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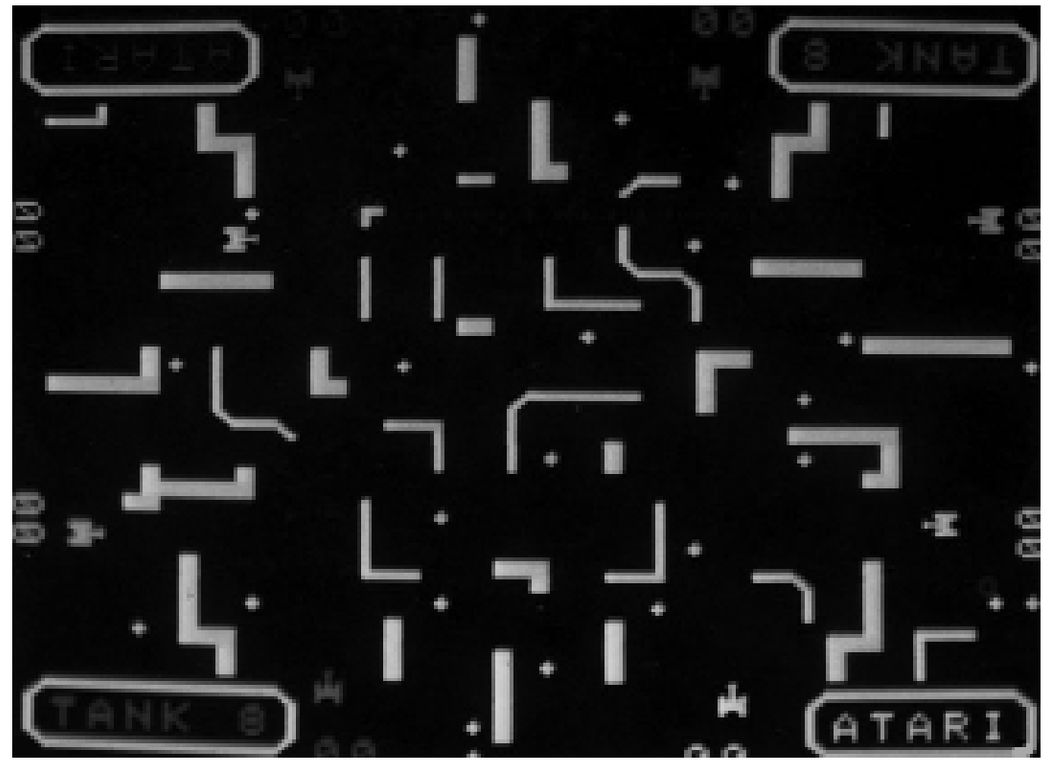
COIN-OP PHYSICS: A VECTOR-GRAPHICS RETROSPECTIVE

In the mid-1970s several companies began putting coin-ops in the lobbies of restaurants, hoping that children would fill them with their parents' quarters while the food was being cooked. I was happy to oblige in this respect. The games immediately drew me in with simple but beautiful flashing shapes and lights, fascinating controllers, and richly detailed fantasy art on the cabinets.

The idea of feeding quarters into a machine to engage interactively in some excitement, fun and time-wasting was a no-brainer. The precedents were pinball and Skee-Ball, which I eagerly played every summer at the Jersey shore. Skee-Ball was a bowling game in which the ball jumped up a ramp at the last second and landed in variously scored pockets. Tickets were then given to redeem for valueless but appealing prizes. The real appeal was not in acquiring the prizes, but in the feeling of having generated value with one's own skill to get them—a feeling not often accessible to children. The tone set in these Skee-Ball/pinball arcades was similar to what I would experience later as a young teenager in video game arcades during the coin-op heyday in the early 1980s—a chance to explore different games and try out my skill in an adult-free darkened space with a slightly sleazy vibe that involved competition, vagrancy, and truancy etc., all appealing qualities to any self-respecting eleven-year-old boy.

The first video game I remember playing in one of these restaurant lobbies in the mid-late 1970s was Scott Bristow's *Tank* (1974), a simple black-and-white game that featured the first use of read-only memory to store graphical data. ROM allowed the images in the game to display just enough detail to represent objects, beyond the simple rectangles and lines that appeared in Atari's *Pong* (1972). *Tank* was a two-player duel-type game with a top-down perspective where the opponents would drive around a maze-like screen peppered with barricades, avoiding mines, shooting each other and trying to avoid being shot. The ultimate goal was racking up enough points within a set time limit to win the game. More quarters bought more time.

