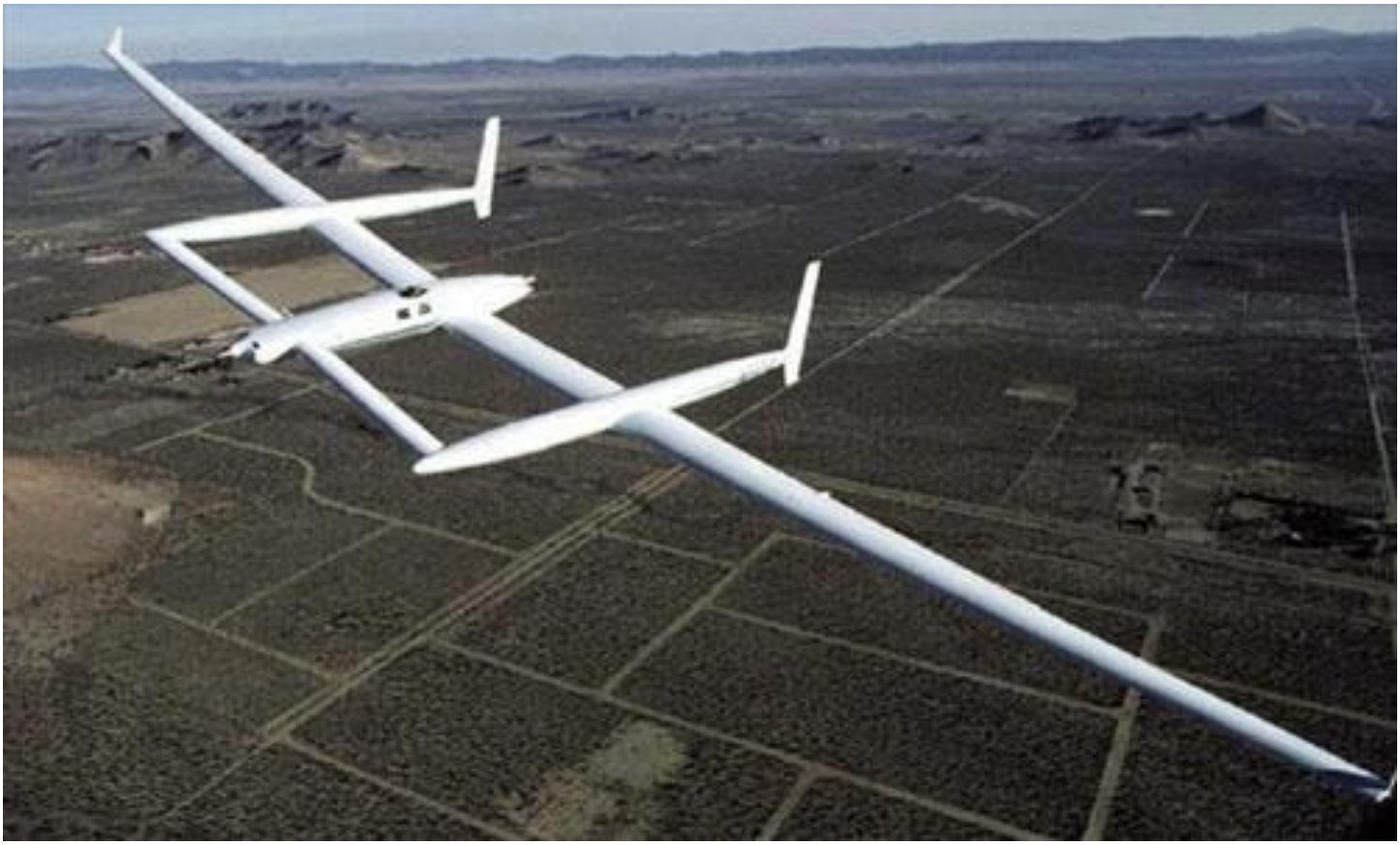
Chapter 29

Voyager, Rutan Design Number 76
1974 to 1990

Updated March 17, 2026 (Version 23)

The Voyager is a very special aircraft that was built for one purpose - to achieve the **Milestone** of "**Around-the-World, Non-Refueled Flight**."



The program was started in early 1981, made its first flight in June 1984, set a closed-course range record on July 9th, 1986, and achieved the **Milestone** on a nine-day flight from December 14th to December 23rd, 1986.

One year after the Milestone flight, the aircraft was trucked to Washington DC and donated to the Smithsonian Air & Space Museum.

This photo shows it displayed
in the entrance lobby of the Mall Museum.

Loaded up for the long drive to Washington DC
The blue covers protect the skins from hailstorms.

**A full-scale replica of its fuselage,
allowing visitors to closely inspect its cockpit,
is on display at EAA's Museum
at Oshkosh, Wisconsin.**

Quotes

“Many of us grow up with dreams we never realize. We just don't take time to live them - or we let others discourage us. We listen to the chorus of "Why bother?" or "What will you gain from it?" and never experience the joys of achieving goals we set for ourselves. Everyone should have a dream - and strive to reach it. Dreams can be big or small. It doesn't matter. What matters is: that a dream-come-true can change a person in some wonderful yet indefinable way. And sometimes the best part is that one dream will lead to another, and another, until finally there is an endless cycle, a limitless horizon as vast as the sky itself.”
– Dr George A “Pop” Rutan

“Aviation is proof that given the will, we have the capacity to achieve the impossible.”
– Eddie Rickenbacker

“The reasonable man adapts himself to the world; the unreasonable one persists in trying to adapt the world to himself. Therefore, all progress depends on the unreasonable man.”
– George Bernard Shaw

“The most rewarding things we can accomplish are those with technical sights set extremely high, with risks requiring courage and with the need to use every aspect of freedom that our country can provide. We cannot leave our destiny to evolution because it gives us inadequate progress to please our egos. We must set our sights on revolutionizing, on trying something that might be out of reach, but still might be just possible.”
– Burt Rutan

“Around the world non-stop, non-refueled …the last first in aviation… and perhaps the last opportunity for our generation to experience the euphoria of the Lindbergh Era.”
– Jack Cox

“Success is not the key to happiness. Happiness is the key to success. If you love what you are doing, you will be successful.”
– Albert Schweitzer

“It'll be a cold day in hell before I put a cancer–stick on the side of my airplane. Your industry doesn’t have enough money for me to put a cigarette on my airplane.”
– Dick Rutan

Briefing

For World Flight Records, many accept a flight of at least 22,858 statute miles - the distance around the world at the Tropic of Cancer (north hemisphere) or the Tropic of Capricorn (south hemisphere). These are at a latitude of +- 23.4 degrees.

However, our goal for the Voyager’s non-stop, non-refueled **Milestone** was to exceed the distance at the earth’s equator (24,901 statute miles) and to have the flight path include the north and the south hemispheres.

Previous attempts had planned to fly the shortcut - just 22,858 miles and would have remained in the north hemisphere.

My goal in designing the Voyager was for it to have a range in still air that was 10% more than the earth’s 24,901-mile equatorial distance and to include north and south hemispheres. I wanted to be sure that there could be no claim that we had flown less than the real Milestone distance.

Chapter 29 General Timeline of Events

Voyager Model 76 Project Timeline - Round-the-World, Non-Refueled Milestone					
	1974	**1981**	**1981**	**1981**	**1981**
	July	**Feb 15th**	**March 26th**	**Feb 24th**	**March 1st**
Voyager Project Event	Feasibility Study	Concept One sketch	Final 2-boom config/spec	VAI contract with Burt	D/J start $2M sponsor search
Scaled Composites Inc	Not Yet Planned	Initial planning for Burt's second entrepreneurial company, Scaled Composites.			
Rutan Aircraft Factory	Founded in Mojave	Beech Starship design contract was with RAF. Transferred to Scaled in 1982.			

	1982	**1982**	**1982**
	June 1st	**July**	**August**
Voyager Project Event	The 2M$ search fails. VAI is now broke.	RAF shows VAI a **Voyager Program Rescue Plan.**	D/J accepts **Rescue Plan**. Fabrication starts immediately.

	1984	**1984**	**1984**
	January	**February**	**May**
Voyager Project Event	Mojave Airport Manager donates hangar.	Components moved to hangar 77 for final assembly.	Public Roll-Out unveiling.

	1984	**1986**	**1986**	**1986**
	June	**January**	**April**	**July**
Voyager Project Event	First test flight.	Peter Riva writes the budget for future sponsor $. His 10% fee never paid by VAI. He did not sue VAI.	VAI buys out RAF contract. A bargain - only $180K.	Closed Course Record Off Calif coast for 4.5 days.

	1986	**1986**	**1986**
	December 14th	**December 23rd**	**Dec 29th**
Voyager Project Event	**Milestone** takeoff EAFB runway.	Nine days later - **Milestone** landing, Edwards dry lakebed.	Reagan awards PC Medals.

	1987 to 1989	**1987 to ~1997**
Voyager Project Event	**Paid Fee talks** Dick/Jeana did ~180 talks. Burt did ~ 33.	**Voyager-related Awards** Approximately 24 Awards. The full list is in BRAB Chapter 85.

Barry Schiff on the 5 Greatest Flights in History

"….. Second place is Dick Rutan and Jeana Yeager's 1986, nonstop, unrefueled, nine-day flight around the world in the Rutan Voyager. Their accomplishment can be described only by a collection of superlatives, and these pilots had more grit and 'right stuff' than I would have believed possible. The unique airplane was simply brilliant in concept, design, and execution. It was the creation of Burt Rutan, arguably the most innovative aircraft designer of his era. ….. During its chancy takeoff, winglets were damaged and later departed the wing.

I do not know of one pilot who then thought that Voyager had any chance whatsoever of completing its circumnavigation.

Barry Schiff, born in 1938, has logged 28,000 hours of flight time and has flown 364 different types of aircraft (a world record) including the B-52, U-2, P-51 Mustang and the V-22 Osprey. Becoming an ATP at 21, he has every category and class rating issued by the FAA. He also has every flight instructor rating and type ratings from the Ford Tri-Motor and Douglas DC-3 to the Lockheed L-1011 and Boeing 747. Captain Schiff retired from TWA in 1998 as a check captain on the Boeing 757 and 767.

Since the Voyager program is described in hundreds of publications, this BRAB Chapter 29 is focused on information that cannot generally be found elsewhere.

The Voyager program started just as I began founding my second entrepreneurial business - Scaled Composites, Chapter 33. This was also the time that the huge Beechcraft Starship program began (refer to the two Links below).

Oshkosh 2024 Talk 4 Slides

Oshkosh 2024 Talk 4 Video

Because I was incredibly busy at the time, I wrote almost no documents then about the Voyager program. I did prepare a technical slide presentation for various engineering audiences. Several of those slides are shown and discussed below.

Personal Stories Never Previously Published

A great number of stories have been written about the Voyager Round-the-World Milestone program in books, magazines, etc. None of these publications has told the complete, unusual story of how the program got started, how it initially failed to find financing, how it got rescued by Rutan Aircraft Factory and how it got restructured when the aircraft was undergoing initial flight tests.

Likely, the main reason this part of the story was not told in co-pilot Jeana's book titled "Voyager" or in Dick's book "The Next Five Minutes" was their

desire to show the program as a grass-roots effort by volunteers and financed only by individual $100 donations from the public.

The full true story is a complex one. Details are finally revealed below.

End of Briefing

Chapter 29 - Voyager Model 76
Achieving the Last Milestone in Aviation

Voyager, on a Phase-One Test Flight
Just South of Mojave

Organization of Chapter 29

This chapter is organized into ten numbered **Topics**.
These include my personal-perspective stories from the Voyager program.

Topic 1 • TECH ITEMS & SOME PERSONAL STORIES

TECHNICAL INFORMATION

This video shows a wealth of technical information on Voyager:

Voyager Flight Summary Video

World Flight Engines

From the data acquired from the first phase of testing, we were able to select the world flight engines and avionics. King Radio is providing the avionics and Teledyne Continental Motors is providing the two engines. The front engine is a standard 0-240 air cooled (130 hp) and the rear engine is the newly developed IOL-200 liquid cooled (110 hp).

Experts Predicted Failure

The reasons experts (including me) predicted the world flight would likely not be possible on the first attempt:

1 • Mechanical Reliability - During the 64-flight, 349 hours of local flight tests, there were 3 or 4 failures that resulted in it not being able to maintain level flight. The predicted 225-hour world flight was 80% over oceans, thus there was a high likelihood of an ocean ditching.

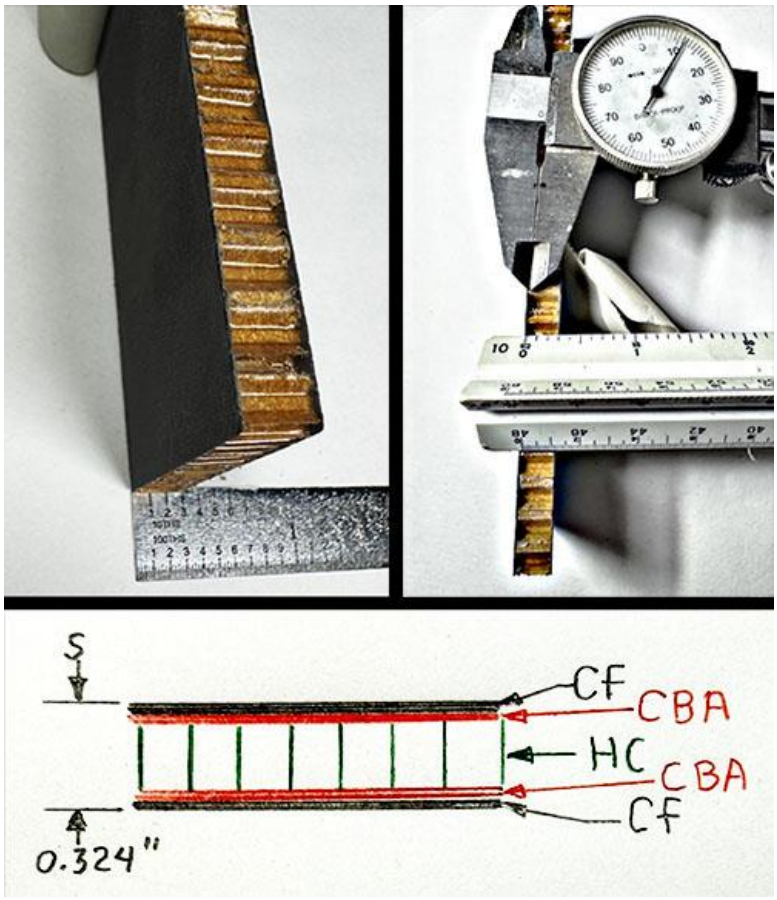
2 •` Crew Fatigue - the original test plan called for a 24-hour flight on flight 4, then a 2-day flight on flight 5, then a 3-day flight on flight 6, etc. However, each time an over-night flight was on the test cards, the crew descended to land before it got dark. They were exhausted; at light weight even “light turbulence” caused a lot of motion in the cockpit, the type of motion that induces airsickness. Two years after the first flight on June 1984 voyager set a closed course distance record by flying many cycles up and down the California coast for 4.5 days. It seems weird, but that was the first time the crew slept while airborne. They addressed the TV media after that flight and during the interview Jenna passed out and collapsed on live TV due to dehydration.

3 • Airframe Structural Failure - Categories of turbulence for aircraft are: Light-chop, Light, Moderate, Severe and Extreme. Severe might cause

structural damage and Extreme will fail the wing and/or cause an inability to control the aircraft. To optimize its range capability, Voyager had very small structural failure margins when it was heavy. When light, the wing and canard could survive near-severe turbulence. But during the first 2 days of world flight the wing could fail during even Light turbulence or during maneuvering of more than 1.8 g. That strength is just an analysis result, since, due to its frail structure, it was not possible to do a normal pre-flight load test of the wing.

Airframe Structure Details

Nearly all the skin, bulkhead and rib structure of Voyager was a Sandwich of thin **Carbon Fiber** tape and **Core Bond Adhesive**, on both sides of a 0.28 inch thick **Nomex Honeycomb Core**. The unidirectional **CF** tape was two, +- 45 degree plies, each 0.0055" thick for a skin thickness of just 0.011 inches. The **CF** skins were so thin that fuel would easily leak through them. Thus, it was the **C**ore-**B**ond **A**dhesive ply that was the fuel-leak barrier. That was so effective that we never had a fuel leak through a fuel tank skin!



This sandwich structure had a weight of 0.23 lb per square foot, 0.17 of which was carbon fiber unidirectional tape.

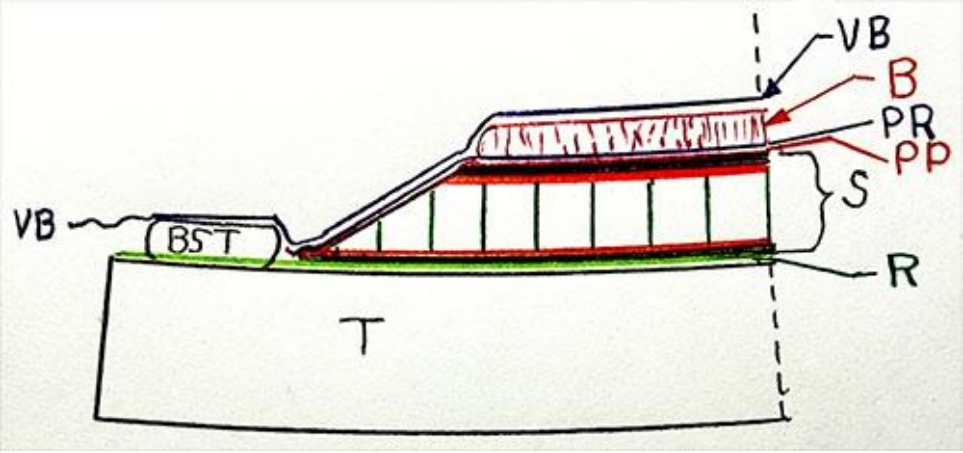
Fabrication of the Sandwich Structure

The sandwich structure was fabricated using the vacuum-bagged, oven-cured method.

This required a rigid, smooth, leak-proof **Tool T**. To avoid the part sticking to the tool, a **Release** agent was applied to the tool. Then, the five components of the **Sandwich S** were laid up, plus a **Peel-Ply**. The **PP** allowed the part to later be bonded to the adjacent ribs or bulkheads without it needing to be sanded. We absolutely could never sand those super-thin **CF** skins.

Then a **Perforated Release PR** film was placed to allow excess epoxy to transfer to the cotton **Bleeder B**. The entire periphery was lined with **Bag Sealing Tape BST** to seal the **Vacuum Bag VB**.

An insulated box oven covered everything, and the inside was heated to 230 degrees F for ~3 hours to cure the part. After cure, we stripped the **VB, B** and **PR**. The **PP** was peeled off just before the parts were assembled.



Wing and Canard Main Spars

For the main wing and canard spars we absolutely needed the highest quality, autoclaved carbon fiber structure, since we determined we would not be able to do the typical static load test. It was clear that we could not load the wing or canard without damaging the support structure.

We could not afford to build a typical autoclave spar tool, so we just bought some cheap construction steel plate, and bolted steel dams to them. We trucked those to Utah and got Hercules to layup the spars and to autoclave cure them.

The Structure is Easily Damaged

Care had to be exercised when handling the fragile skins. They were so thin that just carefully placing a hammer on them or knocking with your knuckles like knocking on a door, could damage them, requiring a repair to prevent growth of a sandwich core dis-bond!

The Voyager Fuel System

The 3-view drawing below of Voyager shows the feed tank where both engines normally get their fuel. The feed tank is the only tank in the aircraft that has a quantity gauge — a simple non-electrical sight gage measuring the full height of the fuselage. It was critical to have a way to accurately monitor the usable fuel volume even during a total loss of electrical power.

This 3-view drawing is not accurate. The real measurements are:

Wingspan = 110.8 ft.

Canard span = 33.3 ft.

Fuselage length = 25.4 ft.

Wing chord, out to boom at BL = 16.65 ft out to 4.11 ft.

