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Living in Space

By

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To those of us born and raised on this tiny ball barely 12,800 kilometers (7900 miles) in diameter, the scale of the vacuum around us is difficult to comprehend. Even the distance between Earth and our closest neighbor in the cosmos, Luna, is vast beyond our experience. The Apollo spacecraft, traveling fast enough to circumnavigate the Earth in less than an hour, took three and a half days to reach the moon, and the same time to return. Yet, the distance between Earth and Mars (at their closest approach) is more than 100 times as far, and the path you must travel to reach Mars is far from a straight line.

If you are to be a science fiction writer dealing in spaceships and planetary adventure, it is imperative that you understand the scale of the Solar System. For without such an appreciation, the spaceships in your stories begin to look like taxis delivering characters from one side of Manhattan to another. Traveling to the moon and the planets is a much more daunting task than even flying across the North Atlantic. Because of the travel times involved, true spaceships will bear more of a resemblance to the sailing ships of yesteryear than they will to the sleek airplanes of today. And no, I'm not suggesting that spaceships will be full rigged Yankee clippers, but rather that accommodations on both vessels will be similar. Specifically, spaceships will have staterooms with beds you can actually lie down in, dining compartments where you can have a leisurely meal at a table, and even secluded places where couples can be alone after the cabin lights are switched from the bright white of day to the deep blue of night.

The arrangements will be similar because the travel times are equivalent. Magellan set off across the Pacific Ocean with a two-month supply of food onboard his ships, and a six-month journey ahead of him! Those of our descendents who choose to travel in space will know how he felt. Interplanetary travel will be a matter of weeks or months, not the relatively few hours required to reach anywhere on the planet in a modern jet airliner. Having traveled to Russia five times in the past few years, I can attest personally to the fact that Phoenix, Arizona, and Moscow, Russia, are 27 hours apart via Frankfurt, Germany. That statistic alone ought to give you some idea of how small this planet has become. Remember that distance is determined not by how fast you go, but by how quickly you get there.

Previous installments in this series included a daunting study of the physics of rocket propulsion, something I suspect many readers wondered if they truly needed to know. The purpose was to instill some understanding in neophyte science fiction writers of the sheer magnitude of the task we set before us when we decide to write about journeys between worlds.

It is a melancholy fact that we have only invented a single method for traversing the blackness of space — the wasteful rocket engine. Why wasteful? Because to make the thing "go," you have to throw vast quantities of reaction mass overboard, mass that has been hauled into space at great expense and which, once used, is lost forever. This reliance on ships that expend most of their mass out their exhaust nozzles will be a huge problem for any civilization that occupies more than a single world. To keep a Mars colony alive, for example, requires not only that we transport people and cargo between Earth and the Red Planet, but that we transport all of the reaction mass they will need as well. And transporting reaction mass requires the expenditure of a many times greater quantity of reaction mass. Either that or we transport whole factories to Mars to make the stuff on the spot. Whichever way we do it, it's going to be expensive.

We have also discussed the paths spaceships must follow between planets. These highways in the sky are molded by gravity into the shape of elliptical, parabolic, or hyperbolic orbits. Each orbit requires tradeoffs in energy and transit time, and many place restrictions on the time of year when travel is possible. Not very convenient for the junketing businessman or the entrepreneur who wants to start an interplanetary package delivery service. Using rockets for transport, such a service will resemble the pony express more than Federal Express!

In addition to orbits, we looked into several advanced concepts for propelling spaceships quickly from planet to planet. Each of these ideas is technologically plausible, but much too advanced for our current level of skill in the technic arts. Still, the fact that these propulsion schemes are currently beyond us should not be disheartening. That which the human race can conceive, it can build. All it takes is genius, perspiration, and will — all of which we possess in abundance.

