WELCOME TO:

Science Fiction \ Space Technology :

Tools for Learning

This material is part of the NASA JSC document: SPACE EDUCATORS' HANDBOOK which is designated as document number OMB / NASA Report Number S677.
SCIENCE FICTION/SPACE TECHNOLOGY: A TOOL FOR STEM LEARNING

(Detailed Abstract and Outline)

For the past 25 years, the presenter, NASA Engineer Jerry Woodfill (creator of the NASA Space Educators’ Handbook) has engaged students and faculty in STEM related lessons. These employ SCI-FI concepts compared to actual spacecraft, rockets and aerospace principles. The effort was an outgrowth of meeting with NASA area math/science educators in 1988. NASA/JSC asked for innovative STEM concepts for the classroom. To this end, using science fiction themes in popular culture, media, comics, and art Jerry authored a popular website for NASA entitled Science Fiction/Space Technology; Tools for Learning. (http://er.jsc.nasa.gov/seh/scifi.html) The content has never been formerly presented at an educational or technical conference though it has been approved by NASA as OMB Report No. 677B. The SEEC presentation will adapt the concept to specific classroom exercises and lessons. A syllabus booklet will be provided attendees for use in their lessons plans. The 90 minute session will be organized in the fashion outlined below:

1. (30 minutes) Description of the approach of comparing science fiction devices to actual spacecraft and rockets for learning purposes. Rudimentary foundations of classical science and space/aerospace principles are employed in this STEM learning process. (Newton’s laws, the gas law, energy, momentum principles, etc. as related to basic spacecraft systems and design) This will include
inexpensive dollar store models and items which instructors can readily acquire to perform lessons in the classroom.

(See inside back cover to continue.)

2. (30 minutes) Analysis of a half dozen science fiction examples (scifi movies, fictional scifi cover art, comic book covers, etc.) demonstrating the analysis process used to engage students in performing a NASA-like feasibility study of the STEM plausibility of the selected examples.

3. study of the STEM plausibility of the selected examples.

4. (30 minutes) Attendees are given models, comic book covers, and pulp magazine cover art to analyze based on knowledge acquired during the previous 30 minute sessions of the presentation. Each attendee will record the item chosen along with scientific flaws the participant discovered based on the process taught in the previous discussions. The presenter will interact with the group to discuss their findings. At the conclusion of the session, each attendee will be provided a 40 plus page booklet as a classroom resource to implement:  *Science Fiction/Space Technology: A Tool for STEM Learning.*

*Science, Technology, Engineering, Mathematics*
SCIENCE FICTION SPACE TECHNOLOGY:
A TOOL FOR LEARNING
by Jerry Woodfill

CONCEPT

Have the students analyze space science fiction rockets, robots, etc. found in movies, comics, and novels. Ask them to find:
(1) What about these devices is possible with today's technology?

(2) What is probably not possible with today's technology?

(3) What new technology is needed to make these science fiction devices work?
STUDY PROCEDURE

Ask each student to choose a science fiction technical device to analyze. Outline for the student a suggested study approach:

1. Study existing technology (space shuttles, space stations, lasers, robots) similar to the selected item.
2. Decide what features of the studied item are like today's technology.
3. Determine what is unlike today's technology.
4. Explain what new way of doing things has to exist for the science fiction item to work.
5. Finally, for extra credit, design (add to the original sketch) items overlooked by the science fiction author or artist that should have been included to make the science fiction device work.

Using the following information familiarize the student with the design of manned spacecraft systems. Next, have the students sketch and analyze science fiction rockets, robots, etc. found in movies, comics, and novels. (SCIENCE FICTION / SPACE TECHNOLOGY : TOOLS FOR LEARNING features numerous examples of this process.)

SYSTEMS REQUIRED BY MANNED SPACECRAFT

Spacecraft, like automobiles, require certain basic systems to function properly. Among these systems are: PROPULSION (engines), GUIDANCE (steering), LIFE SUPPORT (air to breathe, food and water), CABIN QUARTERS (manned operations and living area), COMMUNICATIONS (radio transmission and reception), THERMAL PROTECTION (isolation from the extreme temperatures of space as well as the heat of reentry), DISPLAYS AND CONTROLS (a means of flying/controlling and monitoring the status of the spacecraft's performance - switches and gauges).
SCIENCE FICTION AND MANNED SPACECRAFT SYSTEMS

Science fiction authors, artists, and illustrators generally portray the same basic systems as listed above in their literature and art. This document discusses the fictitious scientific substitutes for the above systems. Additionally, the science fiction spacecraft technology study reviews historic sci-fi artwork for scientific feasibility in light of current knowledge of spacecraft technology. Obviously, much art is drawn simply to represent the appearance of space technology. The illustrator ignores technical details achieving the desired effect through "artistic license." For this reason, no criticism of the reviewed artwork is intended. Some of the most impressive illustrations exhibit the greatest number of scientific incompatibilities.

The following twentieth century space systems have counterparts in the world of sci-fi technology: PROPULSION: (FTL - faster than light propulsion, Cavorite-antigravity material, warp drive - a means of exceeding the speed of light), GUIDANCE (steering without thrusters, spherical thrusters), LIFE SUPPORT (generation ships, hibernation biology, suspended animation, cryonics), CABIN STRUCTURE (space arks, world spaceships), COMMUNICATIONS (mental telepathy, molecular transporters), THERMAL PROTECTION (often ignored), DISPLAYS AND CONTROLS (standard video viewers as well as telepathy techniques).

