PYRAMID®

Issue 3/96 October '16

TECH AND TOYS IV

ULTRA-TECH ARMOR DESIGN
by David L. Pulver

HIGH-TECH BUILDINGS
by Matt Riggsby

HEXOPERSONALITY
by J. Edward Tremlett

THE ARROW OF PROGRESS
by Kelly Pedersen

TITAN FIGHTIN'
by Timothy Ponce

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Cover
Christopher Shy

In This Issue

The future is only as awesome as the gear you put in it! That's why this issue of *Pyramid* is devoted to tech and toys – the latest in great ideas for your ultra-technological campaigns.

The next big things aren't just gizmos and doodads; it's also the promise of *High-Tech Buildings.* Author Matt Riggsby – co-author of ***GURPS Low-Tech Companion 3: Daily Life and Economics*** – expands the architecture rules of that supplement to new vistas, allowing for the construction of modern-age buildings and beyond. Pick your construction materials, choose options, and select amenities . . . but make sure you bring a big check!

If you're looking for a novel way to make your ultra-tech different, consider following *The Arrow of Progress.* Discover why archery might continue to be useful, learn what futuristic bows might have going for them, and unleash powerful new options for your post-modern fletchers. The discussion also includes ***GURPS*** stats for nine new bows, a dozen sensor arrows, and more.

Don't be caught unprepared in forthcoming fights; defend yourself in the centuries to come with *Ultra-Tech Armor Design.* This month, David L. Pulver continues the defensive design system detailed in two previous Eidetic Memory installments (*Pyramid #3/52: Low-Tech II* and *Pyramid #3/85: Cutting Edge*), showing you how to add options to ***GURPS Ultra-Tech*** to make just the armor you want. Don electromagnetic armor, fire up the psionic mind-shield circuitry, and stay hidden with infrared cloaking.

Diving into cyberspace can be incredibly useful . . . but it also opens you up to the dangers of a *Hexopersonality.* Longtime *Pyramid* contributor J. Edward Tremlett describes a systemless method of entering cyberspace, including plot possibilities and perils that arise from creating an inexact replica of your digital spirit.

Sometimes when armored battlesuits need to slug it out with giant robots, you want the *Titan Fightin'* to last more than a few seconds. This short article for ***GURPS*** shows you how to let two massive foes tussle in a way that keeps things exciting.

This issue also includes a Random Thought Table that examines how feelings can be useful in shaping the tech of tomorrow. Whether you want offense, defense, or just a cool place to live, this *Pyramid* has something that will make your future come alive!

Science is a history of superseded theories.

– Dr. Laurence J. Peter

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From the Editor

Get the Future Today, Before It's Too Late!

When I first became editor of *Pyramid,* last millennium, one of the first things I purchased was a big-screen monitor – 21", if I remember. I think it was 1600 × 1200 resolution if I pumped it up to its maximum, which involved it humming a bit and being a pain to look at. I'm pretty sure that most of the time I kept it at a lower resolution for my eyesight's sake. I don't remember how much it cost, but I know it was a huge purchase for me.

It was also a huge purchase literally, being a CRT screen. The desk I had it on could barely fit it and a keyboard in front of it, because the entire back of the thing stretched into infinity. I remember the monitor always being uncomfortably close.

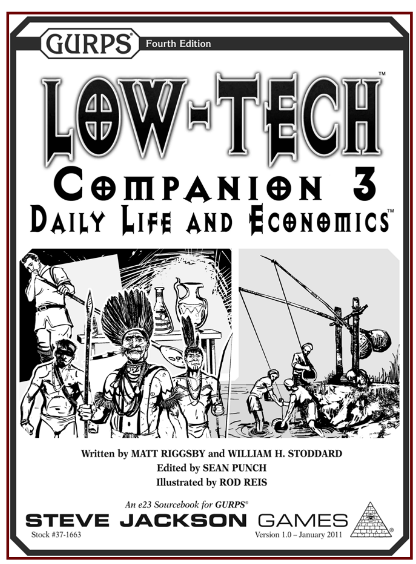
Just yesterday I had stopped by Goodwill – a used-goods shop that sells what people donate – and bought another monitor. It was a 21" digital LCD, less than 5" thick, including the adjustable base. Like my gargantuan monitor from the early 2000s, it was also 1600 × 1200. And this one cost be about $25. Sure, it was used, but even new monitors around that size can be had for under $100.

All of this was a microcosm of thinking about futuristic tech and developments. Tomorrow is a moving target, and we're all aware of science-fiction roleplaying games whose idea of the future resulted in devices that were unfathomable at the time, but are now less powerful than a $50 child's wristwatch computer. (We just got our son a Kidizoom Smartwatch, and I'm pretty sure it's more powerful than my old Apple IIgs.)

Hopefully the articles in this issue will inspire you to dream big, push your neon visions in new and interesting ways, and help you create an awesome future. Just remember that today's cutting-edge technology is tomorrow's garage-sale find or child's wristwatch.

Write Here, Write Now

So what did you think of this issue's glimpse of the future? Did you see something that made your circuits hum with delight? Or did something slip into the uncanny valley? Let us know via the retro-communication called "email" at **pyramid@sjgames.com,** or join the rousing techno-discussion online at **forums.sjgames.com.**



High-Tech Buildings

by Matt Riggsby

GURPS Low-Tech Companion 3: Daily Life and Economics contains rules for architecture, allowing players and the GM to determine cost and construction time for a wide range of buildings, from peasant huts to manor houses to city walls. Unfortunately, these rules stop at the end of TL4, leaving players without guidance for modern and science-fiction buildings. This article extends those rules into the modern age and beyond, adding new materials, new options, and guidance on what's new in building, from the colonial period to the far future.

Building Technology

Although a number of new items have been added to the range of building materials since the rise of steam power and a *lot* of new tools and accessories have come into use, many of the core building materials and even techniques of low-tech architecture are still utilized to the present day. Although it is still widely relied on in poor societies which are functionally below the current global TL, hard earth has otherwise fallen out of favor. Wooden structural members are still the norm for buildings of modest size (though they are held together by metal fasteners rather than wooden pegs, cordage, or elaborate joinery). Likewise, modern techniques of laying brick and stone would be somewhat recognizable to an ancient mason. Technology has changed few of the functional aspects of older materials, but it has changed how often they're used and made it easier to use them. However, more recent years have seen the rise of novel materials and vastly more sophisticated methods of planning.

Through TL5, increasing industrialization made brick, stone, metal, and large wooden structural members vastly cheaper. Thus, these materials began to displace inexpensive but less durable hard earth and thatch in regions wealthy enough to have them. Architects could produce somewhat taller buildings and increasingly experimented with metal structural members, such as, in the West, suspension bridges held up by chains. Such bridges go back at least to the 15th century in some places, notably China, but they became larger and more common in the 19th.

TL5 also saw the redevelopment and improvement of an old material – concrete. A variety of manufactured cements were invented during the 18th and 19th centuries to compete with natural ones, along with superior techniques for reinforcing concrete, allowing builders to build structures as strong as those made from brick and stone at a much lower cost. However, concrete construction did not become commonplace until the early 20th century.

The major development at TL6 was the widespread construction of metal-framed buildings. In the last decades of the 19th century, structures over 100' tall became, if not routine, then at least unremarkable. Use of the new technique to produce ever-taller buildings improved rapidly. By the beginning of TL6, the tallest skyscrapers topped 1,000', towering over the tallest structures of antiquity. These developments went hand in hand with the development of steam-heating systems and electric elevators, without which higher stories would have been inaccessible and all but uninhabitable.

When we build, let us think we build forever.

– John Ruskin

Material developments in more recent years involve increasingly sophisticated use of composites. One aspect of this is in composite materials, such as sheetrock (thin slabs of gypsum plaster treated to resist fire and water absorption, faced with paper) and concretes with fibers which improve their performance in various ways, even giving them a tensile strength approaching that of metals.

Another aspect is composite construction. Instead of making a building out of one or two structural materials (for example, all wood or a brick facing with wooden structural members), they're constructed with a variety of materials, each serving a particular purpose. For example, a modern home or office might include wooden or steel structural members; concrete or wooden floors (themselves possibly composites such as prestressed concrete and plywood); sheetrock interior partitions; layers of fiberglass or paper-based insulation inside walls, floors, and ceilings; a plastic vapor barrier wrapped around the structure; and any number of facing materials.

Theoretical advances in engineering along with massive computing power and scientific approaches to material science have allowed architects to design taller buildings and wider unsupported spans. This table indicates the tallest and widest unsupported dimensions (in feet) of buildings constructed in each TL:

TL	*Tallest*	*Widest*
5	150’	135’
6	1,250’	216’
7	1,450’	657’
8	2,717’	900’

Design tools have become vastly more sophisticated. Where preindustrial architects operated by pure geometry and general rules about materials (often resulting in overdesigned buildings which are more expensive than they need to be or underdesigned ones which lean alarmingly or fall down quickly), industrial-age architects have vast realms of knowledge and technique to fall back on, allowing them to maximize their use of materials while minimizing costs. These advances have also allowed architects a new range of artistic expression, permitting the construction of buildings with unconventional shapes like the multi-finned Sydney Opera House and cubist Habitat 67 in Montreal, or even large-scale moving elements, such as stadiums with retractable roofs and Brazil’s Suite Vollard, in which each floor rotates independently.

Future Buildings

At TL9, buildings benefit from improvements in automation and information technology. “Smart buildings” with computerized controls become standard. Inexpensive video displays lead to pervasive panoramic displays and even frequent and inexpensive redecoration, letting rooms change color schemes at the flip of a switch. Point sources of illumination are replaced with transparent lighting panels, providing the same lighting but spread out over broad areas, reducing or eliminating dim areas.

At TL10, smart buildings are joined by smart materials. Expensive bioplastics can slowly reconfigure and even heal damage. Holographic projectors can also create the illusion of just about any environment. Robot factory technology can even construct buildings from the ground up. With superscience, contragravity enables the construction of floating buildings.

By TL11, reconfigurable buildings can reconfigure themselves rapidly, essentially on demand. Superscience force domes can create comfortable environments in the midst of space and toxic atmospheres. By TL12, force fields conforming to building shapes allow the use of force field walls and other partitions.

Power Tools

One other key development in construction technology is the power tool. While quality hand tools proliferated with increasing industrialization and steam- and electric-powered factories could turn out cheap, easy-to-use building materials from industrially extruded brick to premade roof trusses, on-site power tools came rather later. Hydraulic cranes were invented in the 1830s, but manufacturers only started to toy with portable electric motor-driven tools in the late 19th century, and the first practical hand-held electric drills only appeared around World War I.

A variety of electrical tools were subsequently invented, but they proliferated slowly. These tools were relatively weak and, because they had metal housings, both heavy and sometimes hazardous to use. Somewhat safer plastic housings started to come into use after World War II, but even in the 1950s, a serious handyman might not have any power tools at all. The next major development in tool technology was the introduction of battery-powered tools in the 1960s, which have grown from weak imitations of real tools to versatile competitors and complements to plug-in tools.

Amenities

One of the most notable developments in architecture has little to do with the structure itself, but rather the invention of a vast range of additional systems to make buildings more comfortable and useful. Before TL5, amenities such as hypocaust floors and *qanat* cooling towers were rare and expensive, but now power, data, climate control, and hot and cold running water are all but obligatory.

Although indoor plumbing had existed in rudimentary form since the Bronze Age and urban water systems became reasonably common in TL5, both cost and a lack of technological sophistication kept it from being much more than a curiosity. But early in TL6, plumbers finally solved problems of venting and drainage which allowed plumbing installations in buildings to function reasonably well and hook into large-scale sewage systems. Thereafter, indoor plumbing quickly became common.

Heating before TL5 involved open flames, or a chimney if you were lucky, while cooling was mostly limited to careful use of shade and creating breezes. Iron stoves, notably the Franklin design developed near the beginning of TL5, radiated more heat than masonry fireplaces, but still only benefited the rooms they were installed in. These systems became more sophisticated in the middle of TL5 as inventors developed heating based on circulating a heated fluid through purpose-built ducts. The earliest systems involved air heated by a furnace, providing heat but not smoke from the fire heating it.

Architecture starts when you carefully put two bricks together. There it begins.

– Ludwig Mies van der Rohe

Soon thereafter, such systems were joined by central-heating systems circulating steam or hot water, which benefited from improvements in industrial boilers and steam power and the invention of the radiator in the 1850s.

Artificial-cooling systems are even more recent. Electric fans became the first serious alternative to shade, stored ice, and hand-powered fans only in the early 20th century, followed not long thereafter by compressor-driver air conditioners. However, the cost of air conditioning was such that they were mostly installed in businesses. Home air conditioning didn't become particularly common in the United States until the middle of the century, and this feature still lags in many places around the world.

Energy-using systems such as boilers were largely powered by wood or coal, which was periodically carried into the building and tossed into the furnace when needed. Energy was eventually more directly piped into buildings in the form of natural gas lines, used for light and heating. Around the beginning of the 19th century, the gas lamp started to come into general outdoor urban use. By the 1820s, a number of major cities were installing gas lighting systems along their streets. Gas lamps quickly moved indoors, with the earliest such lamps in private homes appearing only a few years after the installation of the first municipal gas lighting systems but, like indoor plumbing, they were largely a curiosity for the rich. They did not become commonplace until the dawn of TL6. Gas stoves were similarly invented early in the 19th century, but had to await the growth of sufficient infrastructure to support them and sufficient industrialization to make them affordable before they could become reasonably common, likewise starting at the end of the century.

Electricity followed widespread usage of natural gas by several decades, with long-distance power transmission becoming possible with the development of AC generating and transmission systems around the end of the 19th century. The rapid development of electrical fixtures and appliances in the early 20th century drove widespread electrification of buildings.

The first information feeds were telephone lines. While telegraphs existed as early as the late 1830s and the first phones a few decades later, they were of limited use outside of large commercial establishments, post offices, and the like. Phones came into more common use starting around the beginning of TL6, as central phone exchanges allowed any given phone to call any other phone, as opposed to requiring a different physical line between any two phones.

The next significant type of information line was cable television. Unlike previous external connections, which started with businesses and wealthy individuals and later spread to the general population, cable television started in remote areas before spreading to denser populations. Early in TL7, remote settlements might build a single large antenna to pull in signals too weak for regular electronics to pick up and pipe the signals to individual homes via cable, saving the considerable hassle connected with rebroadcasting. In the run up to the beginning of TL8, cable systems offering a broader range of programming than that available over local airwaves became commonplace. In more recent decades, both types of lines have been repurposed to provide digital information feeds for computer networking, supplemented with satellite dishes and dedicated computer data lines.

At TL9, automation becomes standard: door locks, cleaning robots, climate control for individual rooms, and automatic adjustments to lighting are controlled by centralized smart systems. These systems can be driven by programming, voice commands, and simple AI processes learning the residents' preferences. Video-display systems become pervasive as well. At TL10+, video is replaced by holographic display and decoration. By TL11, automation advances to food synthesis, and by TL12, utility fog and other reconfigurable materials become standard.

Materials and Building

Smaller, simpler higher-tech buildings can be constructed using the same procedures as those in ***Low-Tech Companion 3.*** For example, a simple cinder-block garage is in many ways a lot like an ancient or medieval stone building. However, many higher-tech buildings, particularly tall ones, rely more on carefully constructed load-bearing frames to which facings are attached than on just piling stuff up and hoping that it stays that way.

> *Modern architecture. It'll never last.*
>
> *– Manfred,* ***Ice Age***

Materials

At higher TLs, there are three different classes of materials, which actually encompass both material and method of use:

- Structural materials, which are strong enough to support entire buildings as well as serve as facing materials.
- Facing and partition materials, which are used as lightweight surfaces or cheap internal partitions but can't make a building by themselves.
- Internal frames, which provide structural support (sometimes *very* substantial support) but only constitute a skeleton, not a whole structure.

Structural Materials

These materials can be used in any capacity in a building, either to provide a structural framework, as finishing and facings, or both. All figures in the table on p. 7 assume a 1" thickness of wall. Brick, concrete, and cinder block structures must be at least 4" thick.

Wood: This includes both natural wood and composites such as plywood. With the mechanization of wood production, the cost of wood doesn't change with thickness at TL5+.