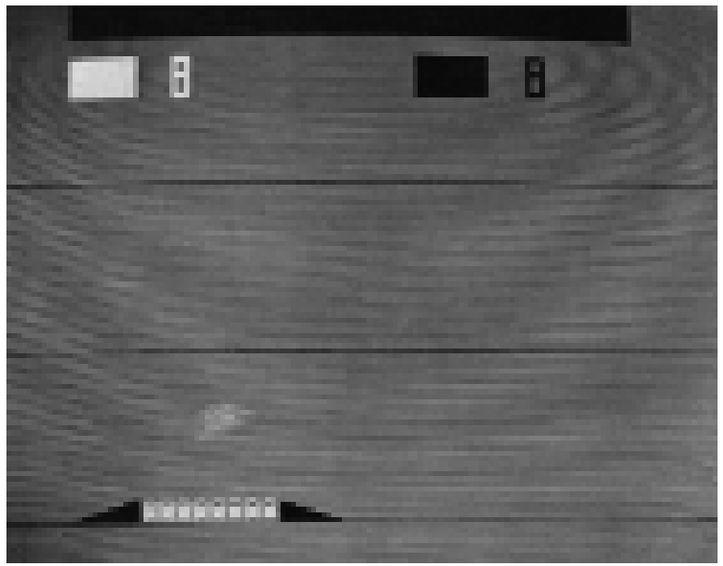


Tank by Scott Bristow for Atari

Tank was produced at a time when the processing power of affordable computers was not advanced enough to produce enemy artificial intelligence. Like *Pong,* the computer in *Tank* provided the interface and game parameters, but the competition had to come from another human. Winning points was certainly important in this game, but more important was entering the space of the game, developing the skills needed for controlling the little square globs of light, and of course the delights of destroying my sister's tank.

I would soon learn that there were other pleasures to be gotten from video games besides destroying my sibling's military equipment. It turned out that the laws of Sir Isaac Newton could be fun.

The first coin-op game I recall playing by myself against a simulation of the laws of physics was another Atari game called *Stunt Cycle* (1976), in which the player controlled an Evel Knievel-type character and jumped over buses. The idea of finding excitement by jumping over things with a two-wheeled vehicle was a concept I was already familiar with, growing up in suburban New Jersey. Inspired by Knievel, my friends and I had spent hours rigging ramps from plywood and cinderblocks and jumping our bicycles over garbage cans, flaming scrap wood, and each other. This was our way of playing around with Newtonian physics.



Stunt Cycle by Bob Polaro for Atari.

The theme, controller, and cabinet art of *Stunt Cycle* drew me to the game, but it was the gameplay and physics engine that kept me there. *Tank* was fun and diverting, but *Stunt Cycle* was addictively fun. The controller for the game was a realistic-looking motorcycle handlebar that featured a rotating grip for acceleration and a brake. These were the only two inputs. Adjusting the motorcycle's speed based on accelerating force, friction, inertia, and time was the key to successfully jumping the buses and landing on the opposite ramp without crashing. Buses would be added as the player advanced. My absorption in the game came from the learning curve involved in gaining control of these simulated aspects of physics. It was about learning skills necessary for successfully interacting with the computer simulation, which was based on mathematical expressions of real-world physics under the likewise simulated game-danger of bodily harm. It was thrilling. Modern racing games with complex physics engines are the descendants of *Stunt Cycle.*

The games I would become most involved with over the next few years, as arcade gaming became more and more popular, would combine the basic elements from *Tank* and *Stunt Cycle*—simulated gravity/inertia/momentum, and shooting stuff.

Games based on computer simulation of the properties of physics have a much older history than most players are aware. *Tank* was basically a land-based version of Steve Russell's *Spacewar!,* a game that preceded it by twelve years. *Spacewar!* (1962) is considered to be the first video game, sometimes along with William Higinbotham's *Tennis for Two* (1958). Inspired by the space-opera fiction of E. E. "Doc" Smith, *Spacewar!,* like