SCIENCE FICTION SPACE TECHNOLOGY SYSTEMS

The following items are found in science fiction literature as technologies useful inauthoring a plausible setting for a sci-fi story:

PROPULSION: Faster Than Light Drive (FTL) is required for stories about star based exploits. Twentieth century
rocketry is limited to activities in the Solar System. At present spacecraft velocities, the nearest star would require voyages of thousands of years. At the speed of light, the nearest stars could be reached in decades of time. Several types of FTL systems are found in sci-fi literature. Among these are warp drive, the use of black holes, and a particle based propulsion concept using tachyons, a type of matter which has no mass but only energy. By converting spaceships to their tachyon equivalent, a speed greater than that of light is supposed to be possible. Einstein's equation requires that the mass of an object grows to infinity as the speed of light is reached. Since the ship is composed of no mass, it does not experience such growth. A nice idea, but one whose time has not yet come except in the annals of sci-fi literature.

The use of black holes to achieve FTL drive is based in part on Newton's law of gravity. Astronomers believe black holes are entities of huge compressed matter so dense that the attraction force (gravity) can pull particles, planets, or spaceships toward them at speeds approaching that of light. Sci-fi authors elaborate on black hole theory theorizing that a space ship can enter a black hole and emerge in another universe. By entering another black hole, the same ship may then return to a different location in the original universe at light year's distance from the initial entry point. This is a variation of the FTL warp drive creation of science fiction.

An oft employed propulsion system is the anti-gravity material. Cavorite was one of the first sci-fi antigravity materials to emerge in the literature. An artful creation of H.G. Wells's protagonist Dr. Cavor, it had the ability to repel mass in the same fashion as like poles of a magnet repel one another. One such author's antigravity device was called the "spindizzy." Others describe antigravity devices as "gravitron-polarity generators" based on the analogy of gravity and magnetism.

**GUIDANCE:** Little is written in science fiction literature about spacecraft steering techniques. Perhaps, that is why sci-fi artwork ignores steering thrusters, a space technology essential to the Apollo lunar landing. Examination of most sci-fi spacecraft fails to reveal reaction control thrusters. NASA uses other means
One of these is the control moment gyro. Within the body of a satellite, a spinning gyroscope device will redirect the direction of the vehicle pitch, roll, or yaw, if the internal gyro's axis is moved to another direction. Such devices are seldom used for spacecraft of large mass because they also would have to be of large mass to quickly alter the course of a space vehicle. CMGs are effective for low mass satellite probes but impractical for manned space vehicles.

A steering device seen in sci-fi art which will serve to guide spacecraft is the spherical thruster. By gimbling a single thruster in three axis, its direction can provide pitch, roll, and yaw without the use of sets of x, y, and z stationary thruster pods.

**LIFE SUPPORT:** Among the types of starship vehicles and science fiction technologies which provide life support for interstellar travel are generation and world ships as well as hibernation biology and cryonics.

The generation ships and worlds in space treat the dilemma of reaching a setting among the stars differently than FTL schemes. Rather than offend those who hold dearly to Einstein's theory, these concepts allow for velocities far below light's by substituting whole worlds for spaceships. If a spaceship is built to a mammoth scale, containing all the atmosphere and resource needs of Earthlings, one need not worry about the length of the journey. Of course, those who rocket to the stars in such craft will never experience the mission's completion, but they will have the satisfaction of knowing that hundreds of years in the future their progeny will finish the journey. Based on the known cost of putting a mass in low Earth orbit, such schemes seem economically as impossible as FTL propulsion. Present 1990s cost of lofting a pound of Earth weight to orbit is approximately $4000. The cost of launching a huge generation ship on a mission to the stars would consume the gross national product of all the countries of the Earth.

Another approach for reaching the star avoids the problems of FTL propulsion as well as the cost of launching a world into space. It treats the biology of aging. If the maturing processes of the human body can be slowed or even terminated such that the
star voyager's body can be revived at the conclusion of the centuries long mission, then neither impossible speeds or spacecraft are needed. The science of cryonics deals with the cooling of the human body to liquid nitrogen temperatures (-196 degrees Centigrade) in hopes of later thawing in a fashion which can resurrect the life of the "frozen chosen." To date, no success has been realized except for using cryonics on embryos. After 10 years a thawed embryo has provided reproductive life.

**CABIN STRUCTURE:** Most sci-fi art portrays reasonable cabin structure architecture for space vehicles except for the mammoth space arks, generation ships and worlds in space discussed earlier. Futuristic artwork need show little about the multilayered design of spacecraft such as the NASA space shuttle, however, artwork showing space wrecks, damage from space combat, and the remains of discarded and damaged spacecraft must consider accurate cabin mechanical design. Showing a superstructure with a skeleton of massive cast iron is, of course, inaccurate.

**COMMUNICATIONS:** Early in the space program, the importance of communicating with vehicles launched into the cosmos became obvious. The primary purpose of communication was to assess the status of the spacecraft's systems rather than conversation with the crew. For starships, the latter purpose is probably most important. At light year's distance from Earth, mission control's assistance would be limited but word from home would do much to comfort the crew psychologically. In either case, some sort of antenna must be available to transmit the radio waves to Earth. This piece of essential space hardware is often not found in space sci-fi art. Without antenna mechanisms, a form of telepathy would be needed where the mind in some fashion can generate a type of "thought-wave" which can be transmitted and received by technology specially created for the purpose.

A particularly fascinating replacement for spacecraft communication is the molecular transporter often used in the STAR TREK series. Why worry about communications when one can simply be transported to the location of the receiver? The matter transporter, as this concept is often called, is one of science
fiction's oldest creations. The device is able to reconstitute the atoms and molecules comprising starship matter at a remote location using material insitu at the distant environment. It would be analogous to having all the parts of a rocket model kit resident on Earth and a constructed version of the rocket in a starship's molecular transporter. By transmitting the instructions to build the kit to Earth, the rocket model is "beamed" to the home planet. Imagine that every atom and molecule of the human body is a kit resident on Earth. Star Trek's Captain Kirk steps into the transporter and his being is reconstructed in microseconds. A problem remains. The intelligence to construct the Earth kit must be transmitted by some form of radio communication which, of course, requires an antenna. In actuality, leaving out the antenna makes the matter transporter another type of telepathy communicator.

