In December 1986 an experimental aircraft named Voyager became the first piloted aircraft to circle the earth without refueling.

<table>
<thead>
<tr>
<th>DAY 9</th>
<th>DAY 8</th>
<th>DAY 7</th>
<th>DAY 6</th>
<th>DAY 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours</td>
<td>216</td>
<td>200</td>
<td>192</td>
<td>184</td>
</tr>
<tr>
<td>Flight</td>
<td>188</td>
<td>176</td>
<td>168</td>
<td>160</td>
</tr>
</tbody>
</table>

Fuel on landing: 18 gallons

Fuel on takeoff: 1,168 gallons

Engine stalled, unable to restart for five harrowing minutes

Transition from tailwinds to headwinds

Oil warning light goes on

Rutan disabled by exhaustion

Passing between two mountains, Rutan and Yeager weep with relief at having survived Africa’s storms

Worried about flying through restricted airspace, Rutan and Yeager mistake the morning star for a hostile aircraft

Flying among the redwoods, life and death struggle to avoid towering thunderstorms

Discovery of backwards fuel flow

Voyager squeezes between restricted Vietnamese airspace and thunderstorms

Voyager flies between feeder band and main storm to maximize tailwinds

Dramatic takeoff, wings tips scraped off

Impromptu rendezvous with chase plane

Take-off

Wind speed, direction, and cloud cover

Mercator map projection

Flight data courtesy of Len Swinman and Larry Burch, Voyager meteorologists

Mapped by David Dillase and John Krygier, Department of Geography, University of Wisconsin-Madison, 1987

Voyager pilots: Dick Rutan and Jeana Yeager

Voyager designer: Burt Rutan

What do you need to know to make this map?
How to Make a Map

Start by looking; what do you see? Looking at maps is easy. Not really. You can glance at the Mona Lisa in a second. But to get the Mona Lisa you have to look more carefully. What do you see on the Voyager map? Words, lines, continents, a grid. A story, some information with the story. What do you notice first? Black lines, gray lines, white lines ... why are they different? Making maps requires that you answer such questions, and many more. Throughout this book, in nearly every chapter, we annotate The Flight of Voyager. By the end of the book, you will understand how to really see – and make – a map.
The Flight of Voyager map was published in 1987 in the book *Voyager* by Jeana Yeager, Dick Rutan, and Phil Patton.

<table>
<thead>
<tr>
<th>DAY 9</th>
<th>DAY 8</th>
<th>DAY 7</th>
<th>DAY 6</th>
<th>DAY 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours off</td>
<td>216</td>
<td>200</td>
<td>192</td>
<td>184</td>
</tr>
<tr>
<td>Fuel on landing: 18 gallons</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The map was split between the front and back book end-papers, half in the front and half in the back. Each endpaper was 9” high and 12” wide.

The map was designed to be viewed at arm's length.

<table>
<thead>
<tr>
<th>DAY 4</th>
<th>DAY 3</th>
<th>DAY 2</th>
<th>DAY 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours Off</td>
<td>96</td>
<td>88</td>
<td>80</td>
</tr>
<tr>
<td>Take-off</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel on take-off: 1,168 gallons</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Flight data courtesy of Len Snellman and Larry Burch, Voyager meteorologists.

Maped by David DiBlase and John Krygier, Department of Geography, University of Wisconsin-Madison, 1987.

Voyager pilots: Dick Rutan and Jeana Yeager
Voyager designer: Burt Rutan

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David DiBlase and John Krygier designed and made a map to tell the story of Voyager and its pilots. The map was created for a map design course at the University of Wisconsin-Madison taught by David Woodward.

The map was made for readers of the book *Voyager* (1987), with its general, educated audience, including those with a specialist interest in flight and aerospace. Given the audience, the map was designed to contain a significant amount of information including detailed data, sure to resonate with pilots.

The publisher of *Voyager*, Knopf, allowed us black and one color for the map. We chose deep red for the most important information (such as the flight path and related text). The map was redesigned in monochrome for *Making Maps, 2nd Ed.* The map still works!

Details of the map’s design – line weights, type size, percent gray of different areas on the map, etc. – were documented, as we were taught in David Woodward’s course and at the University of Wisconsin-Madison Cartographic Lab. Formative evaluation was ongoing throughout the process, and the editors at Knopf provided the final edit and evaluation of the map.
Uh ... why is the Voyager story ending at the beginning of the map?

