For 20 years Constantine Anderson refined this precise axonometric projection of midtown New York (shown here are Rockefeller Center environs), following the tradition of the classic 1739 Bretez-Turgot Plan de Paris (at left, the area around Pont Neuf and Notre Dame, from the 11th of 20 sheets). The Manhattan map embraces such fine points as individual windows, subway stations and bus shelters, telephone booths, building canopies, trees, and sidewalk planters. And the typography is persistently thorough; the entire map (60 by 92 centimeters, or 24 by 36 inches) reports 1,686 names of buildings, stores, and parks along with 657 specific streetaddresses — fora map, an abundant typographic density of 3 characters per square centimeter (20 per square inch). The only major concession to paper flatland is widening of the map's streets to reduce masking of some buildings by others.

This fine texture of exquisite detail leads to personal micro-readings, individual stories about the data: shops visited, hotels stayed at, walks taken, office windows at a floor worked on — all in the extended context of an entire building, street, and neighborhood.1 Detail cumulates into larger coherent structures; those thousands of tiny windows, when seen at a distance, gray into surfaces to form a whole building. Simplicity of reading derives from the context of detailed and complex information, properly arranged. A most unconventional design strategy is revealed: to clarify, add detail.

Michel Etienne Turgot and Louis Bretez, Plan de Paris (Paris, 1739), plate II. Above, The Isometric Map of Midtown Manhattan, © 1989 The Manhattan Map Company. All rights reserved.

1 Italo Calvino's Invisible Cities (San Diego, 1974) records this texture of storied detail: cities are "relationships between the measurements of its space and the events of its past: the height of a lamp-post and the distance from the ground of a hanged usurper's swaying feet; the line strung from the lamp-post to the railing opposite and the festoons that decorate the course of the queen's nuptial procession; the height of that railing and the leap of the adulterer who climbed over it at dawn; the tilt of a guttering cat's progress along it as he slips into the same window; the firing range of a gunboat which has suddenly appeared beyond the cape and the bomb that destroys the guttering; the rips in the fishnet and the three old men seated on the dock mending nets and telling each other for the hundredth time the story of the gunboat of the usurper, who some say was the queen's illegitimate son, abandoned in his swaddling clothes there on the dock." On Calvino and maps, see a fine essay by Marc Treib, "Mapping Experience," Design Quarterly, 115 (1980).
Stem-and-leaf plots of statistical analysis also rely on micro/macro design. Each data point simultaneously states its value and fills a space representing one counted unit, like the names on the Vietnam Veterans Memorial, with those spaces in turn assembling to form a profile of the overall univariate distribution. Envisioned here are the heights of 218 volcanoes; each individual number helps to build the histogram. Micro-data has replaced the information-empty bars of a traditional barchart. This idea of making each graphical element repeatedly effective animated design of the stem-and-leaf plot. In describing his invention, John Tukey wrote: "If we are going to make a mark, it may as well be a meaningful one. The simplest — and most useful — meaningful mark is a digit."

In a similar fashion, this train schedule below positions the individual departure times so that they add up to a frequency distribution. For trains that run often, leading hour-digits need not be repeated over and over, and, instead, minutes can be stacked:

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Keihin Express Line at Yokohama Station, Sagami Tetsudo Company, 1985 timetable, p. 76. Encodings indicate types of trains (super express, commuter, and so on) and various local stops.
Reported is the overall time distribution of 292 daily trains, with peaks during morning and evening rush hours. The shrewd design saves 777 characters, avoiding this typographical extravaganza below, which lacks the intensive annotation of the stem-and-leaf original and also fails to provide clear testimony about frequency of train service by hour.\(^8\)

\[
\begin{array}{cccccccccccccccccc}
\end{array}
\]

\(^8\) The stem-and-leaf schedule contains 619 numbers; the typographic version 1,396 numbers and periods. Thus the stem-and-leaf schedule saves 777 characters, and, more importantly, gives a much better sense of comparison of train times.

