

**DESIGN OF A SAFE AND COMFORTABLE UNDERGROUND  
LUNAR HABITAT**

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**Abstract.** Permanent human settlements on the Moon, and Mars, should be, not in small, flimsy modules with a rocket underneath, standing on four legs on wild and rocky terrain, exposed to all the perils; rather, they should be in a large system of tunnels, built by our self-replicating, remote-controlled robots over a long period of time, so that the inhabitants are protected by at least 200 m of solid rock from radiation, micrometeorites, extremes of temperature, vacuum, etc., and supplied by plentiful local production of air, water, food, fuel, energy, medical supplies, and thousands of other products needed for normal life, plus the centrifugal installations to compensate for insufficient gravity.

It would be irresponsible and inhumane to send human beings again to land dramatically, as Apollo 11 did, on wild and rocky terrain, and then expect them to live for many years in a flimsy, small, kiosk-like module, practically a tin-can standing on four legs, on the surface, exposed to micrometeorites, radiation, extreme changes of temperature, threatened by vacuum from all directions, with only a thin metal wall for protection, without even a bathroom, and without their own production of food, water, air, and many other necessities, all of which would have to be brought from Earth, always with much uncertainty, and at a terrible cost per ton.

Human beings can settle to live permanently on the Moon (and, equally, on Mars) only when a large landing zone is cleared and well marked, and when a large system of tunnels is built, so that people and equipment are protected by at least 200 meters of solid rock above and around them. These tunnels must be built, and industrially developed, by our remote-controlled machinery – the “robots”, carefully controlled, with programs extremely strongly encrypted against hacking by terrorists and fools, because, even on the Moon and Mars, the greatest danger to people will be other people.

Our first few, small robots must take temporary shelter in a natural cave, and begin to self-replicate, on Von Neumann principle – build many more copies of themselves, from local raw materials, and then much heavier machinery. Then they

must build (however long it may take; perhaps hundreds of years) an appropriate underground habitat for people, with many kilometers of storage spaces, apartments (with normal bathrooms! kitchens, washing of laundry, etc.), garages, rescue ships, reservoirs of air and water, and with production of food, clothing, and many other items for normal living, and with large-diameter centrifugal devices for the human residents to compensate for weak lunar gravity, with rescue exits, a large medical facility, anti-epidemic security doors, and other necessities.

But the picture part of our presentation today is about the entrances. A thick, heavy gate is the first thought, but it would be a poor protection against a meteorite, with a mass of, let's say, 1 kg, zipping in at 30 km/sec. It could smash right through the airlock. So, we propose that the entrance should be inside a natural rift, between two hills, perhaps (ideally) in a deep canyon, with two cliffs, facing each other; so, a whole hill or a mountain would protect the entrance from a direct entry of a meteorite. But in the unlucky case of the explosion of a meteorite, or a falling spacecraft, exactly in front of the entrance, there should be about 100 m of straight, empty tunnel, with nothing in it; coming to a dead stop, a "blind alley", in a wall of rock.

After the first 50 meters, a second tunnel should go off, to one side, at a 90° angle, for a distance, perhaps also 50 m, then, one more turn (forward) at a 90° angle, and, 150 m farther, the gate; the real entrance.

If this looks like a small, defensive labyrinth – it is.

So, any kind of incoming hostile material would, probably, hurl itself straight through the vacuum of the primary tunnel, and into the solid mass of the hill (or mountain); and spend most of its force there, harmlessly. Only after two 90-degree turns, deep inside the mountain, would be the armoured gate, and the first airlock. That is our proposal.