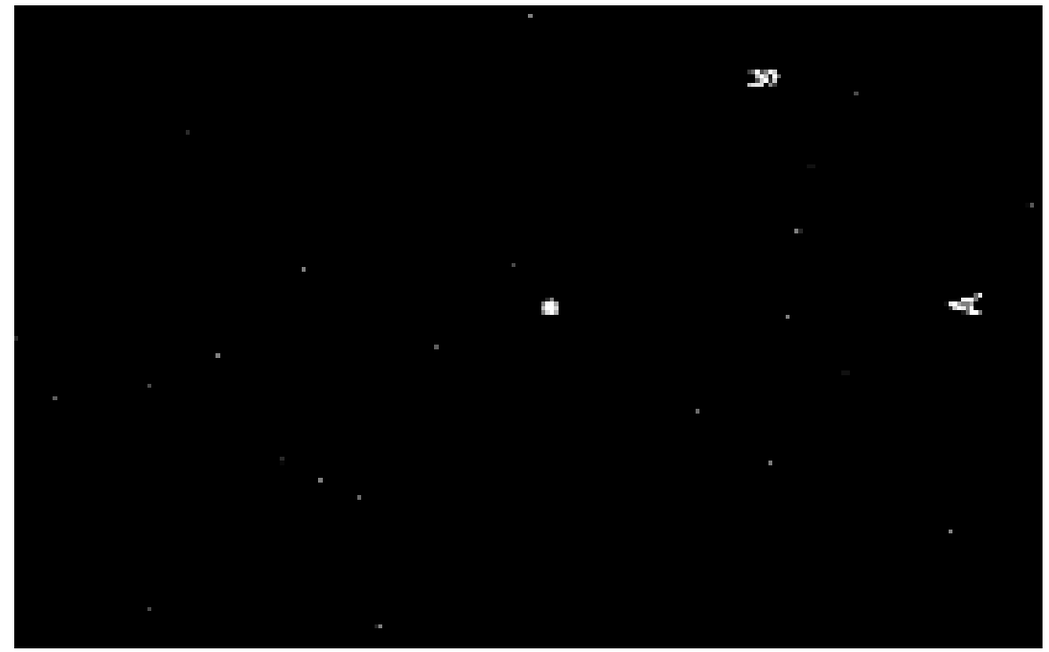
Spacewar! by Steve Russell at MIT.

Tank, involved two-player, two-object combat, but in outer space. The ships battled in around a central sun. The challenge was to duel while controlling the direction and speed of one's ship in the vacuum of space while avoiding being sucked in by the sun's gravity or shot by the other player.

Spacewar! was programmed as a demonstration for the room-filling DEC PDP-1 computer at MIT, long before it occurred to anyone to try to make money on video games. Had the PDP-1 been marketed as a home gaming system at the time, it would have retailed for $120,000. The game spread quickly through universities or research facilities that could afford the computer. It was the first shareware gaming hit—shared via punch cards. Later it came with the computer. The display of PDP-1 was a giant, modified oscilloscope that produced line-based, or vector graphics. Vector graphics systems would later reappear in the arcade game heyday of the late 1970s and early 1980s. This display technology, which facilitated some of most artistically distinct arcade games ever produced, had its origin in military radar-display technology used in World War II, reappropriated for the purpose of generating adolescent fun. A descendant of this graphics format is still in everyday use in the form of Acrobat files.

Vector graphics were basically line art, rather than continuous-tone art or raster graphics. The art in vector games was drawing rather than painting. A vector graphics system allowed for rapid animation and manipulation of the objects being represented, and the glowing segments had a very particular look—thin white undulating lines in reversal against a black background. Because these graphics were based on straight line sections assembled from plotted points, the objects used in the vector games tended to be composed of basic art forms—squares, triangles, and rhomboids assembled together to form objects. By the late 1970s, affordable technology capable of rendering vector graphics had caught up to the PDP-1. Some of the best designs in early videos games like *Asteroids, Tempest,* and *Battlezone* used this system.

The first a vector graphics game I encountered as a kid was Larry Rosenthal's *Space Wars,* a 1977 Cinematronics game. It was the first commercially successful arcade version of Steve Russell's original *Spacewar!*. My sister and I spent hours battling it out in *Space Wars.* The black-and-white graphics, created using Larry Rosenthal's Vectorbeam system, were spare but



