

# NASA Vision & Mission

## **NASA vision for the future is:**

- To improve life here,
- To extend life to there,
- To find life beyond

## **The NASA mission is:**

- To understand and protect Earth
- To explore the Universe
- To inspire the next generation
- as only NASA can





# Gliding Experiments of the Wright Brothers

## The Wrights and Flight Research 1899-1908

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Al Bowers

Jennifer Hansen Cole

Cam Martin

NASA Dryden Flight Research Center

# Background: The Times

## Transcontinental Railroad...



- the great engineering achievement of the time
- understanding of “two-track” vehicle systems (buggys, carts, & trains)
- completed on 10 May 1869 (Wilbur was two years old)

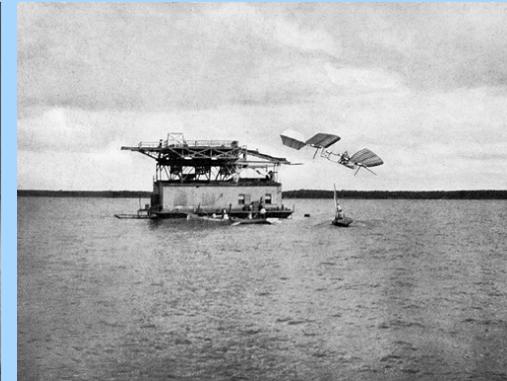
# Otto Lilienthal

- Glider experiments 1891 - 1896



# Dr Samuel Pierpont Langley

- Aerodrome experiments 1887-1903



# Octave Chanute

- Gliding experiments 1896 to 1903



# Wright Brothers Timeline

- 1878 The Wrights receive a gift of a toy helicopter
- 1895 The Wrights begin to manufacture their own bicycles
- 1896 The Wrights take an interest in the "flying problem"
- 1899 Wilbur devises a revolutionary control system, builds a kite to test it; also writes the Smithsonian.
- 1900 The Wright brothers fly a glider at Kitty Hawk, NC
- 1901 The Wrights fly a bigger glider at Kitty Hawk, NC
- 1901 In Dayton, OH, they build a research wind tunnel
- 1902 The Wrights perfect their glider and learn to fly
- 1903 The Wright brothers make the first controlled, sustained powered flight at Kitty Hawk.
- 1905 In Dayton, the Wrights develop a practical airplane

# Wright Brothers' Paper

**WEST SIDE NEWS.**

Vol. 1. DAYTON, OHIO, JULY 20, 1888 No. 15

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<p style="text-align: center;"><b>West Side News.</b></p> <p style="text-align: center;">PUBLISHED WEEKLY.</p> <p>Vilbur Wright      Editor Orville Wright      Publisher</p> <p>TERMS.—Quarter of year, twenty cents a year, ten cents.</p> <p style="text-align: center;">1210 WEST THIRD STREET, DAYTON, OHIO.</p> <hr/> <p style="text-align: center;"><b>Seeing a Bird's Nest.</b></p> <p>Edward Coeles, the inventor of the Coeles engine, in building an addition to his factory, while laying the foundation found it necessary to remove a ledge by blasting. The workmen had been employed, the materials provided, and the blasting begun. The next morning Mr. Coeles passed by the place where work was pro-</p>	<p>gressed out of the way, but with a genuine interest in their growth. The old birds had all the time they had steadily helped the clumsy, reluctant youngsters over the edge of the nest, and they showed themselves able to get about on their own hook, orders were given to resume the building operations; and the dull team of the propounder tearing the rocks apart was heard where the birds had perched.—<i>Boston Transcript.</i></p> <p style="text-align: center;"><b>"Dot Bargain."</b></p> <p>A little colored boy, not over intelligent but full of zeal, called at a house and requested the privilege of coming three barrels of rubbish for the sum of twenty cents. The request was granted, and the next morning the young African appeared with two con-</p>	<p>ners is more interesting to the young people than an adventure of Lasswell Metcalf, one of the best settlers of the town. Metcalf, a young man named Webber, and James Richards were out one day on a moose hunt. The only gun was carried by Richards; the two others went armed with a hatchet each.</p> <p>As the company divided, Richards kept to the base of Mt. Battie, while the others ascended it and kept the same course. Mr. Richards' two dogs had scented up an all bear on the western slope of the mountain, and, after shooting it, Mr. Richards went in search of his companions to assist them of his success.</p> <p>In the mountains, Metcalf and Webber had found the lake, where the two cubs, of considerable size, were seated. They tried to drive them out of the den, by building</p>	<p style="text-align: center;"><b>F. M. NIPGEN,</b> DEALER IN <b>DRUGS, MEDICINES</b> <i>Physician's prescriptions carefully compounded.</i> R. W. Cor. Fifth and Williams</p> <hr/> <p style="text-align: center;">NEW DRUG STORE. <b>WM. P. GRAYBIL</b> <i>dealer in</i> Drugs, medicines, etc. Prescriptions carefully compounded. S. E. Cor. Third and Summit</p> <hr/> <p style="text-align: center;"><b>J. W. COATES,</b> DEALER IN <b>DRUGS, MEDICINES, AND CHEMICALS</b> <i>Physician's Prescriptions carefully compounded.</i> 1143 West Third St.</p> <hr/> <p style="text-align: center;">THE</p>
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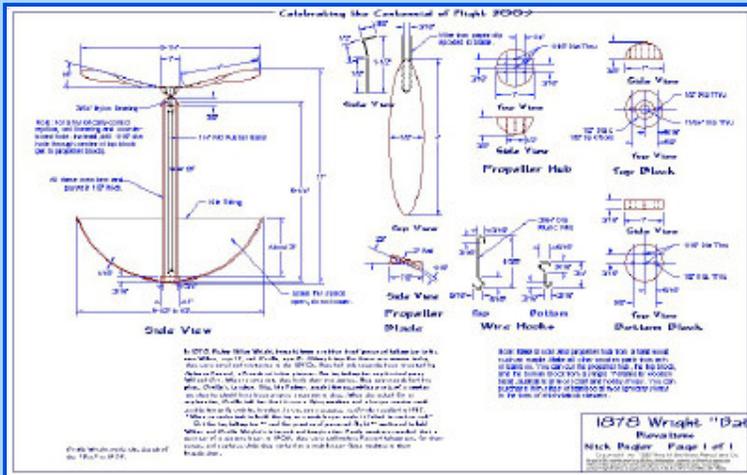
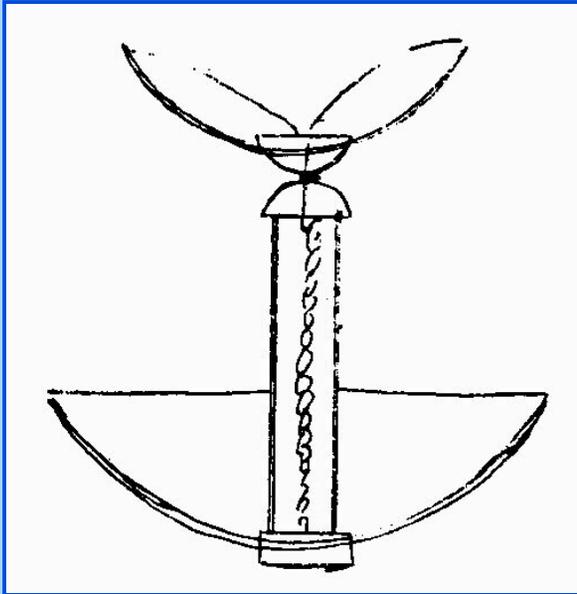
Dayton's "West Side News"

