Heinkel He 176

Douglas Downer-Smith

The story of the worlds first liquid fuelled rocket powered aircraft and the people involved

Lecture of the RAeS
Hamburg University of Applied Sciences
01.10.2009
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Introduction

Peenemünde June 1939

a milestone of flight takes place

Introduction

The path leading to this event:

- Civilian rockets & propulsion 1919 - 1932
- Military rocket development 1931 - 1939
- Rocket aircraft development 1935 - 1939
- Heinkel He 176 1935 -1939

Civilian rockets and propulsion 1919 - 1932

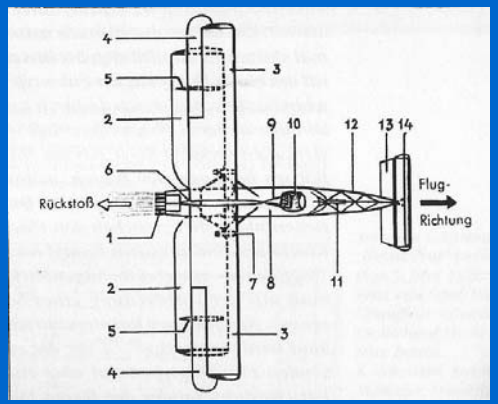
- 1919 Treaty of Versailles?
- 1923 Oberth's Die Rakete zu den Planetenräumen published
- 1927 VfR Spaceflight Society formed and quickly grows
- 1928-29 Emergence of rocket motors as a means of propulsion
- 1930 Raketenflugplatz established (Mirak & Repulsor)
- 1930 Army establishes Kummersdorf
- 1932 VfR winds down through political disputes and funding

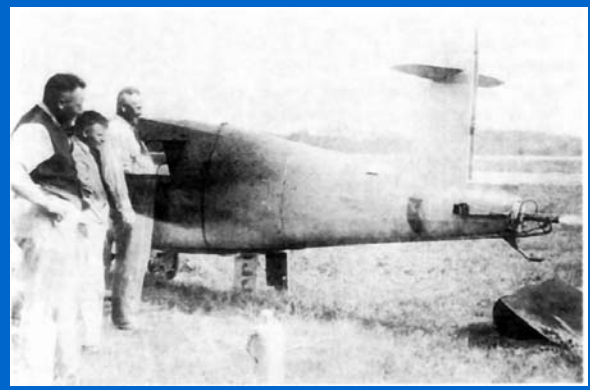
Rocket Aircraft 1928 - 1929

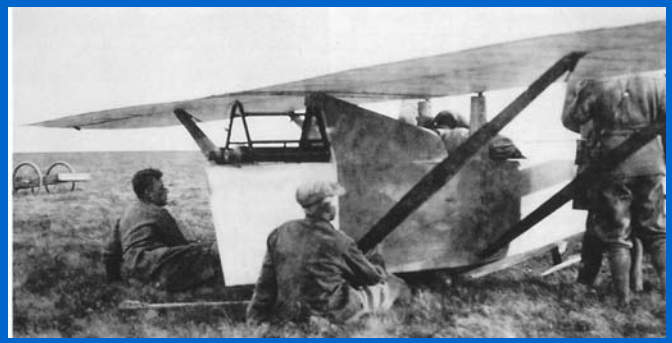
Rocket Aircraft:

- May 1928 - Opel RK 22
- June 1928 - Lippisch Ente
- June 1929 - Opel GMG-RAK
- September 1929 - Opel Rak 1
- October 1929 - Espenlaub RAK 3

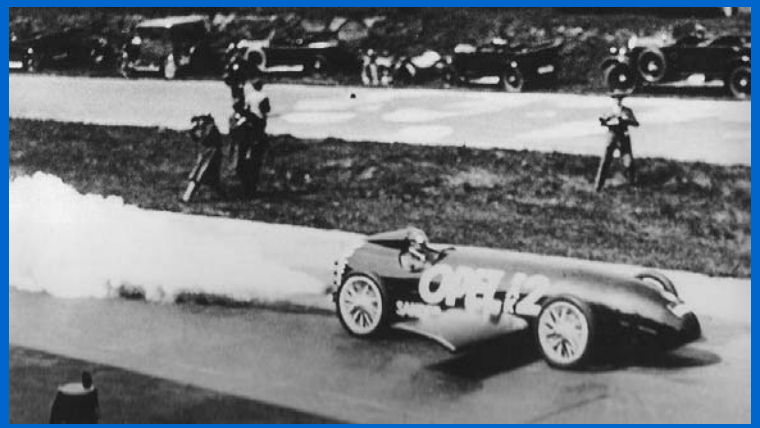
Rocket Aircraft 1928 - 1929

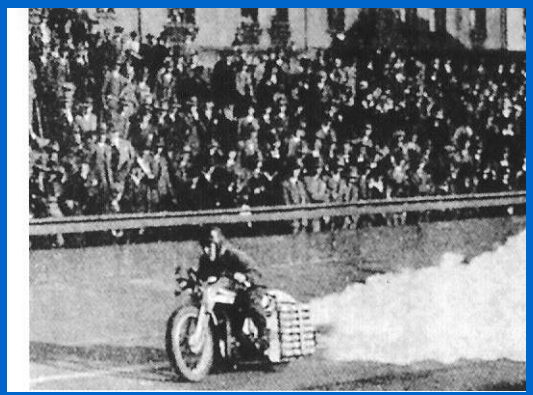






Rocket Propulsion - Entertainment in 1929





Military Rocket Development from 1931

Personalities and Organisations

- Dornberger - Army Ordnance at Kummersdorf
- Werner von Braun - Army Ordnance
- RLM established
- Helmuth Walter - HWK
- Wolfram von Richthofen - Technical Office, RLM
- Junkers
- Ernst Heinkel - EHF
- Eric Warsitz - Pilot

Interservice co-operation 1933 - 1936

- Joint Agreement Oct 1934 (Rockets & ballistics)
- Rocket motor accident at Junkers Feb 35 (RLM & Army visit)
- RLM & Army view Schmiddings pulsejet in Munich
- von Richthofen proposes RLM/Army/Junkers ‘Rocket Interceptor’ May 1935
- Peenemünde proposed for RLM & Army June 1935 - why?
- Joint development of Rocket Aircraft between RLM/Army/ Junkers/EHF summer 1935

Joint development of Rocket Aircraft 1935 - 1936

Construction begins at Peenemünde summer 1936

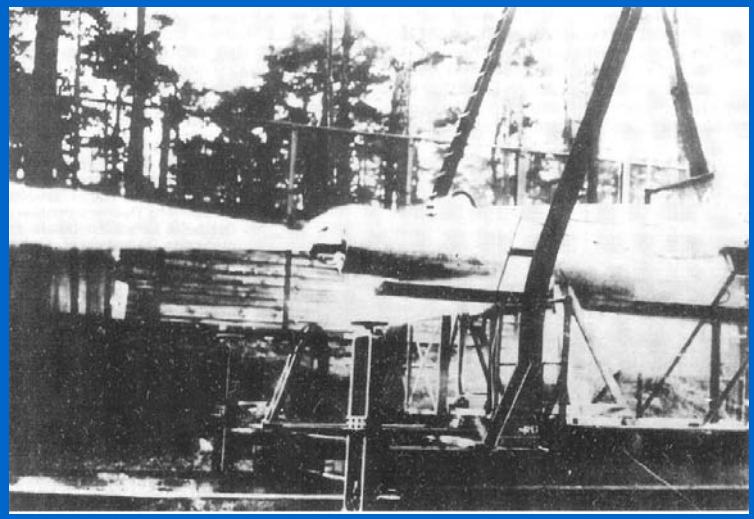
Rocket motors fitted to:

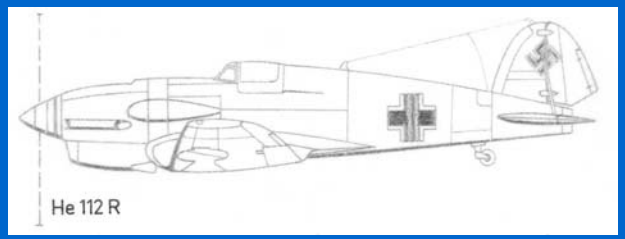
- Ju 50 - explodes during testing late 1936!
- He 112 - EHF supplies airframes for testing rocket motors

and….

He 176 - concept discussed

Rocket Aircraft of the Military Period





Rocket Aircraft Development 1935 - 1939

- Interservice rivalry emerges - why?
  - Dual programme of rocket motor development
    - WvB LOX - development time & performance
    - HWK H_20_2 - simpler & availability

Rocket Aircraft Development 1935 - 1939

- Interservice rivalry emerges - why?
  - Dual programme of rocket motor development
    - WvB LOX - development time/performance
    - HWK H_20_2 - simpler/availability
  - Peenemünde East - Army
  - Peenemünde West - RLM/LfW

….the reasons….

Rocket Aircraft Development 1935 - 1939

- RLM no longer reliant on Army Ordnance rocket technology
- Despite the rivalry co-operation remains
- Rocket Aircraft
  - He 72 (H_20_2) - Jan 1937
  - Fw 56 (H_20_2) - Summer 1937
  - He 112 V3 (H_20_2) and He 112 V4 (LOX) - 1937
  - He 176 V1 & V2 (H_20_2) -1935 and projected V3 & V4 (LOX)
  - DFS 194 (H_20_2) - late 1940*

Rocket Aircraft 1935 - 1940

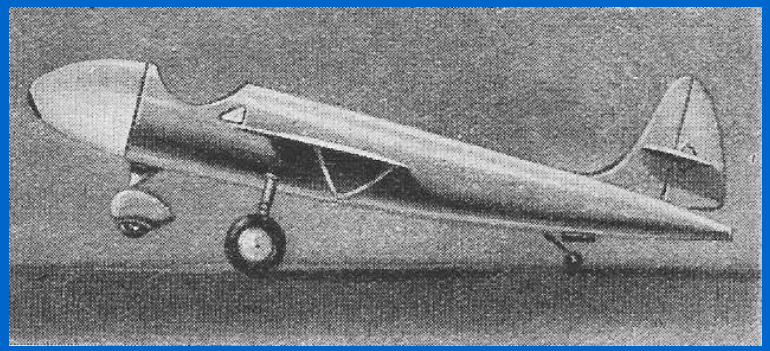
He 176 Concept 1935 - 1937

- 1936 - Conceived at WvB/RLM/EHF meeting
- 1937 - Designated by RLM as Interceptor
  - Construction begins
  - EHF and and the pursuit of speed
  - LOX and H_20_2 motors evaluated
  - Final choice of motor

