

# **New Concepts in Pilot G-Protection**

## **Presentation at the Royal Aeronautical Society – Hamburg Branch**

January 28, 2010



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**1940s Prototype of a Pneumatic G Suit**  
*[Source: McDonnell Aircraft Company]*

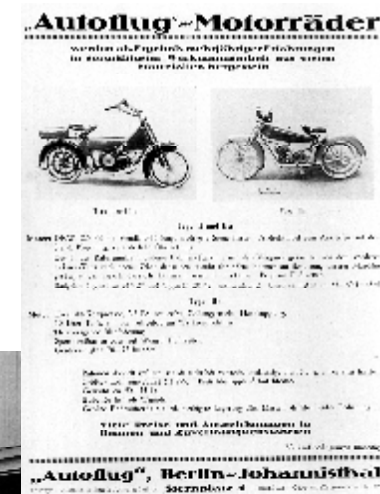
## CONTENTS:

- § Some facts about AUTOFLUG
- § Gravitational Forces and their physiological impact
- § Means of Protection
- § Development, Testing & Qualification
- § Most recent project: the G-Race Suit

## Company History

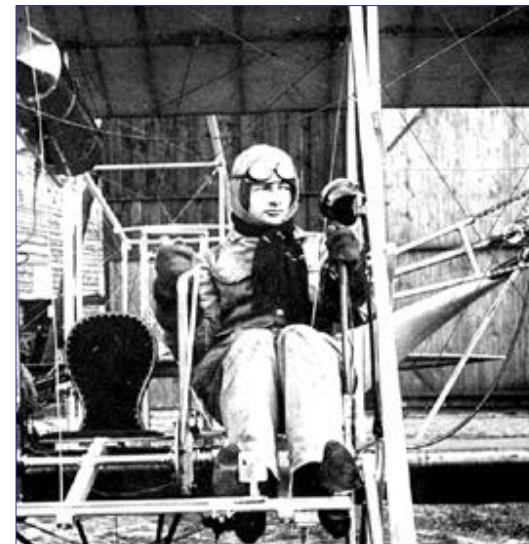
AUTOFLUG was founded in 1919 by pioneer aviator Gerhard Sedlmayr at Berlin-Johannisthal.

From its early beginnings until today AUTOFLUG has remained as an independent family-owned enterprise.





- Gerhard Sedlmayr received the German Pilot licence No. 162, dated 20<sup>th</sup> February 1912.
- He set a German flight record with a flight time of more than 6 hours – performed on 14<sup>th</sup> March 1913.



Gerhard Sedlmayr  
on Wright „Doppeldecker“ [1913]

In 1956, Dr. med. Gerhard Sedlmayr restored the company in Rellingen near Hamburg.

The main product areas in Rellingen are:

- Rescue and Safety Technology
- Measurement and Control Systems



## The AUTOFLUG Locations

### **AUTOFLUG Steuerungs- und Sensortechnik, Kirchheim**

Main activities:

- Gyroscopes
- Inertial Measurement Systems



### **GECO Systemtechnik, Brüsewitz**

Main activities:

- Locking Devices



### **AUTOFLUG Safety Systems, El Paso, TX**

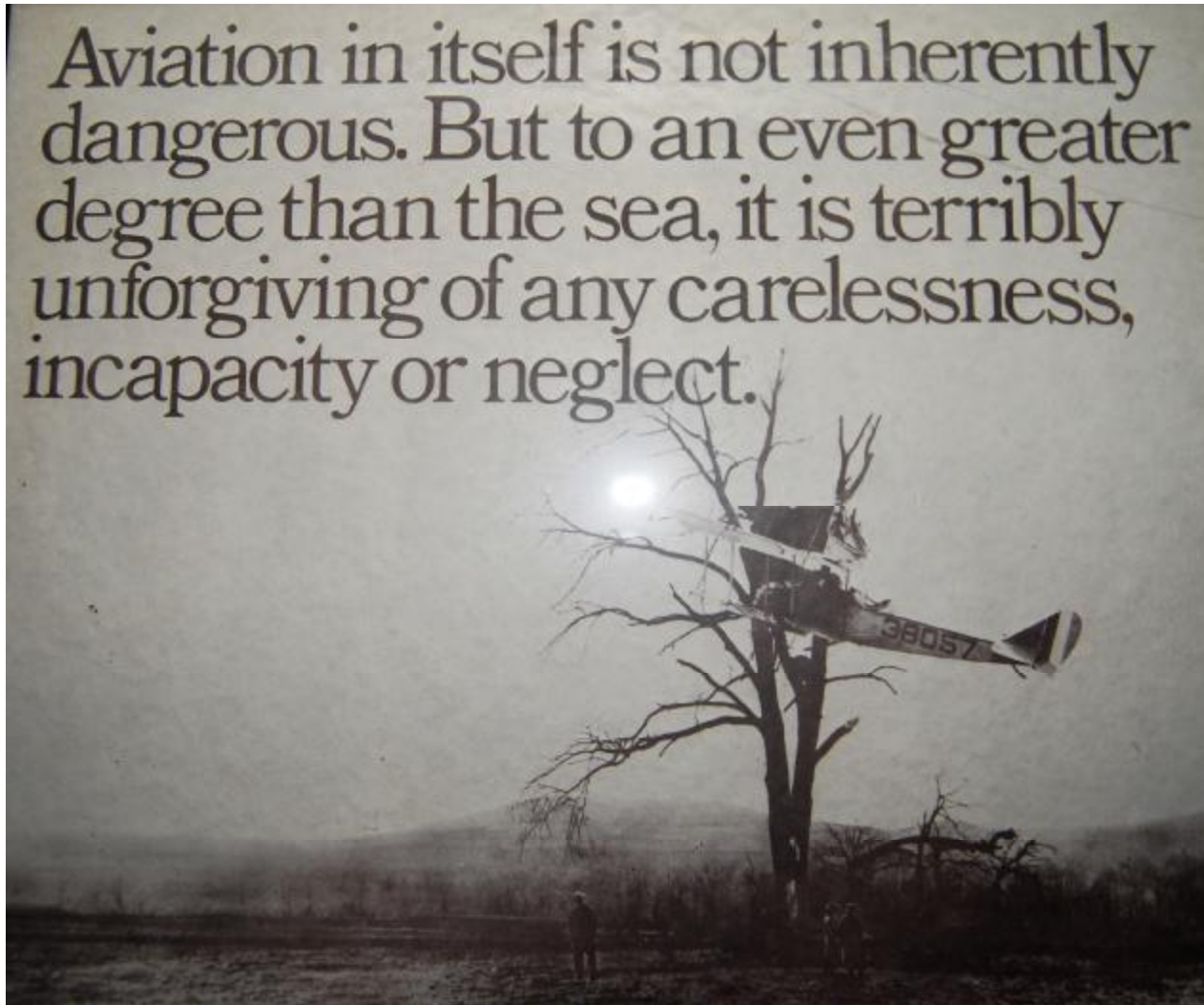
Main activities:

- Textile Safety Seat Systems for the US Armed Forces





Aviation in itself is not inherently dangerous. But to an even greater degree than the sea, it is terribly unforgiving of any carelessness, incapacity or neglect.





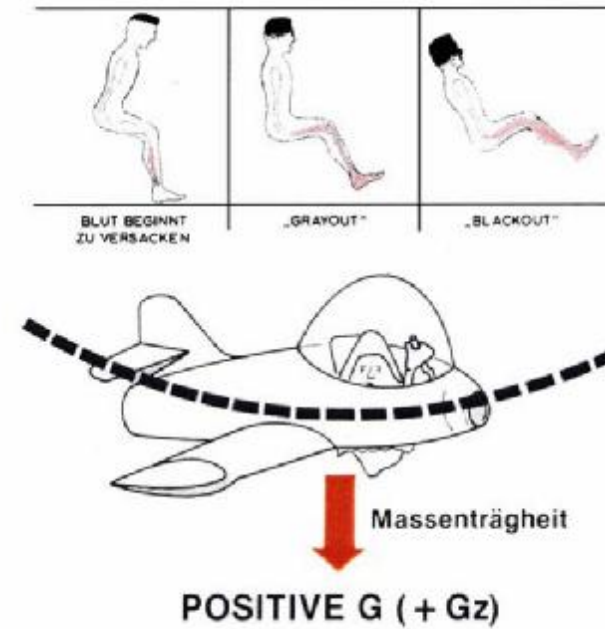
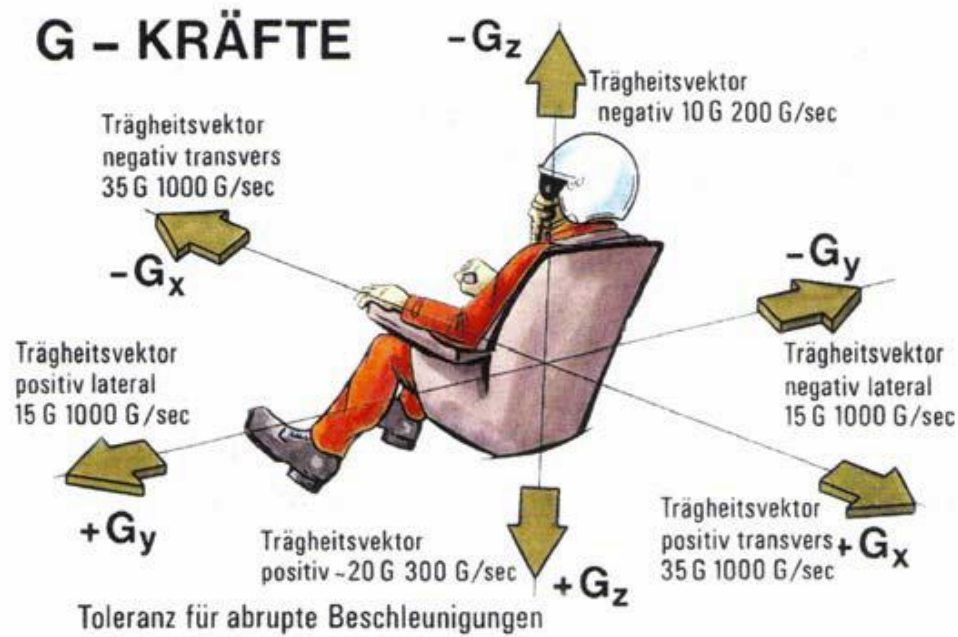
## The Human Aspect

*„It is not the resistance of material which limits the aerobatic performance of the artificial bird, but the physiological resistance of man, who is the brain of the artificial bird“*