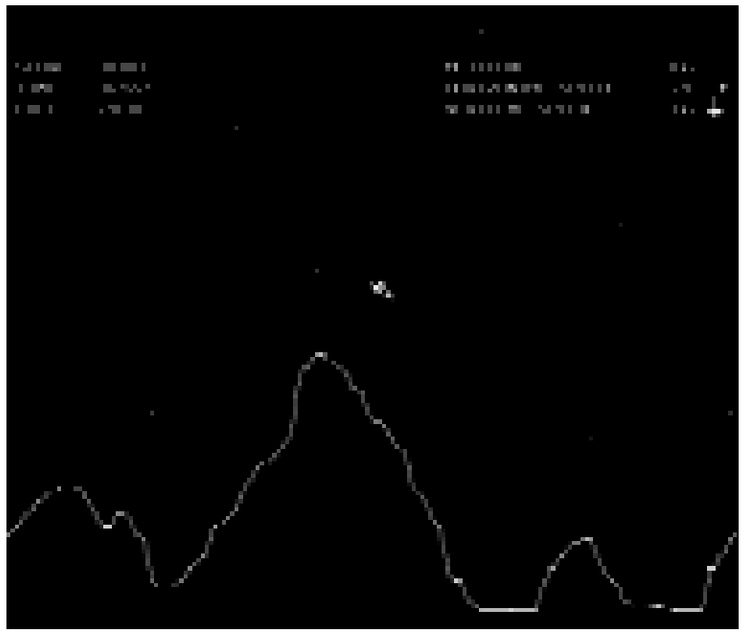
Space Wars by Larry Rosenthal for Cinematronics.

beautiful, mostly negative space with objects composed of small, brightly undulating lines. The five-button controls were Rotate Left, Rotate Right, Thrust, Fire, and Hyperspace. As in Russell's game, the space of the game was finite but continuous, with the ships disappearing from one of the edges of the screen to reappear on the opposite edge. Occasionally an asteroid would streak past, possibly providing the inspiration for a later game based on similar parameters—*Asteroids. Space Wars* included a number of improvements over the original—smoother gameplay, crisper and more detailed graphics, several difficulty settings, and the ability to inflict partial damage to one's opponent. It was possible to blow half of a ship away, leaving the other player spinning around with a single engine, disabled, but still able to play. The cabinet was massive, and of all arcade cabinets, the most reminiscent of the vending machines they seemed to have been based on.

Tom Skelly's *Rip Off* (1979) was a Cinematronics game that took the *Tank* model of top-down rotate/move/shoot and transformed it from a duel into the first collaborative video

game. Two people played against computer-controlled artificial intelligence. The object was to protect a central stash of undulating triangular fuel canisters from pirate tanks that were trying to steal them. These pirate tanks were some of the first AI ever used in a video game. They acted according to independent goals, simple rule-sets that dictated their individual behavior. When several pirate tanks appeared together, this was known as *swarming.* The game design and black-and-white vector graphics of *Rip Off* were not particularly unusual, but this swarming enemy behavior was something I'd never seen before. The tanks didn't follow scripted paths; they moved in graceful, unpredictable, and purposeful ways. They seemed alive. It was possible to play the game individually, but it was most interesting when two people joined forces and developed strategies for defending their fuel. Cinematronics created several different vector games with similar parameters and feel, including *Armor Attack* and *Demon.*

The prearcade, restaurant-lobby vector game I have the most vivid memories of is *Lunar Lander* (1979). Howard Delman developed a vector generator display system for Atari, and *Lunar Lander* was the first game to utilize it. As was true of *Spacewar!,* the *Lunar Lander* game design was public domain. All-text versions of the simulation game had been around for a long time. The first graphic version was written by Jack Burness on a DEC GT40 in 1973. Titled *Moonlander,* this vector-graphics game was controlled with a



Atari's *Lunar Lander.*

light pen and is said to have been quite difficult. The lunar surface in the game featured a McDonald's.

Atari's *Lunar Lander* featured four controllers, Rotate Right and Left, Abort, and a distinctive analog Thrust controller with a spring-resistance mechanism. This controller was incredibly satisfying to operate; it felt like operating a serious piece of equipment. Like *Stunt Cycle, Lunar Lander* was a single-player game in which the challenge was rooted in learning the physics simulation and in gaining enough skill controlling the vehicle to land it safely. The independent rotate-and-thrust control mechanism in *Space Wars* was combined with the gravity-based Newtonian world of *Stunt Cycle,* but with much more complex gamer input than just acceleration and breaking. The player controlled a lunar excursion module that started in free-fall over a mountainous landscape. The idea was to land the LEM on any flat surface without destroying or disabling it. The only enemy to be overcome was one's own lack of experience and skill. The game was about getting somewhere safely. Bonus points were given for landing on platform areas of various difficultly. The repeating one-screen world of mountains scrolled left or right as the ship approached either side, as did the sparse stars in the background. The text-based origins of the game were reflected in a text readout of speed, altitude, and remaining fuel at the top of the screen. It was possible to play through most of the game referencing only the text readout. Instead of a time limit, quarters purchased units of fuel. For those blessed with limitless quarters, the game could be played indefinitely without regard to fuel consumption. For the rest of us, it was necessary to develop an economy of fuel use. There was nothing more nerve-wracking than running out of fuel just as the ship was positioned perfectly for a final decent.

