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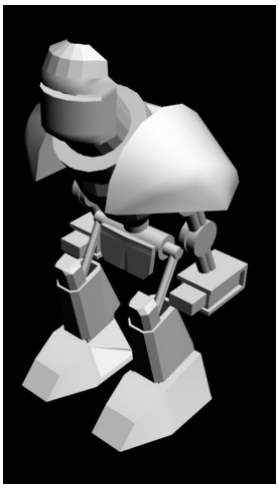
5. EPISODE FIVE – AUTOMATION AND DEFENSE

"Nobody believed I had a running computer and nobody would touch it. They told me computers could only do arithmetic."

Grace Hopper

5.1. FIRST DEGREE THREATS



Most threats will be stopped and solved by the use of robots. Defense robots are built on the same model basis, then alternated, depending on the need, specialized for functions such as fire extinguishing, saving and rescuing, repairs (androids), ruptures, asteroids (helped by the mining robots), depressurization, emergency escapes add and support (android).

Solaris is very safe only by it's design, and in case of a rupture, a severe impact or collision, etc., modules and different tori in Solaris may be separated and united afterwards. This is so in order to ensure safety. In case one tori is down the best must be done in order to protect the other one.

5.1.1. FIRE AND SMOKE

Fire is the first number one degree to threaten Solaris, and will be taken care of as needed. In case of a fire, the fire alarms go out, alerting the Solariens. Fire extinguishing robots will arrive in elevators from the closest fire unit or from the deposit level, using elevators. In order to prevent the fire from spreading, any ignited area will be isolated from the others, the insulation also limiting the oxygen and dramatically lowering the fire's burning live. All these and many others must be taken into account.

Protection		Description
Active protection	Robots extinguishers	Robots endowed with extinguishers are activated in case of a fire
	Sprinklers	Sprinklers turn on based on hear sensors
	Detection	Detection is the most important part, heat, flame and smoke sensors activating all other protection systems
Passive protection	Fire resistant walls, glass, floors	Walls, glass and floors are made fire resistant in order to minimize loss

	Cable coatings	Cables are coated and heat resistant for both protection and safety, as most systems are electronic, and in order to minimize loss
	Smoke control and management	Smoke is diluted and redirected through ventilation. The area with smoke is airtight in order to prevent distribution.
	Enclosures	Fire affected areas are enclosed in order to prevent other zones form being affected and not to feed the fire oxygen
	Escape facilities	Escape facilities are situated every 300 m all around Solaris, and depending on the situation, Solariens are directed either to other zones in the settlement or to the emergency escape ships that take them back to Earth.
	Prevention	Prevention is the most important part, as it is better to prevent fire than put it down and than deal with damage. Inhabitants are educated into certain behavior when dealing with fire, and Solaris is insulated and protected from heat sources.

5.1.2. BREAKAGE OF WATER PIPES-FLOOD

Certain water leaks are to be prevented, as water in very precious in space and on Solaris. Still, if water leaks occur, they will drain in the small reservoirs everywhere under the soil and surface of the residential area on Solaris, used to pump in water for the parks, plants, trees.

Since there are no rivers on Solaris, and the only flowing water is the park “river”, 5 meters wider and 1 meter deep, the probability of a flood is null. Still, water loss must be prevented and absorbing the water in drains is the best solution.

5.1.3. ENERGY FAIL

In the event of an energy fail, the stored electricity in the high-voltage batteries will sustain the functioning of electric systems until the other energy sources are repaired. Still, if one energy source fails to work, another will support it. Solaris has three working power plants, and if one malfunctions, it will be removed and directed towards the Sun in order to prevent space-pollution with hazardous materials. At this moment, two power plants are left, and are available for energy generation.

Solar panels function independently, and if one area fails, the rest of the settlement will provide the necessary energy.

5.1.4. AIRLOCKS, DOCKS MALFUNCTIONS

Airlocks are an important component of Solaris as they prevent air loss and depressurization of cabin. Problems and reactions in case of depressurization are discussed further in this episode.

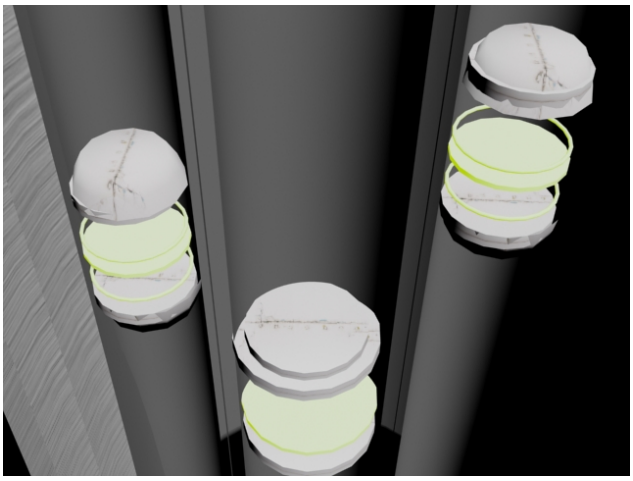
Defections at the docks imply that goods transport is stopped, and this may be a great danger to the settlement. Therefore, if the docking system fails, the certain unit is isolated in order to prevent depressurization and then repaired robotically. After testing, all the dock's previous functions are restored.

