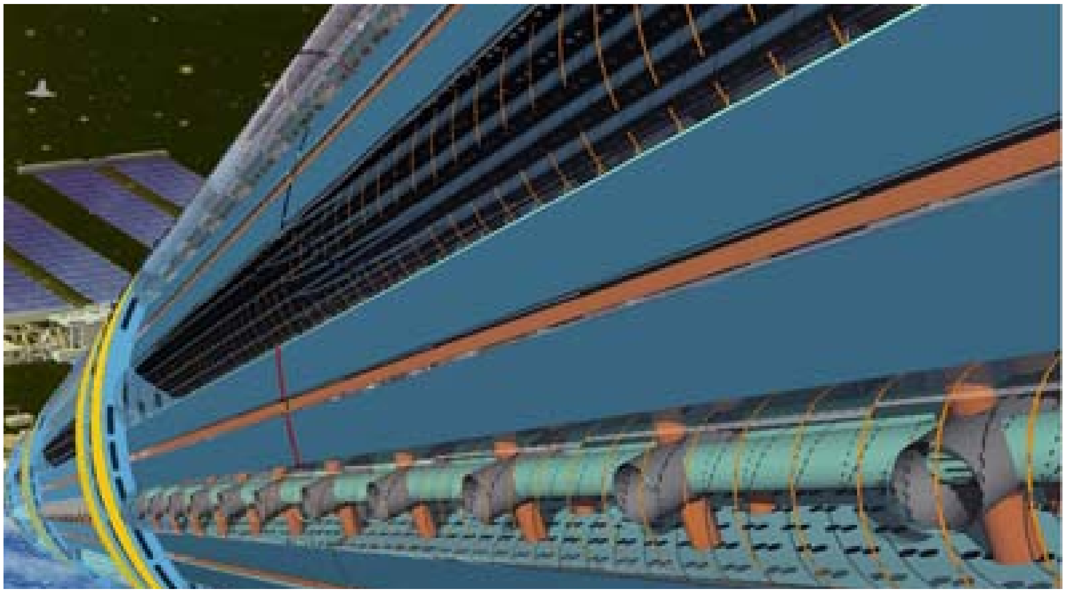

Fig.XX
View of the collectors from outside of an orbital ring

V. CONCLUSION

Surveillance teams ensure that the Earth remains as virgin as possible. This army will accept volunteers who will not be able to belong to it for a period longer than whatever is stipulated by "United Nations". The people who live in *"the rings of the Earth"* can visit Earth during holiday periods also regulated by the UN, and their itineraries will always be protected by conduits that isolate human action from the Earth's biosphere.

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TRANSLATION by Lesley Ann Shuckburgh

NOTES:

(1) JM Prada Poole is Professor Emeritus at ETSAM (U P Madrid). His designs pursue maximum efficiency and sustainability (very similar to RB Fuller's ideas), and he has won numerous awards and international honours: *National Prize for Architecture in 1972 / Resident Professor at MIT (1978-82) / construction of the Palenque for the EXPO in Sevilla'92 / several international awards for architecture /guest professor throughout Latin America for countless classes, workshops, and exhibitions of great scope*. His concern for the urban phenomenon and the planetary balance is a constant in his work. Among his most outstanding projects are: "The house of paradise": 1st prize COAM 1991 / "Atlantida": 2nd prize AIA (USA-1987) / "forest city": published in "4 games for 4 fates" (2010) / "Parkbite": restricted invitations to tender in P. de Mallorca together with R. Rogers+partners, (1995) / … .They are all living proposals based on important infrastructure which leverage their position in nature without overexploiting the land.

(2) in 1975 the L-5 society was founded (to spread the idea of space colonies), and in 1977 O'Neill founded the Space Studies Institute, at the same time that he published the book mentioned.

(3) see Espiritu Nuevo-o2 review, 1995)

(4) R. B. Fuller (1895-1983) American thinker and philosopher who discovered the geodesic dome and applied it to countless buildings and engineering structures in architecture, having a great influence on important architects from the mid-20th century until the present day.

(5) the views shown in figs. XII,XV,XIX belong to the 1st version with segments of 260 m in diameter.