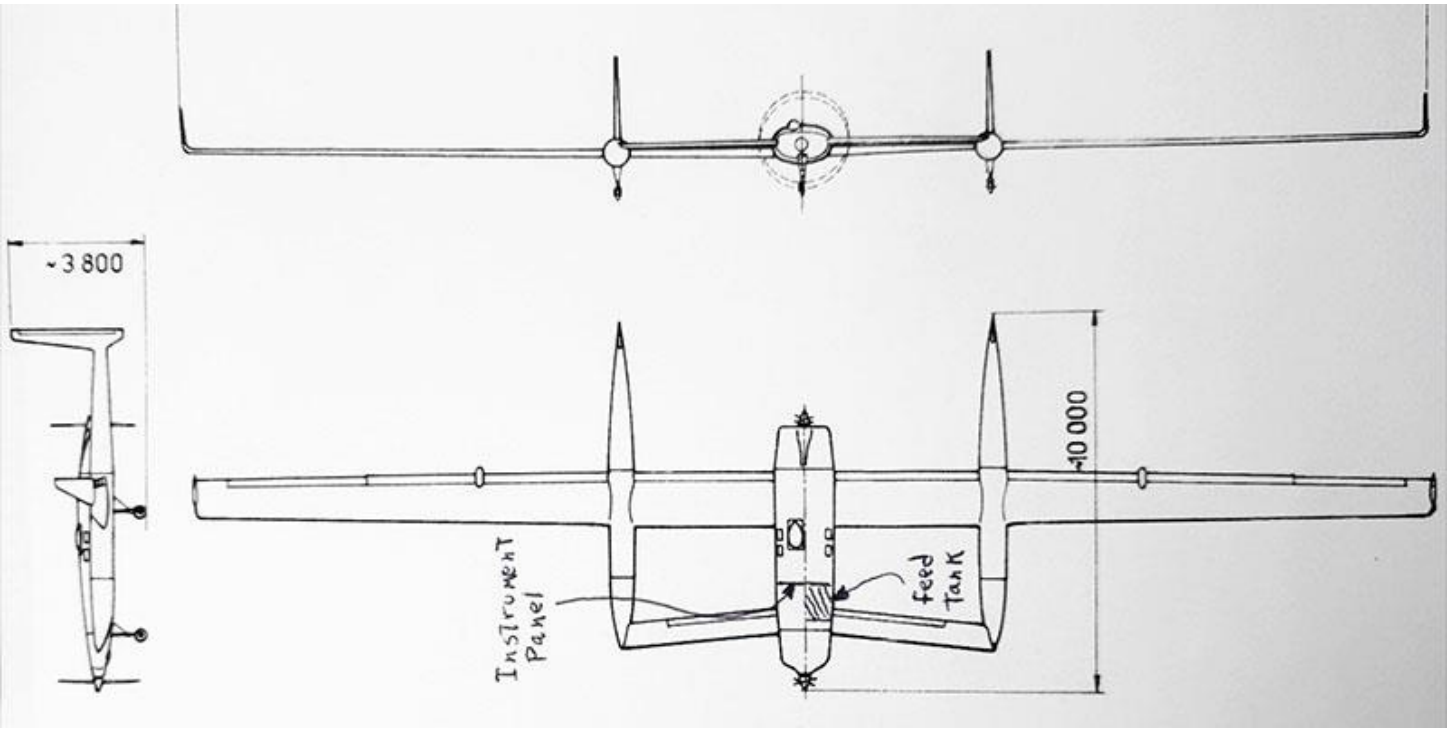
Wing tip chord = 1.83 ft.

Canard chord = 1.84 ft.

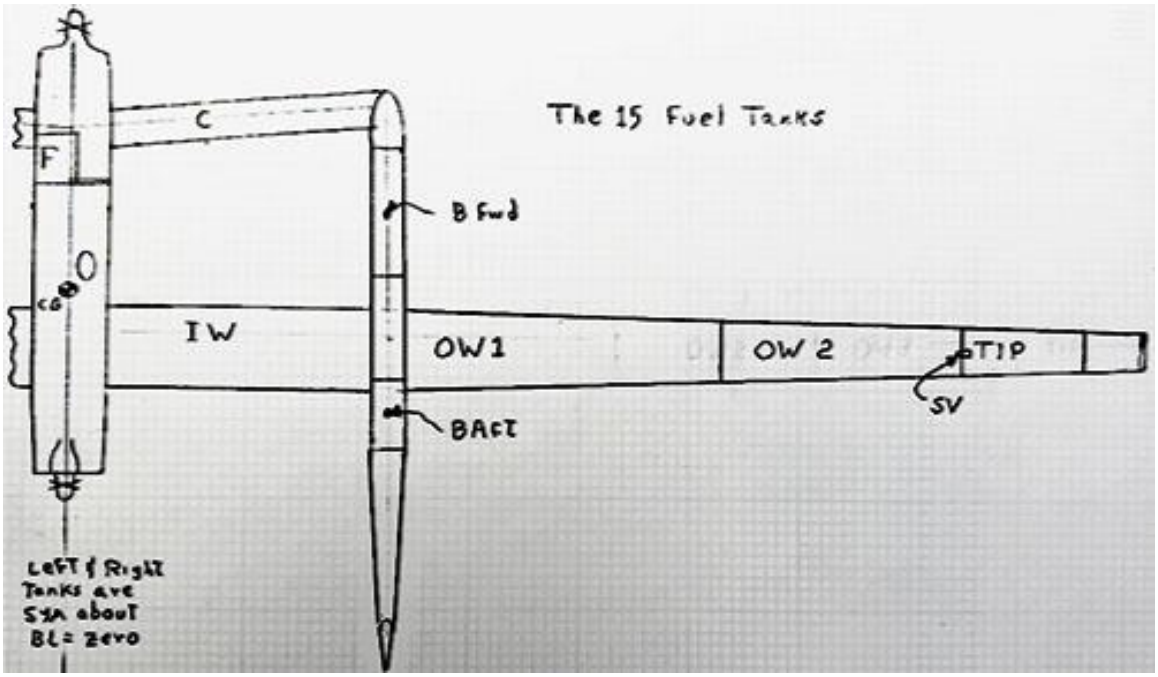
Boom diameter at the forward and aft fuel tanks = 1.5 ft.

Width of fuselage at Instrument Panel = 3.87 ft.

Height of feed tank and fuselage at IP = 3.37 ft.



The drawing below shows Voyager's 15 fuel tanks.



The 15 tanks are named here:

F = Feed tank. Both engines get their fuel from the feed tank. There is only one feed tank, the other 14 are duplicated - left and right sides of butt-line zero.

C = Canard tank.

B fwd = Forward boom tank.

B aft = Aft boom tank.

IW = Inboard wing tank.

OW 1 = Outboard wing root tank.

OW 2 = Outboard wing mid tank.

TIP = Tip wing tank.

SV is a solenoid valve, used very late in the world flight, to dump TIP fuel into OW2.

Why there was No Fuel at the Wing Tips

When Voyager was near completion and ready for its first full-airplane weighing, we found that it was a bit tail-heavy. That meant that it would not have enough static stability when it was empty of fuel. Of course, at higher gross weights we could manage fuel distribution in the 15 tanks to get any static stability we wanted.

I had two options: **1**- add weight to the nose. **2**- add wingspan to the main wing, to move the neutral point aft.

Adding nose weight would reduce the aircraft's range. Adding main wingspan would increase the range - but make the frail wing even weaker.

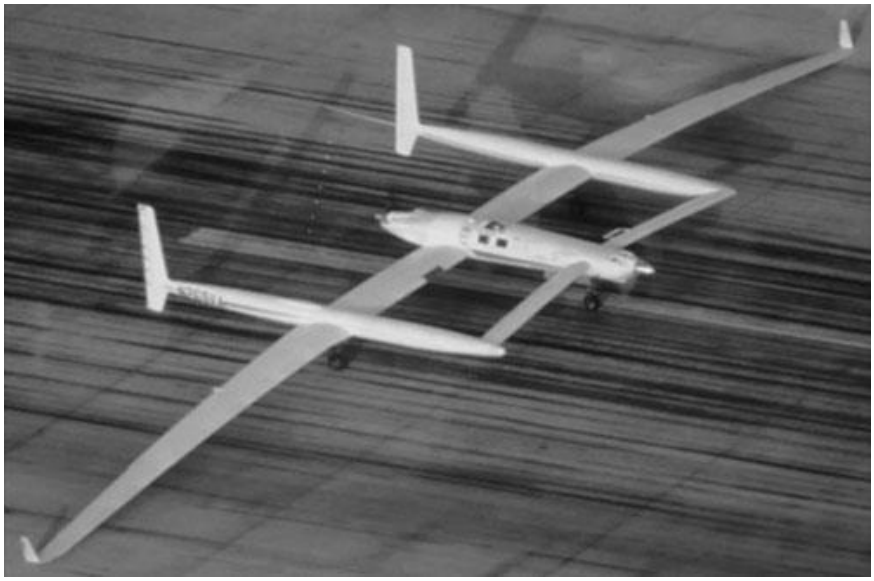
I chose option two, furthering the risk of wing failure, but increasing the chance of getting all the way around the world with some fuel remaining.

We were in a hurry, so I used a simple, homebuilders' method to increase the wingspan - just hot-wire the shape from 2 lb/cuft rigid Styrofoam and skin it with a single ply of bi-directional carbon fiber. This added about 3.5 feet to each wing - bringing the total span up to 110.8 ft.

I then built a winglet and routed the wing tank's vent tube to the top of the winglet. I knew that some fuel would dribble from the vent after fueling, when we lowered the wing from its supports just before takeoff, but that fuel loss would be tiny.

As it turned out, when the wings dragged on the runway because Dick could not see them and didn't want to rotate early, we would have dumped all the fuel in both tip tanks, during the 2-minute takeoff.

That choice to add a section of foam to fix the stability static margin, ended up being one of the reasons that Voyager achieved the Milestone!



Why not Just One Tank for the Outboard Wing?

It was not possible to have the outboard wing be just one tank. This is because near the start of the flight the outboard wing is bent upwards more than eight feet. That height causes a gravity pressure at the root that is enough to fail the bond of the sandwich skin to the ribs or to the spar - thus, a **catastrophic wing failure**.

Making Two Areas Act Like One Fuel Tank

The canard spars and wing spars would normally divide their tanks forward and aft. This was avoided by locally removing the core of the skin sandwich structure to vent the outboard/top and to connect the inboard/bottom. Thus, forward and aft fuel areas acted like a single tank.

Using the Tip Tank's Fuel

For fuel management, the Tip Tank is used last because having it full provides a lower response to turbulence when Voyager is light.

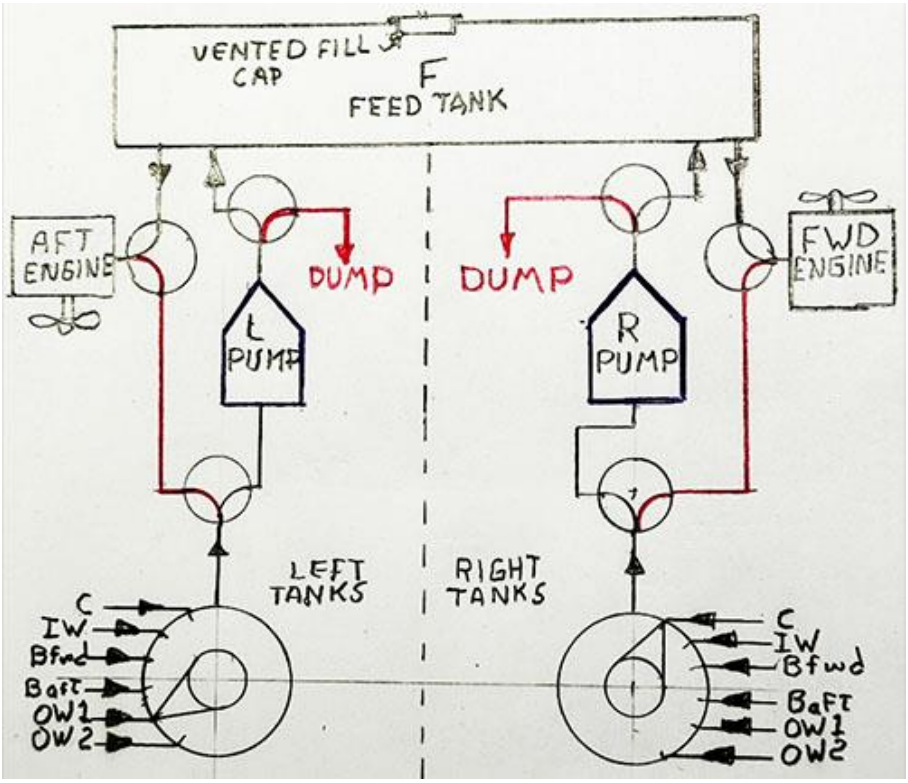
To use fuel from the Tip Tank, a solenoid valve is opened, allowing fuel to drain into OW 2. Then, OW 2 is selected and the tip tank fuel can be pumped to the feed tank. We used a 6-way valve to select which tank's fuel is pumped to the feed tank. We could not locate an 8-way valve. Thus, the need for the solenoid valve.

Fuel Plumbing in the Cabin

The diagram below shows the fuel plumbing in the cabin. All the fuel lines in the cabin are translucent so the crew can see the flowing fuel turn to air when it is being pump-transferred to the feed tank. Air in the line means that the selected tank is now empty.

There are two electric transfer pumps and two 6-way selector valves - one for the six left tanks and one for the six right tanks.

Dick was concerned about failure of the electrical pumps, so he added plumbing to allow him to draw engine fuel directly from any of the fourteen fuel tank without needing the electrical pumps or the feed tank. See the two valves in the red circuit. That method was used just once, near the end of the world flight, and it resulted in the airplane being an un-powered glider descending toward the ocean. See **Topic 8** for a description of that panic.



Inflight Dumping of Fuel

Why dump fuel? Anytime you cannot maintain your altitude (due to heavy weight with a failed engine, for example) you risk having an ocean ditching or a crash because you cannot make it to an adequate airport. By using your transfer pumps to pump fuel overboard, you can lower your weight to possibly avoid a crash with crew fatality. See red circuit titled DUMP in the above diagram.

This photo shows an emergency dump test by pumping the fuel overboard at the inboard wing's TE

It was best to keep the feed tank nearly full during the World Flight, because that allows at least a full day to select a suitable landing airport, in the event of an electrical failure that disables the transfer pumps.

Selecting which of the 14 Tanks to Fill the Feed Tank

When the crew needs to transfer fuel to the feed tank it is important that the transfer does not take the aircraft out of its acceptable fore-aft or left-right center-of-gravity positions.

The traditional method to determine in-flight cg is a calculation that considers the fuel weight and location of all 15 fuel tanks. However, instrumenting all 15 was not possible because of the tiny depth of some and the fact that the wing might be bent way up early in the flight. Also, if just one instrument failed, it would not be possible to calculate the aircraft's cg position.

We knew the actual weight of fuel in 14 of the tanks only when they were filled before takeoff or when they were empty (visible air seen in the line when pumping from them).

When transferring fuel to the feed tank, the crew needed to decide which of the 12 tanks to select. We devised a simple, reliable method that weighed almost nothing.

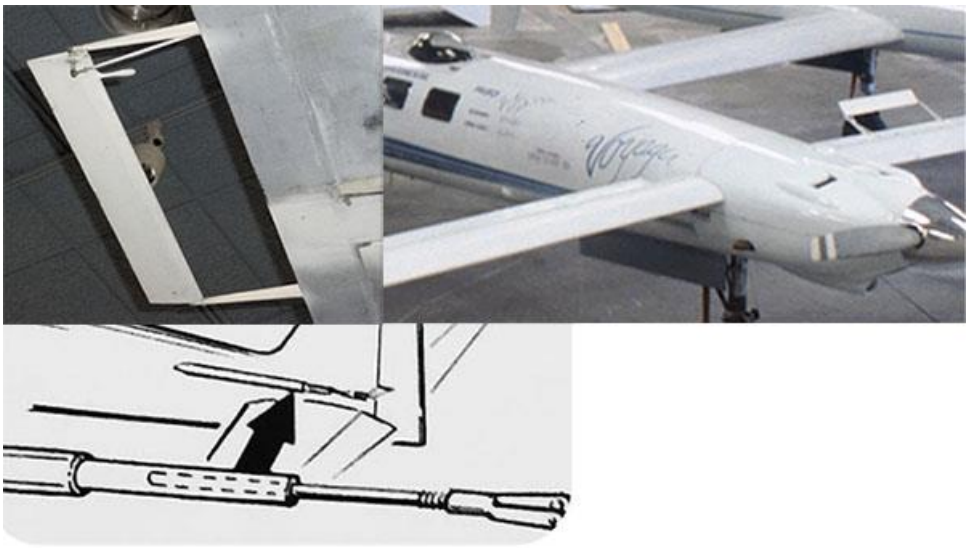
To do that, we measured the position of the control stick. If the average stick position was left of center, it was using left aileron to maintain bank angle. If so, they must remove fuel from any tank on the right. If the average stick position was aft of center, it was using the canard elevators to keep the nose from pitching down. If so, they must remove fuel from the front of the airplane (a canard tank or a forward boom tank).

That clever method was fool proof, weighed nothing and it did not require electrics of any kind.

Unusual Methods Used to Reduce Empty Weight

Lightweight Pitch Trim System

To emphasize the strict attention to light weight,
Voyager's pitch trim system is a tab on the left canard elevator,
adjusted via a model airplane plastic NyRod.

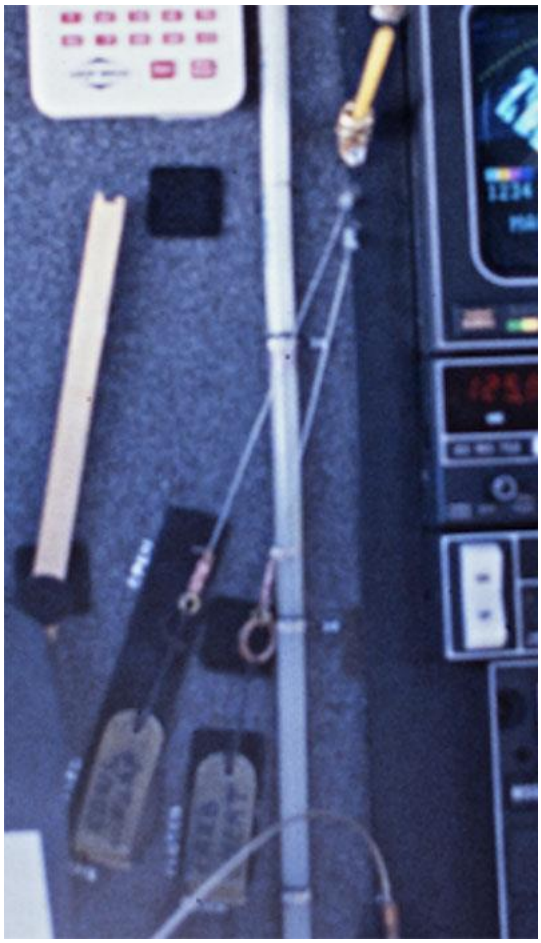


To trim up or down, the pilot directly pushes or pulls
the lightweight yellow NyRod.
That pushrod weighs only 0.006 lb per foot.

Lightweight Landing Gear Retraction System

Retracting and extending the three landing gears was done via 1/16” cables. The pilot retracts the nose-gear by pulling these two tabs, one marked up, the other marked down. To retract or extend a main gear for main gear door, Jeana used a small sailboat winch to pull on a 1/16” stainless steel cable. One cable for gear-up and another cable for gear-down.

This seems crazy, however if conventional hydraulic retraction systems were used, the world flight would not have reached the Milestone goal.



Lightweight Rudder Pedals

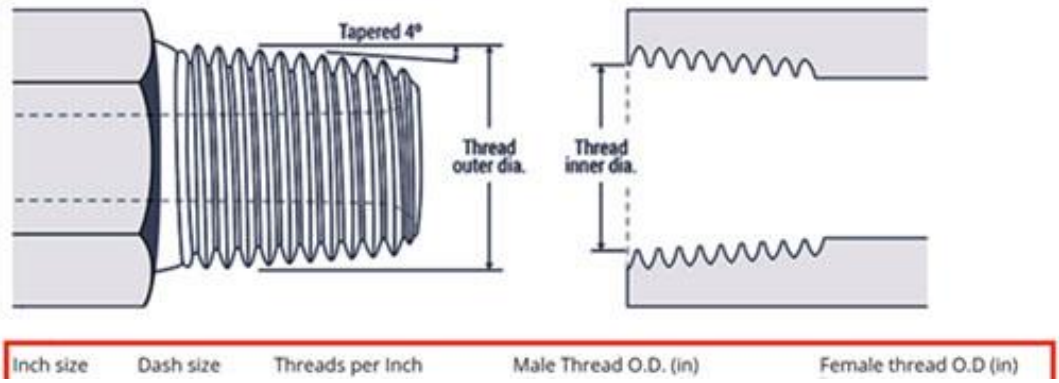
Rudder pedals are normally designed to not fail below a force of 500 pounds - a load that happens when a pilot panics and with strong legs, mashes both pedals at once.

However, the force needed to get full rudder deflection on the slow Voyager is only 18 pounds. So - the Voyager directional control is a “rudder-bar” that can fail at only 50 pounds - and the pilots knew to push just one side, to never push both.

Thus, the pedal system weighed only about 10% of the weight required for “normal” airplanes.

Super Light, Tiny Fuel Caps

The feed tank has a standard cap for fueling. The other 14 tank caps are 1/8 inch NPT nylon plugs. Thus, fueling had to be through a quarter inch diameter tube. That is why it took many hours to load fuel for the World Flight.



The nylon-plug fuel “caps” had an outside diameter of 0.405 inch. When screwed in, they were flush with the wing’s top skin surface. They were very light and were not vented.

A “Normal” Paint Job is too Heavy

Regarding finishing, Voyager had two requirements:

1- It had to be white on top to keep it cool enough when parked in the desert sun.

2- Its wing and canard contours had to support laminar flow to have enough range to achieve the Milestone.