**THERMAL PROTECTION:** The laws of thermodynamics are often violated in sci-fi art and literature. These laws require that heat flows from a hot source to a cold sink, i.e., heat does not flow up-hill from cold to hot. Additionally, the laws of thermodynamics require that order does not result from disorder, i.e., the natural evolution of the universe is from order to disorder. To show a planetary landing craft without means of eliminating or protecting its contents from the frictional heat of atmospheric entry violates the heat flow law of thermodynamics. Air molecules become very hot generating considerable heat which will flow into the cooler interior of the spacecraft and crew cabin either destroying spacecraft systems or killing the crew.

**DISPLAYS AND CONTROLS:** It is a credit to science fiction that the concept of a video viewer (which we now call television) was first predicted. The idea of electronic viewing windows to replace actual windows has long been a feature of science fiction displays. In recent years, computer graphics and digital television have more than fulfilled the sci-fi predictions of video technology. In some cases, the state of the art has exceeded sci-fi as is the case with the application of virtual reality. Generally, sci-fi artists portray spacecraft control and display
technology accurately. The command bridge of the Enterprise has long been a plausible control center for a NASA-like space station.

**OTHER SYSTEMS:** While other systems are required for the successful design and operation of a manned spacecraft or starship, the above are cited by virtue of their viewability in sci-fi illustrations and art. Spacecraft require power generation and distribution systems as well as internal instrumentation sensors with networks of data buses. Such systems are seldom discussed in science fiction literature and will generally be ignored in this document as well. Other essential systems such as environmental control are indirectly addressed in critique of spaceship types, cabin structure, etc.

---

**SCIENTIFIC LAWS OFTEN FOUND INCONSISTENT WITH SCIENCE FICTION**

**NEWTON'S THIRD LAW:** Every action requires an equal and opposite reaction. This is Newton's third law. It is taught in science in elementary school. It is one of the most inconsistencies of sci-fi artwork. Showing a spacecraft doing a space maneuver without steering thrusters is an example of violating this law of science. Having two opposing spacemen boxing in space as though on Earth is another example of its abuse. The first time a punch landed, the fighters would separate so dramatically that the fight would end.

**EINSTEIN'S THEORY OF RELATIVITY:** Energy equals mass multiplied by the speed of light squared which is sometimes stated as the speed of light in a vacuum is the fastest speed possible and equal to approximately 186,000 miles per second. The fastest speed possible is the speed of light which is approximately 186,000 miles per second. This is a part of Einstein's theory. In certain conditions, it can be considered as a law of science. Einstein's equation states that the mass of an object times the speed of light squared equals the energy contained within
an object. Einstein's equation demonstrates that when an object approaches the speed of light its mass increases toward infinity. The speed of light is a limiting speed of starships. Einstein's theory also deals with time. According to Einstein, as a starship's speed approaches the speed of light, the passage of time slows with respect to the launch site where the mission began. Those on board the starship grow older more slowly than those remaining on the home planet. Authors writing about trips to the stars often violate Einstein's theory when they speak of faster than light propulsion, warp drive, alternate universes, and other means of placing the setting of their story at light year distances from Earth.

**CENTRIPETAL FORCE:** Centripetal force is the force that causes a mass to travel in an arc or circular orbit. It is equal to the object's mass times its tangential velocity squared divided by the radius of the arc or circular path. The "pulling away of the mass from the radius of curvature of the arc (the orbit)" is due to the inertia of the object causing it to try to move in a straight line. The pulling away is a result of Newton's First Law. (Newton's First Law: An object at rest tends to stay at rest and an object in motion tends to stay in motion with the same speed and in the same direction unless acted upon by an unbalanced force.)

**THE LAW OF UNIVERSAL GRAVITATION:** The force of gravity is equal to the universal gravitation constant (G) times the product of the masses of two bodies which attract one another divided by the square of the distance between the two bodies. Every particle of matter in the universe attracts every other particle with a force proportional to the product of the masses of the particles and inversely proportional to the square of the distance between them. Newton's law of universal gravitation is often ignored in sci-fi art. To show a hovering flying saucer, suspended above a planet's surface without visible rocketry, rotating propellers or helicopter rotors is a violation of Newton's law of gravitation.

**THE GAS LAW:** The pressure of a gas on the walls of a closed container times the volume of the container equals a constant times the temperature of the gas. The gas law is $PV = nRT$ where $P$ is the pressure of a gas on the walls of a closed
container and $V$ is the volume of the container. The constants, $n$ and $R$, relate $P$ and $V$ to the temperature of the gas, $T$. Showing astronauts in the vacuum of space without pressure suits violates the gas law. Space station crew quarters must be pressurized. Exit from space vehicles requires airlocks to preserve air pressure within pressurized compartments. Opening a pressurized compartment to the vacuum of space without an airlock rapidly releases precious oxygen. Drawing such activity as a nominal procedure causing no detrimental results on the crew is a violation of the gas law.

---

**SPACE TECHNOLOGY ANALYSIS**

NASA rocket scientists often perform feasibility studies which examine a spacecraft design based on the laws of science (physics, mechanics, chemistry, etc.). Scientists, also, use spacecraft design conventions known as "rules of thumb" to determine whether a spacecraft concept has merit. A basic engineering education includes an introductory course in college physics. The same material is covered in less depth in high school physics as well as grade school science. A student can learn much about the laws of science by attempting an informal feasibility study on a spacecraft from a science fiction comic book, a sci-fi magazine cover, or a STAR WARS or STAR TREK video. Listed below are some of the laws of science often violated by artists and authors. Included are descriptive examples of errors often revealed by such feasibility studies.

One of the best ways of determining what is scientifically reasonable is to imagine yourself inside the subject vehicle. Next, try to compare the vehicle to driving a car, piloting an airplane, or even riding a bicycle. These vehicles must obey the laws of science. Each requires a means of steering, an engine or motor for transporting the vehicle, and a way of positioning the driver or passengers in order for them to control and ride inside the vehicle. When something does not seem correct about the science fiction
art, try to classify which of the items below may be violated by the drawing.