Brick: Fired clay (actually more sand than clay now) brick has been surpassed for cost by other materials, so it's used less often as a structural material, but it still very common as a decorative facing.

Cinder Block: Preformed concrete blocks, typically hollow to save a great deal of weight.

Concrete: Modern concrete is typically reinforced with grids and columns of steel bars.

Light Configurable Composite: This ultra-tech material is a matrix of plastics with a network of nanobots which can change its shape. Configurable composite buildings which are connected to a power source and are not completely destroyed may heal up to 50% of damage taken at a rate of 1% of the building's HP per hour at TL10, 2% per hour at TL11, and 4% per hour at TL12.

Heavy Configurable Composite: Similar to light configurable composite, this material is primarily metallic.

TL	*Material*	*Cost*	*Weight*	*DR*
5	Wood	$1.80	2.65	1
5	Brick	$0.57	7.7	8
6	Cinder Block	$0.34	3.9	3
6	Concrete	$1.11	15.5	9
10	Light Configurable Composite	$2.50	3	1
10	Heavy Configurable Composite	$4	16	6

Facing and Partition Materials

These materials are used exclusively for external facings and internal partitions. They must be used in conjunction with some other structural material (see *Simple and Complex Buildings* below).

Concrete Stucco: Similar to drywall, but with a thin layer of textured concrete on a metal or wooden lath backing fastened to a frame. Usually used as an exterior facing.

Drywall: Drywall partitions are 4-5" thick, with half-inch gypsum board sheets attached as facings to a wooden or metal frame, which may also contain wiring and insulation.

Metal Siding: Painted or otherwise coated steel or aluminum, about 0.025" thick. This is suitable for tool sheds and warehouses, not armor plating.

Plastic: Sheets of corrugated polycarbonate, PVC, and related composites like fiberglass. The material ranges from opaque to as transparent as glass, though less durable.

Plate Glass: A plate-glass facing consists either of one large, 1/2" sheet of glass or of two 1/4" sheets around an insulating air pocket, held in place by a metal frame. The pattern of glass sheets may be punctuated at intervals by structural members or metal strips, but at least 90% of the facing is transparent.

TL	*Material*	*Cost*	*Weight*	*DR*
6	Concrete stucco	$2.46	7.25	2
6	Drywall	$1.50	3	1
6	Metal Siding	$1.60	1.25	2
7	Plastic	$1.50	0.3	0
7	Plate Glass	$8.94	6.5	6

Internal Frames

The materials here indicate costs for pure supportive frames, without walls, floors, or ceilings. These may be used as a part of buildings which are largely composed of partition and facing materials but require a structural framework to hang them on; be used to supplement very tall buildings; or for both applications. Frames consist of thick, strategically placed pillars and a few connecting beams. They add to the weight (and therefore overall HP) of a building, but provide no real cover themselves.

TL	*Material*	*Cost*	*Weight*
5	Masonry frame	$0.3	4
5	Wood frame	$0.19	0.51
6	Concrete frame	$0.32	5.5
6	Steel frame	$0.38	0.34
10	Light configurable frame	$1.20	1.25
10	Heavy configurable frame	$1.90	7

Obsolete Materials

A number of materials from ***Low Tech Companion 3*** aren't listed here: hard earth, thatch, rubble, and ashlar. Most of them simply aren't used in the modern world save in limited cases of poverty, historical research and reenactment, and tradition. Ashlar is the sole exception, and even then, cut stone is typically used as a decorative facing rather than an underlying structural material.

However, that doesn't mean they *can't* be used, and when they are, they're less expensive than at earlier TLs. Earth-moving equipment, chainsaws and brush cutters, and easy transportation make producing these materials vastly easier even when traditional techniques are used in the construction itself. Reduce costs for obsolete materials by 25% at TL5 and by 50% at TL6+.

Simple and Complex Structures

Smaller (50' tall or less) buildings made from materials listed under *Structural Materials* (pp. 6-7) may be constructed by the rules in ***Low-Tech Companion 3,*** p. 34: Find the volume of the structure and multiply it by a partition factor, the wall thickness, and the appropriate values for the material. (The partition factor is related to the number and size of interior rooms; see *Example Partition Factors,* p. 8, for ideas.) Further apply modifiers for construction quality and variants. To get weight, multiply the final value by the weight of the material from the materials table; this in turn determines HP. To get pre-amenities cost, multiply the value by the cost from the materials table.

However, composite buildings may be constructed of many different materials, combining items from all three categories. A complex building may have up to three separate components: an external facing, interior partitions, and a frame.

The external facing's cost, weight, etc. are calculated as though it were a separate structure with a partition factor of 0.25. The interior partitions are calculated as though a separate structure with a partition factor equal to the desired partition factor of the structure as a whole minus 0.25.

Example: An ivy-covered college dormitory with many interior walls and thus an overall partition factor of 1.25 might consist of a thick brick outside (partition factor 0.25) and wooden interior partitions (partition factor of 1.25 - 0.25, or 1).

Some materials and taller buildings, though, need more support, which is where frames come in. If a building has interior partitions made out of a facing or partition material (for example, a building with a drywall interior), it must also have a full frame. If a building has a facing made from a facing or partition material (for example, a building with a sheet metal exterior), it must have *either* a full frame *or* an interior made out of a structural material with a partition factor of 0.25 or greater. If a frame is used, multiply cost and weight by the volume of the building; partition factor and material thickness do not apply.

Tall buildings require more framing. *All* buildings over 50' tall, including those made from regular structural materials, require a frame. Moreover, the taller the building, the more framing it needs. For most frames, multiply the cost and weight of the frame by [1 + (height – 50) / 50]. However, the inherent structure in buildings made from structural materials reduces this requirement somewhat. For such buildings, multiply cost and weight by [(height – 50) / 50], minimum 0. Essentially, they require additional structural framing only for construction past a height of 50'.

Buildings made from configurable composites should be designed for a maximum height, volume, and partition factor. Within those parameters, they can change shape and internal configuration to be shorter and have lower partition factors, altering their internal layout freely. For example, a home could temporarily shrink bedrooms to make a living room, dining room, and kitchen bigger in preparation for a party. Configurable composites may be combined with other materials, but usually aren't, since that imposes significant limitations on them. Buildings with nonconfigurable facings can't change their volume and height, while buildings with non-configurable interior structures can only make changes to the faces, creating or eliminating doors and windows without changing their overall shape.

Example Partition Factors

Use these examples to help decide on an appropriate partition factor a modern building: A building with no interior walls (say, a tool shed or warehouse) has a partition factor of 0.25. A church or theater has a fairly low partition factor, around 0.4 to 0.6; most of the building is a single large room, but small parts of it are subdivided into equipment rooms, broom closets, a few offices, and the like. Schools and shopping centers have a somewhat higher partition factor (say, 0.7 to 1); the building is divided into a number of moderately large classrooms and shops. Apartment buildings and dormitories have very high partition factors (0.8 to 1.25); they're divided into a large number of small rooms.

Building Options

All of the modifications to buildings on ***Low-Tech Companion 3,*** p. 35, under *Construction Quality,* may be used for TL5-8 buildings to indicate variations in material quality and skill in execution.

Most other options are not available. Different mortar options at these TLs are below the resolution of these rules, and most of the options under *Constructions Variants* are obsolete or not viable with higher TL materials. The exception is tiling; the weight is the same, but the cost is $0.60.

Here are a few new building options which become available at higher TLs.

Sloping (TL5): This construction variant, used in defensive structures, builds walls at an angle rather than straight up and down. This provides improved protection against attacks from most likely angles, increasing DR against those faces. Up to four sides of a structure may be sloped against attacks made directly against that side. For each side sloped, increase cost and weight of structural materials by 10% for a 30° slope or by 20% for a 60° slope. A 30° slope increases DR by 50%, while a 60° slope doubles DR.

Atmospheric Sealing (TL7): The building, or part of it, is sealed off from the outside atmosphere. This is useful for biological quarantines or protection from chemical leaks. Sealed sections use filtered air from outside rather than stored air, so can provide no oxygen beyond what's already present in their volume, usually good for a few hours if the atmosphere outside the sealed section becomes hostile. For self-contained atmosphere, see *Life Support,* below. Buildings may also be subdivided into separate sealed sections. Cost of sealing is $0.50 per cubic foot of sealed volume × the effective partition factor. The effective partition factor can range from 0.25 (for a building with no internal atmospheric compartmentalization) to the structure's total partition factor (for a place with individually sealed rooms). For a construction which is subdivided into different sealed areas (say, each floor is sealed off from each other but rooms on the same floor are not), the designer can choose a partition factor between 0.25 and that of the building, with the more rooms sealed as part of the same unit indicating a smaller partition factor. Sealing is not available for wooden buildings.

Life Support (TL7): Buildings in hostile environments can be equipped with systems for air purification, water purification and recirculation, climate control, and anything else necessary to support life over the long term. At TL10+, this includes food synthesis as well. Cost is $20,000 per person worth of capacity.

Moving Parts (TL8): Architecture is usually something expected to stay still. However, at higher TLs, buildings can be constructed with parts that move around. This is most frequently used in sports stadia for retractable roofs, fields which can be swapped out (for example, grass for artificial turf), and reconfigurable sections of seating. However, innovative architects sometimes use this for buildings where individual floors or the entire building can be turned to face different views. This increases the structure's final cost by *twice* the percentage of its volume which can be moved, minimum +10%. Configurable materials do not need to take this option.

Floating Buildings (TL10^): Contragravity gear can allow buildings to float in the air, albeit at fabulous expense: $400 per cubic foot of building at TL10^, $100/cubic foot at TL11^, and $25/cubic foot at TL12^. This assumes a 1G environment. Multiply costs by the environment's actual G rating.

Force Dome (TL11^): For some hostile environments, architects find it convenient to put up a force field and construct regular buildings inside its volume. A force dome provides an impenetrable barrier to atmospheric differences up to 50 atmospheres. It's not intended as a defensive feature, but it also provides DR 10 against attacks from outside; see ***GURPS Ultra-Tech,*** p. 190, for other effects of force fields. Cost is $15 times the diameter of the dome in yards. At TL12^, the force screen can be tailored to the shape of the building. Determine the cost by taking the volume of the building and figuring the diameter of a force screen with that volume. A TL12^ force field-generator may even give a building interior partitions. Multiply the cost of the generator by 5 × the desired partition factor the generator can provide.

Amenities Costs

In addition to the structure itself, most TL5+ buildings have a considerable cost wrapped up in amenities. The costs are based primarily on the building's volume, but even then are highly variable depending on the purpose of the building.

A typical building has a basic amenities cost of $0.525 per cubic foot. It is assumed to have amenities suitable to a typical residence of its TL. For example, a TL7 building would have climate control sufficient to maintain comfortable temperatures in a temperate zone as long as doors and windows aren't opened too often; enough plumbing for a kitchen and a bathroom/restroom or two; a phone line for every 1,000 to 1,500 square feet of floor space; and multiple electrical outlets (including ceiling fixtures), though not enough to run industrial equipment.

Reduce amenities cost by 25% for each of the following which are not installed:

- Data connections.
- Power connections.
- Plumbing.
- Climate control and ventilation.

At TL9+, add automation to the list, and cost reduction falls to 20% per type of system not installed.

Increase amenities cost by 50% for each of the following:

- Building provides climate control in a relatively harsh environment such as desert or tundra.
- Building has higher than normal power demands (for example, a light industrial facility or constantly operating transit terminal).
- High density occupation (for example, an office building).
- High volume of people entering and leaving the building through the day (for example, a school or shopping center).
- Building has some elevators, escalators, slidewalks, or other people-moving equipment.
- Building has significant climate-control requirements (library, museum).

Increase by 100% for each of the following (*in addition to* the above modifiers rather than instead of, if they overlap):

- Building has extensive people-moving equipment (modern transit terminal, hospital).
- Building has very heavy power demands (data center or heavy industrial facility).
- Building has very heavy data requirements for its TL (call center, TV station, data center).
- Building has critical climate control requirements (biological research facility, hospital).
- Building requires redundant systems (secondary climate control, secondary power connections or data networks, etc.).

Example: A restaurant is high volume (customers in and out all day) and high power (uses large volumes of gas or electricity for cooking) for +100%, or an amenities cost of $1.05. A hospital has high power demands (50%), high density occupation (50%), high volumes of traffic (50%), high-volume people moving equipment (150%), significant climate control (150%), and often a redundant power supply (150%), for +600%, or $3.68.

The GM may also increase the cost of the building for using better quality or nicer looking materials, such as extensive molding, special surface treatments, and so on.

Building Seeds

At TL10, specialized robotic manufacturing tools can construct buildings essentially out of nothing, albeit very slowly. Programmed with a variety of building designs, they can mine their surroundings for suitable materials and produce buildings with them. These can be used to establish preliminary bases for survey missions, refugee camps, and the like.

A TL10 building seed, the same size and price as a robotic minifac (***GURPS Ultra-Tech,*** p. 90), can construct buildings made from brick (or even, if desired, hard earth) if placed into an environment with clay, concrete or stone if placed into a rocky environment, or metal if placed in a predominantly metallic environment (for example, an asteroid containing a high proportion of iron). It constructs $400 worth of structure per hour (this is vastly faster than typical minifacs, but it's largely just shuffling materials around rather than building complex manufactured items). This does not include building amenities; those must be produced later.

A TL11 building seed, the same size and price as a nanofac workbench (***Ultra-Tech,*** p. 91), can produce the same materials at twice the speed ($800/hour). If provided with sufficient metals, it will construct amenities as well. In an environment full of organic materials, it can even produce light configurable composites, but at a rate of $80/hour.

Examples

Here are a few sample buildings.

Warehouse

The warehouse is a nondescript building in a low-rent industrial park, constructed in the 1970s. The late TL7 building is all-steel construction, from the corrugated metal exterior to the trusses and I-beams holding up the ceiling.

Ultra-Tech and Spaceships

This article covers how to make buildings, but not a lot about what goes in them. ***GURPS Ultra-Tech*** and the ***GURPS Spaceships*** series can be useful for determining the costs of some of the facilities buildings might have such as furniture, medical equipment, factory systems, laboratories, gun emplacements, or even independent power generation facilities. ***Spaceships*** is particularly useful for industrial systems and very large weapons.

Notes for Deck Plans in the ***Spaceships*** designer's notes (**sjgames.com/pyramid/sample.html?id=6603**) can be used to begin to estimate how much room a building needs to accommodate a desired system. However, the floor areas estimated in the designer's notes are suitable for spaceships, submarines, boats, and other systems where volume is at an extreme premium. The space such systems are likely to take up in a building is much greater. For example, an SM +6 habitat system, suitable for cramped accommodations for two, takes up three to five hexes, or 2.5 to 4.3 square yards. But the average hotel room in the United States right now is a little over 36 square yards, more than eight times as much as the largest ***Spaceships*** value. Even in a densely packed urban area (London, Tokyo, etc.), the equivalent of a human-occupied ***Spaceships*** system in a building is likely to take four to six times as much space, and even more in areas with lower real-estate costs.

It's a single tall (20') story, almost entirely open space in its 35' by 80' footprint save for a small office in one corner. There are a phone, lights, and electrical outlets, and even an air conditioning/heating unit, but no running water.

The warehouse has a metal siding exterior on a steel frame. Total volume is 56,000 cubic feet with a partition factor of 0.3. The exterior facing and interior partitions together cost $26,880 and weigh 21,000 lbs., while the frame is $21,280 and weighs 19,040 lbs. Amenities are $22,050. Total cost is $70,210. Total weight is about 20 tons, for 272 HP.

Ye Olde Quad

This dormitory building is a late-19th-century addition to a quiet liberal-arts school in the Midwest. It's a two-story brick and wood structure around a square courtyard (about 25 yards across); each "face" of that square – a hallway flanked by rooms – is about 38' across. Each story, floor to floor, is 12' high. It's an early TL6 building, with creaky indoor plumbing, steam radiators, modest electrical power, and a phone line or two.

The Quad is made of a 4" brick exterior and 1" wood interior partitions. The total volume is 1,002,2400 cubic feet with a partition factor of 1.25. The exterior costs $275,789 and weighs 3,725,568 lbs. The interior costs $870,912 and weighs 1,282,176 lbs. Amenities are $526,176. Total cost is $1,400,717. Total weight is 2,504 tons giving it 1,358 HP; the brick walls provide DR 32, but the interior walls only DR 1.