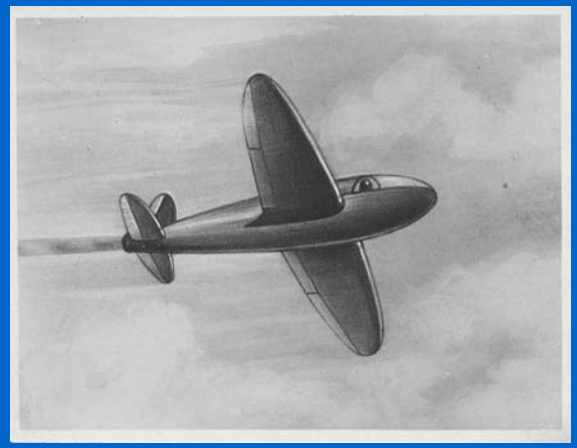
He 176 Development 1938 - 1939

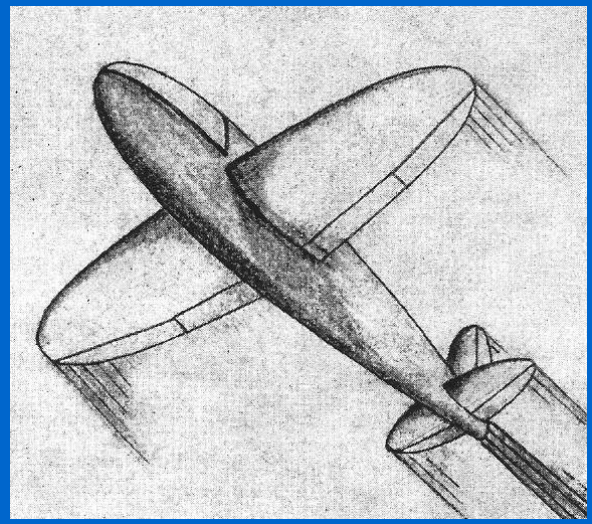
- 1938 - Tow and Taxi Trials at Peenemunde and Wind Tunnel Tests
- 1938 - Short power burst to test handling
- 1939 (Jan to Apr) - 29 flights recorded (throttle problems)
- 15 June 1939 - First official flight
- 20/21st June 1939- Flights before RLM (further flights cancelled!)
- 3rd July 1939 - Demonstrated to Hitler
- 1939 (Jun to Nov) - 19 flights recorded Peenemunde & Rechlin

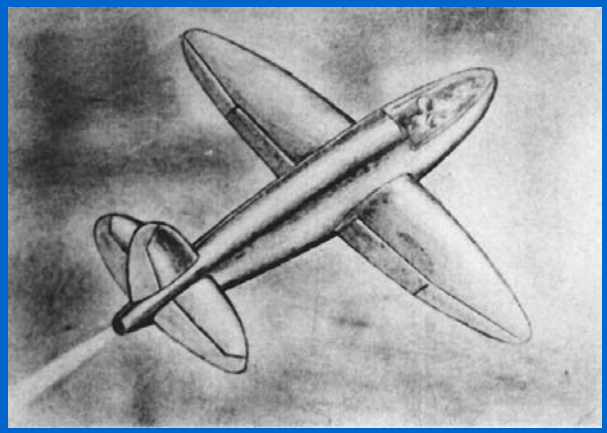
He 176 - Post War - it looked like this…..

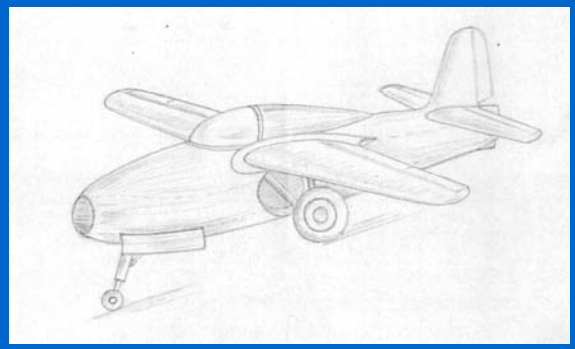


He 176 - post war recollections

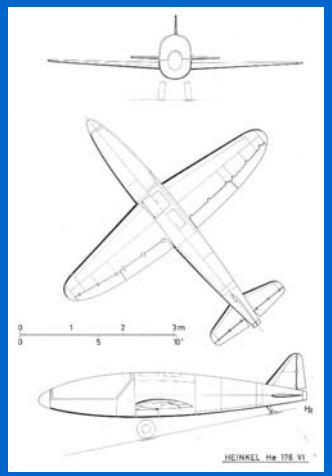


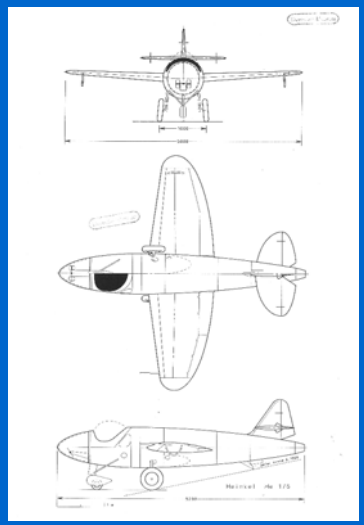


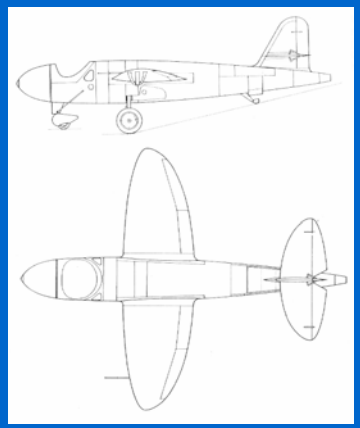


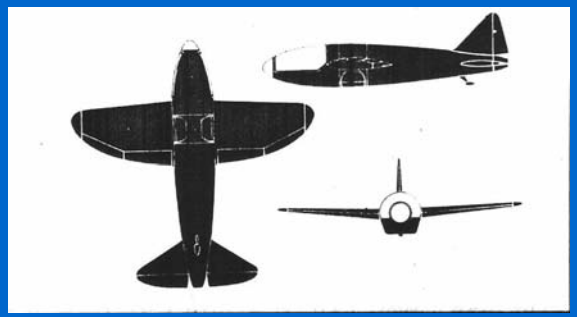


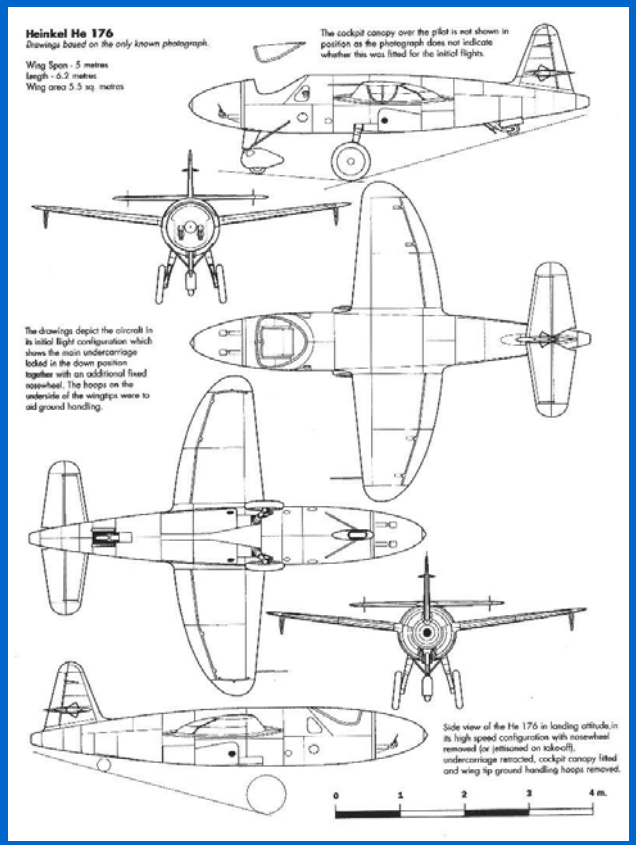
He 176 Post War Technical Drawings





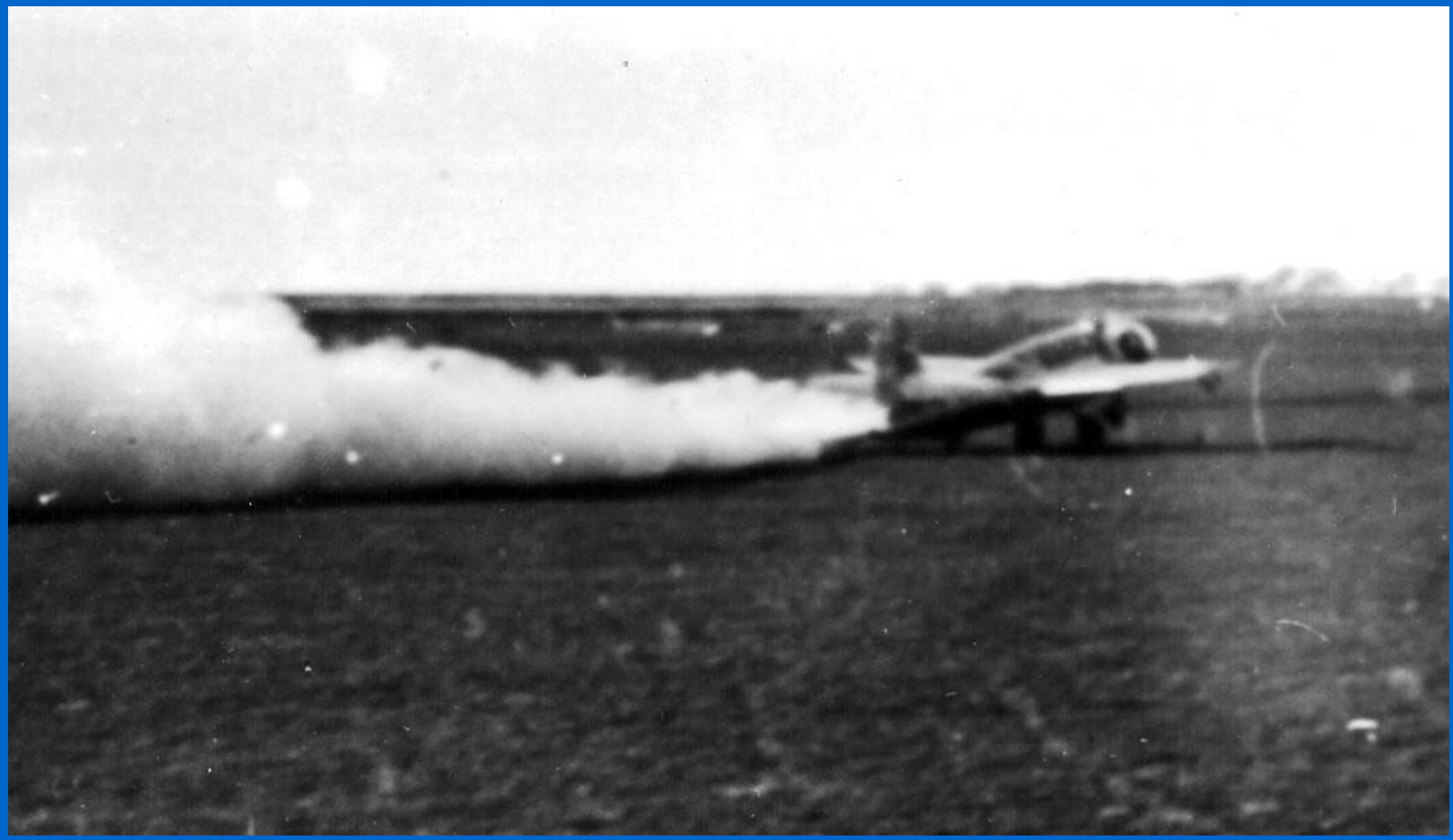






The aircraft actually looked like….this…..

He 176 under power



How might the aircraft have flown?