In all these micro/macro designs, the same ink serves more than one informational purpose; graphical elements are multifunctioning. This suggests a missed opportunity in the stem-and-leaf timetable — surely leaves of numbers can grow from both sides of a central stem. And so it is; the finely detailed timetable below records trains running in several directions from the station, with the platforms 7-8 at left and platforms 5-6 at right (at the arrows, note how numbers serpentine around a bend when times for the morning rush hour exceed the grid). Sometimes this arrangement is called a "back to back stem and leaf plot." Nonetheless, Japanese train passengers have managed to use the schedules for decades without ever knowing the fancy name.

Tokaido Line at Yokohama Station, Sagami Tetsudo Company, 1985 timetable, p. 72.
3 Layering and Separation

CONFUSION and clutter are failures of design, not attributes of information. And so the point is to find design strategies that reveal detail and complexity — rather than to fault the data for an excess of complication. Or, worse, to fault viewers for a lack of understanding. Among the most powerful devices for reducing noise and enriching the content of displays is the technique of layering and separation, visually stratifying various aspects of the data.

Effective layering of information is often difficult; for every excellent performance, a hundred clunky spectacles arise. An omnipresent, yet subtle, design issue is involved: the various elements collected together on flatland interact, creating non-information patterns and texture simply through their combined presence. Josef Albers described this visual effect as \( 1 + 1 = 3 \) or more, when two elements show themselves along with assorted incidental by-products of their partnership — occasionally a basis for pleasing aesthetic effects but always a continuing danger to data exhibits.\(^1\) Such patterns become dynamically obtrusive when our displays leave the relative constancy of paper and move to the changing video flatland of computer terminals. There, all sorts of unplanned and lushly cluttered interacting combinations turn up, with changing layers of information arrayed in miscellaneous windows surrounded by a frame of system commands and other computer administrative debris.

AT left a second color annotates the brush strokes of the calligrapher, Uboku Nishitani. By creating a distinct layer, the red commentary maintains detail, coherence, and serenity, in a crisp precision side-by-side with a gestural and expressive black line in this marriage of color and information. The saturated quality of the red partially offsets its lighter value and finer line (appropriate to meticulous annotation). Alone, each color makes a strong statement; together, a stronger one.

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Similarly, color effortlessly differentiates between annotation and annotated, in this skillful industrial-strength diagram separating 300 small parts and their identifying numbers.

What matters—inevitably, unrelentingly—is the proper relationship among information layers. These visual relationships must be in relevant proportion and in harmony to the substance of the ideas, evidence, and data conveyed. "Proportion and harmony" need not be vague counsel; their meanings are revealed in the practice of detailed visual editing of data displays. For example, in this train timetable a heavy-handed grid interacts with the type, generating a stripy texture and fighting with the scheduled times. The prominent top position in the table shows the least important information, a four-digit train identifier used by railroad personnel and nobody else:


New Jersey Transit, Northeastern Corridor Timetable (Newark, 1985).
A redesign calms the dominating grid, moves the New York departure times to the very top, de-emphasizes less important data, and adds new information. A separating line is formed by tiny leader dots, which read as gray, making a distinction but not a barricade:

The focus is now given over to information, transparently organized by an implicit typographical grid, defined simply by the absence of type. Nevertheless, data-imprisonment spans centuries of information-design struggles. At right is a touchingly ramshackle grid from a 1535 edition of *Cosmographia*. But, from the virtuoso of typographic design: "Tables should not be set to look like nets with every number enclosed," wrote Jan Tschichold in *Asymmetric Typography*:

The setting of tables, often approached with gloom, may with careful thought be turned into work of great pleasure. First, try to do without rules altogether. They should be used only when they are absolutely necessary. Vertical rules are needed only when the space between columns is so narrow that mistakes will occur in reading without rules. Tables without vertical rules look better; thin rules are better than thick ones."

Even quite small changes in line can have significant visual effects. For Paul Klee's sketch, the easy and graceful separation of black line and red commentary collapses into a mishmash when color and light/dark differences are minimized:

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Mrs. K___ has been taken to the emergency room of a renowned hospital on Manhattan's Upper East Side. The doctors "work her up." More than $200 worth of blood tests are ordered ("emer rm lab," "lab serology out"), $232 worth of X-rays taken, $97.50 worth of drugs administered. I never saw Mrs. K___, she wasn't in my hospital, I don't know her medical history. But I am a doctor, and can reconstruct from her hospital bill what is going on, more or less. She is sick, very sick.

