SCI FI-ARIZONA
A Virtual Science Fiction Bookstore And Writer's Workshop

Writer's Workshop Series
The Art of Science Fiction
No. 22

Space War Fundamentals

By
Michael McCollum

"Peace Control Satellite Alpha-Nine floated into view fifteen minutes later. Like all such, it was constructed in two pieces. The thirty-meter-long cylinder that housed the hydrogen-fluorine gas dynamic laser and its fuel tanks was attached by a hundred-meter-long umbilical to a sphere painted in a haphazard pattern of light and dark checks. The ten-meter sphere was festooned with antennas, telescopes, and the more arcane paraphernalia of a dozen different kinds of information sensors and communications devices. The doghouse, as the sphere was called, was crammed solid with hardware that acted as the satellite's eyes and ears and brains. The umbilical — floating limply in space as the shuttle moved in slowly for a hard dock — connected the two halves of the satellite together and isolated the laser module with its sensitive aiming mechanisms from extraneous perturbations. For instance, the force of a hundred-ton shuttle coming to rest in the doghouse's docking collar, or the effect of the satellite commander doing his morning calisthenics.

"The satellite living quarters were located at the end of the doghouse arbitrarily labeled 'top.' They were tiny, consisting of a control center, shower bath, and combination galley and recreation-bunk room. The crew quarters of a PCS didn't have to be large. The satellite commander was the only crewmember. Even so, the UN had a perennial problem keeping seventy-two satellites manned with reliable people on a one-week rotation schedule. And what the satellite commander lacked in numbers, he more than made up for in firepower. At his fingertips were the controls to a hundred-gigawatt laser, powerful enough to strike down any opponent. And if needed, he would be backed up by the power of the space fleet."

#

Those of you who have been taking advantage of the free fiction available at Sci Fi - Arizona will recognize the excerpt above as having come from *Duty, Honor, Planet* (available for free download in the Free Fiction and Short Stories sections at Sci Fi - Arizona). I am particularly fond of this story for several reasons. The first, of course, is that it was my very first piece of fiction ever published. The second reason is that it made the cover of *Analog Science Fiction/Science Fact* in April 1979. At the time, making the cover of *Analog* was the pinnacle of my writing aspirations, and to make it the first time out — well, I didn't calm down for a week! The third reason that I am fond of *Duty, Honor, Planet* is something that happened some four years later.

At its heart, the story is about a series of laser battle stations lofted by the United Nations to act as guardians of the peace. There are 36 of these stations spaced like beads on a string in each of two 60-degree inclined synchronous orbits. That is, the stations

orbit at 35,800 kilometers (22,200 miles) altitude, the same as the communications satellites, but in orbits that are inclined 60-degrees to the equator. Comsats in geosynchronous orbit appear to hover at one point in the sky because they orbit in the plane of the equator. Laser battle stations in inclined synchronous orbits would also "hover" over one part of the planet, but would not appear stationary. Instead, they would sweep north and south in ungainly figure eight patterns, taking a full day to make the circuit. A 60-degree orbital inclination would cause the stations to sweep as far north as Alaska and as far south as Australia each orbit. With two strings of such satellites in orbit, every major city on Earth would have a laser battle station high in its sky four times each day. These guardians would be perfectly positioned to destroy missiles and aircraft launched by an aggressor nation against its neighbors. Thus, the laser battle stations are called Peace Control Satellites and are manned by officers of the UN Peace Enforcement Directorate.

Duty, Honor, Planet was written in 1978, and is obviously fictional. However, on March 23, 1983, President Ronald Reagan took a giant step toward making such a system reality. That was the evening he went on national television to announce his intention to launch the Strategic Defense Initiative (SDI), the program to build "Star Wars." (The name "Star Wars" was applied to the program by its opponents, but stuck. Now supporters call it that as well. If it ever comes to fruition, I wouldn't be surprised if the official logo will be Darth Vader in silhouette.)