Flight data courtesy of Len Snellman and Larry Burch, Voyager meteorologists
Mapped by David Dillilae and John Krygier, Department of Geography, University of Wisconsin-Madison, 1987

Voyager pilots: Dick Rutan and Jeana Yeager
Voyager designer: Burt Rutan

What’s up with that?
There was a problem. Voyager’s route began in California and headed west, sending the reader backwards across the endpapers and so violating reading habits.

**THE FLIGHT OF VOYAGER**
December 14-23, 1986
Wind speed, direction, & cloud cover

Mercator map projection
Scale at equator is 1:43,000,000

Impact points:
- Edwards AFB
- Launch
- Typhoon Marge
- Indian Ocean
- Atlantic Ocean
- Sargasso Sea
- South Atlantic
- Brazil
- Atlantic Ocean
- Transition from tailwinds to headwinds
- Engine stalled, unable to restart for five harrowing minutes
- Triumphant landing at Edwards AFB

Flight data courtesy of Lon Stellman and Larry Burch, Voyager meteorologists
Mapped by David Dillase and John Kuykens, Department of Geography, University of Wisconsin-Madison 1987

Thankfully, north isn’t really up. The data suggest south up, and we suggested south up for the map. “No!” shrieked the publisher. “You can’t have south up.” And we didn’t, in the book. But now, here it is.

6
The Big Picture of Map Design

Map design is tough. What’s the point of your map? What kind of data do you have? What tools are you using? What’s your geographic framework? With answers to these questions in mind, intelligently design the diverse pieces of your map into a coherent whole. One “big picture” approach to map design is borrowed from advertising: layout and visual arrangement. The medium is the message. Another approach is Edward Tufte’s “graphical excellence.” The data are the message. Both approaches played a role in designing the Voyager map, as they should with any mapping project.
The title succinctly describes the subject and dates of the event. The plane’s silhouette visually reiterates the subject. The global context will be clear to the map’s audience, and is left out of the title.

The legend explains the one symbol on the map that may be unfamiliar to a general audience: the wind barb.

Map scale is shown as a representational fraction. The scale on global maps varies significantly, so including a scale can be deceptive. But not including one can be confusing. The compromise is to include a scale with a statement of its limitations.

Key events are described along the flight path. It’s impossible to express this part of the story without explanatory text. The text is brief, clear, and tied to the story told in the book.

Inset maps could be used to reveal more detail. In the case of this map, such inset maps were not necessary given the general overview of the flight the map is intended to show.

The flight data courtesy of Len Snellman and Larry Burch, Voyager meteorologists. Mapped by David Dilllance and John Voyager, Department of Geography, University of Wisconsin-Madison 1987.

The map projection is noted in the legend area. Sources and the map maker’s names are along the bottom of the map. An additional statement about the coordinate system would be superfluous.

The south-up orientation of this map suggests that a directional indicator should be included. But the educated audience will figure out the orientation quickly, as distinctive continental shapes are still recognizable.

There is no border around the entire map, but the alignment of the main map block and data bars provides coherence. A border would be unnecessarily redundant.
With south up, there's a perfect place for the title. The typical reader will read the title, grasp the topic, then set off on the path of Voyager, heading to the right and west.

The title and legend are **asymmetrical** on the page, lending a subtle sense of complexity and creativity to the map.

The story text blocks are distributed in relation to the flight path in order to attain balance over the entire map.

**Sight-lines** on the left and right of the map are kept simple with aligned graphic elements and text.

**Symmetrical** data bars suggest tradition. A mix of both symmetrical and asymmetrical balance suggests that the map, its design, and makers are creative but not altogether untraditional.

The path and the story, reading from the upper left, end triumphantly in the lower right.
The flight path, countries, weather, storms, key events, days, hours, fuel, visibility, altitude, distance … and more reveal the complex flight of Voyager. Designing this map was really hard work.

**Detail was added along the flight path,** including the wind barbs and countries with airspace crossed by Voyager. Similar data elsewhere are not relevant to the story and thus left off the map.

**Design variation reflects data variation** on the map: vital features are included and jump out, like the flight path. Less important features, like the grid, fall back.

**Details of the days, hours, fuel, visibility, altitude, and distance are shown in the five data bars spanning the map.** All inform the story of Voyager.

