

Transplanting Göttingen to the Tidewater:
The NACA and German Aerodynamics, 1919-1926

Richard P. Hallion

The NACA Centenary:
A Symposium on 100 Years of Aerospace Research and Development

3 March 2014

...In the Beginning...



10:35 a.m., 17 December 1903,
Kitty Hawk, North Carolina

But by 1912...

- **Europe has surpassed the United States**
- **Accelerating gap between US and Europe in aviation science**
- **A “Lab Gap” Between U.S. and other aeronautical nations**
 - **Britain**
 - **France**
 - **Germany**
 - **Italy**
 - **Russia**

Stages in Winged Aeronautical Research to 1919

- *Bird Emulative*
 - da Vinci, d'Esterno, Lilienthal
- *Evolving Theory of Forces, Forms, Shapes, and Structures*
 - Cayley, Stringfellow, Penaud, Lilienthal, Chanute, Wrights
- *Beginnings of Rudimentary Measurement and Analysis*
 - Wenham, Browning, Phillips, Lilienthal, Wrights, Eiffel
- *Explication of Physics-Rooted "Scientific" Aerodynamic Theory*
 - Kutta, Joukowski, Lanchester, Prandtl

Characteristics of Emergent Scientific Aeronautics

- **Rigorous analysis based upon college/university-level physics & math**
- **Emphasis upon the study of fluid dynamics and flow circulation**
- **Mathematical calculation of idealized airfoil profiles**
- **Emphasis upon a combination of ground and flight testing**
- **Ground testing via laboratories with instrumented wind tunnels**
- **Some research on aircraft dynamics**
- **Some research on structural loads**
- **Some propulsion research, mostly related to propeller design**

The Path to the NACA and Afterwards...

- **Chambers' National Aerodynamical Laboratory (1912-13)**
- **Walcott's Langley Aerodynamical Laboratory (1913)**
- **Taylor's Aero-Hydrodynamic Basin at Washington Navy Yard (1913)**
- **Hunsaker-Glazebrook MIT Aero Lab (1914)**
- **Walcott-Tillman-Roberts Advisory Committee for Aeronautics (1915)**
- **McCook Field Air Service Engineering Division (1917)**

The NACA: A Summary

Founded by the Naval Appropriations Act of 1915, passed 3/3/15

Model was UK Advisory Committee for Aeronautics (1909)

US Enabling Legislation Incorporated the Same Mandate:

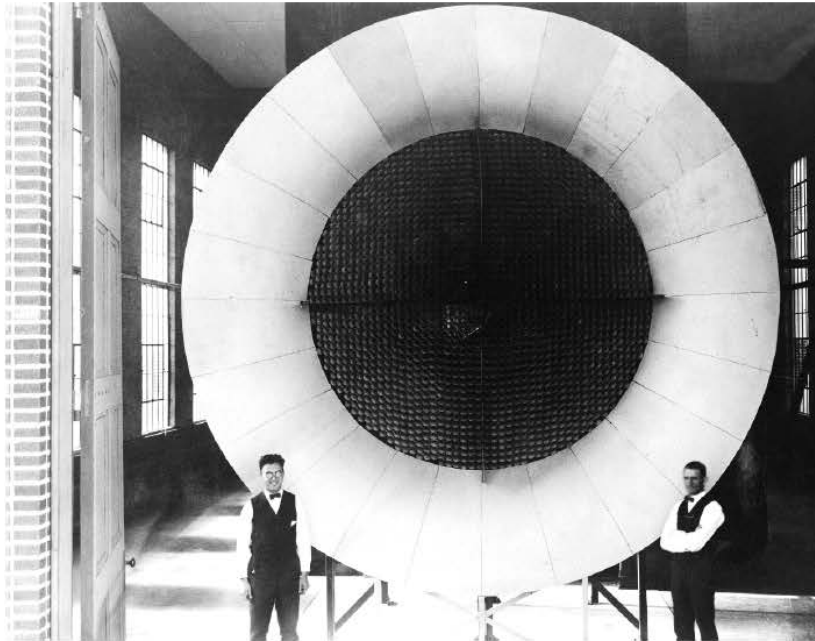
“To supervise and direct the scientific study of the problems of flight with a view to their practical solution....”