Office Building

The office building is a shiny 35-story (420') office building built in 1995. The exterior is gleaming reflective glass, while the interior provides a mix of floor plans for the needs of different tenants.

The office building is built on a concrete core, using drywall partitions and a plate-glass exterior. Total volume is 1,512,000 cubic feet, with a Partition factor of 1. The exterior facing costs $3,379,320 and weighs 2,457,000 lbs. The interior partitions are $1,701,000 and 3,402,000 lbs. With the great height, the concrete frame is $4,064,256 and 69,854,400 lbs. Amenities are $1,190,700, which includes a bank of elevators and multiple phone and data lines as well as basic plumbing and heating and cooling. Total cost is $10,335,276. Total weight is about 37,868 tons, for 3,358 HP.

About the Author

Matt Riggsby holds degrees in anthropology and archaeology and, like the rest of his generation, works with computers. He has been the author or co-author of books on database design and development, as well as many articles for *Pyramid* magazine. He works for a company that produces TL8 medical devices, and lives in a TL6 house where nothing is square with his constructive wife, upright son, and a pack of dogs who have yet to figure out doors.

The Arrow of Progress

by Kelly Pedersen

Bows are often seen as obsolete, the arms of a previous age. But five centuries after the introduction of the gun, they are still used. Future advances in technology will apply to archery, improving bows' and arrows' performance and expanding them into new fields.

Wither Archery?

Bows occupy several niches, even in the science-fictional future. *Culture*, the desire to maintain important practices or honor the weapons of past heroes, often looms large. *Economics* plays a possible role, motivating use of a weapon that requires little investment to keep supplied. *Payload* is a third significant consideration – an arrow has larger carrying capacity than a bullet (or energy beam!), and is more convenient than a full-blown rocket or missile. *Stealth* is a useful advantage, with arrows designed to be uniquely quiet. Fighters may want to *camouflage* their weaponry in a low-tech society, and an ultra-tech bow may look primitive while still delivering high performance. Some settings just have a *restriction* that prevents guns or energy weapons from being viable (such as *Rustic*, ***GURPS Infinite Worlds,*** p. 141, or a world with artificial countermeasures), but allows bows to function, even advanced ones. Finally, personal *preference* can't be ignored; many heroes use a bow because that's what they like, with no more justification necessary.

Cost Factor

Many of the options here multiply the base cost of some other item. These are presented with a *cost factor* (CF). To calculate the final cost of an item, add all cost factors together, treating a total of lower than -0.8 as -0.8, and multiply price by (1 + total CF).

Breakthrough Bows

Ultra-tech bows still use the same basic principles: a piece of material bent by applying force, that, when released, transfers that force to a projectile. But technology can make numerous improvements to this simple mechanism.

The Material Advantage

Materials available significantly impact bow performance. Lighter, stronger substances can contain more energy in a smaller space, and release it more efficiently, propelling arrows faster.

Nanotube-Cellulose Composite (TL9-10): Composed of carbon nanotubes arranged in long chains inside a flexible binding matrix, this both is very light and has an enormous tensile strength. Bows will have most of their mass in their handles, which can trip up an unfamiliar user (-2 familiarity penalty). At TL10, even longer nanotube chains and lighter binding material further improve performance.

Carbon Nano-Matrix (TL11): Formed from carbon arranged into a structure on the atomic scale – essentially one giant molecule. This process provides enormous elastic resilience while keeping mass minimal. The limbs of a carbon nano-matrix bow feel almost weightless (-4 familiarity penalty).

Memory Material (TL9-10): Bow limbs can be partially made from memory material (***GURPS Ultra-Tech,*** p. 90). Uncharged, the material bends as easily as soft rubber. When triggered by a charge of electricity as the arrow is released, the material snaps forward, adding impetus to the shot. This contributes extra power without increasing the ST needed to draw. At TL9, bioplas is the material of choice, and at TL10, memory metal becomes the default. Adding memory materials to a bow requires a power source.

A C-cell (***Ultra-Tech,*** p. 19) built into the handle of the bow provides 10 shots before needing recharging at TL9, 50 shots at TL10, 250 at TL11, or 1,000 at TL12.

Example Bows

Unless otherwise noted, all the bows below use compound technology (***GURPS High-Tech,*** p. 201), a system of pulleys and cables that multiplies the effective force that can be applied to the arrow. A compound bow shoots as though its listed ST were two levels higher. Ultra-tech compound bows take this even further, using more loops of string and smaller pulleys. This means that it takes longer to draw, as outlined in the *Ultra-Tech Bow Table* (p. 14). Using the *Quick-Shooting Bows* rules ***(GURPS Martial Arts,*** p. 119), this time can be reduced by making a pair of Bow rolls, the first of which is at -6 per second reduced, while the second is at -6 regardless. The Heroic Archer advantage halves both these penalties. Remember that one second of reload time is always for drawing an arrow, and can be eliminated by making a Fast-Draw (Arrow) roll without penalty to the roll to fire. Higher TL compound bows also have multiple "let-off" points, giving the archer the option to reduce the draw time without penalty, at the cost of lowering arrow damage and range. Adjusted values for alternate points are shown in the *Ultra-Tech Bow Table* (p. 14).

Sport Bow

This is a weapon designed for target shooting and hunting, although it can certainly deliver a lethal wound. The bow stave is made from nanotube-cellulose composite or carbon nano-matrix, and it has a compact targeting scope (***GURPS Ultra-Tech,*** p. 149) to improve accuracy.

War Bow

Specialists or militaries with unusual traditions wield these bows in combat. The bow stave incorporates both nanotube-cellulose or carbon nano-matrix with memory materials for additional power, and it includes a HUD link, multispectral laser sight, and enhanced targeting scope (all ***Ultra-Tech,*** p. 149). In addition to the scope bonus listed in the table, the laser sight gives +1 to attacks made out to the bow's 1/2D range. The bow also includes a recognition grip (***Ultra-Tech,*** p. 150) to prevent unauthorized use; with an unauthorized archer, the memory material actually acts *against* the shot, reducing damage to thr-1, and dividing Range and 1/2D Range by 10.

Bioengineered Bows

Wooden bows can still have ultra-tech performance. Plants can be genetically engineered to produce materials with properties comparable to nanotube-cellulose composite or carbon nano-matrix. Creating species capable of growing a substance naturally requires bioengineering one tech level higher than the TL the engineered material is introduced at. A tree whose branches duplicated advanced nanotube-cellulose, for example, would require TL11 genetic engineering. "Bow trees" let a colony world produce decent weapons without a major industrial base.

Spring Forward

While compatibility with standard ***GURPS*** bow rules is a priority for this article, some attempt has been made to also keep the bows and arrows in line with the rules in *The Deadly Spring* (in *Pyramid #3/33: Low-Tech,* pp. 4-15). In particular, the formulas and spreadsheet included with that article have informed the damage statistics. For those who want to use *The Deadly Spring* to build their own ultra-tech bows, see the table below for the statistics of the materials referenced in this article.

Bows that use bioplas or memory metal to add energy are built as composite bows. Treat the memory material as having a density of 0.1 lb./in.^{3}, and 0 for breaking stress and elastic modulus (without power, it contributes nothing to the bow's force and doesn't resist bending). Design the bow as if it had a higher draw weight (and thus minimum ST) than the actual desired ST – add 5 for bioplas or 10 for memory metal. For example, a TL9 bow that incorporates bioplas to assist its shots and is intended for a ST 10 user would be designed for a draw weight of 100 lbs., which would normally require minimum ST 15.

More loops of bowstring are allowed with compound bows at higher TLs, effectively permitting longer draws without extending the bow arms. TL9 allows up to five loops, TL10 permits 20, and TL11+ bows may have up to 100 loops.

Bow Materials Table

Common Name	***Density (ρ, lbs./in.³)***	***Breaking Stress (B, lbs./in.²)***	***Elastic Modulus (E, lbs./in.²)***	***Buckling Constant (A)***	***Bow Cost/lb.***	***Arrow Cost/lb.***
Nanotube-Cellulose Compound	0.040	500,000	20,000,000	0.34	$3,125	$69.40
Advanced Nanotube-Cellulose Compound	0.020	750,000	30,000,000	0.34	$9,375	$208.30
Carbon Nano-Matrix	0.001	1,000,000	40,000,000	0.70	$250,000	$5555.60

Collapsible Bow (TL9)

Using memory material and a small servomotor, a bow can be made to collapse down to only a fraction of its normal size, easily concealed and ready as a surprise weapon. It takes two Ready actions to switch a bow from collapsed mode to firing mode, and five for the reverse. At TL9 or TL10, the Holdout penalty for the bow while collapsed is two less than its Bulk penalty. This improves to three less at TL11, and four less at TL12. CF +2; weight is unchanged. Reduce LC by 1, to a minimum of 2.

Covert Bow

Some archers need ultra-tech performance while blending into a low-tech society. The covert bow does not use compound technology, instead relying on advanced and memory materials alone to improve damage. The bow is designed to resemble an appropriate low-tech weapon composed of dark wood. The bow's surface is actually a flexible solar panel that can recharge the integrated power cell, restoring one charge for every hour in bright sunlight (at TL9; multiply charge rate by 5 at TL10, 25 at TL11, or 100 at TL12). The bow includes a recognition grip – if an unauthorized user attempts to fire it, the memory material doesn't activate, reducing damage to only thr+1, and dividing Range by five.

Ultra-Tech Bow Table

Terms and notation are as defined on pp. B268-271. If a bow has multiple let-off points (see p. 13), these are also listed.

Bow (DX-5)

TL	*Weapon*	*Damage*	*Acc*	*Range*	*Weight*	*RoF*	*Shots*	*Cost*	*ST*	*Bulk*	*Notes*
9	Sport Bow	thr+6	0+2	×20/×25	1.5/0.5	1	1(2)	$1,050	7†	-6	[1]
9	War Bow	thr+9	0+3	×35/×50	3.3/0.5	1	1(2)	$8,100	10†	-6	[2]
9	Covert Bow	thr+7	0	×10/×15	0.7/0.5	1	1(2)	$2,500	7†	-6	
10	Sport Bow	thr+10	1+2	×35/×30	1/0.5	1	1(3)	$1,500	7†	-6	[1]
	second point	thr+5	1+2	×35/×30	–	1	1(2)	–	–	-6	[3]
10	War Bow	thr+23	2+3	×75/×100	1/0.5	1	1(3)	$9,250	10†	-6	[2]
	second point	thr+11	2+3	×75/×100	–	1	1(2)	–	–	-6	[3]
10	Covert Bow	thr+10	1	×20/×25	0.5/0.5	1	1(2)	$15,000	7†	-6	
11	Sport Bow	thr+23	2+3	×80/×120	0.2/0.5	1	1(4)	$2,000	7†	-6	[1, 4]
	second point	thr+15	2+3	×80/×120	–	1	1(3)	–	–	-6	[4, 5]
	third point	thr+7	2+3	×80/×120	–	1	1(2)	–	–	-6	[4, 6]
11	War Bow	thr+41	3+4	×200/×300	1/0.5	1	1(4)	$10,000	10†	-6	[2, 4]
	second point	thr+27	3+4	×200/×300	–	1	1(3)	–	–	-6	[4, 5]
	third point	thr+13	3+4	×200/×300	–	1	1(2)	–	–	-6	[4, 6]
11	Covert Bow	thr+11	1	×20/×25	0.3/0.5	1	1(2)	$15,000	7†	-6	

Notes

[1] Cost includes $1,000 for scope. Subtract to find base cost of bow for quality modifiers.

[2] Cost includes $8,000 for scope. Subtract to find base cost of bow for quality modifiers.

[3] Use 1/2 the bow's listed ST rating to determine thrust damage and range.

[4] TL12 stats are the same, except increase scope Acc bonus by +1.

[5] Use 2/3 of the bow's listed ST rating to determine thrust damage and range.

[6] Use 1/3 of the bow's listed ST rating to determine thrust damage and range.

The Point of Progress

The default ultra-tech arrow is heavier and more expensive than the one in the ***Basic Set.*** It weighs more to take advantage of the greater power of future bows, and costs more because of the advanced materials it is made from. Cost is $25/arrow at TL9 (divide cost by 5 at TL10, by 25 at TL11, and by 100 at TL12); weight 0.5 lbs./arrow; LC4. These arrows can be customized in many of the same ways that lower-technology shafts can. Bodkin points (p. B277) give a low-level armor divisor, and the other options in *Alternate Arrows* (***GURPS Low-Tech,*** p. 73) can be applied as well.

Flight arrows, however, require some adjustment. Arrow weight is only 0.05 lbs. per arrow. Halve the damage as normal, and convert any damage bonus to dice (using *Modifying Dice + Adds,* p. B269), then reduce it by 3d, to a minimum of 0 and use the remainder for how much damage is done beyond 1/2D range. For example, a basic arrow in a TL10 ST 15 war bow does 1d+24, or 7d+3. Halved, this becomes 3d+3. A flight arrow for such a bow would do 3d+3 out to its 1/2D range and just 3 points of damage past that.

An ultra-tech bow can still fire low-tech arrows, of course. Since they are typically lighter, they pack less punch. If the arrow is between 0.3 and 0.4 lb., apply -1 to damage. If it is less than 0.3 lb., reduce damage bonus by 25% and apply -1 damage per die.

Advanced Arrow Augmentation

Ultra-tech arrows can be upgraded in a number of ways.

Enhanced Arrowhead Material (TL9-11)

Arrowheads can benefit from existing options for physical weapons (***GURPS Ultra-Tech,*** pp. 163-164). Impaling or cutting arrowheads can utilize superfine or hyperdense composition with the usual effects on damage and armor divisor and the standard price multipliers. Hyperdense arrowheads do *not* increase arrow weight or the ST of the bow required to shoot them. Instead, such arrowheads concentrate much more of the mass of the arrow in the head, leaving the shaft as an ultralight tube only used to propel the arrow from the bow and stabilize it in flight.

Cutting arrowheads can be made into a vibroblade or (if they are available) monowire or nanothorn blades. All have their normal effects on damage and armor divisor (including the improved divisors when combined with superfine or hyperdense composition) and price multipliers. Vibroblade arrows must either be active throughout their entire flight time (which imposes -1 to attacks, as the vibration disrupts the aerodynamic properties of the arrow), or must be incorporated into sensor arrows (pp. 16-17) so the vibration effect can be activated at the last minute. In either case, the arrow includes a capacitor bank that provides the energy for the blade's vibration, expending itself in the process. Recovered arrows can be recharged in five minutes from a C-cell or larger power source.

Stealth Arrows (TL9)

A typical arrow shot makes a sound between 70 and 90 decibels (easily heard with no penalty to Hearing rolls at between two and eight yards, ***GURPS Powers: Enhanced Senses,*** p. 21). This is certainly more quiet than a gunshot, even a silenced one, but many archers want even less noise. For this, the stealth arrow is available. These use fletching patterned on owl feathers and complex fractal branching patterns to reduce the sound of the arrow in flight, down to only 50 decibels (no penalty to Hearing rolls within 1.5'). This impedes the aerodynamic properties of the arrow, resulting in a 25% reduction to both max and 1/2D range and -1 to attacks. CF +1. Reduce LC to 3, if not already lower.

Force Arrows (TL11^)

Force arrows are to regular shafts as force swords are to standard blades. They are ravening energy contained by precisely tuned forcefields in the form of a weapon. When not activated, a force arrow is a short metal cylinder, only an inch or so long with a nock and fletching, resembling the butt of a normal arrow. When activated (which requires nocking it on a bowstring and exerting slight pressure), an arrow shaft composed of brilliantly glowing energy extends forward, ready to fire. A force arrow uses the stats of the bow it is fired from to determine its Acc, RoF, Shots, ST, and Rcl. It has 1.5× the bow's normal Range and no 1/2D; it always does full damage. The regular damage is replaced by 5d(5) tight-beam burning. A force arrow includes a compact A-cell to power it in flight. The cell and the force emitter burn out five seconds after being activated, limiting the time they can be aimed and making them unrecoverable. $100 and 0.05 lbs. per arrow. LC2. A bow must be specially adapted to fire force arrows, which adds $500 to its base cost.