Having faithfully read the predecessor articles to this one, many readers will be wondering how they can apply these rather technical points to their writing. It is probably wise that you *don't* apply them, at least not directly. Your writing career will stall if you begin writing sentences like, *"The spaceship engines roared to life as the turbopumps thrust a thousand kilos of super cold hydrogen and oxygen into the combustion chamber each second, where it was ignited by a modified version of an automotive spark plug into a raging, 4000 degree inferno that sent white hot plasma roaring aft through the venturi restriction of the rocket nozzle."* Unless you are planning on entering the Bulwer-Lytton "Dark and Stormy Night" contest, such writing can only get you a rejection letter from any editor to whom you send your manuscript.

But not writing these technical details in a book is not the same as not knowing them. There are small facts that one can intersperse throughout your descriptions to make them more real. These are things like the conical expansion pattern of a rocket's exhaust in vacuum, or the color of the flame exiting the nozzles, or the sound the turbopumps make as they begin to wind up to their 100,000 rpm operating speed (inside the ship, of course; outside in vacuum, everything happens in silence). On a more personal note, you can talk about the dirty sock smell of the air in a spacesuit, or the cool breeze from a ventilator tickling the hairs on the back of your heroine's neck. If done properly, these insertions will act as subliminal messages to convince the reader that you know what you are talking about. Once they begin to trust you, they will implicitly believe anything you write, and you can get on with the serious business of screwing with their minds!

Attaining believability in a science fiction story or novel is mostly a matter of getting the scale right. Too many authors merely transplant terrestrial situations into a space environment, then try to cover themselves with meaningless jargon. The problem is that even meaningless jargon has to be self-consistent to be believed.

Recently I had someone ask me to comment on his scenario for a science fiction screenplay. After expressing some hesitancy, I agreed to look at a short synopsis. What I found was a fairly conventional terrestrial thriller repackaged for a space background. The problem was that the would-be playwright had no idea of the scale of the backdrop against which he was setting his story. It was as though, having scraped the western face of the Sierra Nevada mountains clean to use as a canvas, he was busily trying to paint *The Lord's Supper* on the head of a pin.

That then is the ultimate reason for this long journey we have been taking through the esoterics of planets, rockets, and orbits. By giving you, the science fiction writer, some idea of the size of your canvas, you will better be able to craft a story worthy of such a mighty expanse.

Having made you plow through a great deal of background material that may never find its way into your writing, let's shift focus. For the rest of this chapter on interplanetary civilizations, we will discuss things that are likely to be directly useful in your writing. We will start by designing a space habitat.

The Space Environment: Unhealthy for Children and Other Living Things

We've all been somewhere that we thought was the most godforsaken place we'd ever seen, right? For me the current record holder is Trona, California. I visited there on one of my lecture tours and met many nice people, gave a talk in the high school library to a group of 30 attentive students, and generally enjoyed myself immensely. Still, except for a certain rugged grandeur, I think Trona is the most barren place I've ever been. Trona is 18 miles northeast of Ridgecrest, California, where the Naval Weapons Center at China Lake is located. (I've been to Ridgecrest numerous times and have many friends at NWC - China Lake, and until I went to Trona, I thought *that* was the most desolate place on the face of the Earth! That from someone who is a native of the Great Sonoran Desert is saying something.) Southwest of Death Valley, Trona owes its existence to a borax deposit deep beneath a dry lakebed. The local mine gives off a faint hydrogen sulfide smell (the rotten egg chemical you experimented with in chemistry), and standing in the high school parking lot and looking north, I swear that there isn't a single living plant visible between you and the mountains on the horizon. The local water is so alkaline that they have to have drinking water piped in from Ridgrecrest, which can ill afford to give water to anyone. If you think I exaggerate, then you can check it out for yourself. In *Star Trek V,* the scenes where they find "God" were filmed just outside of Trona.

Let me get to my point before any of my gracious hosts write me nasty letters for attacking their town. As barren as the countryside around Trona is, it is still a Garden of Eden compared to the environment of space. Future space dwellers will undoubtedly be ready to kill for a few liters of alkaline water, and they will look back with fondness at the time their ship smelled only slightly of hydrogen sulfide. No, the harshness of space is more absolute than any environment yet encountered by human beings. It's hotter than the hottest day the Sahara has ever known, and colder that the worst blizzard at the South Pole. Air is

nonexistent "out there" and your food and water will, of necessity, have to be recycled many times for reuse. Out in space, the process of turning sewage back into pure water will be much more closely coupled than it is here on Earth. People who are squeamish about drinking a glass of water that went down the toilet a few hours earlier may wish to stay home.