5.1.5. ELEVATOR "ISSUES"

Common elevator problems include malfunctioning, blocking, overloading.

In case of overloading, the elevator will signal the situation and until fixed, it will not proceed to the next instruction. Blocking is quite often, and will be fixed as it is on Earth.

Malfunctioning is diagnosed in tests, and repeated every three months. After diagnose, the malfunction is repaired as it would normally be.



5.1.6. HUMAN GENERATED THREATS

Although inhabitant selection is a very complex process and enables choosing the most adequate inhabitants for Solaris, human threat generation must be taken into account.

Penalties are applied to anyone forbidding the Solaris Book of Laws. Moreover, any danger generated by a human proving to threat Solaris' construction skeleton, its inhabitants or any part of Solaris become the subject of exile back to Earth and judged by Earth laws, punished being applied.

Still, it is least probable for Solaris to be threatened by humans, as any threat will attract it's consequences on Solariens lives.

Threat type	Degree	Punishment
Breaking of the law, minor	Third	Punishment according to Solaris' law, trial
Breaking of the law, major (ex. murder)	First	Expulsion, trial on Earth
Threat to Solaris' integrity	First	Expulsion, trial on Earth
Instigating to violence, manipulation, attempt at Solaris' integrity	First	Expulsion, trial on Earth

5.2. SECOND DEGREE THREATS

5.2.1. ANGULAR VELOCITY ISSUES

On Solaris, a constant angular velocity means life. There are three possible problems when regarding angular velocity: a<av, a>av, a=0.

The first one, if the present angular velocity is smaller than the one needed for g=9.80 N/kg, the thrusters will proceed into accelerating the torus to the desired speed.

The second case is more dramatic, as a gravitational acceleration greater than the one on Earth may result into muscular damage, bone system damage, brain damage. Therefore, the settlement must be immediately slowed down by rotating the thrusters into the opposite direction and firing them.

The last case is the least possible one and the most dramatic, probably resulting in case of a collision with an asteroid. In that case, inhabitants must secure themselves and the family until the gravitational acceleration is brought back to normal by the use of thrusters.

5.2.2. DESTRUCTION OF SOLAR PANELS

Since the solar panels on Solaris' tori function independently from one another, destruction of an area covered in solar panels will not stop the rest from working properly and giving away energy.

In the event of damage to the solar panels, a team of robots interferes and replaces/repairs the damaged units. The repair robots for all emergency cases are fully described in the automation sequence.

Solar panels are normally made of heat-resistant and impact-resistant glass, and can withstand strong winds and horrible atmospheric conditions. Still, that occurs on Earth. Solar panels designed for Solaris have to be many times stronger, with a higher life-span and endurance.

Most problems with solar panels are diode failures and burnt terminals, but these will be solved accordingly.

5.2.3. RUPTURES

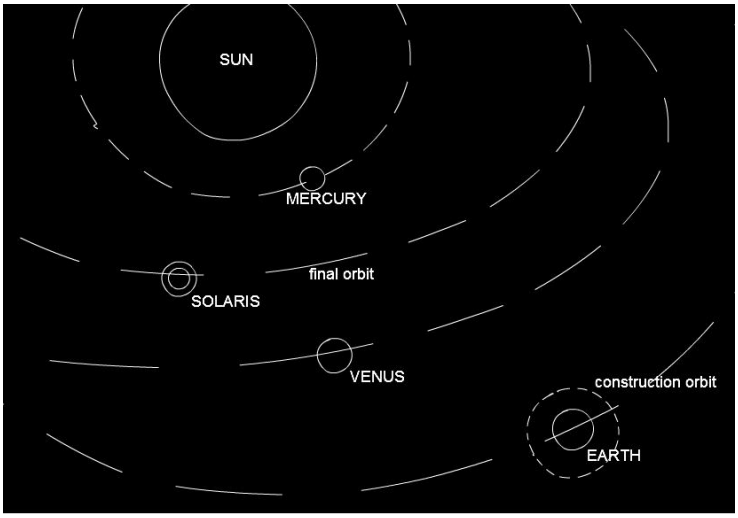
Ruptures are one of the most dramatic events to ever happen on a space settlement. In the event of a rupture, depressurization takes place, which implies the absorption of all oxygen and immediate death for anyone around.

In case of a rupture, the area is insulated to prevent spreading and the rupture is sealed by the use of panels, which will rapidly close up over that area.

The “safe level” is a 2 m thick safety level in the complex material setup of Solaris. It is presented in the material chapter, in the Technical Engineering episode.

5.2.4. FALL FROM ORBIT

In case of a fall from the current orbit, the Solaris translation thrusters situated on both ends of the settlement and rotation thrusters will be activated. According to the coordinates given by the Solaris Orbit Control Computer, the orbit will be adjusted.



Fall from orbits, or slight changes occur, therefore dramatic orbit problems are less likely to happen. The SOCC functions on parameters such as speed, angular velocity and coordinates.

5.3. THIRD DEGREE THREATS

5.3.1. DEPRESSURIZATION

Depressurization implies hypoxia, which leads to loss of conscience and ultimately death, altitude sickness, hyperventilation, etc. and it refers to an unplanned drop in the pressure of the module.