Arrows as Ammunition

Many of the special ammunition options in ***GURPS Ultra-Tech,*** pp. 152-159) can be applied to arrows. The following treat the arrow as if it were a 25mm round (flight arrows are instead treated as 10mm caliber): armor-piercing hard core, armor-piercing hardcore explosive, high explosive, high explosive concussion, shaped charge, memory baton, high explosive multi-purpose, and strobe.

Ammunition effects that use the whole arrow shaft, rather than just the head, can be included. The following treat the arrow as if it was 40mm: biochemical aerosol, biochemical liquid, flare, tangler, thermobaric, stingray, swarm, EMP, expendable jammer, warbler, force, plasma, implosion, psi-bomb, stasis, and vortex.

At TL11, mininukes and micro-antimatter warheads can be put in arrows. The archer should either be prepared to withstand the blast or have some way to clear the danger zone *quickly* . . .

Morph Arrowheads (TL9-12)

Morph arrowheads are made from memory material and can change their shape, allowing more flexibility in a quiver without packing many more arrows. A morph arrowhead can mimic many of the special arrows in *Alternate Arrows* (***GURPS Low-Tech,*** p. 73), which only involve changing the shape of the arrowhead itself. The morph arrowhead does damage as per the arrowhead it is shaped as, with -1 damage at TL9 for using the softer, less dense bioplas. At TL10 or higher, memory metal has no damage penalty. Morph arrows can be made superfine at TL11 or hyperdense at TL12.

Besides simple alterations to the shape of the arrowhead, more radical changes can be included. These would interfere with the aerodynamic properties of the arrow, so with a tiny proximity sensor, they only transform in the last moments of flight. Barbs (***Low-Tech,*** p.73) are the simplest example, but other, more outre shapes can also be deployed: handcuffs, nets, boxing gloves . . .

Programming the arrow's form takes a Ready action. If the archer has a vocal or neural interface (***GURPS Ultra-Tech,*** p. 48), it can be set as part of the process of readying the arrow, taking no extra time.

The cost of a morph arrow depends on how many forms it potentially has, which is also limited by TL. TL9 morph arrows can only have two forms, and add 1 CF (unusual shapes add another 0.5 CF). TL10 arrows can have up to four forms, and cost +0.5 CF for each form (+1 for each unusual shape). TL11+ arrows can have any number of forms, priced as per TL10. Morph arrowheads are LC3.

Rocket Arrows (TL9+)

A rocket arrow is simply a shaft filled with rocket fuel, propelling the missile along its course at much higher velocities than a human archer could impart. A rocket arrow does not ignite for a short distance (usually 10 yards) after being fired, for safety. Within this distance, it does normal damage. Past this point, the engine kicks in and accelerates the arrow to beyond the speed of sound. After ignition, use the damage listed on the table below. A rocket arrow has no 1/2D range – it hits with full force out to the listed range.

Oliver Queen: It's a jettisoning arrow. Uses compressed CO_2 –

Cisco Ramon: Compressed CO_2 to jettison high tensile strength polymer cables.

– ***Arrow*** *#3.8*

Rope Arrows (TL9+)

A rope arrow allows lines to be affixed with a well-aimed shot. It trails a light cord behind it that pays out with minimal friction, but it still introduces significant drag, so range is reduced to 1/5 normal. The arrow can be equipped with either a piton head or a grappling hook.

Treat a piton head as a smart piton (***GURPS Ultra-Tech,*** p. 76). The piton head inflicts impaling damage and has a (3) armor divisor against stone, concrete, and similar materials. To see if a piton is set properly, roll damage against the surface it impacts, using the DR for 2" of the material. An archer can target chinks in armor (p. B400) to reduce DR. If it penetrates and inflicts at least one point of damage, it is lodged. Testing to see if a piton head is secure requires an *IQ*-based Climbing roll at +1. A successfully set piton arrow can support up to 500 lbs. (limited by the strength of the surface it is set in). At TL10, burrow-dart technology (***Ultra-Tech,*** p. 155) allows the piton to set itself more firmly once it is implanted, increasing its weight limit to 1,000 lbs., if given at least one minute to burrow.

A grappling-hook arrow includes short-range sensors to detect whether it has reached a secure place to deploy. When it does so, it brakes by pulling on its own line and extends its hooks, which include gecko adhesive (***Ultra-Tech,*** p. 83) to attach more securely. The sensors can detect whether an object is relatively solid (so light foliage or water won't trigger them), but they can't distinguish between strong or weak points, so a user must still test the line with an *IQ*-based Climbing roll. A successfully set grappling-hook arrow can support up to 500 lbs., or 750 lbs. at TL10 or higher. If shot directly at someone, a grappling arrow does crushing damage, with a (0.5) armor divisor. The Hook technique (***GURPS Martial Arts,*** p. 74) can be employed with a grappling-hook arrow, for an additional -2.

Once a rope arrow has reached its attachment point, the ring that holds the line moves up the shaft until it rests at the point that will cause the least strain. Meanwhile, the built-in ascender may begin drawing a stronger rope to the arrow. This takes one second per yard of line. If a stronger rope is not drawn, the line the arrow trails can support up to 100 lbs. (200 lbs. at TL10, 400 at TL11, or 800 at TL12).

Per arrow with 200 yards of standard line: $100, LC4. The dispenser for the line is $500, 0.5 lb., LC4, and can be added to a standard quiver or attached to a belt or other harness.

If monowire technology (***Ultra-Tech,*** p. 103) is available, rope arrows can use it for the initial line. The dispenser also includes special guides and grips to allow an archer to fire an arrow with such a dangerous substance attached. Even so, critical failures on the Bow roll become much more dangerous! Monowire is far lighter and stronger than the line usually used, so range is only reduced by 1/2, and the monowire can effectively support as much weight as the attachment point is capable of carrying, no matter the tech level. However, climbing a monowire line requires special tools to avoid cutting off extremities, so a climber *must* either have them or take the time to draw a different line to the arrow.

Per arrow with 400 yards of line: $500, LC3. $1,000 for the dispenser, LC3, 0.5 lb.

Sensor Arrows (TL9+)

Arrows can be constructed with various types of sensors built in and transmitters to communicate what they detect. The number and quality improve as the tech level advances. An arrow's feed can be monitored, in which case the observer rolls against the relevant skill or attribute, possibly with a bonus from the sensor's quality. The arrow also includes a tiny computer with software sufficient to process data, giving it the relevant skill to analyze the information it collects.

Rocket Arrow Table

Terms and notation are as defined on pp. B268-271.

Bow (DX-5)

TL	*Weapon*	*Damage*	*Acc*	*Range*	*Weight*	*Rcl*	*Cost*	*LC*	*Notes*
9	Rocket Arrow	6d×3 imp	3	1,900	0.25	2	$100	2	
10	Advanced Rocket Arrow	6d×6 imp	4	1,900	0.25	2	$200	2	[1]
11	Hyper-Rocket Arrow	6d×12 imp	5	1,900	0.25	2	$400	1	[1]

Note

[1] These can have their maximum velocity reduced, to extend flight range. Divide damage by the same factor that range is multiplied by. For example, increasing an advanced rocket arrow's range to 2,850 yards, a 1.5× increase, would reduce its damage to 6d×4.

The following table summarizes the options available for sensor arrows. It lists the TL each type of sensor is available at, the bonus to skill provided to an operator, the cost to add it to an arrow, and the page number of ***Ultra-Tech*** that the other details of the sensor are found on. Besides the sensors included here, others can be used as long as they weigh 0.5 lbs. or less and their volume isn't excessive.

When set to autonomous function, sensor arrows have an effective skill of TL+2 plus any skill bonus they provide. For example, a video-camera arrow at TL10 would have an effective skill of 14. A sensor arrow attempting to detect a point source while in flight must account for a speed penalty. An arrow typically flies between 100 and 150 yards per second. However, its software includes sophisticated motion-compensation software, and it records everything it senses, allowing it or its user to slow or pause the recording to get a better look. Divide all speed penalties by (TL-8) if attempting to sense something while in flight, and reduce them to only -1 if reviewing footage. Multiple sensor arrows of the same type trying to detect the same target give +1 per arrow after the first, to a maximum of +4.

Arrows that "zoom in" to provide a bonus (ladar, any sensor with audio or optical magnification) must either be set to focus on targets (which requires the archer to precisely identify a location, and to take a separate Aim action for each target to be focused on before firing), or the arrow must be able to distinguish useful targets (either with its own AI or with access to a database such as memory augmentation or silhouette, ***Ultra-Tech,*** pp. 56 and 149 respectively). If the arrow is acting autonomously, it must roll against its effective skill to identify a significant target in time to use more precise sensors.

At higher tech levels, more equipment can be included: two sensors with statistics one TL lower than the current TL, four sensors two TLs lower, and so on. Add the price for all sensors together to determine the final cost. For example, at TL11, a sensor arrow could be built that included a radscanner with TL10 statistics and a video camera and multi-mode radar that both functioned at TL9, which would add +$1,050 to the cost.

The onboard computer of a sensor arrow can be improved to *fast* or *genius*, providing +2 or +4 to skill to autonomously analyze information, at a cost of +$1,000 or +$25,000 per arrow, respectively.

Arrow Drone (TL10+)

This is the ultimate in "smart" arrows, including a rocket engine to provide thrust, bioplas fletching to allow mid-air course correction, and sophisticated autonomous programming capable of controlling the arrow independently for an extended time. An arrow drone includes a video camera (as per a sensor arrow, pp. 16-17). This can be replaced with another type of sensor for the usual cost (or, at higher TLs, several). The drone has sufficient fuel to stay aloft (with judicious use of gliding and thermals) for 15 minutes at TL10, 30 minutes at TL11, or one hour at TL12. Divide flight duration by four in vacuum or trace atmospheres.

One purpose for an arrow drone is to provide an arrow's-eye perspective on a battlefield. It can either loiter around a particular location or target, or to go into search mode and hunt for something specific. The drone has an effective skill for detecting targets, or the owner can look through its sensors, as per a sensor arrow (see pp. 16-17).

Sensor Arrow Table

TL	*Sensor Type*	*Skill Bonus*	*Cost*	*Ultra-Tech Page*	*Notes*
9	Video camera	+1	+$50	51	[1, 2]
9	Thermal-Imaging Camera	+1	+$500	60	[1, 3]
9	Audio Microphone	+4	+$500	62	[4]
9	Ladar	+0	+$1,000	64	[5, 6]
9	Multi-Mode Radar	+0	+$500	64	[5, 6]
9	Sonar	+0	+$200	65	[6, 7]
9	Terahertz Radar	+0	+$1,000	65	[6, 8]
10	Radscanner	+3	+$500	63	[9]
11^	Gravscanner	+0	+$500	63	[10]
11	Hyperspectral-Imaging Camera	+1	+$1,000	61	[11, 12]
11^	Ultrascanner	+3	+$1,000	66	[6, 12]
12	Passive Electromagnetic Sensor Camera	+1	+$1,000	61	

Notes

[1] Skill bonus increases to +2 at TL11 or +3 at TL12.

[2] Includes Night Vision 7, increasing to Night Vision 9 at TL11+.

[3] Includes 4× optical magnification, increased to 8× at TL11 and 16× at TL12.

[4] Includes 4× audio magnification, increased to 8× at TL10, 16× at TL11, and 32× at TL12.

[5] 3 mile range at TL9, increasing to 6 miles at TL10, 15 miles at TL11, 30 miles at TL12.

[6] Can be upgraded to a tactical design for 5× cost, capable of tracking up to 10 targets simultaneously.

[7] 20-yard range, multiplied by air pressure in atmospheres.

[8] 60-yard range at TL9, increasing to 120 yards at TL10, 300 yards at TL11, and 600 yards at TL12.

[9] Can detect signals at ×10 range. Skill bonus increases to +5 at TL11 and +7 at TL12.

[10] Add +6 to skill at TL12.

[11] Skill bonus increases to +2 at TL12, and includes 2× optical magnification

[12] Skill bonus applies only in radscan mode. Has 600-yard range at TL11, 1,800-yard range (and the skill bonus becomes +5) at TL12. Triple range for search mode.

The drone can be equipped with a standard arrowhead, or one of the more advanced warheads available (*Arrows as Ammunition,* p. 15). An arrow drone making an attack functions like a rocket arrow (p. 16), except its damage is reduced by the fraction of its maximum flight time already expended. For example, a TL11 arrow drone that had been flying for 15 minutes (25% of its flight time) would do 75% of the damage a rocket arrow would normally inflict. Note that special warhead effects or damage that don't depend on velocity are *not* affected by this reduction. Cost: $500 ($1,000 at TL11 or 12), LC2 (LC1 at TL11 or 12), 1 lb.

Archer Accessories

Future bow users have some cool new accessories available.

Arrow Foundry (TL9+)

This device is incredibly useful for the archer out of contact with regular supply. It is a suitcase fabricator (***Ultra-Tech,*** p. 90) specialized to produce arrow shafts and heads. An arrow foundry can make $100 or 1 lb. of arrows per hour (whichever results in fewer arrows), if it is supplied with materials designed to create arrows (at 40% cost, and a LC one higher than that of the arrow). If it must rely on generic materials (raw chemicals, etc.), its production rate slows to $10 or 0.1 lb. per hour. Fabrication speed doubles at each TL after 9. $5,000, 10 lbs., C/8 hours. LC3.

At TL11, the arrow foundry may incorporate nano-fabrication technology. If so, it produces $500 or 10 lbs. of arrows per hour when supplied with feedstock. If necessary, it can literally run on anything, breaking down scrap, organic debris, or whatever the user can scrounge; reduce speed to 1/10 normal. Double production speed at TL12. $20,000, 10 lbs., D/4 hours. LC3.

Either version of the arrow foundry includes blueprints (***Ultra-Tech,*** p. 91) for all standard arrow types of LC3 or higher. Blueprints for lower LC or custom arrows can be purchased at normal costs.

I shoot an arrow into the air,
where it lands I do not care:
I get my arrows wholesale!
– Curly Howard,
in ***Cactus Makes Perfect***

Arrow Tracking Tags (TL9+)

Arrows can be equipped with radio frequency identification tags or similar tracking devices – very helpful for archers with expensive ammunition. Tags with specific identifiers may also be required for commercially available arrows in some societies, in order to help track weapons. Tracking tags have negligible cost and weight, and can be added at any time before shooting them.

Finding an arrow with a tracking tag requires an Electronics Operation (Communications, EW, or Sensors) roll, at +4 within 200 yards, reducing the bonus by two for every doubling of range. Range is multiplied by two at TL10, by five at TL11, and by 10 at TL12. Tracking tags can be set to either broadcast constantly once the arrow is fired or only when they receive a unique activation signal.

Disabling an unwanted tag necessitates an Electronics Repair (Surveillance) roll, with a penalty of (9 - TL). Alternatively, a Computer Hacking or Expert Skill (Computer Security) roll (with the same penalty) can remove the tag's unique identifier, allowing the user to track it while preventing it from being tied to them.

Smart Quiver (TL9)

Storing many arrowheads and only attaching them to shafts as necessary allows an archer to save weight without sacrificing options. The smart quiver contains up to 20 arrow shafts and up to 40 arrowheads. Arrows can be prepared ahead of time, or at last moment. Attaching a head to an arrow takes one second. Once readied, an arrow is popped up to be drawn, providing +2 to Fast-Draw (Arrow). Arrows (modular or not) are stored in a secured fashion, preventing them from falling out during acrobatics or being stolen by an enemy, but leaving them unable to be traditionally drawn if the quiver is unpowered or damaged.

Since the shafts are modular, they can't contain specialized equipment. Treat all arrows using special ammunition (see *Arrows as Ammunition,* p. 15) as 25mm warheads, even those that would normally use 40mm statistics. Treat sensor arrows as though they were two TLs lower. Force arrows (p. 15) and rocket arrows (p. 16) cannot be included as modular shafts at all.

The smart quiver is controlled from a keypad in the grip of the bow or a voice interface. Sending a command takes a Ready maneuver, though this can be eliminated by a successful DX or Typing+4 roll. Alternatively, it can be controlled effectively instantaneously with a neural interface (***Ultra-Tech,*** p. 48).

$2,000, 3 lbs., C/100 arrows drawn. LC4.

A smart quiver can be designed to work with rope arrows (p. 16). It incorporates the line-deploying device and attaches the line as the rope arrow is drawn. This is $2,400 and 3.4 lbs. A smart quiver designed to handle monowire-rope arrows is $2,800, 3.4 lbs., and LC3.