Mrs. K___ has been moved to the Intensive Care Unit ("room ICU"). It costs $500 a day to stay in the ICU, base rate. California has the highest average ICU rates in the country: $632 a day. In Mississippi, the average is $265. ICUs were developed in the 1960s. They provide technological life-support systems and allow for extraordinary patient monitoring. An inhalation blood-gas monitor ("inhal blood gas mont") is being used to keep a close check on the amount of oxygen in her blood. Without the attention she is receiving in the ICU, Mrs. K___ might already be dead.

Mrs. K___ has been running a high fever. The doctors have sent cultures of her blood, urine, and sputum to the lab to find out why. She is put on gentamicin ("lab gentamicin troug"), a powerful antibiotic. Such strong drugs can have toxic side effects. Gentamicin kills bacteria, but can also cause kidney failure.

It is Mrs. K___'s fifth day at the hospital, and she is slipping closer to death: her lungs begin to fail. She is put on a respirator ("inhal respirator"), which costs $119 a day to rent and requires a special technician to operate. A hospital can buy the machine for about $15,000.

Redrawn from David Hellerstein, "The Slow, Costly Death of Mrs. K___," Harper's, 268 (March 1984), 84-89.

Mrs. K___'s first week in Intensive Care ends in a flourish of blood tests. She has five Chem-8s ("lab chem-8") - tests that measure the levels of sodium, potassium, and six other chemicals in her blood. The hospital charges Mrs. K___ $31 for each Chem-8. Most independent labs charge about half as much; some hospitals charge up to $60. The New England Journal of Medicine has said: "The clinical laboratory is [a] convenient profit center that can be used to support unrelated deficit-producing hospital operations." The Annals of Internal Medicine estimates that the number of clinical lab tests being done is rising 15 percent a year.

Mrs. K___ has started peritoneal dialysis ("dial-peri kit 87110"). Her kidneys are failing. She is still hooked up to the respirator. She is being kept alive by what Lewis Thomas calls "halfway technologies" — "halfway" because kidney dialysis machines and respirators can support organ systems for long periods of time, but can't cure the underlying disease. Some doctors are beginning to question this practice. A recent study at the George Washington University Medical Center concluded: "Substantial medical resources are now being used in aggressive but frequently futile attempts to avoid death."

Mrs. K___ has been put in a vest restraint. Restraints are used in Intensive Care to keep patients from thrashing about or pulling their tubes out. Many ICU patients develop what is called "ICU psychosis." They become disoriented, begin hallucinating. The condition is brought on by lack of sleep, toxic drugs, the noise of the ICU staff and machines, and pain.
Mrs. K___ has been on the respirator for six days. It is breathing for her. But there has been a problem. The tube running from the machine into her mouth and down her throat was not bringing enough oxygen to her lungs. She needed a tracheotomy ("trach care set"). The tube from the respirator is now attached directly to her trachea, through a hole cut into her neck.

This charge - for a blood product ("5 NSA 250MU proc fee") - is not covered by Mrs. K___’s Blue Cross policy. The policy also does not cover the cost of fresh blood plasma ("fsh fr pla proc fee"). These charges have been mounting. Mrs. K___ is bleeding internally.

Mrs. K___ has been in Intensive Care for two weeks. She is still running a very high fever. The doctors are still testing. Mrs. K___ has been placed on a special blanket; it is hooked up to a machine that functions like a refrigerator ("hypothermia machine"). The machine cools the blanket, and the blanket helps lower Mrs. K___’s body temperature. Should her temperature rise too high, she may suffer permanent brain damage.

Mrs. K___ has undergone a gated blood-pool study ("nuc med sec/pool sty"). The doctors have "tagged" her red blood cells with a radioactive isotope. Using a camera that picks up the isotope, the doctors can watch the passage of blood through her heart. In this way, they see firsthand whether the ventricles are functioning properly—whether enough blood is getting pumped, enough oxygen is being sent through the body. First her lungs, then her kidneys. Now Mrs. K___’s heart seems to be going.