Decompression may be classified as in the table below.

Decompression type	Description
Explosive	Extremely dangerous and violent, lungs stop ventilating.
Rapid	Lungs still ventilate, not as fast and explosive as the first type.
Slow or gradual	Occurs slowly, still dangerous, might not be detected in time and hypoxia might settle in.

A very important part in preventing and repairing breaches which lead to decompression is detecting them. Permanent detectors are installed, working constantly on parameters such as oxygenation and pressure in order to find any breach or suspect decrease in pressure level and prevent a rapid or a gradual decompression.

Explosive decompressions are to be avoided, as they are very hard to stop. In case of occurrence, the module is immediately insulated and set apart from the other. The module insulating the breach will be as small as possible in order to minimize human and material loss.

Problems for humans beyond Earth's atmosphere	Description	Conclusions
Embolism	Formation of bubbles in body fluids; severe. Increase of body volume within 10 seconds, circulation stops within 30 seconds.	There are 90 seconds available for the body to be recompressed. If not, death is unavoidable.
Hypoxia	Deoxygenating of blood.	
Hypocapnia	Reduction of carbon dioxide in blood.	
Decompression sickness	Not severe if the human is protected by space costumes.	Not severe.
Temperature variation	Water evaporates, body cools dramatically.	Recompression, body must be brought back to normal oxygen , temperature and pressure conditions.
Cellular mutation	Cells mutate due to high-energy photons and other particles. Long term effect.	Radiation protection treatment.

In the event of depressurization of a module, it will be isolated from the others. There was a decompression incident in which a flight attendant was sucked out of the airplane. In space, the event will prove to be much more dramatic in terms of overall damages.

The rupture causing the decompression will be sealed, then the room filled back with oxygen. In the meantime, oxygen devices will be available for inhabitants exposed.

If any of these threats ever occur, inhabitants will be medically and psychologically supported and may chose to return to Earth anytime.

Decompression management and protection from a similar event is very important and will be particularly taken into account when building Solaris.

5.3.2. EPIDEMICS

Epidemics are least likely to appear, as Solaris is a sterile medium to start with. Plants grown in aeroponic and hydroponic farms are perfectly clean and pests free. Meat is grown *in vitro*, which means that it is consumable and free from bacteria, etc.

Solaris is cleaned up by special unit robots every night, and the waste system and water purification system work effectively from preventing the spread of any viruses, etc. Still, in the least likely event of epidemics, the local infested module will be isolated to limit and solve the threat. If that will not be possible, they will be transported back to Earth through the emergency escape shuttles in the deposit level.

Preventing epidemics	Description
Predictability	Can be calculated depending on the frequency, distribution and conditions.
Improving immunity	Immunity boosters will be distributed in order to raise immunity and help Solariens adapt to life in space.
Health Education	People will be educated into alerting authorities at any sign of an epidemics, and help to stop the spread.
Training	Inhabitants shall be trained into emergency response.

Management of epidemics	Description
Stop outbreak	Identify cause, isolate it, cure disease
Biosecurity	Reducing transmission if any infectious pests or diseases, implies physical, personal, transport security and control.

5.3.3. ASTEROIDS AND SPACE DEBRIS

Asteroids

Asteroids are frequently encountered and represent a big problem in outer space. Although, Solaris' orbit is far from The Asteroid Belt, from the asteroids near-Earth, etc., still space rocks and space debris are more likely to be encountered. However, instead of seeing asteroids as a problem, they would rather be turned to possible solutions to some problems. Thus, as most asteroids are metal-rich and full of precious materials, anytime a medium to large asteroid approaches Solaris, it will be captured by robots, taken away from the settlement's proximity and mined.

"The iron and nickel in Amun have a market value of about $8,000 billion, the cobalt content adds another $6,000 billion, and the platinum-group metals add another $6,000 billion." (John S. Lewis, Mining the Sky, http://www.nss.org/settlement/asteroids/)

According to the quote above, space mining is full of advantages, quite cheap to begin with, and with great profits lying ahead of us. The process should be quite simple, as was thoroughly described before in Episode Three. Using the Asteroid Detection Program on Solaris, in collaboration with the ones on Earth, any asteroid closer than 700 km away will be supervised. If the distance lowers to anywhere below 300 km, scouts and mining ships are sent over to keep any threat away.

The distances at which asteroids are mined should be rather big as any small asteroids or space debris may harm Solaris. This must be prevented, as small asteroids are as dangerous as large ones. Threatening asteroids will be diverted from their present orbit either by altering their form, or by the means of an impact between the asteroid and another object.

Space debris

The real threat in space consists of space debris, which must be avoided in case of large units, or shielded. The ISS uses Whipple Shielding to protect itself unlike the highly affected solar panels of Russian Mir Space Shuttle damaged by debris. As known, for the ISS, damage to the solar panels has been calculated to 0.23% every four years.

Whipple shield is a hypervelocity impact shield, that can withstand impacts at speeds of 3 – 18 km/s. The thin outer bumper shall be placed at a certain distance away of the settlement. Since the shield is made up from layers, with one empty level for each full one, the shield is multi-shock designed with heavy resistance materials such as Kevlar to Nexter. The ISS has over 100 different shield configurations, depending on how exposed the area to be protected is. Whipple shield without hollow layers are called Stuffed Whipple Shields and may be used, as well.

