

Mass Analysis - An Important Discipline of the "Luftfahrttechnisches Handbuch"  
(Aeronautical Engineering Handbook)

by

Dr. Stephan G. Scheidler  
Fa. IABG,  
Einsteinstraße 20,  
D - 85521 Ottobrunn,  
Germany

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Nomenclature / Abbreviations:

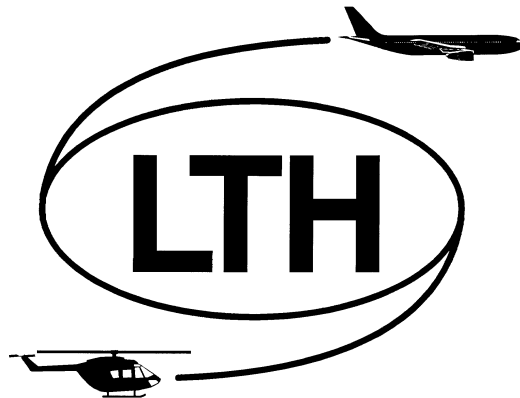
AD	Aerodynamic
AT	Propulsion Technology
BAZL	Bundesamt fuer Zivilluftfahrt der Schweiz (Swiss Civil National Aviation Authority)
BM	Loads
c/o	care of
DIN	Deutsches Institut fuer Normung e. V. (German Institute for engineering standardization)
EASA	European Aviation Safety Agency
FL	Composite Design Criteria
FV	Flight Test Engineering
HSB	Structural Analysis
LBA	Luftfahrt-Bundesamt (German Civil National Aviation Authority)
LTH	Luftfahrttechnisches Handbuch (Aeronautical Engineering Handbook)
MA	Mass Analysis
NL	Normenausschuss Luft- und Raumfahrt (German standards committee for air and space flight)
OEM	Original Equipment Manufacturer
SE	Systems Engineering
WTD 61 - ML	Wehrtechnische Dienststelle fuer Luftfahrzeuge - Musterpruefwesen fuer Luftfahrtgeraet der Bundeswehr (German Military National Aviation Authority)

## **1. Abstract**

The "Luftfahrttechnisches Handbuch" (LTH) is an Aeronautical Engineering Handbook, which contains a number of disciplines such as Aerodynamics (AD), Propulsion Technology (AT), Loads (BM), Composite Design Criteria (FL), Flight Test Engineering (FV), Structural Analysis (HSB), Mass Analysis (MA), and Systems Engineering (SE) - please note that the abbreviation characters are according to the German titles. The discipline Mass Analysis covers various chapters such as General Basics, Methodologies, Mass Control, and Total Mass under Varying Load Conditions, Mass of Structures, Mass of Propulsion Systems, Mass of Equipment, and Payload etc.

The LTH handbook as presented here is a tool for engineers, students, and other interested experts in industry, institutions, universities and authorities to specify, design, develop, verify, qualify, certify and analyse entire aeronautical vehicles, and their systems, engines and equipment. The LTH is aimed at standardising certain procedures and methods, and collects the knowledge of its members centrally. A search function is available for data retrieval. Rationalisation is provided via the generic acceptance of many of the shown verification processes by various civil and military authorities. This allows for optimised and accelerated development of aeronautical systems and provides authorities, OEM's and suppliers with a standardised basis for development and certification.

In addition, the LTH is not only a compendium - it is also a community of the respective system specialists or, in other words, a network between its members and partners. All papers contained in the LTH have been reviewed and approved by the respective discipline's specialists committee, which consists of members from industry, institutions, universities and authorities. All specialists committees allow also other interested national or international parties to attend meetings in a guest status, or to join the committee as a regular member, if jointly accepted by the committee. This allows for a continuous process of improving existing and collecting new knowledge to optimise the LTH. Whilst the LTH originally started off in German language only, an approach has now been launched to internationalise the LTH by conversion into the English language, which has already partially been accomplished with a focus on data and software for actual technical problems and questions in aeronautical engineering. Further details of the LTH are provided on the public section of the website: [www.lth-online.de](http://www.lth-online.de).