Questions and problems:

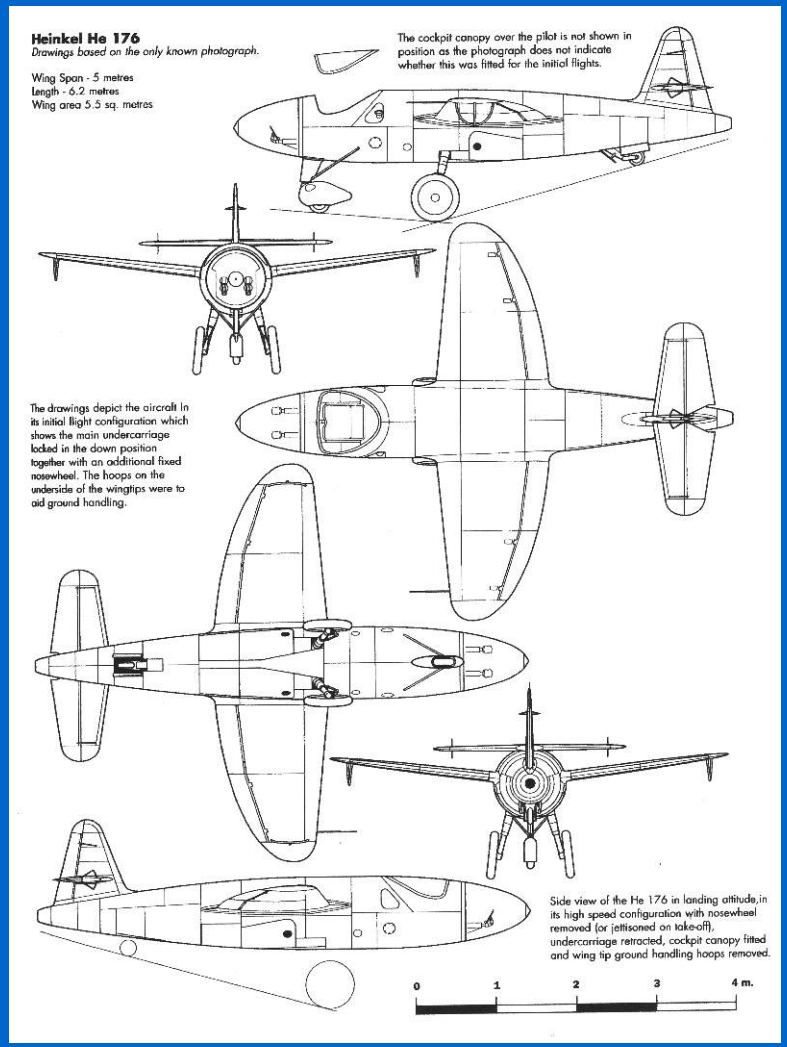
- Speeds claimed post war were up to 800 km/h - possible?
- Could aircraft design software be used to model the aircraft?
- Would aerodynamic students be willing to recreate?
- Any wind tunnel testing possible?
- Limited personal aerodynamic knowledge

The solution….

was to use Aircraft PDQ software

Reconstructing the He 176 from the photograph

Arthur Bentley's drawing of 2002 based on undercarriage type and retract requirements and similarities to the He 178



Reconstructing the He 176 from the photograph

But…..

…..there was a problem.

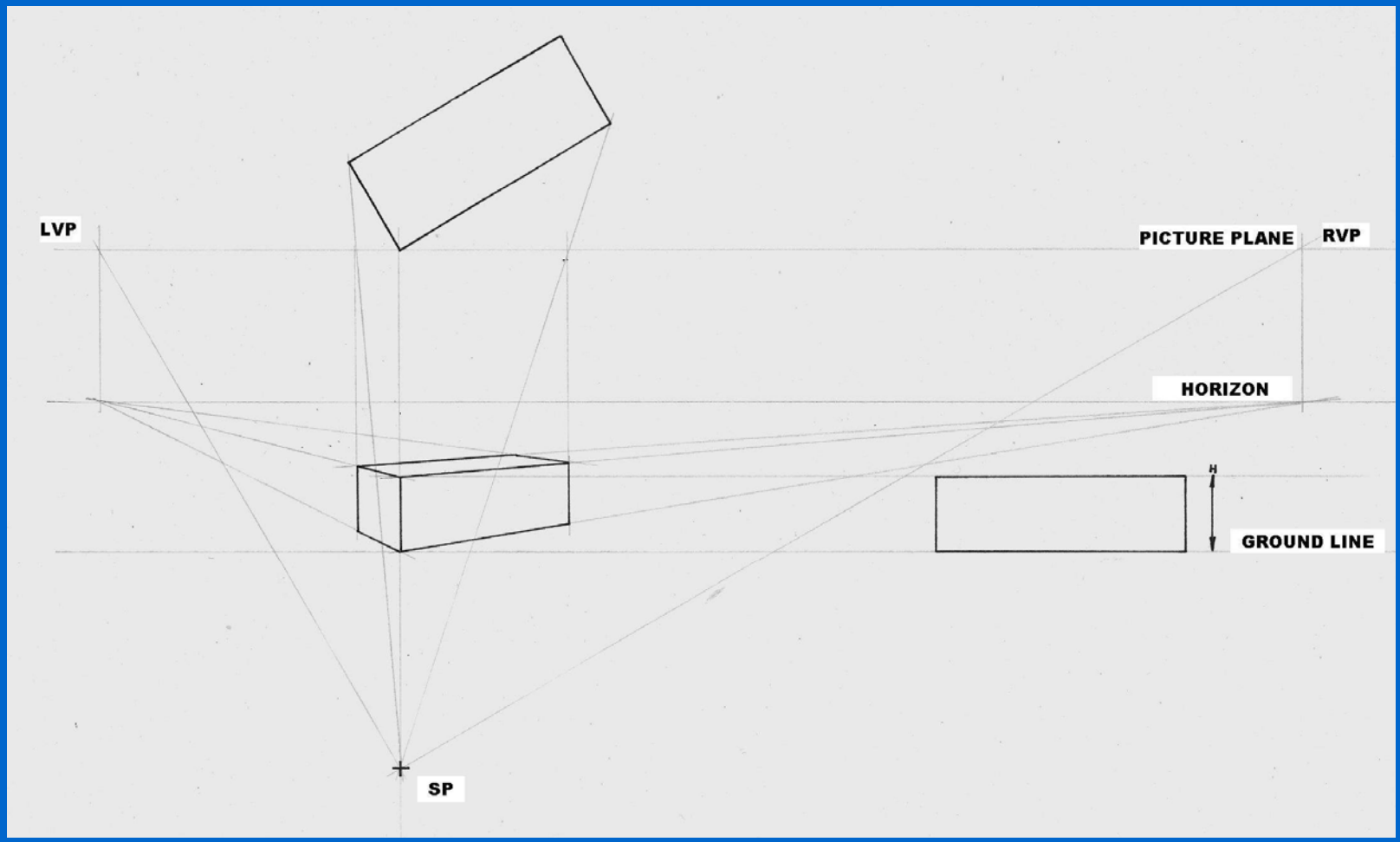
The design as drawn was unstable with poor CG position!

What to do next…..?

Creating a 2D drawing from the photograph

- Discussion with Technical Illustrator
- Understand Perspective Drawing
- Evaluate the wing placement

Perspective Drawing



Perspective Drawing

Difficulties ?

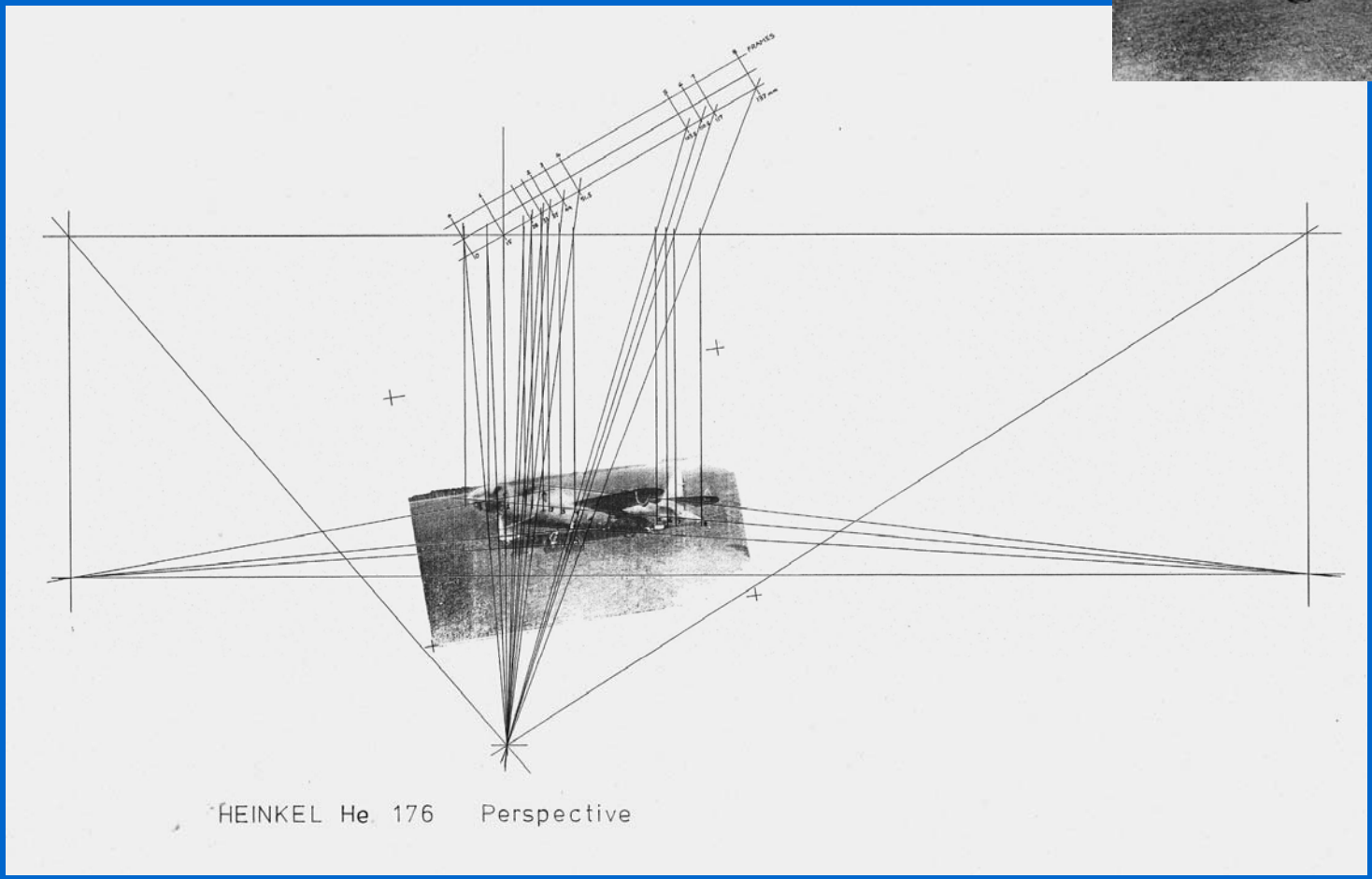
- Shape of the aircraft
- Inclined and worms eye view
- Reliable dimensions

Solutions ?