We sprayed a light primer coat on surfaces back to ~ 65% chord where laminar flow was possible. We then added more primer as needed to allow contour corrections to keep the laminar flow from tripping to turbulent flow. Once we had a smooth-enough contour we then sprayed an extremely light coat of white paint to meet requirement 1. Thus, aft of 65% chord on the bottom it remained bare carbon fiber - no primer & no paint. Near the Trailing edge and on the ailerons, we used balsa wood and mylar - a model airplane technique.

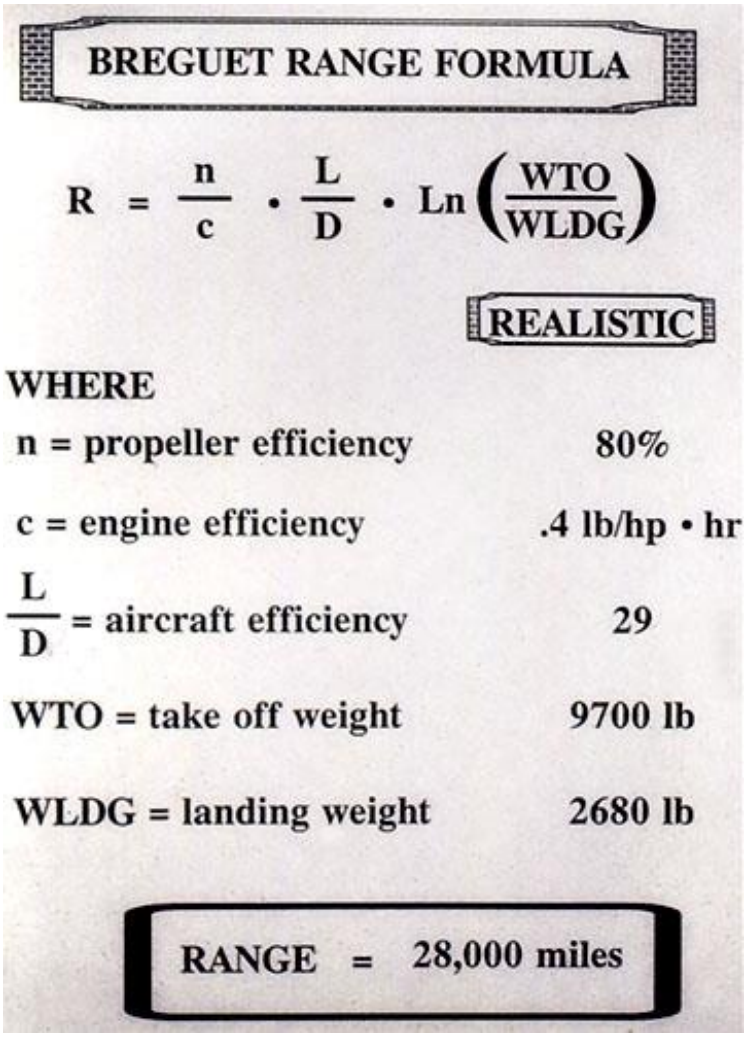
An Interesting Fact

If Voyager had been built to meet all the requirements of FAA Part 23 certification, it would have been out of fuel before it reached Africa!

Some Slides from My Presentations

The basic Breguet formula to calculate aircraft range. However, this simple equation does not consider real flight conditions.

Due to winds & weather, the altitude was often changing. Also, with engine staging the front engine is not as efficient as the aft engine. Initially, both engines are needed for level flight, then only the aft engine would be used when the weight is reduced.



Efficiency Data Measured
During the Phase-One and Phase-Two Test Programs

During the 1984 to 1986 test programs, to get the best prediction of the actual range capability, I plotted hundreds of data measurements on a NM-per-pound vs Gross-Weight plot. **The area under that curve is the total range in Nautical Miles**. Note that reducing a pound of empty weight gives 3.5 times the range of adding a pound of takeoff fuel.

The two plots below show the ideal shape of the NM/lb curve and the typical data measured during flight tests at 8,000 ft altitude. The assumption was that Voyager could climb to 8k feet on the first day running both engines and that 8k feet would be the average altitude for the entire flight.

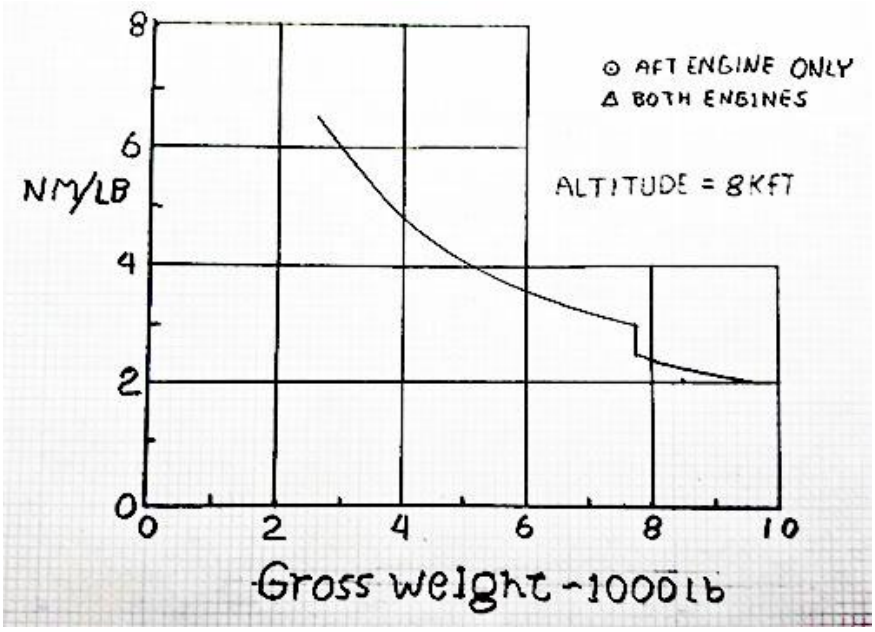
Most of the data was measured with the Phase-Two engines and propellors. Some of the data at the lower weights were measured with the original Phase-One Long-EZ engines and fixed-pitch wood propellers.

There was lots of data scatter, because a tiny amount of turbulence or rising air made large differences in the measured miles per pound. Most of the speed-power data was gathered at various altitudes over the San Joaquin Valley because the desert air is more turbulent.

To estimate the total range, I just ran a line through the middle of the scatter and **hoped** that would be enough to attain the Milestone.

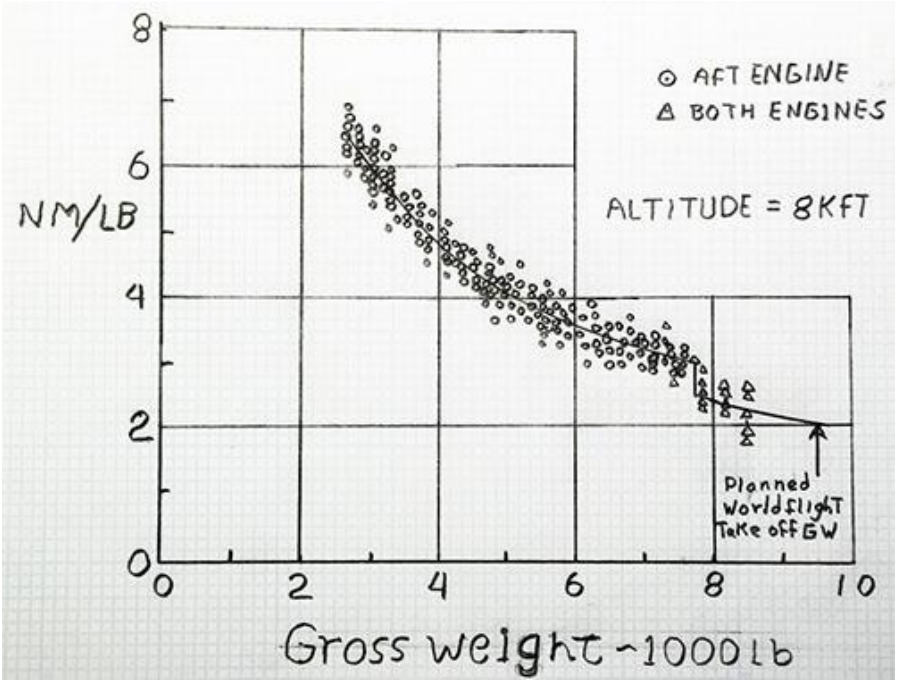
The basic shape of the fairing on the below graphic is based on the Breguet range equation, the jump being caused by the higher SFC when operating just the more-efficient aft, liquid-cooled engine.

Ideal Shape of the NM/lb Curve



Actual Flight Test Data

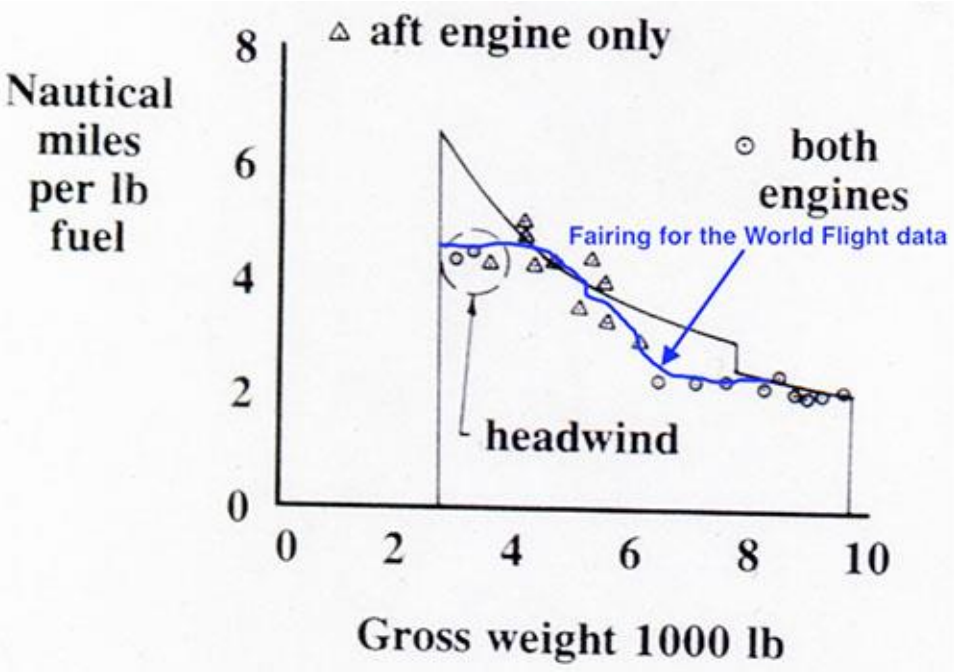
Note that the heaviest weight tested during the 1985 to 1986 flight testing was only 85% of the actual world flight. We considered the fuel load needed for world flight would result in a very dangerous takeoff, so we only wanted to risk it once.



Efficiency Data Measured During the World Flight

The plot below shows some actual data gathered during the World Flight.

The Bad News - the data show that as-flown, the Voyager could not make it around the world in still air - the area under the **blue** curve is not enough range to reach the Milestone.



Efficiency data during the world flight ranged from 2 NM per pound fuel during day one, up to ~ 5 NM per pound on day nine. That last day was flown with two engines operating, so the World Flight was never flown while getting the huge 6.6 NM/lb efficiency it had attained during earlier flight testing.

The plan was to not use the forward engine after the gross weight was reduced to about 7,500 pounds. However, due to the need to quickly climb to avoid bad weather, Dick restarted the front engine several times, once with a gross weight of only 6,800 pounds. He always tried his best to avoid bad weather at night.

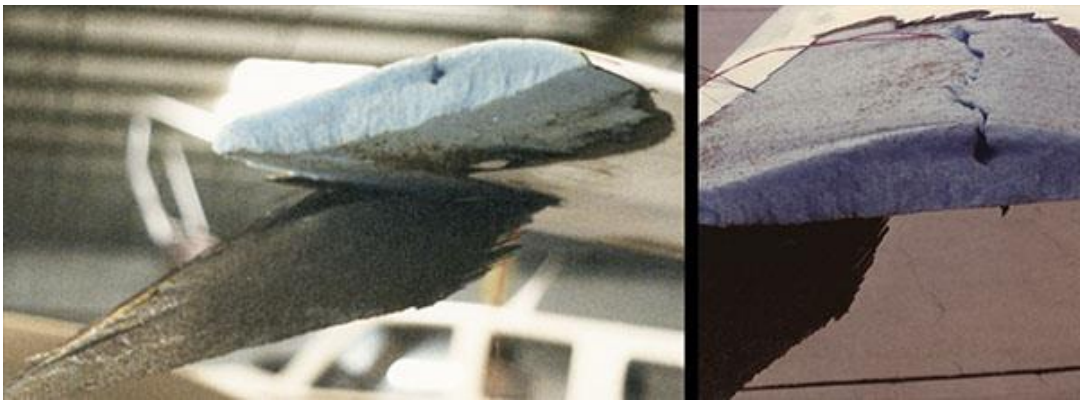
The Good News - the nine-day world flight experienced an average net tailwind, which was enough to achieve the Milestone despite the less than

optimum flight efficiency. The average airspeed for the flight was 101 knots and the **average tailwind was 8.5 knots**.

The range margin during the flight should have been 10%, right at my original design goal. However, the actual margin was reduced to just 2% by two things:

1- the aerodynamic drag of the rough, damaged wingtips from being dragged on the runway during takeoff. The photos below were taken after landing.

At the right wingtip - a single ply of Carbon Fiber flapped in the breeze for 9 days.



At the left wingtip - the vent tube and the nav-light wires were out in the breeze.

2- a very-slow fuel leak from the left tip wing tank. The crew could see a slight smear aft of the tip tank's small nylon cap/plug. It leaked about 18 gallons during about 7 flight days.

When Voyager landed at Edwards dry lake it had just enough usable fuel to fly to Seattle, if it were flown in still air at optimum speed on just the rear engine, at a very slow average true speed of about 55 knots. Of course, that would be a boring 13-hour task for a very fatigued crew!

Other Slides Used in My Technical Pitch

WORLD FLIGHT DATA

EDWARDS TAKE OFF 14 DEC 86

BRAKE RELEASE	7:59:38 PST
LIFTOFF	8:01:44 PST
GROSS WEIGHT	9694 lb
FUEL ON BOARD	7011 lb
WATER/FOOD	140 lb

EDWARDS LANDING 23 DEC 86

LANDING	8:05:28 PST
FLIGHT TIME	9 days, 3 min, 44 sec
GROSS WEIGHT	2699 lb
FUEL ON BOARD	106 lb
WATER/FOOD	40 lb

VARIATIONS FROM PLAN

WEATHER DEGRADED RANGE BY:

DIVERSIONS	–LONGER ROUTE
HIGH ALTITUDE	–MORE 2–ENGINE OPERATION
	–MORE CLIMBS, 7 FRONT ENGINE STARTS
	–HIGHER RPM REQUIRED
TURBULENCE	–PERFORMANCE LOSS
	–OFF OPTIMUM LEANING

THESE EFFECTS WERE ESSENTIALLY OFFSET BY

BETTER THAN EXPECTED TAILWINDS

FLIGHT TIME 8 HRS LESS THAN PREDICTION:

DUE TO HIGHER ALTITUDE THAN PLAN

FUEL

ON BOARD	1209 gal	(7011 lb)	100%
REMAINING	18.3 gal	(106 lb)	1.5%
LEAKED (LT TIP TANK)	18.8 gal	(109 lb)	1.6%
BURNED	1172 gal	(6796 lb)	97%
USED DUE DAMAGED WING TIPS (ESTIMATED)	19.8 gal	(115 lb)	1.6%

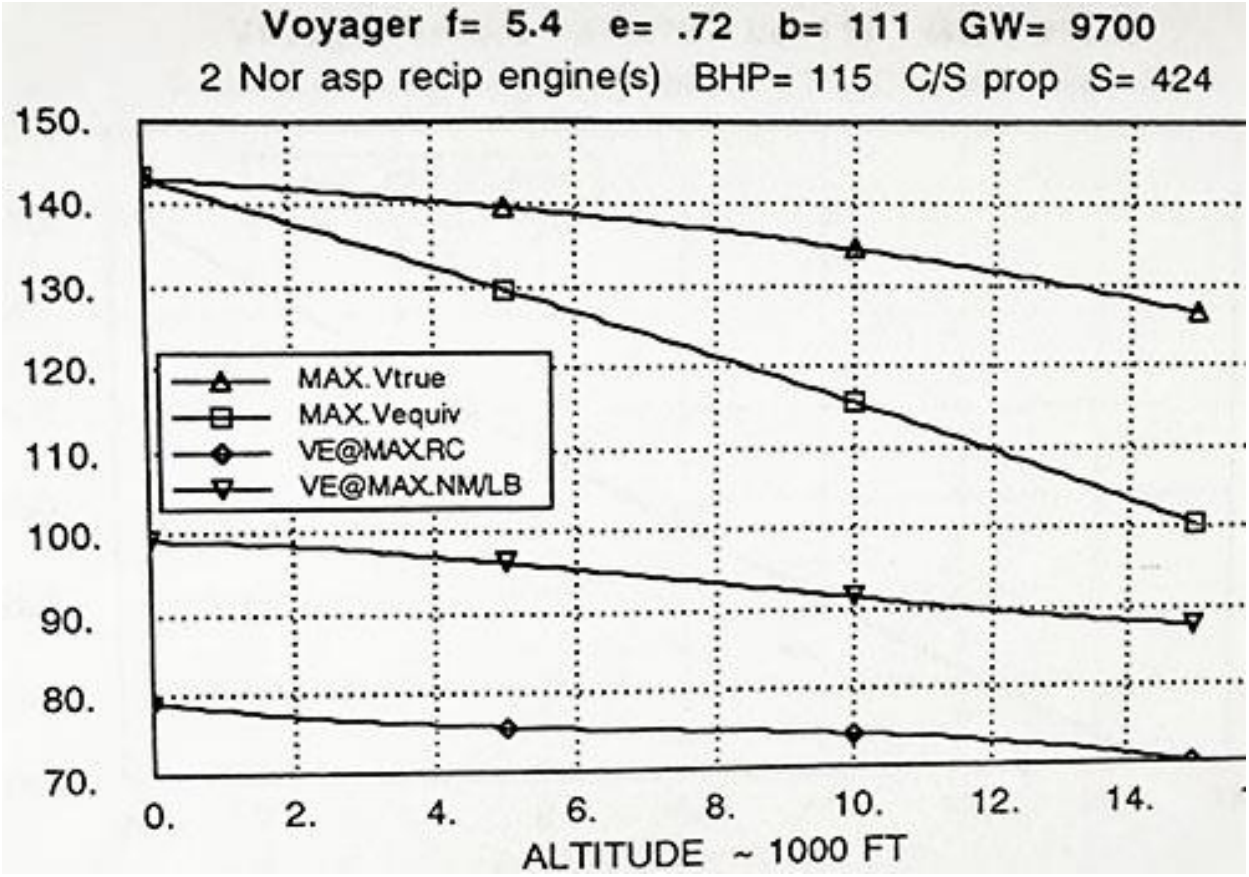
RANGE MARGINS (ZERO WIND)

			% of trip
WITH FUEL REMAINING	18.3 gal	850 miles	3.4
IF NO LEAK OR DAMAGE	56.9 gal	2540 miles	10.2

DISTANCES – STATUTE MILES

MINIMUM OFFICIAL WORLD FLIGHT	22,859 mi	100%
GREAT CIRCLE, FOUR POINTS	25,012 mi	109%
FLIGHT LOG, 36 POINTS	26,178 mi	115%
GROUND TRACK, INCL DIVERSIONS	26,700 mi	117%

After the flight, I re-ran my PerfCalc computer program using the actual weight of takeoff, to see the predicted altitude performance. The scale on the left is knots.



The following is a 2002 essay that was included along with the enshrine portrait for the National Aviation Hall of Fame in the book “Aviation: A Century of Triumph.” This essay includes some technical data not shown above.

Burt Rutan, May 2002
Voyager: Small Team, Giant Challenge

Since 1972 when I left my government job testing U.S. Air Force aircraft, I have had the privilege to work with small groups in a true entrepreneurial environment to develop and test over thirty new aircraft types. Of these, the Voyager was the most rewarding since the challenge involved the globe-circling, non-refueled milestone and the tiny development team was free to make its own rules. We had to develop an aircraft that could double the world's distance record and we had very limited resources. Our original plan was to obtain funding from a major sponsor and to contract out much of the aircraft's fabrication. When we failed to find a sponsor, we decided to structure a two-phase development program. The first phase, managed by Rutan Aircraft Factory, my homebuilt aircraft company, developed the basic Voyager design and got the prototype into initial flight test. The phase one team was only a few people, including the flight crew, and they worked quickly in secret. The second phase, managed by my brother's company Voyager Aircraft Inc., was responsible for getting the aircraft equipped for long-range flight, testing the refined systems and flying the records. This team, including volunteers, was larger and addressed the many complex disciplines of navigation (in a pre-GPS era), world communication and weather planning. Both phases were financially possible because manufacturers and material suppliers eagerly agreed to donate their products.

