How the Wright Brothers Learned!

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Why Attend this Workshop?

- This story we are about to share with you in the foundation for the workshop we will be holding at the LPPDE Conference in Milwaukee in the end of September
- We are using the Wright Brother's Invention of the airplane to illustrate the creation of a product development learning plan in an environment with high uncertainty, requiring new innovation
- The learning plan process sets the stage for reuseable knowledge and visual management, two key components of Lean Product and Process Development, by creating artifacts which link critical design decisions to the technical knowledge base, to enable project planning

Introductions

Carolyn Carter

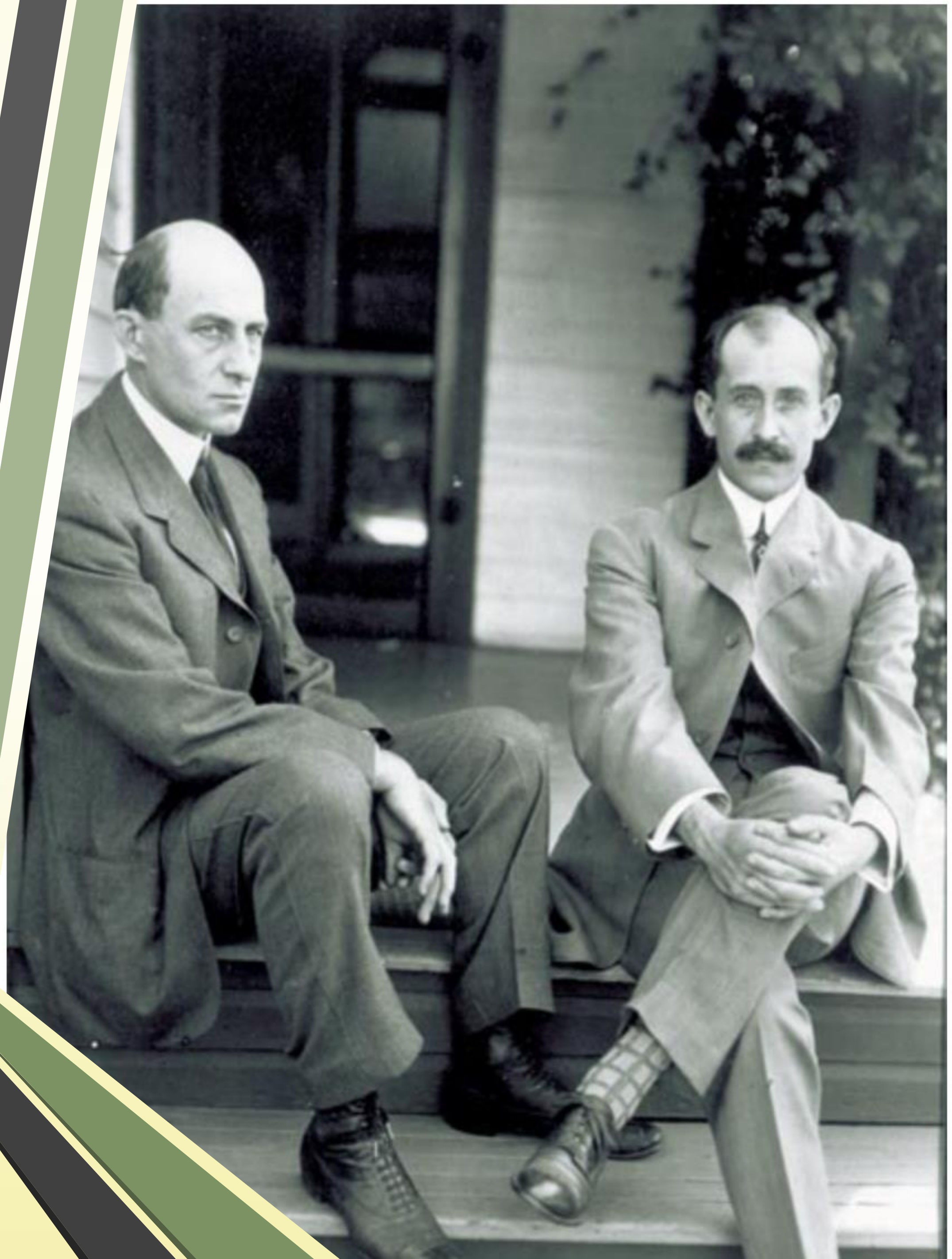
Andy Wagner

Agenda

- Backstory
- Learning Plan
- Knowledge Management
- Key Take Aways
- Invite to the conference

Why the Wright Brothers?