- Develop a technique
- PID = Perspective Interpretation Drawing

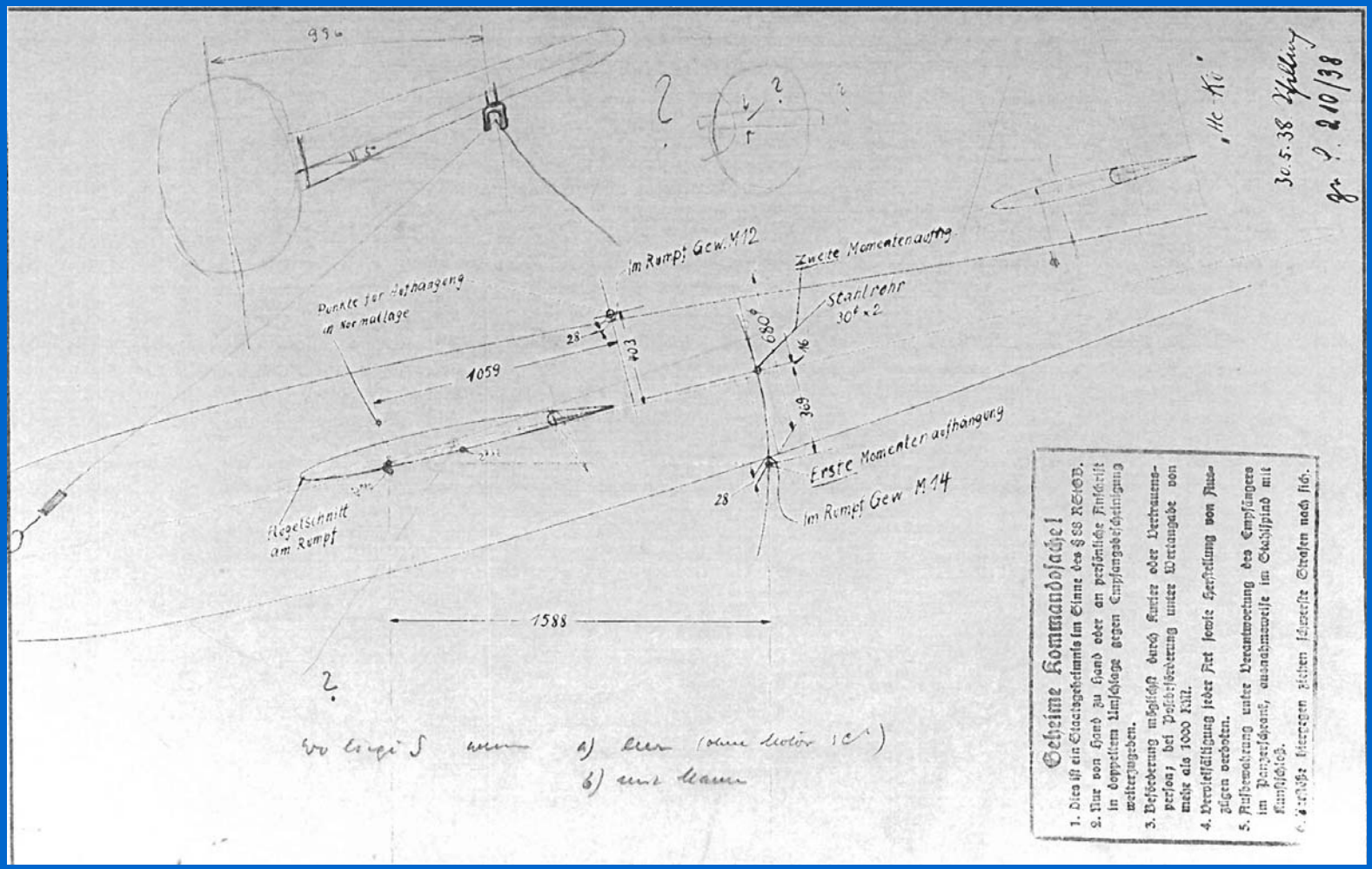
Establishing perspective construct lines

He 176 PID to establish wing position



But…how accurate are the results?

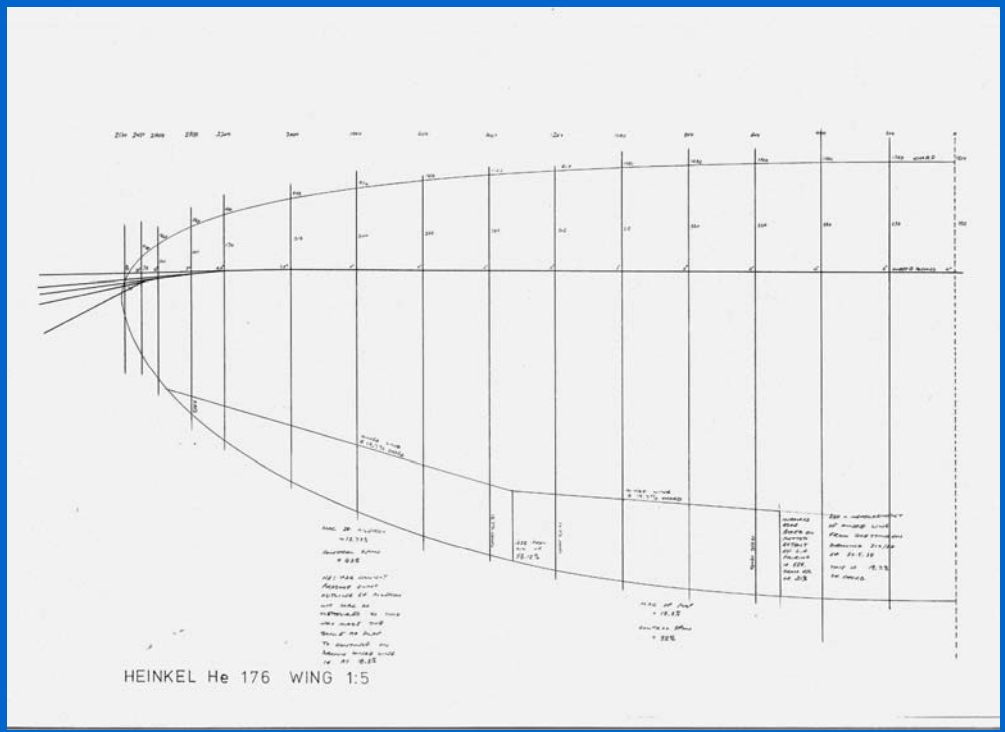
A breakthrough…..found in the Göttingen Archives

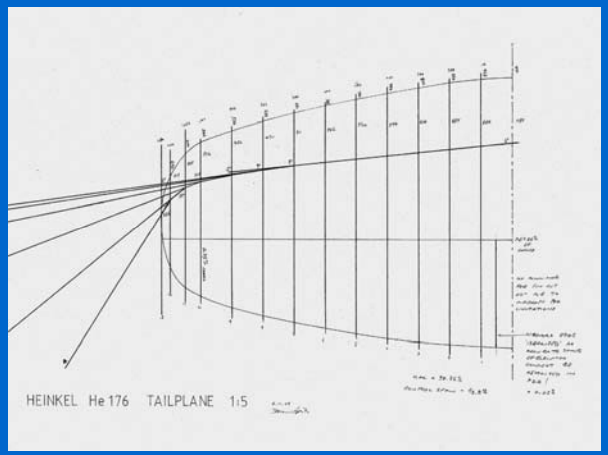


He 176 PID techniques to establish wing shape

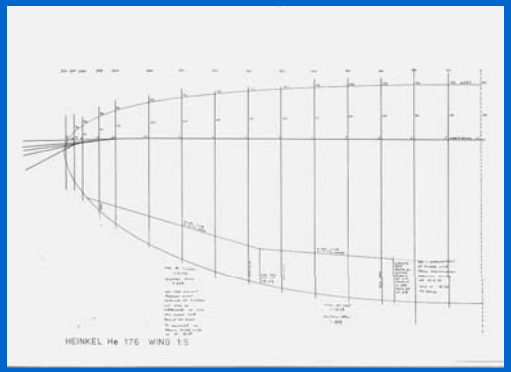
He 176 Wing and tailplane reconstructed using PID

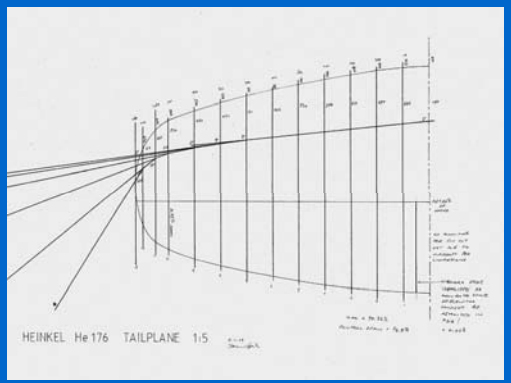
Airfoil sections similar to NACA 0009 - 34