For me as a designer, the most rewarding aspect of the Voyager program was the difficult technical challenge. I knew the required range was possible, but it was only achievable by applying our very best efforts. The range of an aircraft is determined by three basic criteria: its propulsion efficiency, its weight and its aerodynamic efficiency. I had to make major improvements in one or more of these areas in order to build an aircraft that could fly more than twice as far as any previous flight. To maximize propulsion efficiency, I used engine staging: after the first several days of the trip one engine was shut down so the remaining engine could then operate at a higher, more efficient power setting. This cruise engine was a new water-cooled Continental with 7% better efficiency than the usual light aircraft engine. The primary reason

we were able to double the old record was our success in weight control. By using a new, unusual configuration we could place a large amount of fuel at three span-wise locations: the fuselage and two large booms at 30% of the distance out to the wingtips. A very light main wing and canard wing provided just the amount of structural support for this large fuel mass. The two wings supported the fuel-laden booms via their bending stiffness without depending on the torsional stiffness of a single slender wing. This was Voyager's secret to success. Its graphite composite structure weighed only nine percent of the takeoff weight. The fuel consisted of 73% of the takeoff weight. This phenomenal weight performance was the main reason we were able to achieve a range in excess of 25,000 statue miles.

Regarding aerodynamic efficiency, I was unable to achieve a result as high as a typical sailplane since I was forced to use the unusual configuration and I had to accept the drag of an inoperative engine. The lift-to-drag ratio of approximately 32 was achieved by careful shaping of the wings for laminar flow, avoiding drag-producing protuberances, and careful design of the engine cooling air paths.

The basic specification for the Voyager was changed after the aircraft began its early flight tests in 1984. Originally it was to have more powerful air-cooled engines and was to weigh nearly 11,000 pounds at takeoff, 80% of that being fuel. After we encountered serious undamped structural oscillations in flight at weights above 7000 pounds, I decided to limit the maximum weight to approximately 9500 pounds and to incorporate the more-efficient, newly developed water-cooled engine.

The aircraft's structural dynamics were risky at the weights we would see during the first two days of the world flight. Merely flying level required a difficult pilot technique or an autopilot with a carefully selected gain.

How Risky?

The risks we were taking for Voyager's launch on the early morning of December 14, 1986 were high indeed. The aircraft, loaded to a takeoff gross weight of 9700 pounds, was 15% heavier than it had ever flown. This higher weight would nearly double the runway required for its

previous heaviest flight. The structural dynamics were expected to be very bad, maybe even uncontrollable.

The crew had been exhausted before from flying the Voyager in turbulence for only a few hours. Now they were to head off over the Pacific with its equatorial storms, and to not land again for more than nine or ten days. In its 2-year test program of 64 flights totaling 349 hours, the Voyager had experienced many systems failures. Several of these resulted in an inability to maintain altitude, thus forcing an emergency landing. The flight plan for the world flight was for 225 hours, the vast majority of it over the world's oceans. Most of the time they would be positioned many hours from the nearest airport.

Looking back now at these risks, it is easy to conclude that we should not have attempted the flight. However, in late 1986 we were filled with adrenaline even though exhausted after a five-year research and development program and were thinking of little else except the chance to reach the goal. Today, recalling our activities from the concept layout in early 1981 to the world flight in late 1986, the hard part was not the design but the details of building and flight testing a large, fragile, complex aircraft. The job proved to be much more difficult than any of us predicted. That six-year effort involved long hours of hard work from a small group, motivated only by the excitement of someday achieving a historically significant aviation milestone. Our close-knit group operated in an environment that allowed us to revise the ground rules and quickly decide to accept any new risk. This, more than any other factor was the key to Voyager's success and is the reason that significant new breakthroughs are rarely seen in typical research and development programs.

SOME PERSONAL STORIES, IN TOPIC 1

The Quilt

In the hospital, son Jeff holds up the ‘Quilt-of-Valor’ so Dick can review his accomplishments. This photo was taken on May 2nd, 2024 - 26 hours before Dick died of an incurable lung disease. He was 85 years old.

With the hopes of raising money, in July 1984, Dick and Jeana flew the Voyager on its 5th flight, from Mojave to the Oshkosh Air Venture event in Wisconsin. In an airplane in which they planned to fly around the world, they were unable to make the 1,688-mile flight due to pilot fatigue. They landed short in Salina Kansas.

The U.S. Continental Divide is higher than any obstacle on the World Flight’s planned route. The aircraft had a light fuel load, which increased the effects of turbulence. Also, the cabin did not then have adequate ventilation. Here is a report, written by Dick, on what happened just after a horrific night-crossing of the Rocky Mountains:

“It took every ounce of will power to reduce both engines to idle and ease the stick forward. My fears of rough air were not unfounded for the next 40 minutes as we let down the Voyager. We were barely hanging on to the ragged edge of control. I felt the wings go through massive deflection as the up down drafts of a hot summer night on the Kansas prairie engulfed the airplane. I didn't have the courage to look and see what was going on with the wings. I just tried to keep the speed under control to minimize the G loads. I watched Jeana hold on as best she could without a seat harness or safety belt. The turbulence slammed her hard onto the floor and then flung her up against the ceiling.

Somehow, I got the aircraft down on Salina's runway and taxed it into a Hangar. I was absolutely spent.

How in the world could we ever fly this thing around the world? I couldn't have been more discouraged. I wanted no more of flying. I felt like punching a hole in the fuel tank, setting Voyager on fire, using my pilots license as a wick and taking a train home. I couldn't imagine ever getting back into that machine and subjecting myself to such anxiety again."

After a good night’s sleep, Dick and Jeana felt better and took off for Oshkosh. On arrival, they had to orbit high over the airport for 2 hours because the airshow planners wanted Voyager to arrive as the airshow's final act.

A Crazy Way to Steer the Voyager while on the Runway

The initial nose gear steering system was expected to be marginal. So, during the early flight tests, Mike and I devised and tested a way to keep Voyager on the runway. This was a heavy test flight- note the low wingtip clearance.

Mike drives the motorcycle while I drop the pole onto the wing near the tip. I hold the pole steady while Mike throttles the bike to steer. We found it easy to control the taxi direction! Mike is an excellent motorcyclist, as a teenager he rode one from South Africa to northern Europe.

After some tweaking on the nose-gear steering system, we never used the motorcycle for this again.

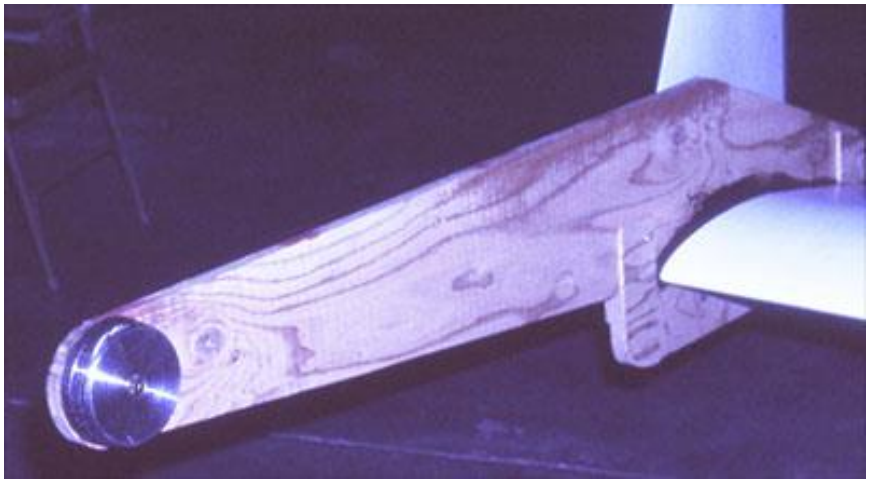
“Controllable Flutter”

The low-frequency pitch dynamics that diverged rather than dampened on the voyager when it had a heavy fuel load, was not recognized as flutter at the time. However, in studying it, I have concluded it was **classic flutter**, just at a low-enough frequency that “Velvet Arm” brother Dick could get in the loop and stop the divergence. The autopilot could also damp the divergence when its flight-adjustable gain was set correctly.

With conventional airplanes, flutter is usually **catastrophic, destroying the structure**. Compared to Voyager, they fly faster and have much stiffer wings, so **flutter diverges faster than a pilot or an autopilot can damp it**.

A Temporary Fix

During the Voyager test program, I designed, built and installed a temporary flutter fix for Voyager - a forward mass at the wingtip, just inboard of the winglet.



The temporary fix was designed to eliminate the flutter and allow the ‘non-velvet-arm’ copilot Jeana to control the voyager at its heavy weights.

If it eliminated the flutter, I planned to replace it with a forward blister that held fuel, increasing the fuel weight. Thus, it would increase range, not decrease it.

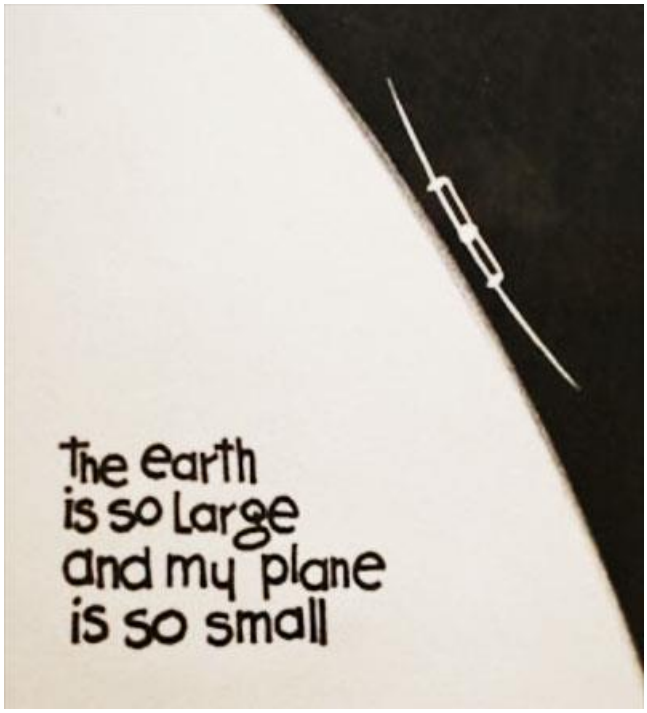
Unfortunately, during Phase-Two, Dick had the authority to change anything, even technical recommendations from his “kid brother designer.” Dick did not flight-test it. He called it ugly and he removed it while I was not looking and threw it in the trash.

Why Jeana was not Trained to Fly the Voyager when it was Heavy

Dick and Jenna were not getting along at the time that the heavy flight tests were flown. So - Dick was not that interested in things that might make her a competent pilot, rather than just someone that would monitor the autopilot while he was sleeping…

Dick decided that it was OK that his copilot was unable to control the Voyager when it was heavy. He recalled that he had earlier flown a distance record in my Long-EZ - solo for 34 hours without an autopilot where he would likely die if he fell asleep. Hey - if Lindbergh could fly solo for that duration on his New York-to-Paris flight in 1927, then the Velvet-Arm could also do it. Dick believed in the power of adrenaline!

A Conrad cartoon published
in the Los Angeles Times newspaper during the world flight.



The Actual World Flight Takeoff as Seen by Mike, Sally and Me
in the chase Duchess aircraft.

Voyager takeoff video that details the risks:

Voyager Takeoff from Duchess Video

The Goodbye Over the Pacific - Dec 14, 1986

After chasing the world flight takeoff, Mike, Sally and I flew formation with Voyager in the Beech Duchess for 2 hours as it slowly climbed over the Pacific Ocean, heading west toward Hawaii. We then spent a few emotional minutes chatting before waving goodbye.

Waving Goodbye at the Second Hour
Mike, Sally and Me in Duchess

After turning back toward California, we discussed the possibility that our goodbye might be the last time that any human saw Dick and Jeana alive. This was before GPS, so quickly finding a ditched aircraft in the ocean might be impossible. The program had no $ for aircraft to chase the world flight - so we were forced to take the huge risk of an ocean recovery. A heavy ocean landing or off-runway landing would likely be fatal.

Sightings During the World Flight

Except for takeoff and landing, there were very few visual sightings during the world flight:

The First was in darkness near Hawaii.

Second was on night four when the strobe light was seen by Bruce Evans from a control tower as it passed over Thailand. Bruce was able to talk to Dick and Jeana on VHF frequency for more than an hour.

The Third was in daylight on day 5 by Scaled's Doug Shane in a rented Beech Baron over Kenya Africa. That join-up included a scary departure from controlled flight by the Baron when it slowed to match the Voyager's low airspeed.

Doug Shane is the only person who watched all these three things: The December 14th Edwards AFB takeoff, a real daytime encounter during the flight and the December 23rd landing on the Edwards dry lakebed.

A Special Secret Video

The day before the Milestone flight takeoff, Dick and Jeana, went alone to a taxiway and setup a tripod and video camera, to record a message that was to be shown to others **ONLY** if they perished on the flight.

I never saw the video - but was told that their message was that the fault of their deaths was solely their own and that no one should ever blame others - no one should ever file a wrongful-death lawsuit.

A "Casualty" of a Mission Control Volunteer

Brent Silver is a very talented engineer who spent more than 18 hours a day in Mission Control during the world flight, helping to analyze the data and making predictions on whether Voyager would make it around the world. He was so exhausted from the lack of sleep that, at home, two days after landing he slept all Christmas Day - missing the holiday with his family. He later told me that his wife was so enraged that she divorced him.

A Personal Note from Bruce Evans to Peter Riva

This hand-written note was written on Christmas Day 1986, two days after Voyager landed on the Milestone flight. Note that it tells Riva "Please

destroy this note it is meant for your eyes only……Shredding or burning will do nicely thank you."

Now, 39 years later, in February 2026, Bruce shared the note with me. I called him, begging him to let me publish it in Chapter 29 because it fits nicely with the BRAB policy of sharing interesting Personal Stories. Bruce gave me permission to publish it, so now you can enjoy reading about some personal emotions of the Voyager program.

Chap29-BruceAfterFlight.pdf

Voyager's Propeller Failure

An article about the prop failure during the 1986 flight testing phase was published by RAF in its "Canard Pusher" newsletter. Here is a portion of that text.

A Horrendous Propeller Failure

As most of you will know by now, the Voyager has suffered a serious setback in its schedule. Things were going very well. A full dress rehearsal for world flight take-off was successfully flown out of Edwards Air Force Base at the heaviest weight flown to date. This flight brought out a few points that required one or two more engineering test flights before a world flight could be attempted.

During one of these flights, while flying level at 9,000 feet, one blade of the front engine's propeller separated from the hub. The ensuing vibration was so intense that several instruments came out of the panel and the rear engine's spinner thrashed enough to run into the cowling. The front engine mount broke in two places - and every mount tube was bent. Fortunately, the engine remained on the airplane. Both engines had safety cables attaching them to the firewalls.

Dick's biggest problem was determining which engine was in trouble. Obviously, he did not want to shut down the wrong engine! The chase plane was able to identify it for him - and he then caged the front engine, declared an emergency with Edwards and made a safe landing on their runway 04.

The Voyager was flown, single-engine, back to Mojave the next morning after substituting a good old reliable B and T wood prop for the variable pitch prop on the rear engine. The front prop, which had failed, was removed and sent away for inspection and evaluation. The manufacturer, as well as the prop shop that did the postmortem, think that some prop rework that had been done by the Voyager team in an effort to improve performance, may have contributed to the failure. It is also possible that the drying of the wood in the desert environment resulted in the loss of shank retention. We adjust for this with our fixed-pitch, wood props by routinely retorquing the bolts. Retorquing is not available on any variable pitch wood propeller.

The Voyager team removed both engines. Beech provided transportation to Mobile, Alabama where Teledyne Continental began an immediate teardown/inspection and complete rebuild. Hartzell Propellers agreed to build up two special props using the latest John Roncz airfoil section blades. Bruce Evans and his team commenced to build a new front engine mount and to repair and modify cowlings to fit the new prop/spinners. Incredibly, this dynamic group will probably fly their next test flight by the end of October 1986. An unbelievable feat in the face of overwhelming disappointment. The support that we have received from Continental, Hartzell and Beech was amazing.

One year after the Milestone flight, Voyager was displayed in the Washington DC Smithsonian Mall Air & Space Museum - the most-visited museum in the world. That event included several other parties. The text

below is how it was reported in the RAF “Canard Pusher” newsletter, issue number 54, January 1988.

Voyager is now on display in the National Air & Space Museum, Washington DC - December 14, 1987

Almost all the Voyager volunteers were there - it was a great time of remembrance - the Voyager looks magnificent, her wing tips ground away and tattered, just as they were when she landed. She hangs in the entrance within a few short feet of the original Wright flyer, the X-1 and the X-15. Lindberg's Ryan is close, too. A fitting place for the Voyager and a tribute to her brave crew and to the volunteers and VIP's who helped her do it.

On the morning of December 14, 1987, exactly one year after that exciting early morning takeoff at Edwards, Jeana and Dick hosted a breakfast for several hundred of the VIPs at the Grand Hyatt not far from the museum. A moment we will all remember for a long time was when Dick called for silence at exactly 8:00 am, Mojave time. Then he described the takeoff roll, from brake release to lift-off, an unbelievable 2 minutes. Sitting on comfortable chairs in the hotel, it was hard to imagine what it must have felt like to roll for that long before lift-off. The wing tips dragging, the radio calls from the chase and ground control - quite a moment, quite a thrill. Jeana, Dick and Burt, as well as Mom and Pop Rutan, said a few words. A very special breakfast - we were glad to be there.

That evening, Teledyne Continental hosted a party right under the Voyager in the National Air and Space Museum for about 500 people. Mostly Voyager volunteers, VIP's (Voyager's Impressive People) and sponsors of the Smithsonian Institute. A band played. The champagne flowed, delicious treats were passed out, and everyone had a ball. The Voyager display, including a video of the whole thing from beginning to end, it’s really fine and well worth a visit if you find yourself in D.C.

After the official opening of the Voyager display at NASM, we got taxis in the rain and returned to the Grand Hyatt. There we had a grand "family" dinner. It really was a great time - a chance to meet with friends

we had made during the record-setting flight. We would not have missed it for the world."

I found it difficult to communicate with Jeana for most of the Voyager program. Her interfaces with me seemed strained. She was silent and stoic. So, when I needed to do something for the Voyager program I always worked with only Dick, never Jeana. An example - one time Jeana asked to talk privately with RAF to discuss "things she was unhappy with." Mike, Sally and I sat down with her at a table at the RAF office. Jeana placed a tape recorder on the table - I thought "this is good, we'll have a recording of our discussions." However, she simply pushed 'Play', turned around and left the room. She never returned. It was weird to be forced to listen to her rant without the ability to respond or to discuss anything with her. From then on, I avoided her.

Topic 2 • THE GENESIS OF THE VOYAGER PROGRAM

In early 1981, when Dick left his employment at Rutan Aircraft Factory, he and his girlfriend Jeana Yeager requested a lunch meeting with me at the Overpass Restaurant, just south of Mojave. They requested that I design a special aircraft for them that they would call the Monarch. They wanted to develop an aerobatic homebuilt. They would start a new business to market it and needed my design talents to design it.

I refused, saying that I had decided that RAF would never market an aircraft for aerobatics, because aerobatic aircraft had an accident rate many times more than non-aerobatic aircraft. I explained the reason the VariViggen, VariEze and Long-EZ were not approved for aerobatic flight — that would result in a larger number of RAF lawsuits. RAF's main business risk was to lose a multi-million dollar lawsuit which would bankrupt the company and even cause the loss of my personal property.

Rather than leaving nothing for Dick & Jeana, I drew a sketch of a much more interesting option - the Model 76, an aircraft that could perform the last aviation **Milestone** left for atmospheric flight- a flight around the world without refueling.

Dick and Jeana then abandoned the Monarch plan. They were instantly hooked on achieving the big **Milestone**, and for the next six years, worked exclusively on that goal.

The First Design Sketches

After quitting my job at Bede in 1974 when I founded RAF, I had been doing a preliminary design for an aircraft that might have a chance to achieve non-refueled world flight. Unlike some stories written about Voyager, the aircraft I drew at the Overpass Restaurant, was NOT the original preliminary design, it was merely a sketch to show Dick and Jeana what I had been concept-designing for the last seven years.

Others That Attempted Non-Refueled World Flight

The First was Jim Bede (Chapter 18) in 1968 with his BD-2, a modified, powered sailplane. He had never flown an airplane over any ocean. He took off, headed over the ocean and returned, claiming failure of his navigation system. I believe he knew that his aircraft did not have the range to accomplish the Milestone.

The Second was Tom Jewett, who I had hired as a design engineer in 1973 when he was Bede's Director of Development. Tom's airplane, named "Big Bird" was also a modified powered sailplane. On a test flight in Mojave in the 1980s, Big Bird crashed. The fuselage broke apart at the cockpit while turning to final landing approach, killing Tom. Dick was jogging in the desert and witnessed the fatal accident.