- Serial Entrepreneurs
  - Team of Knowledgeable Experts
  - Strong Technical Intuition
- Humility
- Psychological Safety
- Passion & Commitment
  - Learning
  - Flying



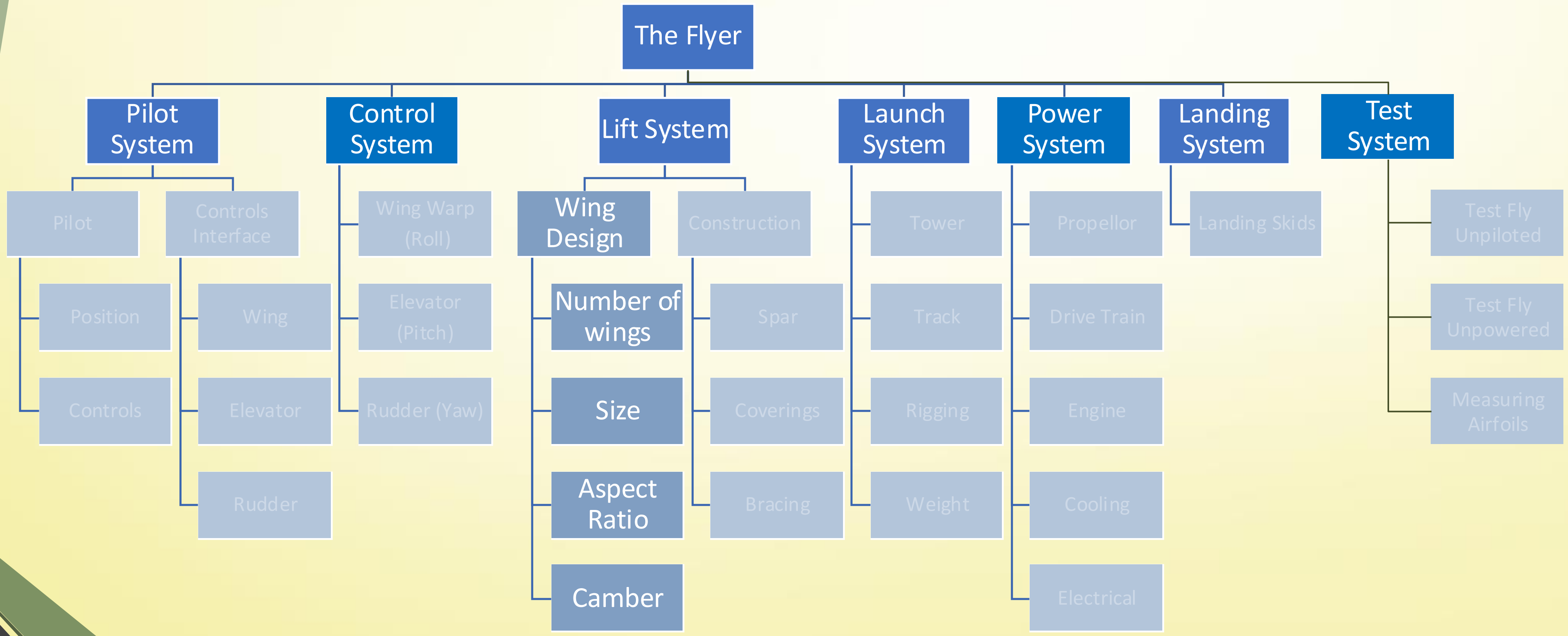
Learning Plan

- Hypothesis
- Functional Block Diagram
- Decision Network
- Causal Diagram
- Knowledge Gaps
- Learning Plan
  - Visual Management
- Trade-off Curves
  - Reusable Knowledge

Hypothesis

- If: We start with the knowledge we have, research what others have done, build hypotheses, do the analysis on paper, conduct experiments around lift, control, and power, build test equipment as needed, gather and document the data and integrate the learning,
- Then: We will be able to provide an effective solution for controlled, powered, heavier than air flight, for all, enabling us to do demonstration flights and educate the population, to create a viable business
- Because: We will have successfully designed an aircraft that all types of customers can safely fly

Functional Block Diagram



What did they know?
What did they need to learn?