Mrs. K___’s fourth week in the hospital begins with a spinal tap. Using a long needle, a doctor drains fluid from her spinal cord. The fluid is sent to the lab for a doze tests ("lab sp fl cell et"). A spinal tap is performed when a patient has what are called "neurological signs." Partial paralysis is one such sign, loss of consciousness another. When doctors order a spinal tap, they suspect brain disease.

Weeks of halfway technology have given the doctors time for testing. The doctors may even have diagnosed what is wrong with Mrs. K___; it is hard to say. But the ICU and its technology have not given them the ability to cure her. Now the heart, which has been failing, gives out. Cardiac arrest. There is a burst of activity. Bicarbonate, epinephrine, and other drugs ("pharmacy") are administered. Thirteen bottles of intravenous solution ("phar iv solutions") are poured in.

Mrs. K___’s last minutes are recorded on the various ICU monitors. The level of oxygen in her blood falls. She dies.

Mrs. K___’s bottom line. Total cost of twenty-six days in the hospital, nearly all this time in Intensive Care: $47,311.20. Of this, Blue Cross will pay $41,933.87. The doctors' bills, not covered by hospitalization insurance, probably come to thousands of dollars more. Perhaps Mrs. K___ had Blue Shield, which covers doctors' fees. In 1982, the last year for which figures are available, Americans spent $32 billion on health care. Of this, $135.5 billion was spent on hospital care. There were 56,241 ICU beds in 1982 like the one Mrs. K___ was kept alive in, and about $277 was spent for their use. That represented nearly one percent of the gross national product.
All elements in the map at right — contours, rivers, roads, names — are at the same visual level with equal values, equal texture, equal color, and even nearly equal shape. An undifferentiated, unlayered surface results, jumbled up, blurry, incoherent, chaotic with unintentional optical art. What we have here is a failure to communicate.

Far more detailed than the perfect jumble, this map below separates and layers information by means of distinctions in shape, value (light to dark), size, and especially color. The negative areas are also informative; light strips formed by the grid of buildings identify roads and paths. The water symbol is a blue field, further differentiated from other color fields by a gentle fading away from each outlined edge. Shown against a dull background rather than bright white, these colors remain both calm and distinctive, avoiding clutter. The map exemplifies the "first rule of color composition" of the illustrious Swiss cartographer, Eduard Imhof:

Pure, bright or very strong colors have loud, unbearable effects when they stand unrelieved over large areas adjacent to each other, but extraordinary effects can be achieved when they are used sparingly on or between dull background tones. "Noise is not music . . . only on a quiet background can a colorful theme be constructed," claims Windisch.²

Signal and background compete above, as an electrocardiogram trace-line becomes caught up in a thick grid. Below, the screened-down grid stays behind traces from each of 12 monitoring leads.\(^4\)

Similarly for music notation, some staff paper is better than others:

In Stravinsky's sketchbook for *Sacre du printemps*, a grid quietly but clearly and precisely locates the music. Gray grids almost always work well and, with a delicate line, may promote more accurate data reading and reconstruction than a heavy grid. Dark grid lines are chartjunk.

When a graphic serves as a look-up table (rare indeed), then a grid may help with reading and interpolation. But even then the grid should be muted relative to the data. Often ready-made graph paper comes with darkly printed lines. The reverse imprinted side should be used, for then lines show through faintly and do not clutter the data. If the paper is heavily gridded on both sides, throw it out.

\(^4\) The preferred example is redrawn from J. Marcus Wharton and Nora Goldschlager, *Interpreting Cardiac Dysrhythmias* (Oradell, New Jersey, 1987), p. 123. Color also layers, as a gray grid calibrates this signal of ventricular fibrillation, a final collapse of the heart, with only a disorganized rhythm remaining. A similar trace can result from recording artifacts such as a loose monitoring wire; however, one textbook dryly notes, "As the patient will usually have lost consciousness by the time you have realized that it is not just due to a loose connection, diagnosis is easy." John R. Hampton, *The ECG Made Easy* (Edinburgh, 1986), p. 66.
In the masterly 1748 Nolli map of Rome, the river’s heavy inking activates what should be a visually tranquil area, causing bridge names and a little boat to vibrate in a moire prison, albeit a quiet one. Muting the river encoding calms vibration and brings names and other details forward, while retaining a symbolism of rippling water.\(^5\) This redesign and others that we have seen are visual equivalents of Italo Calvino’s approach to writing:

My working method has more often than not involved the subtraction of weight. I have tried to remove weight, sometimes from people, sometimes from heavenly bodies, sometimes from cities; above all I have tried to remove weight from the structure of stories and from language. . . . Maybe I was only then becoming aware of the weight, the inertia, the opacity of the world — qualities that stick to writing from the start, unless one finds some way of evading them.\(^6\)

Layering of data, often achieved by felicitous subtraction of weight, enhances representation of both data dimensionality and density on flatland. Usually this involves creating a hierarchy of visual effects, possibly matching an ordering of information content. Small, modest design moves can yield decisive visual results, as in these intriguing demonstrations of the illusory borders of subjective contours:

\(^5\) Giambattista Nolli, *Pianta Grande di Roma* (Rome, 1748; from a facsimile edition by J. H. Aronson, Highmount, New York, 1984). Note the seemingly English word "or" in the names under the bridge, a result of the 18th-century custom of contracting the Italian *ore*, meaning now, at this time, currently. On his map, Nolli cites first the old name *Ponte Gianicolo or* [a] *Ponte Sisto* (the bridge’s new name). Ironically, the English "or" works in this context, although the meaning is not quite right. See Barbara Reynolds, *The Cambridge Italian Dictionary, Italian-English* (Cambridge, 1962), p. 521.


Visual activation of negative areas of white space in these exhibits illustrates the endlessly contextual and interactive nature of visual elements. This idea is captured in a fundamental principle of information design: \( 1 + 1 = 3 \) or more. In the simplest case, when we draw two black lines, a third visual activity results, a bright white path between hues (note that this path appears even to have an angled end). And a complexity of marks generates an exponential complexity of negative shapes. Most of the time, that surplus visual activity is non-information, noise, and clutter.\(^7\)

This two-step logic — recognition of \( 1 + 1 = 3 \) effects and the consideration that they generate noise — provides a valuable guide for refining and editing designs, for graphical reasoning, for subtraction of weight.\(^8\)

In a little-known essay on \( 1 + 1 = 3 \) effects, Josef Albers conducts the demonstrations below, a visually sensitive and artistic approach to the cognitive contours of perceptual psychologists. Albers, seeing area and surface rather than border and edge, escapes the preoccupying magic of optical illusions to conceive a broad idea of negative space activation:

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\(^7\) Rare exceptions are the Turgot-Bretez map of Paris and the Nolli map of Rome: streets, absent of ink, are defined — tersely, clearly, and precisely — by the surrounding ink of blocks and buildings, creating subjective contours.

\(^8\) Note the additional \( 1 + 1 = 3 \) effects, on this page, as the interaction between the examples and the surrounding type enlivens the white space, forming shapes, profiles, and paths. These reverberations are vivid because our examples are printed in black; strong light/dark contrasts accentuate the clutter of \( 1 + 1 = 3 \) or more.

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Stumbling over $1 + 1 = 3$ has produced perhaps the worst index ever designed, a rare perfect failure. The preface to this guide for flying small aircraft says, "This manual is primarily intended for use during actual flight instruction." Imagine now noisy vibration in a plane as we search through this visually vibrating list, looking for, say, an entry on "forced landing" ... and the index turns out to have no page numbers. Only a small segment of the unbearable original is shown.

The noise of $1 + 1 = 3$ is directly proportional to the contrast in value (light/dark) between figure and ground. On white backgrounds, therefore, a varying range of lighter colors will minimize incidental clutter. Three maps at right show these tactics in action. In the first, the bold shapes promote vibration all over; and with only nameless streets down on paper, this map is already in visual trouble. At center, thinning two sides of each block results in every street bordered by one thick and one thin line, thus deflecting $1 + 1 = 3$ effects (the thin lines, like gray lines, are visually light in value). On the bottom map, gray establishes serene, motionless edges - an arrangement that will easily accommodate additional geographic detail.