**Figure 1: Label and brand mark of the "Luftfahrttechnisches Handbuch" (LTH)**

## **2. Formation, Development and Content**

### **2.1 Formation and Development**

The LTH was, based on personal initiatives, started with two thematic volumes in 1969 by some official departments, aircraft industries and aircraft research institutions.

Initially, existing working documents (e.g. data for static analyses by company Airbus) and then-current work results have been prepared in a handbook-suitable version, to make the knowledge base of that time available for a broader user spectrum. In the next steps the number of thematic volumes has been increased continuously and the aims and contents of the reports have been extended on a supplementary basis. A systematic order of the entire structure of all disciplines and a methodical formation of the topics to be covered in the individual reports have been arranged. The result is a handbook, which covers the most important disciplines of development, verification, qualification, certification and utilization of air vehicles, aerial systems and sub-systems.

### **2.2 Content**

The subject area - specific content of the LTH volumes encompasses:

- Presentation of dedicated general basic principles
- Description of procedures and data for development, verification and certification
- Technical interpretations of design and manufacturing specifications
- Supply of research results conditioned for application
- Experience from development, build process and operation of air vehicles.

The following figure shows the eight disciplines and volumes of the LTH:

### **Disciplines / Volumes:**

<b>AD</b>	<b>Aerodynamics</b>
<b>AT</b>	<b>Propulsion Technology</b>
<b>BM</b>	<b>Loads</b>
<b>FL</b>	<b>Composite Design Criteria</b>
<b>FV</b>	<b>Flight Test Engineering</b>
<b>MA</b>	<b>Mass Analysis</b>
<b>HSB</b>	<b>Structural Analysis</b>
<b>SE</b>	<b>Systems Engineering</b>

**Figure 2: The eight disciplines and volumes of the LTH**

Please note that the abbreviation characters are according to the German titles.

Six of the above listed volumes, the contents of which are relevant for certification and qualification aspects, are approved by the German Civil National Aviation Authority (Luftfahrt-Bundesamt, LBA) and by the German Military National Aviation Authority (Wehrtechnische Dienststelle fuer Luftfahrzeuge - Musterpruefwesen fuer Luftfahrtgeraet der Bundeswehr, WTD 61 - ML) for application in the verification process during the certification and qualification management process of air vehicles, engines and subsystems. Since then also certain individual reports of some volumes have been accepted by the European Aviation Safety Agency (EASA) for certification activities. This allows specialists to access commonly accepted procedures and practices in a broad application range for a lot of activities. This is reducing time and effort considerably. Due to its non-certification related contents, the volume "Mass Analysis" (MA) does not contain the formal endorsement of acceptance of the above mentioned authorities for certification and qualification processes.

### **3. Aims, Benefits and Application**

#### **3.1 Aims and Benefits**

Basic idea and aim of the LTH is to contribute to a rationalization of engineer's work, beginning with the sketches of the preliminary design via the certification and qualification processes to the utilization phase, based on defined and accepted standards for technical procedures, methods and data. This is an ongoing process, which continuously has to be performed and adopted. Due to limited resources of the individual working groups, some of the chapters have to be further developed and amended with data content.

The standardization of technical methods, procedures and data contributes to an optimized and accelerated development phase and to a credible assessment of projects and systems. When using the standards and methods defined in the LTH, subcontractors can deliver products which fulfill the requirements specified by the customer. This enables a non-controversial contractual relationship. A further benefit results from the acceptance of the Aviation Authorities (see above) by reduction of the effort necessary during the verification process when the LTH is applied as a common base document.

Since the LTH is also used in the education of students in universities and other academia, and in some research activities, students are already introduced into complex problems of design and verification during the certification and qualification processes in an early stadium. So, once they work as engineers in industry, they are already familiar with the contents of the LTH volumes and can enhance the topics of the individual disciplines. Consequently, a kind of transfer of requirements and results between research, development and utilization is established by this way. Additionally, also the degree of popularity of the LTH is increased.