Lunar Lander was also the first multiple-perspective video game. As the descending LEM grew closer to any point in the mountain range, the perspective snapped into a close-up position, making all the elements of the game larger and faster for the final landing scene, adding dramatic tension and requiring a slight shift in response time. I remember getting a huge rush from this moment. The magnification effect intensified my focus, which was already concentrated on the limited parameters of the game world, just as the critical moment of the game arrived. The perspective switch also created a sense of depth in the space of the game. There was more to the spatial dimension of the game's world than what could be experienced at first. This sudden, additional power of vision created a feeling that was something like first

Asteroids by Ed Logg & Lyle Rains for Atari.

seeing the scene in *Blade Runner* in which the main character uses a magnifying machine to see around corners in a photograph.

Lunar Lander was a popular game, but it was quickly superseded by another vector graphics game that proved to be so popular that it would help establish video games as a form of art and entertainment rivaling television and film: Ed Logg & Lyle Rains's *Asteroids* (1979). When Atari realized how popular the game was going to be, they stopped production on *Lunar Lander* and started shipping *Asteroids* in the remaining *Lunar Lander* cabinets.

I experienced the *Asteroids* phenomenon in the Space Port arcade in the Quakerbridge Mall in Lawrenceville, NJ. An entire wall of the arcade was reserved for the game. Adults were playing *Asteroids* to blow off stream on their lunch breaks. Players had to queue up behind games to get access, and anyone playing had a audience of other players watching from either side, taking notes on rock-destroying technique. The combined thruster rumbles and the pings and crashes of the games mixed in a beautiful, crazed cartoon-like experimental-music sound space in the resonating chamber of the arcade.

Asteroids was similar in design and look to *Space Wars,* but instead of dueling other players, it featured a single-player design in which the object was to destroy and avoid a swirling field of rocks that broke into smaller rocks as the player shot at them. Part of the game's unique

feel came from the contrast of the player's constant active attack with the inert but chaotic momentum of the orbiting asteroids. No game had ever incorporated as many animated objects. It was possible to just watch someone playing *Asteroids* and marvel at the sight of multiple rocks of different sizes and shapes rotating and tumbling through the closed, continuous world of the game at different speeds. Quarters bought lives, not fuel, and points lead to extra ships, extending the gameplay. Since skill was rewarded with an extension of game-playing time, a good player could play for a long time, fighting the increasing speed and difficultly. Gaining skill, winning more game time, and achieving a high score became part of a reward system that made the game especially addictive. *Asteroids* was also the first game that allowed high-score players to distinguish themselves by entering their initials for permanent display.

Gravitar by Mike Hally for Atari.

A color version of the Atari vector graphics system was eventually developed, leading to one of the most original and visually striking games of the time—*Tempest* (1980). Other vector games less related to the *Space Wars* model were also produced, including the original first-person shooting games, *Tailgunner* and *Battlezone,* and the World War I dogfighting game *Red Barron,* all of which I devoted significant time to. The game that most fascinated me, though, was Mike Hally's *Gravitar.*

Gravitar (1982) was a hybrid game that combined, refined, expanded, and improved on several games that had come before it. It merged the basic gameplay elements of *Lunar Lander* and *Asteroids,* added a number of new elements, and distinguished itself as being one of the most challenging arcade games ever produced. It was not a particularly popular game. The game's difficulty split the players into two camps: Those who wanted a quick blast of excitement tended to hate it, since its initial learning curve was steeper than most new games at the time. Players with more patience and an interest in a greater challenge found it highly rewarding.

