

CS as Science

CSCI 8901:
Research & Evaluation Methods

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GWU

Computer Science

“Science is not science fiction.
***It accepts the tests of observation
and experiment, acknowledges the
supremacy of fact over wish or hope.
The smallest experiment can crash
to earth the most attractive theory.”***

– Herbert A. Simon

Why think of CS as Science?

Offers a systematic approach to explore phenomenon and discover new things

Science provides a rigorous structure to ensure that new advances are significant and correct

- Provides a methodology to structure research activities
- Ensures the integrity of results

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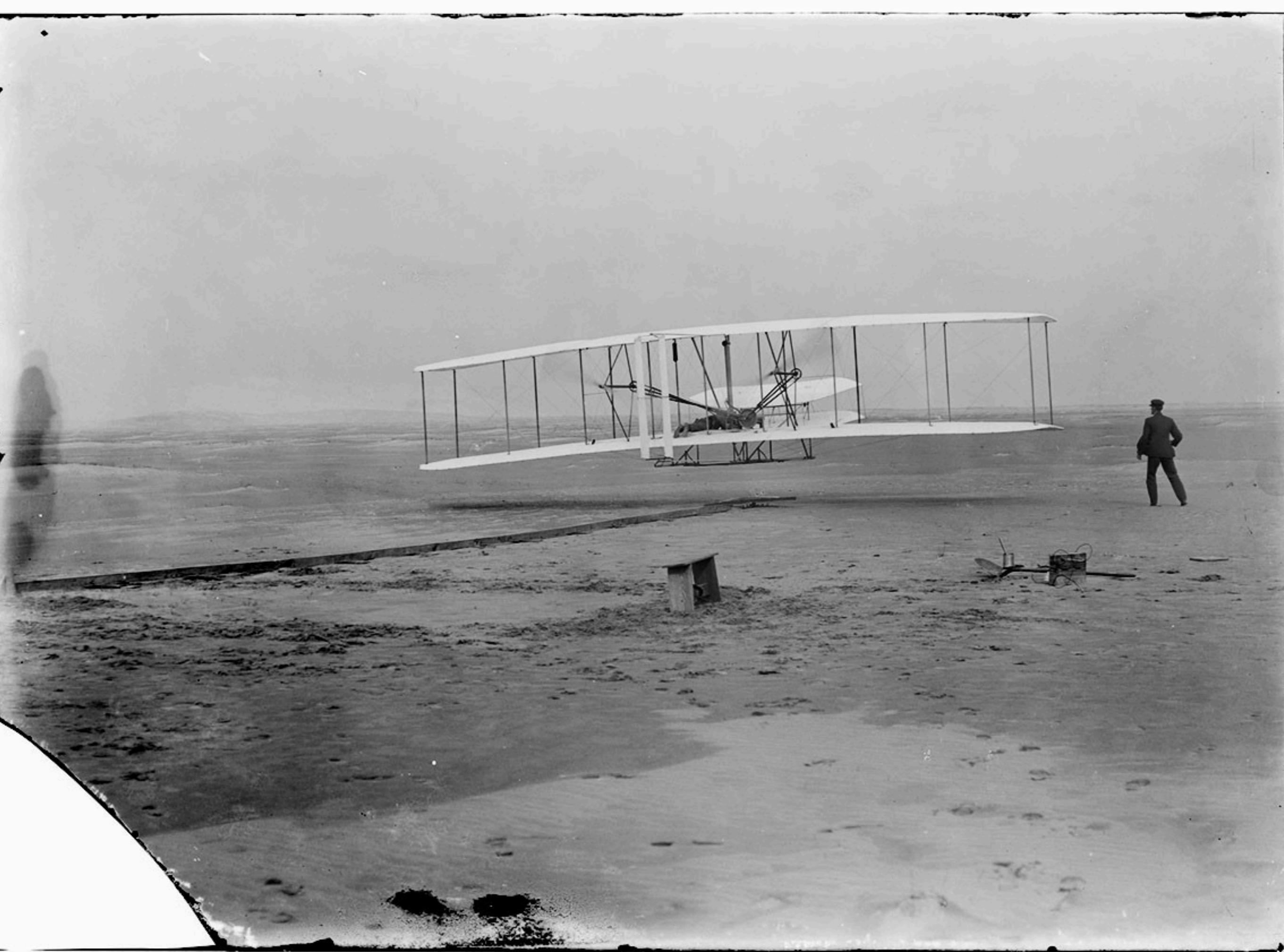
Kitty Hawk N C Dec 17

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~~ Christmas .