# Wright Brothers' Cycle Company

- “single-track” vehicle mechanics



# Inspiration: 1878

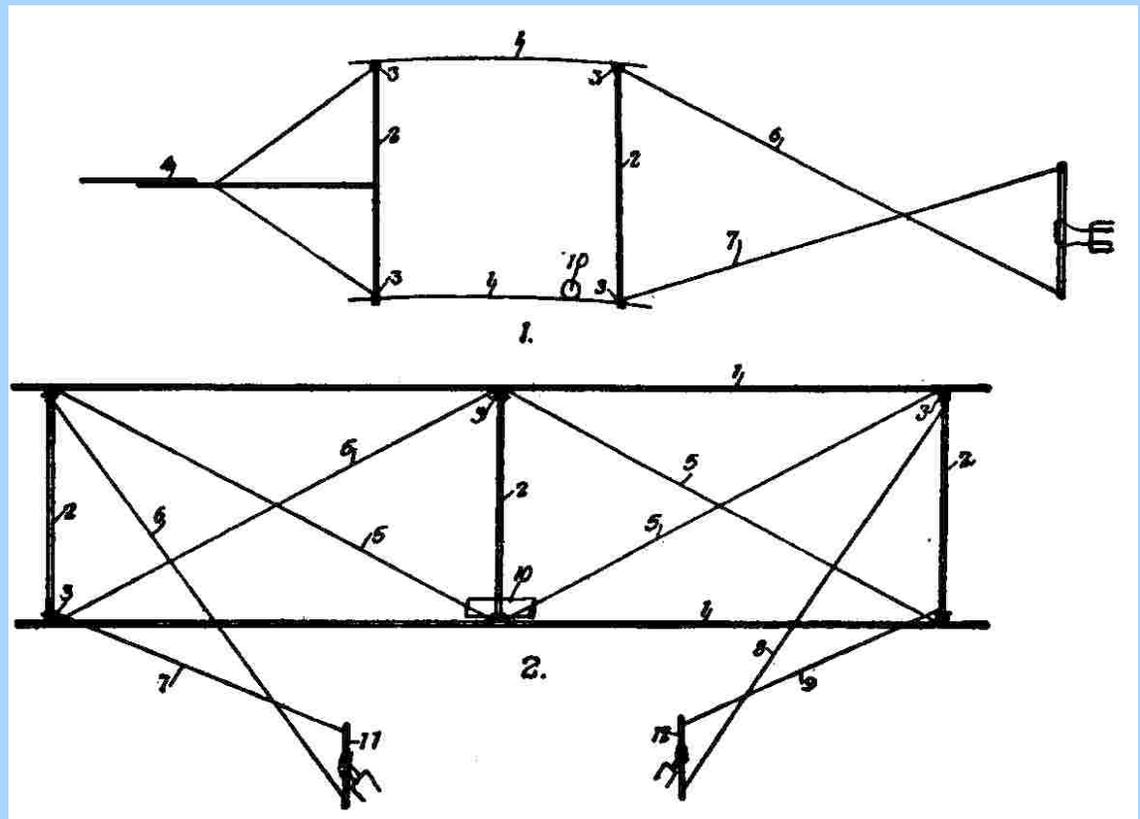


# Inspiration: July 1899



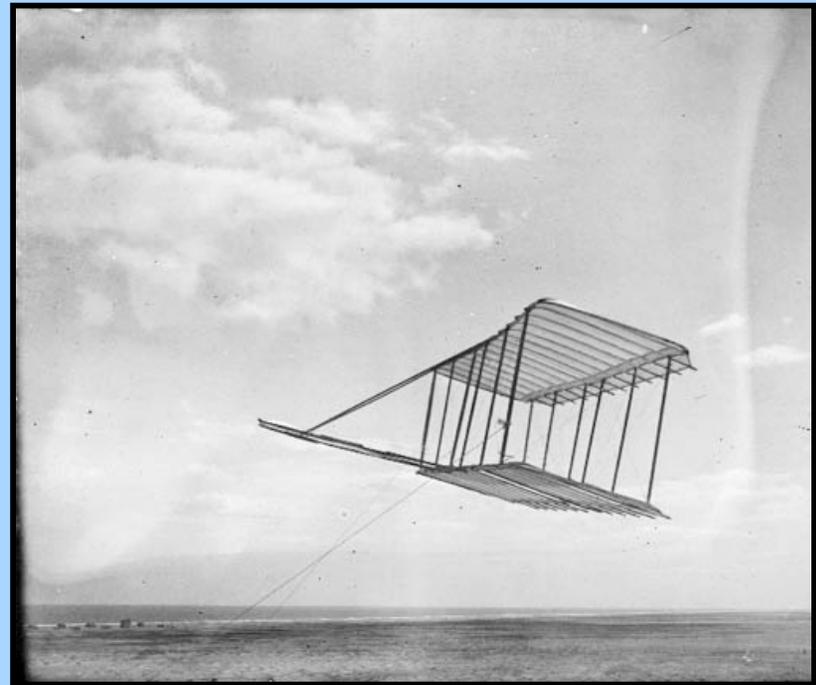
# 1899 Kite Experiments

Dayton Ohio



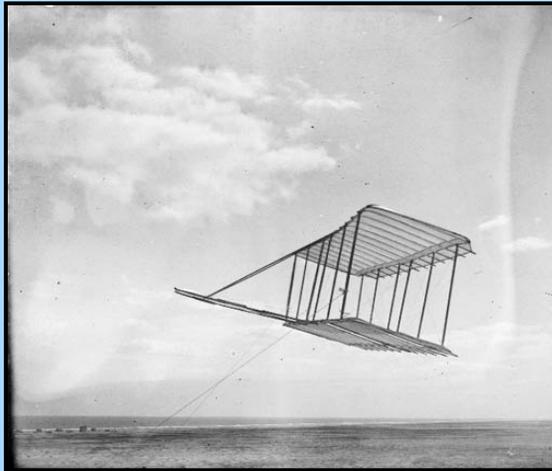
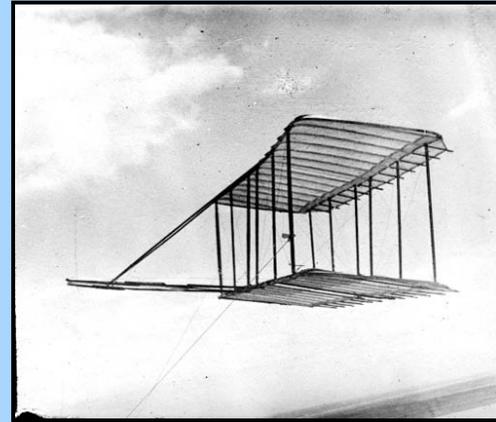
# 1900 Wright Glider

- Span: 17 feet
- Chord: 5 feet
- Gap: 4 feet, 8 inches
- Camber:  $1/23$
- Wing Area: 165 sq ft
- Weight with operator  
190 lb



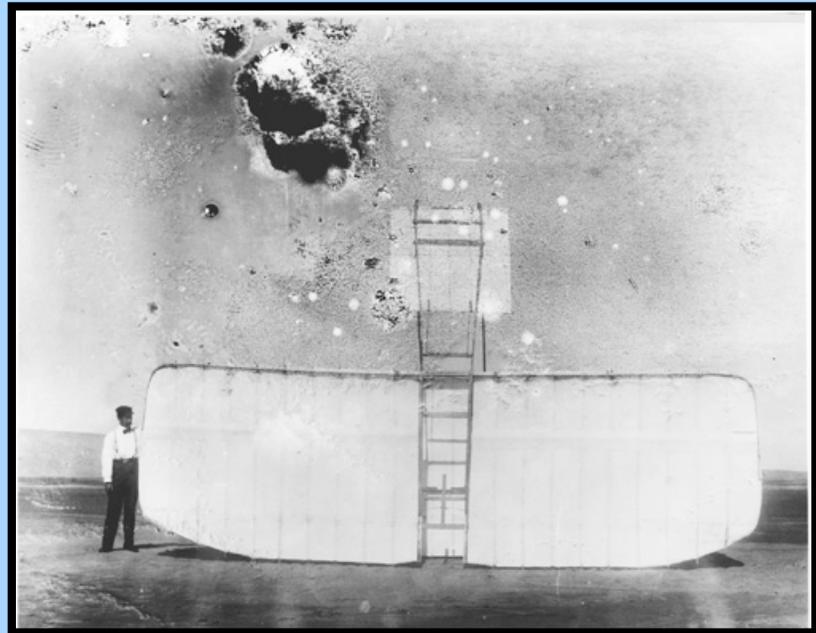
# 1900 Wright Glider

Kitty Hawk September - October 1900

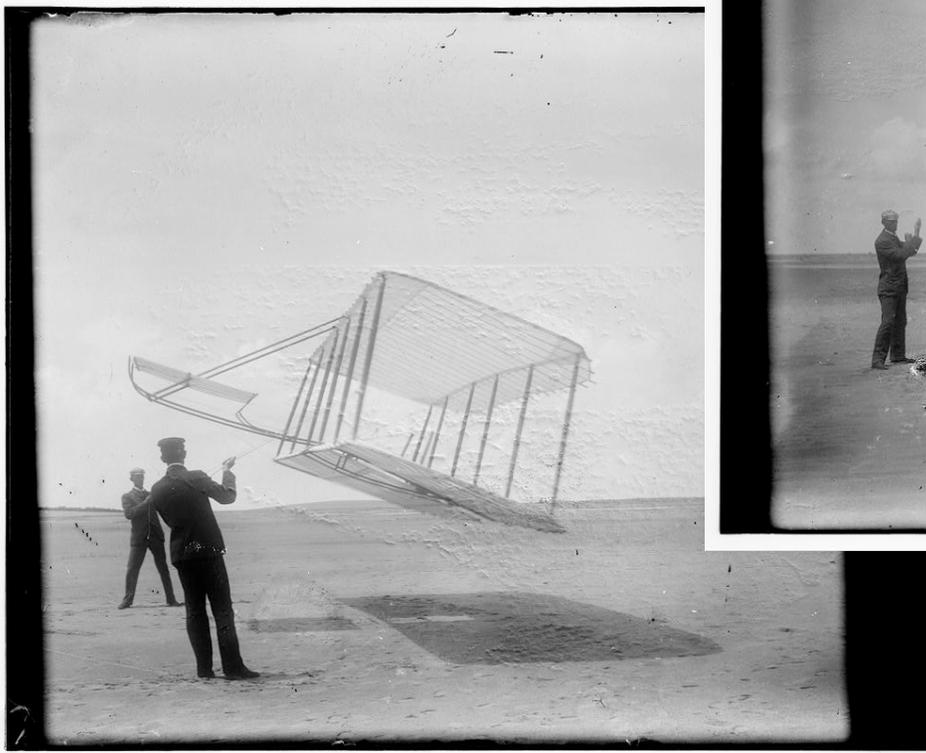


# 1901 Wright Glider

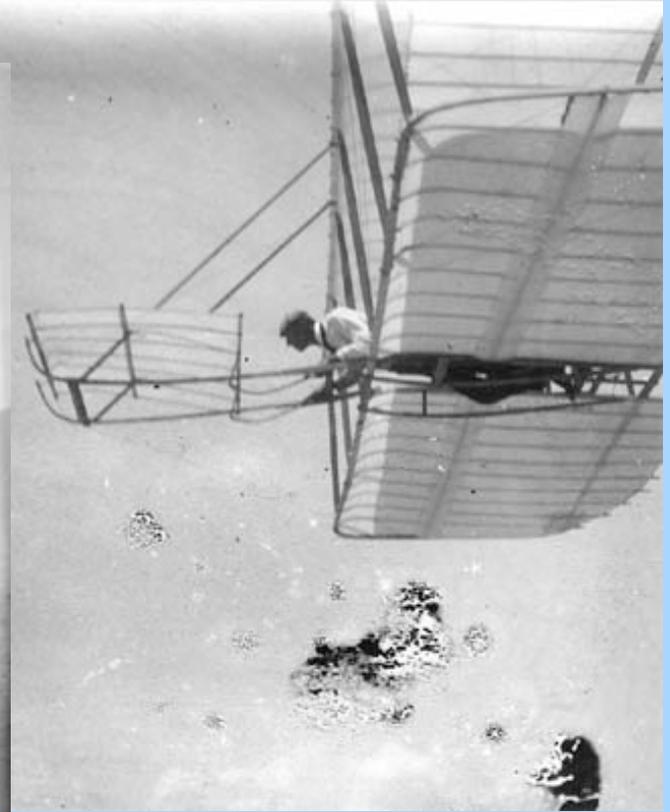
- Span: 22 feet
- Chord: 7 feet
- Gap: 4 feet, 8 inches
- Camber:  $1/17$
- Wing Area: 290 sq ft
- Horizontal Rudder Area  
18 sq ft
- Length 14 feet
- Weight 98 lb