Of course, the specific details of SDI were different from my constellation of laser battle stations in *Duty, Honor, Planet*. For one thing, my system was much more technologically advanced than anything we could build today. Still, the basic plan is similar. If you place a laser or an orbital interceptor above the atmosphere, you have dramatically altered the military equation. No longer will the defenders have to gaze skyward to detect an incoming reentry vehicle falling down on their heads at Mach 6. With antiballistic missile lasers in orbit, the advantage moves to the defenders. It is the aggressors whose rockets must climb ponderously into space, fighting gravity every moment; while overhead, potent weapons systems track the rocket's every move. A laser battle station with a sufficiently powerful laser can knock down anything it can see, and do so at the speed-of-light. Any propaganda you may have heard about defending against a laser attack is just that — propaganda.

As Ronald Reagan pointed out at the time, this technology renders the doctrine of "mutually assured destruction" obsolete. Personally, I think this would be a very good thing. Even after the fall of the Soviet Union and the end of the Cold War, most people don't realize that we are defenseless against any sort of ICBM attack. With the current flap over North Korea's nuclear ambitions and the fast approaching deployment of our first, extremely limited antiballistic missile interceptor system, the subject is even more timely today than when I originally wrote the short story.

(Because my story was published four years before Ronald Reagan proposed SDI, I tell people that it was my idea before it was his. In fact, I would like to think that he got the idea from me. This is unlikely since Reagan was not known for his love of science fiction. Still, I wouldn't mind starting the rumor!)

What my first short story and the Strategic Defense Initiative have in common is the idea of using space as a theater for military operations. And, in fact, we have already done so. We operate dozens of spy satellites and military communications satellites in

orbit, as well as the Global Positioning System. All of these will figure prominently in any future war. Thus, it is hardly surprising that our potential adversaries have developed systems to shoot these satellites down. In fact, both the US and the Soviet Union built anti-satellite weapons in the final years of the Cold War. These weapons were relatively crude and ineffective, but you can be sure that progress in anti-satellite weaponry will be rapid should a need arise in the future.

I spent much of my adult life building weapons to fight the Cold War, yet nothing would have made me happier than if we could all live in peace forever. As we all discovered the hard way on 9-11, that was not to be. (As I write this, Specialist Michael K. McCollum, 855 Military Police Company, Arizona National Guard, is just finishing up a one year tour of duty in Iraq. This time next month they will be packing to leave the garden spot of Al Fallujah behind and in the tender care of the U.S. Marines!)

War in space will be fundamentally different from any conflict we have yet seen on Earth. There will be no hordes of infantrymen crawling through the mud on their bellies while machine guns cleave the air with bullets just above their helmets. Nor will there be great ships plunging through giant waves, white foam breaking over their bows as the massive 16-inch gun turrets swing ponderously into line with their targets. Nor will squadrons of aircraft engage in vast dogfights that turn the clear blue sky into a Gordian knot of contrails.

War in space will take place amid infinite vacuum against an ebon backdrop sprinkled with a few stars and one large yellow-white glowing ball. The only color in space will be the violet bursts of nuclear tipped missiles; or the red, green, and violet sparks of lasers stabbing across the vacuum to destroy their enemies. The usual din of battle will be likewise absent. War in space will take place in complete silence. The only sounds to be heard will be the rapidly diminishing radio screams of those whose spacesuits have been punctured by flying debris. Nor will space war be restricted to the narrow band of atmosphere that blankets our puny 12,700-kilometer diameter world. In the future, combat will range from a low of 100 kilometers altitude to a high of — well, infinity! Someday, the very stars in the sky will be our species' battleground.

This, then, is the topic for this month — combat beyond the atmosphere, conflict above the clouds, battle beyond the moon. Put on your armored spacesuit, dog the helmet into place, make sure your faceplate isn't fogged over, warm up the tactical display on your acceleration couch, and strap yourself in tight! Space war is about to commence!