Orevelle Wright 525P

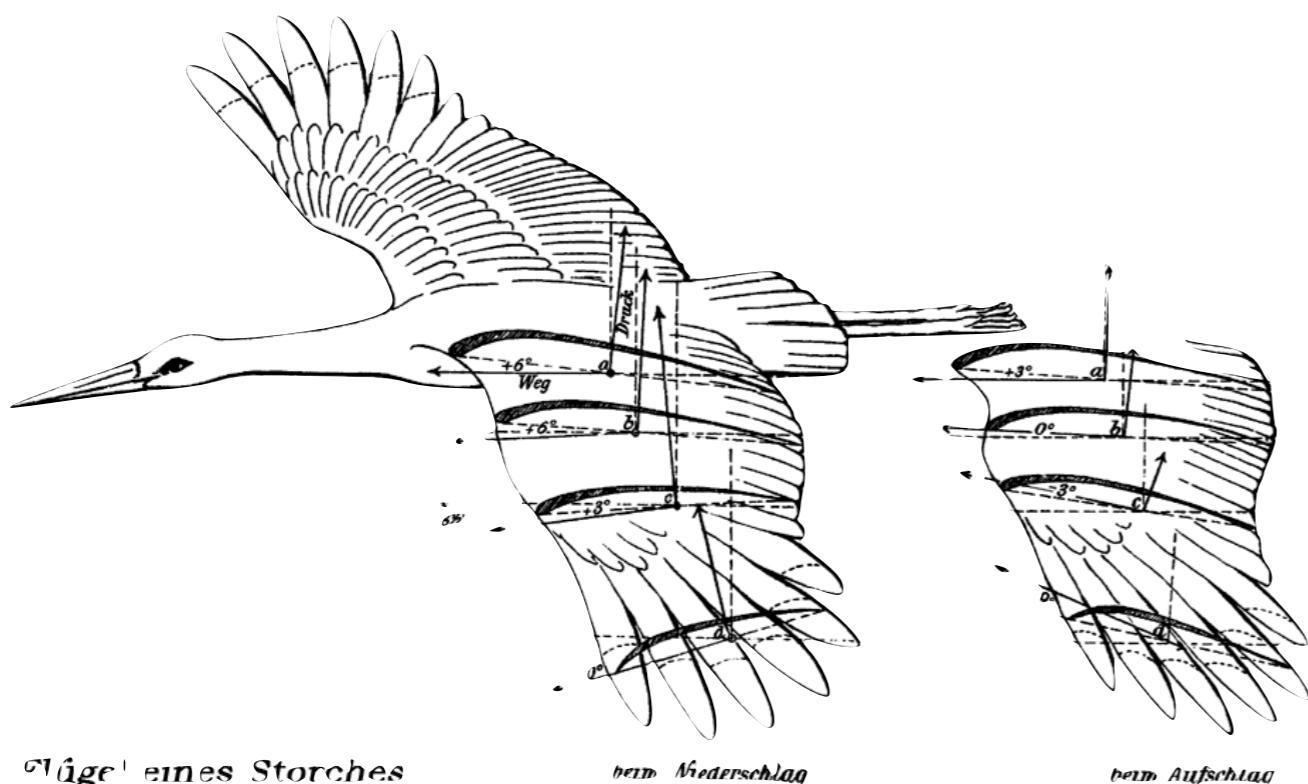


Otto Lilienthal

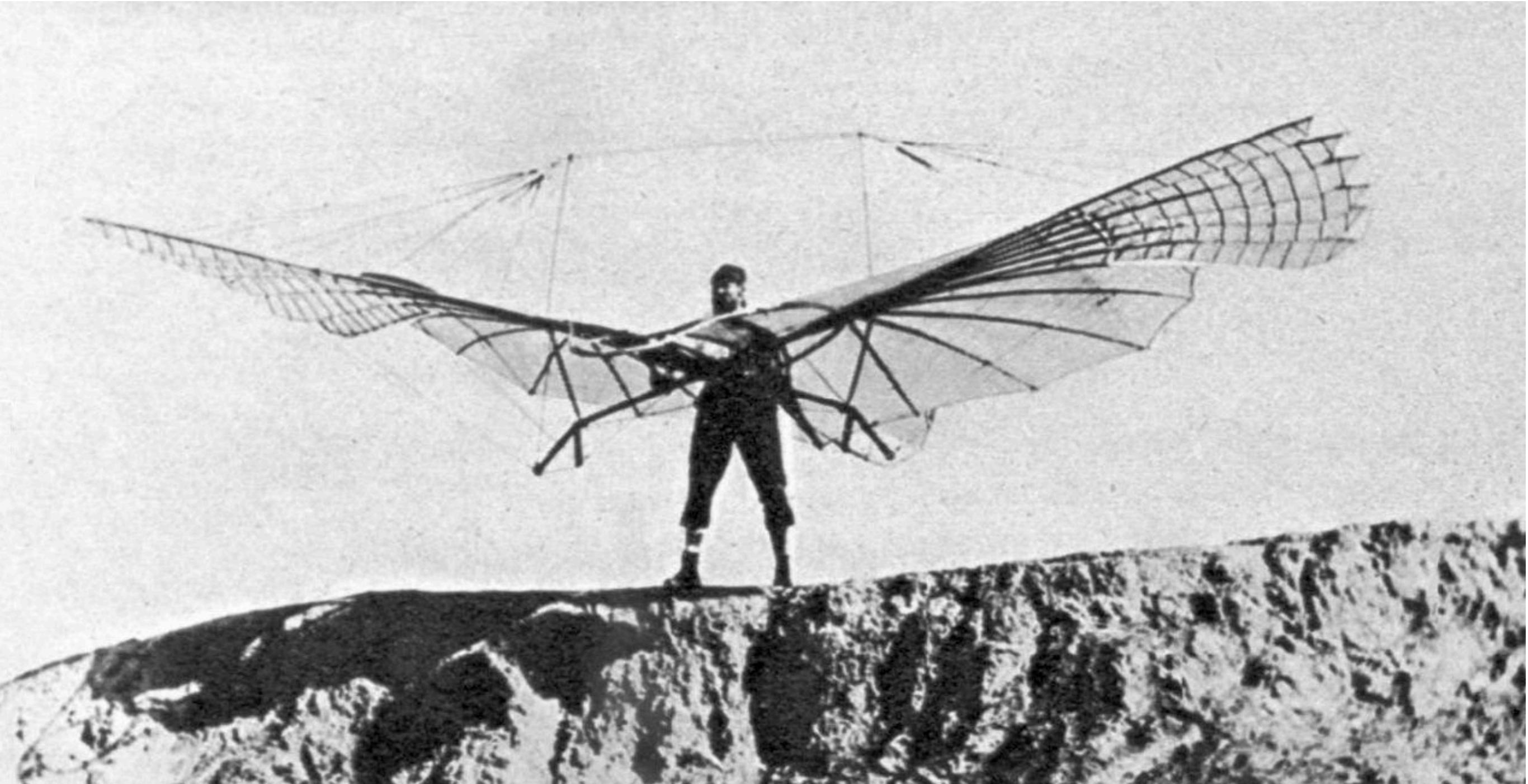
German engineer

Published *Birdflight as the Basis of Aviation* in 1889

Gathered extensive aeronautical data



Bird-inspired Glider



Lilienthal's Legacy

Successes

- Flew 820 feet, which was a record until after his death
- Provided extensive data about aerodynamics

“Of all the men who attacked the flying problem in the 19th century, Otto Lilienthal was easily the most important. ...many others were reported to have made feeble attempts to glide, but their failures were so complete that nothing of value resulted.”

— Wilbur Wright

Failures

- Died in 1896 when his glider crashed
- Thought birds would give us the secret to flight