I explained to Dick and Jeana that the Big Bird structure failed due to a stupid mistake. The fuselage structural composite plies had been sanded away in the finishing process. Thus, the death of Tom should not affect their focus on achieving the Milestone.

Unveiling the Voyager Project

Published in the Rutan Aircraft Factory Canard Pusher Newsletter #34, October 1982

RAF has agreed to join with Burt's brother Dick and his girlfriend, Jeana to build a very special airplane. This will be an interesting project, due to its use of the very latest state-of-the-art technology. Voyager will be built at RAF and should be flying in the summer of 1983.

"RAF's Secret Back-Room project."

The existing absolute non-refueled distance record for aircraft was set over 24 years ago with a B-52 at a distance of about halfway around the world. Since the advent of high-performance advanced composite materials, the goal of global non-refueled flight has been within reach. A global non-refueled flight has been called the last remaining major milestone for aviation's history.

In 1981 Burt designed a rather remarkable aircraft with a specific mission - flight around the world without refueling. The model 76 Voyager was optimized for long range and intended to shatter (even double) existing distance records.

Dick Rutan and Jeana Yeager then formed Voyager Aircraft Inc. (VAI) and planned to get this aircraft built and to achieve the goals of setting new distance records and to attempt the Round-the-World, Non-Refueled Flight.

In mid 1982, VAI and RAF agreed to a team plan where RAF and Burt would design, build and flight test the aircraft to prove its structure, flying qualities and range-performance. VAI would then equip it with special engines and props - and the navigation systems required - and conduct the record flights.

After two years work by a very small team, an awesome aircraft will emerge. Its fabrication is being done by some very hard work by a few dedicated people. RAF contracted Bruce Evans, an early VariEze builder/flyer. He has virtually lived with the project working continuous

long hours on everything from tooling to structure and systems. Jeana and Dick have also made a full-time commitment to the building process. Wedged in with the Solitaire development, the Voyager has been a primary task for all the people at RAF. Chuck Richey, a Scaled engineer and VariEze builder/flyer did the detail design work for the landing gear system.

Its prepreg carbon fiber tape/Nomex honeycomb sandwich structure required us to build a special, large oven for vacuum-bagged, 250-degree cure skins. Bruce and Dick travelled to Utah to use Hercules autoclaves to cure the carbon spars for the immense 100 foot plus wing.

The team was assisted by donations of materials and tooling help from Hercules, Aircraft Spruce, Wicks, Brock, Task Research, American Cyanamid and Hexcel. Ken Brock's donation included fabrication of the high-efficiency oleo landing gear assemblies. These units are works of art. They weigh only a couple dozen pounds each but will support an aircraft weighing as much as a business turboprop aircraft. Bruce Tifft has donated the interim propellers for the initial flight tests.

The Voyager is an imposing sight. Though designed to fly slow, its fuselage aerodynamically resembles a high speed racing aircraft. Like spacecraft, its structure is highly refined and optimized to support fuel weighing over 10 times the airframe structural weight.

Watch for announcements and photos in the aviation press, probably before Oshkosh next year. Its unusual design philosophy and details will be a guarded secret until next summer. This is being done to assure this last-coveted Milestone in aviation will be owned not just by Americans, but by grassroots "homebuilders."

Topic 3 • INITIAL PLAN & D/J-PROPOSED CONTRACT

Soon after the Overpass Restaurant lunch meeting, Dick and Jeana presented me with a detailed four-page contract proposal.

Chap29-OrigionalVAIContract.pdf

I do not know who wrote this proposed contract. It was formatted much like something written by lawyers. Note that it was not a contract with RAF. It was an agreement between two entities:

1- Dick Rutan & Jeana Farrar (Yeager) via their new company named "Voyager Inc."

2- Burt Rutan, an "independent individual aeronautical engineering consultant."

Dick and Jeana's "Voyager Inc." plan was to get sponsors to invest up to 2 million dollars, then they would form a new entrepreneurial company, with them being President and Vice President. Their dream was to own a new company, i.e. to do what the "kid-brother" had been successfully doing since 1974.

Of course, they needed me to design the Milestone airplane, then they would hire several companies to build structural components - maybe one to build wings and another to build the fuselage and the booms, plus a third to build systems like landing gear, navigation/avionics, etc. They incorrectly reasoned that by having multiple remote companies working, the airplane would get built sooner!

Their plan was to do final assembly and flight testing by themselves at Mojave, so that my advice could be available without me having to travel.

I initially **refused to sign** their proposed contract, since it gave them exclusivity of any world flight activities with no specific time limit. It had initial schedules for my completion of tasks that were not realistic: "one week, 30-days and so as not to delay progress."

Also, I was working 60+ hours a week at RAF on two new critical projects - planning Scaled, my second entrepreneurial business - and doing preliminary designs for the Beechcraft NGBA (Next-Generation Business Aircraft) later to be called "Starship One."

My initial refusal caused a heated "brother-vs-brother" argument. Dick's argument was that he was totally changing his goal - he would not compete with RAF with his homebuilt aerobatic airplane program.

However, his proposed contract gave me only 3.5% of all the initial sponsor money they raised ($35k for each $ million they raised). They also were to

later pay me 5% of all their future Voyager-related income (Merchandise, books, movies, paid talks, etc.).

Five % is a similar amount generally paid for just non-exclusive use of Patents. However, per their proposed contract, they did not need to pay me for the years of my work to support the fabrication, flight testing and other engineering tasks that would require my support to achieve the Milestone's goal.

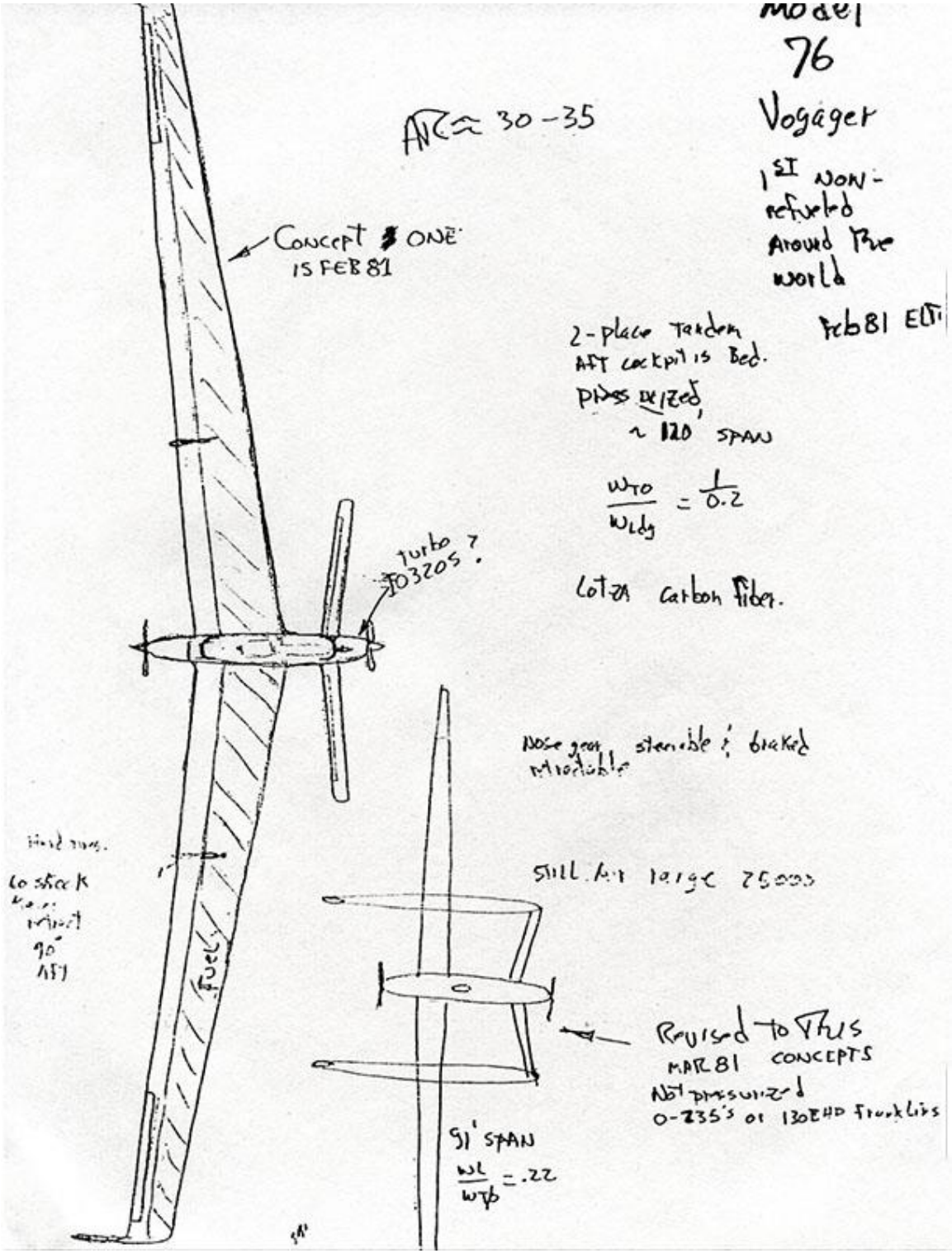
I knew that Dick would not respond softly if his "kid-brother" outright criticized his business skills and lack of management experience. However, inside I was thinking that he would have trouble running this complex program.

A huge brother-to-brother argument is the stuff that can split entire families. That was unacceptable to me, so I signed their original contract on February 24th, 1981. At the time, because of their lack of experience, I was skeptical that they would be successful at managing this huge, complex project.

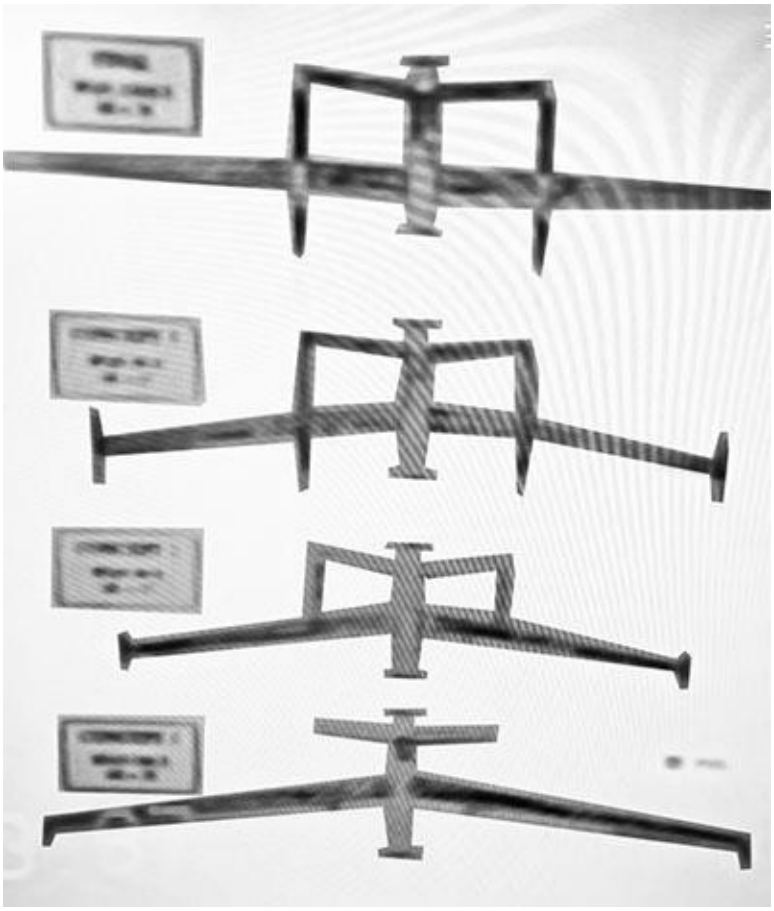
The "kid brother" Me and the Vietnam Hero Dick.
Christmas, 1983 at Pop's Big Bear Lake Cabin.
In 1983 I was 40 and Dick was 45.

I quickly completed the contract task 2.1 (which I had actually done in secrecy in 1974) and I drew the top-view sketch below for Dick and Jeana at a second Overpass Restaurant lunch. The "revised" part of the sketch was added later.

Configuration at Voyager-Inc contract, then a month later.
Final wingspan is 111-foot, not the 91-foot shown.



My Voyager Inc. Contract Task 2.1 & 2.2.
Progression from the Feb 1981 concept
to the final design configuration a month later.



Topic 4 • FAILED EFFORT TO GET MONEY, VAI BROKE

Armed with the Burt-signed, initial Topic 3 design contract, Dick and Jeana set off to raise funding for their big dream: a new, independent entrepreneurial business based on achieving the last remaining Milestone in atmospheric flight. They were estimating that they would need at least one million dollars, maybe two. They hoped the Milestone flight would be flown in 1983 or 1984.

They quickly found that raising million-dollar-sponsors was very difficult. They did get two firm offers to fund the project:

1. From a cigarette company. Dick turned this one down, due to his hatred of smoking.

2. From Caesars Palace resort in Las Vegas. This one required the World flight to take off and land in the hotel's parking lot and the takeoff must be done on a specific date in 8 months, during their planned promotional event!

During the time that Dick and Jeana searched for a big $ sponsor there were several times when a large company's management decided that it would be a good marketing idea to provide the needed funding and to get their logo prominently displayed on the Voyager aircraft. They envisioned the benefits of their participation in this historic Milestone. However, when their company lawyers were asked, they had a totally negative vision. They reasoned that the last photo taken of Voyager would likely be just before it sank into an ocean. Then, the only thing recognizable would be their company's logo painted on the tail as it sank into the sea.

A lesson learned - large company important decisions are actually made by the lawyers - not by the tough decisions of top management.

By mid 1982, Dick and Jeana had failed to get their requested million dollar sponsor money. They had spent all their savings. They were broke - and thus had no way to accomplish their dream of owning a new independent entrepreneurial Voyager-related business.

They needed money while the "kid brother" did not. This observation continued to result in an adversarial relationship. One that would continue into the future.

Topic 5 • RAF RESCUE - FAB STARTS, NEW CONTRACT

I recognized that a successful Round-The-World Non-Refueled Milestone accomplishment would be an important personal Legacy item for myself, as well as for Dick and Jeana.

So, on June 2nd, 1982, I made a proposal to Dick & Jeana for a totally different type of program - one that would start building the Voyager

prototype immediately and one that would require no money from Dick & Jeana during the initial phase of development.

Terms of the Rescue Contract:

- The original contract from Topic 3 shall be cancelled, null and void.
- The rescue program would be done in two distinct Phases. Phase-One would be managed by RAF. Phase-Two would be managed by Dick & Jeana.
- The Phase-One tooling and components of the Voyager would be built at the RAF facility with final assembly at a TBD hangar. Voyager Inc. would not need to pay for the use of the RAF facility or for any other Phase-One expenses.
- Burt would be responsible for all design, supervision of the fabrication process and he would be the Test Director for all Voyager Phase-One flight tests. Dick would be the test pilot. Dick, Jeana, Mike Melvill, Sally and Bruce Evans would build the tooling and the structure. Bruce would be a paid, temporary RAF employee. All others would not be paid for their Voyager work.
- Phase-One would start immediately. First flights would use two off-the-shelf Long-EZ engines with fixed-pitch wood propellers. Phase-One would end when and if flight test data showed that Voyager could indeed attain the Milestone, after the final engines and propellers were installed.
- Phase-Two would involve installing the world flight engines, propellers and all the world flight avionics - these expensive systems would hopefully be donated by the manufactures. Phase-Two would include the flight tests that would build up to the weight needed for the attainment of a closed-course range record and the Milestone flight. Any record flights, promotional flights and the Milestone world flight attempts would be a Phase-Two responsibility. Dick would be the Test Director for all flying after Phase-One was completed.
- RAF would have no responsibility to pay for any Phase-Two costs.

- Phase-Two expenses were likely to be paid by public donations - $100 gets you named a “VIP” - a Voyager Impressive Person.
- Funds raised during Phase-Two would be shared by Dick/Jeana (Voyager Inc) and by RAF.
- If the Milestone world flight is a success and for five years thereafter, all Voyager-related money received from paid talks, interviews, merchandise sales, books, movies etc. by Burt, Dick and Jeana would be collected in a bank account. Then every month, half would be paid to RAF and half would be paid to Voyager Inc.

Dick and Jeana, of course were not happy with My rescue contract. It was a huge difference from their original designer contract. Now, RAF would get half of all post-Milestone money, instead of just the 5% to me.

The justification for RAF getting half of the possible big money: RAF pays for all Phase-One expenses - including the Bruce labor & RAF solely takes the huge risk that the Milestone will not be achieved. Also, Dick and Jeana instantly go from failure/broke, to seeing all Phase-One activities happen without them needing to raise money.

That last fact closed the deal. Dick and Jeana decided to accept the terms of the rescue plan and they signed up.

Important Observations:

1- Unlike the initial plan of hiring multiple companies to build the structure, having D & J do the hands-on fabrication gave them the proper focus on quality work since a structural mistake could kill them.

2- D & J wanted to get the program done as soon as possible. Thus, they were forced to personally work long hours and avoid all distractions. This huge, complex project might have failed without these two motivations.

As the fabrication proceeded, Dick did not like me making all the decisions, so he moved to start Phase-Two earlier than the plan. He and Jeana essentially managed the program after they had their own place to work - the donated Hangar, east of RAF (Topic 6).

Hangar 77 is where final Voyager assembly was done. The early start of Phase-Two was accepted by me, because of my extreme workload at

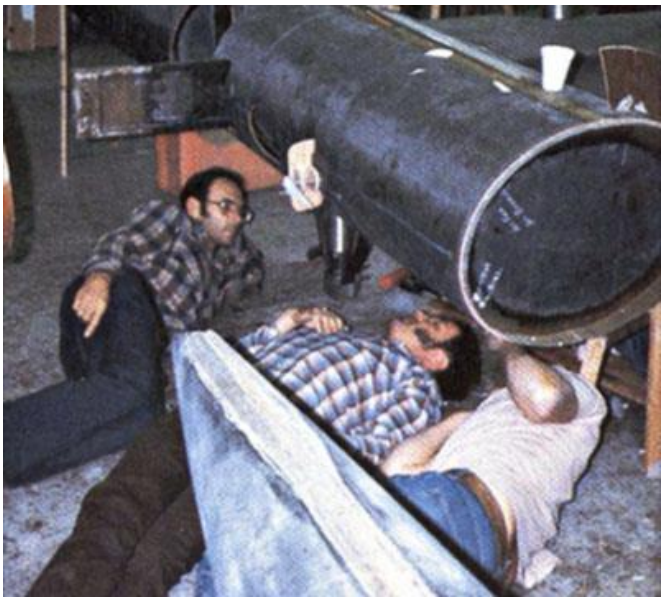
Scaled - design, fabrication and test of Beech Starship & Triumph, DARPA SMUT, CM-44 and ARES.

Photos of Voyager Construction at RAF Facility During Phase-One

Wood Mockup for Crew Fitting

Bruce Evans building canard structures.
These entire structural boxes
forward of the elevators were fuel tanks.

Mike, Me & Dick
working on landing gear interface.



Topic 6 • FINAL ASSEMBLY BY VAI AT HANGAR 77

The program had many things that "just happened" to make it a success. A major one was the observation by the Airport Manager, Dan Sabovich of the importance of the Milestone. He noted that there was a vacant hangar on the flight line (Hangar 77) that was large enough for final assembly, and he donated it rent-free for the program.

Hangar 77, Just East of the
Mojave Airport Management Headquarters

The Parts of Voyager that were Built at RAF when they were First Moved to Hangar 77

Voyager Near Ready to Fly in Hangar 77 At this time VAI had many volunteers.

Photo of the Cockpit Environment

The long vertical white tube is the sight-gauge showing the feed tank's fuel volume. That sight gauge is the only instrument in Voyager that shows fuel tank volumes.

The 14 other tank volumes were determined by measuring the fuel pumped into them during fueling, then subtracting the fuel as it was transferred in-flight to the feed tank.

The transferred fuel volume was measured by integrating flow-meter data when fuel is pumped to the feed tank. The results of that data were manually written on the large spreadsheet seen on the left.

Roll-out unveiling event, June 1984

The 110.8-ft span would not fit the 85-foot hangar door - so the landing gear scissors were disconnected so it could roll-out diagonally.

RAF CANARD PUSHER NEWSLETTER #42 OCT 1984

Burt has turned the Voyager over to Dick and Jeana - he is satisfied that the airplane has the capability to do the Milestone flight. He has specified what the power requirement will be and how Dick and Jeana will take the Voyager through Phase-Two. That is to prepare it for the around the world flight, this is mainly avionics, engines as well as the human factors. Phase-Two includes all the heavy weight flight tests.

A lot of EZ builders and pilots have joined the Voyager VIP (Voyager Impressive People) Club. This has been a great help. A lot more financial help is needed. We encourage donations from anyone interested in seeing the Voyager successfully fly around the world. Let's keep Voyager as a grass roots effort. To join the VIP Club, send in $100.

Voyager Aircraft Inc.
Hangar 77, Mojave Airport,
Mojave, CA 93501 (805) 824-4790

Enter Peter Riva

Riva was an aggressive New York literary Agent who usually advised business startups. He was an airplane nut and wanted to be a part of the Voyager program.