Many of the industrial companies also use the LTH for initial skill adaptation training of young engineers, as well as for training on-the-job and qualification of employees coming from other technical disciplines. Therefore, the LTH is a perfect tool to assure a continuous crossover from education and training to practical experience.

Due to the inter-disciplinary cooperation of system and equipment companies an exchange of experience in the working panels is achieved. This is accompanied by an improvement of the knowledge of the individual working panel members. Also, when compared to company-based documentation, an improvement of the technical quality of the reports is required.

Since the time of national-only projects is over, the LTH has today also been applied as a basic document for pre-design, development, certification and qualification, verification, manufacturing and utilization of aircraft, air vehicles and aerial systems and subsystems in inter- and transnational cooperation projects.

### **3.2 Application of the LTH**

The LTH provided a fundamental contribution to the development, certification, qualification and verification processes of important civil aircraft, air vehicles and propulsion systems. As an example for its application in the pre-design and development phases the following projects are listed:

- Airbus A 300, A 310, Beluga
- Airbus A 321, A 320, A 319, A 318
- Airbus A 330, A 340
- Airbus A 380, A 380 F
- Airbus A 350
- Dornier Do 228, Do 328
- Dornier Do 728 (Development)
- Pilatus PC-6, PC-12
- MBB Bo 105
- Eurocopter EC 135
- Eurocopter EC 145
- IAE V 2500
- Rolls-Royce BR700, Tay
- Saab 340, Saab 2000
- P&W (MTU) PW 6000, PW 7000, PW 8000

Comparable to this is its implementation in military applications:

- Airbus A 400 M
- Eurofighter EF 2000
- Panavia Tornado
- Saab Gripen
- Dornier Alpha-Jet
- Eurocopter NH 90
- Eurocopter Tiger
- Grob Strato 2C
- Pilatus PC-7, PC-7 MkII, PC-9, PC-21
- Cassidian UAVs (Barracuda, Talarion)
- Eurojet EJ 200
- Turbo-Union (MTU) RB 199
- EPI (MTU, Rolls-Royce) TP400-D6
- MTR (MTU) MTR 390

## **4. Organization and Funding**

### **4.1 Organization**

The organizational work of the "Luftfahrttechnisches Handbuch" (LTH) is defined in the "Terms of Reference", current version 2008 [1].

Beside the preparation of technical papers the LTH requires a considerable amount of conceptual, systematic and organizational work. To execute the required tasks, the following organizational structure has been established in 1970 between the official customer, the Aviation Authorities and the industry.

The **LTH Coordination Committee** is the umbrella organization, in which all comprehensive questions and problems of the LTH are discussed and the further development, including e.g. internationalization of the LTH, is determined. This committee is composed of representatives of the actively involved companies, (research) institutes, universities and official departments, the LTH Coordination Office and the chairmen of the individual working groups. This allocation assures that the interests of all involved parties are accounted for. The **Steering Board** of the **LTH Coordination Committee** consists of the elected chairman (member of the **LTH Coordination Committee**), the representative of the funding official department and the Coordination Manager of the **LTH Coordination Office**.

The **LTH Coordination Office** is in care of (c/o) company IABG and is responsible for the following tasks:

- Staffed office to support the **LTH Coordination Committee**
- Technical coordination, overall organization and long-term management of a standardized and uniform conception; e.g. issue of terms of reference, preparation of guide lines for LTH technical papers
- Editorial and publishing supervision of the handbook

The **LTH Working Groups** prepare the technical papers (each **LTH Working Group** individually for its volume) in qualified discussion and decide about the inclusion in the corresponding volume. They enhance the conceptual design of the volume, which is supported by the **LTH Coordination Office**. The **LTH Working Groups** complete and revise the data content of the volume to keep it permanently state of the art as much as possible. Altogether about 150 qualified experts convene in the eight **LTH Working Groups**. The **LTH Working Groups** act as editors for their individual volumes and they define the group of subscribers.