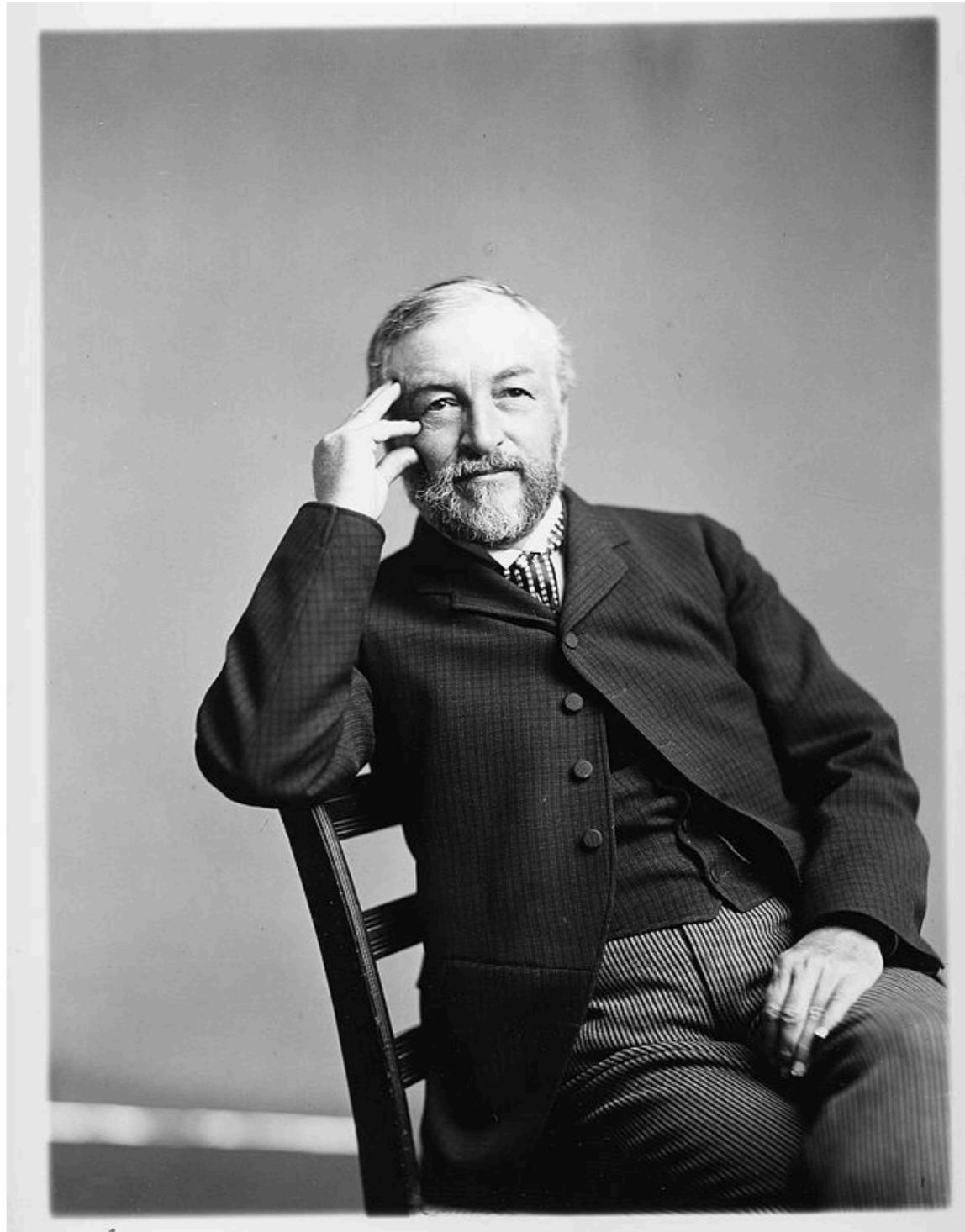
Samuel Langley

Astronomer and physicist

Head of the Smithsonian
Institution

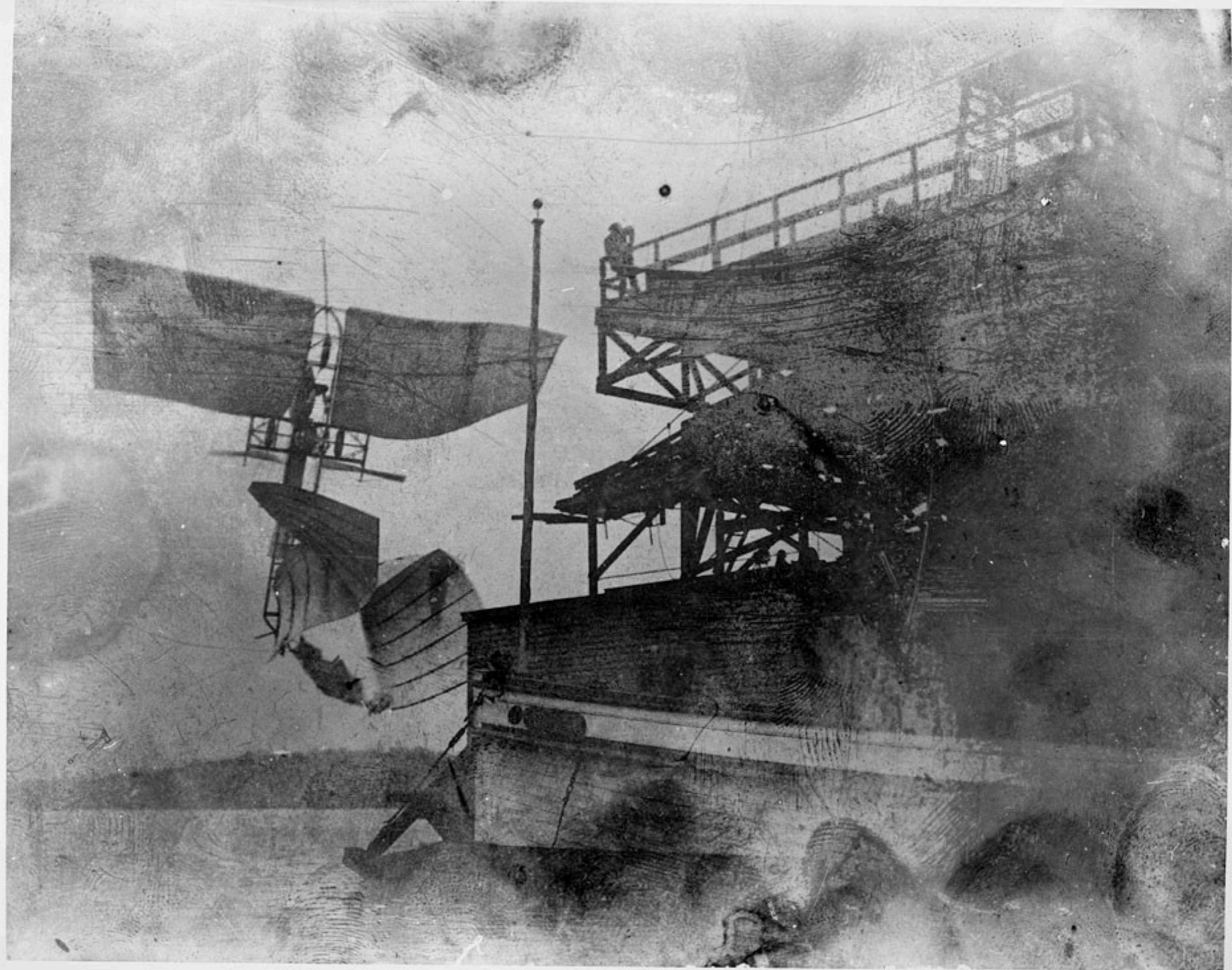
~\$100,000 in funding to
pursue “heavier than air
flight”