The Whipple Shields work wonderfully as the first layers works as a bumper effect, decreasing the impact level with the next shields, and so on. Whenever a shield is damaged it will be immediately replaced.

5.3.4. FORCE FIELDS

An alternative to the Whipple shield are force fields. They may sound Science Fiction, and are very energy consuming, but in the event of a collision with a big asteroid that can not be avoided, a force field may help save lives and the probability of constructing one must be taken in consideration.

Force fields will probably be plasma windows (gas heated at high temperatures, if the gas heated is argon, the plasma windows become blue), followed by a complex laser web, and ultimately carbon nanotubes. The technology needed for the nanotubes is not available yet, nanotubes being produced only in small, lab quantities.

Other applications would be in magnetism, such as the maglev trains, but conducting electricity on big distances is very expensive. Still, if we cool down metal, it's resistance lowers. Therefore, if we find an inexpensive way of producing superconductors at low temperatures and lowering conducting resistance in metals, energy may be transmitted will little or no effort and powerful magnets will be obtained.

Levitation as an application has been achieved, a hamster being levitated by the creation of a 15 Tesla strong magnetic field. That is 30,000 times Earth's magnetic field.

5.3.5. FALL OF LIFE SUPPORT SYSTEMS

Life support systems as food production, water production and management and waste management are not likely to fail, as food production extends on various levels, pests spreading is not likely to take place.

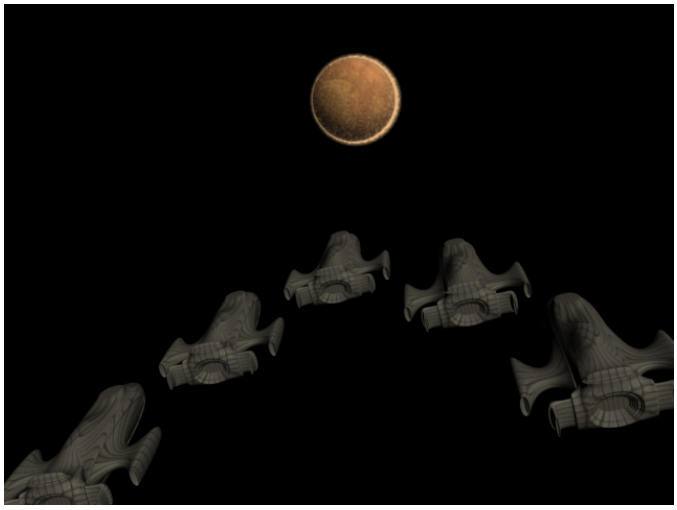
Food production takes place on separate floors in the residential tori, while meat production develops in the research tori. To experience a fall of both systems is not likely to happen, but in case of one, Earth will be alerted, and several reserves of food will be used in order to sustain the population of Solaris.

Water production is the most secure and safe of all systems, as it is one of the most important. If it is to fall, Earth should immediately be alerted and until fixed, water reserves shall be used.

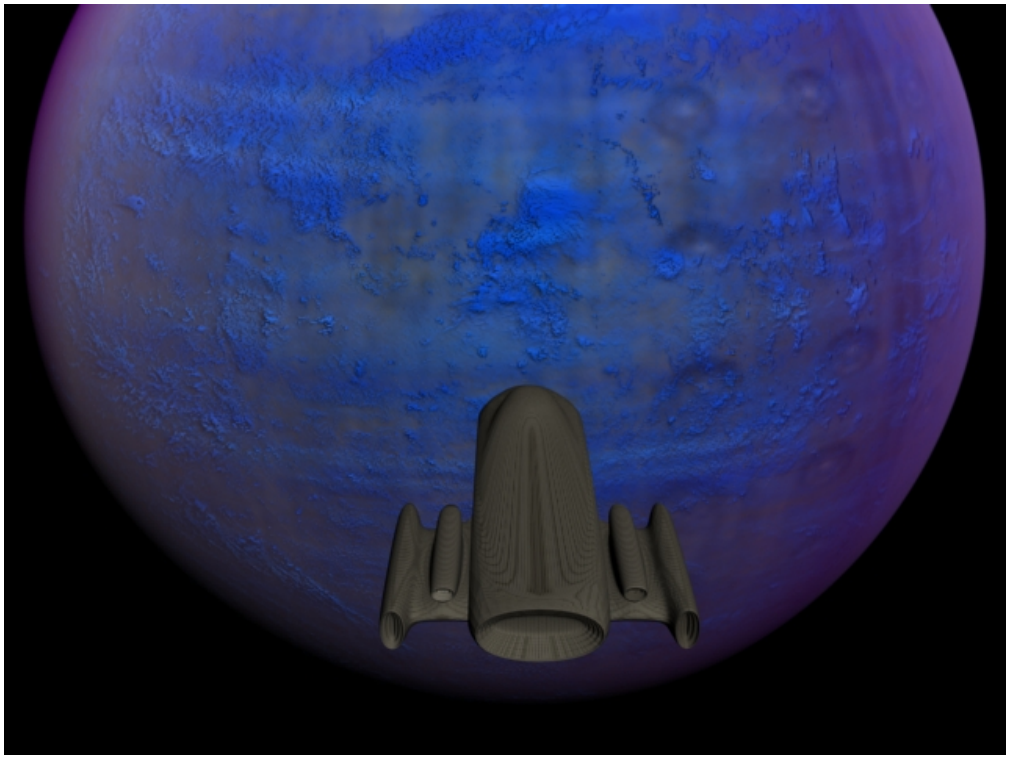
Waste management is to be repaired if a fall occurs.