## **4.2 Funding**

The activities mainly are funded by the actively participating entities, thus the industrial companies, institutions, universities and official departments. A limited number of technically and scientifically valuable papers are sponsored by the customer with a dedicated amount of budget to reward the best two papers of each discipline per year. The German Procurement Office (Bundesamt fuer Wehrtechnik und Beschaffung - BWB), Koblenz, is acting as awarding authority.

## **5. The LTH Working Groups**

### **5.1 Methods of Operation**

The meetings of LTH Working Groups proceed twice or three times per year at the sites of the participating companies and institutions. Beside the classical editing and processing of technical reports also the exchange of members' experience via short presentations, dedicated work shops and discussions about specific, particularly current technical topics and solutions is in the strategic focus of the working groups. This mainly contributes to increase the efficiency of the working groups meetings. The audit of the technical quality of the reports to be edited and published is performed by the individual working groups as well. During the working group meetings tours of the company (production) facilities are conducted, which contribute to verify the transfer from the theoretical description within the reports to the practical experience to the attendees. Also a feedback from the production experience to the theoretical basis can be gathered by the participants by this way. Since new members are consistently affiliated in all working groups, the knowledge base of the working groups is permanently enhanced and kept state-of-the-art.

The European / international orientation of the LTH is represented not only by the participation of German-speaking members from companies of European countries (beside Germany; Austria, Netherlands, Sweden, Switzerland) but also by the data content and the English language of reports and presentations. This business trend is promoted by transnational cooperation and fusion and consolidation of aerospace companies and supplier companies. Furthermore, the LTH Coordination Committee concluded a further internationalization of the LTH and its working groups.

## **5.2 Contributors to the LTH**

All important German / European system companies and many of the mid-size supplier companies contribute actively to the relevant working groups. Additionally, research institutions, universities, official departments and authorities are involved. Beside the above mentioned entities also specialists from European partner countries and organizations engage in the activities of the different LTH working groups. They all compose technical reports, give lectures and verbal presentations and exchange their experience in technical discussions.

Some of the major industry contributors are:

- Airbus Operations
- Astrium
- Cassidian
- Diehl
- Elbe Flugzeugwerke
- Eurocopter D + F
- Grob Aircraft
- IABG
- Liebherr Aerospace
- Lufthansa Technik
- MT Aerospace
- MTU Aero Engines
- Pilatus
- Premium Aerotec
- Rolls-Royce D
- RUAG
- SAAB
- Stork Fokker AESP
- Zeppelin LT

Participating institutions and universities are:

- Deutsches Zentrum fuer Luft- und Raumfahrt (DLR), German Aerospace Center, facilities in Braunschweig, Göttingen, Köln-Porz, Stuttgart.
- National Aerospace Laboratory of the Netherlands (NLR), Emmeloord, Netherlands.
- (Technical) Universities in Braunschweig, Darmstadt, Hamburg, Munich, Stuttgart and Delft (NL)

Participating authorities are:

- European Aviation Safety Agency (EASA)
- Luftfahrtbundesamt (LBA), German Civil National Aviation Authority
- Wehrtechnische Dienststelle fuer Luftfahrzeuge - Musterpruefwesen fuer Luftfahrtgeraet der Bundeswehr (WTD 61 - ML), German Military National Aviation Authority
- Bundesamt fuer Zivilluftfahrt (BAZL) der Schweiz, Swiss Civil National Aviation Authority
- Normenausschuss Luft- und Raumfahrt (NL) im Deutschen Institut fuer Normung e. V. (DIN), German standards committee for air and space flight within the German Institute for engineering standardization