- Equal to \$78 million in today's currency



Langley's Aerodrome, 1903





Langley's Legacy

Failures

- Massive media presence at failed launches hurt his reputation
- Too focused on the “craft” of airplanes, motors, etc. Didn’t worry about *how* they would be flown

Successes

- His unmanned models set records and established much of the early science for aeronautics
- Aerodrome was displayed in the Smithsonian in 1914 as the first manned vehicle “capable” of flight
 - Suspicious story involving a Wright brother’s competitor who was attempting to get lawsuits thrown out

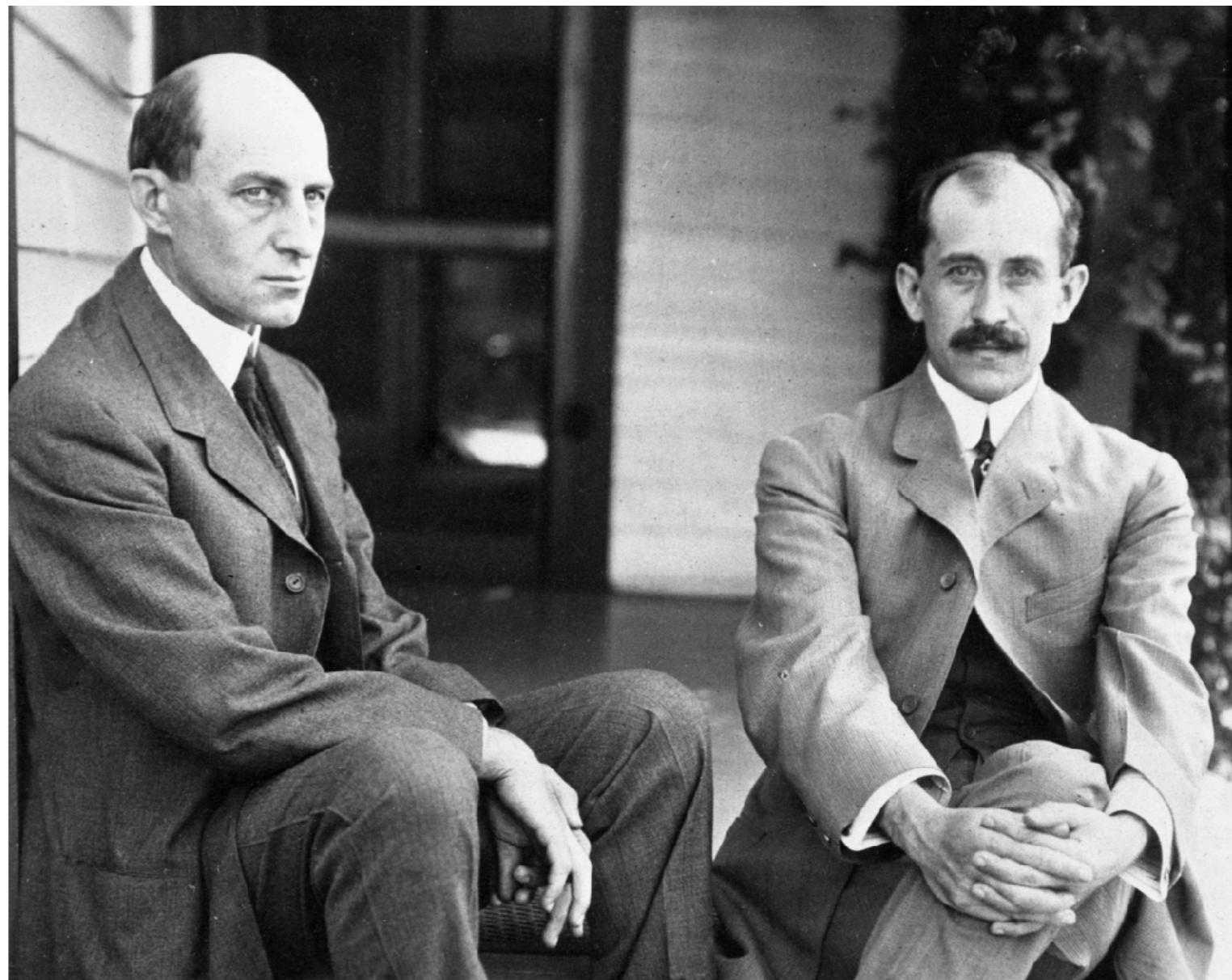
Wright Brothers

Didn't graduate high school

Owners of Wright Cycle Company

Self financed

No experience prior
to 1899



Why did the Wright Bro's get it right?

The perfect combination of...