Louis Bleriot, 1922

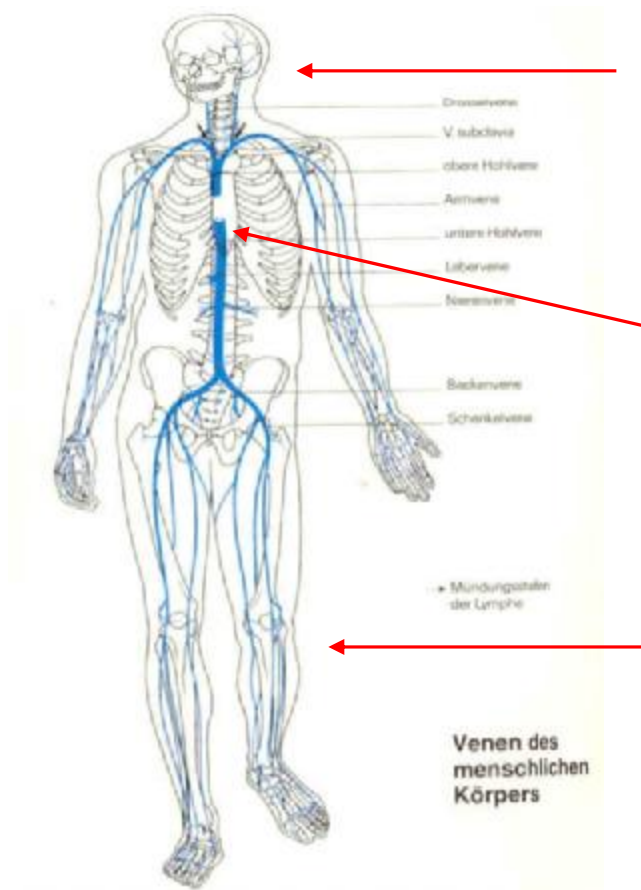


## Gravitational Forces



[Source: Flugmedizinisches Institut der Luftwaffe, Königsbrück]

## Human Body and G-Forces

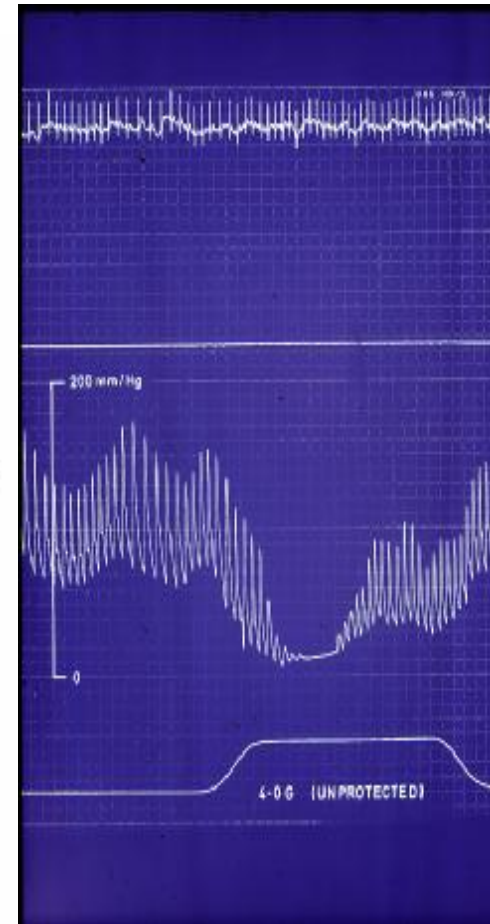
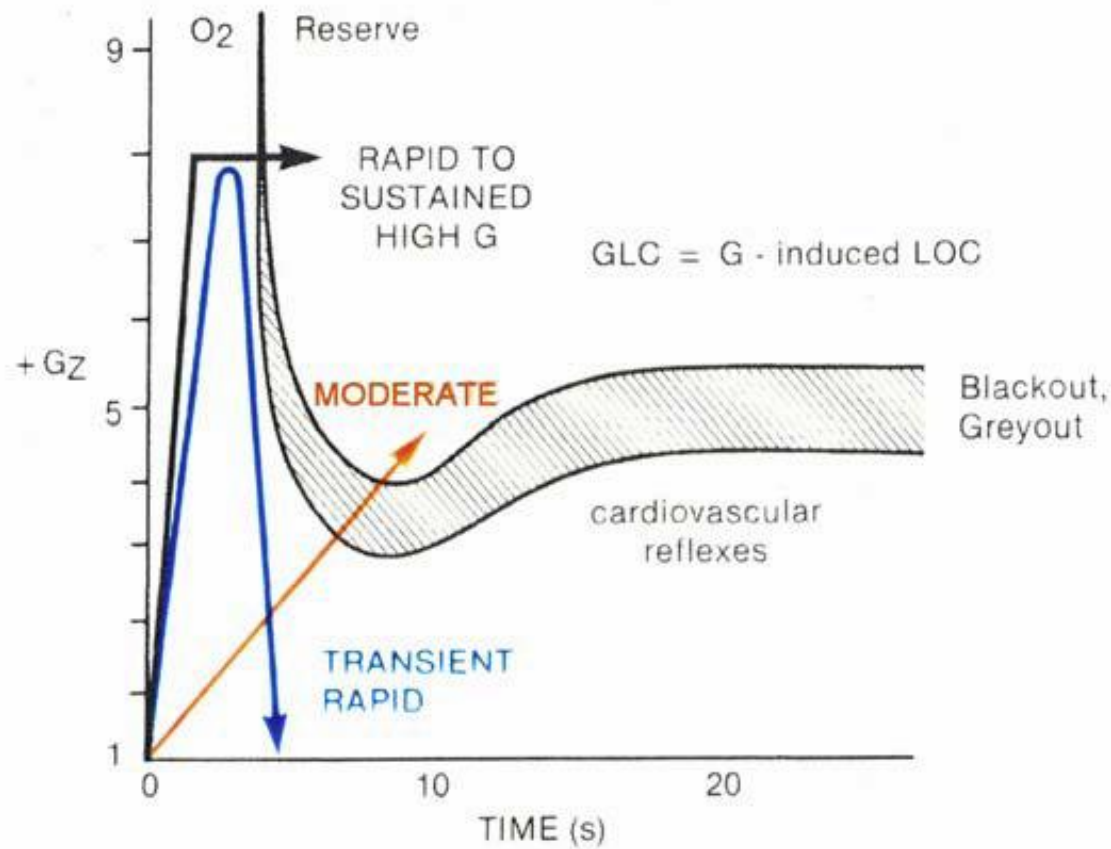


Drop of blood pressure and lack of oxygen will cause visual symptoms.