High

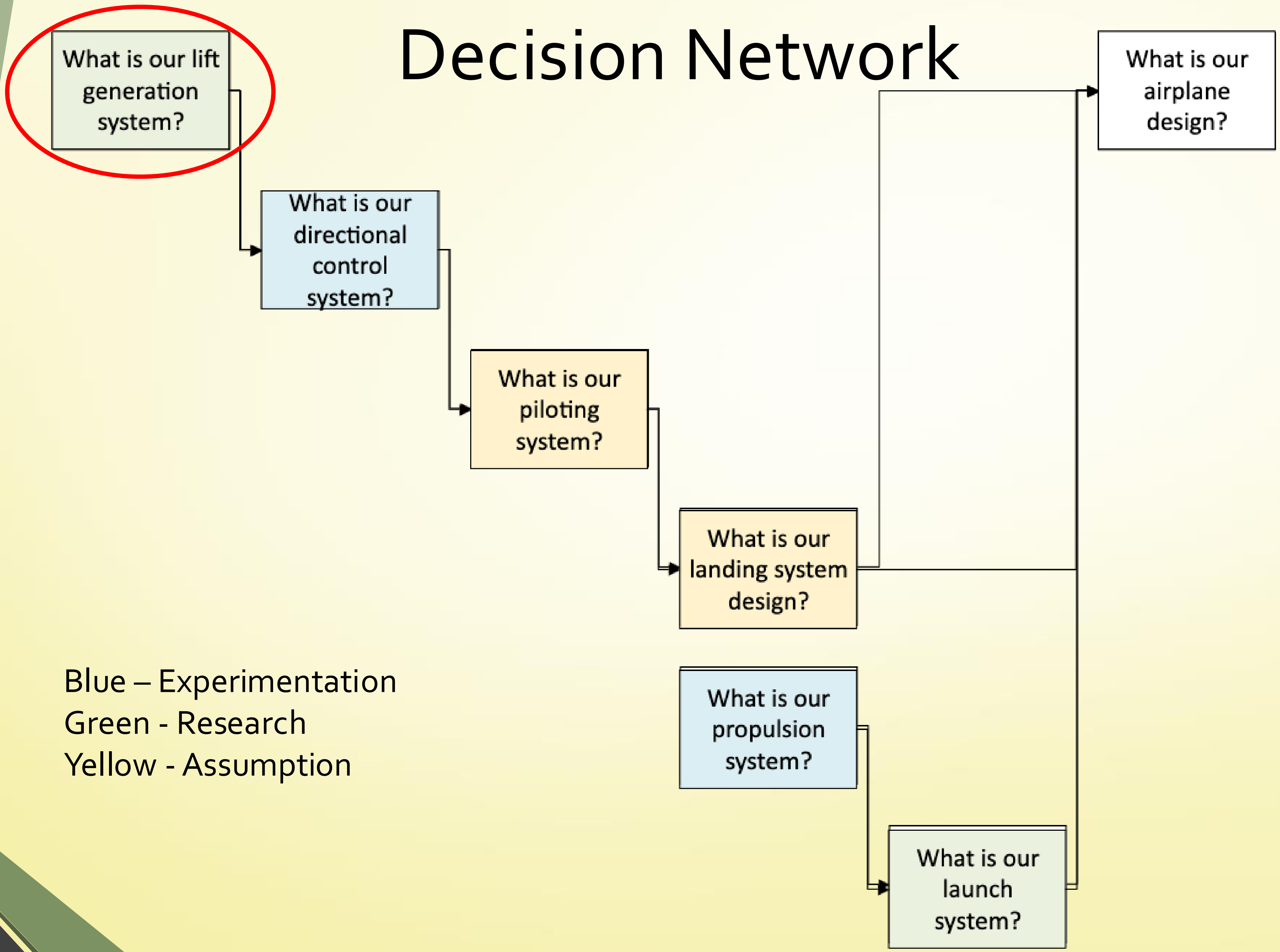
Launch System **Landing System**	**Lift Generation System** **Piloting System**
	Control System Propulsion System