# 1901 Glider Flown as a Kite



# 1901 Wright Flown as Glider

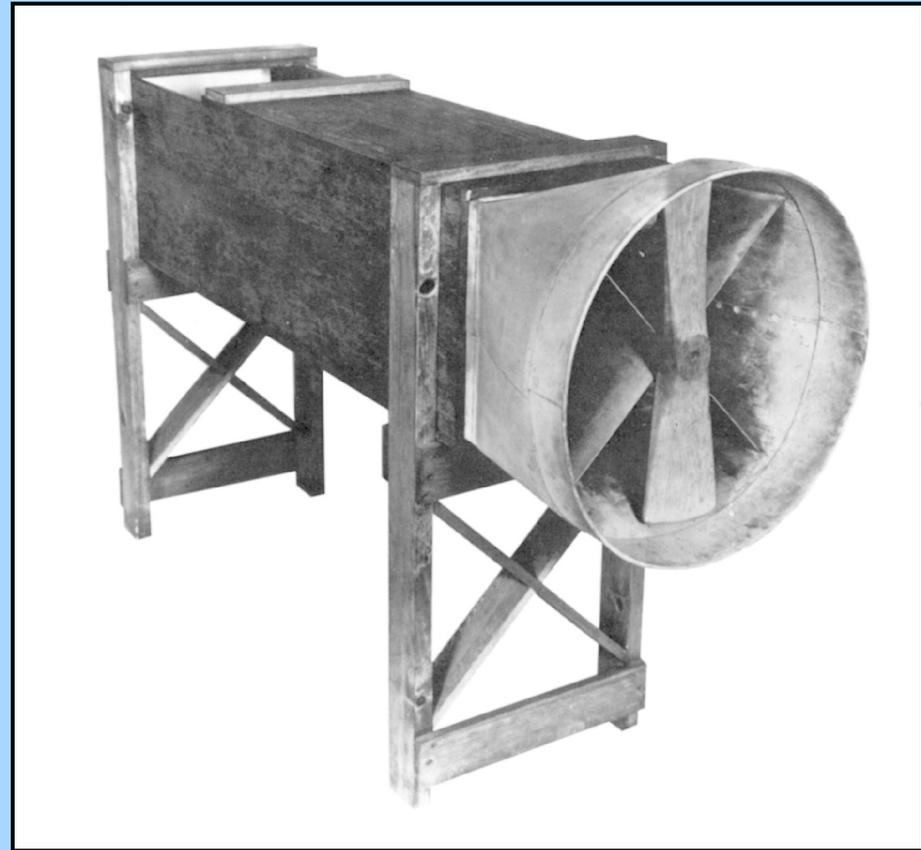


*They go home, very discouraged.*

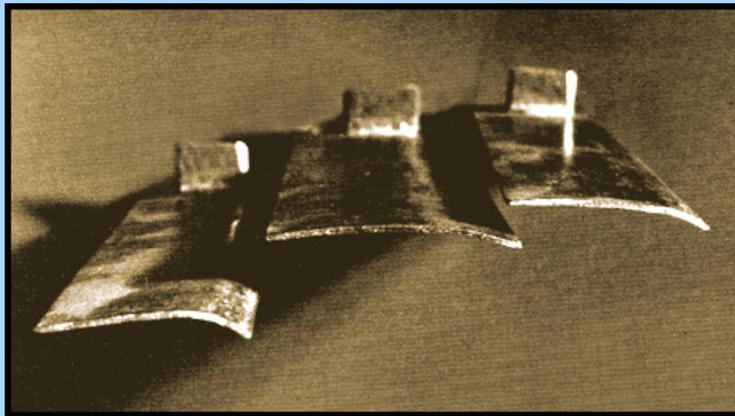
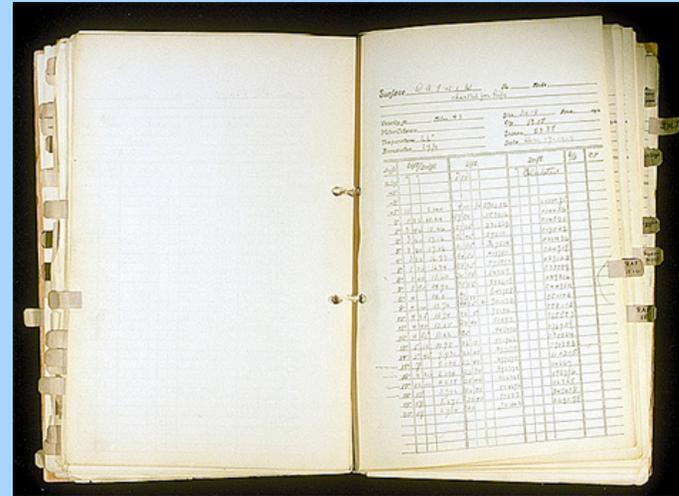
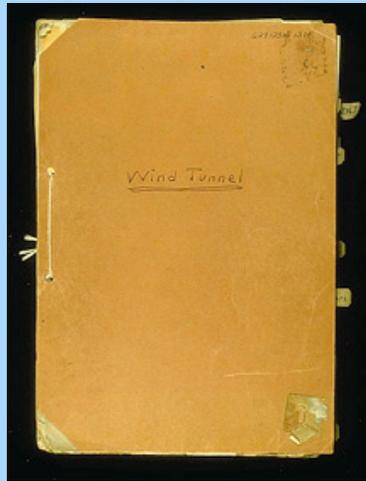
**On the train back to Dayton,  
Wilbur tells Orville that men would  
not fly for another fifty years...**

# 1901 Wind Tunnel

16 inch square section x 6 feet



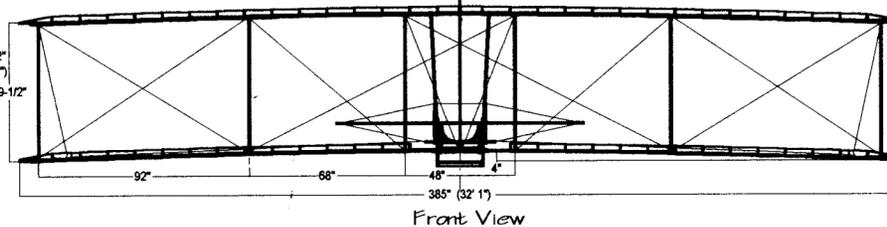
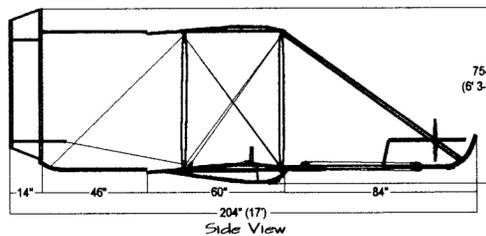
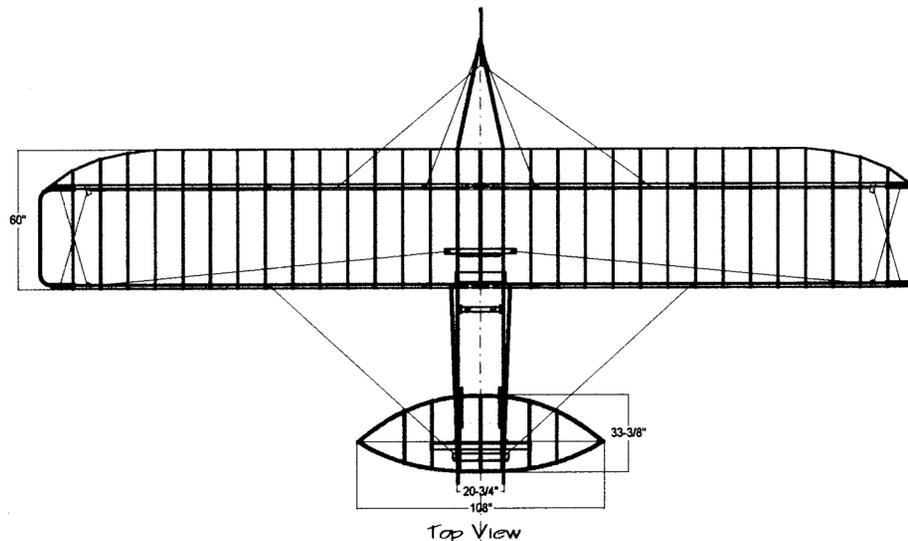
# 1901 Wright Wind Tunnel Results



# 1902 Wright Glider

## Specifications

Wingspan: 32 feet, 1 inch  
 Chord: 5 feet  
 Camber: 1/20 to 1/24  
 Anhedral: 4 inches  
 Wing Area: 305 square feet  
 Elevator Area: 15 square feet  
 Rudder area: 5.7 square feet  
 Overall Length: 17 feet  
 Overall Height: 6 feet, 3 inches  
 Gap between wings: 5 feet  
 Weight: 112 pounds  
 Number of flights: Approximately 2000  
 Longest distance flown: 622 feet  
 Longest time in flight: 1 minute, 12 seconds  
 Frame materials: Spruce, ash, waxed linen cord  
 Hardware: Mild steel, boxwood (for pulleys)  
 Rigging: 15-gauge steel wire  
 Wing covering: Cotton muslin, 209 thread count



**Not for sale or profit; these plans are to be distributed freely and free of charge.**

To help celebrate the upcoming Centennial of Flight in 2003, the Wright Brothers Aeroplane Company offers the engineering drawings we developed for the 1902 Wright Glider free. This is a wonderful project not just for those who enjoy building historic aircraft, but also for young people. If you're a teacher or a youth leader, there is no more exciting group project than an airplane and no better example of good character to expose young people to than the Wright brothers. Use these plans and distribute them with our good wishes. However, remember these are copyrighted plans and the copyright holder claims all privileges and protection afforded by law. If you use or distribute these plans, you are bound to these conditions: 1. You may not sell or profit from these plans. 2. You cannot charge copying, handling, postage, or shipping fees.

If we can contribute hundreds of hours of research, you can kick in a little paper and postage. 3. If you find a mistake of these drawings, you are honor-bound to let us know so we can correct it. 4. If you know of or discover better methods or additional suppliers of materials for building this glider than those we describe here and on our web site, you are honor-bound to tell us so we can distribute the information and continue to make this project a better experience, especially for the young people who participate. 5. You may make single copies but you may not publish these plans in any form, electronic or paper, without written permission of the copyright holder.

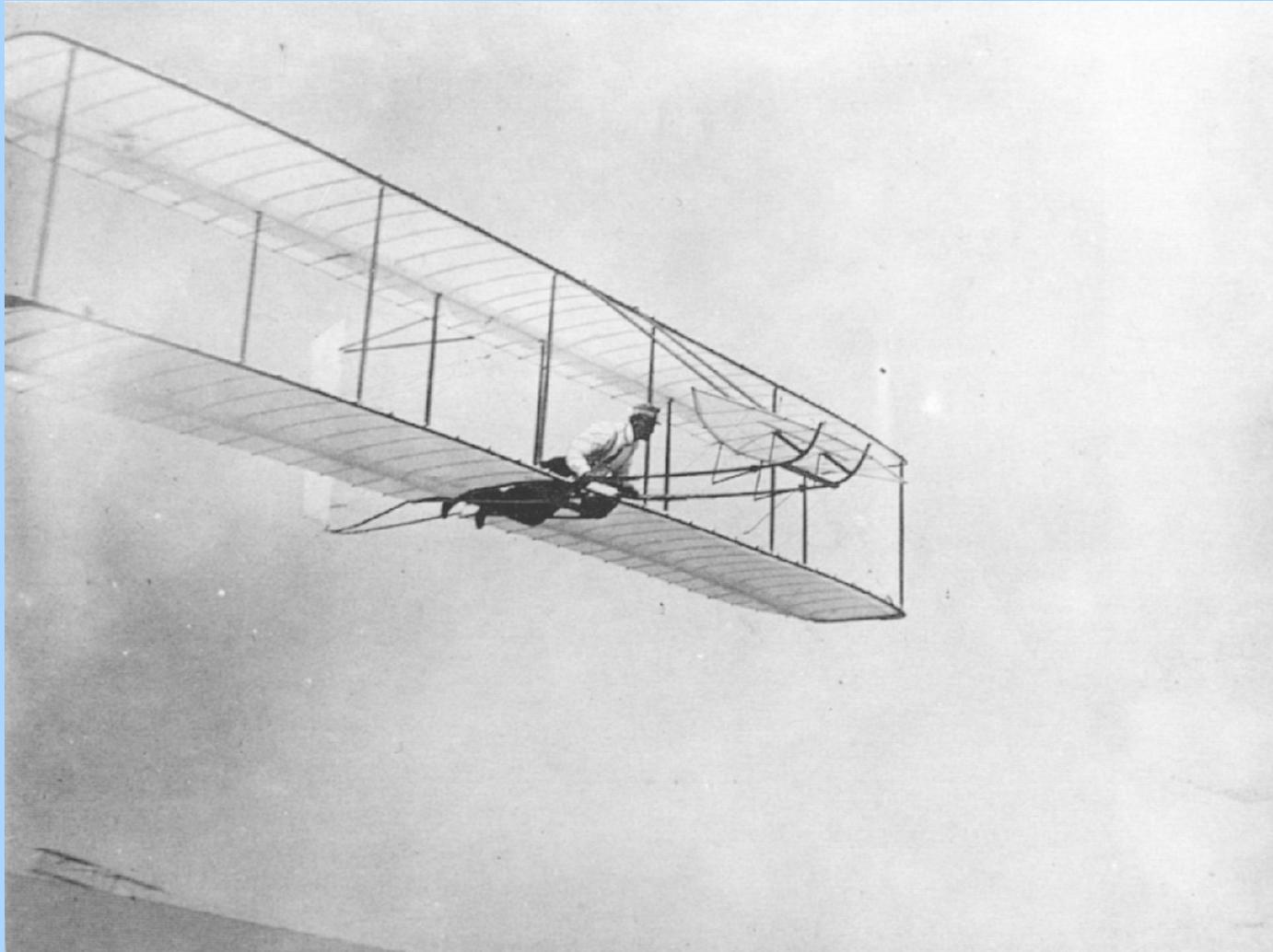
1902 Wright Glider  
 Elevations  
 Nick Engler Page 1 of 20  
 Copyright (c) 2000 Wright Brothers Aeroplane Co.  
 P.O. Box 204, West Milton, OH 45353  
[www.wright-brothers.org](http://www.wright-brothers.org)