For example, some artists fail to draw a viewing window for the pilot of a spacecraft to see where the craft is going. Others, leave out a hatch for the astronaut to enter or leave the vehicle. Can you imagine a car without doors? Below is more details about the list of some of the most obvious inconsistencies of the laws of science in science fiction art.

Having familiarized yourself with the science of space and the technology of spacecraft, you are ready to examine the pictures included in SCIENCE FICTION / SPACE TECHNOLOGY: TOOLS FOR LEARNING. Before reading the discussion following each picture, try to find errors or oversights the artists may have made in their ideas of what space rockets and spacecraft look like.

Now that you are familiar with the technology of rocketry and spacecraft as well as scientific laws often abused by science fiction art begin examining the feasibility of sci-fi illustrations by analyzing EARLY SCIENCE FICTION TYPES below.
Early Science Fiction Concepts

Moon Ship: Jules Verne (1865)

Jules Verne knew there was no atmosphere in space though his illustrator appears to be ignorant of that fact in drawing a man waving to those on Earth at an altitude where thin air would make breathing difficult. Verne was proud of his novel's scientific accuracy, but careful study of the text based on current knowledge shows numerous mathematical and scientific errors.

His 900 foot cannon contained 200 foot of explosives. Sunk vertically in the ground, it fired a 9 ft. diameter capsule / bullet whose walls were supposedly a foot thick. Based on Verne's data, the projectile would have a muzzle velocity of 1,200 yards per second, not the 12,000 yards per second calculated by Verne. At this velocity, the space bullet and contents would vertically loft 12 miles before falling to Earth. Not only would the descent have terminated the lives of the passengers, the initial acceleration (from zero to 24,545 miles an hour in 700 feet -if we use Verne's figures) would have turned the contents of the capsule into a puddle of red jelly. At such an acceleration, a 170 pound man would achieve a weight of 3,422 tons in a fraction of a second.
Scenes from "Round the Moon" (Jules Verne)

Verne did predict weightlessness, as did his illustrator in the above drawing. More than a hundred years later, some science fiction comics inaccurately show astronauts experiencing the effects of gravity, though in orbit. Though Verne predicted a zero gravity state for his moon men, he speculates that this is the case only at the midpoint of the journey where the gravity of Earth and Moon cancel one another. Though we know of libration orbits where the Earth's and Moon's gravitational attraction balance satellite and spacecraft orbits, the phenomena of spacecraft weightlessness is a result of the balancing of centrifugal force with the weight of astronauts.

Verne wrote that firing of the space projectile caused the three passengers to be knocked out (a gross understatement). Remarkably, he correctly predicts the size of the first Moon crew
as three men (same as Apollo) and accurately sizes the Columbiad as about the size of the Apollo command module which first orbited the Moon with men in 1968, approximately a century later. Another Verne foresight was the use of retro-rocketry with his attachment of a type of retro-rocket to "break the fall" of his craft on reaching the Moon. Unfortunately, its extremely feeble thrust was much too small to have slowed the Columbiad's mass for capture by the Moon's gravity.

The Girl in the Moon (1929)

Though the picture above shows rocket fins for aerodynamic stability, they could be drawn more streamlined to reduce atmospheric drag during ascent. "Die Frau im Monde" (German for "The Girl in the Moon") was authored by a woman named Thea Von Harbou who consulted German rocket scientists for technical advice on accuracy.

Regardless of how aerodynamic the booster's fins appear, the book did predict the advent of women cosmonauts and astronauts long before Valentina Tereshkova and Sally Ride donned a spacesuit.
The consultants for the movie, "The Girl in the Moon," were German rocket scientists. Their sizing of the Earth launch rocket is remarkably close to that of a Saturn V moon rocket or a space shuttle launch system. It is interesting to note that the German scientists included a VAB (Vertical Assembly Building). A remarkable forecast!

Note the windows for passenger viewing. The tram-craft has clustered rockets, a concept much used in booster systems of the 1950s. Clustering helped rocket designers size booster thrust. The passenger craft features several decks similar to ocean liners of the era.
The "Wonder Quarterly" illustrator, Frank R. Paul, "The Great Paul," predicts an extravehicular activity (EVA) with pressure suited astronauts, life support tethers, and guidance gun (later created by NASA using compressed gas rather than combustible propellant). These are remarkable predictions for the year 1929, despite the childish "Tonka Toy" appearance of the bulbous spacecraft. The craft's massive armor plated appearance speaks of the era's limited rocket structure knowledge.

**Astounding Stories**

(Cover by permission of Davis Publishing, Inc., Artist: Hans Wessolowski)

The astounding prices indicate the old age of the magazines pictured above and below. The design of the 1930s rescue vehicles in the above artwork is quite un-aerodynamic. The vehicles escape
potential disaster aboard the blimp-like space station but face certain disaster reentering Earth's atmosphere with such a blunt non-streamlined shape.

The artist of "Astounding Science Fiction" updates Verne's shotgun barrel launcher with a silo scheme. Note the enormous hex head nuts...OVER A HUNDRED FEET IN DIAMETER! Imagine the size of the wrench! Who would hold it?

**Wonder Cover (1930s)**

A striking illustration, this picture is quite inaccurate with regard to space technology. There is no extra vehicular activity
(EVA) backpack, tether, or pressurized suit to provide life-support for the space travelers. They simply wear coveralls and motorcycle-like helmets.

Their view of Earth suggests an altitude of more than 50,000 miles. There, the vacuum of space offers no oxygen to breathe. Perhaps, these are not astronauts, but robots who, having no lungs, need no air to breathe.