Meticulous experimental research



A transformative approach

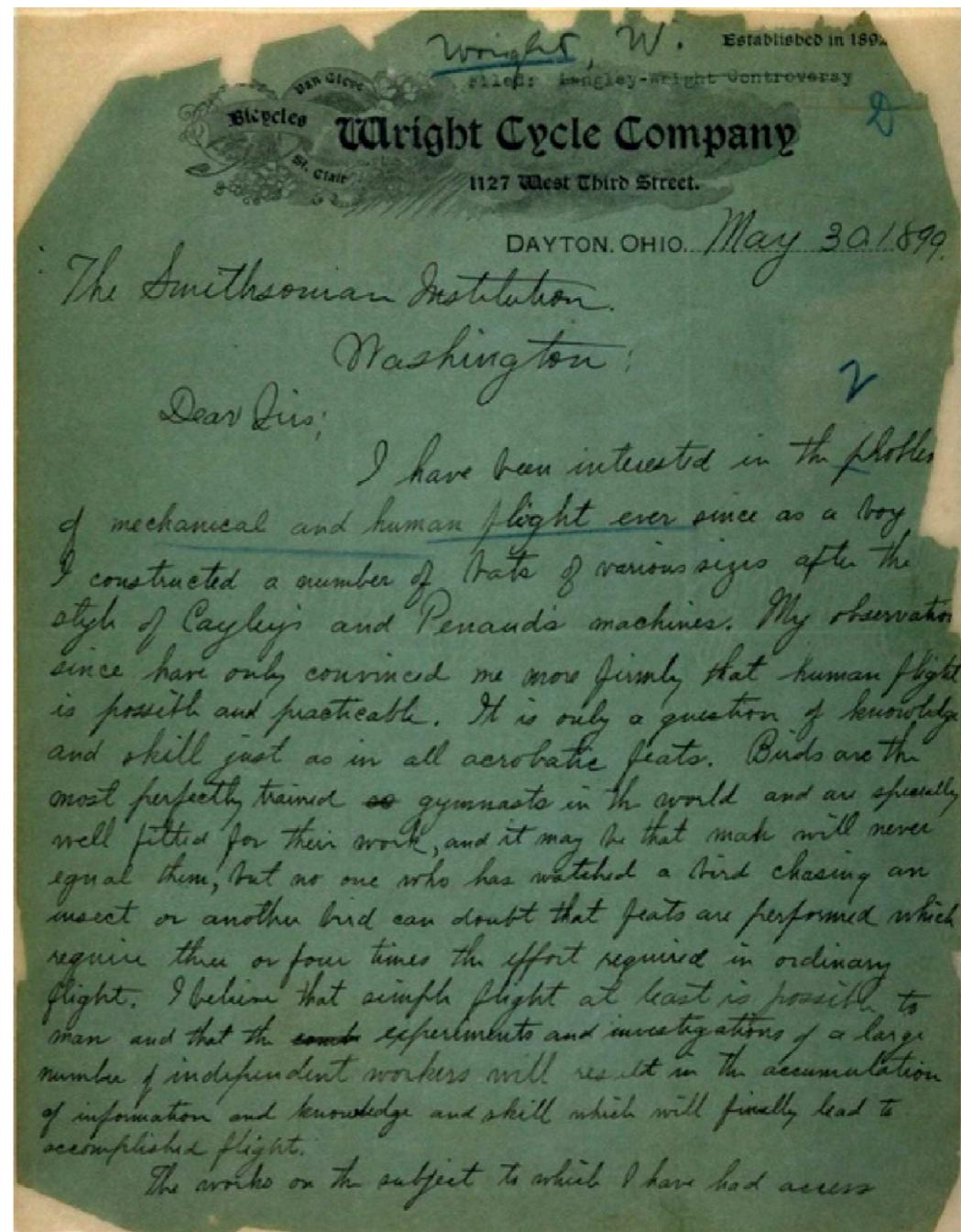
1) Survey the Literature

Wrote to the Smithsonian to ask about relevant literature

"I am an enthusiast, but not a crank in the sense that I have some pet theories as to the proper construction of a flying machine. I wish to avail myself of all that is already known and then if possible add my mite to help on the future workers who will attain final success." – Wilbur Wright

Got back 2 book, 3 journal issues, and 4 pamphlets

- This was everything known at the time about flight!



2) Focus on a problem

How should you control an aircraft?

Why did this seem like an important problem?

Because glider operators kept dying!

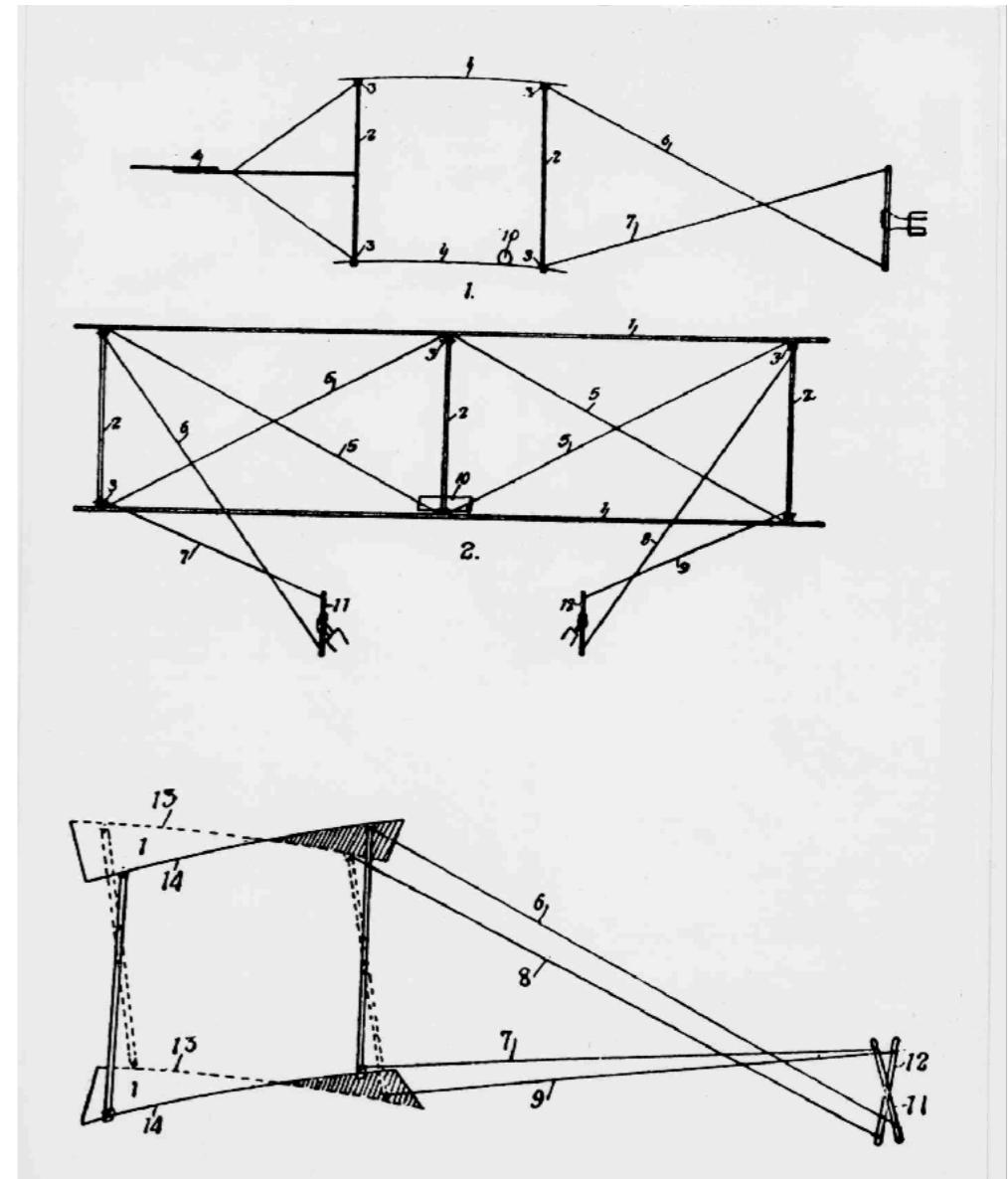
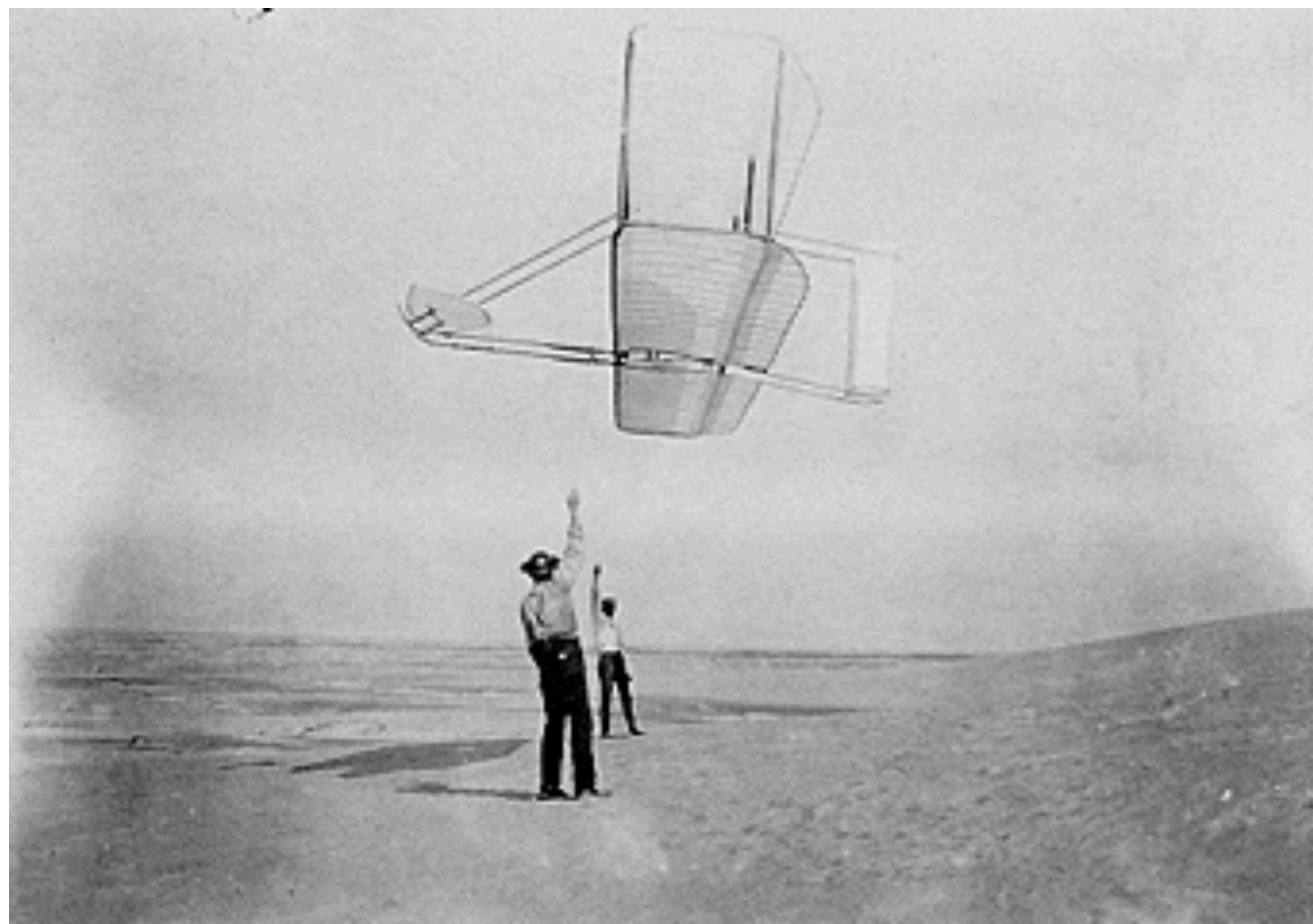
- Otto Lilienthal in 1896, Percy Pilcher in 1899