5.3.6. EMERGENCY ESCAPE

In the event of an emergency escape, where all inhabitants must leave Solaris, the emergency escape ships, named "*The League*" will be available for transferring them to Earth. Each ship has a total capacity of 500 people, slightly above the average capacity of a Boeing. Therefore, for the 5,000 inhabitants per torus, a total of 10 ships per torus will be needed. Dimensions are determined by comparison to a Boeing 777-300 ER, with a total capacity of 365 persons. Unlike the Boeing 777, the constitutive ships of "*The League*" have rather small wingspans, as they are made for space travel.



Component	Value
Crew members	2 pilots, 3 space attendants
Passengers	500
Length	135m
Wingspan	20m
Width	12m



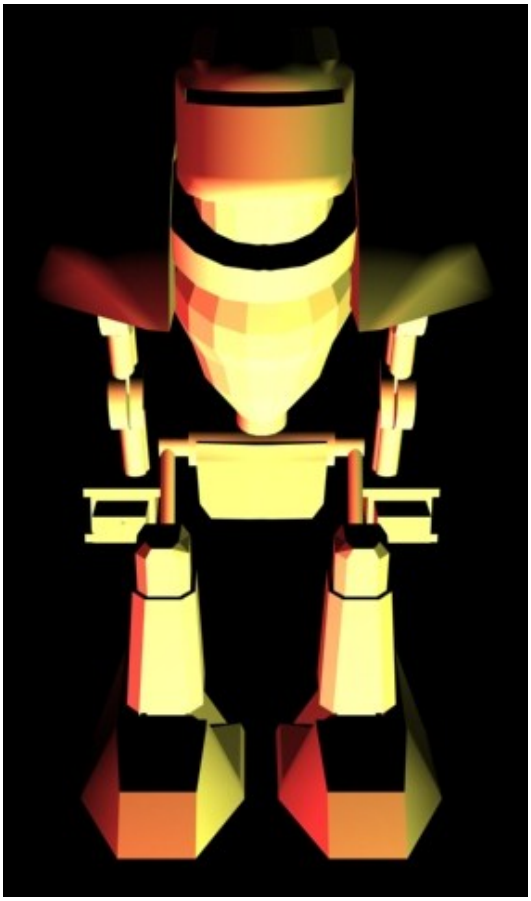
5.4. AUTOMATION

5.4.1. ABOUT ROBOTICS

When designing robots, it is vital to ensure consistent focus to the engineering components, power source, electrical sources, linear sources, air muscles, piezo motors, elastic nanotubes, environmental sensors, human-robot interaction, speech recognition, robotic voice, motion and kinematics, sensitivity, touch, vision, mechanical grip, and locomotion based on wheels, snake-model, hopping, and possibly the development of walking and climbing techniques.

Solaris will use mainly five types of robots:

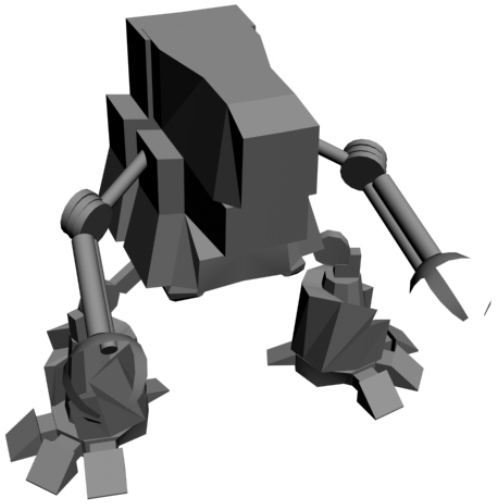
- a defense-specialized robot (*photo*)
- a human-interaction cleaning robot
- an android specialized in relationship with humans
- a robot used in construction
- a spider-like robot for mining.



Also, programming must be considered as important as the above mentioned aspects as part of designing them. Thus, the artificial intelligence must be intensively used in order to endow the robots with the human conscience, way of thinking, and resemblance between the connections of the two brain hemispheres (it is known that humans which suffered accidents disconnecting the two hemispheres, mathematical tasks are still easily accomplished, whereas simple decisions as the ones which are made when shopping may seem impossible as all objects appear to be the same).

A robot with slight improvements in conscience simulation and AI is SOINN, which can pour water and add ice – it may not seem revolutionary, but SOINN can decide whether to put the bottle down and add ice, which to use first, etc. Bots will be programmed into making decisions based on the information available, observation and analysis of mediums and environments. It is expected that until the construction of Solaris, AI will be improved.

5.4.2. AUTOMATION FOR MINING



Mining, as the preparatory phase, is one of the most important phases as it funds the construction of Solaris. The solely investment will be the construction and launch of the robots and the exoskeleton of the settlement. From that point on, materials and money for other parts and components will be obtained when mining asteroids similar to Amun, described in the Defense part of this episode.