Careful visual editing diminishes $1 + 1 = 3$ clutter. These are not trivial cosmetic matters, for signal enhancement through noise reduction can reduce viewer fatigue as well as improve accuracy of readings from a computer interface, a flight-control display, or a medical instrument. Clarity is not everything, but there is little without it. Editing this statistical graph (showing variability about local averages) remedies the visual clutter induced by parallel lines and equal-width white bands. The redesign, at far right, sweeps the noise away, with color spots now smartly tracking the path of averages.

Harmonizing text and line-drawing requires sensitive appraisals of prolific interaction effects. Unless deliberate obscurity is sought, avoid surrounding words by little boxes, which activate negative white spaces between word and box. And below, the first three maps place the type poorly, with an awkward white stripe materializing between name and river. Type from above adjusts to graphics better, in part because most words have fewer descenders than ascenders (in map 3, a diverting white shape is formed by the ascending letters). These small local details will promptly accumulate on the entire map surface, deciding quality.

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This array above, an information prison, employs a narrow range of strong shapes. Grid, silhouette, and type compete at the same nervous visual level. Too loud and too similar. Thick bars of grid boxes generate little paths around both type and silhouette by exciting the negative white space: \(1 + 1 = 3\), all over again. Why should the trivial task of dividing up the already free-standing elements become the dominant statement of the entire display?

To direct attention toward the information at hand, the revision below extends the light to dark range of color, separating and layering the data in rough proportion to their relevance. Gray calms a contrasty silhouette, bringing about in turn more emphasis on the lamps and their position and motion. Coloring these lights helps to separate the signals from all the rest. Some 460 lamp-whiskers were erased, whiskers which originally read in confusion as glowing light and also trembling motion. Note the effectiveness and elegance of small spots of intense, saturated color for carrying information — a design secret of classical cartography and, for that matter, of traffic lights. Finally, in our revised version, the type for the title (upper left corner) has emerged from its foggy closet. Also the labels, now set in Gill Sans, are no longer equal in visual weight to the motion arrows, among several typographical refinements.

10 "If one limits strong, heavy, rich, and solid colors to the small areas of extremes, then expressive and beautiful colored area patterns occur... Large area background or base-colors do their work most quietly, allowing the smaller, bright areas to stand out most vividly, if the former are muted, grayish or neutral." Eduard Imhof, Cartographic Relief Presentation (Berlin, 1982), edited and translated by H. J. Steward from Imhof’s Kartographische Geländedarstellung (Berlin, 1965), p. 72. On visual issues and map-making, see essays by Samuel Y. Edgerton, Jr., Svetlana Alpers, Juergen Schulz, Ulla Ehrensvärd, James A. Welu, and David Woodward, in Woodward, ed., Art and Cartography (Chicago, 1987).
In the statistical graphic at top, the visually most active elements are, of all things, glowing optical white dots that appear at each intersection of grid hues. (The arrangement of many computer interfaces is similarly overwrought.) The doubled-up, tremor-inducing lines consume 18 percent of this technically ingenious chart, a multi-window plot. Here the redrawing, in ungrid style, eliminates the visual noise, concentrating our viewer's attention on data rather than data containers.

Too often epidemics of data-imprisonment and decorative gridding break out when contemporary commercial designers are faced with information. The aggressive visual presence of stylized grids, little boxes surrounding words here and there, and cadenced accents — also empty of content, irrelevant — becomes the only way you can tell if something has been "designed". At any rate, the self-important grid is for the birds, providing only a nice place to perch:


INFORMATION consists of differences that make a difference. A fruitful method for the enforcement of such differences is to layer and separate data, much as is done on a high-density map. In representing various layers of meaning and reading, the most economical of means can yield distinctions that make a difference: the small gestures of Calder’s pen easily separate the stag and his watery reflection. Failure to differentiate among layers of reading leads to cluttered and incoherent displays filled with disinformation, generated by the unrelenting interactive visual arithmetic of flatland, $1 + 1 = 3$ or more.