Lilienthal showed the importance of practice

- But clearly they needed better control mechanisms than he had or they would share the same fate!

3) Build Prototypes

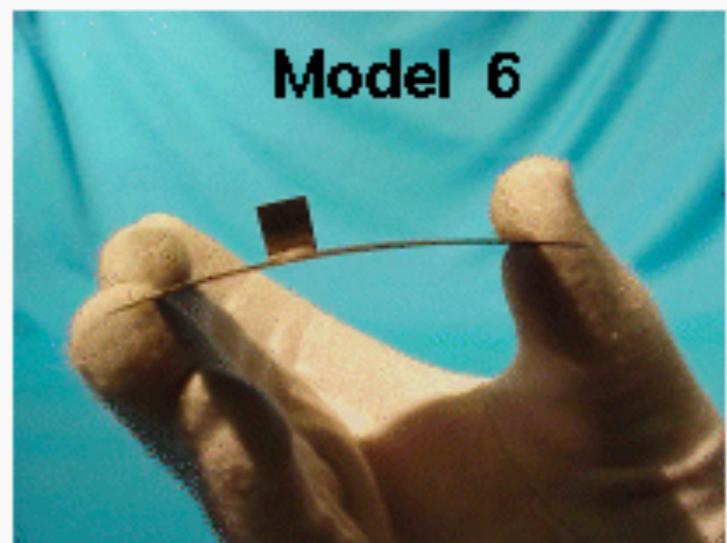
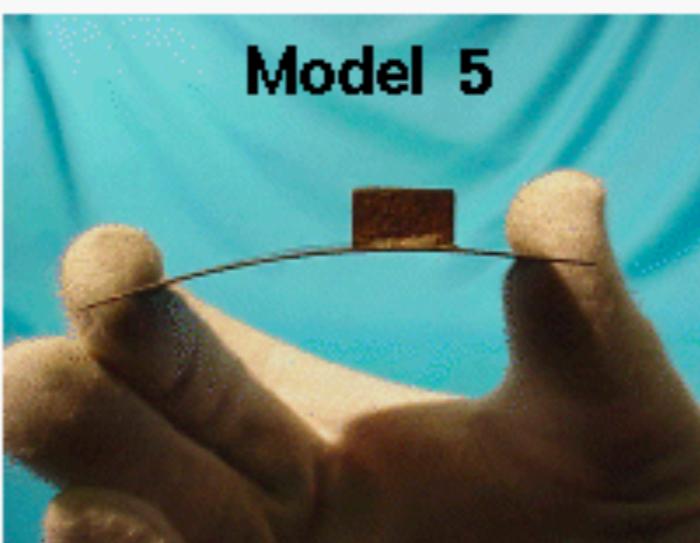
Spent 1900-1902
building unmanned
prototypes to test their
theories



4) Conduct Experiments

Designed wind tunnels and other experimental apparatus to help them run experiments