Prolonged exposition to Gs may lead to G-induced loss of consciousness (G-LOC).

Increased heart rate due to reduced blood volume.

Due to blood pooling, the amount of blood circulating will be reduced.



[Source: Flugmedizinisches Institut der Luftwaffe, Königsbrück]

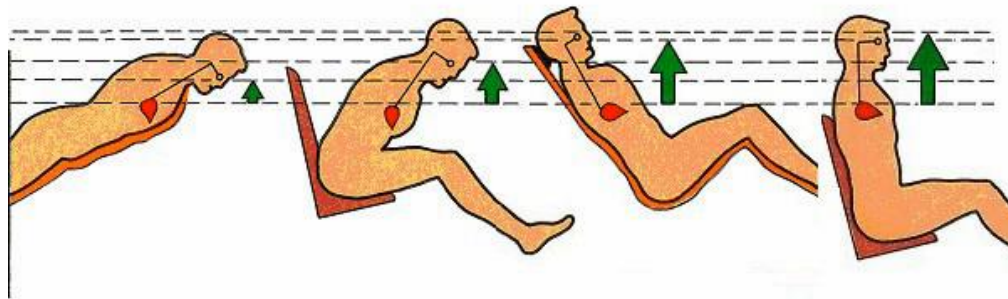
Natural (relaxed)  $G_z$ -Tolerance as  
a Result of negative  $G_z$ -Preload

Preload:	30 sec	16 sec	2 sec
+ 1.1 $g_z$	4.11 ± 0.43	4.23 ± 0.33	4.13 ± 0.30
- 1.0 $g_z$	2.66 ± 0.44	3.00 ± 0.39	3.36 ± 0.27
- 1.4 $g_z$	2.49 ± 0.51	2.80 ± 0.26	3.30 ± 0.21
- 1.8 $g_z$	2.47 ± 0.21	2.67 ± 0.24	3.19 ± 0.23

A.K.Lehr et. al.: ASMA 1992

## G-Forces: Means of Protection

- Pilot Equipment (G-Protection Systems)
- Aircraft Provisions (Seat Angle, Arm & Foot Position)



- Pilot Conditioning & Training



## Examples for a prone pilot position



Henschel HS 132 (1945)



XP-79 "Flying Ram" (1945)



Gloster Meteor F8 "Prone pilot" (1954)

## Physiological Factors adversely affecting G-Tolerance

- Dehydration
- Low blood sugar level
- Low blood pressure
- Fatigue
- Illness / use of medications
- Smoking
- Drugs & Alcohol
- Cardiovascular fitness level
- ...



## Early G-Suit Developments



**Figure 2. 1940s Prototype of a Pneumatic G Suit**

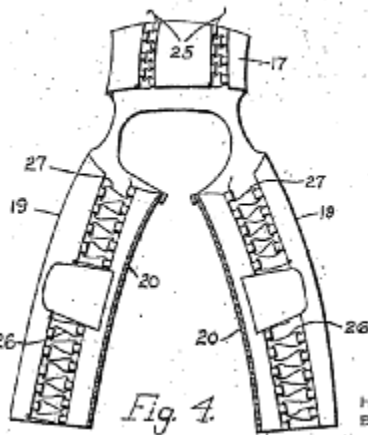
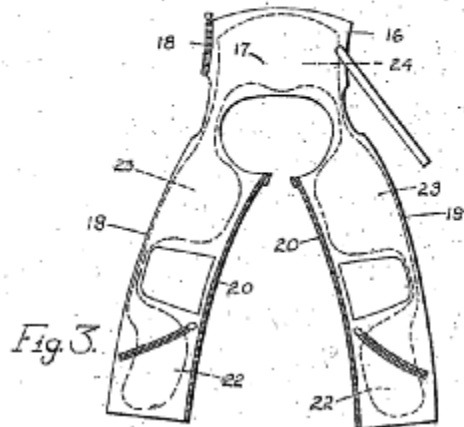


**Figure 5. Frank's Flying Suit**  
1940s prototype of a fluid-filled G protection garment.

*[Source:  
McDonnell Aircraft Company]*

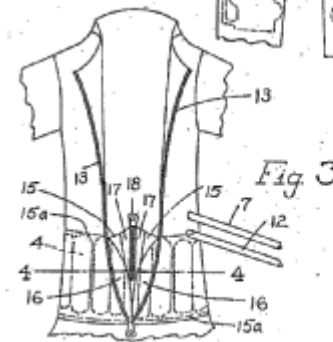
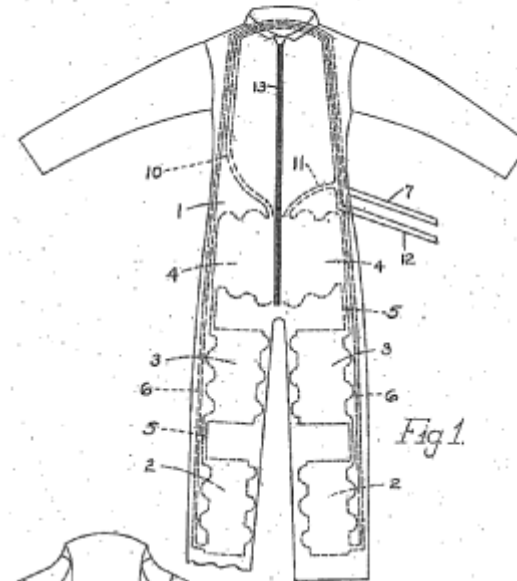
# First Patent Anti-g Suit