However...

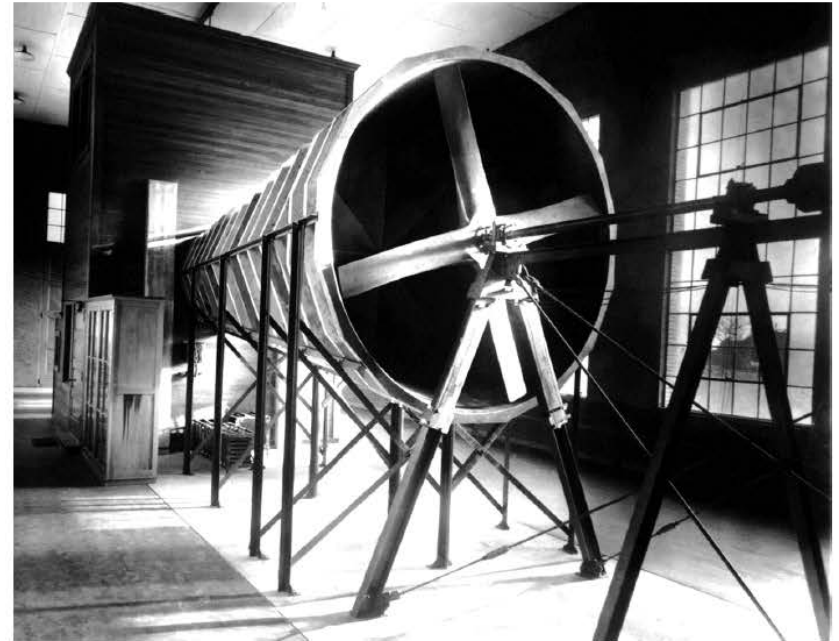
This is much easier said than done...

Early NACA Research Capabilities are “Legacy” ...

“Front”

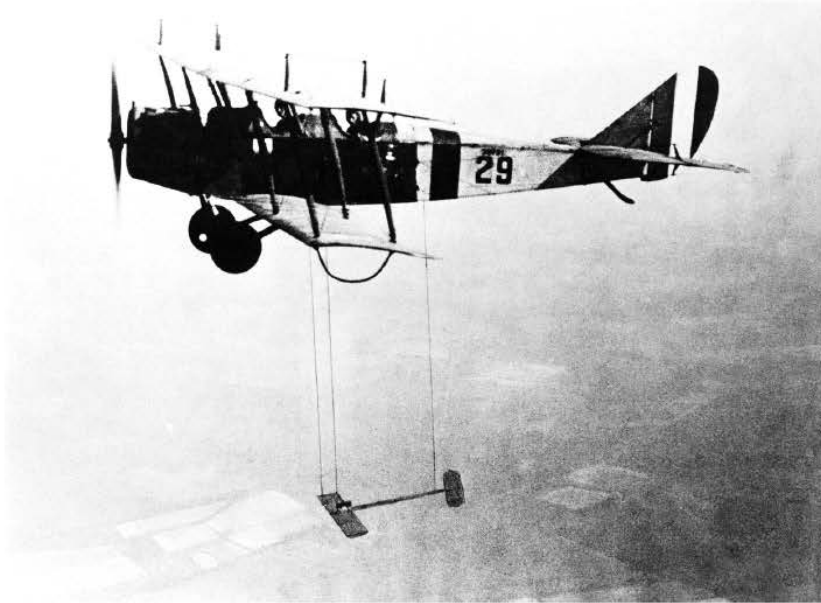


“Back”



First NACA Tunnel—UK Rooted, Outdated, Open-Flow

NACA Rudimentary Flight Test Offers Some Alternative... ...but still not an Effective Substitute...



