THE COMPLETE COSMOS

Chapter 15: Where Next?

A spaceport in Earth-orbit, the colonization of the Moon and Mars, the taming of Mars - plus an elevator into space!

Outline

A futuristic shuttle soars into orbit and docks with a spaceport. Is this the weekend-break of the future? Would such a station be the staging post for onward journeys to the Moon and beyond? A glimpse of cities-of-the-future on the Moon and Mars. That's the dream. The reality is the International Space Station (ISS) currently under construction in Earth-orbit. ISS is scheduled for completion in 2004. As assembly gains momentum, so do test flights of X-33, the half-size prototype of Venturestar, the next generation of Space Shuttle.

Preview of a self-sustaining human colony on Mars - laboratories, factories, offices and homes connected by airtight corridors. The possibility of terraforming Mars - giving it breathable air. But the job would take 100,000 years.

To travel beyond the Solar System, we would need new sorts of craft with ion or nuclear propulsion systems. But even at one-tenth the speed of light, a journey to the nearest star would take over 40 years.

Some futurists believe we could colonize Venus. Currently, it's a hellish hot-house. Could it be tamed by seeding the Venusian clouds with green algae? Hundreds of thousands of years later, could Venus look like Earth - with oceans, a cooler climate, even life? For space guru Arthur C. Clarke, "Where Next" is closer to home. He visualizes Earth girdled by a gigantic space wheel supported by four huge towers rising from the equator. Within, people would ride into geostationary orbit - and back again.

Sub-chapters

Airport to Spaceport

- A shuttle craft-of-the-future ferries weekenders to a "leisure wheel" in Earth orbit.
- Airport to spaceport in one smooth hop. Such a spaceport would be a staging post for onward journeys to the Moon.
- A transporter pod touches down at a Moon-base. Beyond is a lunar city.
- Next stop, a self-contained Martian city - modeled on the lunar cities and serviced from the Moon.

International Space Station

- From science fiction to science fact. The International Space Station (ISS) under construction in Earth orbit. Scheduled for completion in 2004, it takes over where Mir leaves off.
- Robots will carry out checks and assist the multi-national crews. The main objective: testing of the long-term effects of living in space.

A New Shuttle

- Initially ISS crews will travel aloft on the old Space Shuttle - but a new generation of shuttle craft is planned.
- Test flights of a half-size prototype, the X-33 - forerunner of Venturestar, an entirely reusable shuttle that will lift cargo into orbit at one tenth of today's costs.

Cities on Mars

- The late 21st century. Thanks to spaceports like ISS, Mars has been colonized. A solar-powered, self-sustaining city of laboratories, factories, offices and homes - interconnected by airtight corridors.
- The possibility of turning Mars into a planet like Earth - but it would take 100,000 years to "terraform" the Red Planet.

Journeys to the Stars

- Problems of traveling to the outermost planets and beyond. We are held back by our propulsion systems and limited fuel capacity.
- Solar power and solar sailing are not the solutions.
- Ion or nuclear propulsion might provide the thrust to travel to the stars. But even at one-tenth the speed of light, journeys to the nearest stars would take decades.
- For the time being such voyages are science-fiction.

Planetary Engineering

- Possibilities of colonizing Venus, perhaps our next target after the Moon and Mars. Seeding the planet's poisonous clouds with green algae might eventually produce an Earth-like world with a breathable atmosphere, oceans, and a cooler climate - a place where life could take hold.
- But is such planetary engineering desirable?
- Another vision of the future - the notion of space guru Arthur C. Clarke. Four towers - each housing a space elevator - stretching upwards from the equator to an encircling "halo" in geostationary orbit 36,000 kilometers above the Earth - the spokes of a gigantic space wheel with our planet as the hub.

Background

The International Space Station (ISS)

Construction of the ISS began on November 20, 1998, with the launch of Russia's 24-tonne Zarya "Sunrise" module on a Russian Proton rocket. The module comprises ISS's "Functional Cargo Block".

A few days later, America's Space Shuttle "Endeavour" deployed ISS's "Unity Node" and two "Pressurized Mating Adaptors" (PMAs). PMA-1 connects the Unity Node and Functional Cargo Block, while PMA-2 provides a dock for Shuttle.

It will take 44 launches and numerous supply missions to complete the $100 billion space station. When finished, hopefully in 2004, ISS will have an end-to-end wingspan of 108 meters. The station will be 88 meters long and 44 meters tall.

ISS will weigh 400 tons and be assembled in orbit from almost 100 separate components.

The work will involve more than 1,700 hours of spacewalks - twice as many as the hours jointly accumulated by Russian and US astronauts in the first 37 years of manned space flight. The total structure will cover 4000 square meters, the size of two football pitches.

The station will accommodate six to seven astronauts and scientists. Both living and working space will be pressurized and have roughly the same cabin volume as two Boeing 747 jumbo jets, approximately 1,300 cubic meters. ISS will orbit at an average altitude of 350 kilometers above the Earth, at an inclination of 51.6 degrees to the equator. If all goes well, ISS should be manned from 2001, when a multi-national crew of three will begin its stay aboard the station. The trio will use robotic arms to maneuver components into place. The astronauts will make spacewalks to connect the complex power, computing and utility connections.