Space War – Hollywood Style

Since *Star Wars* (the movie, not the Pentagon program), we have all become familiar with what space battles look like. Ponderous Star Destroyers and Cruisers lumber through the void while around them dart the small, agile shapes of X-Wing and Tie Fighters. The smaller ships weave and bob while the larger ones blast away with turrets that bear a striking resemblance to the anti-aircraft gun mounts on a World War II battleship. We know that space war will be a bobbing, weaving affair with slashing lasers and stabbing guns because the special effects wizards of Hollywood have told us so.

The prototype for this action, of course, is the air-to-air combat in which airplanes have engaged since the first time a World War I pilot pulled out his pistol and blasted

away at an enemy aircraft. For more than eighty years we have become familiar with the swooping, dodging, dog fighting that is aerial combat. When two opposing pilots encounter one another, they quickly engage in a duel of maneuver. They wrench their aircraft into high gee turns, vertical loops, and split-S maneuvers. This deadly dance goes on until one of the contending pilots gets behind his opponent or inside on a turn. As soon as his sights come to bear on his opponent's silhouette, the victorious pilot squeezes off a killing burst of machine gun fire or launches a missile.

Have you ever considered the reason behind this fast paced game of "chicken" that takes place high in the sky? The violent motions of aerial combat maneuvers are compelled by the way an airplane flies. An airplane is nothing more than a winged dart under its own power. Thus, an airplane goes wherever it is pointed. Its ability to maneuver is constrained by the need to "keep the pointy end into the wind." The large wings and the empennage (tail surfaces) guarantee that any attempt to fly sideways will result in loss of lift and control, and if done at sufficiently high velocity, could cause the plane to disassemble itself violently in midair! Thus, aircraft are confined to banked turns, lateral rolls, and vertical loops, and prevented from ever turning around in flight and proceeding ass-backwards through the wild blue yonder. The enemy pilot, of course, knows this limitation and strives to take advantage of it by getting behind his foe.

If the space battles in our movies resemble air battles of the past, something similar can be said of our movie spaceships. No matter how far in the future a story is set, the spaceships of that era invariably reflect the aircraft designs of the age in which the movie is made. This isn't to say that cinematic spaceships necessarily resemble aircraft in a physical sense. Yet, the futuristic technology we dream up has an unbreakable bond with present-day flying machines. They reflect our era more than they accurately portray what will eventually be possible. In some respects, this is inevitable, given the inherent difficulty of predicting the future. But there is also a cultural phenomenon at work, one that every writer needs to understand in order to use the effect to his or her advantage.

One of the first science fiction movies was by an early French director in which he chronicled a journey to the moon. In that movie the intrepid astronauts travel inside a giant, hollowed-out cannon shell. And, why not? That was the way Jules Verne did it in *From Earth to the Moon*. There are also a few balloons in evidence at the launch, not to mention dancing girls (it *was* a French movie, after all). Balloons were state-of-the-art aviation at the time, and to a contemporary audience, they must have looked very modern indeed. In the 1930s, Buck Rogers and Flash Gordon's spaceships were reminiscent of the ungainly biplanes of the day. Not that they looked anything like the cloth-and-bailing-wire kites that were state-of-the-art 25 years after Kitty Hawk. The spacecraft were much sleeker machines without propellers or wings. Yet, the mighty dreadnoughts of Ming the Merciless droned steadily through the sky, making flat turns, and generally aping the movements of a 1930's airplane, all the while spewing a stream of rising smoke out the tail. If I didn't know better, I would have suspected someone had stuck a sparkler up the tail of a balsa wood model!

Then there was the early 1950's serial hero, *Commando Cody*, the prototype for Disney's *The Rocketeer*. When he flew his spaceship from Earth to the Moon, he flew through a blue sky populated by fleecy white clouds, apparently because the audiences of the day didn't realize that the atmosphere doesn't reach infinitely in all directions. Or

perhaps they did know, but the cost of simulating space would have been financially prohibitive for the cash-strapped Republic Studios.