All these ideas — figure and ground, interaction effects, $1 + 1 = 3$ or more, layering and separation - have compelling consequences for information displays. Such concepts (operating under an assortment of names) are thoroughly tested, long familiar the world over in the flatlands of typographers, calligraphers, graphic designers, illustrators, artists, and, in three dimensions, architects:

In every clear concept of the nature of vision and in every healthy approach to the spatial world, this dynamic unity of figure and background has been clearly understood. Lao Tse showed such grasp when he said: "A vessel is useful only through its emptiness. It is the space opened in a wall that serves as a window. Thus it is the nonexistent in things which makes them serviceable." Eastern visual culture has a deep understanding of the role of empty space in the image. Chinese and Japanese painters have the admirable courage to leave empty large paths of their picture — surface so that the surface is divided into unequal intervals which, through their spacing, force the eye of the spectator to movements of varying velocity in following up relationships, and thus create the unity by the greatest possible variation of surface. Chinese and Japanese calligraphy also have a sound respect for the white interval. Characters are written in imaginary squares, the blank areas of which are given as much consideration as the graphic units, the strokes. Written or printed communications are living or dead depending upon the organization of their blank spaces. A single character gains clarity and meaning by an orderly relationship of the space background which surrounds it. The greater the variety and distinction among respective background units, the clearer becomes the comprehension of a character as an individual expression or sign. 11


Our story concludes with a new perspective, a very close look at the Galilean satellites. The remarkable 1979 flights near Jupiter by Voyager spacecraft revealed not the luminous pinpoints of reflected sunlight tracing out swift cycles of an elegant and reliable geometry—ashad been seen through telescopes for centuries—but, instead, satellites that appeared, frankly, a bit on the lumpy side.¹

Narrative Itineraries: Timetables and Route Maps

Schedules are among the most widely used information displays, with a sheer volume of printed images comparable to road maps, daily weather charts, catalogs, and telephone books. Design efforts for 150 years the world over have yielded some imaginative display strategies. The issues of timetable design are at the heart of envisioning data—large arrays of fussy annotated numbers, thick information densities, type and image together, and multivariate techniques for narrating what is a four or five variable story.⁴ And the audience for schedules is diverse, ranging from experts at timetables such as travel agents to those who are not travel agents, an audience of uncertain skills, eyepower, patience.

¹ Among the scant literature is Christian Barman, "Timetable Typography," Typogaphy, 5 (Spring 1938), 9-17; Ruari McLean, Typography (London, 1980).
A comprehensive narrative description of a transport system requires a record of both time and spatial experiences. Here a complex network of routes is brought together with flight times and identification numbers in a brilliant map/schedule for the Czechoslovakia Air Transport Company in 1933. A playful and polished cover makes the brochure an exceptional union of graphic and information design.
A similar multifunctioning pattern presides over this diagram, a fine combination of flatland and data table. Route map and index, an unusual pairing, are merged in this 200-page timetable for the railroads of China. Although the linework and typography are faltering, the overall layout has a directness and clarity of organization — maintaining the full spatial relationships of towns, patterns usually reduced to a witless alphabetical ordering in a conventional typographical index.

*China Railway Timetable*, Railway Ministry of the People's Republic of China (Beijing, April 1985), index 4. The numbers along the route lines are page numbers, showing where to look up the detailed schedule for that route.
SOME tables are better than others; an example reveals the difference design makes. Millions of copies of this standard typographical table (shown below) have been distributed by the railroad for years. Space is poorly allocated; much of the paper is given over to categories at top that labor incessantly to make only three binary distinctions (between New York/New Haven, leaving/arriving, and weekdays/weekends). All the little boxes create an elaborate but false appearance of systematic order. It resembles the county court house in Vicksburg, Mississippi — a big portico, inflated Ionic columns, with the real work done in back rooms. And so, in this timetable, left-over space beneath the introductory grids and rectangles reports on 80 different times of arrival and departure (410 characters). Only 21 percent of the timetable’s area is devoted to display of times that trains run. Disorderly footnotes lurk in the basement, waiting to derail sufficiently vigilant travelers.

The most troubling defect of this timetable, however, is the content of the information, for the same journey runs no faster than it did 70 years earlier for several trains! At upper right is an antique schedule of October, 1913. Note the wise practice back then of putting names of the people responsible for railroad operations on the cover, a sign of pride as well as an effective force for quality control.