Confidence

Low

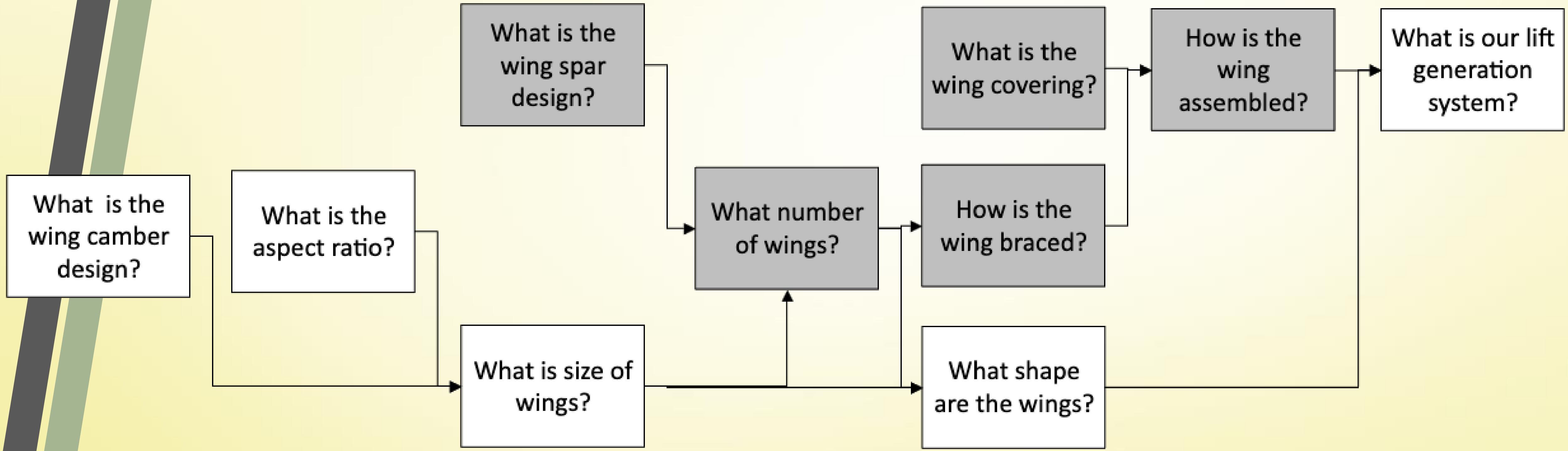
Impact

Decision Network



Blue – Experimentation
Green - Research
Yellow - Assumption

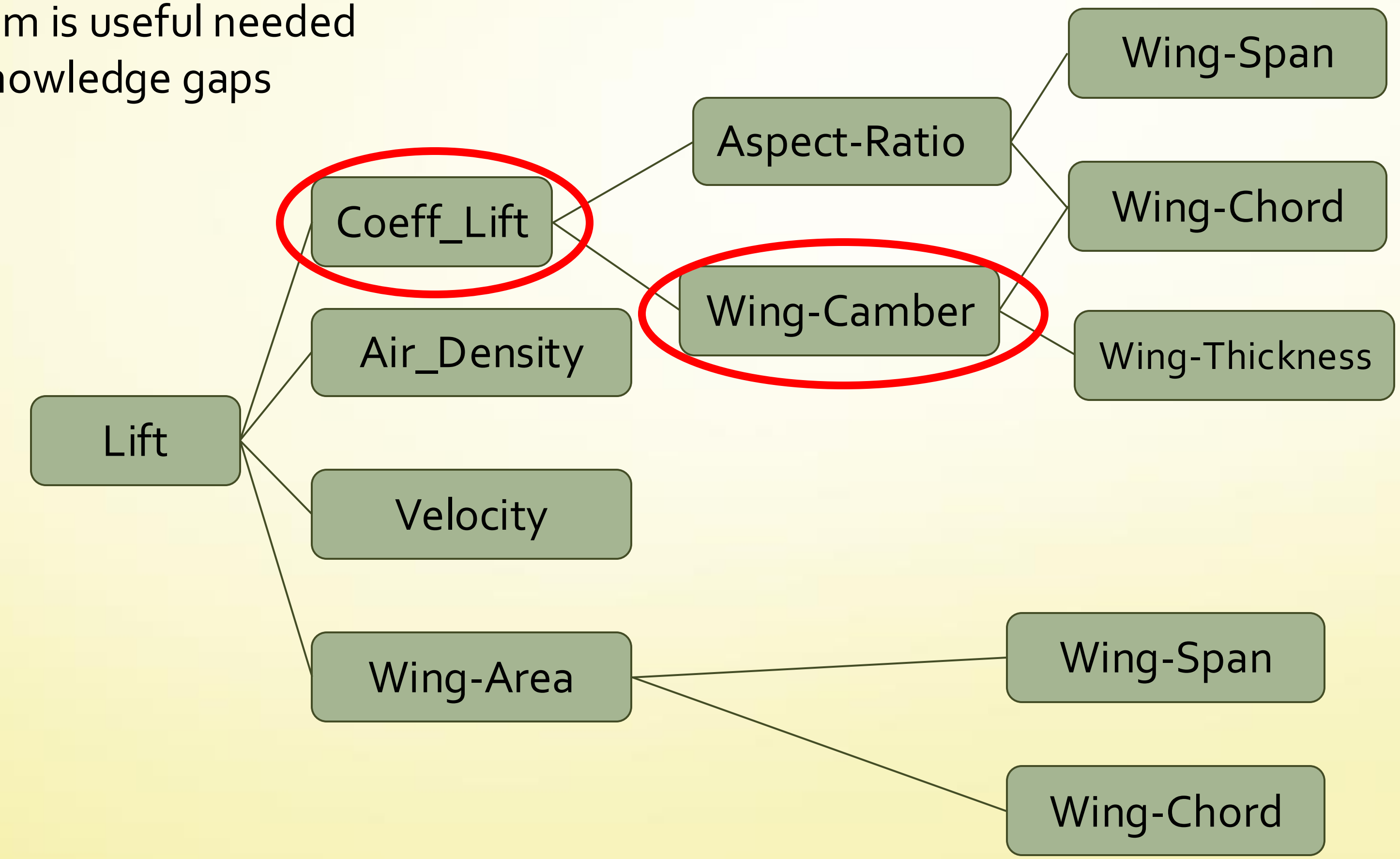
What are the lower tier decisions?