Capturing the essence of the events central to the flight in a brief sentence or phrase took repeated critical revision.

Scraped wingtips, typhoons, high headwinds, backwards fuel flow, exhaustion, and a mere 18 gallons of fuel left on landing are not boring.

**THE FLIGHT OF VOYAGER**
December 14-23, 1986

Wind speed, direction, & cloud cover
Mercator map projection
Scale at equator is 1:13,000,000

**Impromptu rendezvous with chase plane**

**Dramatic takeoff; wingtips scraped off**

**Edwards AFB**

**United States**

**Very little non-data ink remains on the map,** with its high data-ink ratio. Just about every mark tells something relevant to the story.

**Explanations of key events** of the flight data are included on the map.

**Chartjunk** – in this case, map crap – was ruthlessly excised. No gaudy north arrow, no 3D shadow effects, no goofy fonts.

**Redundancy is minimized** unless it helps explain the data. The flight path is shown twice: in plan, on the main map, and from the side, on the altitude data bar. Both altitude and route are vital to the story.

**The multiple variables of the Voyager flight are mapped out in multiple interrelated data bars and maps.**

**Data are shown in context:** geographic, meteorological, diurnal, altitudinal, experiential.

Flight data courtesy of Len Snellman and Larry Burh, Voyager meteorologists

Mapped by David DiBlase and John Krogh, Department of Geography, University of Wisconsin-Madison 1987

Voyager pilots: Dick Rutan and Jeana Yeager
Voyager designer: Burt Rutan

Substance, statistics, design: the greatest number of ideas in the shortest time with the least ink in the smallest space. The Voyager map won the 1987 Donnelly and Sons / American Congress on Surveying and Mapping Map Design Competition.
Without **visual differences** among the symbols on the map you have a nasty, unintelligible mess.

**THE FLIGHT OF VOYAGER**
December 14-23, 1986

- West wind, direction, and cloud cover
- Mercator map projection
- Scale at equator is 1:45,000,000
- Unpromising rendezvous with satellite plane
- Dramatic takeoff; Friendship scrapped
- Voyager flies between feeder bands and main storm to maximize tailwinds
- Coolant seal leaks toward end of flight
- Voyager enters into 90° bank
- Two prominent squares indicate Voyager is near the South Pole
- Voyager flies through 240° band, achieving record of 12,532 miles previous record
- Voyager pilots: Dick Rutan and Jeana Yeager
- Voyager designer: Burt Rutan

**Flight data courtesy of Len Snellman and Larry Burch, Voyager meteorologists**
Mapped by David Dilliane and John Krygier, Department of Geography, University of Wisconsin-Madison, 1987

So, add **visual differences**—driven by your data and the goals for your map...
The simple shape of the Voyager icon makes it stand out as a strong figure.

As a closed object, Australia stands out more than other land areas.

The east-west and north-south directions of the grid make it hang together as a coherent whole behind the entire map.

The distinctive shapes of continents make them stand out as figure; they are pushed back into the ground by the use of gray and white.

The familiar shape of South America creates a recognizable figure even though it is oriented south up.

THE FLIGHT OF VOYAGER
December 14-23, 1986

Wind speed, direction, & cloud cover

Mercator map projection
Scale at equator is 1:45,000,000

Voyager squeezes between restricted Vietnamese airspace and thunderstorms

Voyager flies between feeder band and main storm to maximize tailwinds

Voyager makes a dramatic takeoff, wingtips scraped off

Discovery of backwash fuel flow

Flying among the redwoods: life and death struggle to avoid towering thunderstorms

Raiding two mountains, Ratan and Yeager work with relief at having survived Africa's storms

Thunderstorm forces Voyager into 90° bank

Voyager disabled by exhaustion

Oil warning light goes on

Engine stalled; unable to restart for five harrowing minutes

Transition from tailwinds to headwinds

Triumphant landing at Edwards AFB

Flight data courtesy of Len Sneedman and Larry Burch, Voyager meteorologists
Mapped by David Sibley and John Krygier, Department of Geography, University of Wisconsin-Madison 1987

The grid falls into the ground because it appears to be on a layer behind the continents, which in turn are behind the flight path and its details.

Soft edges of land masses push them into the background, as less important parts of the map.

The complex texture of the storms makes them stand out as figure on the map.

The details surrounding the flight path and lack of details away from the flight path create a strong figure-ground relationship.