This tendency to translate the technology of the day into futuristic hardware is not due to the lack of imagination of those who make the movies. Rather, it is often predicated on the level of knowledge of the viewing public. As late as the 1960's, when Gene Roddenberry produced his landmark *Star Trek* series, it was necessary to give the *Enterprise* a quiet "swishing" sound as it rocketed past the camera during the initial credits. Apparently, Roddenberry tried it without the *swish* (which is the norm for space due to the lack of atmosphere), and found the scene to be lifeless. The sound effect was added to give the audience an impression of great speed, and in fact, the anachronism is hardly ever noticed.

Hollywood caters to the viewing public, giving them only what the directors think they can understand. Thus, even the most futuristic movie becomes quickly dated because it is tied to the concepts and conventions of the year in which it was made. Even Stanley Kubrick's *2001* is dated by such mundane things as the fact that the orbital craft belongs to *Pan American Spacelines,* and we all know what happened to *Pan Am* in real life.

It is important for writers to remember that movies and books aren't objective pictures of how things will be, and indeed, are not intended to be. For one thing, we have no idea how things will turn out in the future. If you disagree, ask yourself the following question: "How many science fiction writers accurately predicted the advent of the personal computer?" They can be counted on the fingers of one foot!

Futuristic movies and science fiction books are translations of a story into terms viewers and readers can understand. You've all seen movies in which the characters are all German, yet the dialogue is in English. The characters speak our language while everyone pretends they are speaking their own. Sometimes the technique is rendered more effective by having the foreign characters begin speaking his own language, then quickly transition to English after a few seconds. By starting out in their native tongue, the characters establish their "foreign-ness," then the director gets on with the serious business of entertaining the paying customers and eliminating the subtitles. I can think of two movies that did very effective jobs of pulling off this transition: *Judgement at Nuremberg,* when the German defense lawyer switches languages in the middle of his opening remarks, and again in *The Hunt For Red October,* when the *zampolit* (political officer) is reading out of the captain's book of scriptures.

Think of your average science fiction novel as being an English language film about a group of foreigners. The people in the future will undoubtedly have different mores, as well as different ways of thinking and acting; yet, if the reader is going to be entertained, you must translate your characters' actions into an idiom that contemporary audiences can understand. This, then, is why space war, no matter how far in the future, inevitably ends up looking like contemporary war. It has to if the readers are going to understand it!

Which brings us back to the subject at hand, namely how do you write a convincing battle scene between spaceships? As in much of life, the answer to that question is: "It depends on what sort of spaceships they are." At our current level of technology, war in space is liable to be fairly boring. That is because our ships lack the propulsive capability to do much maneuvering beyond getting themselves to the scene of the battle, then getting the survivors home again. Space conflict in the near term will resemble a duel

between two supersonic fighters less than a duel between sailing ships in the Napoleonic Wars. They will spend hours or days maneuvering into position for a short, sharp exchange of "broadsides." Except, of course, no spaceship is ever likely to synchronize its orbit with another and then begin trading cannonballs. Spacecraft are too delicate for pounding duels.

So, let us look at how space battles will take place in the real world rather than in the movies.

Space War – The Reality

One of the human race's difficulties in conquering space is that we have invented only a single method for maneuvering in vacuum. That method is the rocket engine. Although there are a number of ways to build a rocket, they all work by throwing mass away at high velocity in the direction opposite that in which they move. Such an engine is called a *reaction engine* because it operates on the principle of Newton's Third Law: *For every action, there is an equal and opposite reaction.*

The problem with rockets is that they aren't very efficient. Remember, in generating its forward velocity, the rocket throws reaction mass out into space faster than the *Titanic* took on seawater. In fact, it is losing mass a *lot* faster! Since a rocket ship has only a limited supply of reaction mass onboard, it doesn't take long for the engine to exhaust every gram of this precious stuff. Once that happens, the crew has a problem. In the friction-free, microgravity environment of space, Newton's First Law (an object in motion will tend to stay in motion) takes over with a vengeance. If a ship runs out of fuel, it is stuck in that orbit until someone either delivers a new load or hell freezes over, whichever occurs first. Without fuel, the hapless crew is on a journey to infinity. A common characteristic of infinite journeys is that you tend to run out of food, water, and air long before you get where you are going.