An additional error shown in the above picture is the trajectory of the "space-divers." Their descent violates Newton's laws of motion. Newton stated that every action requires an equal and opposite reaction. The astronauts float serenely toward Earth as though they are sky-divers drawn to Earth by the force of gravity. In orbit the force of gravity and centrifugal force cancel each other making astronauts weightless.

Imagining that one can space-dive to Earth in the fashion of sky-diving is incorrect, but further discussion of the above cover is useful in explaining orbital mechanics. The craft appears to be passing Earth in route to another destination. Because its engines are firing, an accelerating force is present. While the astronauts are within the vehicle, they also will continue to accelerate past Earth. As soon as each space walker egresses from the side hatch into space, the accelerating force of the rocket no longer acts on the astronaut.

Each of the astronauts will continue to travel in the direction of the spacecraft at the ship's velocity at the instant of egress. Since the craft's orbit is likely not around the Earth, none will either orbit Earth or reach Earth's surface. The trail of space-divers would approximate the path of the spacecraft rather than the direction of Earth's gravitational attraction. While Earth's gravity would affect their orbit, it would be a modest factor compared to the orbital momentum established by their spacecraft. Admittedly, the egressing astronauts would form a trail since their egress would be over a period of time. The trail would be a result of the ship's velocity rather than the Earth's gravitational attraction. Also, the trail would be in line with the spaceship's orbit toward Earth.

Before concluding study of the "Thrilling Wonder Stories" cover, note the presence of a thruster rocket plume near the aft
engines on the topside of the vehicle. (You will need the large view of the cover to examine this item.) The artist correctly employs a means of steering this interplanetary spacecraft. Unfortunately, no thruster orifices are present other than this single thruster for positive pitch. How would the vehicle pitch in the opposite direction, roll, or yaw without other thrusters for orientation control? Since a clustered propulsion configuration thrusts the ship past Earth, perhaps, selective throttling provides guidance.

Science Fiction Past and Present (1920s - 2010s)

The pictures above and below are two issues of the popular science fiction magazine "Amazing Stories." The first issue (above), published in November 1928, features a painting by Frank Paul of space tourists exiting their planetary lander and setting foot on a lushly vegetated satellite of Jupiter. Nearly 60 years later, the cover of "Amazing Stories" (below) was published (July, 1986). The cover artist, Vincent Di Fate, also depicts a planetary lander touching down on a solar system body other than Earth. Comparing each artist's understanding of space technology shows
not only advancement in space technology, but also science fiction artistic realism.

As a result of knowledge gained from planetary explorers like the Pioneer and Voyage unmanned spacecraft, we know that depicting a satellite of Jupiter as a space traveler's Hawaii is not correct. The lifeless scene characterized by Di Fate is typical of most planetary satellite in our solar system.

The 1928 "Model T" lander sketched by Paul is in certain ways as different from Di Fate's 1986 "Ford Thunderbird" lander as their automotive counterparts. Paul's vehicle lacks fuel tanks. It appears as simply a mission-module type interplanetary habitat for crew ferry between planets rather than the "lunar lander" type craft depicted by Di Fate with its numerous fuel tanks clustered about the descent engine core.

Additionally, Paul's craft lacks most essential spacecraft systems. Where is a communication antenna? Orientation control thrusters? A propulsion system? The 1986 art amply attends to these essentials except for reaction control thrusters, a usual omission even in the 1990s. However, both artists portray deployable landing gear with broad footpads similar to those used by the Apollo lunar lander.
Planetary Landing Concepts in Science Fiction

Early Lunar Landing Concepts in Sci-Fi

During the late 1950s and early 1960s, a controversy arose in NASA and other scientific communities about the best approach to landing on the Moon. Two concepts flourished: the direct ascent mode (DA) and the lunar orbit rendezvous mode (LOR). Additional debate dealt with the type of spacecraft needed to support the alternate methods of going to the Moon. Science fiction artists portrayed each type as seen in the following artwork.

The direct ascent mode, championed by Werner von Braun, employed an enormous Nova class Earth launch rocket of 12-14 million pounds of liftoff thrust. (The Apollo Saturn V had seven and one half millions pounds of thrust at liftoff.) The concept launched a single vehicle from Earth to the Moon's surface. After a retro type landing on the Moon's surface, the vehicle would take off intact for the return trip to Earth. The lunar liftoff would approximate an Earth launch, a single rocket launching its crew for a voyage to Earth.

The lunar orbit rendezvous approach employed two vehicles, a command or mother ship for travel to lunar orbit and a lander or lunar module for descent to and ascent from the Moon's surface while the command ship orbited the Moon awaiting for the return of the lander. Still a third approach (also favored by von Braun) proposed an Earth orbit rendezvous before leaving Earth's orbit for the Moon's surface. The third approach was much like the direct ascent as far as the vehicle which would land on the Moon. It would be a single stage rocket with powerful engines for the retro landing and later lunar ascent.

The lunar orbit rendezvous approach proved most efficient, requiring a much less powerful Earth launch booster. It is thought that the Russians attempted the direct ascent approach by building a Nova class booster which exploded on the launch pad sometime in 1967. Fortunately, the LOR approach experienced no such catastrophe.
Lunar Craft Based on von Braun Design

(Bonestell graphic is used by permission of Space Art International.)

The artist, Bonestell, consulted with von Braun and Ley, former WW II German rocket experts. The use of multiple engines is similar to the configuration of the Saturn 5. Though there are other similarities to Apollo's Lunar Module (LM), differences include: (1) the scale - It is much too grandiose. Too large. Too many engines; (2) engines too large - Compared to men in the sketches, the size approximates the huge F-1 engines used for Apollo's Saturn 5 first stage; and (3) too many engines - The blast at liftoff in 1/6 gravity would accelerate the crew at a scale similar to Jules Verne's shotgun launch system. Despite the oversized propulsion system, the lunar spacecraft does appear authentic, unlike later drawings of Starwars' fighters. Also, the craft includes communication capability, an oft left out feature of sci-fi space art.
Direct Ascent

The vehicle shown above is representative of the direct ascent lunar rocket mode. The pictured single stage rocket would launch from the Moon in a fashion similar to Earth launch, returning directly to Earth. Most artists made the mistake of showing a cloudless Earth and much too jagged lunar topography (landscape).