# 1902 Wright Glider

- Span: 32 feet 1 inch
- Chord: 5 feet
- Gap: 4 feet, 7 inches
- Camber  $1/24$
- Wing Area: 305 sq ft
- Horizontal Rudder Area 15 sq ft
- Length 16 feet 1 inch
- Weight 112 lb
- Three configurations



# 1902 Wright Glider

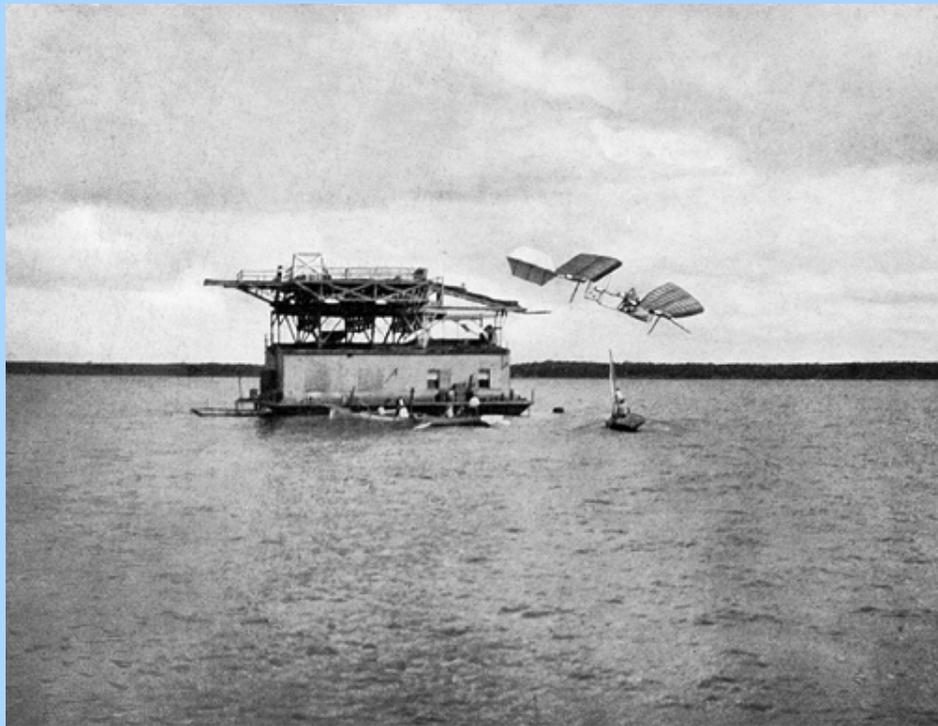


# Centennial of Controlled Flight

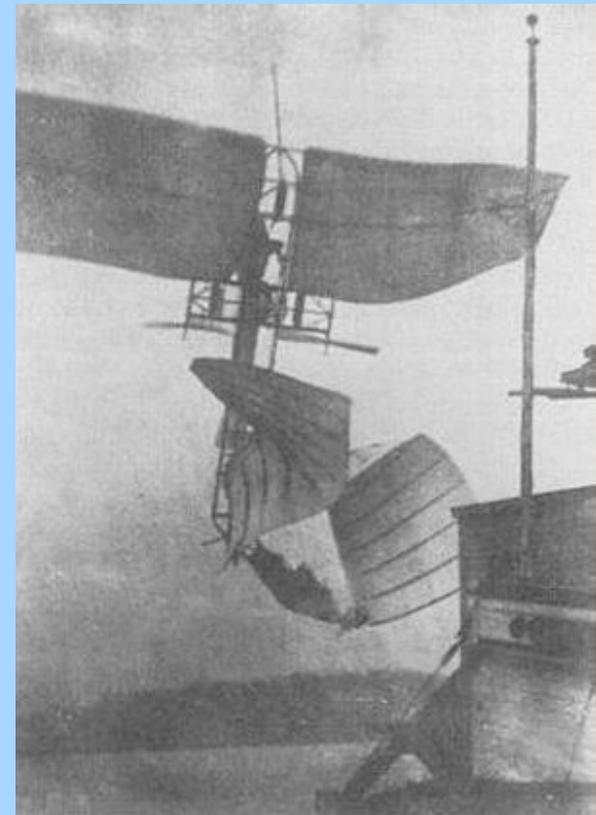
24 October 1902



# 1903 Langley Aerodrome



Oct 7, 1903

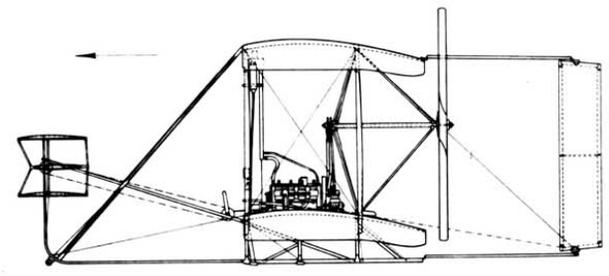
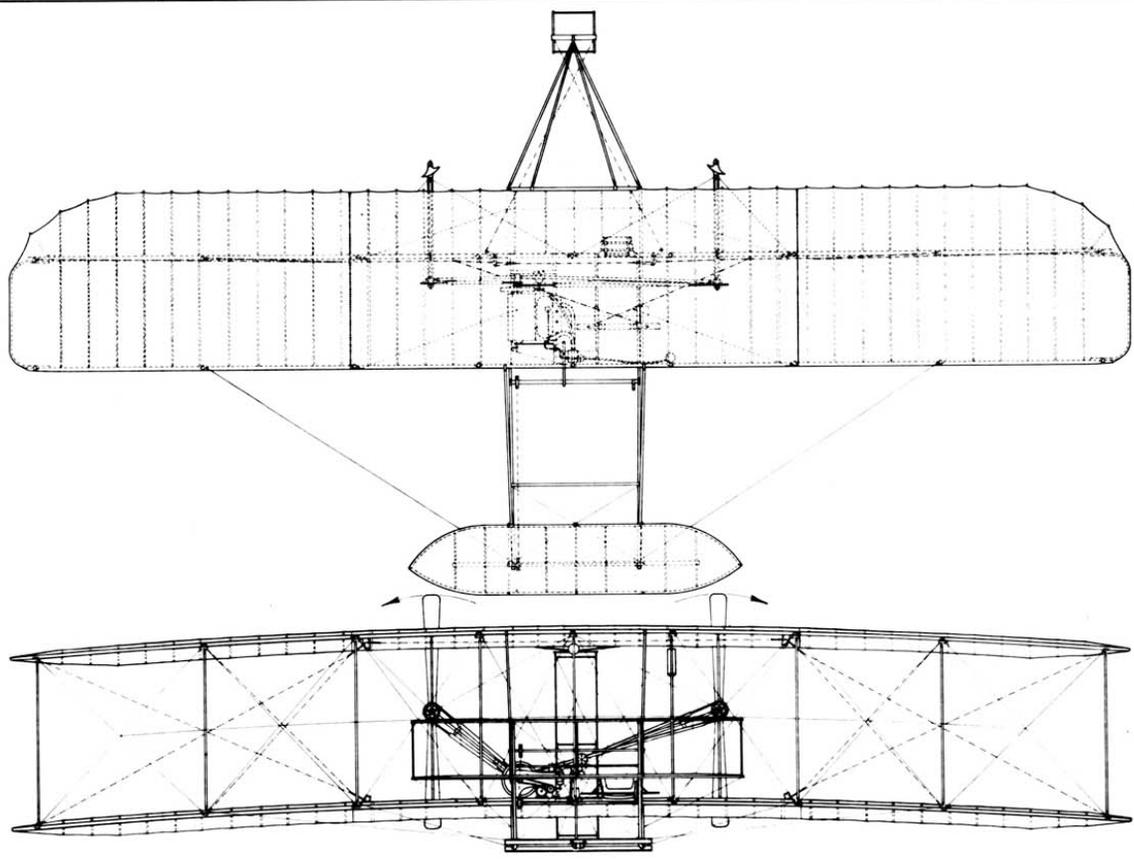