Bold sans serif capitals weak in distinguishing between two directions:

Column headings repeated 3 times and 24 AM’s and PM’s shown due to folded sequence of times. The eye must trace a serpentine path in tracking the day’s schedule; and another serpentine for weekends:

Poor column break, leaving last peak-hour train as a widow in this column.

Too much separation between leave/arrive times for the same train.

Too little separation between these unrelated columns.

Most frequently used part of schedule (showing rush-hour trains) is the most cluttered part, with a murky screen tint and heavy-hand symbols.

Rules segregate what should be together; a total of 41 inches (104 cm) of rules are drawn for this small table.

Wasted space in headings cramps the times (over-tight leading, in particular). Well-designed schedules use a visually less-active dot between hours and minutes rather than a colon.

Ambiguity in coding: both X and E suggest an express train, or even F for Economy.
At any rate, the redesign below eliminates all the assorted convolutions from the modern-day schedule and yields a graceful but unceremonious layout. The numbers, no longer serpentine, are now set in Matthew Carter's Bell Centennial, a telephone-book typeface designed for clarity of reading in tight spaces (such as the convenient pocket schedule).  

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### NEW YORK — NEW HAVEN

<table>
<thead>
<tr>
<th>Grumman Center Service</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monday to Friday, except holidays</strong></td>
</tr>
<tr>
<td>Leaves</td>
</tr>
<tr>
<td>New Haven</td>
</tr>
<tr>
<td>5:40 am</td>
</tr>
<tr>
<td>1:05 pm</td>
</tr>
<tr>
<td>2:05 pm</td>
</tr>
<tr>
<td>5:00 pm</td>
</tr>
<tr>
<td>5:42 pm</td>
</tr>
<tr>
<td>6:07 pm</td>
</tr>
<tr>
<td>6:15 pm</td>
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5 Center for Design and Typography, Cooper Union, “Matthew Carter: Bell Centennial,” *Type & Technology Monograph*, 1 (1982). Ami Stern did the initial redesign of the New Haven schedule as a student project, Yale University, 1983.
SERPENTINED data formations, like the New Haven timetable, spring up when data collide into a rigid grid. Authentic graphical treasures can result, especially when the data are lognormally distributed as so many variables are. Above, two rivers meander boustrophedonically around a tight frame, weakening comparison of their lengths. And a delight from the 1935 Graphic Illustration of Tokyo City (a book too often forgotten), analyzing the water supply system with a very bent bar chart:


Tokaido Line at Yokohama Station, Sagami Tetsudo Company, 1985 timetable, p. 72.


Tokyo City Government, Tokyo shisei Zuhyo [Graphic Illustration of Tokyo City], April, 1935, p. 17 (at left).
In this time-series, William Playfair ingeniously spilled outlying data over, first by temporarily extending the grid at top (like ledger lines in musical notation) and then by topologically gluing the data surface from top around to bottom (like octave displacement in music). The result is a torus-graphic. Thick horizontal lines identify periods of war, when British government spending for weapons multiplied. A ratchet effect appears, as post-war expense fails to shrink back to its pre-war level:

This, like the three former Charts, is made out from the yearly Accounts laid before the House of Commons; like those, too, it rises in time of war; and has, like them, not returned to its former low establishment. The people, in every different line, are interested in raising the consequence of their department; and example is contagious, when seconded by inclination or by interest.\(^6\)

Playfair's enfolding resembles the gluing of music repeats as well as the visual-musical round at right, a becoming curiosity. Moreover, the 24-hour graphical timetable can likewise be glued end-to-end onto a cylinder, to show a fully connected cycle and to prevent running off the right side of a schedule at midnight. Simply prolonging the grid a few more hours will also show a complete cycle — as in the airplane schedule below, which itemizes a day's visit to Chicago after flying from Atlanta. Globes may likewise be recycled, avoiding ethnocentrism and showing, somewhere in the picture, every country and ocean together in full.

\(^6\) William Playfair, *Commercial and Political Atlas* (London, 1786), text facing plate 34. A failure to deflate monetary units weakens his argument, especially in light of possible postwar inflation.