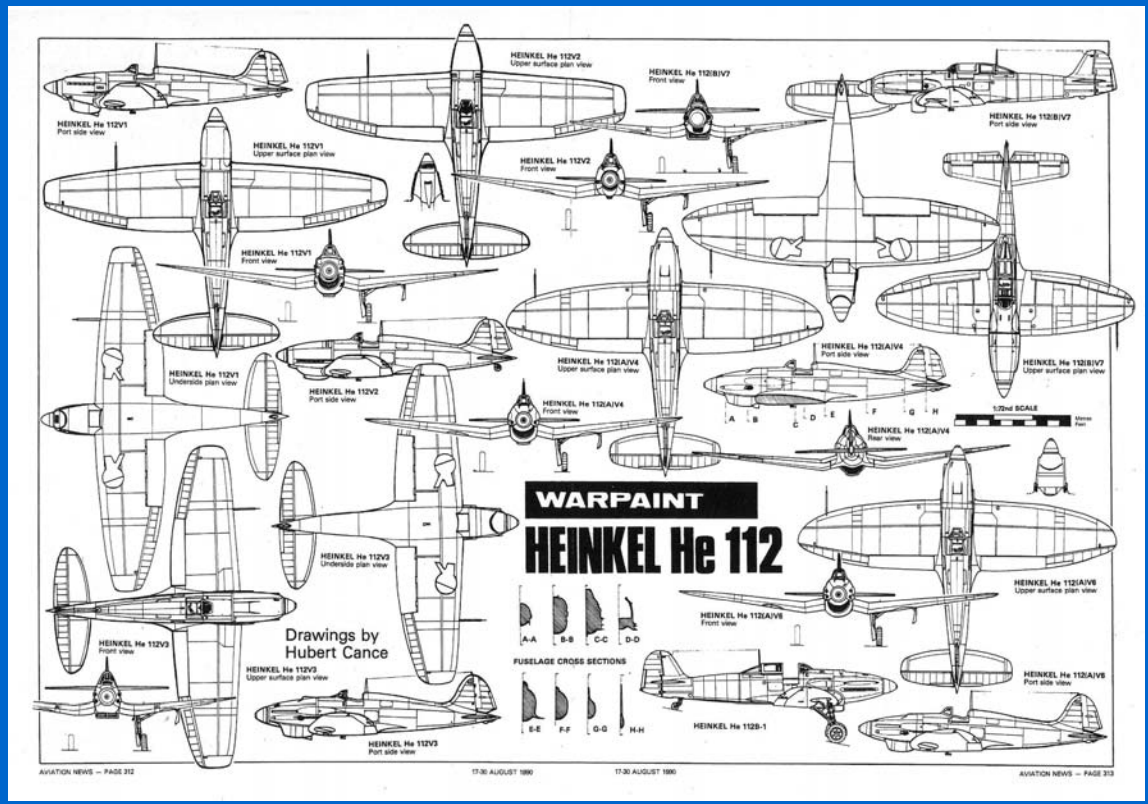




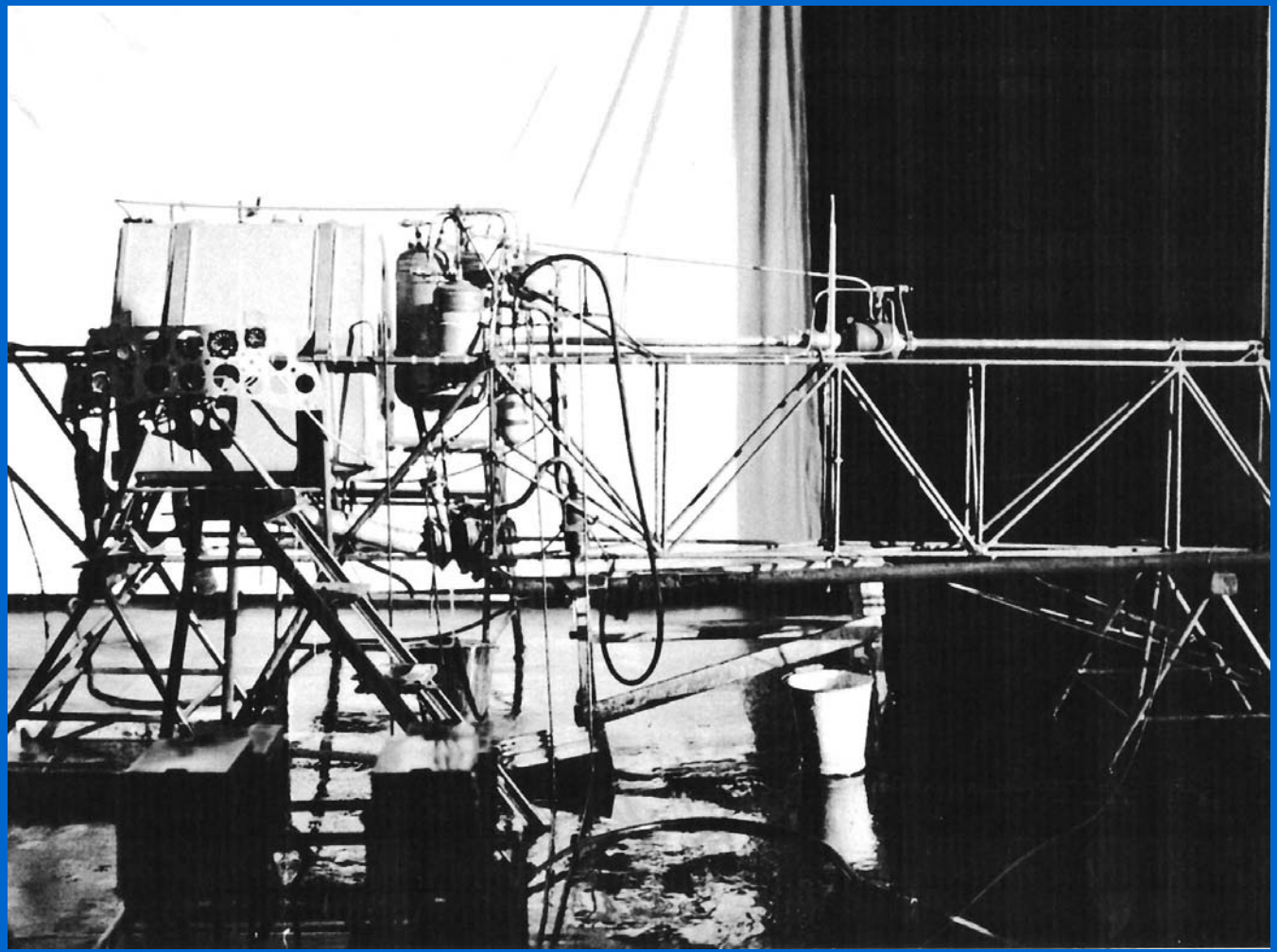
Other Heinkel wings and tail planes used for comparisons





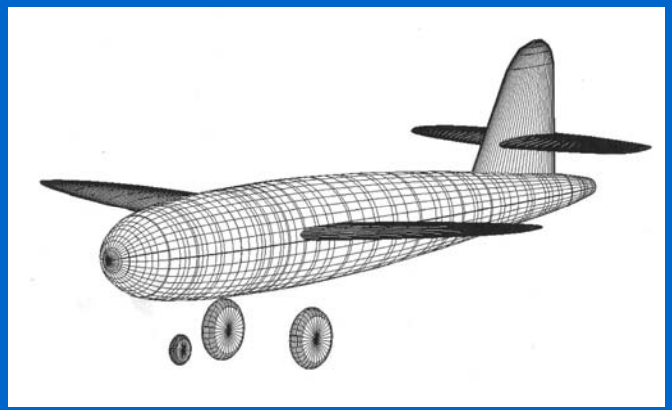


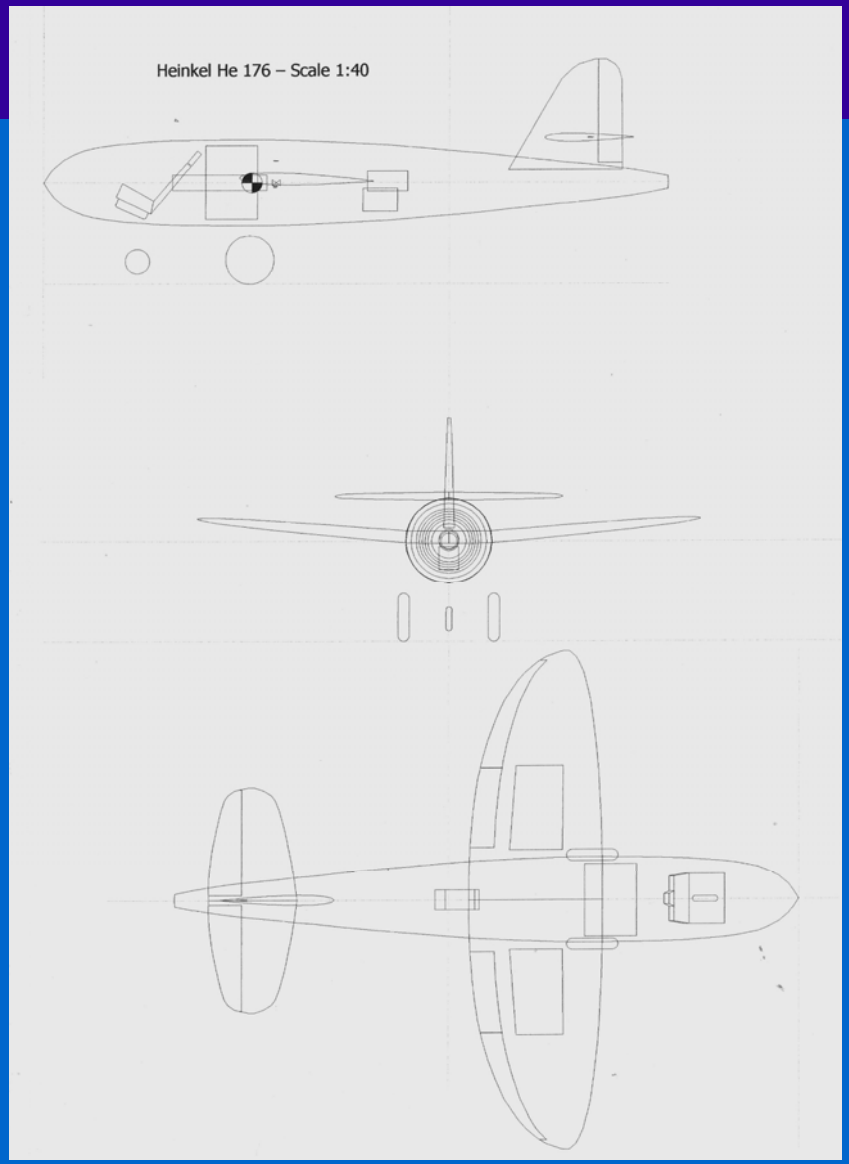
HWK H_2O_2 Rocket Motor similar to the He 176



He 176 Drawings 2009

2D and 3D drawings constructed from Göttingen sketches and Perspective Interpretation Drawings of photograph in PRO - Kew





He 176 - The aircraft was small for the pilot!