Dec 8, 1903

# 1903 Wright Flyer



SPECIFICATIONS.	
<b>EXTERIOR DIMENSIONS:</b>	
40 FT 4 IN.	OVERALL WIDTH.
21 FT. 1 IN.	OVERALL LENGTH.
8 FT. 1 IN.	HEIGHT OVER WINGS.
8 FT. 4 IN.	HEIGHT OVER SWEEP OF PROPELLERS.
8 FT. 8 IN.	WING CHORD.
1 IN. IN 20 INCHES.	WING CAMBER.
3°-25'	ANGLE OF INCIDENCE.
10 IN.	WING DROOP, (ANTI-DIHEDRAL).
<b>SURFACE AREAS:</b>	
510 SQ FT.	WING AREA, (UPPER AND LOWER WINGS).
48 SQ FT.	FRONT RUDDER AREA, (TWO SURFACES).
20 SQ FT.	REAR RUDDER AREA, (TWO SURFACES).
<b>WEIGHTS:</b>	
605 LBS.	TOTAL WEIGHT WITHOUT PILOT.
145 LBS.	PILOT WEIGHT, ORVILLE WRIGHT.
140 LBS.	PILOT WEIGHT, WILBUR WRIGHT.
<b>ENGINE:</b>	
4 CYLINDER,	4 CYCLE, HORIZONTAL GASOLINE TYPE.
4 INCH BORE,	4 INCH STROKE.
12	HORSE POWER AT 1020 REV. PER MINUTE.
152 LBS.	WEIGHT OF BARE ENGINE.
170 LBS.	WEIGHT COMPLETE WITH MAGNETO AND ACCESSORIES.
<b>ENGINE IGNITION:</b>	
LOW TENSION MAGNETO, MAKE AND BREAK SPARK.	
ENGINE STARTED WITH DRY BATTERIES, THEN SWITCHED TO MAGNETO.	
<b>ENGINE LUBRICATION:</b>	
INTERNAL SPLASH ACTUATED BY THE CRANKSHAFT.	
<b>ENGINE COOLING:</b>	
THERMO SYPHON WATER CIRCULATION THRU RADIATOR.	
<b>FUEL SYSTEM:</b>	
GRAVITY FEED THRU RUBBER TUBING FROM 0.4 GALLON CAPACITY TANK MOUNTED ON UPPER END OF WING FRONT STRUT.	
<b>LOADINGS:</b>	
1.47 LBS.	PER SQUARE FOOT WING AREA.
625 LBS.	PER ENGINE HORSE POWER.
<b>PROPELLERS:</b>	
TWIN PROPELLERS, PUSHER DRIVE INSTALLATION, CHAIN DRIVEN, ROTATING IN OPPOSITE DIRECTIONS.	
ROLLER CHAINS, 1 INCH PITCH, 5/16 DIA X 3/8 WIDTH ROLLERS.	
SPACERS: 8 TEETH ON CRANKSHAFT.	
23 TEETH ON PROPELLER SHAFTS.	
2.7:1 ENGINE TO PROPELLER R.P.M. RATIO.	
880 R.P.M. APPROX. ENGINE SPEED IN FLIGHT.	
340 R.P.M. APPROX. PROPELLER SPEED IN FLIGHT.	



— KITT Y HAWK AEROPLANE —

CONCEIVED AND BUILT AT DAYTON, OHIO, AND SUCCESSFULLY FLOWN BY ORVILLE AND WILBUR WRIGHT, DECEMBER 17, 1903, AT KITT Y HAWK, NORTH CAROLINA.

# 1903 Wright Flyer

- Span: 40 feet 4 inch
- Chord: 6 feet 6 inches
- Gap: 6 feet 2 inches
- Camber  $1/20$
- Wing Area: 510 sq ft
- Horizontal Rudder Area 48 sq ft
- Vertical Rudder 21 sq ft
- Length 21 feet 1 inch
- Weight 605 lb



# 1903 Wright Flyer

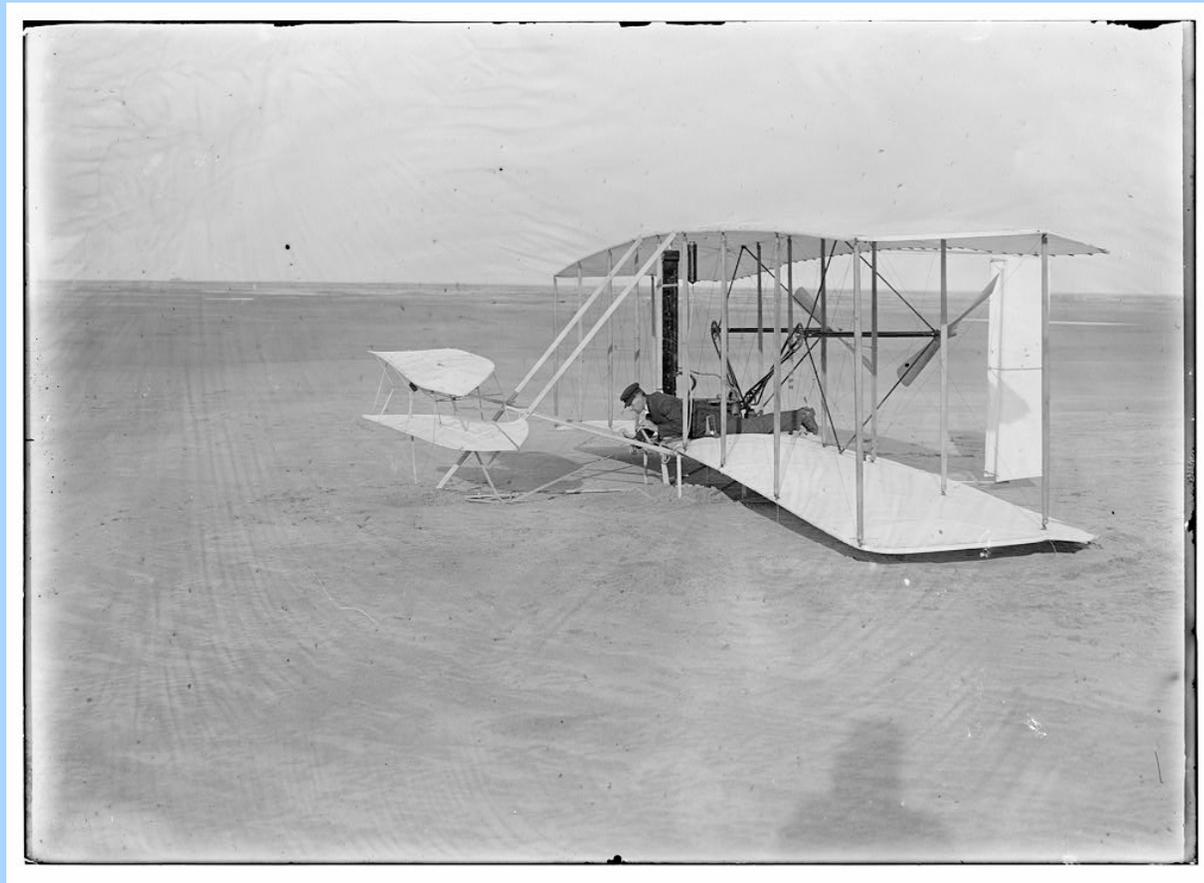
December 14, 1903



Wilbur wins the coin toss, and...

# 1903 Wright Flyer

December 14, 1903



Oops!

# 1903 Wright Flyer

December 17, 1903



# 1903 Wright Flyer



# They tell the world...

Form No. 168.

**THE WESTERN UNION TELEGRAPH COMPANY,**  
INCORPORATED  
**23,000 OFFICES IN AMERICA. CABLE SERVICE TO ALL THE WORLD.**

This Company TRANSMITS and DELIVERS messages only on conditions limiting its liability, which have been assented to by the sender of the following message. Errors can be guarded against only by repeating a message back to the sending station for comparison, and the Company will not hold itself liable for errors or delays in transmission or delivery of Unrepeated Messages, beyond the amount of tolls paid thereon, nor in any case where the claim is not presented in writing within sixty days after the message is filed with the Company for transmission.

This is an UNREPEATED MESSAGE, and is delivered by request of the sender, under the conditions named above.  
ROBERT C. CLOWRY, President and General Manager.