Scene from the 1948 Movie "Destination Moon"

The moon rocket shown above is poised for a return launch to Earth. Its design is similar to the V-2 rocket used by the Germans in World War II. How such a rocket could ever land on Earth after traveling to the Moon is a mystery. A single stage rocket does it all in this concept. Yet, a similar V-2 design could only lift hundreds of pounds from Germany to England during World War II.

Closer examination reveals insight of technical merit by the artist. The V-2 clone has added two wing-like fins where a jet's wings might be positioned. A thin stabilizing rib along the body of the rocket suggests a return flight through Earth's atmosphere.
though no deployable landing gear for an Earth runway appears in the picture. A ladder extends from the hatch to the lunar surface, sixty feet below. This might have been a very "giant step for man" and also a fatal one without the ladder, even in 1/6th gravity.

Two Stage Lunar Lander Painted in October of 1960 by Bonestell

(Bonestell graphic is used by permission of Space Art International.)

This was an insightful concept at the time it was authored. The lander has a descent stage, but the ascent stage is a space plane. A space plane similar to a Space Shuttle does allow for Earth reentry, and its size is fairly realistic compared to the landing stage. Such an approach might have worked if the thermal technology of materials would have been more advanced in the era of the sketch.

The lander size (five times the LM) is realistic judging from a comparison of astronauts to engine thrust nozzles. These appear as J-2 size engines (200,000 pound of thrust) rather than those derived from von Braun’s early concepts which were F-1 sized developing 1,500,000 pounds of thrust. Also, the Bonestell drawing shows only two of the J-2’s. The fuel tanks appear of reasonable size. The actual Lunar Module descent stage used a single 10,000 pound thrust engine.
Planetary Landers: Jack Coggins (1954)

The picture above shows three types of planetary landers. The Jack Coggins' "Thrilling Wonder Stories" Winter 1954 cover portrayed the categories of spacecraft which would ultimately serve to land on the Moon. The largest of the vehicles is much like the Grumman designed Apollo Lunar Module, as is the lower center lander. However, the lander drawn to the far lower left features an Apollo-like Command Module capsule design with the addition of landing struts. Such vehicles could also land on other planets or their satellites. Each vehicle utilizes multiple (clustered) rocket engines. Such configurations provide a safety margin should a single rocket fail. Additionally, Coggins shows multiple propellant tankage for both fuel and oxidizer. Again, redundancy offers reliability and safety, factors considered in the design of the Apollo lunar lander.

Coggins correctly depicts crew modules as somewhat streamlined structures for entry into planetary atmospheres. No such requirement existed for the Apollo lander's touchdown on the airless vacuum of the Moon. Happily, Coggins provides a
communication antenna and adequate viewing ports for the crew. The planet in the background is apparently Mars (depicted in hues of red).

Study of the above cover painting reveals two interface seams across the large vehicle. This indicates three stages of approximately the same size. Such a design would provide for: an Apollo lunar module-like descent stage which would remain on the planet after ascent stage lift off, a support module for consumables (supplies) similar to the Apollo Service Module (SM), and finally, a capsule-like crew station module for Earth atmospheric reentry.

Such a configuration, drawn seven years before the American single astronaut Mercury spacecraft, exhibits a keen knowledge of spacecraft design. Examination of the rocket plume in the painting brings forth questions about the craft's design. Note that the outboard cluster of engines are dormant while a core engine provides thrust. The extended landing gear indicate all three vehicles are, most likely, descending for a planetary touchdown. In such a case, the outboard engines would probably be for ascent. Using the outboard engines for ascent leads to the conclusion that the descent stage is not left on the planet but is reused. On the other hand, the outboard engines may have served as "OTV" (orbital transfer vehicle) propulsion between planets. If this is the case, they will remain on the planet after touchdown with the descent stage.

Reversing the scenario shown in the cover art scene leads to the conclusion that the artwork portrays ascent rather than descent and the outboard engines might have served as descent propulsion as well as OTV rocketry. In either case, the artist may not have considered the utility of leaving the landing gear, etc. on the planet surface as did the Apollo Lunar Module (LM). Finally, note the mechanical design of the landing gear. Foot shocks appear automotive. Perhaps, strut shock absorbers in the lower stage help cushion planetary landings.
1965 Callisto Landing Craft

The landing craft pictured above on a planet's satellite other than the Earth's moon is typical of a direct ascent configuration. The distant planet appears to be Jupiter. The crew must have landed on Callisto (4870 kilometers in diameter and 1,883,000 kilometers from the planet Jupiter). Though the gravity of Callisto is somewhat more than lunar gravity, the artist (1965) chose not to draw a LM-like landing craft instead of a direct ascent type vehicle. Several years earlier NASA made the decision to use a lunar orbital rendezvous vehicle for landing on a planet's satellite.

Lunar Robotic Vehicle (1939)

The magnificent painting above appears to be a likeness of the four-legged Apollo lunar lander sketched two score of years prior
to the first manned lunar landing. Careful examination of the vehicle reveals great emphasis on mechanical design: a massive bulkhead with through-bolts on the upper structure, ball and socket landing gear joints, and support struts throughout. Though the machine looks like the Apollo lunar lander, it is actually a walking moon robot.

SPACE STATIONS IN SCIENCE FICTION

The Space Ark or Generation Ship

The above cover shows a space station that looks more like a dirigible, an airborne people transporter of the magazine's era, than a passenger carrying spaceship. The purpose of the space ark or generation ship is to give credibility to the concept of humans rocketing to the stars. Fashioning a science fiction plot at light year distances from Earth requires a vehicle able to transverse vast interstellar distances. Such a trip is impossible based on today's technology even if atomic propulsion is used. A solution is to draw a "world-craft" traveling in space.