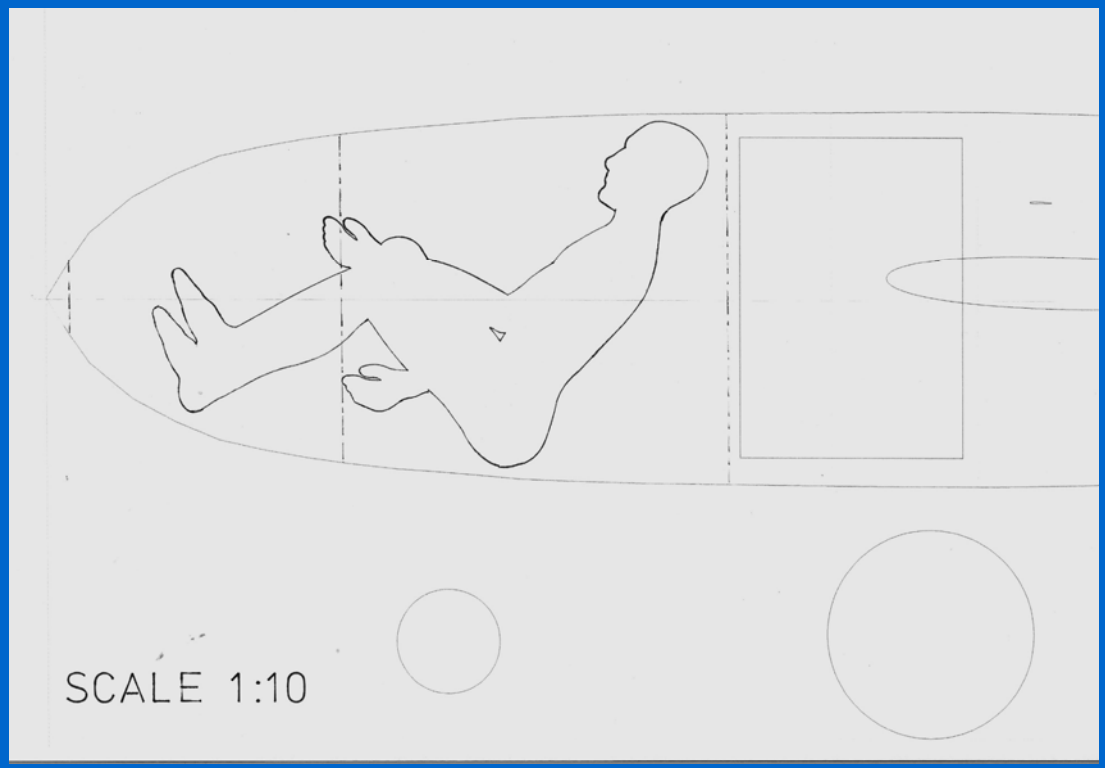
Max length from bulkhead to tip

= 1580 mm

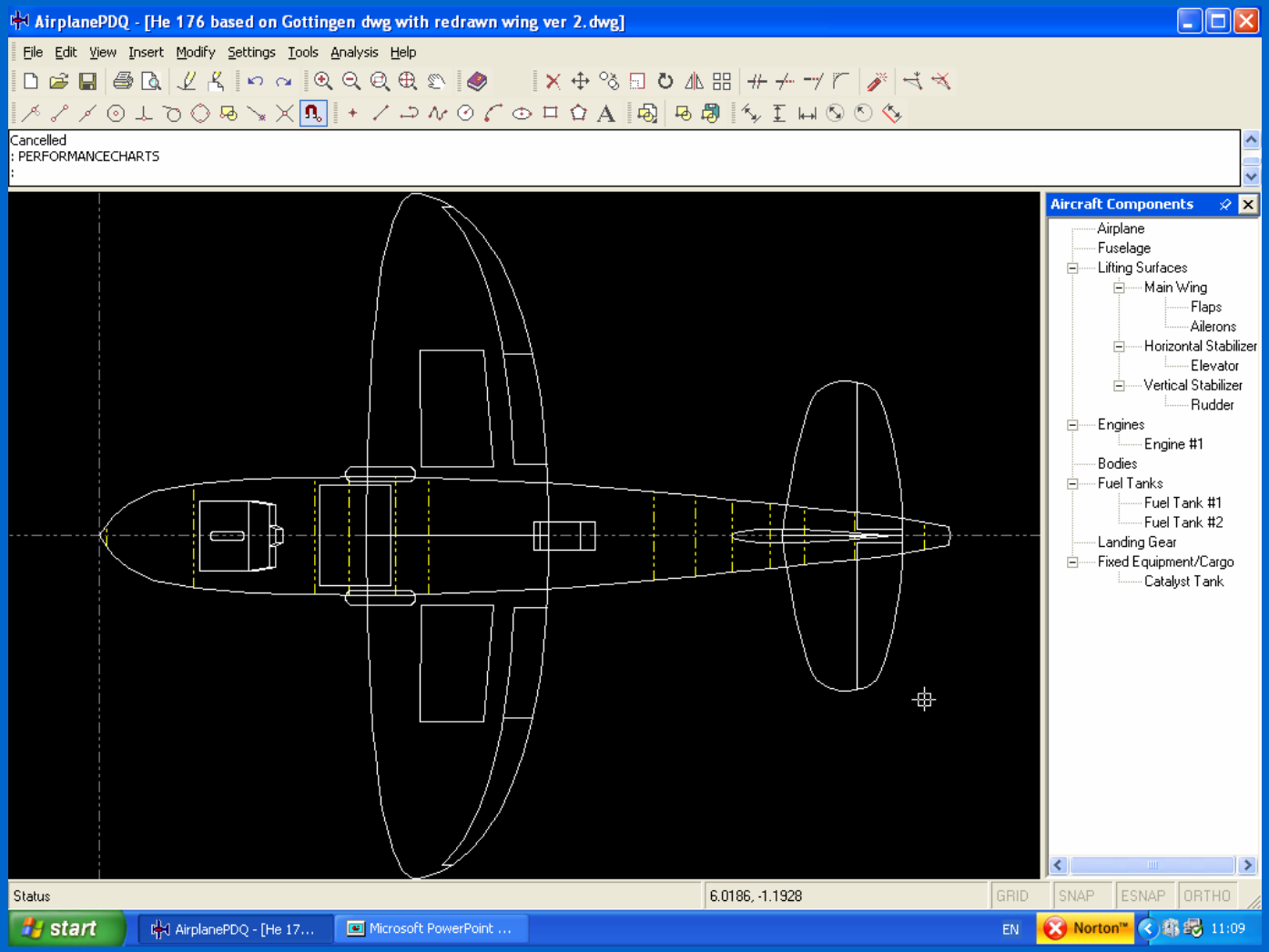
Max dia. of fuselage = 850 mm

Room required for instrumentation, motor controls, aircraft controls and pedals

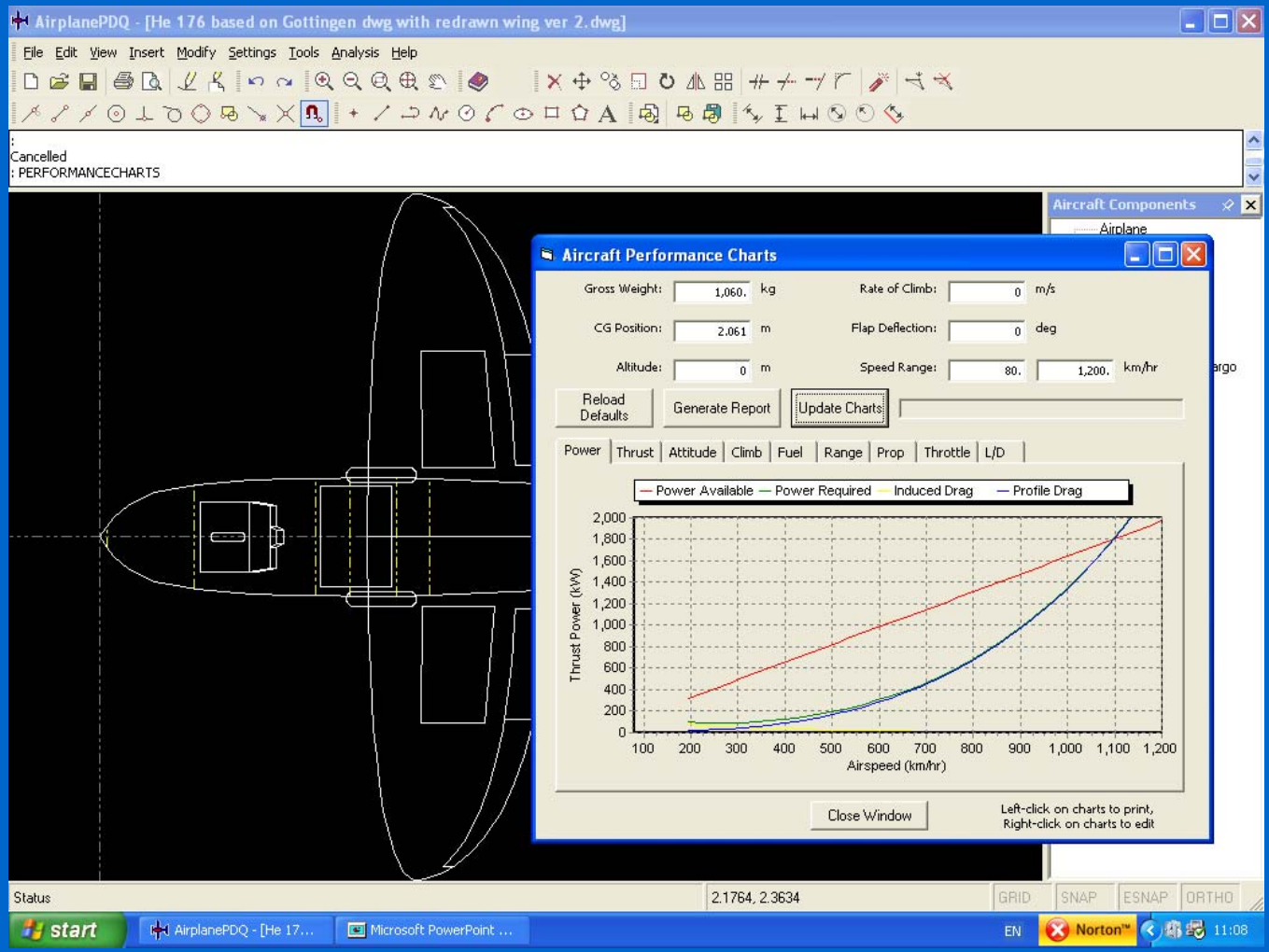
Verdict = tight!



How could it have flown using Aircraft PDQ



Aircraft PDQ - generating Performance Charts

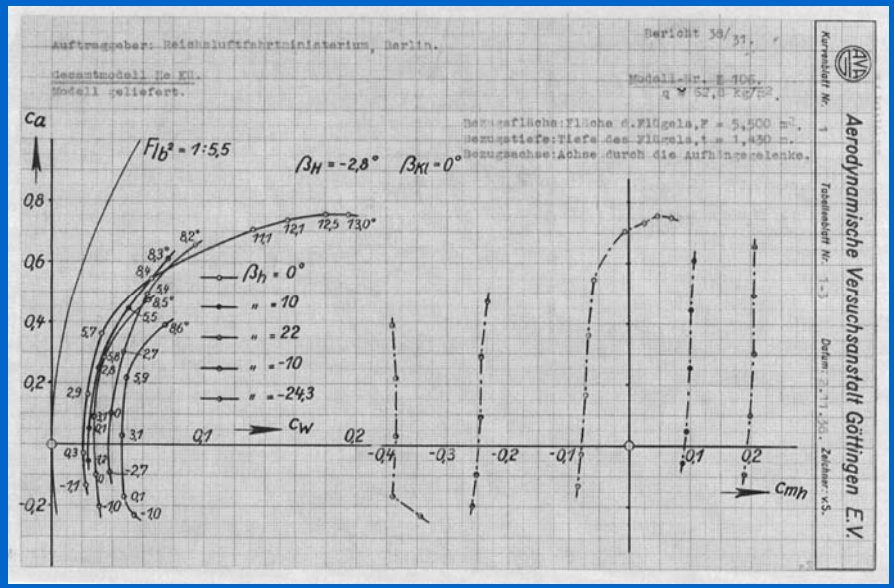


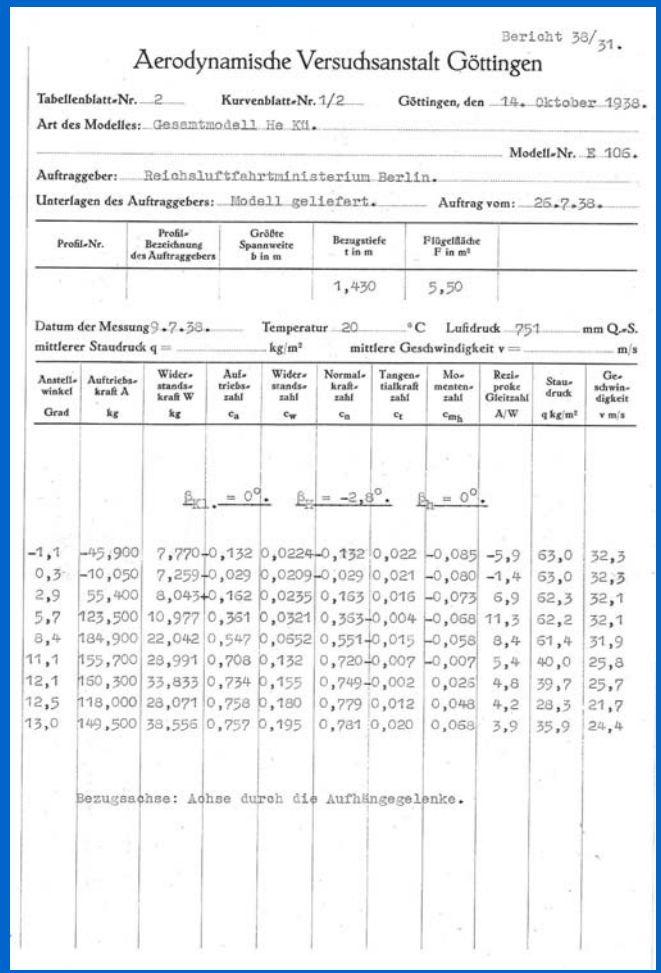
Preliminary Aircraft PDQ performance figures

- No effect of compressibility
  - Wing data optimised for low speed < M 0.3
- Calculated top speed just over 1000 km/h
- Lift curve shows lift ~9.5 times drag
- Drag co-efficient at ~0.02
- Drag overall
  - Appears to be for max. speed without compressibility
- C_D of wing ~0.005

Validating Aircraft PDQ results

Göttingen Wind Tunnel data used to reconstruct basic flight performance





Bericht 38/31.