RECEIVED at

170

176 C KA OS 33 Paid. Via Norfolk Va

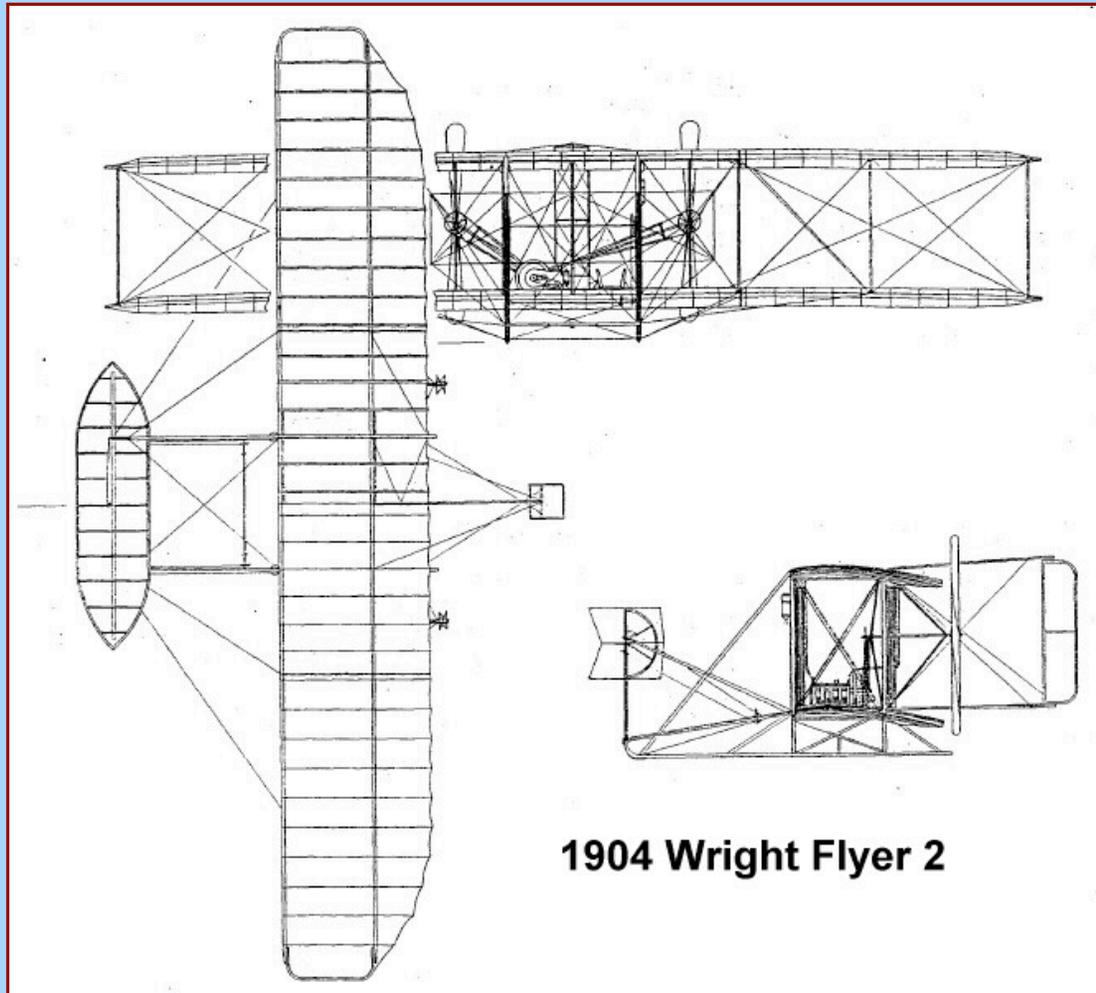
Kitty Hawk N C Dec 17

Bishop M Wright

7 Hawthorne St

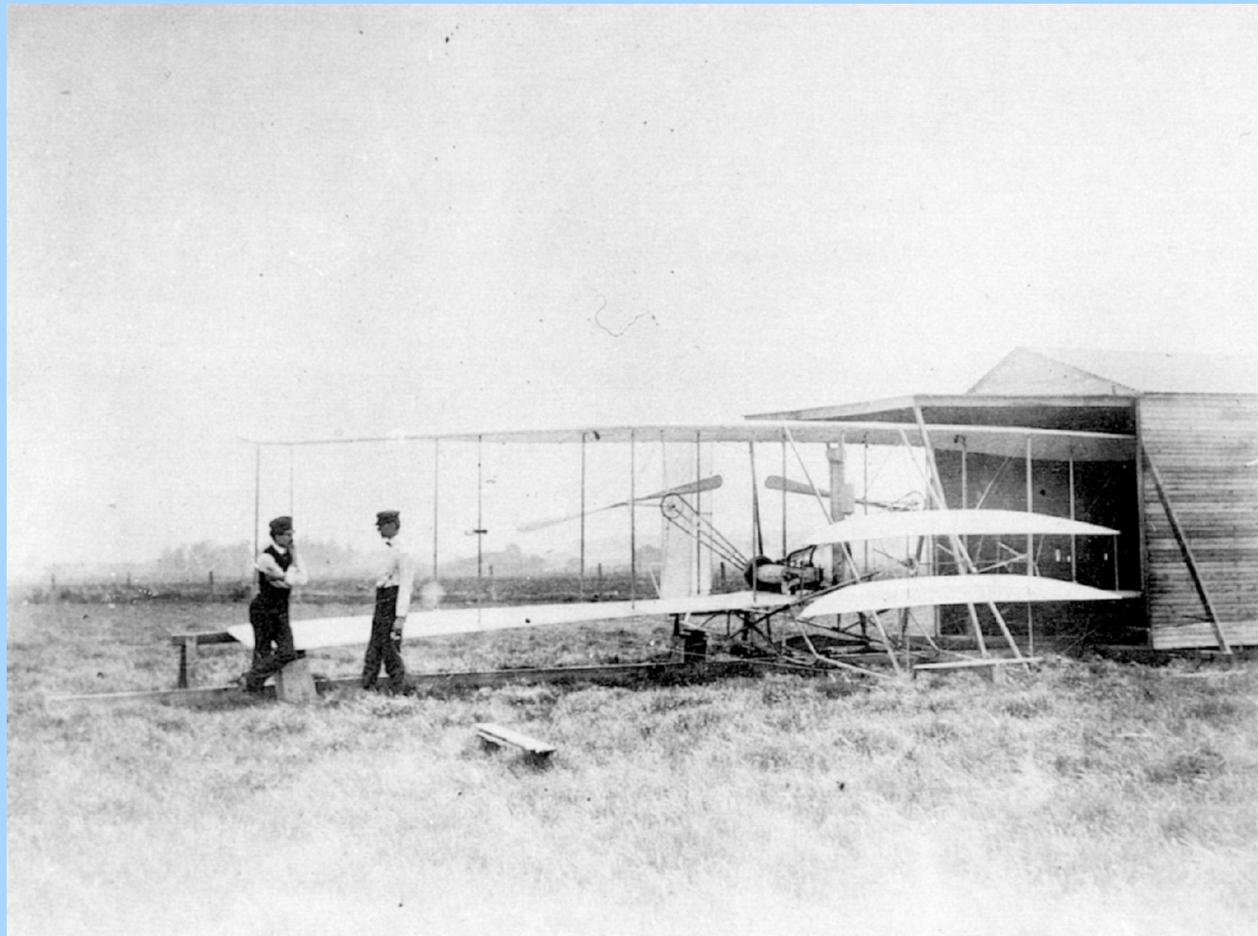
Success four flights thursday morning all against twenty one mile  
wind started from level with engine power alone average speed  
through air thirty one miles longest 57 seconds inform Press  
home ~~####~~ Christmas . Orevelle Wright 525P

# 1904 Wright Flyer



# 1904 Huffman Prairie Ohio

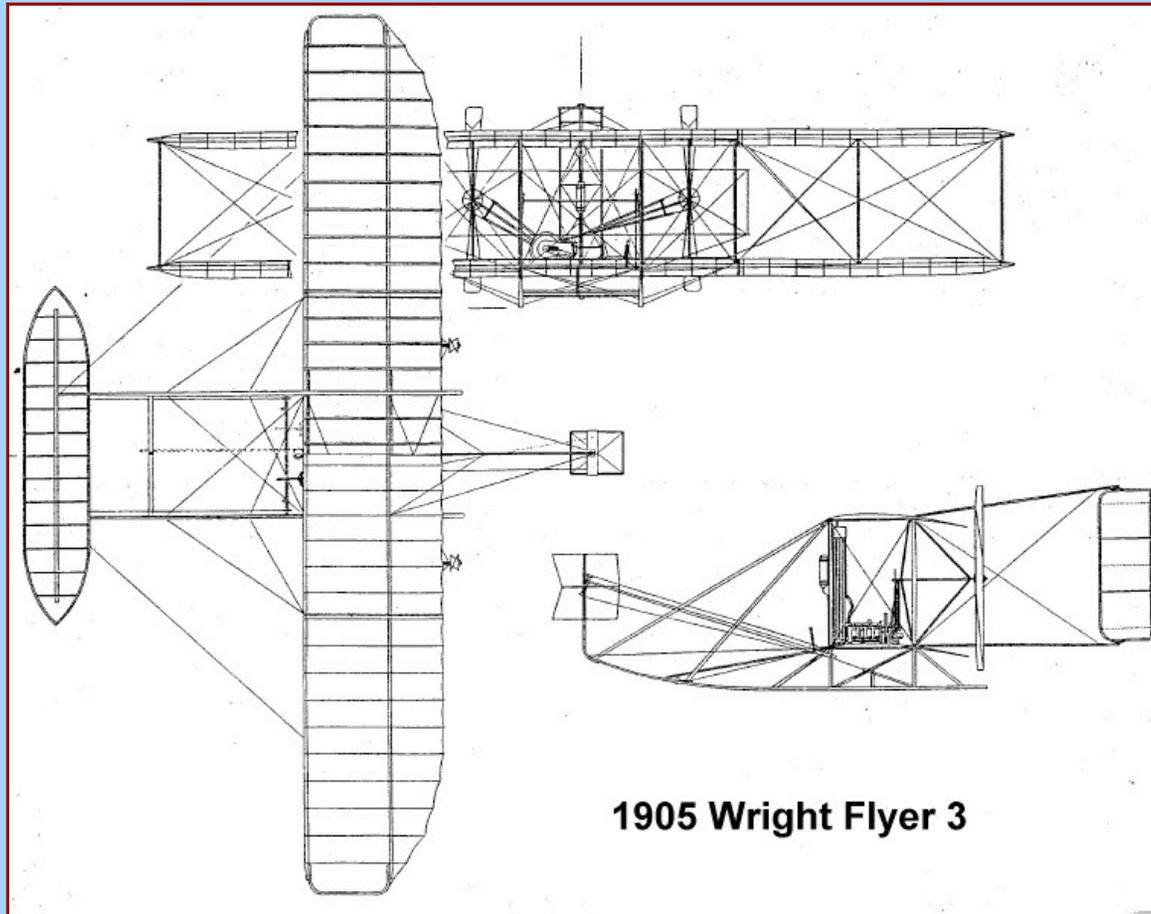
September 20, 1904 First Complete Circle in an Airplane



# 1904 Wright Flyer II



# 1905 Wright Flyer



# 1905 Huffman Prairie OH

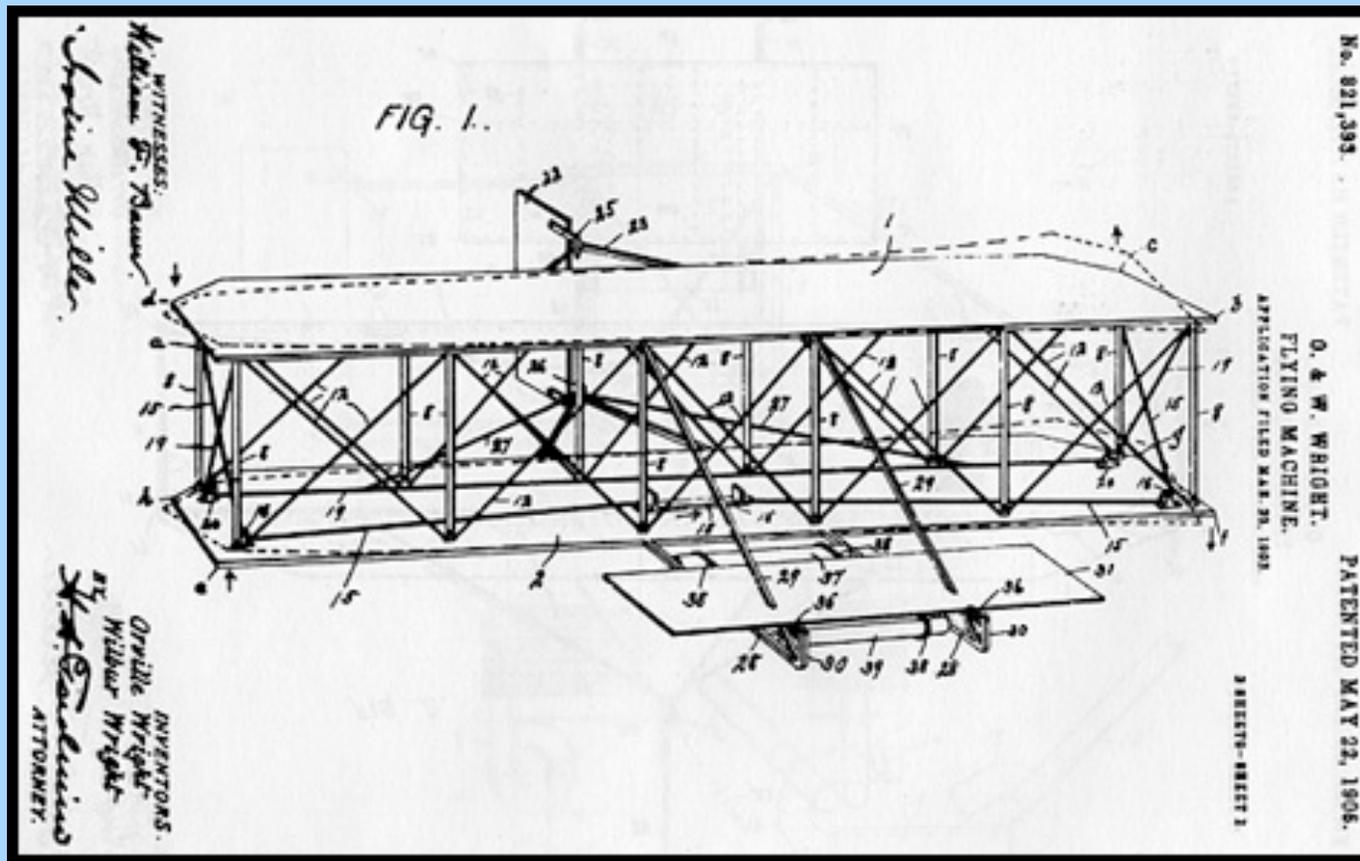
Oct 4, 1905 Extended Flight in an Airplane (38 minutes)