The full-color *Gravitar,* like *Lunar Lander,* involved descent onto a planet, but instead of one lunar surface, the game featured eleven unique planets divided into three universes. Each planet had a unique landscape and a different level of gravity—the game featured true level design. The menu screen was itself a game, with gravity from a "Death Planet" dragging at the player's ship as he tried to reach each individual world. Once the player made it to a planet, his ship would appear in free fall over the planet's surface, but landing wasn't part of the program. Multiple gun emplacements peppered the landscape. Gameplay involved shooting out the emplacements, evading or shooting enemy ships, and using a tractor beam to get fuel from various locations on the surface. Fuel was a limited resource; it couldn't be bought with quarters. The tractor beam doubled as a shield for protection against enemy fire. The controller set-up was similar to that of *Space Wars* and *Asteroids,* and the gravity physics was similar to that of *Lunar Lander,* so players familiar with those controls could use skills they had already developed. Using the buttons separately was adequate for the first few planets, but as the difficulty and complexity of the game increased, more finger-independence on all five controllers was required. Different combinations of thrusting and rotating had to be mixed with toggling between shields and firing, which couldn't be done simultaneously. The finger-

independence required to get good at *Gravitar* approached the level of skill needed for playing a percussive musical instrument.

In *Gravitar,* the close-up perspective switch of *Lunar Lander* was upgraded with real-time zooming animation. This combination gave the multiple perspectives a more dynamic quality, and, combined with several planets to be explored in the game universe, deepened and expanded the game unlike any that came before it. This quality of depth, combined with the patience and leaning curve leading toward mastery of the game, and the relative openness of the universe and freedom of approach, related *Gravitar* more closely to later console games that combined action with long-term resource management and strategy—like *Halo*—than to its precursor vector-graphics games. The fact that simpler gameplay and faster games made more commercial sense may have accounted for *Gravitar*'s lack of popularity in arcades.

Even more than that of *Asteroids,* the *Gravitar* scoring system rewarded skill with points that generated extra ships, increasing the player's odds of getting deeper into the game and exploring previously unknown landscapes. And that was really the central point of playing—getting deeper into the game.

Gravitar required unflagging concentration. A momentary drifting of thought or second of worry about something outside the game would quickly lead to disaster. This is an important part of the particular quality of the fully absorbed gamer—playing well requires forgetting about the rest of life, granting a welcome respite from the normal chains of thought, feelings, associations, and worries. Playing a half-hour of *Gravitar* left me energized and refreshed. This respite was mixed with the pleasure of learning motor skills through repetitive practice and developing various strategies for solving problems. I could go in any order though any of the planets in a given system, there was no forced linear path. The game balanced navigation skills with fighting skills, which would often come into conflict because of the design of the ship—it could only shoot up as its thrusters worked against gravity. Most of the enemy bunkers were below the ship, requiring complex shoot, rotate, and thrust and defend combinations.

The task-balancing in *Gravitar* amounted to patiently learning the artful management of inertia and limited resources, skills that extend beyond the gaming universe. Along these lines it could be said that the game also encouraged me to learn to use forces I couldn't control to my advantage. Luckily, it didn't take long to figure out that the gravitational field of the death star could be used to swing around to the planets. Far better than wasting fuel dumbly

struggling against it.

Economy of time is an element of many video games that helps to create their unique feeling of drama. *You have gotten this far, don't die now or you'll have to start from the beginning. Gravitar* upped the ante on this basic video game dynamic by rewarding skill with a way to save time and skip to the good stuff, using a mechanism that was almost a minigame in itself. Since there was no way to save, the depth of the game created a problem—it was tedious to replay all the planets that had already been mastered in previous games just to get to a deeper level. To deal with this, Hally placed a Red Planet within each solar system, with a spiraling tunnel that lead to an exploding nuclear reactor that had to be activated. Successful activation was followed by a timed escape, like the last few minutes of *Alien*. When the Red Planet quest was completed, the entire solar system could be skipped. Once I got good at this, I could pick up the drama at its most interesting point. Starting the game by warping twice in a row with full fuel and many extra ships meant there was a lot to lose very quickly. It also meant that each time I might get deeper into the game than ever before.

The Red Planet concentrated the themes and dynamics of the game—depth, subtlety, and variation. There was no gravity, so I had to master new navigation skills, maneuvering precisely within new physics parameters. This pattern of new challenges created with limited graphic and memory resources repeated into the deepest levels of *Gravitar.* Once all three universes had been played, they repeated, but with their physics reversed and the number of bunkers increased. This cycle was followed by a stage in which the planet's surface was invisible, and finally by invisible landscapes with reversed gravity. Hally got around limited computing power with creative permutations of the rules of the game.

What made *Gravitar* engaging even by today's gaming standards was the drama created by the depth of the game design, combined with the subtlety of its gameplay. The ability to navigate the ship across many different terrains and situations was the central skill needed. *Gravitar* was about the joys of developing self-control and patience as a way of discovering new challenges.