Aerodynamische Versuchsanstalt Göttingen

Tabellenblatt-Nr. 2 Kurvenblatt-Nr. 1/2 Göttingen, den 14. Oktober 1938.

Art des Modelles: Gesamtmodell He KH. Modell-Nr. E 106.

Auftraggeber: Reichsluftfahrtministerium Berlin.

Unterlagen des Auftraggebers: Modell geliefert. Auftrag vom: 26.7.38.

Profil-Nr.	Profil-Bezeichnung des Auftraggebers	Größte Spannweite b in m	Bezugstiefe t in m	Flügelfläche F in m²
			1,430	5,50

Datum der Messung 9.7.38. Temperatur 20 °C Luftdruck 751 mm Q.-S.

mittlerer Staudruck q = kg/m² mittlere Geschwindigkeit v = m/s

Anstell-winkel Grad	Auftriebs-kraft A kg	Widerstands-kraft W kg	Auftriebs-zahl c_a	Widerstands-zahl c_w	Normalkraft-zahl c_n	Tangential-kraft-zahl c_t	Momenten-zahl c_{m_h}	Reziproke Gleitzahl A/W	Staudruck q kg/m²	Geschwindigkeit v m/s
			$\beta_{Kl} = 0°$.		$\beta_H = -2,8°$.		$\beta_H = 0°$.			
-1,1	-45,900	7,770	-0,132	0,0224	-0,132	0,022	-0,085	-5,9	63,0	32,3
0,3	-10,050	7,259	-0,029	0,0209	-0,029	0,021	-0,080	-1,4	63,0	32,3
2,9	55,400	8,043	0,162	0,0235	0,163	0,016	-0,073	6,9	62,3	32,1
5,7	123,500	10,977	0,361	0,0321	0,363	-0,004	-0,068	11,3	62,2	32,1
8,4	184,900	22,042	0,547	0,0652	0,551	-0,015	-0,058	8,4	61,4	31,9
11,1	155,700	28,991	0,708	0,132	0,720	-0,007	-0,007	5,4	40,0	25,8
12,1	160,300	33,833	0,734	0,155	0,749	-0,002	0,026	4,8	39,7	25,7
12,5	118,000	28,071	0,758	0,180	0,779	0,012	0,048	4,2	28,3	21,7
13,0	149,500	38,556	0,757	0,195	0,781	0,020	0,068	3,9	35,9	24,4

Bezugsachse: Achse durch die Aufhängegelenke.

Comparison of Aircraft PDQ with Göttinger results

- Using Göttinger C_L/C_D graph for no flaps
- Use weight calculated weight estimates from APDQ
- Calculate C_L for V m/s
- Read off graph the values of C_L

Comparison of Aircraft PDQ with Göttinger results

- Calculate new values for Drag
- Calculate Power Available = 650 kW
- Calculate V_{ROC} = 66 m/s
- Calculate Stall Speed = 234 km/h
- Calculate Take off Speed = 180 km/h
- Calculate Approach Speed = 300 km/h

Comparison of preliminary data with contemporary data

Ing. Walther Künzel - EHF	DDS - 2009
•Max speed = 1000 km/h	•Max speed = 1090 km/h
•R.O.C. = 67.5 m/s	•R.O.C. = 66 m/s
•Min Speed = 170 km/h	•Min Speed = 180 km/h
•Take off Weight = 1000 kg	•Take off Weight = 1060 kg

How could it have flown? - Aerodynamic Summary

Analysis in chart and tables for:

- Summary Report
- Geometry
- Weight and Balance
- Drag
- Trim
- Aerodynamics
- CG Limits
- Design Check Report

Aircraft PDQ He 176 Dimensions and Weights

- Wing Span - 5.007 m
- Length - 6.203 m
- U/C track - 0.9 m
- Fuselage Width - 0.862 m
- Wing Area - 5.379 m^2
- Wing Loading - 197.1 kg/m^2

Motor Thrust - 5900 N

- Empty weight - 550.1 kg
- Gross Weight - 1060.1 kg
- Fuel capacity - 312.4 l
- Thrust to Weight - 0.5676

Aircraft PDQ He 176 Performance - theoretical

- Max. level speed - 309.4 m/s (1113.8 km/h)
- Cruise - 301.4 m/s (1085.1 km/h)
- Stall Speed Clean - 54 m/s (195 km/h)
- Stall Speed 45° Flaps - 46 m/s (166 km/h)
- Max. ROC - 66 m/s
- Max. Lift/Drag - 9.6
- Max. Cruise - 79 km
- Fuel Consumption - 5477 l/h*

How did it actually fly?

According to Eric Warsitz…..

The flight overview consisted of:

•Pre-flight checks

•Take Off

•Observations

•Flight

•Landing

Duration of flight…..

Approx. 55 seconds !

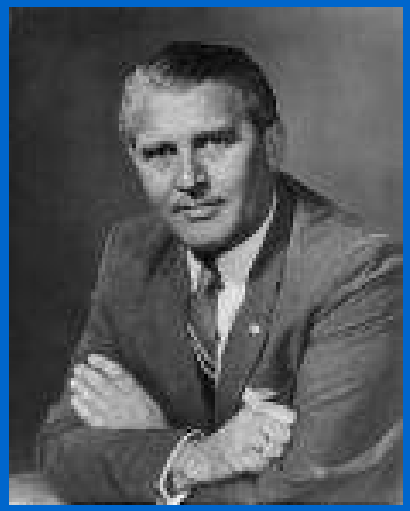
Did it fly or could it have flown?

- Documentary evidence
- Theoretical calculations
- Modern day Test Pilots' views
- Aerodynamicist's views
- Effects of undercarriage and nosewheel on drag
- Preliminary conclusions
- On-going work

Celebrations...!

What became of those involved…..?

Ernst Heinkel



Werner von Braun

Eric Warsitz

Heinkel’s Legacy - milestones of flight

He 178

The world’s first turbojet powered aircraft

He 280

The world’s first twin jet turbojet powered aircraft

He 162

The world’s first single turbojet powered fighter aircraft

….and the subject of this presentation

Heinkel’s Legacy - milestones of flight

The world’s first liquid fuelled rocket aircraft

Heinkel He 176

My thanks to all those who have helped and guided...

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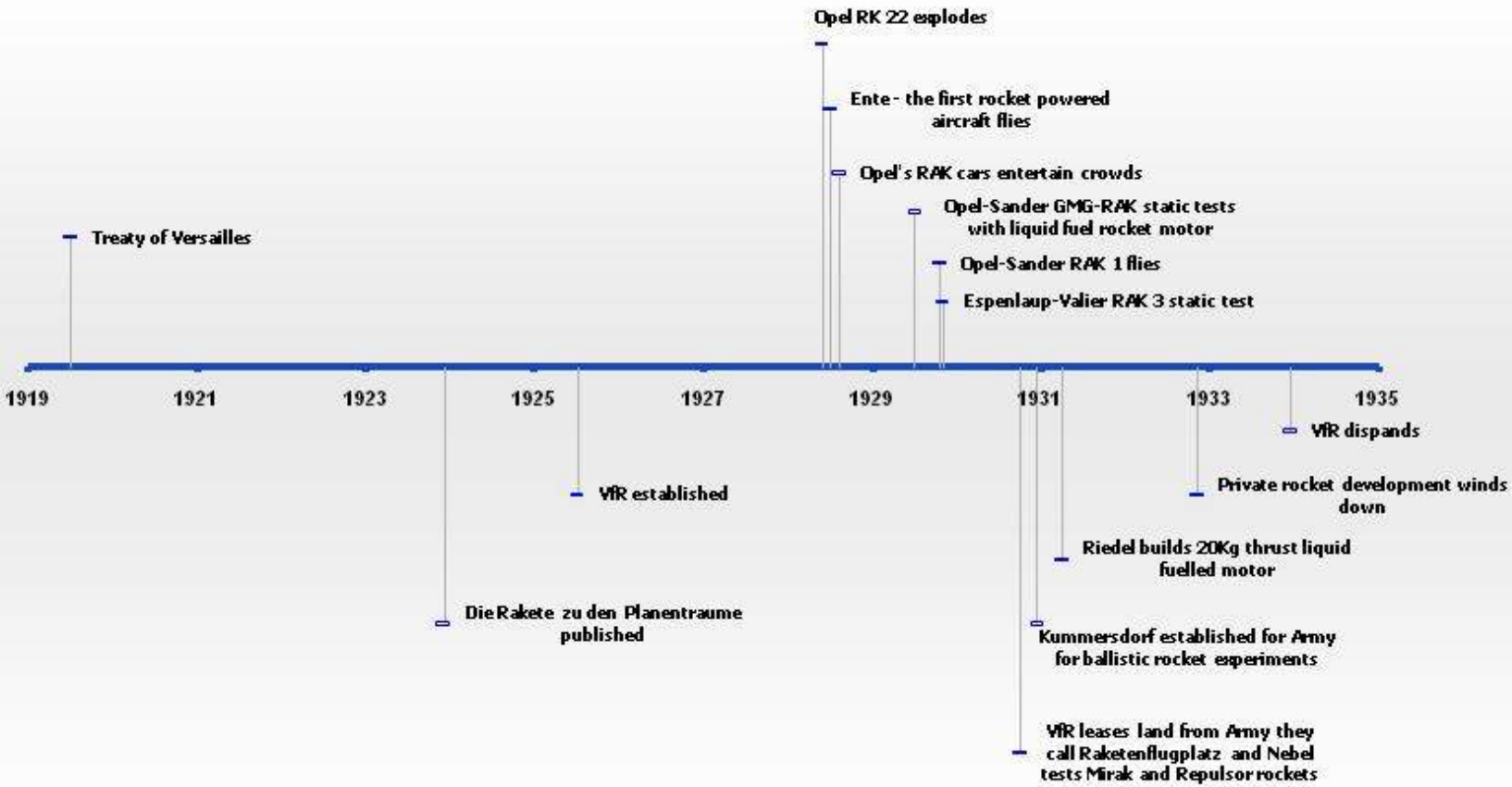
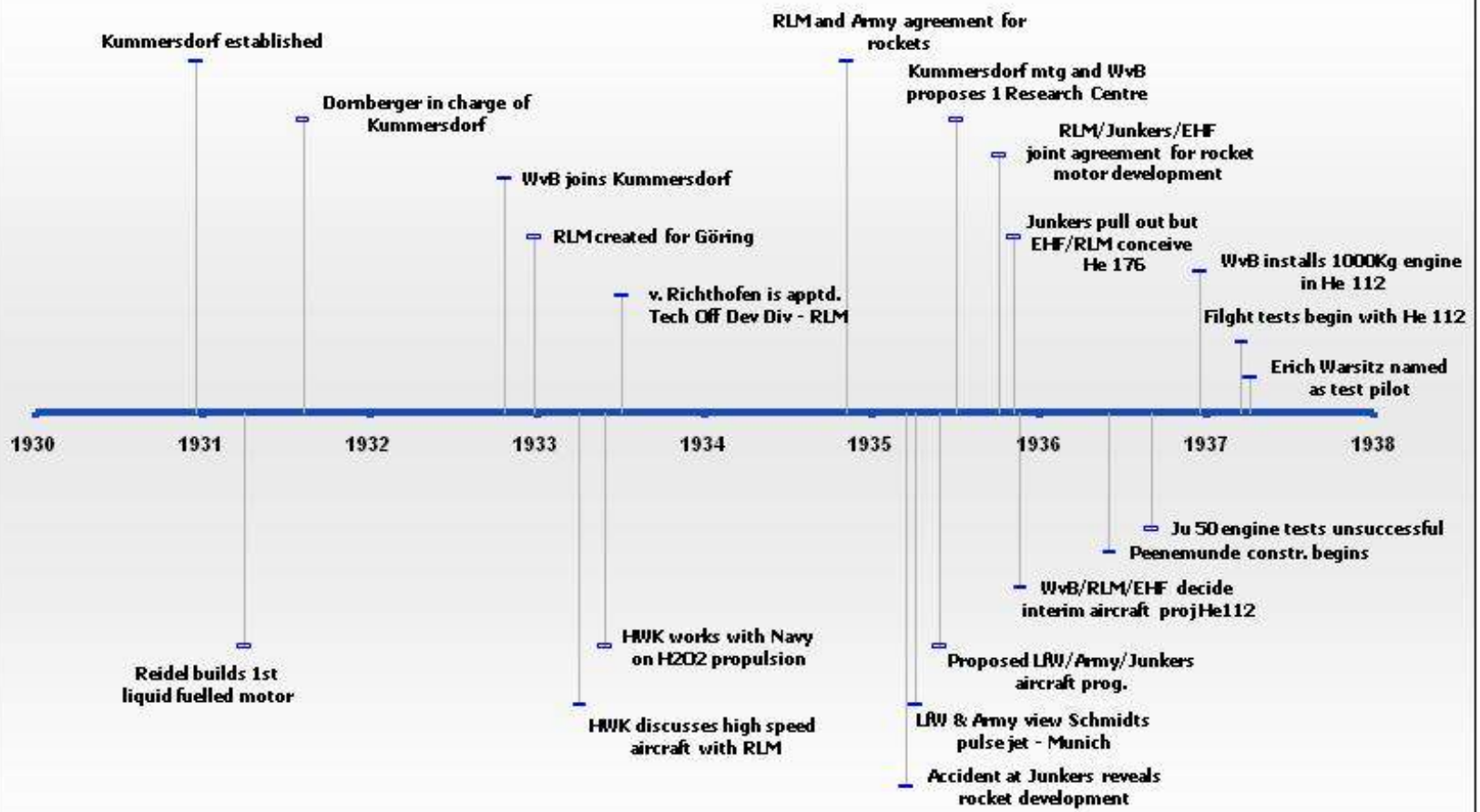
The story of the worlds first liquid fuelled rocket powered aircraft and the people involved