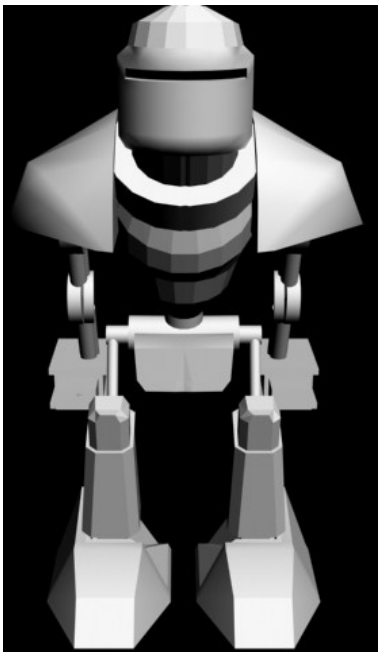
Mining will be done in the Near Earth asteroid system, on the Moon, and in defense eventualities, in the case an asteroid approaches the settlement and proves to turn into a threat. In order to optimize the mining procedure, the robot shall be accurately adapted to an asteroid-like environment. Moon-buggies shall be used as scouts on the Moon and on larger asteroids.

The table below fully presents the characteristics of a mining robot, and will do so for every major automation chapter.

Component type	Components	Description
engineering components	power source	nuclear batteries
	electrical motors	DC motors
	elastic nanotubes	Artificial muscle technology
	muscle wire	Contracts slightly (5%) when electricity runs through it
environmental sensors	Tactile info	Less tactile information than in human
	speech recognition	Personal bots recognize owners voice
	robotic voice	adaptation, reasonably close to human voice
	grippers	two fingers
	Computer vision	optics
locomotion	wheels	May be used
	snake-model	Adaptation for asteroidal environment
	hopping	Adaptation for asteroidal environment
	walking	Improvement stage

5.4.3. AUTOMATION FOR CONSTRUCTION

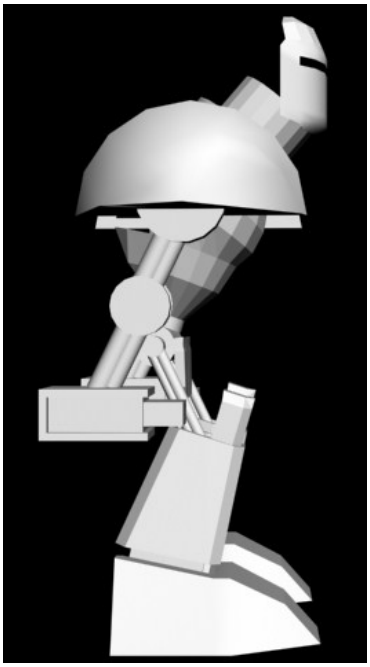
Component type	Components	Description
engineering components	power source	nuclear batteries
	electrical motors	DC motors
	elastic nanotubes	Artificial muscle technology
	muscle wire	Contracts slightly (5%) when electricity runs through it
environmental sensors	Tactile info	No tactile information
	speech recognition	Not necessary
	robotic voice	Not necessary
	grippers	Multiple arms endowed with grippers
	Computer vision	Optics, thermal sensors, radar
locomotion	wheels	May be used
	snake-model	Adaptation for asteroidal environment
	hopping	Not necessary
	walking	Improvement stage



As it is such an important part, constructions must be completed in a perfectly and faultless manner. To have it properly done, constructions will be primarily developed by robots, as space is a dangerous environment for humans, and robots provide a much faster completing of tasks in a safer and secure way.

A construction robot will be endowed with multiple arms and tools while robots will be specialized also into fixing solar panels, securing construction panels, etc.

It is vital that these are programmed on clear and multiple tasks, and be made as efficient as possible.



5.4.4. AUTOMATION FOR DEFENSE

Defense may be regarded twofold as - *interior threats defense* and *exterior defense*. Exterior defense from any damage or malfunction is most significant, crucial for the success of space inhabitation. Therefore, this will be further emphasized.

Defense robots are impressively looking and huge in dimensions. They are specialized in domains such as fire protection, asteroid capturing, etc.

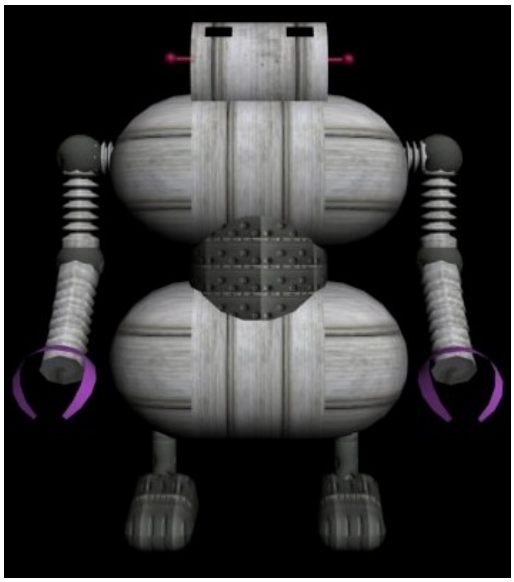
Probably one of the most important areas is *asteroid catching* as it provides resources, money and materials for Solaris. Therefore, it may be considered as the primary business resource and an active domain for both jobs coverage and multiple living costs.