So a rocket-powered space navy is unlikely to be gallivanting around the universe, flitting hither and yon. Their movements will be careful and direct, with no wasted motion or long detours. In space, you fly directly at your enemy, not because that is the best tactic, but because your fuel stocks leave you little other choice. Attacking an enemy space fleet with a rocket-powered warcraft involves careful calculation, a few minutes of powered flight, followed by days, weeks, or months of coasting in a predictable orbit. Only at the end of the journey, when the enemy is about to come into range, can a rocket spare sufficient fuel for evasive maneuvers, and those involve randomly changing the ship's transverse velocity by a few meters-per-second to throw off an enemy's aim.

Ships in space can either close on the enemy in a parallel orbit, which will put the two sides in a position to trade broadsides like the old ships-of-the-line, or else they can intercept on intersecting orbits, in which case the exchange of fire will be short and furious. For head-on attacks, both fleets move in the same orbit (but in opposite directions) and interpenetrate each other's formations at speeds in excess of 20 kilometers per second. The human eye is too slow to see the enemy in such an engagement. The only way to tell you are at war is via long-range detection, and possibly, when an unseen missile suddenly vaporizes your ship.

After the two fleets interpenetrate one another, there will come long hours or days of deceleration as both attempt to reverse their orbits, assuming that either retains sufficient fuel to do so. Most battles may be a matter of a single pass and then a return to base.

There is one special case that will allow repeated passes between two combatant ships or fleets. If the two foes are both in orbit about Earth or some other planet, and if their orbits intersect at some point, then they can engage one another repeatedly without using up additional fuel. That is, they can do so assuming their orbits are synchronized such that they reach the same point at the same time. The easiest way to ensure multiple passes at your enemy is to take up their orbit going in the opposite direction. That way, the two fleets can slug it out each time they pass until one of them gives up the fight and breaks orbit.

One thing that most people don't realize is that, unlike an airplane, a spacecraft's orientation with respect to its forward velocity is completely arbitrary. The reason for this is the lack of atmosphere in space. This means that spaceships are perfectly happy flying upside down, backwards, or at right angles to their orbital direction. The Space Shuttle routinely flies upside down and tail first (when it isn't grounded, of course). Not only does it give the crew a better view of Earth; it makes it easier to de-orbit when the time comes. A space fighter is more liable to be a collection of haphazard geometric shapes than a sleek winged dart; unless, of course, the ship is designed to fly in atmosphere.

So in space, individual ships will no longer swoop and weave, chasing one another through the sky, each trying to get behind its opponent. Unlike airplanes, spaceships don't have to keep the pointy end into the wind. And since such a ship can fly facing backwards as well as forward, attempting to sneak up behind it is a good way to get shot.

Orbits

Since a spaceship is not under continuous power like an airplane or a ship, it travels a predictable path through space; a path called an "orbit." Most orbits in the solar system are egged shaped, or ellipses. Even Earth's "circular" orbit is actually an ellipse, although only barely so. (The Earth's orbit is within 2% of being perfectly round).

By changing its velocity, a spaceship changes its orbit. Thus, maneuvering in space is mostly a matter of transitioning from one orbit to another until you get where you are going. Take, for instance, the problem of getting from Earth to Mars. A ship in Earth orbit bound for Mars doesn't merely light off its engines randomly. It waits until its orbital velocity is aligned with the Earth's own orbital velocity as it circles the sun. This happens with the ship in total darkness as it passes over the night side of the planet (assuming that the ship is in an east-west orbit).

The spaceship transitions from Earth orbit to solar orbit when its speed increases to 1.4 times Earth orbital velocity. Shortly after that, it shuts down its engines to conserve fuel. Having escaped the home planet, the ship coasts along an elliptical orbit, rising away from the sun as it moves slantwise outward toward the orbit of Mars. After that, there isn't much to do but wait. It takes a spaceship in a minimum energy orbit nearly two years to reach the vicinity of Mars. Assuming the captain has planned his mission properly, he finds Mars coming up fast behind him just as his ship reaches apogee, the

highest point in its orbit. (Actually, the technical term is aphelion for solar orbits, but this subject is complex enough without becoming pedantic.)