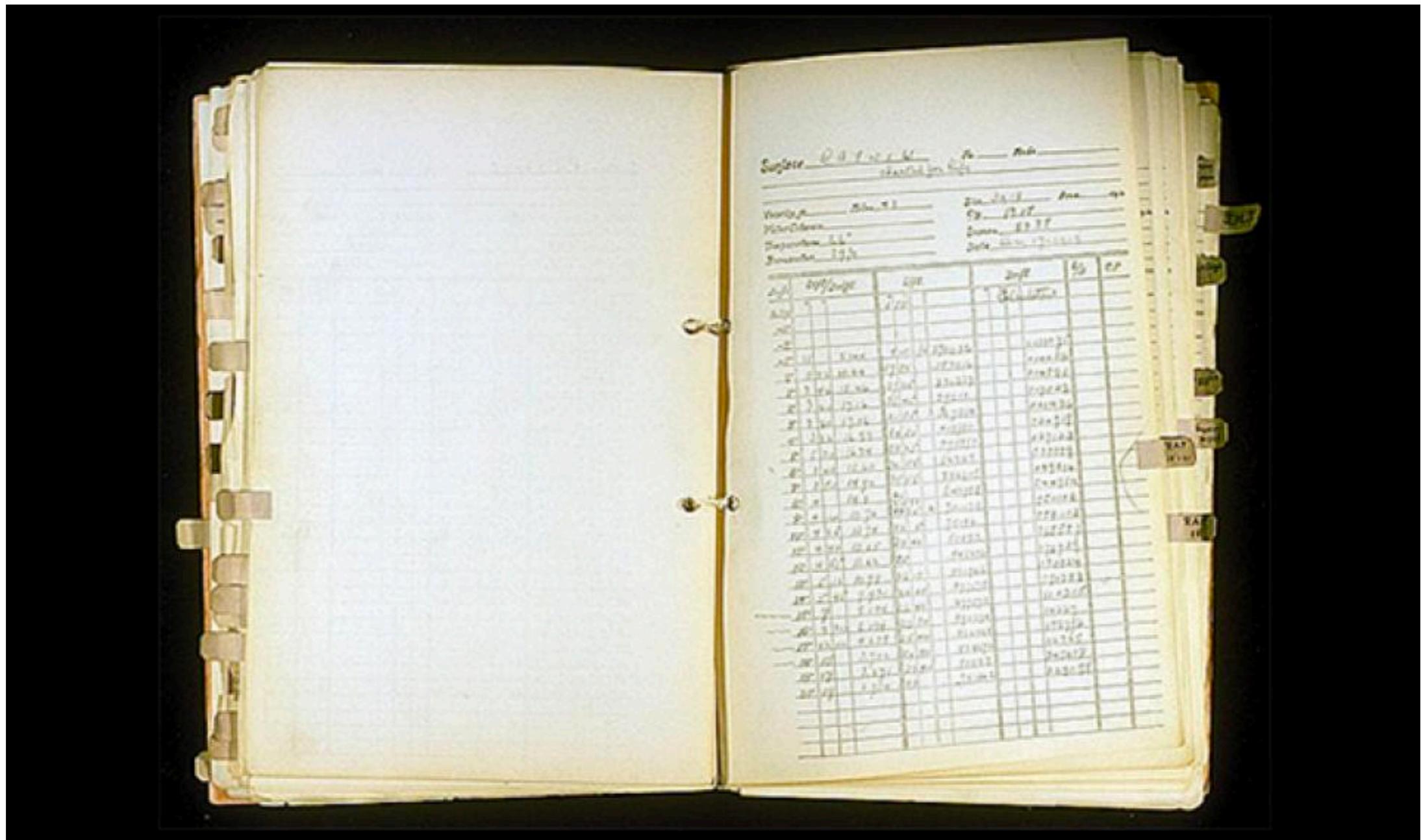
- Tested 200+ different wings and airfoil models



Camber test, arc foils, low aspect ratio

5) Analyze Results

Recorded detailed performance data for hundreds of variations



6) Compare to Prior Results

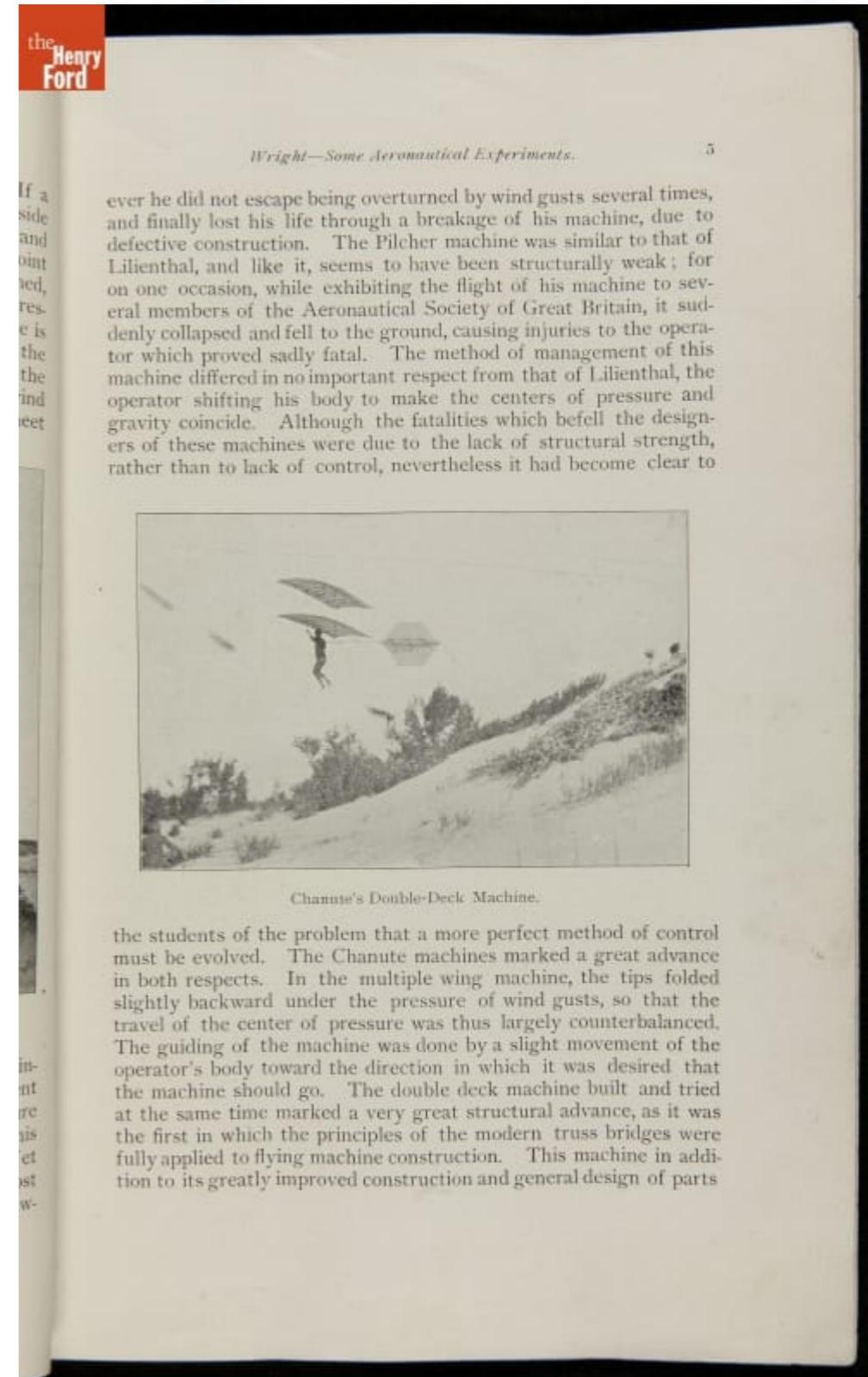
Built tools to let them evaluate and falsify other's research