The space environment has two dominant characteristics: vacuum and zero gravity, and whatever spaceships or space habitats you design in your writing will have to take these into account. Living on the surface of the planet will be better, but only slightly. For on any planet besides Earth, you find yourself surrounded by deadly poisons, noxious gasses, heat, cold, and an environment where the slightest bit of inattention will kill you quickly.

Space, then, is not for the faint of heart.

Life in a Zero Gravity Thermos Bottle

Most people have a good idea what weightlessness is like from the movies. To move in zero gravity (more accurately called *microgravity*) requires that you have a wall to push off from, or a line along which you pull yourself hand over hand, or some kind of rail mounted to the walls, floor, or overhead. The one thing you cannot do in zero gravity is walk. The act of walking is essentially one of unbalancing yourself, falling forward, and getting that other foot in front of you before you land on your face. In zero gravity you don't fall on your face, you float across the room. If you've ever tried standing on the bottom of a swimming pool and walking while submerged, you'll understand the problem.

Zero gravity also causes other problems. For one thing, hot air no longer rises. This means that there is no air circulation due to density variations. When you exhale hot, humid, carbon dioxide laden air, it tends to hang in a cloud around your head. After a few minutes you find yourself suffocating in your own exhalations. In microgravity, it is necessary to always keep moving in order to breath, and failing that, to have the cabin ventilators going all the time.

Zero gravity also makes drinking a fairly tricky and arduous task. Obviously, a common drinking glass won't work. The first movement of your glass toward your mouth will cause a big globe-shaped mass of liquid to rise into the air and splash you in the face. After that, it breaks up into smaller globules and floats everywhere, eventually getting into the electronics and shorting them out. It's bad enough if the liquid is water or some other potable. But what if the floating liquid is vomit or another bodily fluid ... well, I don't have to draw you a word picture, do I?

The above observations are only the most obvious difficulties involved in living in space, and many a 1950s science fiction author used them to good effect to give the readers a feeling of being somewhere no one had yet gone. And, why not keep using the old standards as long as they work? The next time you have a scene where everyone is in microgravity, then write about how the women's hair creates a furry cloud around their faces, how the crew is dressed in skintight, elastic bodysuits because skirts don't work in zero gravity, and how wine spurts from the hero's nose and floats around the room when the heroine says something startling.

But what of the less obvious difficulties of living in space. What about heat?

"Yeah, heat!" you reply, having heard that it gets up to a couple of hundred degrees on the surface of the moon at noontime. (But it's a dry heat! — Arizona humor.)

No, what I am talking about is internally generated heat. Human beings are sophisticated heat engines and we generate a surprising amount of heat through the process of living. Food is our fuel. Whether you eat a jelly doughnut or you burn it in a fire, you obtain exactly the same number of calories. And having obtained them, you must reject them somewhere if you aren't going to burn up.

We have all experienced this phenomenon in our lives, usually when crowded into the poorly air conditioned lobby of a movie theater with several hundred other patrons. Have you ever noted how quickly it gets hot in a crowd? That stifling, oppressive, humid heat that makes you sweat is coming from yourself and those around you. Now imagine that the movie theater lobby is surrounded by a double walled flask of mirrored glass with vacuum in its interior. In other words, imagine that you are trapped inside a Thermos bottle. With no place to reject waste heat, it will be a race to see whether you die of oxygen starvation or heat prostration.

But isn't that what a spaceship or space habitat is, a perfectly insulated container surrounded by vacuum? So in addition to having a ventilation system that circulates the air so inhabitants won't suffocate in their own exhalations, space habitats will also require sophisticated systems for collecting internally generated heat, pumping it outside, and then radiating it away into space.