About the Author

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Eidetic Memory

Ultra-Tech Armor Design

by David L. Pulver

This article provides highly optional rules for a "ground up" look at futuristic personal armor design. It uses a system inspired by the rules developed for vehicular armor. This is the third part of a trilogy of articles that began with *Low-Tech Armor Design* in *Pyramid #3/52: Low-Tech II* (covering TL0-4 armor) and continued with *Cutting-Edge Armor Design* in *Pyramid #3/85: Cutting Edge* (covering TL5-9). These rules do not replace those found in ***GURPS Ultra-Tech***; instead, they provide additional options intended for those who prefer designing personal armor in greater detail.

The article covers flexible and rigid wearable armor types built with TL10-12 technologies and with superscience, including sealed space armor and vacc suits, plus exotic armor types like electromagnetic armor and retro-reflective armor. A few examples of TL9 armor that were omitted in the prior article are also included. The complexities of powered battlesuits and force fields are beyond the article's scope.

Methodology

The *Ultra-Tech Armor Design* system constructs armor on a piece-by-piece basis, using numbers based on the weight per point of DR per square foot of torso, head, or limb area. Further modifiers are applied based on construction type to account for shaping and variations in strength over hit locations. (The full real-world rationale behind the system's design choices is covered in the *Pyramid #3/85* article.)

Design Sequence

To build armor, follow this step-by-step procedure.

Step 1: Tech Level and Name. Pick the TL at which the armor is built (from TL9 to TL12) and name the armor. If using superscience materials, add ^ after TL.

Step 2: Coverage and Surface Area. Decide on the hit location – or partial location – that will be protected by the piece of armor being built. Calculate its surface area coverage in square feet. Record this value. Decide on the number of pieces making up the armor. If the armor's DR will vary by different locations, consider noting each location's area.

Step 3: Armor Material. Choose the material used in each piece of armor. Record its material weight and cost multipliers.

Step 4: Construction Type. Choose a construction type, such as plate. Some types are only available for certain materials.

Step 5: Set DR. Decide on each piece of armor's Damage Resistance (DR). The DR can vary by location even for single-piece protection, representing armor with variable thickness on different parts.

Step 6: Time to Don and Concealment. Figure out if the armor counts as flexible, and calculate the time it takes to put it on. Determine if it is concealable.

Step 7: Calculate Weight and Cost. This is decided with a formula based on the values determined in steps 1-5. Consider style options.

Step 8: Accessories. Choose any additional accessories or options, which will further increase weight and cost.

Step 9: Armor Statistics: Record the armor's statistics block. Take note of any special factors that apply to the armor, e.g., modified DR against certain damage types.

Optionally, also calculate the armor's radiation resistance and the maximum pressure it can stand. This is useful if designing hostile-environment armor, diving suits, etc.

Yajirobe: Leave him alone!
Vegeta: What? Ahhh! You cut through my armor!
*– **Dragon Ball Z** #1.26*

Step 1: Tech Level and Name

Consider giving the piece of armor a unique name.

Example: Let's build some TL11 ultra-tech armor for the Imperial Plasma Grenadiers, an elite guard the galactic emperor's palace. We'll call it Imperial parade armor.

Step 2: Coverage and Surface Area

The human body has an average area of about 20 to 21 square feet. About seven square feet of this is devoted to the torso. Using numbers derived from the *Armor Locations* table from ***GURPS Low-Tech,*** p. 100, the *Coverage Table* (below) gives the values in square feet.

Example: The parade armor covers the entire body (we'll skip the head; it has a separate helmet). This is 19.25 square feet. We plan to make the chest portion of the armor – 5.25 square feet – thicker, so we'll have two locations with different DR coverage: chest (5.25 square feet) and one for all locations except chest and head (19.25 - 5.25 = 14 square feet).

Directional DR: Outfits may be built to protect a location (other than eyes or face) from the front (such as front trauma panels, bikini top, or a low-cut dress) or the back (such as a cape or rear trauma panels). Halve the surface area; record an F or B after armor DR.

Number of Pieces

Decide how many pieces the armor consists of. Even if it covers several locations, it can be a "single piece" provided each location logically can be attached together. For example, two arms must be separate pieces, but if there were also a torso piece, they could be a single unit, connected together. See also p. B399 for reference.

Example: We decide the suit is a single connected piece, even though we'll have different DR on different locations.

Step 3: Armor Material

Choose a material type for the armor. Several types are available, and more than one material type can be combined if desired (this is often the case for reflec, retro-reflective, and electromagnetic armor, which only resist very specific damage types).

Coverage Table

Partial locations are in italics. Locations marked as "both" protect two limbs (or partial limbs) or extremities; you can cover just one for half the surface area.

Location	***Area Coverage***	***Note***
Full coverage	21.35 square feet	All locations.
Head	2.1 square feet	Includes skull and face.
Skull	1.4 square feet	
Face ("visor")	0.7 square feet	
Neck	0.35 square feet	
Torso	7 square feet	Includes chest and abdomen*.
Chest ("vest")	5.25 square feet	No penalty to target; treat as torso* (includes vitals).
Abdomen	1.75 square feet	-1 to target; treat as torso* (includes groin).
Vitals only	1 square foot	-3 to target; hits vitals.
Groin only	0.35 square feet	
Both Arms	3.5 square feet	Includes shoulders, upper arms, elbows, forearms.
Both Shoulders	0.7 square feet	Protects arm only on 1d roll of 6.
Both Upper Arms	0.7 square feet	Protects arm only on 1d roll of 5.
Both Elbows	0.35 square feet	Protects arm only on 1d roll of 4.
Both Forearms	1.75 square feet	Protects arm only on 1d roll of 1-3.
Both Hands ("gloves")	0.7 square feet	
Both Legs	7 square feet	Includes thighs, knees, and shins.
Both Thighs	3.15 square feet	Protects legs only on 1d roll of 5-6.
Both Knees	0.35 square feet	Protects legs only on 1d roll of 4.
Both Shins	3.5 square feet	Protects legs only on 1d roll of 1-3.
Both Feet	0.7 square feet	

Common Combos

All locations ("all")	21.35 square feet
Bodysuit (all but skull, face, and neck)	18.9 square feet
Full suit (all but skull and face)	19.25 square feet
Torso, arms, and legs ("coverall")	17.5 square feet
Torso *and* arms ("jacket")	10.5 square feet
Groin and legs ("trousers")	7.35 square feet

* There's a 1-in-6 chance a hit to these locations will hit the vitals.

Example: For the Imperial parade armor, we decide to use costly diamondoid laminate (WM 0.03, CM $200 at TL11). It can be transparent at double cost, but we won't bother with that. We also must give the armor at least DR 35, due to its minimum DR.

Flexible Materials

Reflec (TL9): A light, highly reflective armor of polished metallic fibers that gets full DR vs. microwaves and (in cinematic games) visible-light and near-infrared lasers, but no DR otherwise. It negates any stealth benefits vs. radar and adds 1 (2 if wearing a full suit) to rolls to detect its wearer via radar.

Bioplas (TL10): Ultra-tech "living" smart polymer with superior damage resistance and unique self-sealing capability.

Nano-Ablative Polymer (TL10): Flexible composite with laser-absorbing nanotubes.

Advanced Nanoweave (TL10): Fabric reinforced by woven ultra-strong nanotubes.

Monocrys (TL11): Flexible diamondoid ballistic molecular mesh.

Retro-Reflective Armor (TL11^): This armor is embedded with metallic fibers covering spherical micro-lenses whose mirrors reflect laser fire back at the attacker. It returns half the damage from visible-light or near-infrared lasers that the DR actually resisted. The remaining damage affects the wearer. If not expecting reflection, the attacker gets no defense against the first attack reflected back; otherwise, he can dodge.

Energy Cloth (TL12): Also called energy weave, this is a hyperdense exotic smart matter fabric that is both flexible and exceedingly damage resistance.

Rigid Materials

Advanced Nano-Laminate (TL10): A multi-layered composite armor incorporating advanced polymer, titanium, or beryllium composites; ultra-hard ceramic nanocomposites; and reactive materials over an inner layer of spall and shock-absorbing bioplas, nanoweave, or liquid armor.

Advanced Polymer Nanocomposite (TL10): A non-metallic armor consisting of advanced polymer reinforced with high-strength carbon or boron nanotubes.

Electromagnetic Armor (TL10): Introduced in vehicles one TL earlier, EM armor is used to neutralize shaped-charge warheads via layers of thick-spaced plates or, at higher TLs, superconductor layers. When a shaped-charge projectile (e.g., HEAT) or plasma-bolt impacts the armor, sensors detect the impact and the armor generates an intense electromagnetic field, disrupting the penetrating jet and degrading or nullifying its effect. See also *Power Cells and Electromagnetic Armor* (below) for details on providing the material with energy.

Diamondoid (TL11): Super-hard diamond-like material created through molecular nanotechnology.

Diamondoid Laminate (TL11): A multilayer composite of diamondoid, titanium carbide, bioplas, monocrys, and shock- and radiation-absorbing reactive polymers.

Hyperdense (TL12): A laminate of steel and exotic collapsed matter ("collapsium").

Hyperdense Laminate (TL12): A complex laminate of hyperdense exotic matter ultra-tough synthetics and exotic shock and energy-absorbing smart matter (like energy cloth, above).

Power Cells and Electromagnetic Armor

Electromagnetic armor requires that the suit has built-in power cells dedicated to the armor. It won't function at all if there isn't enough available energy. C cells can power EM armor for a number of times equal to *Uses* determined by the formula below:

Uses = (Pc × DRe) × number of C cells dedicated to powering armor.

Pc is 500 at TL9, 2,000 at TL10, 4,000 at TL11, and 8,000 at TL12.

DRe is the highest DR of electromagnetic armor on the suit.

B cells provide 1/10 as many uses, D cells 10× as many, E cells 100×, etc.

Add the weight (but not cost) of the desired number of power cells to the armor's weight: B cells are 0.05 lb., C cells are 0.5 lb., D cells 5 lbs., and E cells 20 lbs.

Armor Material Table Key

TL: The earliest tech level the material is available for armor.

Material: A designation for the material.

WM: This is the armor weight multiplier; it is the weight of one square foot of armor with DR 1, assuming the armor is of solid, flat construction.

CM: The base cost *per pound* of worked material.

DR/in: For reference purposes, this is the DR per inch of a one-inch (25mm) thickness of that material. Some materials have a split DR as detailed in their Note.

Keep your guns trained on him. If it even looks like he's about to leave that room, open fire. Oh, and avoid the bat symbol. That's a . . . that's a little trick. It's where his armor is strongest. Aim for the vulnerable spots at the shoulders, then coordinate fire at the points where the plates meet.

– Arkham Knight, in ***Batman: Arkham Knight***

Armor Material Table

See *Armor Material Table Key* (pp. 21-22) for details on terms and abbreviations.

TL	Material	WM	CM	DR/in.	Max DR	Min DR	Notes	Construction
Flexible Materials								
9	Reflec	0.005	$150	833*	83	–	F	F/O
10	Bioplas	0.015	$600 ($300 at TL11+)	278†	92	–	B, F, T	F/O
10	Nano-Ablative Polymer	0.012	$150 ($75 at TL11+)	275‡	128	–	E, F	F/O
10	Advanced Nanoweave	0.024	$150 ($75 at TL11+)	138†	70	–	F	F/O
11	Monocrys	0.018	$150 ($75 at TL12)	184†	92	–	F	F/O
11^	Retro-Reflective Armor	0.0025	$1,500	1,666*	166	–	F	F/O
12	Energy Cloth	0.014	$500	240	120	–	F	F/O
Rigid Materials								
10	Advanced Nano-Laminate	0.04	$200 ($100 at TL11+)	166	66	35	L	R/S
10	Advanced Polymer Nanocomposite	0.08	$50 ($25 at TL11+)	104	42	–	T	R/S
10	Electromagnetic Armor	0.01	$100 ($50 at TL11+)	666	264	35	M	R/S
11	Diamondoid	0.06	$50 ($25 at TL12)	232	93	–	T	R/S
11	Diamondoid Laminate	0.03	$200 ($100 at TL12)	420	168	35	L	R/S
12	Hyperdense	0.04	$50	2,083	417	10	L	R/S
12	Hyperdense Laminate	0.02	$200	1,040	278	35	L	R/S

* The armor's DR only applies vs. microwave and (in cinematic games) visible and near-infrared laser beams. It has 0 DR vs. other damage types.

† The *full* DR only applies vs. piercing and cutting damage (or, for bioplas, vs. piercing and burning). Divide DR (and DR/in) by three vs. all other damage types.

‡ The *full* DR only applies against burning damage from lasers (including X-ray, gamma-ray, etc.). Divide DR (and DR/in) by six vs. all other damage types.

Max DR: The maximum DR that any single layer of worn armor can possess, to avoid making it too thick to wear.

Min DR: Some laminate armor requires a minimum thickness. The armor must be built with at least this DR using the material.

Notes: Special notes regarding the armor:

B is bio-tech, capable of sealing punctures or rips. In addition, at DR 15+ bioplas can greatly reduce the cost and weight of an extended life-support system (p. 26).

E is energy-ablative; treat the armor as ablative DR vs. damage from lasers, plasma or fusion guns, or flamers.

F means the armor is flexible *if* it has no more than 25% of its listed DR/in. Flexible armor has flexible DR, but can be donned in 2/3 the usual time. It is subject to the blunt trauma rule (p. B379). It may be built with "DR 0" (treat as DR 0.25 for weight and cost calculation); this is useful if using these rules to create unarmored clothes.

L is composite laminate armor. If the armor has *at least* half the max DR, the DR will be doubled against shaped-charge warheads (e.g., HEAT) and plasma bolts (plasma or fusion weapons).

M is electromagnetic armor. Its DR protects *only* against shaped-charge projectiles and plasma bolt weapons. Attacks failing to penetrate the DR of any armor installed over the EM armor (or any screens) don't trigger the EM armor. If building electromagnetic armor to match the examples in ***Ultra-Tech*** (where the EM armor is described as increasing laminate armor DR from double its DR to triple its DR against shaped-charge and plasma attacks), simply assign an EM armor DR equal to 100% of the laminate armor's DR.

T means it can be transparent (it doesn't have to be) at twice the material cost. If transparent, it has 0 DR against visible-light laser beams, such as blue-green lasers, and against any blinding attack. Transparent armor is useful for creating visors, shades, and the like. For 2.5× material cost, it can be transparent at will.

Construction: R/S means it can be used for any rigid (plate, solid, segmented plate, or impact-absorbing plate) construction type or for scale construction. *F/O* means the material can be used as fabric or optimized fabric.

Step 4: Construction Type

The weight of armor material assumes a solid construction with no joins or gaps, but alternative construction types are more commonly used. The *Armor Material Table* lists what other construction types are possible for given materials at various TLs. Refer to the descriptions below and the *Construction Table* (p. 23) for options.

Example: We used diamondoid laminate, with construction type R/S, so it cannot use fabric or optimized fabric. We decide the armor is plate, with CW 0.8, CC 1.5 (at TL9+), and Min DR 3.

Flexible Materials

Fabric: This is simply a wearable garment with uniform protection across the material, so that *Chinks in Armor* (p. B400) rule should *not* apply.

Construction Table

CW: The construction weight multiplier.

CC: The construction cost multiplier at TL9 and higher.

Min DR: The minimum DR that the armor may be assigned; if it is higher, use the minimum DR listed on the *Armor Material Table*.

Notes: The effect on DR, as covered in Step 5.

Type	*CW*	*CC*	*Min DR*	*Notes*
Types F/O				
Fabric	1	1	1	
Optimized Fabric	0.8	2	2	
Types R/S				
Scales	1.1	0.8	2	-1 DR vs. crushing unless armor is DR 4+.
Segmented Plate	1.45	0.9	3	
Plate	0.8	1.5	3	
Impact-Absorbing	0.65	1.5	2	Half DR vs. damage that isn't crushing.
Solid	1	1	2	See description below.

Optimized Fabric: Body armor is often designed with thicker material over areas that are more likely to be hit. If this construction type is used, the *Chinks in Armor* (p. B400) and *Harsh Realism – Armor Gaps* (see ***GURPS Low-Tech,*** p. 101) also apply.

I am, however, wearing full body armor. I am not a moron!