July 5, 1949. D. M. CLARK ET AL. 2,475,479  
 GARMENT OR ATTACHMENT FOR CONTROLLING THE DISTRIBUTION,  
 PRESSURE AND CIRCULATION OF BODY FLUIDS  
 Filed Sept. 26, 1946 3 Sheets-Sheet 3



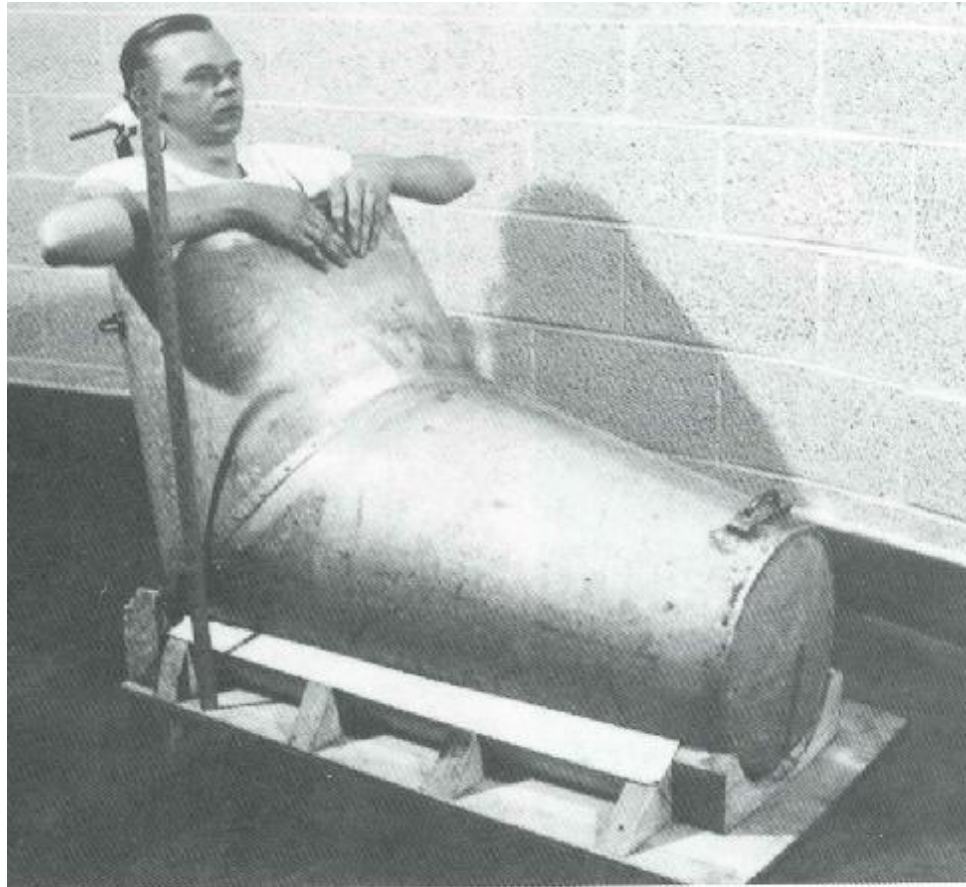
INVENTORS:  
 DAVID M. CLARK  
 EARL H. WOOD  
 HENRY A. SCHROEDER  
 BY *Charles A. Williams*  
 ATTORNEY

Jan. 24, 1950 D. M. CLARK ET AL. 2,495,316  
 GARMENT OR ATTACHMENT FOR CONTROLLING THE  
 DISTRIBUTION, PRESSURE, AND CIRCULATION  
 OF BODY FLUIDS  
 Filed Sept. 14, 1946 4 Sheets-Sheet 1



INVENTORS:  
 DAVID M. CLARK  
 EARL H. WOOD  
 BY *Charles A. Williams*  
 ATTORNEY