If the captain does nothing, his ship will begin to fall back toward the sun just as Mars reaches his position. Since that is not his intent, he fires his engines at apogee, speeding up and moving from the elliptic "transfer" orbit to a circular orbit about the planet.

If you didn't completely understand any of the technical stuff above, don't worry about it. Just remember that a spaceship changes its orbit by changing its velocity, which in turn requires it to expend reaction mass. Thus, for any given fuel load, there is a limit to how much a ship can maneuver, and that limit puts a serious strain on the range and flexibility of any rocket-powered warcraft.

So space battles are likely to be fast, violent affairs rather than prolonged slugging matches. This sort of battle will put a premium on weaponry that can do a lot of damage in a short time. What sort of weapons would be best for space battles?

Weapons In Space

As in the overall shape of space battles, Hollywood has provided us with a good idea of what sort of weapons spaceships will use against one another. The *Starship Enterprise*, for instance, is armed with phasers and photon torpedoes. Just exactly what a phaser is, of course, is a secret Gene Roddenberry took to the grave with him. However, it isn't too much to call it by its older name — ray gun. A photon torpedo, on the other hand, is some sort of nuclear tipped missile.

In real life, of course, we have nuclear weapons and lasers as the preferred weapons for space battles. Yet, here too, people may have some misconceptions about how things will be.

Fission, Fusion, or Laser?

As I noted at the beginning of this chapter, a laser in space is a weapon unlike any we have ever seen. With no air to deflect or refract the beam, a spaceborne laser has a nearly unlimited range. The power the laser can deliver on a target is only governed by the inherent power of the beam and the weapon's ability to focus the beam on a target.

Compared to a laser, a nuclear weapon is a crude device indeed. However, in battles that rage over thousands of cubic kilometers of vacuum, something smaller probably won't be sufficient to get the job done. In addition to their heat, light, and particle radiation (all good for boiling the hull plating off opponents' ships), nuclear explosions generate electromagnetic pulses (EMP) that are liable to wreak havoc with your opponent's electronics.

Still, why kill flies with an intercontinental siege gun (a nuclear weapon) when you can slice them open with a tiny little scalpel (a laser)? In real life there may be no reason to revert to nuclear tipped missiles, but we aren't in real life. We're fiction writers. And as I have discovered to my dismay more than once, in fictional space battles, missiles are to be preferred over lasers.

That statement may seem counterintuitive, but it is true nevertheless.

In my book *Life Probe*, the climactic scene is a space battle between the UN Peace Enforcers and the villains. When I originally wrote the scene, I had the two sides pounding away at one another with high-powered lasers. I remember finishing that scene and not being satisfied with it. After studying the problem for a few days, I realized what it was that was bothering me. When the ships fight with lasers, the story doesn't develop enough dynamic tension. The reason for this wasn't difficult to figure out.

Do you remember your mother or father telling you not to be frightened of thunder? Probably they explained that it couldn't hurt you by saying, "if you hear it, then the lightning has already missed you." The same is true for combat with lasers. A laser can hit anything it can see, and it destroys its target at the speed of light. Both of these characteristics combine to rob the laser of its suspense building power.

Now if the combatants are fighting with missiles, there is an automatic buildup of suspense the moment an enemy ship launches its missile. You've all seen the effect in submarine pictures. One moment the ship is cruising along without a care in the world, and the next the sonar man screams, "Torpedo in the water!" Instantly, the captain orders his ship to full speed and to release "countermeasures." That evasive action taken, there is nothing to do but listen to the whine of the torpedo getting louder through the hull, while the whole crew wonders if it will hit them.