You've all seen pictures of the International Space Station. Note that some of the things that look like solar panels are actually turned edge on to the sun. These appendages aren't for generating energy from sunlight. Rather they are radiators used to radiate waste heat to space, thereby keeping the interior of the habitat at a livable temperature.

Then, of course, there are the essentials of life — air, food, and water; as well as the other plumbing systems required to keep a hygienic living environment. I am referring, of course, to waste reclamation systems.

If you think drinking out of a bulb in zero gravity is a project, just consider the choices you face when you "have to go." On the Apollo missions they handled the problem with relief tubes (a very *male* oriented appliance) and fecal bags. Have you ever considered, however, how you keep from floating away when you are trying to operate one of these bags? I attended a lecture by an astronaut once who said that the best way to handle such business is for one astronaut to sit in another's lap. The astronaut on the bottom would lightly hold his fellow astronaut at arm's length, steadying him, leaving the second man's hands free to handle the bag. Needless to say, the crewmates must be on very good terms for this procedure to work.

We've advanced beyond those primitive days, of course. Now we have the Space Shuttle toilet that has a fan system for drawing the waste down into the collection point. If you can visualize the appliance, you can understand my concern that a well-endowed male astronaut might have a serious industrial accident while in the waste reclamation compartment.

Am I starting to gross you out? (American slang meaning to cause you some mental and emotional discomfort). Good! One of the ways to convince your readers that they really have been transported into the future and are no longer sitting in their easy chairs, reading a book, is to make your story less than antiseptic. Men and women are going to urinate, defecate, ovulate, copulate, regurgitate, and expectorate in space just as they have on this planet for millions of years. The only difference is that in space, these simple acts take on a new complexity. Personally, I don't much care for the bodily function school of

science fiction writing, but you have to agree that when you are looking for a certain atmosphere in your story (no pun intended), it has its uses.

There are other things that we take for granted that will not be readily available in space. Personally, I like to take long, hot showers. It relaxes me and I get some of my best ideas while feeling the soothing massage of water droplets against my skin. In fact, it is an open secret among writers that if you get stuck on a plot problem, a soothing shower will often bring the solution to the forepart of your brain.

Up where the nearest large body of water is 50,000 kilometers straight down, it is unlikely that extended bathing will ever gain the popularity it has here on Earth. Even if you can build an appliance for taking a shower in zero gravity (which we can), there would seem few more lavish wastes of that life-giving fluid than submerging our dirty bodies in it. No, your average space station citizen will probably have to do with a damp sponge and a lot of patience, which of course, is why many science fiction authors equip their stories with "sonic cubicles" and other non-aqueous systems for cleaning the grime off the hero (and heroine if it's that kind of story).

Speaking of which, there is the matter of sex in zero gravity, which those of us who have not yet tried it all agree must be wonderful. Whether it is or isn't, I personally have no way of knowing. There have been rumors of unauthorized experiments aboard Russian spacecraft from time to time, and NASA has on at least one occasion launched a married couple aboard the Space Shuttle (no, I'm not making any accusations here!). Even so, the subject remains one of general interest and speculation.

For a number of years I have gone to the local science fiction conventions in the Phoenix area, and there is always a panel on Saturday at midnight titled "Sex in Space." Since I worked on the Space Station for more than three years, I would often describe my various tours of the Space Station mockup. The living quarters aboard the station (before they downsized it) consisted of eight cubicles that looked like furnished airplane lavatories. There were pairs of these cubicles in each of the four walls of the module (port, starboard, overhead, and deck). The astronauts sleep by climbing into a sleeping bag that is hung up on the outer bulkhead, much as one would hang a suit in a closet. The cubicle has lights, television, and one feature that I personally found fascinating. Between a cubicle decorated in a tasteful shade of pink and the adjoining cubicle (decorated in blue), is a removable partition. What the lucky couple who remove their partition might be doing in there is, of course, none of our business.

But What If I Don't Want My Characters in Zero Gravity?