## Hydrostatic G-Protection



**Figure 4. Bathtub Tested at the Mayo Clinic**  
1940s investigations proved the principle of fluidic G protection.

*[Source:  
McDonnell Aircraft Company]*

# Atlantis Warrior Prototype by McDonnell Aircraft Company



Figure 1. Atlantis Warrior™  
Prototype

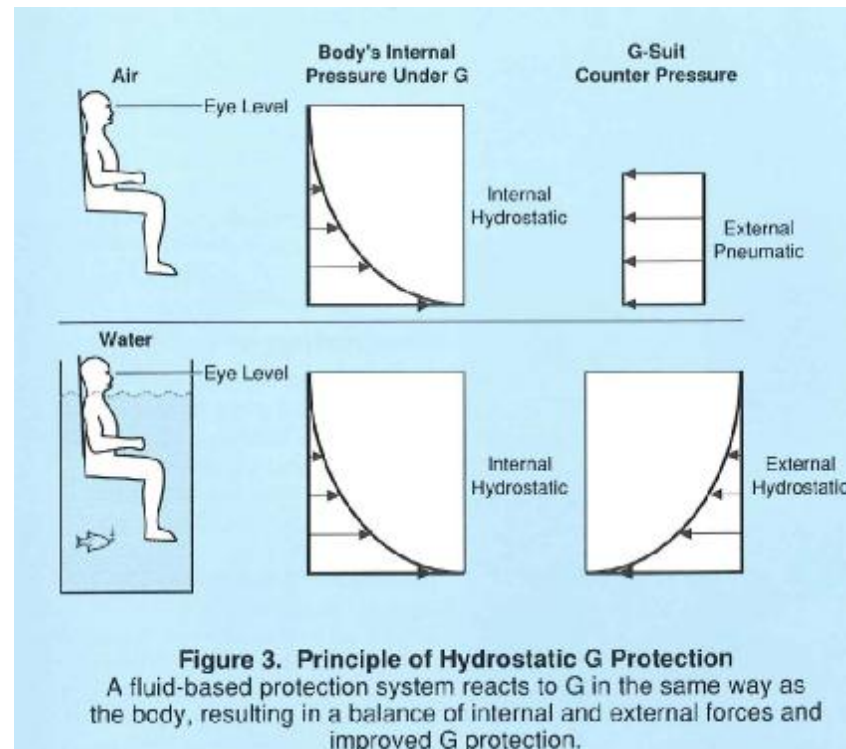


Figure 3. Principle of Hydrostatic G Protection

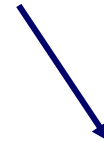
A fluid-based protection system reacts to G in the same way as the body, resulting in a balance of internal and external forces and improved G protection.

[Source: McDonnell Aircraft Company]

## Pneumatic Systems - Developments



- Five Bladder Suit  
Example: CSU-13 B/P



- CSU-13 B/P plus PBG/CCPB  
Example: Combat Edge



- Full Coverage Anti-G Trousers  
plus PBG/CCPB  
Example: EF2000 AEA

## Shortfalls of operational pneumatic G-Protection Systems



- Time delay (compensated by newest onboard regulators)
- Significant thermal discomfort
- Pain (depending on system used and cockpit layout)
- G-induced fatigue
- No means to compensate system malfunction
- Physiological long term effects due to positive pressure breathing (PBG)?
- Restricted communication/voice recognition at G
- Newer Systems: single aircraft solutions
- “Onionshell Design”

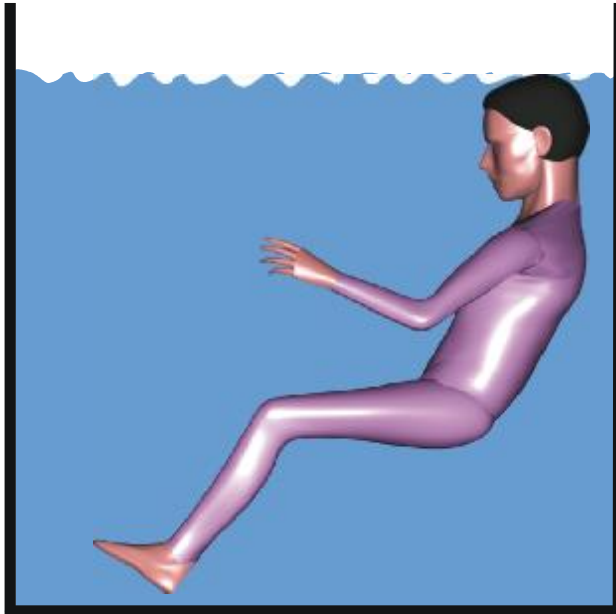


## The third and fourth generation challenge



- Highly agile fighter aircraft:
  - sustained 9 G capability
  - G-Onset rates of up to 15 G/sec
- Complex operational scenarios
- New theatres of operation
- New threats