Thirteen nations are contributing practical resources to ISS, along with scientific and technical expertise. Astronauts and scientists will be chosen from those nations. The first laboratory module is to be called "Destiny". It will be central to investigations in life sciences, earth sciences, space science, microgravity and engineering, as well to the research and development of space products.

Venturestar - the Future Shuttle

Venturestar is being developed to replace the US Space Shuttle. It is hoped that Venturestar will deliver a wide range of payloads more reliably and less expensively than today's launch vehicles. As well as a full ISS replacement crew, this "future-shuttle" should to ferry up to 20 tons of cargo to Earth orbit.

The new craft is a fully reusable single-stage-to-orbit vehicle. That means Venturestar will not have to jettison fuel tanks or rocket boosters along its flight path as Shuttle does today. Venturestar will operate more like an airplane, undergoing inspection, refueling and reloading between flights. By reusing the entire vehicle, the operating expenses should be just one-tenth of today's costs.

Before Venturestar goes into production, a demonstrator vehicle is to prove the concept. Known simply as X-33, the model will be one-half the size, one-ninth the weight and a one-quarter the cost of the full-size Venturestar. The X-33 will not reach orbit or carry payloads. It will merely fly sub-orbital trajectories specifically designed to test the thermal protection system, aerodynamics and flight capability of Venturestar. Propulsion is one of the main differences between the Space Shuttle and Venturestar. The linear aerospike engine was initially designed and tested in the 1970s for use on Shuttle. As it transpired, engineers opted for another design - the "Space Shuttle Main Engine". But NASA returned to the aerospike engine in 1995 when the concept for the X-33 was proposed.

Venturestar's aerospike engine will be lighter then today's conventional rocket engines. The aerospike automatically adjusts to changing atmospheric conditions, enhancing its efficiency as the vehicle climbs into orbit. In addition, with multiple combustion chambers on each engine, the aerospike should be more "fail-safe" than conventional rocket engines with their single combustion chambers.

Colonizing the Moon and Mars

Will humans be living on the Moon or even Mars in the 21st century? It is now a real possibility. Teams of scientists are working hard to realize the dream. Their first step is to establish large, permanently occupied space stations in Earth orbit. And who knows? We could have space cities, as first suggested by the Russian rocket pioneer Konstantin Tsiolkovskii. An orbiting metropolis

might be home to more than 1,000 people. They would produce electricity from solar power. Waste products and water would be recycled to reduce supply needs. Ferries would bring regular cargoes of raw materials and shuttle passengers to and from Earth.

Moon colonies would be the next step. The lunar surface is firm enough to support buildings. Disadvantages are a lack of atmosphere, bitterly cold nights and scorching days. Initially, a lot of supplies would have to come from Earth - which is very expensive. Minerals, however, could be mined on the Moon. They would be vital in constructing lunar bases, as well as supplying factories in Earth orbit and for use on Earth itself. Additionally, if lunar water is confirmed on the Moon, bound up in rocks at the north and south poles, then this would be an invaluable resource for future lunar exploitation.

Work on a lunar base could start in 2005 or even earlier. This "frontier town" would probably have a number of inflatable domes. Some would be used as living quarters, others as workshops. Inside too, plants would be cultivated for food and amenity. By 2025, there could well be lunar colonies of several hundred people.

After the Moon, Mars will almost certainly be the next world colonized in the 21st century. The Moon will act as a supply base, a staging post, for the Red Planet. And just like the Moon, agriculture would be developed under pressurized Martian domes. By the end of the century, Mars could have a population of several thousand - humans as the first real Martians!

The colonists would soon adapt to the planet's weaker gravity. But a trip home would be quite uncomfortable - with Earth's gravity so much stronger. Inside the Martian domes life would have its restrictions. Outside would be worse. Colonists would have to wear spacesuits. One day, perhaps, Mars would be "terraformed" - providing an atmosphere like that on Earth. Only then would humans be able to walk unprotected on the surface of Mars.

Links for Further Information

Background and current status on the International Space Station.
http://station.nasa.gov/reference/status/index.html

Special reports from NASA and background information on Mir - plus a weekly status report link.
http://shuttle-mir.nasa.gov/shuttle-mir/specrpts/

A site about the project and construction of the International Space Station
http://space.miningco.com/msub20.htm

A page about VentureStar with graphical images of the spacecraft.
http://www.venturestar.com/index.html

Questions and Activities for the Curious

1. As the cost of launching payloads is reduced, so outer space will be liable to exploitation. What problems may ensue?

2. Imagine a colony on the Moon. What sort of work would go on there?

3. Describe the various stages in the construction of the International Space Station.

4. Think of an appropriate name for the International Space Station. Give reasons for your choice.

5. Imagine you are a travel agent specializing in space destinations. Devise an advertisement to promote a holiday on Mars.

6. There are plans to terraform Mars - to turn it into another Earth. It would take 100,000 years. Is such planetary engineering desirable? Would it be worth the effort?

7. Since colonies on the Moon and Mars are likely to be international, how would they be governed and by whom?

8. Traveling at one tenth the speed of light, a return trip to the nearest star system beyond the Sun would take 85 years. How might humans make such a journey?