No problem. Don't put them there. But artificial gravity brings with it problems of its own. For one thing, we have only limited ways to cause everyone to fall to one side of the room, which by convention we call *the floor*. In microgravity there is no such thing as a floor since no one tends to fall in any particular direction. Many a science fiction writer has used this to establish verisimilitude in his story. Sometime during the proceedings, the hero calls an emergency meeting and everyone congregates with their head toward a central point and their feet arrayed outwards in a star formation.

Actually, this is a 1950s era image. When we finally made it to space we discovered that people like to orient themselves all in the same direction; in effect, to pretend that there is gravity where none exists. The space station has been decorated to maintain this illusion

because, among other things, it aids people fighting the nausea that often accompanies microgravity.

Lacking a really big mass, often referred to as a *planet*, about the only way to simulate gravity is through angular acceleration. In other words, you have to swing your people and their habitat around some central point like a child swinging a bucket of water around them at the end of a string.

And no, I'm not talking about centrifugal force, mostly because there is no such thing. Centrifugal force is a mathematical fiction; an optical illusion brought about by the fact that you are undergoing acceleration whenever you travel along a curved path. For the more technically minded among you: acceleration is defined as a change in velocity, and since velocity is a vector quantity consisting of both magnitude (speed) and direction, any change in either magnitude *or* direction results in an acceleration which we perceive as a "force." If you don't know what I'm talking about, don't worry about it. Frankly the fictitious nature of centrifugal force is not that important. Its primary use is for tripping up physics majors and engineers on final exams.

There is one effect of generating artificial gravity through rotating a giant coffee can of a space station that is worth mentioning, however. That is the Coriolis "force" or acceleration. Coriolis acceleration is what causes hurricanes to rotate clockwise in the Northern Hemisphere and counterclockwise in the southern. And if you are aboard a spinning space station and moving from the rim toward the center of the station (such as in a lift), Coriolis acceleration will cause extremely strange sensations in your inner ear where your sense of balance lies. That is because as you decrease your distance from the center of rotation, your speed changes continuously, causing the fluid in your inner ear to pile up on one side of your head and sending your brain the false signal that you are tipping over. You don't have to understand the phenomenon to mention it in your story. Just knowing the name does wonders for your credibility if you happen to be writing a hi tech science fiction story.

Then there's the problem of how people enter and leave your rotating ship or space station. Obviously, your space liner can't just fasten itself to the rim of a rotating-wheel-type station (a classic design originally proposed by Werner Von Braun about 1950, and still far more advanced than anything we can build today). To attempt the feat will result in a crash that will destroy both ship and station. Instead you will have to go aboard at the station or ship axis, much as the Pan Am spaceliner enters the wheel station in the movie *2001, A Space Odyssey.* You can get a lot of mileage (kilometerage?) out of scenes where the ships dock to the non-rotating central core of a space station, then the passengers disembark and make their way "down" a series of lifts to the outer rim, with the pseudo-gravity around them increasing with each meter traveled.

Then there is the old scene, also from *2001* where two people approach each other around the curved deck of a wheel-style space station. To anyone aboard such a craft, it appears that they are in the bottom of a valley, and that those who come into view in front or behind are walking down the side of a curved wall. Yet, when they converge with these people, everyone appears to be at the bottom of the curve.

Really Big Space Habitats

Despite the problems of living in space, I have no doubt that eventually human beings will live there. For one thing, we have nowhere else to go. Despite numerous fanciful stories about miraculous creatures at the bottom of the sea, when we finally plumbed the ocean depths, we found nothing but a desert down there. Few creatures live on the bottom, and except for deep-sea mineral extraction and oil wells, it's difficult to see what would attract people there.

Space is important because it's the true source of limitless resources and the only real outlet for excess population (if you are one of those people who believe the Earth is overcrowded). Personally, I would argue that it is more crowded than I personally find comfortable, but would have difficulty arguing that it is *inherently* overcrowded. After all, whether there are too many people on Earth is largely a matter of technology. That, of course, is the subject of an entirely different discussion.