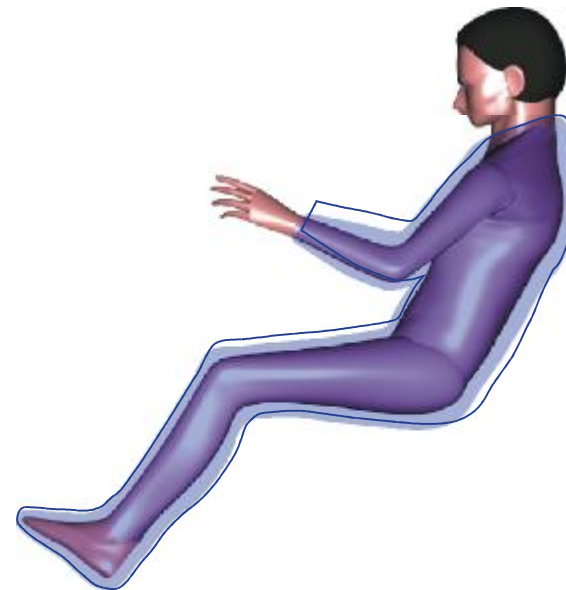




The practical solution:  
The Immersion or  
Buoyancy Suit

## Back to the roots

The perfect solution:  
Same hydrostatic height,  
same density of liquid





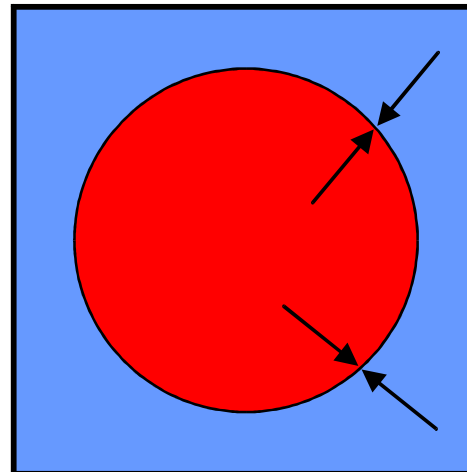
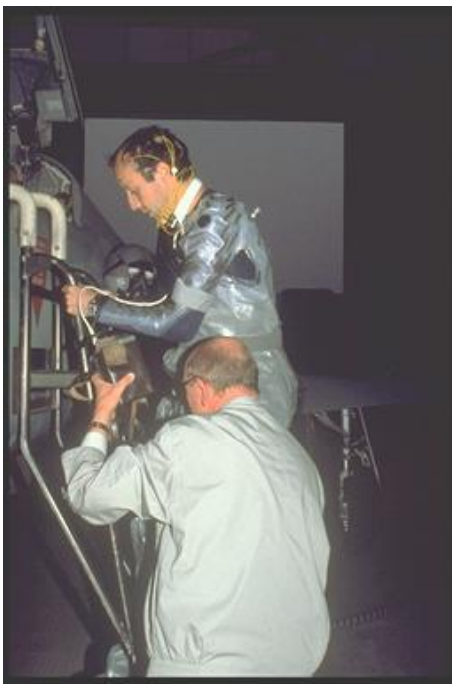
## Hydrostatic compensation under G's (demonstration in a Learjet)



*[Pictures: Prospective Concepts]*

## Prototyping and testing (1988-1997)

*[Pictures:  
Prospective Concepts]*



**„Buoyancy“-Principle**

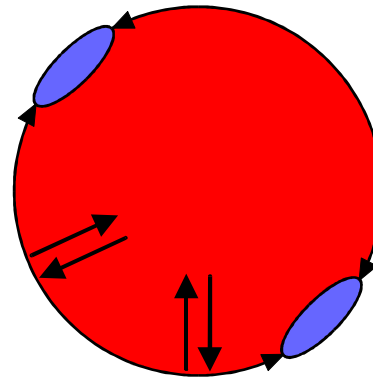


For basic calibration tests: the rigid „Headless“ (1997)



*[Pictures:  
Prospective Concepts]*

„SIGMA“-principle: the first „Fluid Muscles“  
(1996 - 1998)