# Wright Flying Machine Patent

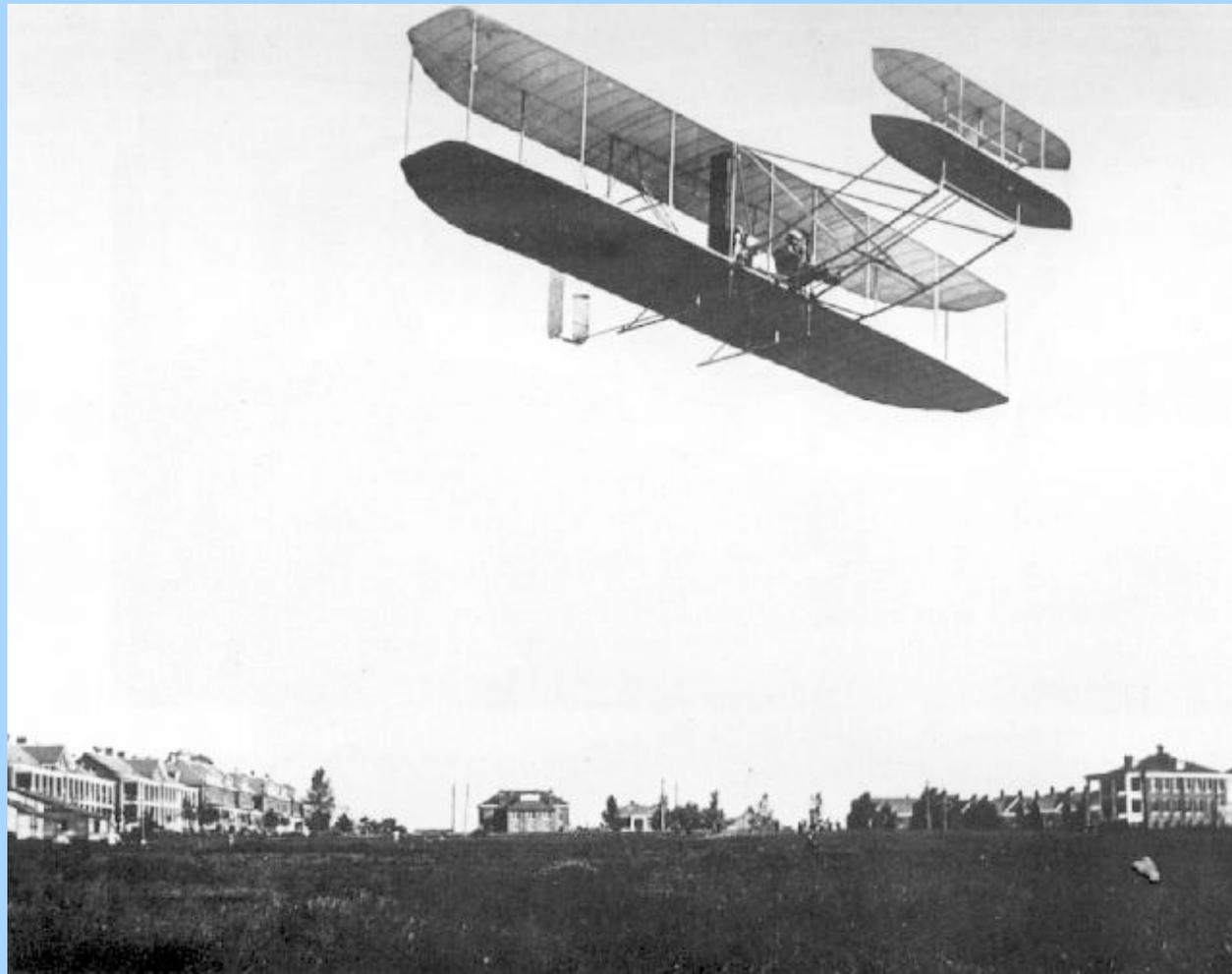
#821,393

May 22, 1906



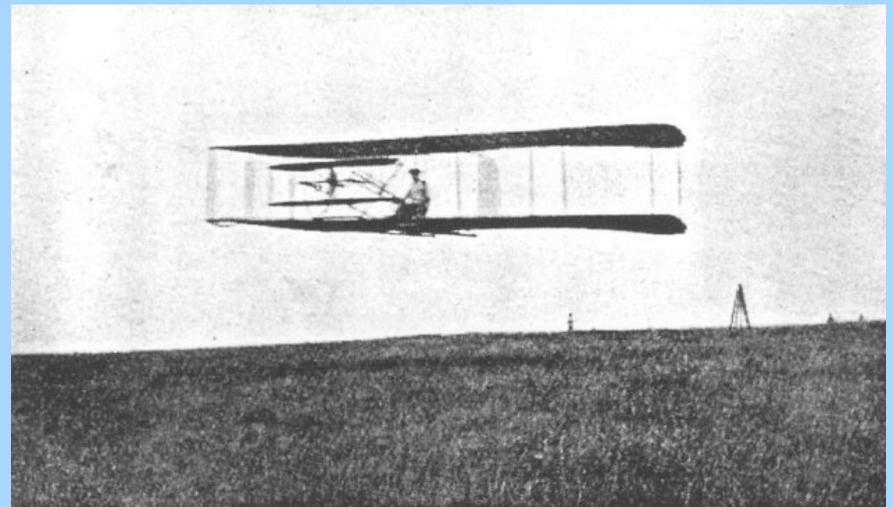
# 1908-1909 France & Virginia

Public trials of the first practical airplane



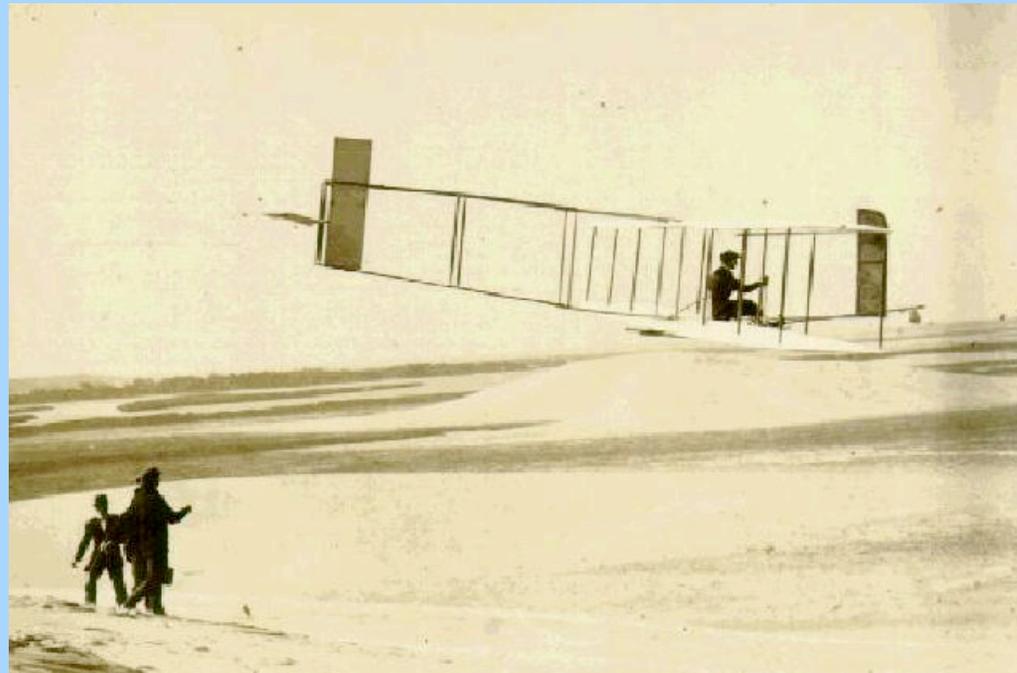
# 1909 Clarke-Wright Glider

- Built as a trainer to Wright specs



# 1911 Wright Glider

- Built for autopilot experiments
- Set duration record (9 min 45 sec)



# The Rest is History...

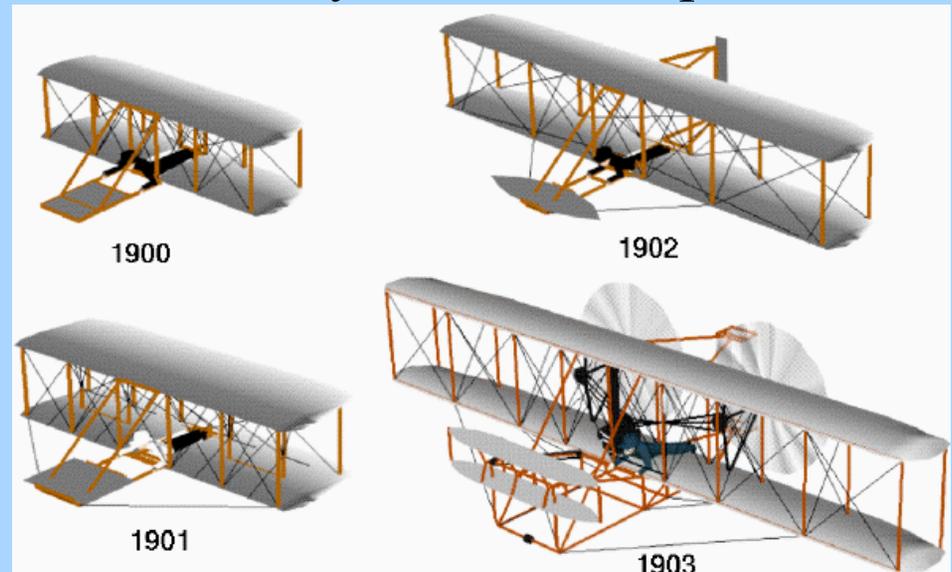
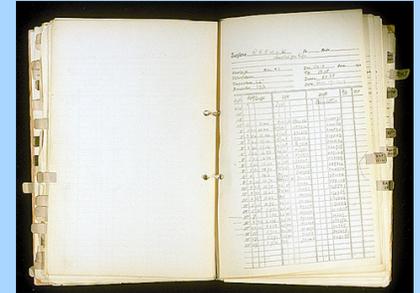
- 1904 Flights of 5+ minutes duration
- 1905 Flights to 38 minutes duration
- 1906 - 1907 Commercialization
- 1908 - 1909 Flight Demonstrations
  - Wilbur in France, Italy and Germany
  - Orville in United States
- 1909 The Wright Company is established
  - Clarke-Wright glider in England
  - Established Flying School in Alabama, OH
- 1911 Glider Experiments with autopilot
- Orville serves on NACA board from 1920 to 1948