The proximity of flight path symbols and text binds them together as strong figure on the map.

While color would be nice, a remarkable range of visual differences can be achieved with monochrome.
For the map, the entire book-length story of the flight of Voyager was simplified into 18 briefly described episodes capturing the essence of the story.

In a few places, near storms, the flight path was enhanced, showing more detail when supported by the pilot's account (and not captured by the cruder locational data of the flight path).

Coastlines are simplified by reducing the number of points in the line. Details of the coastlines are not necessary for the story of Voyager.

Coastlines are smoothed, reducing overall angularity. Coastlines are natural features that typically don't form sharp angles.

Volumetric temperature, wind, and cloud phenomena are dimensionally changed into two-dimensional wind barb symbols. They capture enough of the phenomena for the purposes of the story.

We selected and labeled countries whose airspace Voyager passed through. A considerable effort was required to clear Voyager to enter restricted airspace. Other countries are not relevant to this part of the story and are

Country labels are displaced away from the center of some countries to make room for more important flight path symbols.

Stroms were caricatured by simplification, smoothing, and enhancement to resemble the more abstract map symbols occupying much of the map.
The wind barb symbols are multivalent, showing wind speed, direction, and cloud cover. The symbol orientation, a subset of shape, shows wind direction (qualitative).

The size and number of the wind barb tails shows wind speed (quantitative).

The value of the wind barb circle, empty, half full, or full, suggests amount of cloud cover (quantitative).

The size of the type suggests importance (quantitative). Larger-size type labels the more important phenomena, smaller type the less important.

The shape, size, and value of the flight path – wide with a white core – suggests the symbol is very important. The distinctive symbol shape, size, and value also tie the symbol on the main map to the symbol on the altitude map.

Value is used in the top and bottom data bar to provide overall balance and stability for the map. The gray tones provide a solid base and cap to the overall map.

### The Flight of Voyager

December 14-23, 1986

Wind speed, direction, Mercator map projection

Scale at equator is 1:43,000,000

Fuel on takeoff: 1,100 gallons

Fuel on landing: 18 gallons

Flight data courtesy of Lon Stallman and Larry Burch, Voyager meteorologists

Mapped by David DiBlase and John Vogler, Department of Geography, University of Wisconsin-Madison 1987

Flight times:

<table>
<thead>
<tr>
<th>DAY 1</th>
<th>DAY 2</th>
<th>DAY 3</th>
<th>DAY 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours Afloat</td>
<td>Take-off</td>
<td>Hours Afloat</td>
<td>Take-off</td>
</tr>
<tr>
<td>8</td>
<td>16</td>
<td>24</td>
<td>32</td>
</tr>
<tr>
<td>48 hours</td>
<td>64 hours</td>
<td>80 hours</td>
<td>88 hours</td>
</tr>
</tbody>
</table>

### The Text of the Storm

Symbols are used to suggest the turbulent character of the phenomenon that provided much of the excitement and terror of the voyage.

On the original printed Voyager map, red color hue was used for important map elements, including the route, storms, story type, and weather symbols. Red stands out more than other hues, signifying importance (quantitative).
**The Flight of Voyager**

December 14-23, 1986

Wind speed, direction, & cloud cover

Voyager squeezes between restricted airspace and thunderstorms

Autopilot failure

Coolant leak

Engine stalled; unable to restart for five harrowing minutes

Flight data courtesy of Len Snellman and Larry Burch, Voyager meteorologists

Mapped by David Dilliae and John Kryger, Department of Geography, University of Wisconsin-Madison 1987

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**Typeface** (font). It is less mechanical-looking than typical sans serif fonts while retaining a clean, modern feel. It imparts qualities of significance and modernism to the flight of Voyager.

Quantitative differences are suggested by the use of value (type form). Gray type is used for less important information, black type for more important information.

**Type weight** isn’t used much on the Voyager map as Stone Sans Bold seems a bit pudgy and inelegant.

**Type size** tells you what is more and less important (quantitative) on the Voyager map. The title and story text are the largest, grid degrees and ocean names the smallest.

Qualitative differences are suggested by the use of italics (type form). Italic suggests flowing, natural phenomena, like water.

Voyager pilots: Dick Rutan and Jeana Yeager
Voyager designer: Burt Rutan

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Fuel on takeoff: 1,168 gallons

Fuel on landing: 18 gallons

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*Stone Sans is a humanist*