Let's set aside the structural elements, for now, and focus the shape alone…

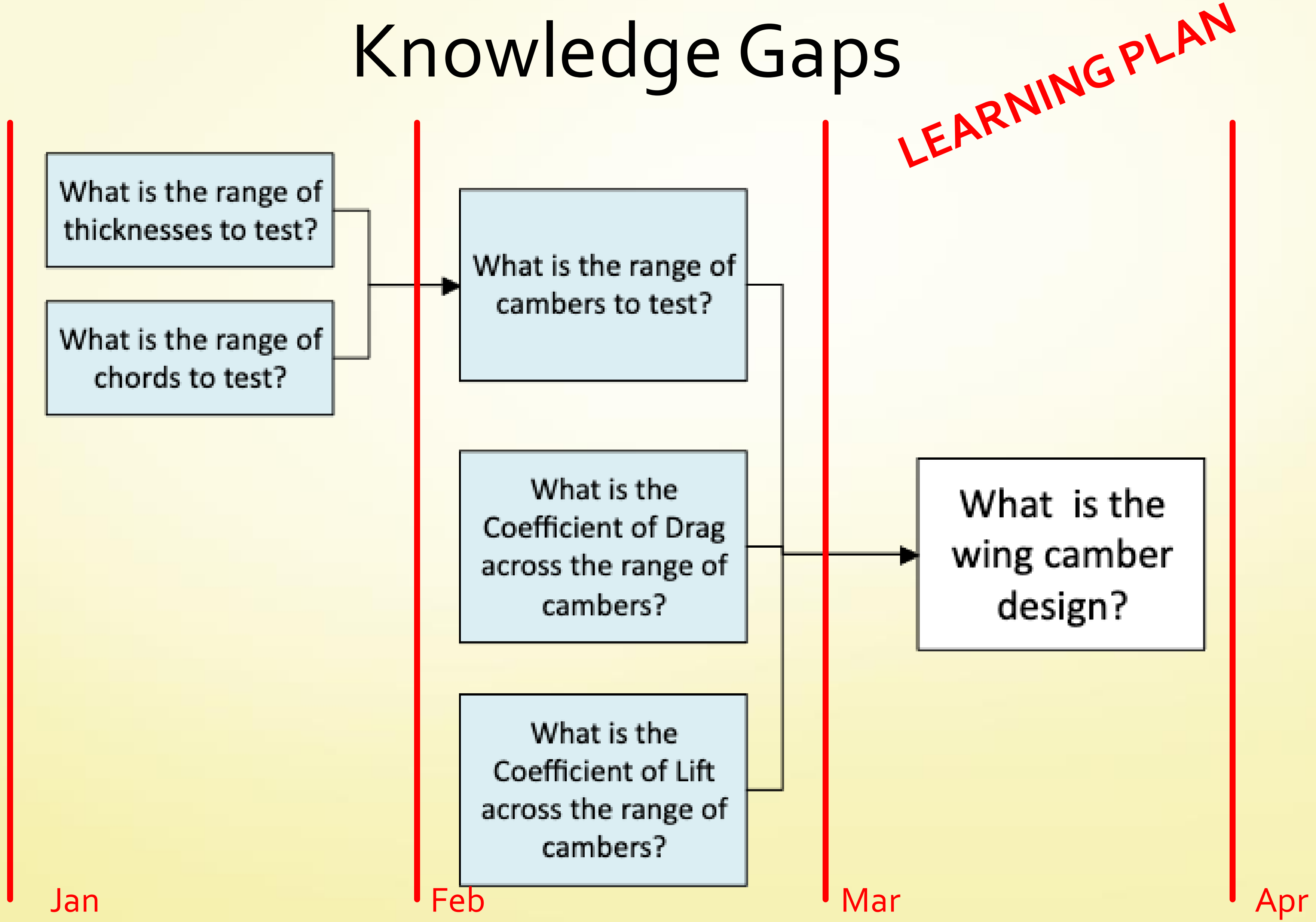
Causal Diagram

Causal diagram is useful needed to identify knowledge gaps



$L = Cl * r * 0.5V^2 * A$

Knowledge Gaps



Research & Validation

- The Wrights had data from Otto Lilienthal's pioneering glider flights

Glider	Camber	Performance
1900	1:22	Bad
1901	1:12	Worse
1901 (rev)	1:19	Just Bad, again

- Three data points, three failures
- "Not in a thousand years, will man every fly."