Another approach is "faster than light" drive or FTL. Based on the theory set forth by Einstein, FTL is not possible. Other concepts proposed by sci-fi authors and artists include suspended animation, a type of human hibernation, where the biology of aging is so slowed that the stars might be reached during the lifetimes of the crew with craft of finite velocities. Such concepts
conveniently eliminate the need for large amounts of food and water (supplies) for the centuries long trips to the stars in space arks. Can you imagine spending two centuries in a deep freeze? What a dull trip for both the crew and readers! Then, who would want to awake in a microwave oven? The generation ship without hibernation makes a better story: a world in space with its unique social problems and ecological challenges.

More unbelievable than the impossibility of placing a billion ton space world on a ten mile a second trip to the stars would be finding people to take the trip knowing they would never arrive. Noah had faith for 40 days adrift at sea, but 400 years?

---

**Tom Swift Flying Saucer**

A much used alien space station in science fiction literature is a space vehicle called a flying saucer. The name is based on the craft's saucer-like shape. The Tom Swift flying saucer shown above was conceived in 1956. It, like most sci-fi saucers, exhibits no translational propulsion system. Note, the tentacle-like grabbers descending from the saucer orifice. Like the saucer, they violate Newton's action / reaction principle in that they move in a guided path without the assistance of thrusters. They, too, have no
apparent means of translation or direction control. Yet, the hapless astronauts are powerless to escape the grasping jaws. While the astronauts must contend with the force of gravity, the saucer hovers in place as though no gravity is present. Saucers float in space without the assistance of retro-rockets, helicopter-like rotors, or use of lighter-than-air gases. Early sci-fi authors devised "anti-gravity" materials and shields to explain such hovering and floating of spaceships. H.G. Welles in "The First Men in the Moon" employs these concepts with the invention of "Cavorite" by his protagonist Dr. Cavor.

Star Trek Space Station Enterprise

The starship Enterprise has a saucer-shaped space station crew quarters. Some think it was designed to appeal to the flying saucer mysteries of the era. Originally, the saucer was to be detachable. Though the initial STAR TREK series failed to detach the saucer in any of the episodes, later series have episodes where the saucer detaches.

The cylindrical module also holds crew members and serves as the central structure to which the pair of propulsion modules attach. The outrigger propulsion pods feature antimatter propulsion, a technology which has not yet been achieved, though plausible in many ways. If achieved, the energy of such engines would exceed that exhibited by cryogenic fuels (liquid oxygen and hydrogen) by factors of 1,000. STAR TREK alludes to impulse drive technology as well as "molecular-atomic-decomposition-recomposition-technology." "Beam me up, Scotty."
Imperial Space Explorer Ship

Of special interest in the painting above is the communication antenna drawn by the artist. The exploration spaceship has a huge antenna for collecting very weak radio signals from vast distances. Its size is comparable to a ground based antenna dish rather than those used by spacecraft. Such a large antenna would be difficult if not impossible to stow in the event the vehicle needed to pass through a planet's atmosphere and land. The crew would have to jettison the antenna prior to entry. Additionally, spacecraft mechanical designers would be challenged by the lop-sided effect of the antenna. Correctly positioning the craft's center of mass during propulsive maneuvers would be impossible.

A number of descent rockets suspend the craft above the planet's surface. Apparently, the terrain is too rugged for landing. Note the pontoon-like landing pods for sledding into a landing. This, of course, would not work for irregular surfaces. The Apollo Lunar Module (LM) used a descent engine to suspend the craft above the lunar surface in the event of finding rough terrain.

The purpose of the pictured craft's rear sphere is a mystery. Perhaps, it rotates forward and aft, starboard and portside about the circular tunnel as sort of a thrust bubble (3-D thrust effector), allowing the rear rocket port to be directed for guiding the imperial explorer spaceship.
The above sketch is a scene of a space shuttle orbiter hangered in an orbiting space station. The hangered shuttle picture has questionable characteristics: Though no means of artificial gravity is indicated (such as a spinning centrifugal force configuration), the shuttle does not float nor is it tethered to the hanger floor and the servicing staff walks upright under the influence of a gravity-like force. Additionally, the volume of atmosphere (air containing oxygen) is quite large because the crew members wear no spacesuits. They simply breathe the ambient atmosphere. The following sketch shows the space station hangar door open. This would release the atmosphere so quickly that the shuttle, service hardware, and space mechanics would experience a hurricane-like wind which would push them into the vacuum of space. This could be avoided by slowly venting the atmosphere into space, but no vent ports are shown in the drawing. The shuttle
cargo bay is vented during ascent to avoid the sudden release of the cargo bay's atmosphere when the shuttle cargo bay doors are opened to the vacuum of space. Note the four vent ports accurately drawn on the sides of the hangered shuttle. A better design of the space station hanger would include space-suited servicemen and women. Only the crew quarters should be pressurized with an oxygen atmosphere. Additionally, the shuttle should be tethered to the floor of the hanger.

Shuttle Maneuvers as Depicted in "New Wave" Comics


The above sketch is inaccurate in showing the space shuttle's main engines (SSMEs) operating without an external tank (ET). Such a maneuver would use the orbital maneuvering system (OMS) engines or even the reaction control system (RCS) jets rather than the SSMEs. Firing SSMEs in such a "hair-pin" turn over the short distance shown (90 degrees yaw at 100% SSME thrust) would destroy the shuttle. Additionally, the hanger would probably be destroyed by hot gases from the engines' flaming exhausts. NASA would never permit engines to fire in such a fashion inside or near a crew carrying space station. The comic book panel has the words, "THE END," printed at its lower right corner. Yes, this would certainly be the end for the shuttle, its crew, the space station, and all those on board.
Science fiction illustrators and authors know of their reader's fascination with both the past and the future. The present bores sci-fi fans. For this reason, the concept of the future looking to the past make movies like MAD MAX very popular. An oft shown scene of sci-fi covers and movies is a futuristic vehicle flying above a decaying and damaged likeness of the Statue of Liberty ravaged by time and atomic warfare.