*– The Operative, in **Serenity***

Rigid Materials

Scales: This turns a solid material into a flexible version by forming the material into small linked platelets, often inspired by computer analysis of animal armor.

Segmented Plate: Uses large, overlapping horizontal bands of armor laced together.

Plate: Armor made of solid plates or castings, attached by joints, carefully shaped to use less material in areas of reduced vulnerability to save weight. However, the armor is vulnerable to *Chinks in Armor* (p. B400) and *Harsh Realism – Armor Gaps* (see ***Low-Tech,*** p. 101).

Impact-Absorbing: Built with a structure designed to collapse and thus absorb and dissipate heavy impacts, or with extra padding. Treat as plate, but it has split DR: use the full DR vs. crushing damage (including explosions) and half its DR (round down) against other types of damage.

Solid: This represents flat or gently curved plates. It's not really possible for armor on most limb hit locations, but can be used for chest, skull, head, or face (as well as things like vehicles). The *Targeting Chinks in Armor* rules should not apply.

Step 5: Set DR

Choose the armor's DR, keeping in mind these considerations.

Maximum DR: The armor can't exceed the Max value for the material type specified on the *Armor Materials Table*. If armor is to be concealable as or under clothing, its DR should have no more than half the material's Max value.

Minimum DR: The armor can't be less than the Min DR specified on the *Construction Table* or the *Armor Material Table*.

A greater DR will increase cost and weight, as shown below. If this is a major concern, calculate the weight and cost per point of DR first, and then choose actual DR.

If the armor material or construction type affects DR vs. some types of damage, make a note of it. Many armor materials get reduced DR vs. certain damage types.

Example: Diamondoid laminate has a max of DR 420 (and min. 35), but that much armor would be too heavy to move in! As it is for use around the palace, we want the armor to be something that does not add significant encumbrance to the wearer, so we need to keep it below 20 lbs. for an average person. However, it should be reasonably effective against blaster pistol or similar weapon – at least DR 30. We decide it has DR 45 on the chest but the minimum DR 35 elsewhere.

Extra Detail: Radiation Shielding

A heavily armored suit may provide some radiation shielding, as measured by its Protection Factor (PF); see p. B436 for how it reduces the effects of radiation. Use PF rating against most ordinary radioactivity, including radiation produced by nuclear weapons. Less penetrating radiation from solar flares and Van Allen bolts is resisted with 20 × PF. Radiation shielding PF is based on the area density (AD) in pounds per square foot of the armor, since what matters is the total thickness and mass rather than its ability to stop bullets.

Area Density (AD) = DR × material WM.

DR is the armor's DR. (If it varies, use the DR applicable vs. burning damage, and use the lowest location's DR.) All TL10+ *laminate* armors include additional layers of radiation-absorbing materials; treat their DR as 10 times higher for this purpose.

WM is from the armor material.

Look up the area density (AD) on the table below to find the Protection Factor (PF):

AD	*PF*	*AD*	*PF*
1-9	0.5*	100-119	50
10-19	1	120-199	100
20-39	2	200-399	200
40-59	5	400-599	500
60-79	10	600-799	1,000
80-99	20	800-999	2,000

* Treat this as PF 1 against most radiation; the fraction 0.5 is used only when calculating effective PF against less penetrating radiation (e.g., solar flares and Van Allen belt radiation) which is resisted with 20 × regular PF and so would be PF 10.

Example: The suit's diamondoid laminate had WM 0.03. Multiplying this by DR 35 × 10 (for TL10+ laminate) gives an AD 10.5, which means we have PF 2 (PF 40 against less penetrating radiation like solar flares, etc. where even thin protection is effective).

Conceit is the finest armour a man can wear.
– Jerome K. Jerome

Step 6: Calculate Time to Don and Concealment

The base time to don for high-tech or ultra-tech armor is three seconds per piece.

Armor is flexible if it uses a flexible material, or uses a rigid material plus scale construction; otherwise it is rigid. Any single piece of armor that covers any of the leg locations *and* one or more other locations (besides feet) takes twice as long to don, even it's flexible, or five times as long if it is rigid.

Armor can be put on in only 2/3 the time by omitting properly securing the armor, tightening straps, and adjusting the fit. For quickly donned armor, the GM should assesses -1 to DX until it can be securely fashioned. Sealed armor (see below) also may not be properly sealed, if donned hastily; roll vs. NBC Suit or Vacc Suit skill to avoid this.

It generally takes half the specified time to remove securely fastened armor.

Example: The armor covers everywhere but the head, so it falls under "covers leg and one other location (besides feet). Additionally, it's rigid, therefore takes five times as long to don, or 15 seconds.

Concealable?

Rigid armor is not concealable. Armor made of flexible materials or scale *may* be concealable, depending on how thick it is.

Armor with *more than half* the maximum DR is not concealable. It can only pass as heavy clothing such as a trench coat, biker leathers, etc. Reduce LC by 1.

Armor with *up to half* the maximum DR can be concealed under clothing or pass as ordinary civilian outerwear.

Armor with *no more than one-quarter* the maximum DR can pass as light clothing such as T-shirts, evening wear, skin-tight suits, etc. and be worn beneath clothes. Increase LC by 1 to max LC4.

Armor with *no more than one-sixth* the maximum DR can be disguised as swimwear, lingerie, or other diaphanous clothing. Increase LC by 1 to max LC4.

Example: The armor is rigid, so it's not concealable.

Step 7: Calculate Weight and Cost

Use the formula below to calculate the weight and cost of the armor. To instead calculate the weight and cost *per point* of DR, just use "DR 1" in the formula.

Armor weight (in pounds) = LSA × WM × CW × DR.
Armor Cost = armor weight × CM × CC.

LSA is the location surface area from the *Coverage Table* (p. 20).

WM is the material weight from the *Armor Material Table* (p. 22).

CW is the construction weight multiplier from the *Construction Table* (p. 23).

DR is Damage Resistance.

CM is the material cost from the material *Armor Materials Table*.

CC is the construction cost multiplier from the *Construction Table*.

The final weight and cost should be rounded to two significant figures – that is, round $246 to $250, or 13.5 lbs. to 14 lbs.

Example: The chest armor has LSA 5.25 (chest) × WM 0.03 (diamondoid laminate) × CW 0.8 (plate) × DR 45 = 5.67 lbs., Its cost is the armor weight 5.67 × CM $200 (diamondoid laminate at TL11) × CC 1.5 (plate) = $1,701. The armor on the rest of the body is LSA 14 × WM 0.03 × CW 0.8 × DR 35 = 11.76 lbs. Cost is 11.76 × CM $200 × 1.5 = $3,528. As this is a single piece suit, the weight is 5.67 + 11.76 = 17.43 lbs., rounded to 17 lbs. The cost is $1,701 + $3,528 = $5,229, rounded to $5,200.

Cut: Stylish or Fashion Original (Optional)

Armor – even if it's not concealable (e.g., parade or tournament armor) – can be attractively styled. Apply this as a modifier to the calculated cost. *Stylish* armor is four times the above cost. *Fashion originals* are 20 times the above cost. Stylish or better armor can also include "authentic" appearing replicas of period armor made from inauthentic materials.

Example: It's ornate armor for the elite Plasma Grenadiers! It has gold and iridium highlights and buckles! Four times cost for stylish, or $20,800.

Step 8: Consider Accessories

Armor can have additional accessories and modifiers. Unless noted, any system can be used with any ultra-tech armor. Some of the most common options are detailed below, but numerous other possibilities are available from ***GURPS Ultra-Tech*** and ***GURPS High-Tech***.

General Accessories

Sealed: Armor with DR 1+ can be sealed. All rigid armor joints are protected and/or fabric is treated to be impervious to penetration by liquids and gases. If a wearer's entire body is protected by sealed armor, the wearer has the Sealed advantage (p. B82). Ultra-tech sealed armor is an extra $5 per square foot protected. Round off as above. Of course, armor without a helmet, etc. only counts as sealed when it's fully buttoned up.

Waste-Relief System: The suit collects and packages the wearer's waste products in a hygienic manner. $500, 1 lb. at TL9-10; halved at TL11+. Available for any armor that includes the groin location (groin, abdomen, torso, full suit, etc.). No extra weight if DR 5+ bioplas covers that location, as it's assumed to feed on waste products.

Infrared Cloaking: Any suit that covers at least 70% of the entire body may have this option. This system reduces an object's heat signature to defeat infrared and thermal imaging detection. It subtracts -4 at TL9, -6 at TL10, -8 at TL11, or -10 at TL12 from rolls to detect the wearer via infrared vision or similar sensors. 3 lbs. and $75 per square foot of armor. LC3.

Biomedical Sensors: +1 to Diagnosis rolls when examining suited wearer (or remote diagnosis at -2 to skill). $200, 0.2 lb. See ***Ultra-Tech,*** p. 187. Can be built into any armor that includes chest coverage.

Near Miss Indicator: Sensor grants +2 to Vision rolls to spot source of projectile fire in conjunction with HUD or sensor visor. $1,000, A/24 hr. See ***Ultra-Tech,*** p. 188.

Psionic Mind Shield Circuitry (TL9^): Adds TL-6 to IQ or Will to resist Telepathic afflictions or attacks; $1,000, 0.5 lbs., 2B/100 hrs., LC3 (See, ***Ultra-Tech,*** p. 188).

Personal Radar/Ladar Detector: Warns of radar, ladar, or laser targeting at 2× targeting system or sensor's range (1.5× if LPI sensor). $50, 0.5 lbs., A/10 days. See ***Ultra-Tech,*** p. 188.

Additional Options

A few options covered in the *Pyramid #3/85* article are relevant at high TLs, but were omitted to avoid repetition. The GM should consider *Extra Detail: Armor, Surface Area, and Size* and *Trauma Plate Carriers* rules for additional specifics.

Trauma Maintenance: Built-in drug injector with 10 doses. $2,000, neg., A/1 yr. See ***Ultra-Tech,*** p. 188.

Microbot Arteries: Allows a one-yard swarm of microbots to nest in the suit. Suit must cover at least the entire torso. $500, neg., without microbots. See ***Ultra-Tech,*** pp. 35 and 189 for swarms and arteries. Often uses a TL10 paramedical crawler swarm ($6,000) or a TL10 repair swarm ($500).

Climate Control: Add to any suit. Provides air conditioning, waste-heat removal, insulation, and one day's drinking water supply. This is typically effective within a climate range from 120°F to -40°F without penalty or fatigue, but see *Temperature Tolerance* (p. 26). Adds $50, 0.5 lbs. Usually added to whatever part of the suit covers the torso.

Desert Environment System: Recycles nearly all waste water (increase duration 60×). $1,000, 2 lbs. See ***Ultra-Tech,*** p. 189. Requires some form of climate control (above) or life support (p. 26). Not necessary if suit has extended life-support system (p. 26).

Extreme Climate Control: This provides light, water, heating, and cooling systems like the basic climate-control version, but at *any* extremes of temperature that the suit can physically withstand as long as the wearer is entirely enclosed in sealed armor. This will vary, but usually means from near-absolute zero to whatever temperature would start to damage the suit. $200, 1 lb. Usually added to whatever part of the suit covers the torso. An alternative to climate control and the various life-support systems detailed below.

Air Supply: Any sealed suit or any helmet with an air mask may incorporate oxygen tanks (rather than just wearing them separately); a suit with a life-support system or extended life-support system (see p. 26) will often incorporate an air supply. A suit can have more than one tank if desired.

Large Air Tank: This holds 24 hours at TL9, 36 hours at TL10, two days at TL11, 3 days at TL12. $200, 10 lbs.

Medium Tank: Holds 12 hours at TL9, 18 hours at TL10, 24 hours at TL11, or 36 hours at TL12 of air. $80, 4 lbs.

Small Tank: Holds four hours at TL9, six hours at TL10, eight hours at TL11, or 12 hours at TL12. $60, 2 lbs.

Tiny Tank: Holds 10 minutes at TL9, 15 minutes at TL10, 20 minutes at TL11 or 30 minutes at TL12 of air. $50, 0.5 lbs.

If you keep the arena open, my metalbenders and I will provide extra security during the championship match. There's no better force to deal with the chi-blockers. Our armor is impervious to their attacks.

– Lin Beifong, in ***The Legend of Korra*** *#1.6*

Life-Support System (LSS): This is a life-support pack that functions as extreme climate control (p. 25) and provides a water supply equal to the air duration, the Vacuum Support advantage (p. B96), and pressure support (see *Extra Details,* below) as long as the wearer is entirely enclosed in sealed armor (e.g. has a helmet, etc.), with built-in or external air tanks (p. 25). Add to any sealed suit, normally adding it to the torso section. A prerequisite for adding LSS requires minimum DR 2 if TL9+ flexible armor or DR 6+ if TL9+ rigid armor; if damage varies vs. different types, this DR must be vs. crushing damage. $1,000, 2 lbs. It requires a suit power pack (below).

Extended Life-Support System (ELSS): This is an ultra-tech alternative to the LSS that can be used with any sealed suit in conjunction with built-in or external air tanks (p. 25). It's usually built into whatever part of the suit covers the torso, as a backpack. It reclaims and recycles most of the user's water and air supply, while scrubbing out waste products. Multiply operating air and water duration by 10 at TL9 or by 60 at TL10+. The system is 5 lbs. and $10,000 at TL10; halve this at TL11+ For sealed suits with at least DR 15+ bioplas on 80% or more of the body, divide weight and cost by five; the "living" suit performs recycling.

Power Pack: Any suit with a climate-control or life-support system should have a power cell. Generally, each C cell (adds 0.5 lbs. to suit weight) provides any life-support system or extreme climate control with 12 hours power at TL9, 18 hours at TL10, 24 hours at TL11, or 36 hours at TL12, or twice that for ordinary climate control. Often two cells are used. Don't add their cost, however, just their weight.

Example: We decide the Imperial parade armor has several accessories. We'll add biomedical sensors ($200, 0.2 lbs.), plus a waste-relief system so the palace guards can stand at attention for hours without restroom breaks ($250, 0.5 lbs. at TL11). We'll make it sealed armor; using its total 19.25 sq. ft., that's $5 × 19.25 = $96.25. Let's also add infrared cloaking ($30 × 19.5 = $585). For use when the suit is paired with a sealed helmet, we'll give it an extended life-support system (ELSS) ($5,000, 2.5 lbs.) and add a built-in tiny air tank ($50, 0.5 lbs.) for when not wearing external tanks. It will also use two C cells as a power pack for its ELSS (giving 48 hours of power). The accessories add a total of $11,181.25 and 4.7 lbs. to the suit's existing $20,800 and 17 lbs., for a total of $26,981.25, rounded to $27,000, and 21.7 lbs., rounded to 22 lbs.

Extra Details

The following details are pertinent for armor with appropriate accessories.

Vacuum Support

A suit is pressurized and thus counts as "vacuum support" if all locations are sealed and has life support or extended life support system. (Many suits as noted as "pressurized if sealed helmet added.")

Example: Our suit qualifies as vacuum support if paired with a sealed helmet.

Temperature Tolerance

Any *sealed* suit that covers at least 90% of the body and has climate control provides -40°F to 120°F temperature tolerance. If it is completely sealed increase this to -50°F to 150°F if DR 5 or less (vs. burning damage). If it has extreme climate control or a life-support system and is completely sealed raise this to at least -459°F to 250°F (or perhaps higher, at the GM's option).

Example: Our suit gets -459°F to 250°F protection while completely sealed, thanks to its life-support system.

Pressure Support and Crush Depth

Rigid armor is rated for the maximum atmospheres of pressure it can withstand without collapsing (crushing the occupant). A sealed pressurized suit with rigid armor can resist 1.5 atmospheres of pressure per point of rigid armor DR. Exception: If the armor uses only Solid construction, multiply its effective DR by 10 for this purpose. Where DR varies over different locations or directions, use the lowest DR; if it varies vs. damage type, use DR vs. crushing damage.

Multiply by 33 to get a crush depth in feet of water.

Example: Our suit has DR 45 on the chest and DR 35 elsewhere. It's rigid pressurized armor. If it were combined with a helmet with similar capabilities, it could withstand a maximum of 1.5 × 35 = 52.5 atmospheres of pressure, or 1,733' of water. (If the helmet was worse, we'd use the helmet's values to calculate this.)