  -Wilbur Wright, after 1901 gliding at Kitty Hawk

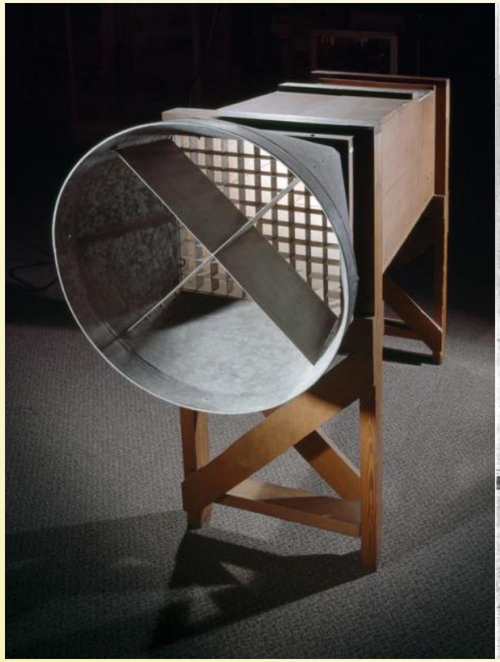
THE AERONAUTICAL ANNUAL.

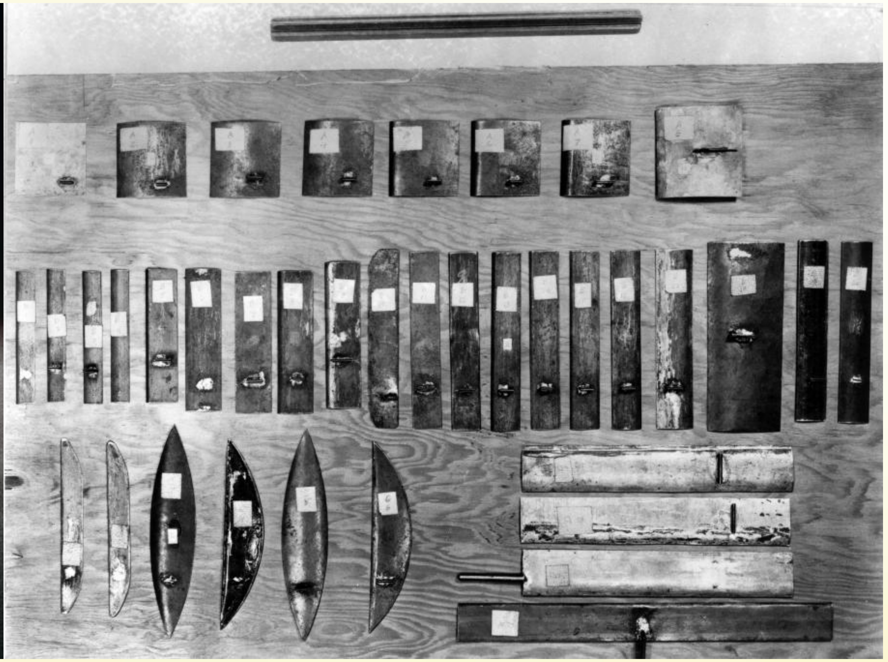
TABLE OF NORMAL AND TANGENTIAL PRESSURES

Deduced by Lilienthal from the diagrams on Plate VI., in his book "Bird-flight as the Basis of the Flying Art."