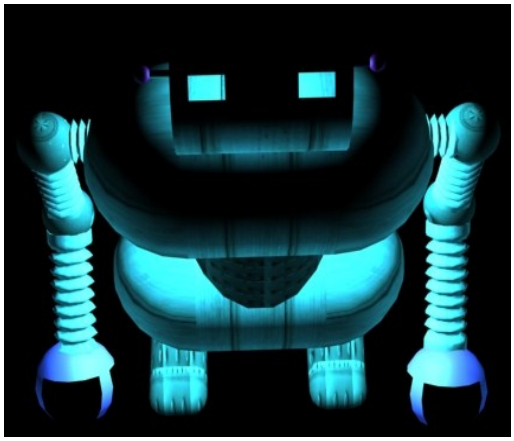
Component type	Components	Description
engineering components	power source	nuclear batteries
	electrical motors	DC motors
	elastic nanotubes	artificial muscle technology, better than air muscles
	muscle wire	contracts slightly (5%) when electricity runs through it
environmental sensors	tactile info	very good tactile sensors, fine olfactive glands
	speech recognition	used in detecting humans in emergency situations
	robotic voice	resembles human voice
	grippers	multiple arms endowed with grippers
	computer vision	optics, thermal sensors, radar
locomotion	wheels	basic locomotion system
	snake-model	not necessary
	hopping	not necessary
	walking	second most used locomotion system

5.4.5. AUTOMATION INSIDE SOLARIS

Automation inside Solaris must cover plant harvesting, cleaning, guiding support on the settlement, and house cleaning. These robots will mainly share similar components, as the ones above, but are very different in both construction and appearance.

Component type	Components	Description
engineering components	power source	Electric batteries
	electrical motors	DC motors
	elastic nanotubes	Artificial muscle technology, better than air muscles
	muscle wire	Contracts slightly (5%) when electricity runs through it
environmental sensors	Tactile info	Very good tactile sensors, fine olfactive glands
	speech recognition	Used in detecting owner and obeying requests
	robotic voice	Resembles human voice
	grippers	Human-like android arms
	Computer vision	Optics
locomotion	wheels	Basic locomotion system
	snake-model	Not necessary
	hopping	Not necessary
	walking	Second most used locomotion system





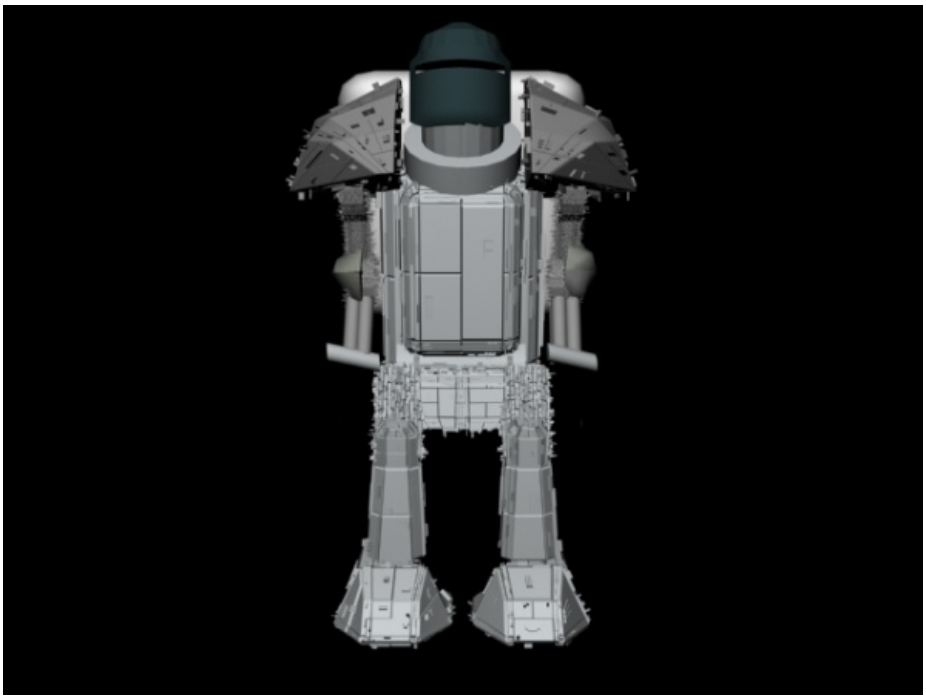
When discussing interior needs - robots on Solaris, three sub-categories must be brought up.