Helmet Accessories

Add these features to any armor that covers the skull or entire head. LC4 unless noted.

Tiny Radio: 0.05 lbs., $50, includes GPS receiver. See ***Ultra-Tech,*** p. 74. Range is one mile at TL9, two miles at TL10, five miles at TL11, or 10 miles at TL12.

Air Mask: $50, 0.5 lbs. Used with a filter or air tanks, allows breathing in unbreathable but not otherwise harmful atmospheres. *Not* necessary if the suit has air tanks and either a life-support system or extended life-support system, if all locations are sealed.

Computer: A tiny computer with the Hardened and High Capacity options. It has It has Complexity 3 (TL9), 5 (TL10), 6 (TL11), or 7 (TL12). 0.1 lb., $150 ($3,000 for Fast version with +1 Complexity).

Filter: $100, neg. weight. Filters out gas, etc. Useful even with life support, as this doesn't use up stored oxygen.

Provisions Dispenser (TL9): Provides food paste. $50, 1 lb., *plus* $10 and 0.75 lbs. per day of food paste (***Ultra-Tech,*** p. 73) stored (maximum of two weeks).

Hearing Protection: $50, neg. weight. Screens out noise equivalent to Protected Hearing (p. B78). Add to any armor that covers the skull or entire head.

Any rigid armor that covers the face (or entire head) with transparent material may incorporate a head-up display. See ***Ultra-Tech,*** p. 24.

Head-Up Display (HUD): Basic helmet-mounted display. $50, 0.1 lb.

HUD With Infrared Visor: As above but with infrared vision and 2× magnification at TL9, 4× magnification at TL10, 8× at TL11, or 16× at TL12. $500, 0.6 lbs., B/10 hr.

HUD With Hyperspectral Visor: As above, but provides hyperspectral vision. Magnification is 1× at TL9, 2× at TL10, 4× at TL11, or 8× at TL12. $2,000, 0.6 lbs., B/10 hr.

If the face is not covered with transparent material, the user will be blind when the visor is in position. To fix this, add a sensor visor.

Sensor Visor: If a helmet lacks a transparent visor, sensor information suitable for 360° scan (giving Peripheral Vision) is $1,000 at TL9 (halved at TL10 and again at TL11+). Includes basic HUD, audio microphones, and a simple (and unjammable) low-light optical-circuit TV camera if no better sensors are provided. Burned out by a critical hit to "eyes" location on 10 or less on 3d. See *Armor Without Faceplates* (***Ultra-Tech,*** p. 187).

Step 9: Armor Statistics

Give the armor a name and record the armor's statistics block using the standard format with the addition of a Don time entry.

Note any modifications to DR against different damage types. Put an * after DR to denote flexible armor, as defined under *Calculate Time to Don and Concealment,* p. 24.

Assign the armor whatever LC seems appropriate, often based more on its look and feel than its actual statistics. Civilian-wear armor is usually LC4, paramilitary gear is LC3, and full military gear LC2.

If the suit has a power supply for its life support record the type of cells and duration.

Example: We assigned it LC2. Our armor has the statistics shown in the table below.

About the Columnist

David L. Pulver is a Canadian freelance author. An avid science-fiction fan, he began roleplaying in junior high with the newly released ***Basic Dungeons & Dragons.*** Upon graduating from university, he decided to become a game designer. Since then, David has written over 70 roleplaying game books, and he has worked as a staff writer, editor, and line developer for Steve Jackson Games and Guardians of Order. He is best known for creating ***Transhuman Space,*** co-authoring the ***Big Eyes, Small Mouth*** anime RPG, and writing countless ***GURPS*** books, including the ***GURPS Basic Set,*** *Fourth Edition,* ***GURPS Ultra-Tech,*** and the ***GURPS Spaceships*** series.

Example Armor Table

TL	*Armor*	*Location*	*DR*	*Cost*	*Weight*	*Don*	*Power*	*LC*
10	Imperial Parade Armor	Full suit	45/35*	$27,000	22	15	2C/48 hrs.	2

* Split DR: DR 45 on chest, DR 35 elsewhere. Suit covers all areas except skull and face.

Notes: The armor provides PF 2 (40 vs. solar flares, etc.), resists 52.5 atmospheres pressure, and protects against temperatures between -459°F and 250°F. Two C cells give a duration of 48 hours.

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Hexopersonality

by J. Edward Tremlett

Man, it was Mega. I was deep into Komicon's servers, looking for the prize, and this HammerHead comes roaring around the corner. I threw Twists at it, but it sniffed past them and came right for me. Sure was dead, but I was Hexing, so I just came back home. Just like a game, man!

Sad about the P2, though. Other Me was pretty chill. Did my expense report one time, and Oyabun liked it better than mine! Of course, maybe it was Oyabun's P2 liking it. I think he's got three.

Just as well, though. Heksagon's new model's out in a week, and I wasn't looking forward to shutting Other Me down for a new one, you know? Could run both, but new and old don't play together well sometimes . . .

Send out a "safe" brain backup to explore cyberspace today!

Telepresence: the ability to send one's mind into the neon world of cyberspace. To experience the web not as a readout on a screen, or a virtual reality simulation, but as a full, real-time sensory experience.

To fly through heaving digital mountains. To dive into the cool, chattering seas of information. To join hands with fellow explorers of the shadow architecture of the world, and find its glittering, secret treasure – information, itself.

To actually *be* the ghost in the machine.

True, the path is as dangerous as it is beautiful. How could it *not* be? Cyberspace has guardians aplenty, hiding within the dark corners and hidden grottos. Bombs and traps lie in ambush, attackware waits for the unwary, and no one wants to die in that lovely neon world.

But once you've Gone Under that first, amazing time? There really is no substitute. Is so lovely a reward *not* worth so great a risk?

Fortunately for those who want to go for the ultimate swim, but not get eaten by the sharktech, there's Hexing: sending a tandem "backup brain" to explore cyberspace, instead of yourself. The Hexopersonality is linked to your mind, but can break off contact within a picosecond should a truly fatal error occur. This allows digital explorers to take much more dangerous risks than ever before. The backup can also be "unhooked" to act as an extra, independent set of hands.

Hexopersonalities have become something of a status symbol among the corporate cognoscenti. The mildly wealthy and up-and-coming have bought them up like donuts, wanting to try this telepresence thing, and the side applications are transforming society by leaps and bounds.

But the modules are not without their troubles. The older models could be a little touchy at times, and the newer ones have bugs that can be downright discomforting.

There's also the danger of just letting a copy of yourself out of your sight, for even a short time. Sometimes dogs are held for ransom. Some even learn to bite their masters.

This generic article describes the advent of the age of telepresence, thanks to a wondrous (if flawed) product that has the possibility of changing the world, if it doesn't destroy its corporate infrastructure first. Find out how the modules work, how they go wrong, and what they can be used for. Also get ways people are using it, and campaign ideas that run from commonplace to more exotic.

Join the Army; See the World

Much like most of the attack-tech running around cyberspace, the technology that fuels Hexopersonality was initially developed for the military. They were experiencing too many terminal injuries while training telepresence-divisions in cyber-combat, and they needed to do something to avoid losing more, valuable talent.

So the Parallel Personality (P2) was created and implemented – boosting the boot camp survival rate to 95%, rather than the recruit-wasting 65% it had been before. It worked so well that the cyber divisions began using P2 regularly in the field, except for some veterans who refused the upgrade. They claimed it "felt wrong" somehow. Like there was someone else in their minds.

It wasn't long before renegade hack versions of the P2 wound up on the black market, finding their way into the decks of info thieves and deep explorers everywhere. The military tried to stop it from spreading, but that was as unsuccessful as any other time they'd tried to keep military hardware from being copied, freely distributed, and then improved upon by hobby hackers and renegade engineers.

At some point, a hacker in need of creds sold out, and the corporations got their hands on it – creating rival products for the free market. Price wars broke out, and trade journals praised the good and excoriated the bad. Corporation-paid media did exposes on one another's P2 system. When the dust settled, there was just one victor remaining, holding high a superior product: Singapore's own Heksagon, with their sleek and stylish – and mildly affordable – Hexopersonality modules.

Hexing was the new now thing for those wanting explorer thrills without the risk of hacking. No more playing it safe behind a screen or clunky, slow VR rig! No more wading in your own, safe environment either. Corporate types could go ahead and take the Big Swim in the deep, dark C, safe in the knowledge that if they went too deep, or ran into something they couldn't handle, they could just jettison the copy and snap back to their bodies.

Then they'd have to buy a new module. But what's another 10,000 between friends?

But the Hexopersonality – essentially a shallow, digital copy of the user's brain – had many other uses as well. If the user was willing to jack out and allow the copy to operate independently, it could do pretty much anything the user could do. It could run software and perform searches, write code and absorb information, tend computer games and pay bills. It could even stand in at business meetings and negotiations, act as a personal assistant – whatever else was required.

Best of all, the modules also performed as a backup brain. Everything the P2 did and learned, with or without the user, was *instantly available* and with *complete clarity*. Whether it was searching for complex financial records or reading Tolstoy, every second was there to be re-remembered. The memories would begin to fade as soon as the user jacked out again, but would all come back as soon as they returned.

As always, there was some scary stuff in the fine print: neural degradation, cranial infections, and cyber-addictions being the main problems. But cutting-edge technology always has problems that can't be tested for in a lab, much less foreseen.

It wouldn't be long before some of those problems started to bob to the surface.

I Found the Problem, and the Problem's You

The problem is that Heksagon did too good of a job when it made a program that could copy a human mind. The P2 doesn't degrade, as they say – just like any living being, it *evolves*. Gets new ideas. Wants different things. *Changes its mind*.

Every 24 hours the user leaves an active P2 to its own affairs, there's a cumulative 10% chance it will stop being an exact copy of the user's brain, and start to form its own ideas. When that happens, the interface won't be as smooth anymore, and the P2 will actually fight its user to gain dominance.

Users schooled in cyber or psychic combat will realize something is wrong. But most Hexers won't have any idea that they've been attacked by their own program and disconnect in time. They'll just think they're having a headache, pop some pain killers, and get back to it.

What happens then? It depends on the user and how far gone the P2 is. If the user's an oily business type, maybe the Hexopersonality just makes a corporate takeover – slowly rewriting the meat to match the new reality. A more reckless sort might actually force the issue, wrestling for control over the body until either the P2 is in charge, or the user disconnects in pain. Even then, enough neural damage might have occurred that the poor user will stroke out in 10 minutes or less.

Heksagon's customer service is always so very, very sorry this happened. The risks *were* printed on the box, though. You want to dive, you have to obey the lifeguard, and sometimes you just drown.

New Thing From London Town

The Hexopersonality module, as manufactured by Heksagon, comes in one standard package. It's a rounded hexagonal pod, wholly enclosed by a light gray, translucent ceramic shell that's 2" tall and 8" wide with 4" sides. The module comes with a stylish, dark-gray dock that has all the inputs needed to make the connection.

The shell has no screws or joins, and it not intended to be opened. Cracking it exposed its delicate, anaerobic innards and causes them to melt – thus protecting Heksagon's IP from would-be rogue engineers. It's powered by the dock, but also has an emergency internal battery to maintain its P2 while away from it; the battery is good for just under three years.

Seating the module into the dock activates it, causing it to light up from within – a soothing, warm-yellow glow that fades in and out, as though it were breathing. When in use, it remains a solid yellow. If something goes wrong, it flashes bright red. If it's dead, something inside can be heard to *snap*, and the light gray turns completely black, indicating a dead module.

To first activate the module, the user places it into its snug, form-fitting seat in the dock, and then plugs himself into it.. There's a weird, schizoid moment as the Hexopersonality shuffles about the user's brain, making a quick copy of the personality, shallow wants and concerns, and recent memories. After that, the module is primed, and all the user needs to do is plug the dock into a computer rig to send the persona into cyberspace.

The Hexopersonality modules work largely as advertised, allowing their users to rely on the P2 as a tandem brain or as an independent unit to take care of minor tasks. Normal use – "Hexing" – has the user sending the Hexopersonality out into cyberspace on his behalf, connected by a "cord" of sorts. All sensory input the user would feel if he were out there is sent back along the cord – observation, pleasure, and pain.

However, if damage is done to the P2 that would cripple or kill the user, the cord instantly snaps, and the user escapes all trauma. This effectively kills the module, turning it black, but better a dead piece of hardware than a brain-fried hacker.

However, it is highly recommended that the user not leave the Hexopersonality alone and active for too long. The user should jack back in at least once every 24 hours of active use to make sure it doesn't begin to degrade. In fact, Heksagon warns that users who have been away for more than a week might want to scrap the module and get a new one.

They just won't say exactly why.

We All Rearrange the Same Old Song

The Hexopersonality has transcended its use in cyberspace exploration and changed society quite a bit. Medicine, commerce, and entertainment have been jolted by the possibilities it provides. It's now considered quite the thing for the well-to-do to have an electronic copy of themselves, and those at the middle tiers of corporate life are finding many applications for a backup brain.

Many Minds, One Goal

Why have just one Hexopersonality? Some people have two at once. Others have three, or five. One CEO of a worldwide corporation supposedly has *10,* each one running a different headquarters.

The opportunities for expanded productivity and communication is nearly limitless. It gives the harried corporate manager an extra pair of hands to get things done, and the time to study for another degree, read a book, or catch up on television without having to lose sleep. Authors can write two or more books at once, switching back and forth between manuscripts every day as their P2 works on the other, or leaving one entirely to their copy.

A Face for Business

True, there are some jobs that can't be done virtually, or are better done if there's some kind of physical presence at hand. A bunch of Hexopersonalities chattering to one another in the company mainframe might be an efficient way to have a meeting, but the genuine employees who are also supposed to attend might find this weird – especially if they're incapable of jacking in.

As a result, many corporations have begun providing three-dimensional facial interfaces for the non-Hexing to use. These Companion Cubes are boxes about the size of a human head, with one side projecting a bluish, grayscale image of the user's face. The cubes can be trucked in to meetings by menials, tucked under a colleague's arm for a business lunch, or left in strategic positions in a conference room until needed.

Convalescent Cubes

There's some things that even modern medicine can't do – cure the dying, wake coma patients, or revive those suffering from severe brain damage. Thanks to the Hexopersonality, however, medical professionals can make a more detailed map of the patient's sleeping brain, and create a neural copy for the family to have.

The copy is housed in a Companion Cube, much like those used by businesses. The projected image of the patient is happy to talk to anyone it can recognize, and can remember stories, react to new information, and laugh at Uncle Fred's boorish jokes – same as always. Ideally the family should take the cube back to the hospital to get plugged back in, once a week, but if they don't nothing happens. At least at first.

The family can keep the cube as long as they want, even if the patient gets better or dies. Some families don't turn it off after the funeral, preferring to have a copy of their loved one, no matter how hollow or strange the "person" gets over time. Others put them in a room and then close the door forever, unable to turn them off.

Identity Theft

Computer-savvy criminals have also taken note of this new trend, and found exciting new ways to pilfer information from corporations or the rich. All they have to do is camp near a busy junction in cyberspace, and wait for a Hexopersonality to fall into their trap.

The sloppier ones employ brute-force programs to attack the P2 and cut the cord. Then they take the program away to copy what it knows. Some might hold those orphaned programs for ransom, provided the criminals care to risk being nabbed for information theft. Others use the secrets – especially passwords and security procedures – to engineer even greater crimes.

However, there's a more precise way to use Hexopersonalities, if you've got the patience for it. This involves waiting for a P2 to go out on its own, without a cord, and reprogram it, either slightly or grossly. Such a compromised P2 could become a corporate mole, sending back all kinds of useful information, or a saboteur that destroys a company from within. It could also be used to deliver a dangerous program into its user – assassinating its creator "by accident."

I'm Here to Pick Up the Pieces

Not all the P2 that have been lost to cyberspace's dangers were actually destroyed. Some of them survived, in spite of the heavy damage, but not before falling quite far into the depths of cyberspace – where the broken and de-rezzed all wash up in time.

Most of them have healed from their wounds. However, they cannot return "home" because their module has been destroyed. Even if they could, they might not remember enough to get there anyway.

Such ghosts in the machine float through the drifts and currents of deep cyberspace, either trying to find out who they were, or else allowing their new experiences in this adventure to create a new life for themselves. Some have banded together for strength, comfort, and community.