The principle I learned in writing the battle scene for *Life Probe* was that lasers strike in zero time, but missiles give you a heightened feeling of suspense. The former is better if you are in a real space battle, but the latter is better for the purposes of fiction. If you know the outcome of the combat the instant a weapon fires, then there is no time to let that delicious, cold shiver traverse the length of the reader's spine. Worse, you haven't given the hero time enough to work his magic and save the ship. And make no mistake about it. We writers will choose building suspense over technical accuracy any day. We call it entertainment!

Unconventional Weapons

What if, as we postulated earlier, space battles are hit and run affairs? If the two sides approach on converging orbits, open up with everything they have for a few seconds, then pass one another and head off into the deep black, do we really need the power of a nuclear weapon to destroy the enemy? Wouldn't a load of gravel work just as well?

"Gravel?" you ask.

That's what I said. Given the right conditions, a missile that exploded in front of an enemy ship and dispersed a cloud of tiny particles into its path would destroy it every bit as effectively as a direct hit with a nuclear weapon. That is because a spaceship traveling at tens of kilometers per second has considerable kinetic energy. A relatively small projectile can totally vaporize a ship if it has a high enough velocity.

The destruction that accompanies impact at hyper-velocities is something that is not well understood. In books and movies, a spaceship hit by a meteor has a hole punched in it, one that the crew can patch. However, the SDI program actually intercepted an incoming reentry vehicle with an antiballistic missile in the late 1980s, and the result surprised everyone. Instead of being wrecked by the collision like two cars that hit head-on on the highway, both interceptor and target were instantaneously vaporized. It

happened so quickly that the collision didn't truly have a chance to get started. At the first touch of the interceptor against the target, a strong compression wave raced through both spacecraft, turning them instantaneously into hot, glowing gas. The result was that instead of canceling out their mutual forward momentum, the two clouds interpenetrated one another and continued on the same course the spacecraft had held moments earlier.

This discovery that even a tiny object traveling at hypervelocity can vaporize a much larger target is the genesis for the "Brilliant Pebbles" idea. Brilliant Pebbles was another concept of the Strategic Defense Initiative, one where designers would miniaturize anti-satellite rockets to the size of a large baseball. As the scientist who thought up the idea said, "If a single gram is all you need to knock down an ICBM, then everything more than a gram is overkill!" And since spaceships in countervailing orbits are approaching one another many times faster than the SDI antimissile tests, the principle holds even more true in space war than for missile defense. Never mind spending all of that money on expensive nuclear warheads. Just load your orbital dump truck full of sand, haul it into orbit, and let Newton's various laws take over the task of destroying your enemies.

Conclusion

We have concentrated this month on space war in the near term and have discovered that our ability to project power into vacuum is likely to be limited for some time to come. Perhaps this is good. If our ships are only capable of sporadic hit-and-run attacks, and vulnerable to well-aimed bits of flotsam, then perhaps we will "practice war no more." Perhaps, but I wouldn't bet on it. Human beings are too cantankerous for eternal peace to ever break out; at least, not until we learn to control our tempers, our pride, and our will to dominate everything in sight. But then, would we still be human?

The End

Sci Fi - Arizona
A Virtual Science Fiction Bookstore and Writer's Workshop

Michael McCollum, Proprietor
WWW.SCIFI-AZ.COM

If you enjoy technologically sophisticated science fiction or have an interest in writing, you will probably find something to interest you at Sci Fi - Arizona. We have short stories and articles on writing– all for free! If you like what you find, we have full length, professionally written science fiction novels in both electronic form and as hard copy books, and at prices lower than you will find in your local bookstore.

Moreover, if you like space art, you can visit our Art Gallery, where we feature the works of Don Dixon, one of the best astronomical and science fiction artists at work today. Don is the Art Director of the Griffith Observatory. Pick up one or more of his spacescapes for computer wallpaper, or order a high quality print direct from the artist.

We have book length versions of both Writers' Workshop series, "The Art of Writing, Volumes I and II" and "The Art of Science Fiction, Volumes I and II" in both electronic and hard copy formats.

So if you are looking for a fondly remembered novel, or facing six hours strapped into an airplane seat with nothing to read, check out our offerings. We think you will like what you find.

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.