In late 1984 he contacted Dick, asking to be the project manager, fundraising manager, public relations manager and staff manager. He said he had the skills to bring in millions of dollars due to his numerous contacts, and that Dick and Jeana needed him because they lacked experience on how to bring in big money. Dick told him he was completely wrong.

Riva advised Dick that within six months he would lose all the sponsors that he currently had. Dick later called Riva, saying he was mistaken - it wasn't six months, it was four months.

Dick then asked Riva to come aboard and take over as fundraising manager and personnel manager. He was to manage the current sponsors and raise post-milestone money - books movies, merchandise, etc. Riva agreed and moved to Mojave. He considered himself the “de facto project manager,” since he did not see anyone in Hangar 77 that had any real management experience.

He later arranged for the three key players to be awarded the Presidential Citizens Medal.

Riva on the left, with the Reagans, Jeana, Dick and Me.
Photo taken on Dec 29th - 6 days after Voyager landed.

Riva was the Voyager manager until the summer of 1987 when Dick sued him, claiming that he had stolen $200,000 of VIP donation income. In discovery, Dick then found that it was Jeana who was the thief. She was the one watching the office and no one was checking on her. She had deposited the $200k in a secret personal Savings Account in a Naval Credit Union.

One of the “secret deposits” was a birthday gift to Dick by Irene “Mom” Rutan. Kelly Hall did some research after looking at the cancelled bank check and she thus discovered the Jeana fraud.

I never did see the contract that Voyager Inc. had with Riva and was not aware that they had ever signed one. Riva’s normal agreements with clients gave him 10% of the money that he brought in, potentially at least $100K if

everything over the next 5 years went as he planned. Much of the sponsorship money, like the Hartzell propellers, was never counted as “sponsorship.” These were not cash, just donations of custom propellers. Since Riva helped bring Hartzell on board he expected to get a portion as his normal fee. He was never paid. He might have sued, but he decided it wasn't worth it - like the volunteers on the program, he was proud to have Voyager on his resumé.

The Riva Voyager Budget

As part of his task to bring in big money for things like movies and books, Riva needed a detailed Budget document to show during negotiations. Riva showed his two-million dollar budget to me and allowed me to make it available to BRAB readers. It includes essentially all costs that would be claimed if it were for a big corporation aerospace program.

Chap29-RivaVoyagerBudget.pdf

Topic 7 • A BARGAIN, VAI BUYS OUT RAF CONTRACT

I was initially not aware of the Riva prediction told to Dick and Jeana - that a Voyager Milestone flight success would bring in multi-million-dollar sponsor income from movies, books, etc.

It was unacceptable to Dick & Jeana for RAF to get half of the (possible) millions, so they made a request to RAF: “How much would they have to pay, in order to cancel the Rescue Contract - i.e. to change it so Voyager Inc. could keep all the future money they made and RAF or Me would keep all their future Voyager-related income.”

That change was attractive to RAF for two reasons:

1- It would greatly simplify accounting, and the entities would not have to audit each other’s books.

2- It might remove the animosity that exists between friends and brothers.

RAF assumed that if the buy-out were large, Dick & Jeana would never be able to pay it. Also, RAF thought it was likely that big money would never be

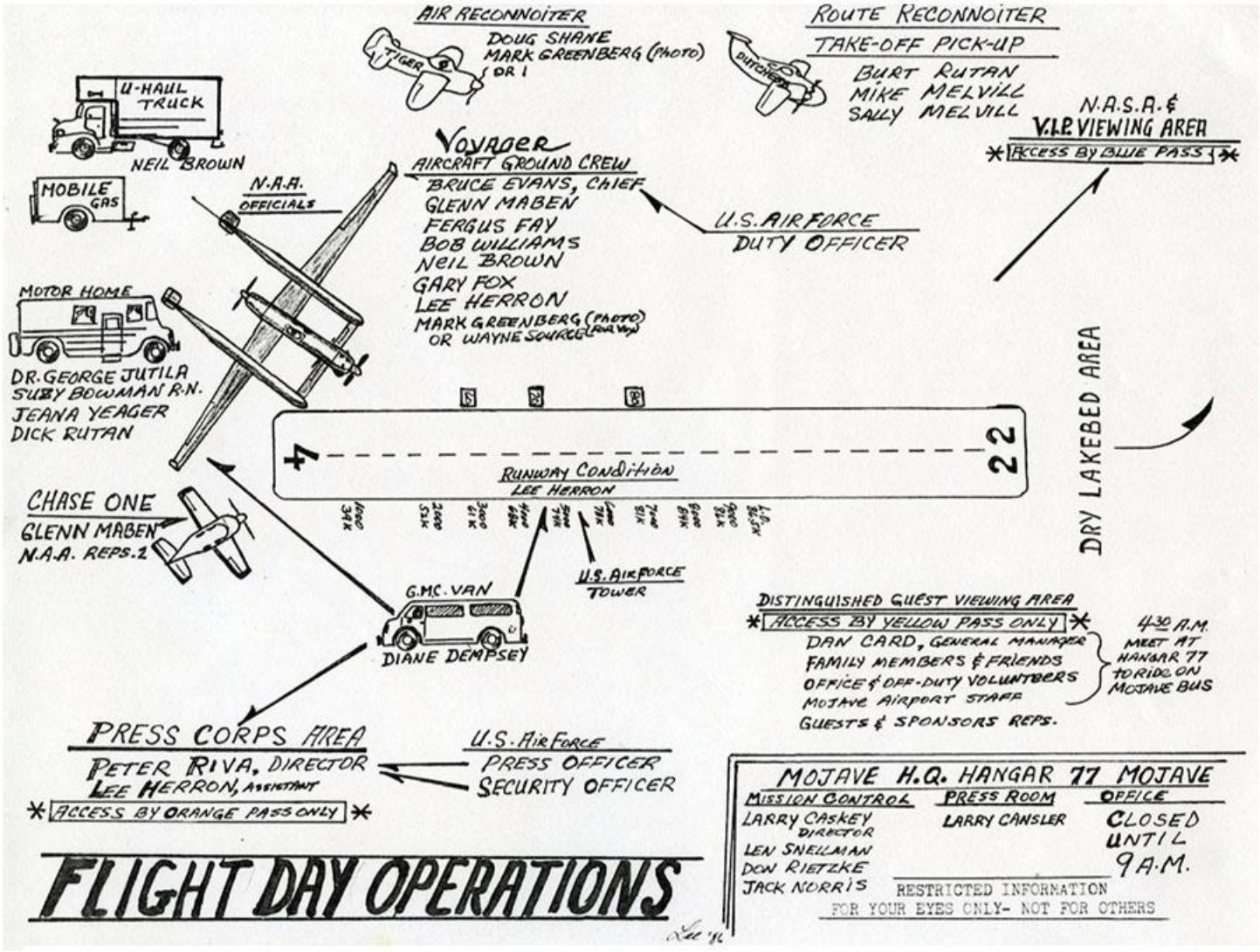
received. So, RAF told them a real low-ball number - 180K dollars - essentially just the direct materials cost to build and flight test Voyager during Phase-One, not counting any of the “free” labor or use of the RAF shop.

Dick and Jeana said, “Can we pay half now and take a loan for the other $90K when we get future income?” RAF said yes, so the Rescue Contract became null and void.

After that, everyone working the Voyager program at Mojave got along much better.

Topic 8 • THE NINE-DAY WORLD FLIGHT & THE RISKS

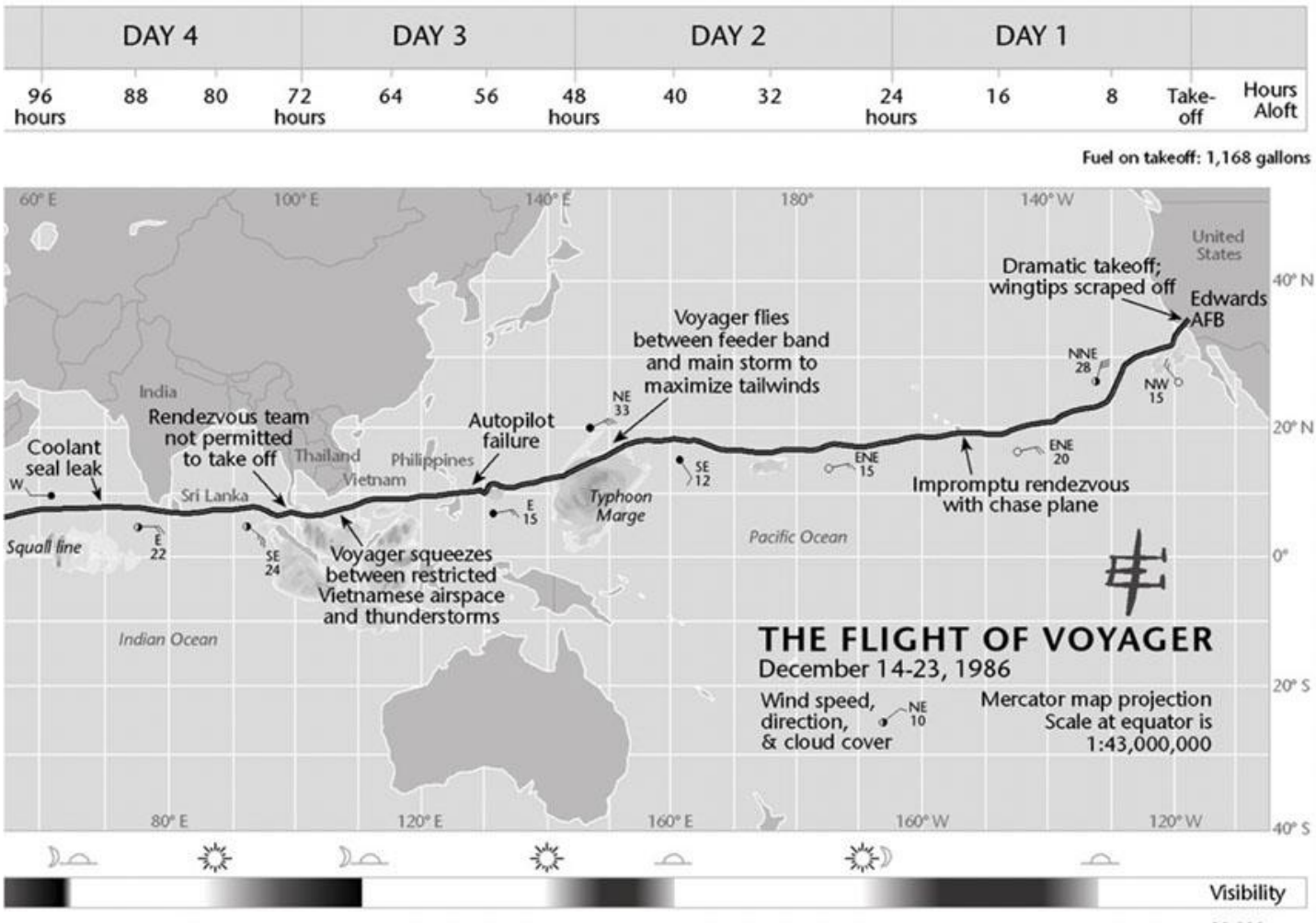
Assignments on World Flight Takeoff Day

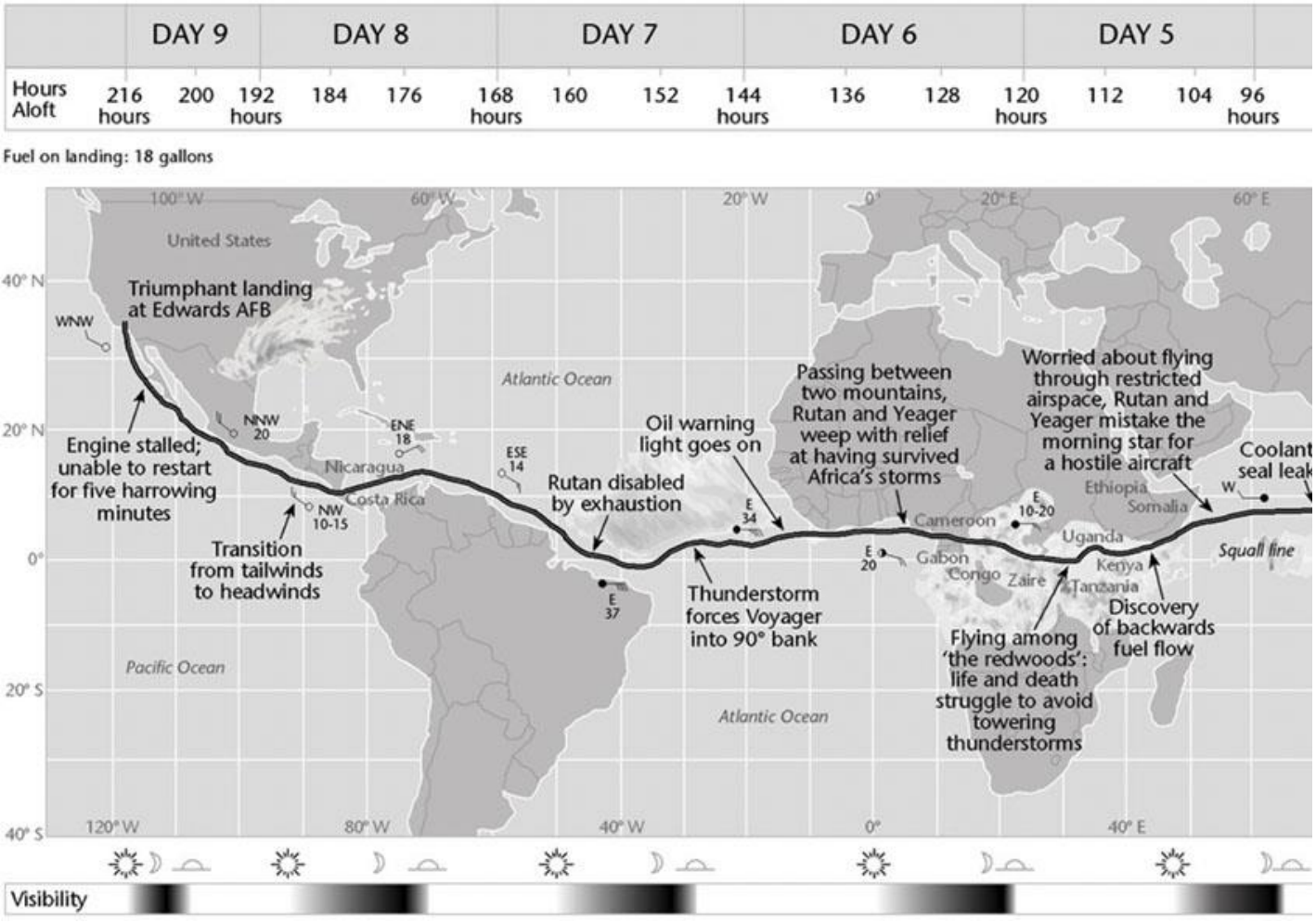


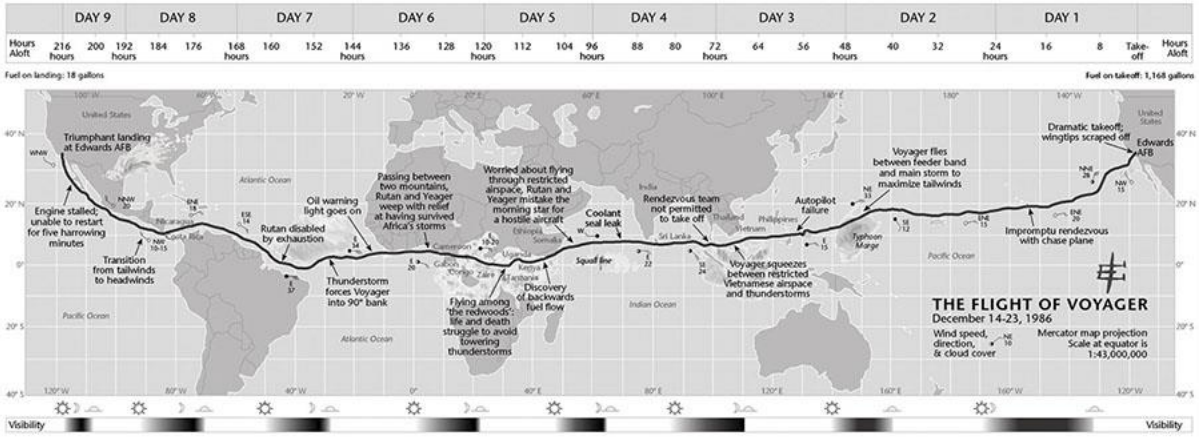
After the airplane was ready, everyone expected to wait days or even weeks for the perfect weather and lack of turbulence for takeoff. To everyone's surprise, when the aircraft was finally ready, the takeoff happened on December 14th, the very next day!

Like Lindbergh in 1927, Dick had very little sleep the night before the World Flight takeoff. Dr George Jutila woke Dick for a blood-draw during his short sleep. Dick was livid. Jeana was recovering from a cold on takeoff day.

The graphics below show the actual flight path of the Milestone nine-day flight. They show the days, when it was in darkness, the winds and many notable events. The graphics do not show the Doug Shane/Baron formation rendezvous over Kenya on day 5.



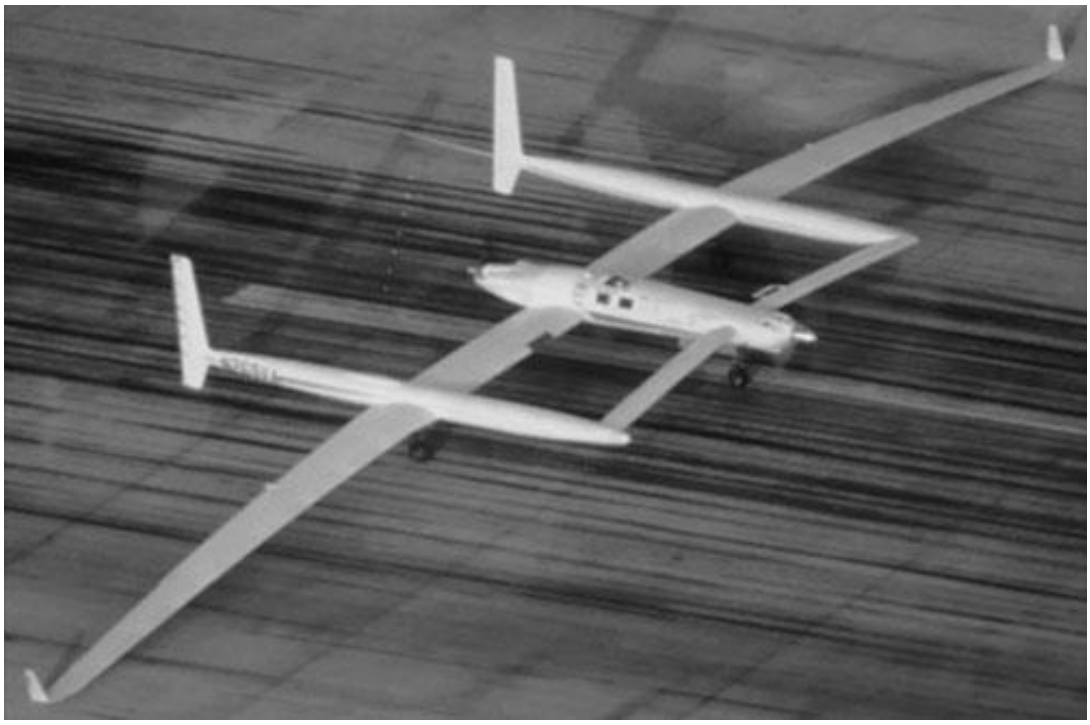

DAY 9
DAY 8
DAY 7
DAY 6
DAY 5
Hours Aloft
216 hours
200
192 hours
184
176
168 hours
160
152
144 hours
136
128
120 hours
112
104
96 hours
Fuel on landing: 18 gallons
100° W
60° W
20° W
0°
20° E
60° E
40° N
20° N
0°
20° S
40° S
120° W
80° W
40° W
0°
40° E
United States
Atlantic Ocean
Pacific Ocean
Atlantic Ocean
Triumphant landing at Edwards AFB
WNW
Engine stalled; unable to restart for five harrowing minutes
NNW 20
ENE 18
ESE 14
Nicaragua
Costa Rica
NW 10-15
Transition from tailwinds to headwinds
Rutan disabled by exhaustion
E 34
E 37
Oil warning light goes on
Thunderstorm forces Voyager into 90° bank
Passing between two mountains, Rutan and Yeager weep with relief at having survived Africa's storms
Cameroon
E 10-20
E 20
Gabon
Congo
Zaire
Uganda
Kenya
Tanzania
Ethiopia
Somalia
Worried about flying through restricted airspace, Rutan and Yeager mistake the morning star for a hostile aircraft
Coolant seal leak
W
Squall line
Discovery of backwards fuel flow
Flying among 'the redwoods': life and death struggle to avoid towering thunderstorms
Visibility


DAY 9
DAY 8
DAY 7
DAY 6
DAY 5
DAY 4
DAY 3
DAY 2
DAY 1
Hours Aloft
Take-off
Fuel on landing: 18 gallons
Fuel on takeoff: 1,168 gallons
Triumphant landing at Edwards AFB
Engine stalled; unable to restart for five harrowing minutes
Transition from tailwinds to headwinds
Rutan disabled by exhaustion
Oil warning light goes on
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
Thunderstorm forces Voyager into 90° bank
Flying among 'the redwoods': life and death struggle to avoid towering thunderstorms
Discovery of backwards fuel flow
Coolant seal leak
Squall line
Rendezvous team not permitted to take off
Autopilot failure
Voyager squeezes between restricted Vietnamese airspace and thunderstorms
Voyager flies between feeder band and main storm to maximize tailwinds
Dramatic takeoff; wingtips scraped off
Edwards AFB
Impromptu rendezvous with chase plane
THE FLIGHT OF VOYAGER
December 14-23, 1986
Wind speed, direction, & cloud cover
Mercator map projection
Scale at equator is 1:43,000,000
Visibility

Final Fueling at Edwards AFB Runway
Early Morning, December 14th, 1986
Bruce Evans and Glen Mabin

Blowing Frost from Wings Before Takeoff

Wing Tips Dragging on the Runway During Takeoff



The world flight takeoff as experienced by Mike, Sally and Me in the chase Duchess aircraft.

