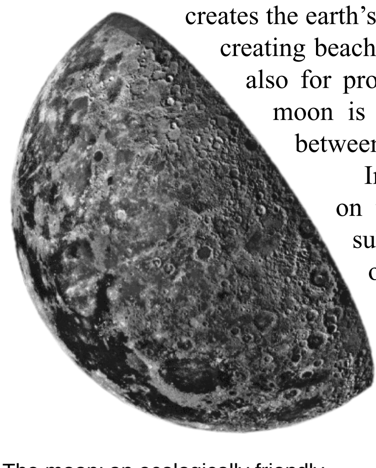
Chapter 1

Why Are We Here?

Parents like to think of their children as more handsome, more successful, and happier than the parents themselves are, but nowadays especially the focus on offspring is not so much achieving Lake Wobegone “above average” status, but rather consummate genius. The misconception that satellite engineering is a fantastically complex undertaking has really been a boon to my own parents’ wish fulfillment, and probably many others.

Filial piety being a concept reserved not solely for the Orient, it is easy to ignore how useful some rather simple, inert satellites actually are. The moon comes to mind in this regard. It has no digital electronic systems, no radios, no photovoltaics, no batteries. The moon sports not a single moving part (“active component” in today’s jargon).

Despite having not a line of software to its credit, the moon is more useful than most of us acknowledge. It provides an efficient, even aesthetic, nightlight. It is a passive reflector used to relay radio signals between distant places on earth. Landing on it provided a major challenge to our own space technologies, not to mention returning from it. The moon’s gravity has been used to assist interplanetary spacecraft on their trajectories and to test Einstein’s gravitational theories. The moon also creates the earth’s oceans’ tides, themselves pretty handy not just for creating beaches, inlets, and breeding territories for animals, but also for producing electricity and for harvesting clams. The moon is incredibly reliable, with an MTBF (mean time between failures) measured in billions of years.



The moon: an ecologically friendly nightlight.

In the future we could be lucky enough to find ice on the moon, or maybe minerals containing useful substances like oxygen to use in establishing a lunar outpost. It can be argued that building a space station is redundant, because the moon provides a ready base for operating in space.

The moon is such a clearly good idea that it is interesting to wonder what the world would be like if the moon weren’t there and NASA were to propose building it. The environmental impact studies alone would cost billions. It is doubtful that building a moon would ever be approved. Fishing interests would decry the moon, claiming its tides would destroy ocean navigation as we know it. Astronomers would point out that a significant percentage of viewing opportunities would be totally spoiled. I suppose artists would decry the loss of night's velvet cover of darkness, unaware of the charm a large yellow moon can add, hanging huge over the horizon, to a warm summer evening, or the mystic chill it gives us when it is high overhead of a midwinter night's snowscape. The moon speaks to us without radios and in its own language, a language people, plants, and animals all understand.

Technology changes things, even low-tech stuff like earth's moon, and people don't like change. As a technologist, you have to accept that and work with it, realizing that nobody is going to thank you for delivering change, even change for the better. Know any cities or countries named after scientists and engineers? Einsteinville? Archimedesland? Gausstown? People prefer politicians, despite what you read in the press. Leningrad (gone but not forgotten), The Tom Bradley International Terminal at LAX, Cape Kennedy. Politicians are predictable, and they haven't made anything fundamentally better, or really changed anything about our lives, in hundreds, even thousands of years. At best they cook stuff up with the ingredients society provides them, but they are players on the existing field. They don't create new worlds, or even new fields.

If it's not too late, you might consider violin making. If you can figure out how to make violins exactly like they did 500 years ago, you'll be rich, famous, and popular beyond your wildest dreams. But if you invent a new piano that is played beautifully, mysteriously, hauntingly, without touch or training, simply by modulation of your own brain waves, the art world would assassinate you for alleged debasement of human culture. Have you ever walked into the office of a CEO of a major corporation, or an Ivy League college dean's office, or the office of a celebrated politician and found a bunch of aircraft radios, gyrocompasses, and air navigation charts festooning the place? Maybe a GPS receiver? Of course not, they're all new and crass. But if you find a yellowed old globe missing most of the detail of the New World, maybe a wooden ship's wheel, and a compass that Columbus could have used, complemented by a worn, useless brass sextant thrown in for good measure, that wouldn't surprise you at all. Change has very little constituency. You have been warned.

The moon has an important lesson for we who build artificial satellites. Complexity and usefulness are not two sides of the same coin. They are often traveling companions on our technological journeys, but a single drop of water says just as much as the powerful river and the massive ocean it flows into. Where complexity and usefulness part ways is often where you get the greatest overall value. Books, paper, bricks, arrowheads, soap. One of my many language instructors (I needed a lot of tutoring) gave me some good advice. She said, as I left the security of her living room about to cross two oceans and apply my faltering language “skills” on a real world full of native speakers:

“Only say what you know how to say, don’t try to say more.”