7) Publish Results

Published “Some Aeronautical Experiments” in Western Society of Engineers September 18, 1901

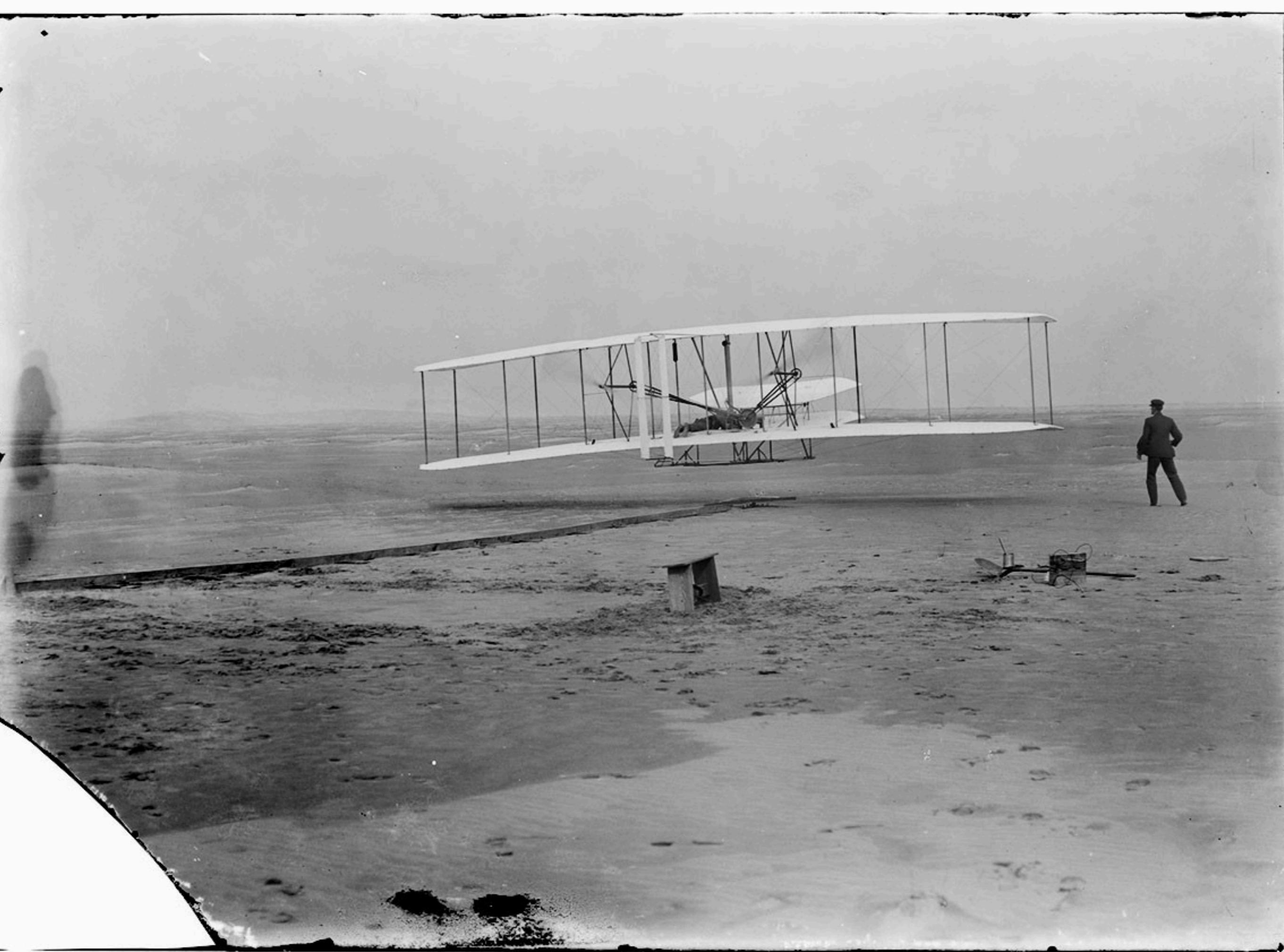
Challenged prior wing designs



8) Iterate

Repeated this process until eventually they flew!

- 1) Learn the background material and prior work
- 2) Determine the most important problem
- 3) Build prototypes
- 4) Conduct experiments
- 5) Analyze results
- 6) Compare against other approaches



Secret Ingredient

Why focus on control and why were they good at solving that problem?

Langley was a “Skilled Insider”

Orville and Wilbur were “Passionate Outsiders”

- Their history as cyclists may have been what let them fly!

Learn More...

<https://wright.nasa.gov/overview.htm>

<https://medium.com/@ade3/zombies-in-flight-f0bd6c1c3ba4>

Public Speaking 1

Speak for ~2 minutes

Pick one of these topics:

- Your favorite food or an experience related to eating
- Describe where you grew up and how it is different from DC

I will record you!

- Don't worry, it won't go on youtube
- Homework: watch your own presentation and think about how you can improve upon it
- Due in 2 weeks

Acknowledgements

Much of the slide content, and almost all of the amazing quotations, are derived from the *Research Methods for Empirical Computer Science* course taught by **David Jensen**

- <http://dx.doi.org/11084/10002>
- <https://people.cs.umass.edu/~jensen/courses/index.html>
- <https://people.cs.umass.edu/~jensen>
- Many thanks for allowing me to make use of his materials!