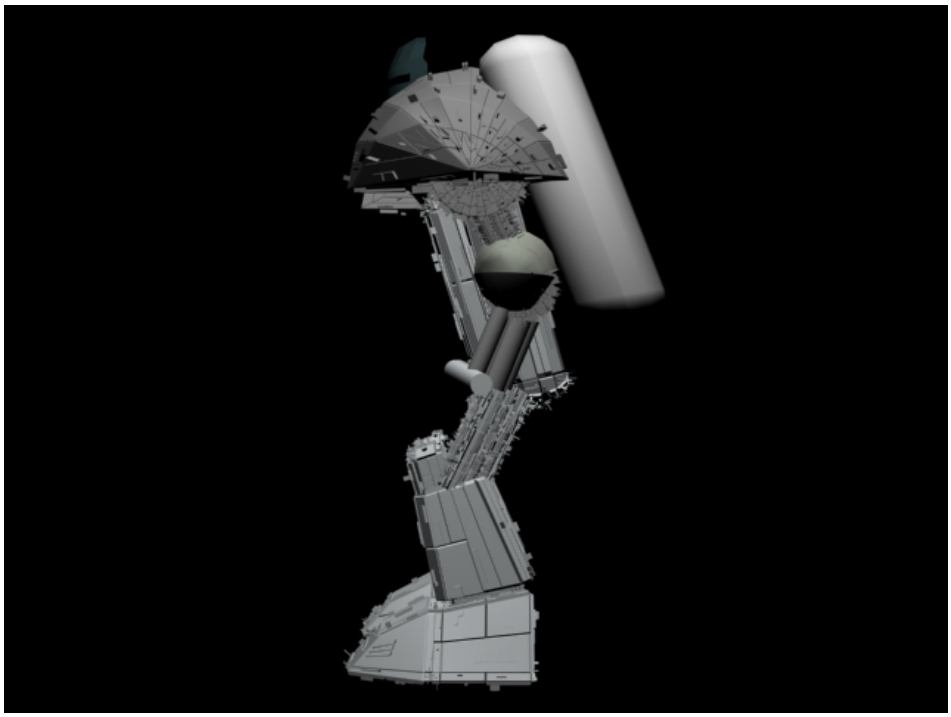
An android will cover human sector, assuming future developments in AI and robot conscience will be made by that time.

A house cleaning robot will be designed as well, helping Solariens with chores and taking care of children, teaching them basics.

Finally, harvesting robots will be similar to the machines used today in agriculture, and will be endowed with any future developments made by that time.

Droid robots – front and left view



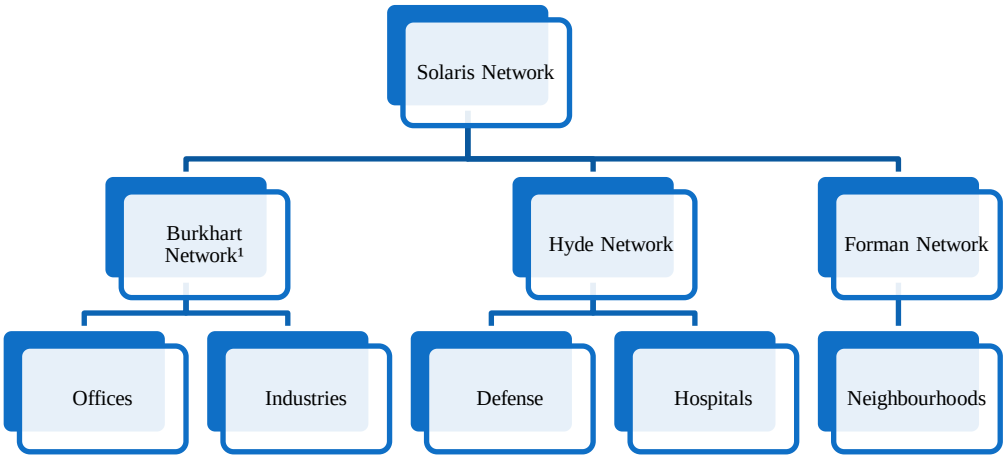


5.4.6. SOLARIS CENTRAL ROBOT ENERGY AND AUTOMATION MANAGEMENT (SCREAM)

All robots on Solaris will be produced and repaired by SCREAM. They manage energy resources, repair damaged robots, help with pieces construction and, most importantly, monitor all technological activity on Solaris. Technological activity ranges from Internet, personal computers, personal house ware, electrical ware, robots, Wi-Fi, electronic management in malls, museums, etc., and any automated system on Solaris. Personal computers, personal and all electric house ware is designed and built by SCREAM, and further distributed throughout the system in special, designed shops. A thorough record of all the machines distributed in kept. Electronic management and all user interfaces, Solaris e-mail, etc., is created by software engineers in Solaris Industries. Robots make a very important sector, and Wi-Fi & Internet access is monitored constantly and created by SCREAM. No disruption of Internet or Internet based systems will take place, as the settlement is perfectly insulated from solar flares, or any other threat to Internet connectivity.

5.4.7. COMMUNICATIONS

Communications will be fully covered by a complex Wi-Fi and *ad-hoc* Wi-Fi networks for computers. Optical fiber will not be used, as it would imply the consumption of massive resources and maintenance for both the fibers and the panels covering, etc. All signals are to be transmitted through electrical systems means.



Moreover, computers may interconnect with duplex systems, etc. as desired. Wi-Fi routers will be placed every 20 m. Networks are to be secured with WEP (Wired Equivalent Privacy).

The scheme above applies for each torus. All the systems are controlled by Solaris Network central computer. The communications system functions independently from the robot control system.

[1] *The Burkhart Network* is the abbreviation for Business, Offices and Industries main network. *The Hyde Network* is used for Defense, Hospitals, etc. *The Forman Network* is used for Residential networks.