α Angle.	η Normal.	ϑ Tangential.	α Angle.	η Normal.	ϑ Tangential.
— 9°	0.000	+ 0.070	16°	0.909	— 0.075
— 8°	0.040	+ 0.067	17°	0.915	— 0.073
— 7°	0.080	+ 0.064	18°	0.919	— 0.070
— 6°	0.120	+ 0.060	19°	0.921	— 0.065
— 5°	0.160	+ 0.055	20°	0.922	— 0.059
— 4°	0.200	+ 0.049	21°	0.923	— 0.053
— 3°	0.242	+ 0.043	22°	0.924	— 0.047
— 2°	0.286	+ 0.037	23°	0.924	— 0.041
— 1°	0.332	+ 0.031	24°	0.923	— 0.036
0°	0.381	+ 0.024	25°	0.922	— 0.031
+ 1°	0.434	+ 0.016	26°	0.920	— 0.026
+ 2°	0.489	+ 0.008	27°	0.918	— 0.021
+ 3°	0.546	0.000	28°	0.915	— 0.016
+ 4°	0.600	— 0.007	29°	0.912	— 0.012
+ 5°	0.650	— 0.014	30°	0.910	— 0.008
+ 6°	0.696	— 0.021	32°	0.906	0.000
+ 7°	0.737	— 0.028	35°	0.896	+ 0.010
+ 8°	0.771	— 0.035	40°	0.890	+ 0.016
+ 9°	0.800	— 0.042	45°	0.888	+ 0.020
10°	0.825	— 0.050	50°	0.888	+ 0.023
11°	0.846	— 0.058	55°	0.890	+ 0.026
12°	0.864	— 0.064	60°	0.900	+ 0.028
13°	0.879	— 0.070	70°	0.930	+ 0.030
14°	0.891	— 0.074	80°	0.960	+ 0.015
15°	0.901	— 0.076	90°	1.000	0.000

Accelerating Learning



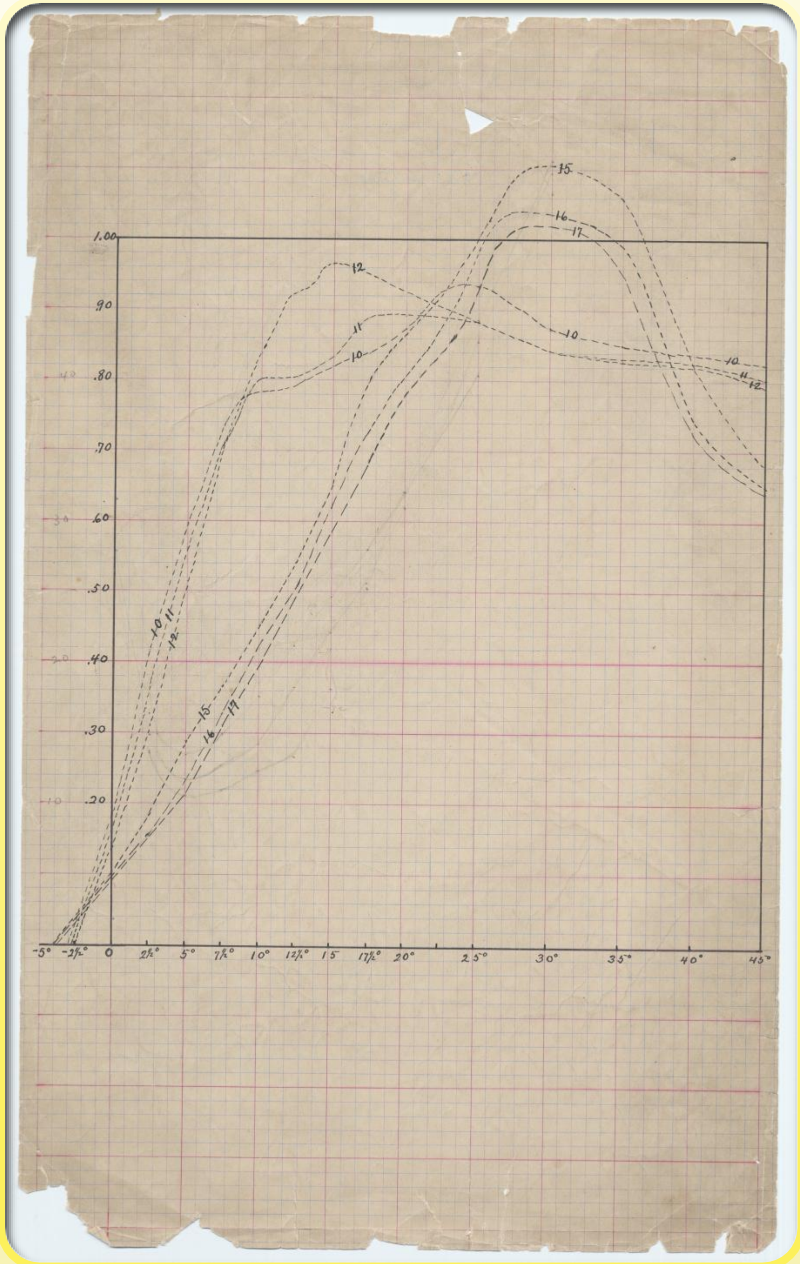


In the Winter 1902:

- Built a wind tunnel
- Invented a lift balance
- Tested 200 shapes
- Collected detailed data on 50 shapes