Still, people will go to space for the same reason Magellan set out across the Pacific with too little food onboard. Because we are restless, avaricious, prideful, vindictive, and too stubborn to admit when we have made a mistake — and those are our good qualities! Just as the sixteenth century explorers were attempting to get rich, future generations will find ways to make money in space, ways that will require their presence. And since the millions of farmers, miners, bureaucrats, bankers, and small shopkeepers who will eventually migrate to space need a place to live, we will build cities in the vacuum. Big ones!

Describing these giant colonies as they are seen from inside or out provides the science fiction writer with copious material with which to lull the readers in order that the writer may perform his magic on them. Space habitats in the Earth-Moon Lagrangian points became popular during the 1980s, but in reality, you can put them anywhere. (A Lagrangian point is an oddity that comes from the mathematics of gravitation. An object placed in one of five points in the Earth-Moon system will tend to rotate at the same speed that Luna does. It won't be stationary, mind you; but it will always remain in the same spot with respect to the moon)

A mega-habitat would probably be cylindrical in shape, with farms spread out around the inner surface of the “coffee can” and either a “sun tube” at the axis or else a series of mirrors at one or both end caps which would reflect in real sunlight. If your habitat is ten kilometers long and say two kilometers in diameter, the habitat begins to look like a miniature (albeit cylindrical) planet. By setting your story in a mega-habitat, you can regain some of the expansiveness that is present in stories set on Earth (with its wide vistas and blue-softened mountains on the horizon).

And, of course, there is no limit to how big a structure you can build in science fiction. You can expand your space habitat until it is truly gigantic. What about this for an idea? How about a race of aliens who build a ring shaped structure that completely encircles their star? Think of the elbow room on which to stage your adventures! If you are thinking of writing such a story, I have bad news for you. Larry Niven already did. *Ringworld* is one of the classics of science fiction, and there aren't too many editors who will purchase a novel that is an obvious rip-off of it. Too bad. Just about every science fiction writer I know wishes he or she had written it.

Spaceships versus Habitats

Here I have gone on prattling about how to design a space habitat and all you want to know is how to design a spaceship. Guess what? There is very little difference between the two. Both are artificial environments that must provide air, water, heat, light, and possibly gravity to your characters. Both require air purification and circulation systems, heat collection and rejection systems, electrical systems, waste collection systems, etc.

The only difference between a spaceship and a habitat is that the former moves under its own power from place to place while the latter orbits continuously in one spot. (We won't delve too deeply into the concept of "orbiting continuously in one spot" since it makes no literal sense, but I think you know what I mean.) About the only difference between a ship and a space station is that the ship may have two forms of artificial gravity. When under power, everyone tends to float to the aft bulkhead due to the thrust of the engines, and when not under power, everyone floats to the outer rim if the ship is spinning. You can establish verisimilitude in your story if you describe the arrangements for changing over from the "aft is down" orientation of powered flight to the "out is down" of coasting flight.

You can even turn a mega-habitat into a spaceship if you want to. That way the people can have their adventures as their "city" moves from place to place in the Solar System. Wouldn't that be more civilized than cramming yourself into a little phone booth of a ship and spending long weeks strapped to an acceleration couch? Of course, it depends on how much reaction mass you are willing to expend to get where you are going.

Conclusion

The space environment provides limitless opportunities for these little details of daily life in space, all of which go to establish the reality of the situation in your readers' minds. Nor is it necessary that you be a physics major to use them. All that is really necessary is to read the works of Robert Heinlein, Arthur C. Clarke, and to a lesser extent, Isaac Asimov. After all, if you are going to steal ideas, why not steal from the very best?

Are you having trouble visualizing what a spaceship or space habitat will look like? If it's a small ship, visualize the last time you found yourself strapped into the seat of an airliner. A small spaceship will have to perform many of the functions of an airplane, and the designs will probably be quite similar. Except, of course, that the spaceship is more likely to be spherical than cylindrical if it never enters a planetary atmosphere. Why? Because a sphere holds more volume than a cylinder, and out in vacuum, there is no need for streamlining.