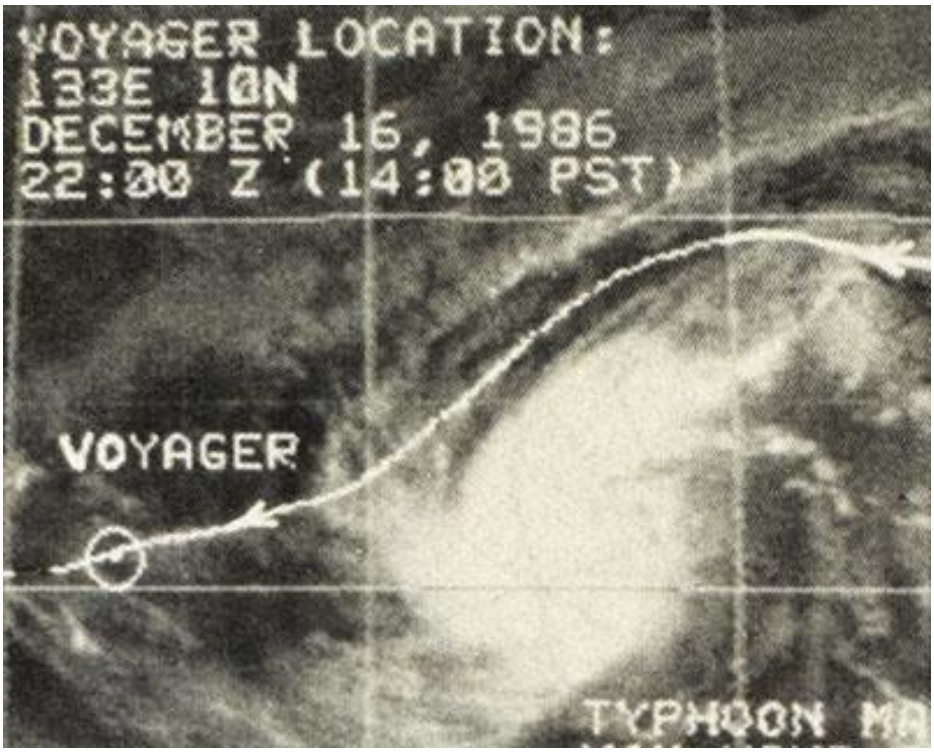
Voyager takeoff video that details the risks:

Voyager Takeoff from Duchess Video

Autopilot Failure

On day 3 the autopilot failed. Since general aviation autopilot gyros in the 1980s were prone to failure, we had a spare in the cabin. Jeana crawled under the instrument panel and replaced the failed gyro.

Guiding Voyager Between the Bands of Typhoon Marge



An Addition to the Rutan Family

As Voyager flew over the Philippine Islands on December 17th, my daughter Dawn gave birth to Whitney - my first grandchild.

Fuel Leak Back - a Missing-Fuel Mystery

During the 1986 flight testing I calculated that we could get more than a half-day of safety, in the event of a forward engine failure at the heaviest gross weights. If, on day one we could dump fuel at a higher rate, the Voyager, while descending at full throttle on the aft engine might be able to fly level at sea-level. This was assuming that the forward engine failed above our “normal” cruise altitude of 8,000-foot.

So, for the last flight before the World Flight, we removed the low rate pumps and installed more powerful fuel transfer pumps. We tested the new pumps in flight by dumping fuel at the higher rate.

These pumps added just 2.4 pounds to the airplane's empty weight. An additional advantage was that for the entire World Flight it would lower the time to transfer each gallon to the feed tank by a factor of four.

Bad News

As we emptied the first of the 14 tanks on day 3, Jeana's spreadsheet showed that the Voyager was lighter than expected. For three days we were finding that Voyager might run out of fuel before arriving back at Edwards.

Then Dick noticed that there was an occasional bubble slowly moving backward in a tank line with the pumps turned off. This should not be possible - since pumps have a one-way check valve that makes reverse flow impossible.

Mission Control Trailer, Day 5
Mike Melvill, Me & Len Snellman
Trying to sort out the missing fuel.

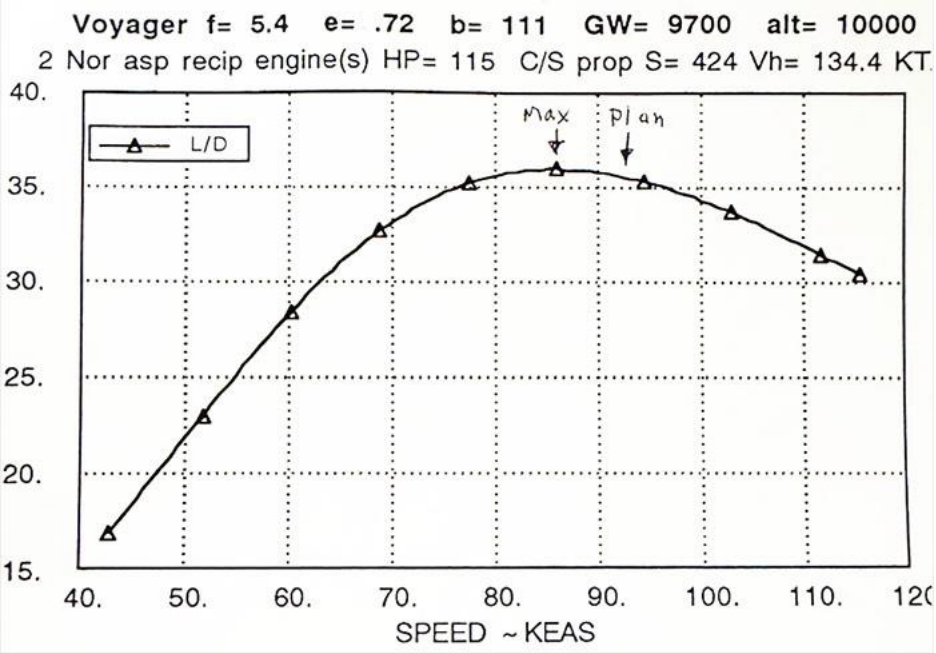
Studying the fuel system in Mission Control trailer we concluded the only way fuel could flow **from** the feed tank **to** another tank was if the reverse-flow check valve in the transfer pumps was not completely closed.

Finding that the new pump's check valves were leaking was very good news. The weight of Voyager was actually right at where it should be.

The Trade - to Fly Faster and Lose Efficiency

For the World Flight, we had planned to reduce the flight time by an entire day by giving up just a little bit of flight efficiency.

Note: range is reduced 2.5% if the speed is flown 10% faster than the speed for max range.



An interesting thing about this is that, for three days we thought the gross weight was lower than the plan and we had been giving a too-slow 'speed-to-fly' instruction to Dick. Thus, we were flying more efficiently than the plan. The leak-back problem gave us a bit more remaining fuel when Voyager arrived at Edwards.

During the nine-day-flight, Mike primarily did night shift duty at Mission Control.

I spent very little nighttime in Mission Control because I needed sleep after doing crazy overtime at Scaled: flight testing the Beech Starship, building the DARPA Model 133, building the model 143 Triumph, testing the model 144 CM-44 and designing the ARES model 151.

Fuel Transfer Pump Failure - a Near Disaster

At about 2 am on the early morning of December 22nd, Voyager was off the coast near the Baja Peninsula, heading northwest over the Pacific Ocean. The crew was using the two transfer pumps in an attempt to transfer wing fuel to the big feed tank with its sight gauge. That would assure that there was enough fuel to get back to Edwards. Then, the right side electric transfer pump failed. The cause of failure was not electric power or a circuit breaker — the **pump was dead**.

Me and three others in Mission Control advised Dick to transfer all the remaining fuel from the left wing, then to move the good transfer pump to the right side. However, Dick had always been concerned about fire risk from fuel vapor in the cabin.

Despite the fact that all four of us in MC had a lot more sleep than Dick, he proceeded to use his other valves (See Topic 1) to have **the aft engine draw fuel directly** from the wing tank, instead of the feed tank. Immediately **the aft engine quit**. It was fuel-starved because of air in the lines. The aft engine was generating no thrust, just a lot of drag from its windmilling propeller.

Dick had to act fast to keep the windmilling prop turning, because the aft engine had no starter. He pushed the nose down into a dive to increase speed to assure the prop would keep turning. The problem with that was the fuel pickup in the selected wing tank was now taking in air due to the steep dive. He had no way to start the aft engine. For the next five minutes the voyager was a draggy **glider** descending to the ocean!

Dick feared that the front engine might not start since it had not operated for nearly a week. He pushed its starter button. The start took a long time because its oil was cold. The starter was turning a feathered propeller - and it needed oil pressure to un-feather.

When it did start, just above the ocean, he ran it at high power to recover from the dive. This forward acceleration now brought fuel to the wing pickup and the aft engine started running, producing its normal thrust.

Now there was only one option to get enough fuel into the Feed Tank - swap the good transfer pump to the right side so it can transfer right wing fuel. That fuel was needed to get to Edwards. Jeana got the tools and a rag and moved the pump to the other side, assuring that for the rest of the flight all fuel could be moved to the reliable feed tank.

The glide-to-ocean scare was so traumatic that Dick decided to not shut down the front engine. He left it running all the way to the Edwards landing on December 23rd.

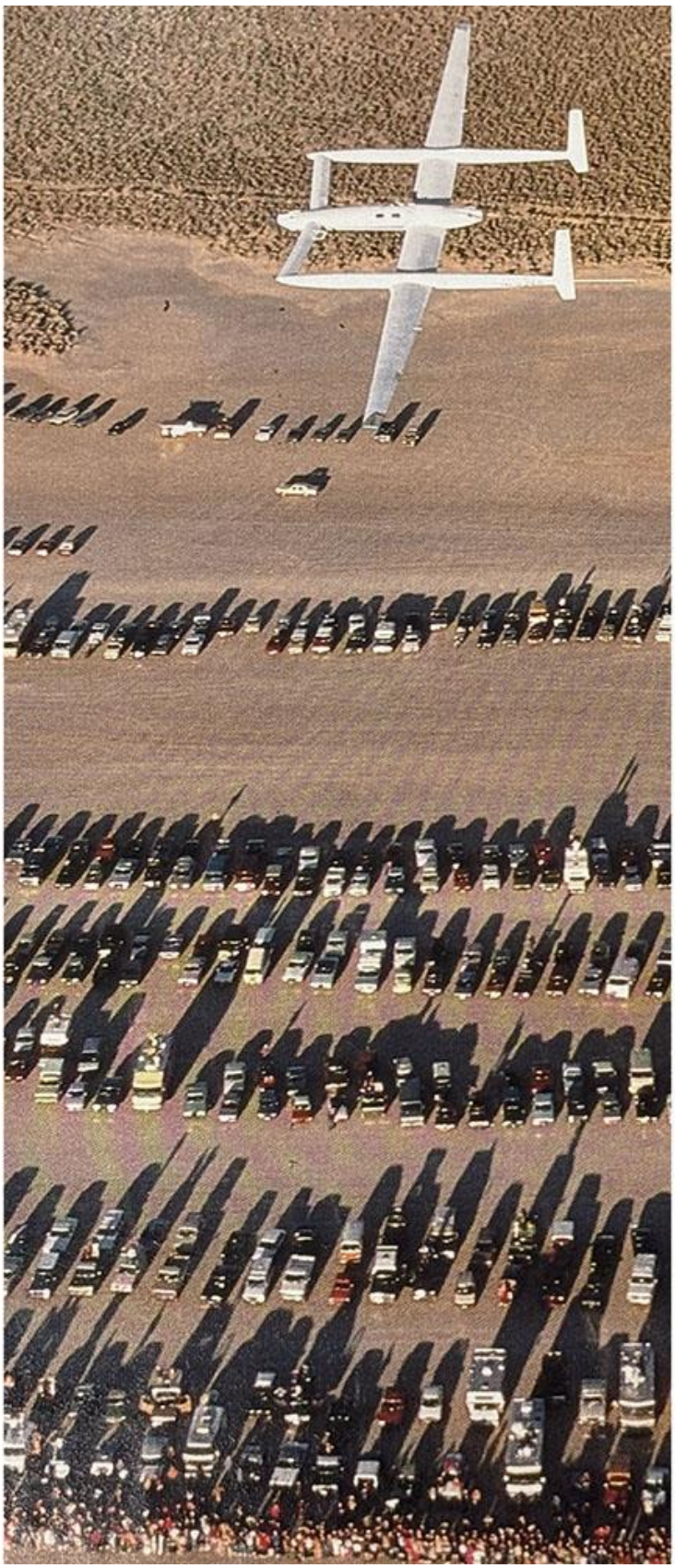
After the pump was moved, the feed tank did not yet have enough fuel to get to Edwards. As the wing fuel was being transferred to the feed tank, its sight gauge **slowly** moved up. When the gauge showed enough fuel to reach Edwards, we in Mission Control were elated - for the very first time we were **assured that Voyager had enough accessible fuel to reach Edwards**!

During the nine flight days, when any notable event occurred, I would leave the Mission Control trailer, go into the hangar and inform all the Media reporters. Now, I could inform them the very best news — that Voyager would definitely **have enough fuel to make it**. Walking into the hangar, I found it empty. The media had already packed up and moved to Edwards dry lake to cover the landing!

At 10,500 feet altitude, just south of Edwards.
Chased by Mike and Me in the Beech Duchess.

Over the Los Angeles basin, an airliner dipped
its wing so the passengers could see Voyager.

The welcoming thousands at the Edwards dry lakebed. Most had started their day at 2 am to watch the landing.



Sister Nell at Voyager Landing
HOORAY FOR THE PURE!

After landing on World Flight Dec 23, 1986.
On the Rogers dry lakebed at Edwards AFB.
Someone handed Dick his black cowboy hat. He sat on the fuselage top for a long while until he felt his legs could support him.
Jeana was slowly walked to a van for transport to the base hospital.

Did Government Track Voyager?

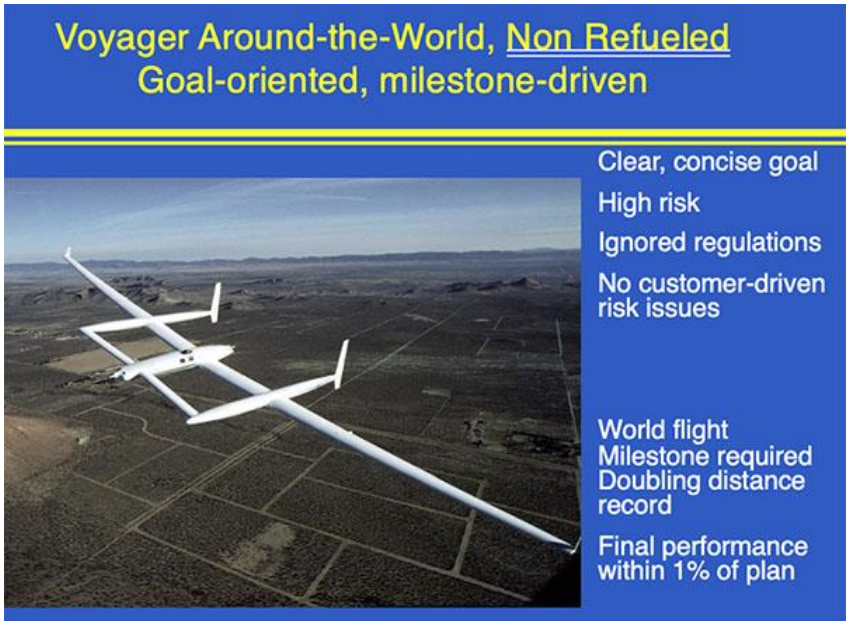
After day 1, we got an unidentified call - “Call this number if you lose track of Voyager **xxx-xxx-xxxx**.” The caller would not tell us how, but apparently they tracked the precise position the entire 9 days!

Topic 9 • THE PRESENTATIONS AND THE AWARDS

Paid Voyager Lectures

Starting in early 1987, and for about 5 years thereafter, Dick and Jeana did about 180 paid Voyager lectures. I, having a full-time job at Scaled, did about 33 paid Voyager lectures. The paid lectures were initially managed by the New York lecture firm Royce & Carlton. For most of these, the client paid $7k and RC collected 25% of it. Thus, D&J made about $945k and I made about $173k (before taxes). The $945k is equal to today’s 2.7 million dollars.

A PowerPoint Slide Shown during My Typical Rutan Voyager Lecture



Some videos shown during my typical Voyager lectures:

Voyager Wing Tip Damage Assessment Video

1988 Burt Rutan in Reaching for the Skies Video

Voyager Takeoff from Duchess Video

1984 Voyager Visit to Oshkosh Video

Dick, Jeana and Riva present at US Congress C-Span Coverage of Voyager Hearing in Congress, February 17th, 1987

Voyager Testimony to Congress Video

I had a hard conflict, so I did not present Voyager in Congress. I later testified in Congress after the SpaceShipOne Milestone in 2004.

Frontiers of Flight Voyager Video Part 1/4 (14 minutes) How Jeana Met Dick

Frontiers of Flight Voyager Video 1/4

During some of the voyager program and afterwards,
Peter Riva sent Press Releases to Media.
These releases were generally accurate,
but they had several intentional errors and omissions.

[Chap29-VoyagerPressReleases.pdf]

The Peter Riva Letter to the Smithsonian at the
Tenth-Year Anniversary of the Milestone Flight

[Chap29-RivaVoyager10Year.pdf]

Voyager Awards

Six days after the Voyager milestone flight landed at Edwards Air Force Base, President Ronald and Nancy Reagan presented the Presidential Citizens Medals to Dick, Jeana and Me in Los Angeles. You can read all the remarks via a White House transcript in this PDF.

[Chap29-ReaganAward.pdf]

Here, I Meet with the Reagans

A list of my 24 Voyager-related awards can be found in BRAB Chapter 85. The three most significant awards were:

1- The solid Gold Medal from France (Grand Medal Aero Club of France), which is identical to the medal presented to Charles Lindbergh after he landed in Paris in 1927.

2- The 1987 Collier Trophy, the highest award in Aerospace.

3- The president Reagan-awarded Presidential Citizen's Medal.

The Paris Medal was presented with a repeat of the Lindbergh award - same room, same furniture, etc.!

My two Collier Replica Trophies
One for Voyager and One for SpaceShipOne

When you win a Collier, you must pay for your small replica trophy. Voyager had very little money, so its replica is cast plaster with gold color paint. Paul Allen was worth Billions at the time of SS1, so the replica is bronze and mahogany, just like the huge Collier trophy in the Smithsonian Museum.

Shown below is some of the coverage of the Voyager project that was published in the Rutan Aircraft Factory's "Canard Pusher" newsletter.

This pre-internet publication, which was published for builder-support of homebuilt airplanes, was mailed four times per year - Jan, Apr, July and Oct from 1974 to 2001.

THE CANARD PUSHER #41 JULY 84

On June 22, 1984, early in the morning before the desert warmed up or it became windy, the Voyager left Hanger 77 and began a series of taxi runs on Mojave's runways 30-12. Each run was made a little faster. Soon daylight was seen between the tires and the runway - the Voyager was airborne! The taxi runs were conducted with the rear engine running, but with the front prop removed. The front prop was installed out on the taxiway - a quick but thorough inspection was made. Dick taxied into position on Mojave's 30. Mike and Doug took off in the Grizzly to fly chase and to document the event on video tape.

The Voyager began to roll. The acceleration was amazing! The Grizzly pulled in low and close on the right wing just as the Voyager rose majestically into the air. It looked incredible. Dick climbed out straight ahead, gently feeling out longitudinal, lateral and directional control and stability. The Grizzly moved underneath looking for discrepancies. Mike called Dick on the company frequency, "You have a major oil leak on the front engine". Dick calmly replied that he was shutting down and securing the front engine. A quick discussion with Burt and it was decided to continue the flight but to remain in the immediate vicinity of the airport.