Curtiss JN-4H with study model



**Tom Carroll and Gus Crowley in
DH-4 Research Aircraft**

...as a Consequence...

“I don’t think we need worry ourselves very much at present about USA experimental establishments.”

*AIR 5/489: Charles Walker to Secretary, Air Ministry (UK), 5-18-21,
& attached Minute 45, TNA-UK*

The Evolution of the Airfoil

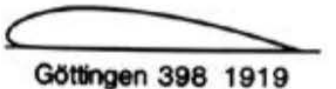
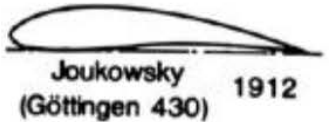
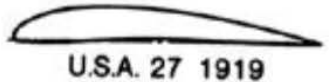
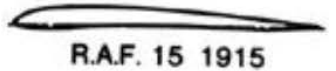
From:

Bird-Imitative based → braced truss biplane (Chanute)

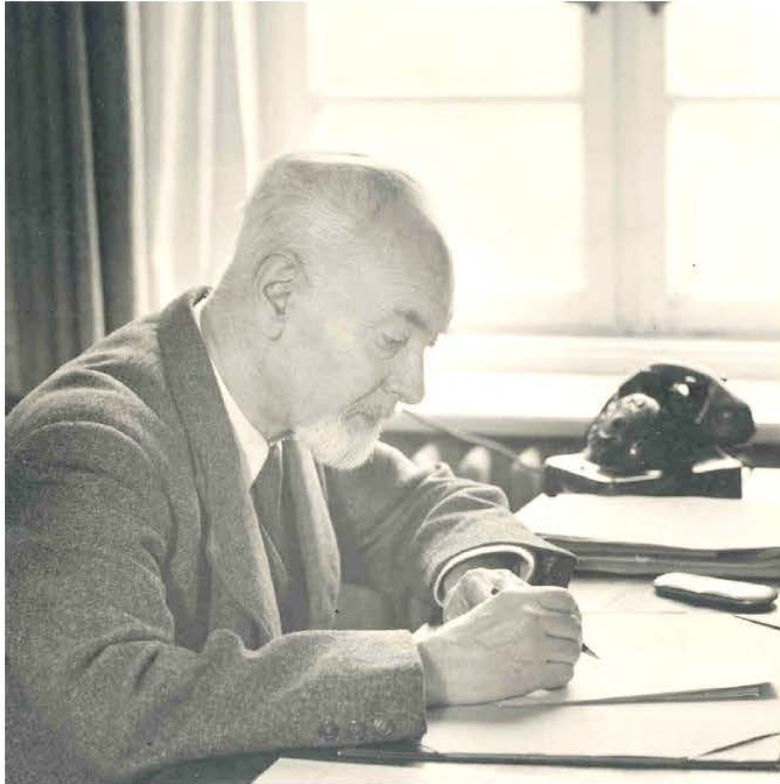
To:

Fluid Dynamics based → cantilever monoplane (Junkers)

Reflects Passage of Leadership in Airfoil Design From U.S.A. (Wrights) to France (Eiffel School) to Britain (RAF/NPL) to Germany (Prandtl School)



Ludwig Prandtl and the Göttingen School



NASA

- “The man who gave modern wing theory its practical mathematical form.”
 - *Theodore von Kármán (1954)*
- Stressed Need for Model Experimentation
- Pioneered Closed-Circuit Low Turbulence Tunnel Design
- First to demonstrate the intrinsic relationship of lift to total wing circulation, not just “wing slice” perspective.

...Hugo Junkers and Applied Design...



LC

- Recognized symbiotic relationship between advanced aerodynamics and structural design by making possible a thick, high-lift cantilever wing.
- Pioneers dural structures
- All-metal cantilever military aircraft in operational service in late 1917 (Junkers J I)
- All-metal cantilever enclosed cabin civil monoplanes in service in 1919 (Junkers F 13)

...The German Aeronautical State-of-the-Art, c. 1919...