What about a mega-habitat? How does one visualize such a huge structure? On this point I'll let you in on a little secret. When I think of a really large habitat in space, I imagine that I'm inside my favorite shopping mall and then imagine what it would look like if you rolled it up into a cylinder. Try it. I think you will be surprised at how well it works.

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NOVELS

1. Life Probe - ^{US}$5.00

The Makers searched for the secret to faster-than-light travel for 100,000 years. Their chosen instruments were the Life Probes, which they launched in every direction to seek out advanced civilizations among the stars. One such machine searching for intelligent life encounters 21st century Earth. It isn't sure that it has found any...

2. Procyon's Promise - ^{US}$5.00

Three hundred years after humanity made its deal with the Life Probe to search out the secret of faster-than-light travel, the descendants of the original expedition return to Earth in a starship. They find a world that has forgotten the ancient contract. No matter. The colonists have overcome far greater obstacles in their single-minded drive to redeem a promise made before any of them were born...

3. Antares Dawn - US$5.00

When the super giant star Antares exploded in 2512, the human colony on Alta found their pathway to the stars gone, isolating them from the rest of human space for more than a century. Then one day, a powerful warship materialized in the system without warning. Alarmed by the sudden appearance of such a behemoth, the commanders of the Altan Space Navy dispatched one of their most powerful ships to investigate. What ASNS Discovery finds when they finally catch the intruder is a battered hulk manned by a dead crew.

That is disturbing news for the Altans. For the dead battleship could easily have defeated the whole of the Altan navy. If it could find Alta, then so could whomever it was that beat it. Something must be done…

4. Antares Passage - US$5.00

After more than a century of isolation, the paths between stars are again open and the people of Alta in contact with their sister colony on Sandar. The opening of the foldlines has not been the unmixed blessing the Altans had supposed, however.

For the reestablishment of interstellar travel has brought with it news of the Ryall, an alien race whose goal is the extermination of humanity. If they are to avoid defeat at the hands of the aliens, Alta must seek out the military might of Earth. However, to reach Earth requires them to dive into the heart of a supernova.

5. Antares Victory – First Time in Print – US$7.00

After a century of warfare, humanity finally discovered the Achilles heel of the Ryall, their xenophobic reptilian foe. Spica – Alpha Virginis – is the key star system in enemy space. It is the hub through which all Ryall starships must pass, and if humanity can only capture and hold it, they will strangle the Ryall war machine and end their threat to humankind forever.

It all seemed so simple in the computer simulations: Advance by stealth, attack without warning, strike swiftly with overwhelming power. Unfortunately, conquering the Ryall proves the easy part. With the key to victory in hand, Richard and Bethany Drake discover that they must also conquer human nature if they are to bring down the alien foe …

6. Thunderstrike! - US$6.00

The new comet found near Jupiter was an incredible treasure trove of water ice and rock. Immediately, the water-starved Luna Republic and the Sierra Corporation, a leader in asteroid mining, were squabbling over rights to the new resource. However, all thoughts of profit and fame were abandoned when a scientific expedition discovered that the comet's trajectory placed it on a collision course with Earth!

As scientists struggled to find a way to alter the comet's course, world leaders tried desperately to restrain mass panic, and two lovers quarreled over the direction the comet was to take, all Earth waited to see if humanity had any future at all…

7. The Clouds of Saturn - US$5.00

When the sun flared out of control and boiled Earth's oceans, humanity took refuge in a place that few would have predicted. In the greatest migration in history, the entire human race took up residence among the towering clouds and deep clear-air canyons of Saturn's upper atmosphere. Having survived the traitor star, they returned to the all-too-human tradition of internecine strife. The new city-states of Saturn began to resemble those of ancient Greece, with one group of cities taking on the role of militaristic Sparta...

8. The Sails of Tau Ceti – US$5.00

Starhopper was humanity's first interstellar probe. It was designed to search for intelligent life beyond the solar system. Before it could be launched, however, intelligent life found Earth. The discovery of an alien light sail inbound at the edge of the solar system generated considerable excitement in scientific circles. With the interstellar probe nearing completion, it gave scientists the opportunity to launch an expedition to meet the aliens while they were still in space. The second surprise came when *Starhopper's* crew boarded the alien craft. They found beings that, despite their alien physiques, were surprisingly compatible with humans. That two species so similar could have evolved a mere twelve light years from one another seemed too coincidental to be true.