An illustrator can depict technology and space mechanisms even though he has little knowledge of physics or space technology. By adding extremely fine detail to a structure, the artist creates an illusionary spacecraft which connotes technical reality. The above artwork is an example of this ability. The rocket exhaust would never burn in such a sooty manner, but the oily appearing exhaust certainly suggests a shuttle relic whose engines need an overhaul, i.e., valves, rings, etc. Such an exhaust color in the vacuum of space would be highly unlikely, however, most readers know little more about rocket engines than they understand
about the internal combustion engines of today's automobiles. They do know that a cloudy grayish blue exhaust means many miles and many missions for a used car or space shuttle. The above drawing succeeds very well in conveying the aura of a spacecraft relic.

Continuing with the junkyard auto theme, the artist depicts the space shuttle as something of a automotive "dragster", an automotive-like vehicle specially designed to accelerate quickly to the end of a quarter mile racetrack. Unfortunately, the ancient space dragster has no guidance mechanism. Reaction control thrusters are omitted in the painting. Additionally, a communication antenna is not found in the sketch, and aero-engineers would be puzzled at the inclusion of an aerofin without a moldline skin of aluminum to cover the protruding engines and tanks. How could the shuttle vehicle enter a planetary atmosphere as indicated by the fin without streamlining the remainder of the vehicle's surfaces? At the expense of technical plausibility, the artist created an aura of spacecraft antiquity.

Another error is the omission of a crew hatch, required on all manned shuttle vehicles. Can you find one? I was not able to in my examination. The crew is latched into the vehicle without the possibility of performing a space shuttle type EVA spacewalk.

A final oversight is the design of the spacecraft's viewing window. Backing into a parking space for this craft would be a ticklish task with no rearview mirror and window. The sizing of the plumbing for the rocket engines is too robust. The pipes are sized for an J-2 Saturn booster engine with several hundred thousand pounds of thrust rather than the tug-boat sized shuttle used for sorties from the space station base. Such a modest vehicle would only require thrusts in the order of tens of thousands of pounds.

The shuttle relic appears to be returning to the hanger, perhaps, after noticing the ground crew left off its skin by mistake. The artist shows the craft to have areas of rust covering its outer surfaces. Since the shuttle does not exhibit the ability to enter a planet's atmosphere (no aero-shield, ablative covering, or streamlining), it is a purely a spaceship, always operating in the
void between planets having atmospheres. In this case, how can rust have formed without oxygen? Perhaps, it formed in the hangered volume of the space station. To show such corrosion and decay on a pure spaceship seems inaccurate. Furthermore, the craft certainly would not have a superstructure of iron. Spacecraft utilize light materials such as aluminum. Aluminum does not rust. Yet, space is a detrimental environment as NASA demonstrated by placing the LDEF (Long Duration Exposure Facility) many months in space then retrieving it with the space shuttle. The Sun blisters spaceship paint, and the presence of fine particles orbiting the Earth certainly pits spacecraft skin as gravely as any road rubble or flying insect bruises an automobile's painted finish.

**Finally:**

From an editorial letter to AD ASTRA, Jun 1990: "Science fiction is not only the best way to predict the future, it has also helped to create the civilian space program."Name any other method of attempting to forecast the future...including the work of professional scientists...Read their predictions five or ten years after they were written. Pitiful! Science fiction writers, on the other hand, have predicted virtually every aspect of our modern world - often 30 or more years before the events came to pass." Ben Bova, Chairman, National Space Society Board
Student Exercises

Use these four comic book covers as exercises for students to apply the principles of *SCIENCE FICTION/SPACE TECHNOLOGY: TOOLS FOR LEARNING*. For a YouTube analysis by Jerry Woodfill analyzing the Dennis the Menace cover, go to: [http://www.youtube.com/watch?v=zf9qNLKVfcU](http://www.youtube.com/watch?v=zf9qNLKVfcU)
Lesson 2.

The following YouTube analyzes both the Donald Duck and Mighty Mouse comic book covers.
http://www.youtube.com/watch?v=6qz2-oknks8
Copyright 1991 by Viacom International, Inc.
Lesson 3.

The YouTube address below links to the lesson discussing flaws in the Planet Terry comic book cover.
http://www.youtube.com/watch?v=4TRiqzVisvI
Jerry Woodfill: Former Apollo 11 and 13 Warning System Engineer

For more than 47 years, Jerry Woodfill has been employed by NASA in Houston. He holds BAEE and BSEE degrees from Rice University which he attended on a basketball scholarship. At the onset of the lunar landing program, he managed the spacecraft warning systems so that he was monitoring spacecraft Eagle's descent when Neil Armstrong landed on the Moon. Likewise, on April 13, 1970, Jerry was monitoring Apollo 13's warning system when the vehicle exploded. His system was the first alert of the life-threatening malfunction depicted in the Tom Hanks-Ron Howard movie APOLLO 13. Universal Studios designated Jerry as a national spokesman to the media for the release of the film Apollo 13, The IMAX Experience. This has led to Jerry sharing a multi-media program entitled: THIRTEEN THINGS THAT SAVED APOLLO 13.

For his role in the rescue of Apollo 13, he shared the Presidential Medal of Freedom as a member of the Apollo 13 Mission Operations Team. A popular educational speaker, he presents a recreation of President John Kennedy’s Rice Stadium Moon Race talk. Present as a student, Jerry was inspired by JFK’s message to the extent that it led to Jerry’s career at NASA.

Jerry is the author/creator/editor of the popular NASA SPACE EDUCATORS’ HANDBOOK:

website: [http://er.jsc.nasa.gov/seh/](http://er.jsc.nasa.gov/seh/)