Junkers F 13 Transport

The “Bottom Line”

“There is no question in the minds of either the French, English or Americans but that Germany is technically miles ahead of any other country in the air.”

Col. W. N. Hensley, Jr., U.S. Air Service, Memo re Assigning a Military Observer to Germany, 3-29-20, Box 34, Fol. 1, Foulois Papers, LC

Challenge:

***Transplant German Aerodynamics in
America***

The NACA Paris Office

- **Established in 1917**
- **First Chief was William Knight**
 - *Secures “The first information on German aeronautical science that has reached us.” (Jerome Hunsaker to Knight, 4-8-20)*
 - **Furnishes translation of key archival and current documents**
 - **Spots Max Munk and assesses him as a potential recruit**
 - **Via Hunsaker, hires Prandtl as a contract author**
- **Potential Value Compromised by Relations with Military**

John Jay Ide: A Too-Brief Digression



- Reserve naval intelligence officer
- Careful analyst
- Nurtured long-term foreign contacts
- Most prolific U.S. air intelligence collector of his time
- Careful not to stray into outright espionage
- Master of open-source collection
- Scored multiple coups

Mr. Roy C. Kintland

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NATIONAL ADVISORY COMMITTEE
 FOR AERONAUTICS

3841 NAVY BUILDING, 17TH AND B STREETS NW.
 WASHINGTON, D. C.

TELEPHONE NATIONAL 5212

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 EO 11652

OFFICE OF THE TECHNICAL ASSISTANT IN EUROPE
 5, rue de Chaillot,
 Paris.

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September 27, 1930.

From: Technical Assistant in Europe,
 N. A. C. A.

To: National Advisory Committee for Aeronautics,
 Washington, D. C.

Subject: Visits to Germany, August-September, 1930

During my visits to Germany in August and September, 1930 the following establishments were visited:

(A) Deutsche Versuchsanstalt für Luftfahrt, Adlershof.
 (B) Albatros Flugzeugwerke, Johannisthal.
 (C) Rohrbach Metall-Flugzeugbau, Berlin.
 (D) Schiffbautechnische Wasser Schleppversuchsanstalt, Charlottenburg.
 (E) Bayerische Flugzeugwerke, Augsburg.
 (F) Luftschiffbau Zeppelin, Friedrichshafen.
 (G) Dornier Metallbauten G.m.b.H., Friedrichshafen.
 (H) A.G. für Dornier Flugzeuge, Altenrhein, Switzerland.

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Samples of his Product

歐亞航空公司
 Eurasia Aviation Corporation
 滬滿線飛航時刻表
 Shanghai Manchuli Time Table

北上 up.	站名 Station	時刻 Time		日期 Date	日期 Date
	上海 Shanghai	上午 5:00 a.m. Dep	開	星期三 Wednesday	星期日 Sunday
南下 Down	南京 Nanking	上午 6:45 a.m. Arr 上午 7:30 a.m. Dep	到 開	"	"
	濟南 Tsinan	上午 11:15 a.m. Arr 上午 12:00 a.m. Dep	到 開	"	"
	北平 Peiping	下午 14:30 p.m. Arr 下午 15:30 p.m. Dep	到 開	"	"
	林西 Linse	下午 18:30 p.m. Arr 上午 6:00 a.m. Dep	到 開	星期四 Thursday	星期一 Monday
	滿洲里 Manchuli	上午 12:00 a.m. Arr	到	"	"
	滿洲里 Manchuli	上午 9:00 a.m. Dep	開	星期日 Sunday	星期二 Tuesday
北上 up.	林西 Linse	下午 15:00 p.m. Arr 下午 15:45 p.m. Dep	到 開	"	"
	北平 Peiping	下午 19:15 p.m. Arr 上午 4:00 a.m. Dep	到 開	星期一 Monday	星期三 Wednesday
	濟南 Tsinan	上午 6:30 a.m. Arr 上午 7:15 a.m. Dep	到 開	"	"
	南京 Nanking	上午 11:00 a.m. Arr 上午 11:45 a.m. Dep	到 開	"	"
	上海 Shanghai	下午 18:30 p.m. Arr	到	"	"

Fig. 1
 Time table of Eurasia Aviation Corporation.