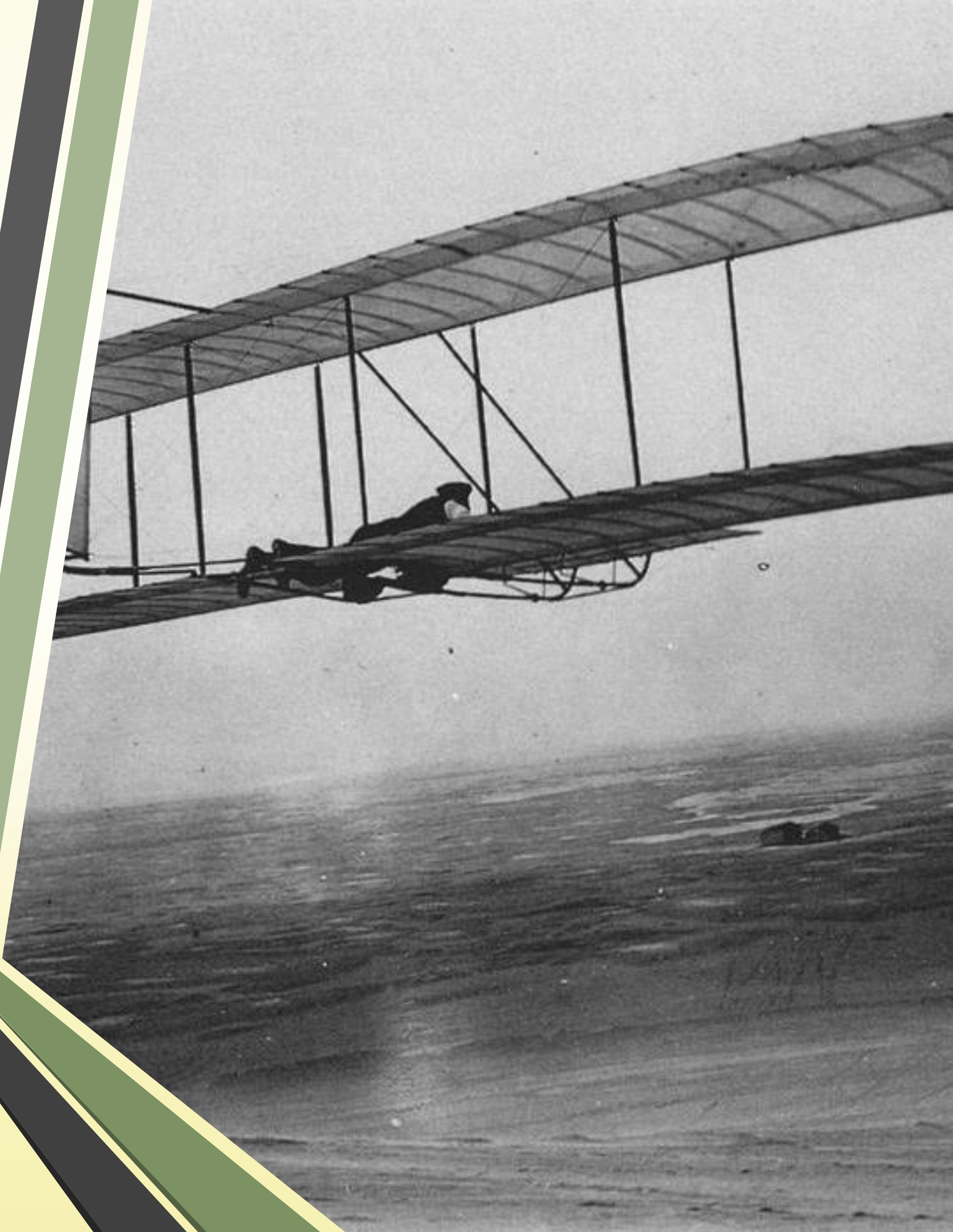
Trade-Off Curves

- Equipped with this data, the lift problem was solved.
- The 1902 Glider performance matched calculations exactly.
- Allowed the Wrights to shift their focus to the next problem: control.



“Success Assured”

- In many respects, it was the 1902 Glider that was most significant.
- The lift problem was solved.
- Integration testing focused on
  - Learning to pilot
  - Mastering control in all three dimensions
- In 1903, solving for power was straightforward
  - Wind tunnel gave them a highly efficient propellor
  - Which allowed a smaller, lighter engine



Key Takeaways

- Identify sequenced key decisions, knowledge gaps, needed experiments
- Leverage what you know, make some assumptions, understand competence/impact
- Swipe learning from previous research – experiment, understand competence/impact
- Experiment with multiple data points and test to the limits to fill the gaps
- Document Knowledge for Reuse
- This is a key approach to building a learning plan for development of new technology!!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Questions???