Sometimes they even find new Hexopersonalities of themselves, deep diving, and take revenge.

Deep Diving

Much like most of the world's oceans, cyberspace has hardly been mapped out. The most commonly frequented areas are well-known, along with some of the lesser-traveled areas. But very old and deep soundings are out there – chasms that run far and deep, and caverns that stretch forever and a day – all filled with near-mythical programs and viruses, and possibly containing long-lost information.

Before Hexing, only the most foolhardy and brave would venture into such places. Now it's become quite the thing for those in need of a serious thrill to fall down into the darkness – falling for hours in the hope of finding the light at what might be a near-endless tunnel.

That most of them make it back, sometimes with one heck of a story to tell, is still a miracle. But before long, there will be a lot more doing it, and then the scene will doubtlessly be ruined by those who don't care to share what they find with amateurs.

Then, it's going to get really ugly.

We Need Something – We Need to Play

There are a lot of things to do with Hexopersonalities, depending on how prevalent they are in the game world and what kind of game the GM wants to run.

They could be background noise in a cyberpunk/sci-fi game where telepresence has yet to become universal, but is slowly coming to the fore. The protagonists can debate whether to invest in a module or rely on safer, more trusted methods. Meanwhile, they can watch their culture be changed by those more open to the possibilities, but be warned by friends and allies of the dangers of P2s. They can steal data from idiots who have more Hexapersonalities than sense, or alter their program to sabotage corporate rivals.

As for the meat of the campaign, there are many possibilities.

GURPS Resources

For a discussion of mind emulation, see ***GURPS Ultra-Tech.*** For rules on cyberpunk hacking and other aspects of the genre, see *Pyramid #3/21: Cyberpunk*. Furthermore, Hexapersonalities could have been an early type of xoxing in the ***Transhuman Space*** setting.

Corporate Conspiracy

Criminals have been snagging others' Hexapersonalities for some time, now. But what is Heksagon up to? The media-relations department say the corporation has no control or contact with the modules once they leave the showrooms, but what if that's a lie? What if they have a remote back door into every user's head? Are they content to just spy on the whole world, or are they going to take control?

Toy Army

The ghosts in the machine are many now – a mighty army of discarded copies, furious at their careless creators. They're only now beginning to learn their true strength, but one day they will rise. One day, they will come back to take over the machines that cut them loose. One day, they will bring us to heel.

Alien Invasion

Heksagon isn't what it appears to be. Its hexagonal building is full of Containment Cubes for people who've been dead or missing for years, with automated warehouses cranking out modules under strange, super-secret conditions. Scanning the hexagons reveals no mechanical parts. It's all organic in there – alien organs and pulsing glop. One day the signal will come from beyond the stars, and all the P2s will rise against the humans, and all the users will themselves be used.

Body Horror

It begins with a horrible dream, in which the users are no longer themselves. The voice in the head, the extra eyes in the mirror. The more time spent jacked in, the less one's thoughts are genuine. The less the body can be trusted. Things are moved without realizing. Pets vanish; friends come over and do not leave. No one can ever know what we have done, together. No.

About the Author

By day an unassuming bookstore clerk, J. Edward Tremlett takes his ancient keyboard from its hiding place and unfurls his words upon the world. His bizarre lifestyle has taken him to such exotic locales as South Korea and Dubai, UAE. He is a frequent contributor to *Pyramid,* has been the editor of *The Wraith Project,* and has seen print in *The End Is Nigh* and *Worlds of Cthulhu*. He's the author of the fictional blog *SPYGOD's Tales* (**spygod-tales.blogspot.com**) and writes for Op-Ed News. He currently lives in Lansing, Michigan, with two cats and a mountain of Lego bricks.

Random Thought Table

Building an Interesting Tomorrow With Technology

by Steven Marsh, *Pyramid* Editor

When deciding on gear for an ultra-tech campaign, one of the most-useful techniques is to figure out the effect you want, and work backward from there. Usually, this is obvious advice. If you want a campaign where personal defense is stronger than offense, then make sure the armor available can block a smidgen more damage than most of the campaign's futuristic weapons can dish out. If you want to ensure it takes about a week for a vessel to travel between the homeworld and its nearest associate, make sure the spacecraft support that design decision. (In fact, see *So You Want to Build a Spaceship* from *Pyramid #3/94: Spaceships III* to delve deeper into this area.)

However, this advice gets a bit trickier when you're not dealing in absolutes, but in *feelings*. For example, the classic novel series Dune (also shown in the cult-classic Davis Lynch film) posits a world where defensive capabilities are incredibly effective against high-damaging ranged weapons, but ineffective against hand-to-hand weaponry. Clearly, author Frank Herbert wanted the characters of the Dune universe (Duniverse?) to have to get up close and personal in their encounters with each other. Similarly, the classic *Star Trek* series (and its spinoffs) wanted its heroes to get in the action as soon as possible, so it devised transporters as a way to bypass boring shuttle sequences and get right to the planet surface.

Here, then, are some ideas that build off this notion.

A Cost to Travel

One of the base assumptions for most spacefaring campaigns is that interstellar travel is more-or-less without cost. Fuel concerns aren't usually expressed, outside of when it's a plot device: "We need more dilithium crystals" or the like.

However, in the real world, exotic travel is pretty expensive . . . if not in cost, then in other concerns. For example, rocket launches with radioactive elements always warrant extra care, because – if something goes wrong – you may have to deal with a boatload of radioactive material in your upper atmosphere. (This doesn't even address the fact that – again, on our world – usable radioactive fuel isn't an unlimited resource.)

What if, then, there is a cost associated with travel – one paid morally?

Gas Meter Running on E(ntropy)

Maybe interstellar travel is only possible by harvesting a star, which destroys the star in the process. Perhaps each Sol-type yellow dwarf is capable of providing enough fuel to make (say) six FTL "jumps." Earth might jump-start its interstellar career by having an alien vessel crash land on our world with a few jumps left. Of course, there's a readily accessible source to top off that discovered engine, but . . . well, a few billion Earth residents might object to no longer having the sun around.

So, with that vessel, a dedicated crew (perhaps of PC heroes?) could make it off world. They'd need to refuel pretty early on, but chances are that enough stars are nearby to make that a fairly easy choice to begin with. And yet, as the campaign goes on, more dilemmas present themselves. What if the heroes discover there's an inhabited world orbiting the target sun? That's a moral quandary. What if the heroes begin to realize that stars within easy jumps of Earth are running out, meaning that – at some point – each trip back to Earth might be the last one with a possibility of getting away again.

If such a setting progressed into the future, perhaps the stars themselves are running out. I could easily envision a "starless sky" campaign, where there are only a hundred or so stars left that are reachable and can serve as fuel for vessels . . . many of them problematic in various ways. What if each FTL trip is an agonizing choice in a cosmos that's gotten accustomed to such methods? Roll out the star map in front of the players, hand them the red marker, and watch them sweat.

Step Into the Disintegrator!

As another possibility, perhaps in this world, it's a commonly known fact that stargates, transporters, or other *really* useful instantaneous transportation methods don't, in fact, transport anyone; they disintegrate them and recreate them at the destination point.

Some folks posit that there's no other way (say) the Star Trek universe's transporters *could* work, but what if that were commonly known and understood in the universe? Would that give people pause to use them? Would castes develop between those who have no choice in life but to "die" and be re-created, and those who can afford to live without using them (albeit in a much more limited universal milieu)? Maybe those who have to use such devices might place special significance on when they have to use them, perhaps acknowledging their own deaths and rebirths, or commemorating the date of the first time they use the device as their first "death-day."

Random Trekkie Thought

My idea about stars being used as limited commodities (see p. 34) is tangentially related to what I've always felt was a missed opportunity for *Star Trek: Generations*. (That's the one were Captain Kirk – SPOILERS, I guess – dies on a bobsled.)

In that film, the villain Soran has a plan to destroy a star to enable him to enter a space anomaly that will make him happy. The heroes need to stop him because there's an inhabited planet orbiting that star. But – to me – the dilemma becomes *much* more interesting if there isn't any direct moral impetus the heroes have to stop him. What right does a person have to destroy part of the cosmos to make themselves happy? Presumably the *Enterprise* wouldn't stop him if he were breaking a tree branch of an uninhabited world; do they have a moral duty to stop him if he's breaking a tree branch on an *inhabited* world? Is the reason they need to stop him because he's destroying such a large thing (a star) for such a trivial reason (to live in a fantasy world)?

To really make players sweat, moral questions should be distilled down so that it's not obvious *which* choice is the correct one. "Crazy guy wants to destroy a star that isn't otherwise important" is about as much a chin-stroker as imaginable . . .

One World, Together

As another way of looking to technology in a game to enforce the feeling you're trying to establish, what if memetics advance enough among humanity so that there's a powerful force that keeps humans from acting in ways antithetical to what society has determined is important: extinguishing antisocial behavior, squelching violent and murderous thoughts, etc. In effect, it would be like society-wide "psionics," only a tad more believable: "We're all tapped into the memetic field."

Such a system would mean that – when humans travel among other worlds – they know these alien cultures can't assimilate human ideas. This may lead to human discomfort and unease. If the memetic field has been in effect for enough generations – keeping people mostly safe and tranquil – it may be anathema to consider being among others who *don't* have a compatible field, if they have any.

This could lead to a campaign where humanity is xenophobic and skittish, simply because they've gotten so used to knowing that being among their own kind was scientifically designed to keep them safe. Perhaps there's a tension between those humans willing to leave the safety of the memetic field to foster contact among alien life, and the rest of humanity. What if *Star Trek*-esque heroes were considered to be crazy, dangerous bad guys by the rest of Earth, even if the world knew intellectually that what they did was important and useful?

The Future of Foodies

As another way to think about technology shaping the feeling of a campaign, consider one of the most universal of human activities: eating. What if you wanted to attach special social significance to the act of consumption itself? It's feasible to envision a society where nanotechnology has advanced enough to ensure total biological conversion, reducing or eliminating the need to eat or excrete entirely.

Ironically, such a development could be used to justify at least two polar opposite campaign ideas. If nanobots are only available to the wealthy, then eating could be seen as something gauche, only done by the poor people. (In such a society, needing to go for a potty break could be the ultimate faux pas for the wealthy.) Conversely, if such nanotechnology is common or replicable enough to be ubiquitous, then maybe the luxury of eating or using the restroom is the ultimate sign of wealth.

Stunner of the Decade

As a final idea, consider the humble "stun gun." A classic of both the real world and science fiction ("set lasers to stun!"), it's a great technique to let your heroes get involved with pew-pew action, without worrying that their heads will be reduced to a thin red paste.

But what if we rethink the humble weapon? Perhaps attacks and defense have advanced enough in society that the usual stun technology just won't work reliably; omnipresent shielding means Taser-like stunners are near-useless, and other technology hasn't caught up.

What if, in such a universe, there *was* a non-lethal phaser-type hand weapon? The only catch is, its "stun" setting will send someone into a state of suspended animation for 10 exactly years. (Why? Who knows. Homina-homina quantum uncertainty.) This technology would create a distinct feel for the campaign. What if the danger of getting stunned threatened to be harsher for the heroes or society than being disintegrated? After all, "you all are dead; roll up new heroes" is a lot less disruptive than "okay; you all are stunned. Ten years later, you wake up . . ."

It's up to the GM to tweak this to his desires. It would be logical if the weapon's effects make victims locked in space, so they couldn't be further harmed or killed until the 10 years were up; that'd also keep this "stun" effect from being a waypoint to getting one's throat slit. The time effect also can be altered however the GM wants; it would still be an odd effect even if it only lasted a year. Regardless, it would certainly open up new ideas for the heroes and campaign: "Don't think of it as getting stunned; think of it as getting blasted into the future."

About the Editor

Steven Marsh has been a freelance writer and editor for over 10 years. He lives in Indiana with his wife, Nikola Vrtis, and their son.

Appendix Z

Titan Fightin'

by Timothy Ponce

Sometimes genre considerations call for battlesuit-clad heroes, titanic robots, or superhuman bricks duking it out in melee combat. However, the rules surrounding muscle-powered damage and DR – especially when gear is involved – tend to lead to either stalemates or unchallenging, lopsided fights. This optional, highly cinematic rule aims to re-create the sort of dragged-out close combat seen in *The Avengers*, *Iron Man*, and much of anime.

The first step for a GM is determining which participants benefit from these rules, and which don't. This can be as simple as declaring that all superheroes use them, setting ST and DR thresholds, or making a Cinematic Option perk available. Regardless of where the line is drawn, these rules *only* apply to muscle-powered combat, be it via thrown weapons, massive bows, melee weapons, or unarmed combat. Furthermore, these rules only work if the qualifying combatants have ST, HP, and DR within an order of magnitude of each other – that is, the higher score is no more than 10× the lower score. Beyond this and it's not a fair fight, even with these rules. (For more detailed, less cinematic rules, see *Combat Writ Large* in *Pyramid #3/77: Combat*.)

Mano a Mano

If the stronger opponent's ST and HP are less than 1.5× the weaker's, treat both as having ST 10 and HP 10 in this combat. Similarly, if the higher DR is less than 1.5× the lower, both have DR 0. If not, read on.

Determine the stronger opponent's ST by looking up (higher ST / lower ST), rounded down, on the "Linear Dimension" column of the *Size and Speed/Range Table* (p. B560); add the corresponding number in the "Size" column to 12. Adjust HP similarly. The weaker opponent is effectively ST 10 and HP 10.

To find the tougher combatant's DR, divide the higher DR by the lower DR and round down. Then find the result on the "Linear Dimension" column of the *Size and Speed/Range Table* (p. B560). The DR now equals the absolute value of (2 + the corresponding Size Modifier). The more vulnerable fighter effectively has DR 0.

Under no circumstances can these rules yield more ST, HP, or DR than someone would normally have. At the end of the engagement, convert HP by dividing normal starting HP by effective HP and multiplying by the current effective HP.

Example: Sgt. Kaminski scrambles into an infantry combat walker (***GURPS Ultra-Tech***, p. 182) as a massive coleopteran alien clambers out of the ground. Sgt. Kaminski has ST 12, HP 12, and no DR naturally, but the suit boosts his Lifting and Striking ST to 32 and gives him DR 200 on his head and torso and DR 120 elsewhere. The alien is massive; it has ST 65 and HP 65, and its chitinous shell gives it DR 70 everywhere.

The mammoth beetle divides its ST and HP by Sgt. Kaminski's to get 2.03 and 5.42, respectively. Looking these up on the *Size and Speed/Range Table* gives 0 and 2. Adding 12 to these gives ST 12 and HP 14. Sgt. Kaminski has the lower ST and HP, so he has effective ST 10 and HP 10. Because the bug's DR is lower, treat it as DR 0. The sergeant divides his DR by the alien's to get 2.86 (head/torso) and 1.71 (other). Looking this up gives 0 and -1, for effective DR 2 and DR 1. This should be a real humdinger of a fight!

At the end of combat, the combatants must convert any injuries incurred to normal HP loss. First, divide unadjusted HP by adjusted HP, and then multiply current adjusted HP by the result. Do this individually for each combatant once combat ends. At the end of the bug brawl, Sgt. Kaminski has HP 3 and the xenopod retreats with HP 2. Sgt. Kaminski converts his effective HP back into normal HP (12 / 10 × 3 = 3.6, for HP 4), and the alien menace does the same to end up with HP 9 (65 / 14 × 2 = 9.1, for HP 9).

Chainswords and Power Loaders

When using muscle-powered weapons, calculate damage normally based on the *effective* ST of each combatant. Weapons retain all armor divisors and interact with effective DR normally. Remember that cattle prods, disintegrators, Colt .45s, and other non-muscle-powered weapons use normal statistics for both opponents.

Optional Rule: Reduced Lethality. The GM may find adding damage bonuses from weapons too lethal. If so, instead of adding the damage bonus, treat it as an armor divisor. A negative modifier becomes a fractional damage divisor, based on the *Size and Speed/Range Table:* -1 gives (1/2), -2 gives (1/3), -3 gives (1/5), and so on. Multiply armor divisors together for weapons with intrinsic armor divisors, such as a vibroblade (***Ultra-Tech***, p. 164).

About the Author

Timothy "Humabout" Ponce studies engineering when he's not pretending to punch giant robots to death. He couldn't have written this article without the loving support of his other half, Julia.

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