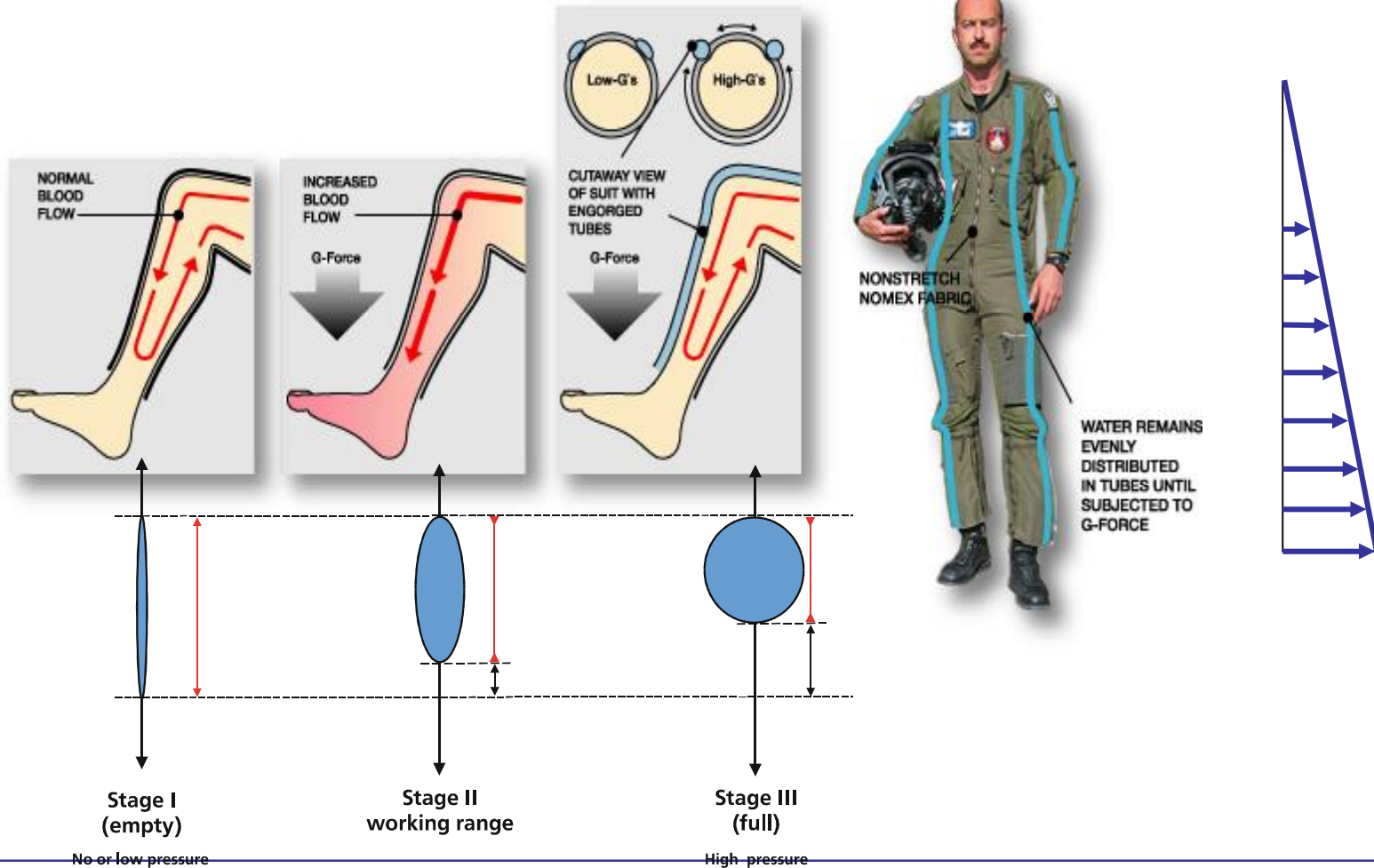


**SIGMA-Principle**

*[Pictures:  
Prospective Concepts]*



## The Hydrostatic Principle



**LIBELLE G-Multiplus®**  
**From Prototyping to Certification**



Starting Point:  
Prototype in **2000**

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**March 2003**  
First operational System



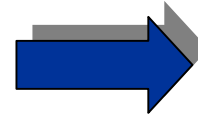
**June 2006**  
Fully operational System

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### Manufacturing Process



CD- ROM



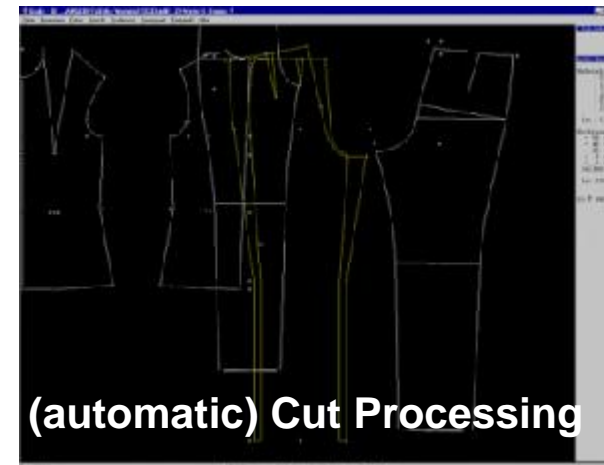
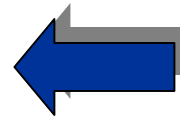
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## G-RACE SUIT for the RED BULL AIR RACE WORLD CHAMPIONSHIP



**Paul Bonhomme**  
**Red Bull Air Race World**  
**Champion 2009**

Safety Has a Name

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## Red Bull Air Race The Track



## Red Bull Air Race Race Airplanes



## **G-RACE SUIT The Task**

Use the LIBELLE-Technology to design a G-Suit for the Pilots performing in the Red Bull Air Race World Championship:

- Best possible G-Protection
- Compatible with Race Aircraft
- “Sexy” Design
- Multicolor
- Comfortable to wear
- Very short time frame until start of season

Our Starting Point:

- Military Product (colours limited to sage green and sand)
- Design und Appearance are “third” priority

## How to get the mission accomplished?

- Specify the customer requirements
- Build some prototypes (standard available colour)
- Evaluate system at human centrifuge
- Perform cockpit & equipment compatibility tests and familiarization flights
- Inflight evaluation
  - Step up program (basic flying, high performance manoeuvres, race track)
- Adapt the design
- Fabricate the G-Race Suits (all individual designs and sizes)
- Pilots: individual fitting, briefing, practical training, familiarization flights
- Autoflug acts as Official Safety Supplier and provides constant Product Support

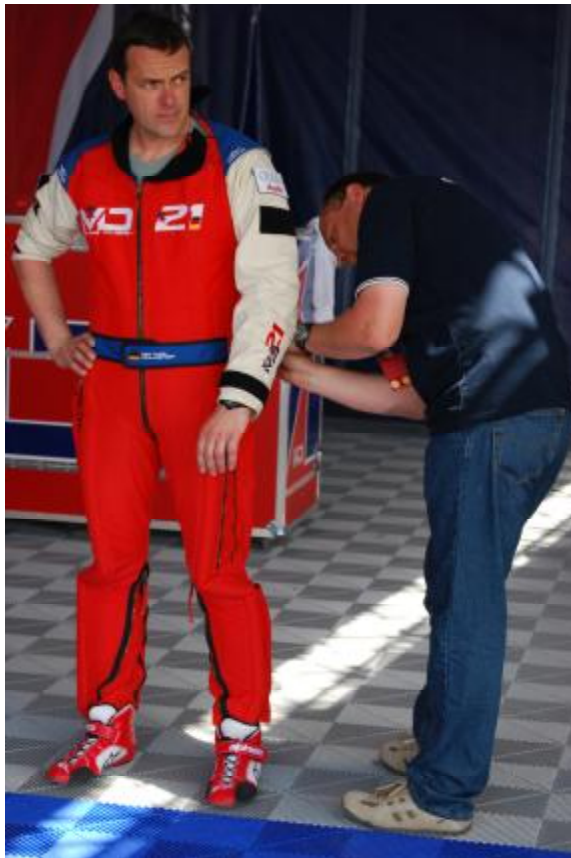
## G-RACE SUIT Development Process



## G-RACE SUIT Evaluation, Testing & Modification



## G-RACE SUIT Training & Introduction to the Red Bull Air Race





## G-RACE SUIT Mission „almost“ complete



## AUTOFLUG's OVERALL OBJECTIVE



Provide the best possible G-Protection to pilots while minimizing the physiological and medical short-term and long term negative effects.

Thank you very much for  
your attention!