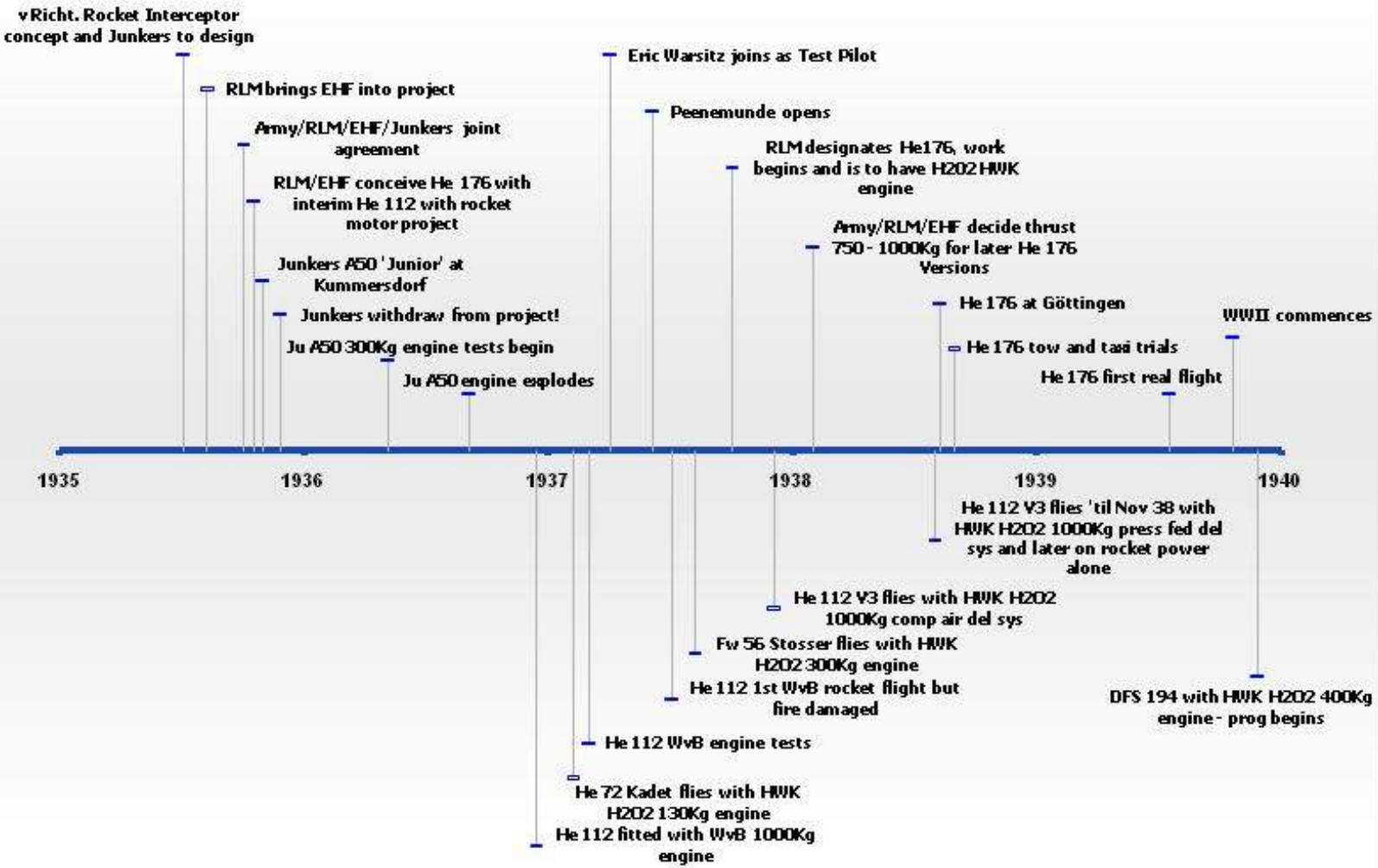
Rockets and Propulsion - Civilian Period



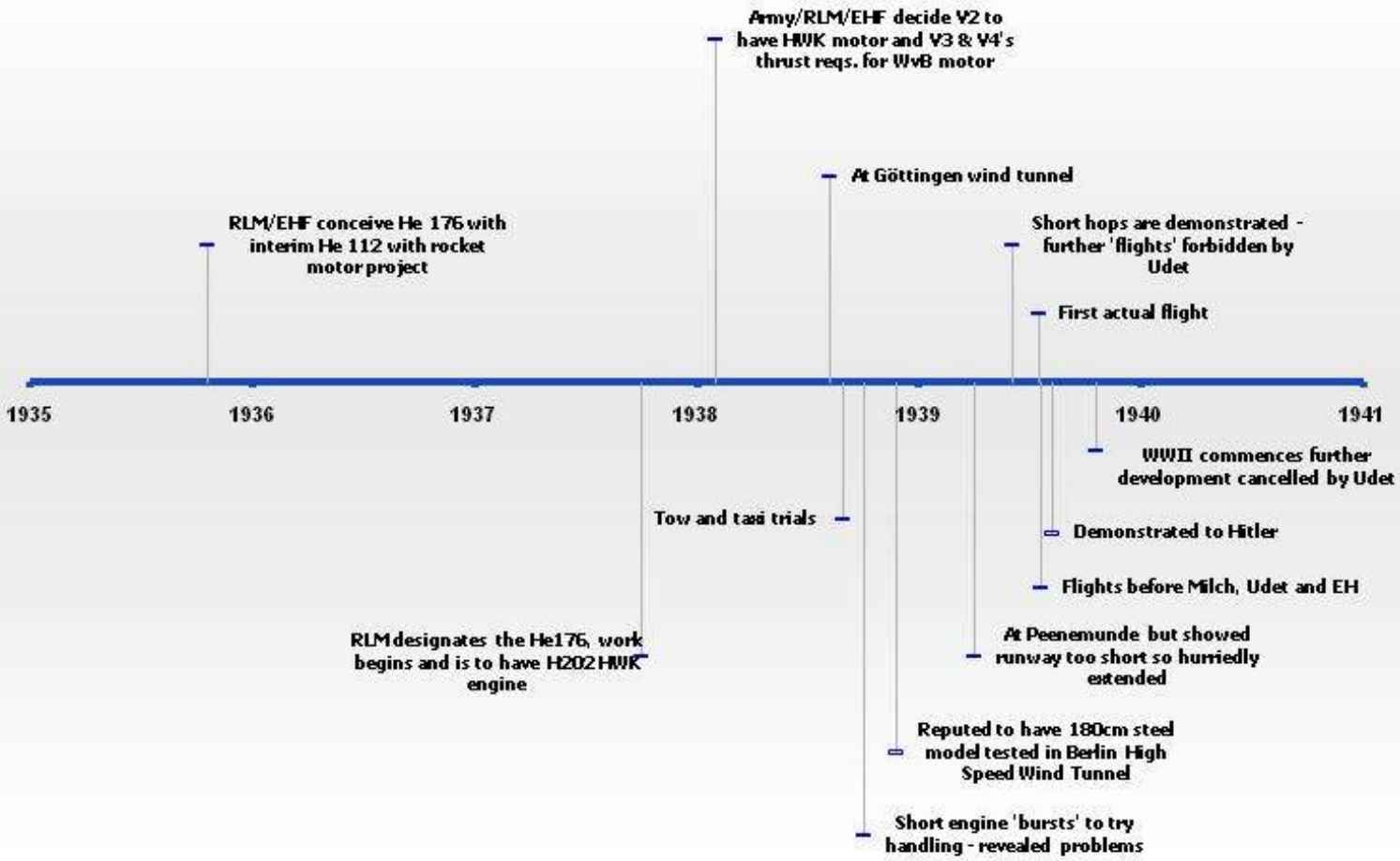
Rockets & Propulsion - Military Development



Rocket Aircraft Development



Heinkel He 176 Development



Graph to show for Power Available and max. speed (theoretical)