15622A C
 Paris Office NACA, Sept. 1931

Mr. DeG's visit to Germany, Sept., 1931
 Fig. 1



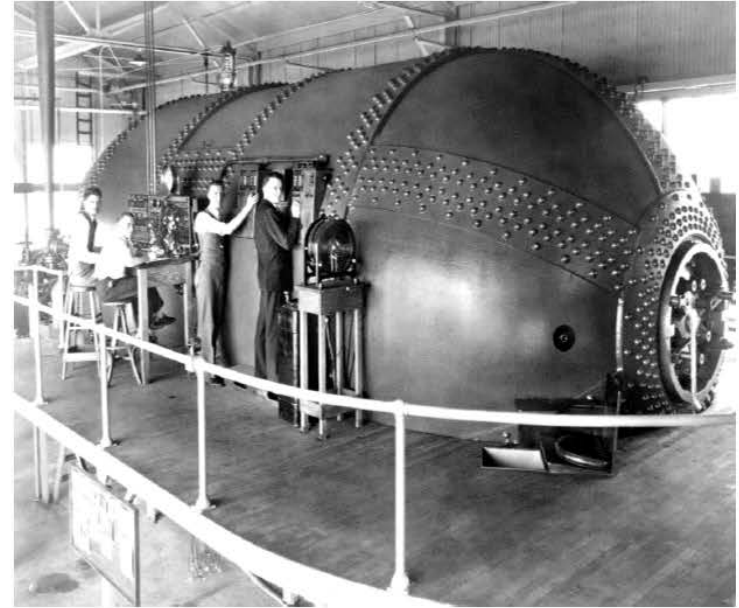
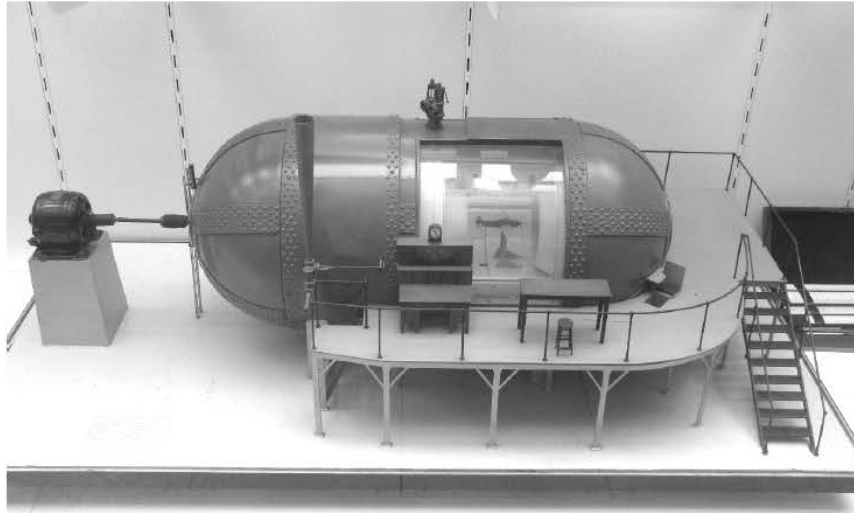
Max Munk

Simplified and extended Prandtl-Betz lifting theory

Advocated elliptical lift distributions and elliptical or near-elliptical wing planforms

Undertook influential studies of airship aerodynamics

Munk's "Important Invention:" The Variable-Density Tunnel



The Munk Transformation

Munk effectively “transplants” Göttingen research practices to the Tidewater...