The air was glass smooth, and the Voyager was an awesome sight to see. The wing tips were bent up like a huge bird. The impression Mike had from the Grizzly chase was that the airplane was sailing across the sky, much like a sailboat on the ocean, a very exciting and satisfying feeling for all of those who worked so hard to reach this point.

After about 40 minutes of getting familiar with this large of an airplane, Dick announced that he was returning to land. Cameras were clicking and video cameras running as he entered left downwind for runway 30. A slight breeze (5 knots) has come up, giving him a slight crosswind

from the right. He turned final, the gear was down (it had not been retracted) and floated down to a perfect touchdown.

Of course everyone was elated. The aircraft had performed aerodynamically flawlessly. Burt had predicted how it would fly and once again, he was exactly correct.

The airplane had been under construction in the RAF hanger for 18 months. Dick was pleased with the flying qualities. The pitch stability, its ability to hold a trimmed airspeed is really amazing. The airplane has 6 flights on it at this time for a total of 20 hours. One flight alone accounted for 11 hours. Dick reports that he has flown for hours at a time without touching the control stick. He turns with the rudder - and the airplane holds airspeed and altitude all by itself.

So far, the flight test data is very encouraging and has backed up Burt's original calculations and predictions almost exactly. A few more flights are needed to really nail down the power requirements - and it is a possibility that the Voyager may attempt a closed course distance record between Mojave and Oshkosh during the week of the Oshkosh fly-in. This will depend on the weather of course, and on our ability to get the airplane thoroughly ready for such a flight. We are optimistic currently. In fact, everyone involved with the program is pretty much elated by the excellent results of flight testing so far.

We had an "official" press day on July 3, 1984 - and as a result, the Voyager was seen in flight on all three major TV networks, as well as on many local TV stations. See Page 9 for more photos of the Voyager.

The Voyager's first time into the light of day, on June 2, 1984. The Voyager's 110.8 foot wingspan means it must be wheeled out of the 80 foot side door, with the three gear scissors disconnected and the wheels turned to allow it to roll straight out while remaining at a diagonal.

The response to our request for comments on the idea of a VIP club (Voyager Impressive People) has been excellent. Based on this response, a decision has been made to go ahead with the VIP Club idea. A final format or contribution level has not been decided on. Voyager expects to have all the details thrashed out before Oshkosh,

1984. Voyager will have a booth at Oshkosh - and anyone interested in the VIP Club can obtain details at the booth or you can write or call:

Voyager Aircraft Inc.
Airport Hanger 77, Mojave, CA 93501 (805) 824-4790

THE CANARD PUSHER #46 OCT 1985

Voyager update, from Dick and Jeana. First - I would like to thank Burt for this opportunity to include in the RAF newsletter an update of the Voyager Around the World Flight Program. The project is still alive and well and progress is being made as fast as funds and resources will permit.

The last flight Voyager made was mid-November 1984, at which time the Phase One flight testing was completed. Phase One was done with worn out junked Long-EZ engines and instrumentation we had readily available. Out of this we were able to evaluate the performance and handling qualities of the aircraft. The conclusion was that Voyager is capable of its designed goal- The Milestone of around the world non-refueled flight!

From the data acquired from the first phase of testing, we were able to select the world flight engines and avionics. King Radio is providing the avionics and Teledyne Continental Motors is providing the two engines. The front engine is a standard 0-240 air cooled (130 hp) and the rear engine is the newly developed IOL-200 liquid cooled (110 hp).

For the past year it seems little has been said about the project but as usual, if we're not talking, we're working! Our time has been tied up in test cell runs, wind tunnel evaluations, propeller acquisition/testing, putting together the avionics package, making new cowls, engine mount-hook up, aircrew life support systems (heat-vent- oxygen), the deployment planning and operational logistics. Things are coming together nicely. We expect to have Voyager flying before the end of the year and continue testing with the new engines, avionics and aircrew systems.

When are we going? I wish we knew! Voyager is a research and development (R&D) program that basically means there is more to it

than first meets the eye and working towards a schedule is somewhat of a laugh. A very frustrating one at that. As it looks right now like we will not be ready for a world flight attempt before the "weather window" closes toward the end of November. Although we should be flying, testing the new engine/avionics before that. At present we are looking at some time next year before any attempt on the world flight can be made.

As you are all pretty much aware, Voyager has been funded mainly by individual contributions. If it hadn't been for this kind of support the project would have folded a long time ago. WE STILL NEED YOUR HELP!

Please let everyone know Voyager is alive and well. We have no intentions of giving up! There's a challenge to be met and with your help we will make it happen.

Thank you, Dick Rutan and Jeana Yeager Voyager Aircraft Inc.

THE CANARD PUSHER #48 APR 1986

Mike Melvill was extremely fortunate a few weeks ago when Dick Rutan offered him a ride in the Voyager! Jeana was not in town - she was back in the Midwest adding a couple of ratings to her pilot's certificate. A test flight had to be flown, and since there was so much to do during a test flight that a co-pilot is a necessity, Dick invited Mike to go along.

Mike reports that it was a tremendous experience and that he is really impressed with the airplane and the team which is now rapidly moving toward the goal of world flight. The date has been set, Sept. 14, 1986 (weather, or course, permitting). It is not too late to help them along. Send a few dollars to: Voyager, Hangar 77, Airport, Mojave, CA 93501.

Look for an article in an upcoming Sport Aviation which details Mike's experience in this incredible flying machine.

THE CANARD PUSHER #49 JULY 1986

VOYAGER CLOSED COURSE RECORD ATTEMPT Dick and Jeana took off from Mojave just after 8:00 AM on Wednesday morning, July 9th. After

flying for about 7 hours, the electric variable speed prop on the rear engine developed a problem and Dick decided to land at Vandenberg Air Force Base to check it out. After a good night's sleep, they repaired the problem the next morning and then made the decision to try again. They took off from Vandenberg at 2:47 PM on Thursday, July 10th and flew up and down the California coast about 20 miles out to sea around a closed course that is 500 nautical miles per lap.

The decision was made not to chase the Voyager continuously, but to fly out and join up with them for an hour or two at dawn each day and then again for an hour or so before dark. The reasoning here, of course, was to be able to assure the crew that there were no visible problems such as oil or fuel leaks.

On Friday evening, June 11th, Mike, Sally and Mark Greenberg (a professional photographer) took off in the Voyager chase aircraft, a Beech Sierra, and with excellent help from LA Center, we were vectored to an intercept with Voyager 20 miles off the California coast at Big Sur. The sun was getting low in the sky - the ocean was sparkling blue and the Big Sur coastline was beautiful. All eyes in the chase were searching the endless blue skies. Center called them at 12 o'clock and six miles. Sally was the first to spot them, a thin, curved line in the sky.

As we closed with them, the air was glass smooth and the sight of the regal shape of Voyager, as it slowly floated back towards us, was breathtaking. Mark, the photographer, was shooting film, like a mad man as we slid into close trail formation to give the Voyager a quick look. She was absolutely clean - except for a thin trace of oil from the aft engine breather which is normal. Dick and Jeana were fine and sounded in good spirits. Both had managed to get some sleep and were very confident of the Voyager's ability to fly for almost four more days and nights!

We joined on their wing and floated up the coast beyond San Francisco. We chatted and took photos - and they took photos of us. We made the north turn point at dusk. As the sun sank into the ocean like a ball of red fire, the Voyager looked magnificent against the skyline - the photographer was blowing his mind! As it got dark, we moved in very close for a thorough inspection of the machine, reported to the crew that they looked great, and

said "good night". We were low on fuel ourselves and headed toward the coast to refuel at Salinas.

As we drifted away from Dick and Jeana, the silhouette of the Voyager against the night sky with the evening star and a two day old new moon just above her, it was a sight we will never forget.

As I write this, it is Sunday June 13th. I have just checked in with Voyager base, and all is well. They are both in good spirits, both have managed to sleep quite well, and the Voyager is running like a Swiss watch. Fuel condition is excellent and it is a "GO" for the record. The weather looks like it will hold, but a small system which may have some rain in it, is expected to move in on Monday night. I will be joining up with them again on Tuesday morning at dawn and will escort them home. What a superb effort - what a tremendous team, to have got this record attempt off in such good shape. Go for it Dick and Jeana - we are all pulling for you!

THE CANARD PUSHER #51 APR 1987

We would like to apologize for the fact that there was no January 1987 newsletter. Unfortunately, we simply did not have time to write it, type it, paste it up and get it printed. This process usually takes about 3 weeks - and we would normally have been doing this in late December and early January. As most of you know, during that period the Voyager was on its historic "round the world" flight and we were heavily involved in that effort. Burt, Mike and Sally departed from Mojave in a Beech Duchess very early in the morning of December 14, 1986. They arrived over Edwards Air Force Base so early the tower had not even opened! After a few minutes of conversation with Edwards Approach Control, the runway lights were turned on and the Duchess landed and taxied to the "hammerhead" area of runway 4 where the Voyager had been parked all night while Bruce Evans and his crew had worked virtually all night fueling her up for the world flight! The wings and canard were covered in household bedsheets! This was an effort to prevent the formation of frost on the flying surfaces. These sheets had been loaned by many homeowners from the town of Mojave.

Obviously, there is not nearly enough space in this newsletter to cover an event of this magnitude in any detail, however we would like to share a few highlights with you.

The take-off roll! Wow! We lined up on Runway 4 off the right wing of the Voyager. Burt was ready with his video camera as Mike eased in the power. The Duchess slowly rolled with the Voyager as she started on what we think may be the longest take-off time ever! At the 7,000 foot marker, we still were not going fast enough to lift off in the Duchess! The Voyager wingtips were dragging on the runway, Jeana was calling out indicated airspeeds each thousand feet, and the Voyager was behind schedule on speed.

Finally, we lifted the Duchess off and continued following the Voyager while we were a few feet off the ground. The end of the runway was rapidly approaching, the end of the 15,000 foot runway! Finally, Jeana called 87 knots, the speed Burt had predicted the Voyager would need to fly. Dick began to rotate and slowly, magnificently, the wingtips rose off the runway and the wings bent into a graceful arch - she lifted off with less than 1,000 feet of runway remaining! The take-off roll lasted for an unbelievable 2:04 minutes! The excitement in the chase plane was short-lived when we realized that the winglets were failing. The frightening moment when the winglets failed and fluttered off, ripping the top and bottom wing skins inboard to the outboard wing tanks - the beautiful sight as the Voyager crossed the coast at Point Mugu and headed out over the Pacific - these are the unforgettable memories. We followed them in close formation until we were almost 300 miles off the coast. A last careful look at the engines, wings, everything but the wingtips looked optimum. We said our tearful "good- byes", waved to Dick and Jeana, and with difficulty, turned 180 degrees and headed back to the coast.

Working in the Communications trailer at Mojave, some highlights come to mind: threading the needle, when Len Snellman guided Voyager around the cyclone "Marge" out in the Pacific - fighting sleep near Sri Lanka - trying to persuade Dick to quit flying and go to sleep - trying to figure out what was going on in the fuel system. The storms and unfriendly countries in Central Africa - oil starvation in the middle of the Atlantic at 4:00 am - the right side fuel transfer pump failing - both engines stopped, gliding for a full five minutes off the coast of the Baja Peninsula at 2:00 in the morning on the

last night. Jeana re-plumbing the fuel system and then they can pump fuel from the right side - both engines running. Burt and Mike leaving the trailer at 4:30 am to take off in the Duchess to greet the Voyager and escort her in.

At first, we communicated via the trailer and HF. Then suddenly, we were able to talk plane-to-plane on VHF. We tracked out of Seal Beach VOR on the 155 degree radial while Dick and Jeana tracked inbound on the same radial with a 1,000 foot altitude difference. It was a black night over the Pacific, almost 100 miles off the coast and we were about to attempt a night join-up. The Voyager had only a very small strobe on the bottom of the left boom tank just aft of the wing. Our DME to Seal Beach was the same - we did not see them, we turned 180 degrees and descended 1,200 feet - now we were 200 feet below them and suddenly, there was a small strobe. Mike requested Dick turn off the strobe for identification and, yes, it was the Voyager, and tears flowed. Slowly we stepped closer, like an apparition, the dark shadow of the Voyager with almost perfectly straight wings, appeared against the background of clouds over the Los Angeles Basin.

The emotional join-up was something Burt and Mike will never forget. There, after completely encircling the globe, was Voyager containing Dick and Jeana, so close we felt we could touch them. It was incredible.

As the day dawned, we sailed over Los Angeles, over an almost solid cloud deck at 10,500 feet. An airliner curved around and descended across our bow as our Duchess flown by Mike and Burt, TV/camera plane flown by Fitz Fulton, the Grumman Tiger flown by Doug Shane, and the Beech Sierra flown by Crew Chief Bruce Evans, all joined up on the Voyager. And we all headed for Edwards.

The excitement of flying off the edge of the clouds and seeing Edwards and Rogers Dry Lake far below, clear and calm; the talk over the radio with Edwards and between all the chase planes and Voyager: the sight of all the thousands of people who had got up at 2 and 3 o'clock in the morning to line the edge of the dry lake as Dick and Jeana flew several passes over the crowd - these are the memories.

Finally, the gear is down, and we float into land on the compass rose, right behind the Voyager. What an effort, what an incredible achievement, what a super couple of real live heroes, Dick and Jeana. What an unbelievable airplane, the Voyager. Success at last! The last major unlimited world record

in atmospheric flight, captured forever by Voyager and the Voyager team. Congratulations Burt, Dick and Jeana - and the whole team of Voyager volunteers.

Burt has put together a technical talk that includes slides and some exciting original videos of Voyager testing and the world flight. He is doing a limited number of these talks to large engineering audiences.

Topic 10 • VOYAGER CREW, DICK & JEANA RESUMES

Ref: PROJECT MANAGEMENT JOURNAL

Richard "Dick" Rutan was born on July 1, 1938, in Loma Linda, California, the eldest of George and Irene Rutan's three children. On his 16th birthday, he received his student pilot's license as well as his driver's license.

After graduation from high school in Dinuba, California, Dick joined the Air Force Aviation Cadet program, where he later received a Bachelor of Science Degree at the American Technological University through the Air Force Professional Education "Boot Strap" Program.

As a Tactical Air Command fighter pilot during most of his two decades in the Air Force, Rutan flew 325 combat missions in Vietnam. While on his last Strike Reconnaissance mission over North Vietnam in September of 1968, he was hit by enemy ground fire and forced to eject from his burning F-100 and was later rescued by an Air Force "Jolly Green" Helicopter.

Before retiring from the Air Force in 1978, Lt. Col. Rutan had been awarded the Purple Heart, the Silver Star, five Distinguished Flying Crosses and 16 Air Medals.

After retirement, Dick joined his brother Burt, as Chief Test Pilot at Rutan Aircraft Factory. He flew the first flight of the Defiant, the Beech Starship Proof-of-Concept Prototype and the Fairchild sub-scale T-46 demonstrator Aircraft.

In 2019 Dick and his wife Kris moved from the California desert to North Idaho, to be close to his brother Burt.

Dick died on May 3rd, 2024. You can view the tribute shown at his memorials here:

Remembering Dick Rutan Video

Jeana Yeager was born on May 18, 1952 - in Fort Worth, Texas. Most of her early years were spent in Garland, Commerce, and Houston, Texas, where she developed her love of horses. She became an expert rider, training horses at the early age of 10.

In 1977, Jeana moved to Santa Rosa, California, where she continued studying the fields of energy, aerospace design, and commercial engineering draftsmanship. For several years, she worked in engineering and administration for Thermogenics, Inc., a Geothermal firm, and then for Robert Truax's Private space Enterprise, aimed at developing a reusable spacecraft for the private. If it continued, she might have been the first non-government astronaut.

That same year, Jeana met Dick Rutan, then learned to fly airplanes. She soon set FAI and NAA world records for speed and distance in the VariEze and Long-EZ homebuilt aircraft.

In 1981, Dick Rutan and Jeana Yeager founded Voyager Aircraft, Inc. They crewed the Voyager round-the-world-non-refueled milestone flight in December 1986.

A Unique Voyager Salute by Aviation Week

Salute to Voyager

For years it has been the tradition at AVIATION WEEK & SPACE TECHNOLOGY to devote this page in the first issue of the New Year to a listing of those individuals who made outstanding contributions in the field of aerospace during the preceding 12 months. At the risk of breaking a time-honored tradition, Aviation Week will postpone its annual Laurels editorial until the second issue of 1987 and devote this column to a single extraordinary event that occurred in the closing days of 1986. That event, of course, was Voyager's spectacular nonstop, unrefueled flight around the world.

The nine-day, 25,000-mi. odyssey Dick Rutan and Jeana Yeager completed in the unique Voyager aircraft, designed and built by Burt Rutan and his talented team at Mojave Airport, Calif., captured the attention of citizens around the world. If one had to cite the single most important accomplishment of this fantastic flight, tops on the list would be the respite it gave a world jaded by a daily diet of turgid reports on the political scandal in the U. S., terrorist attacks and riots in Europe, human rights outrages in the Soviet Union and South Africa, and the interminable fighting in the war-ravaged Middle East and Afghanistan.

News agencies around the world broadcast daily—sometimes hourly—reports of the Voyager crew's progress starting with their harrowing takeoff from Edwards AFB, Calif., Dec. 14; through their nine-day battle against the weather, mind-numbing fatigue and a sometimes cantankerous flying machine, and finally to their triumphant return to California Dec. 23. After several graceful flybys over the large welcoming crowd at Edwards, during which he seemed reluctant to end the flight, Dick Rutan brought Voyager in for a whisper-soft landing on the Edwards dry lakebed.

A Triumph of Spirit

Many questions have been raised about the technological or operational significance of the Voyager flight, as if the undertaking needs to be justified on the basis of the spinoff it will provide to military and civil aviation endeavors. There will be more than a little of both, but why not for the moment just accept the Voyager flight for what it was—a triumph of the human spirit?

The flight culminated a six-year quest by the Brothers Rutan, Jeana Yeager and a team of another 40 persons, many of whom donated their time. Where else but in the U. S. could a project of this magnitude take form during a discussion between two brothers over lunch in a small desert town coffee shop? Once Burt sketched the design he thought would meet the challenge of carrying two pilots more than 25,000 mi. without enroute stops or aerial refueling, the dream came alive and there was no looking back.

The Rutan brothers are unique individuals with many different personality characteristics. But they share an ability to doggedly pursue their dreams and are complementary in many other ways that ideally suited them for achieving this historical feat. Burt brought his design genius to bear on the project, while Dick applied his piloting skills and extensive operational experience. Jeana Yeager, who also has a solid aviation background, added an entirely different element to the formula and proved to be a steadying influence both during the development of Voyager and throughout the globe circling flight.

It is difficult to estimate the total cost of the Voyager project because so many members of the team volunteered their time and several corporate sponsors donated goods, services and equipment. An estimated price tag of $2 million has been put on Voyager, but the actual figure could well be less than that. Even if it were double the estimate, it still would be a bargain as well as a tribute to the low-key, cost-effective way things are done around the Rutan Aircraft Factory at Mojave Airport.

Technology Breakthrough

The aircraft was handbuilt over a period of 18 months by Voyager Aircraft, Inc., a company Dick Rutan and Jeana Yeager formed specifically to develop a machine that could complete the record breaking flight. The final product is an unusual twin-engine design—ungainly and yet sleek, streamlined and beautiful in its own way. Its primary breakthrough is the way in which it combines a variety of advanced, and yet state-of-the-art technologies, ranging from its graphite composite and honeycomb structure to its slim 110.8-ft. high-aspect-ratio wing.

In fact, Burt Rutan said early in the Voyager design process that the basic rule was to keep the aircraft simple and avoid using any experimental or otherwise unproven systems or technology. Other than the use of graphite composite for all elements including basic structure, this policy generally was followed. The one exception—an initial attempt to use advanced propellers—almost brought the project to grief when a modified blade broke loose during a test flight and the resultant vibration of the unbalanced propeller tore the forward motor off its mount before Dick Rutan could shut it down.

With the successful globe girdling flight completed, engineers from NASA, the Defense Dept. and various aerospace companies will want to inspect the Voyager airframe and add their assessments to the growing database on composite structural materials. Proponents of high-altitude, long-endurance (HALE) aircraft for various manned and unmanned reconnaissance and surveillance missions will take heart in Voyager's endurance. And, aerodynamicists and structural engineers will draw insights from Voyager's performance, which enabled it to lift a whopping ten times its basic structural weight.

In the final analysis, however, the Rutan brothers, Jeana Yeager and the Voyager team are to be saluted for an even greater achievement—the excitement they generated as their ungainly craft chugged around the world at an average speed of 115.8 mph. It is heartening that the spirit of the early age of aviation could be felt again in a world grown accustomed to the fire, smoke and sonic booms of the supersonic jet and space age.

Another famous aviation brother team—the Wrights of Dayton, Ohio—would have loved it.

—DONALD E. FINK/New York

END OF CHAPTER 29