One human being soon discovered that coincidence had nothing to do with it...

9. Gibraltar Earth – First Time in Print — $6.00

It is the 24th Century and humanity is just gaining a toehold out among the stars. Stellar Survey Starship *Magellan* is exploring the New Eden system when they encounter two alien spacecraft. When the encounter is over, the score is one human scout ship and one alien aggressor destroyed. In exploring the wreck of the second alien ship, spacers discover a survivor with a fantastic story.

The alien comes from a million-star Galactic Empire ruled over by a mysterious race known as the Broa. These overlords are the masters of this region of the galaxy and they allow no competitors. This news presents Earth's rulers with a problem. As yet, the Broa are ignorant of humanity's existence. Does the human race retreat to its one small world, quaking in fear that the Broa will eventually discover Earth? Or do they take a more aggressive approach?

Whatever they do, they must do it quickly! Time is running out for the human race…

10. Gibraltar Sun – First Time in Print — $7.00

The expedition to the Crab Nebula has returned to Earth and the news is not good. Out among the stars, a million systems have fallen under Broan domination, the fate awaiting Earth should the Broa ever learn of its existence. The problem would seem to allow but three responses: submit meekly to slavery, fight and risk extermination, or hide and pray the Broa remain ignorant of humankind for at least a few more generations. Are the hairless apes of Sol III finally faced with a problem for which there is no acceptable solution?

While politicians argue, Mark Rykand and Lisa Arden risk everything to spy on the all-powerful enemy that is beginning to wonder at the appearance of mysterious bipeds in their midst…

11. Gridlock and Other Stories - US$5.00

Where would you visit if you invented a time machine, but could not steer it? What if you went out for a six-pack of beer and never came back? If you think nuclear power is dangerous, you should try black holes as an energy source — or even scarier, solar energy! Visit the many worlds of Michael McCollum. I guarantee that you will be surprised!

Non-Fiction Books

12. The Art of Writing, Volume I - US$10.00

Have you missed any of the articles in the Art of Writing Series? No problem. The first sixteen articles (October, 1996-December, 1997) have been collected into a book-length work of more than 72,000 words. Now you can learn about character, conflict, plot, pacing, dialogue, and the business of writing, all in one document.

13. The Art of Writing, Volume II - US$10.00

This collection covers the Art of Writing articles published during 1998. The book is 62,000 words in length and builds on the foundation of knowledge provided by Volume I of this popular series.

14. The Art of Science Fiction, Volume I - US$10.00

Have you missed any of the articles in the Art of Science Fiction Series? No problem. The first sixteen articles (October, 1996-December, 1997) have been collected into a book-length work of more than 70,000 words. Learn about science fiction techniques and technologies, including starships, time machines, and rocket propulsion. Tour the Solar System and learn astronomy from the science fiction writer's viewpoint. We don't care where the stars appear in the terrestrial sky. We want to know their true positions in space. If you are planning to write an interstellar romance, brushing up on your astronomy may be just what you need.

15. The Art of Science Fiction, Volume II - US$10.00

This collection covers the *Art of Science Fiction* articles published during 1998. The book is 67,000 words in length and builds on the foundation of knowledge provided by Volume I of this popular series.

16. The Astrogator's Handbook – Expanded Edition and Deluxe Editions

The Astrogator's Handbook has been very popular on Sci Fi – Arizona. The handbook has star maps that show science fiction writers where the stars are located in space rather than where they are located in Earth's sky. Because of the popularity, we are expanding the handbook to show nine times as much space and more than ten times as many stars. The expanded handbook includes the positions of 3500 stars as viewed from Polaris on 63 maps. This handbook is a useful resource for every science fiction writer and will appeal to anyone with an interest in astronomy.