...and the combination of this plus his VDT transforms both NACA research and the way industry designs the wings of new aircraft



M-6 1926



R.A.F. 34 1926

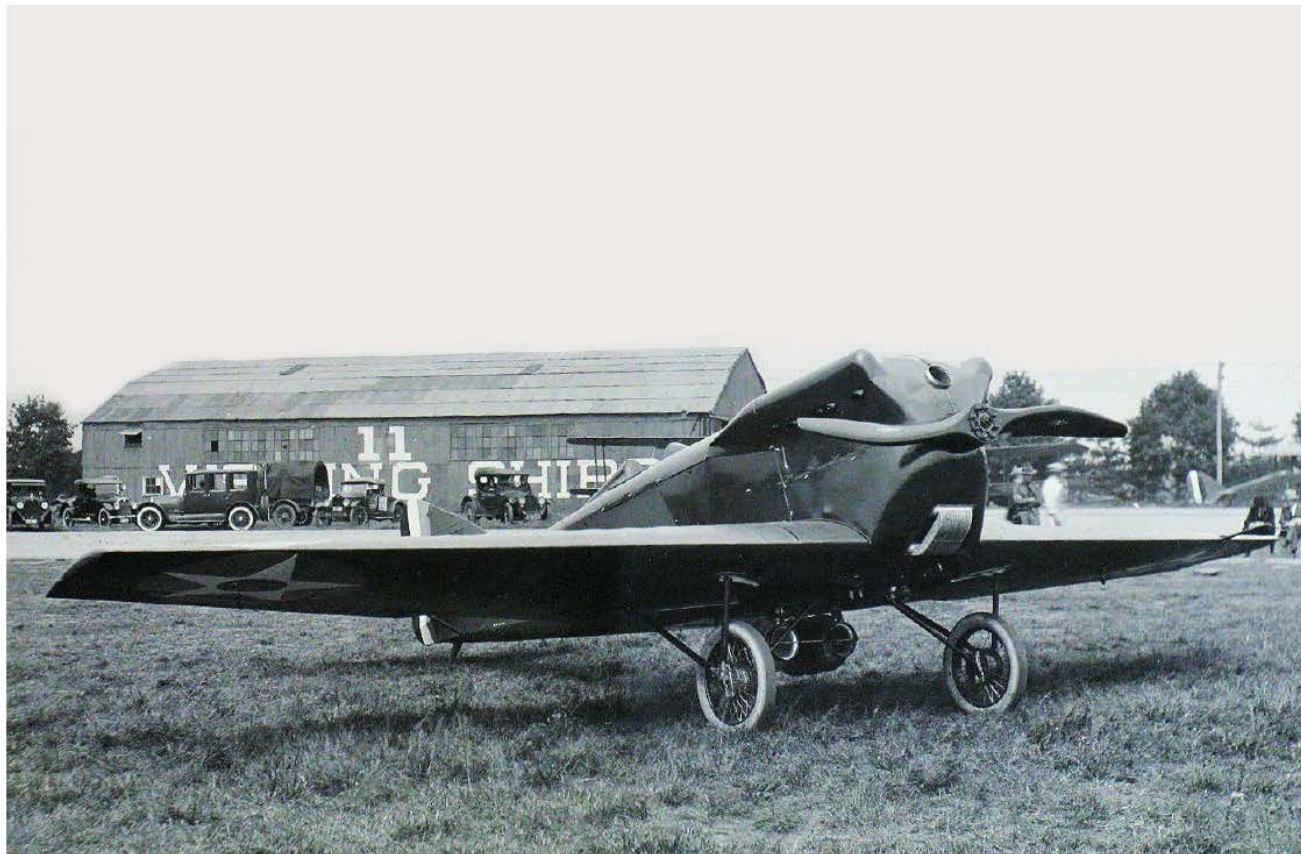


N.A.C.A. 2412 1933



N.A.C.A. 23012 1935

First Application...



Verville R-3 Racer

**First US aircraft to
blend all the
elements of
modern design,
including a Munk
airfoil section**

Munk and von Kármán



Munk as Mentor

Robert T. Jones