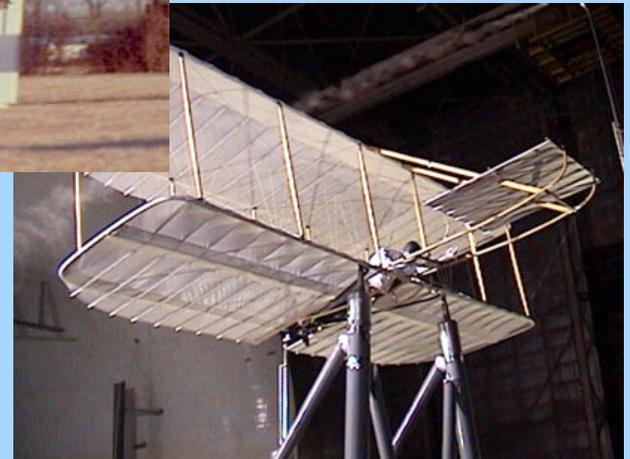
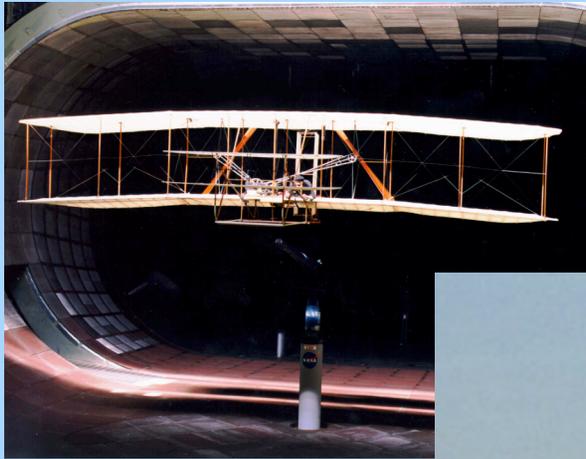
NACA Board, 1938

# Flight Research Lessons Learned Then...Still Apply Today

- Make sure you really understand the problem
- Do a literature search and read and talk
- Plan carefully...and record as much as possible
- Identify and measure your most important parameters
- Plan for the unexpected...and expect differences
- Test over a large envelope but not necessarily a full envelope
- Fly early, as much as possible
  - more visibility
  - more attention to “Real” problems
  - much more credibility
  - faster technology transfer
- *Get a simulation going ASAP*



# Understanding the Wright's Accomplishments Through Evaluation



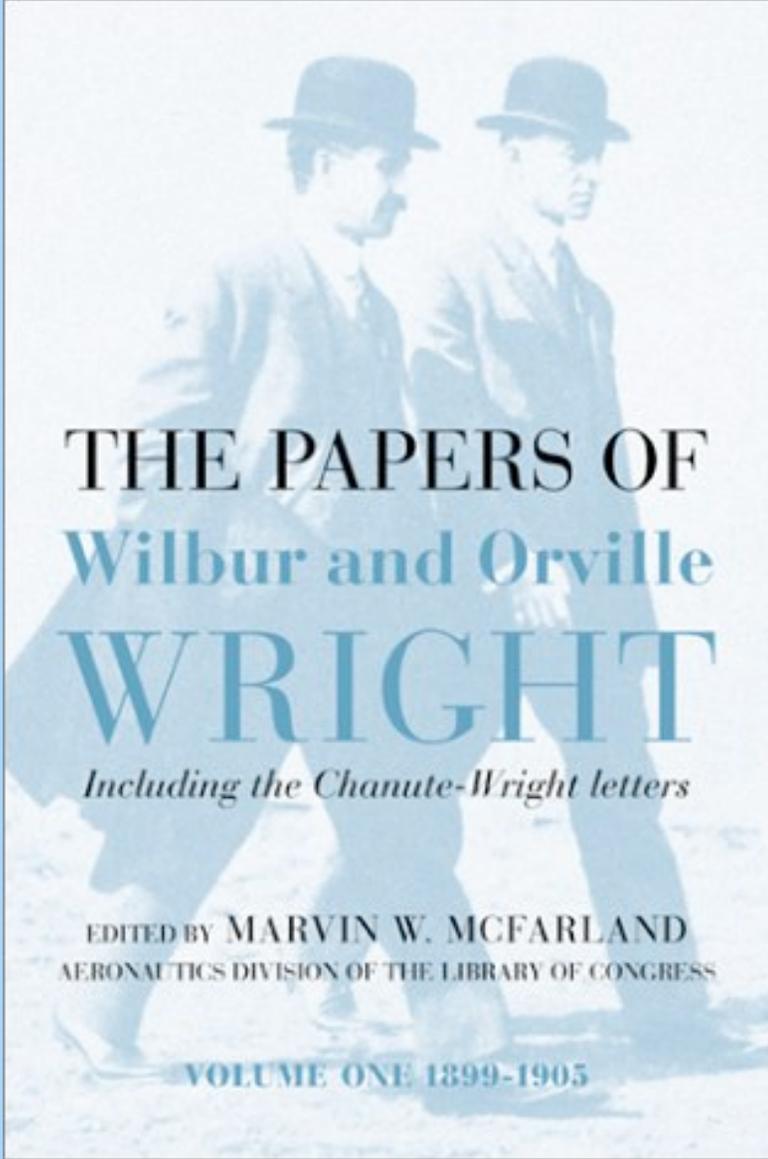
# Wright Flyers Today



1903 Wright Flyer I  
National Air & Space Museum



1905 Wright Flyer III  
Carillon Hall

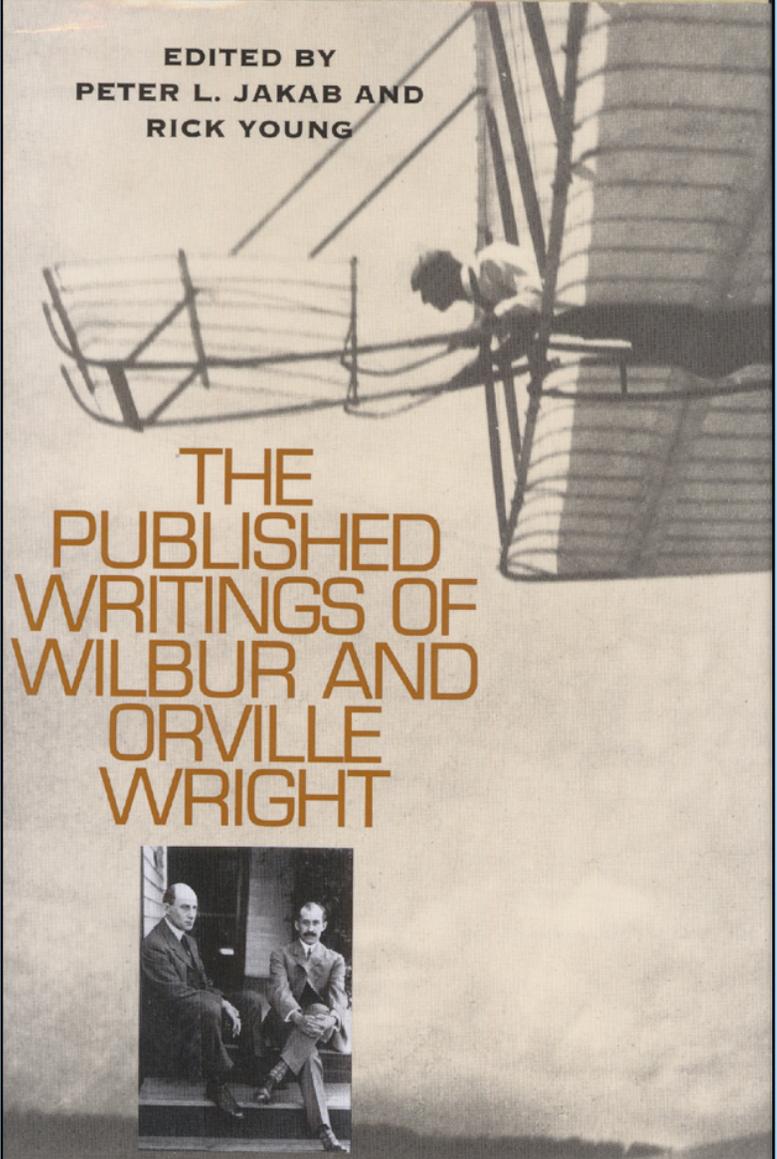


THE PAPERS OF  
Wilbur and Orville  
WRIGHT

*Including the Chanute-Wright letters*

EDITED BY MARVIN W. MCFARLAND  
AERONAUTICS DIVISION OF THE LIBRARY OF CONGRESS

VOLUME ONE 1899-1905



EDITED BY  
PETER L. JAKAB AND  
RICK YOUNG

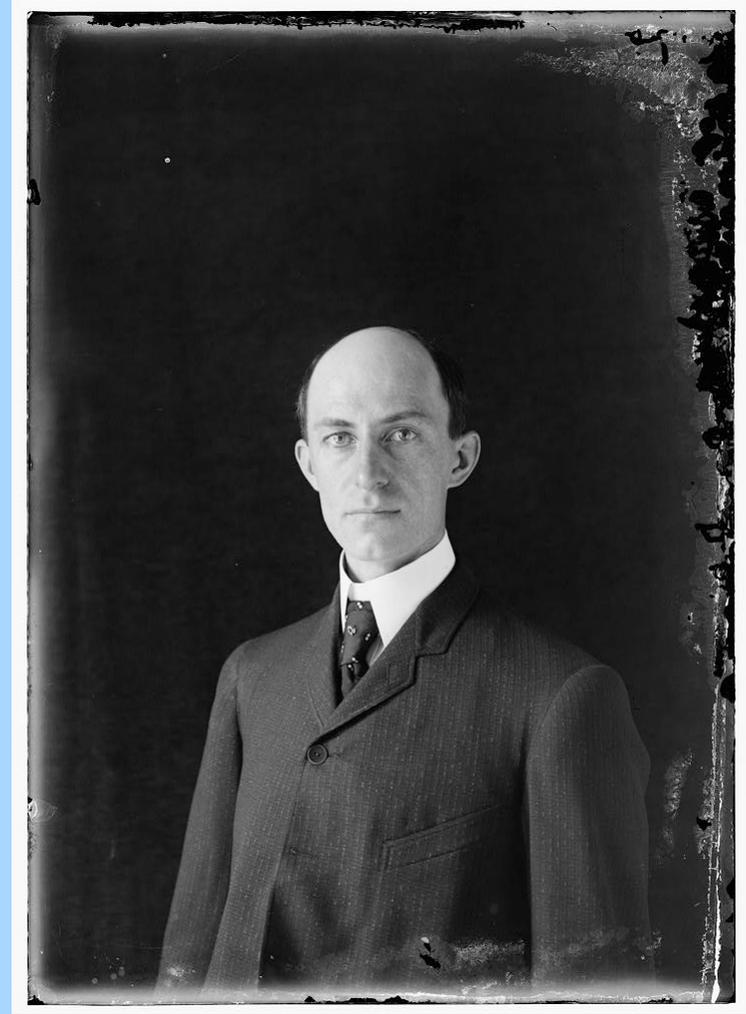
THE  
PUBLISHED  
WRITINGS OF  
WILBUR AND  
ORVILLE  
WRIGHT





*Orville Wright*

16 Apr 1867 – 30 May 1912



*Wilbur Wright.*

19 Aug 1871 – 30 Jan 1948

# Orville's Camera: 1902 to 1905