If you want to build a satellite, do it. Build what you can build. A junior high school class can build a satellite. That satellite can be observed and tracked in the night sky or heard on a radio for a few days as it orbits overhead. A single college class could build a satellite with a radio repeater, and a group of students working over several years can build a stabilized platform with a pretty capable computer, digital radios, and some scientific instrumentation.

All of these projects are just as much a valid application of satellite engineering as the most complex devices our societies have produced— satellites like Voyager that sent back images of Saturn and Uranus; Pioneer, which transmitted to us for decades from beyond the edge of our solar system; and TDRS, one of the most complex communications terminals ever built in daily operation from 40,000 km (24,000 miles) above earth.

People build things in a fundamentally different way from nature. We’re always in a big hurry. To survive in a Darwinian world, our minds have evolved an intense focus on the individual, and the individual lifespan is short. Similarly, we are preprogrammed to be deterministic. So for us, it’s not good enough to wait for a lot of trees to grow along a river, for some of them to die and to fall over in a bunch someplace across that river to create a bridge that our descendants can walk across 100 or 1,000 or 100,000 years from now, even though that certainly is a viable way to create a bridge. Plants work that way. People don’t. We chop down a bunch of trees, build a truss structure, and in a few months we have a bridge. In the process, we also create the field of civil engineering and a whole technology grows up—rope bridges, truss bridges, suspension bridges. And we fit bridge technology into the other technologies we have synthesized. For example, we make wide concrete bridges that cars drive over at 65 mph.

Same human behavior at work in space. In 50 years of frantic effort we have surpassed the ancient, majestic moon in several respects. We have satellites that point at the earth, even at special spots on the earth, or at particular stars or planets. We have satellites with active radio receivers and transmitters for relaying television, radio, telephone, and data. Our satellites carry advanced optics for astronomy and reconnaissance, radio receivers for spying on people’s telephone conversations, electric power supplies using solar energy, nuclear energy, and chemical energy that we use to power refrigerators, lights, heaters, even personal computers in orbit. Like civil engineering, a whole technology has grown up around how to do stuff in space. Whereas our medieval ancestors studied the moon, the planets and the stars, we study calculus, analytical geometry, dynamics of rigid bodies, orbital mechanics, automatic control, and thermodynamics.

But as another of my patient mentors (all my mentors were patient, which sort of says it all) once explained, starting from first principles is fine if you don't want to get past first principles. This is therefore not a set of chapters on engineering fundamentals underlying spacecraft engineering; in fact, you might wonder if this is actually a coherent book at all! It's more of a collection of short subjects—sort of a satellite fan's *Readers' Digest,* or an aerospace engineering equivalent of an aboriginal approach to fishing and hunting. A person who learned from some elders passes on to you the ancient ways of catching a salmon, avoiding crocodiles, or building an igloo. There's a lot of science behind salmon, crocs, and igloos, but neither you nor your mentor is concerned about it. There are pilots and there are aerospace engineers; there are musicians and there are cello builders; there are hungry people and there are gourmet chefs. This book, and particularly this section, is for people with an appetite for space.

Building, launching, and using spacefaring stuff has developed a pretty significant bag of tricks. The tricks are not magic but there is a great danger in treating them. You can die. Of boredom. OK, I have a short attention span, so that danger lurks ominous in my mind every morning. Treatments in this treatise err on the side of the quick read. Blame it on a spoiled child of the second half of the twentieth century known locally as the author. So my apologies if technical sensibilities are trampled. It's a lesser of many evils.

The bag of tricks includes what we know about orbits and getting into orbits; about radio communication; about keeping our orbiting creations at the right temperature; surviving in the space environment; figuring out in advance of launching something whether it stands an ice cube's chance at a Texas Bar-B-Que in August of surviving "up there"; stabilization and pointing things; space computers; data storage and software; remote sensing from space and other satellite applications; electric power production and storage; why we ever invented clean rooms (and why satellite customers always want to see them). A few geopolitical tidbits are also included like radio frequency allocation; why it is fundamentally impossible to get a small satellite program funded adequately even though it's one hundred times cheaper than large satellite programs; and why the real frontier of satellite technology is to figure out how to build satellites in less than 15 months even though it takes 8 years to get the bureaucratic machinery rolling to turn on the contract in the first place. See above disclaimer on technical purity; this is not the Church of Aerospace Technology. We're closer to the dusty ol' sarsaparilla bar back behind the train station to space. Plant your spurs up on the tabletop, pour yourself a cool one and enjoy the ride.