### **5.3 Technical Documentation**

The current edition of the handbook encompasses about 20,000 pages across its eight disciplines. Since the year 2002 six of the eight disciplines (Aerodynamics - AD, Propulsion Technology - AT, Loads - BM, Composite Design Criteria - FL, Flight Test Engineering - FV and Mass Analysis - MA) are available on CD Rom. The older reports have been digitized to insert them into the CD. All reports are stored in pdf-format. The CD is equipped with a comfortable full-text search function to facilitate accessibility. Calculation tools, procedures and simulation tools are also available on the CD to support the practical application and realization of the described methods. The LTH CD Rom has first been issued in 2002. Reissues have been published in 2004, 2006 and 2008 [2]. At present it is envisaged, to make the content of the LTH CD available on the LTH website ([www.lth-online.de](http://www.lth-online.de)) and to issue the next version of the LTH online with download functionality in a closed membership area of the homepage. Please find more details with respect to this website under section 5.3 Internet.



**Figure 3: Label and brand mark of the CD "Luftfahrttechnisches Handbuch" (LTH)**

Since the Working Group "Systems Engineering" (SE) has started its work after the editorial deadline of the latest LTH CD, the reports of this discipline are not yet available on the LTH CD but can be downloaded from the LTH website.

The "LTH Handbuch Strukturberechnung" (HSB), Handbook Structural Analysis, is separately published by the working group "Industrieausschuss fuer Strukturberechnungsunterlagen" (IASB), Industrial Committee for Structural Analysis, on a DVD. The subject matter of this volume concentrates on fundamentals and methods for aeronautical design and analyses. Since the data content of this volume is very broad and comprehensive, the working group IASB decided to edit and publish their reports separately from the other disciplines on a DVD by their own. The actual version of this DVD has been issued in 2009 [3].

### **5.4 Internet**

The LTH website ([www.lth-online.de](http://www.lth-online.de)) provides important basic and useful information for all interested parties [4]. In the open area of the website next to primary information about the LTH and its different disciplines and volumes, the contact data of the LTH Coordination Office together with an online questionnaire form for a direct query are available. Additionally, the tables of contents of the six LTH volumes which are contained in the LTH CD are free for download.

The closed area of the website is reserved for LTH members only. The access to it is secured by individual user names and passwords. In this closed area the LTH members are provided with further information like next meeting dates, meeting minutes of the working groups and the LTH Coordination Committee, group pictures of meetings and the latest LTH reports of the different disciplines since the issue of the last version of the LTH CD. It is planned, to make the content of the (next version of the) LTH CD available on this closed area of the LTH website ([www.lth-online.de](http://www.lth-online.de)) and to issue future versions of the LTH online with download functionality for the LTH members therein.

## **6. Source of Supply**

The LTH CD with the handbook volumes can be purchased from the LTH Coordination Office. The group of subscribers is limited and is defined by the LTH Working Groups. They care for a long-term related contribution and cooperation. The active members of the LTH Working Groups receive the LTH CD exempt from charges. Usually every two years actualizations are made. For further information and point of contact please refer to the website: [www.lth-online.de](http://www.lth-online.de).

## **7. Future Development**

The continuous Europeanization and globalisation of the aerospace industry and the almost exclusive international projects require a European / international orientation and development of the "Luftfahrttechnisches Handbuch" (LTH) as well. In parallel, the opening of the LTH to new subscribers in the working groups shall provide a new and broader knowledge base to all LTH disciplines and LTH working group members. This extension of the spectra of the disciplines increases the attractiveness of the LTH and is connected with an enhancement of the broadness of applications and utilization.

For this reason, the focus of future LTH reports will concentrate on topics, which result in a simplification and acceleration of working processes in the development, certification, qualification and verification phases within the European / international network. As an example of this development to expand and modernize the spectrum of the technical content of LTH, the subject "Systems Engineering" (SE) has been picked up in a new discipline / volume of the LTH, corresponding to nowadays requirements in the industry. A new LTH working group has been founded which is dedicated to technical topics of "Systems Engineering" (SE) aspects.

The ongoing Europeanization of civil type certification and verification via the foundation of the European Aviation Safety Agency (EASA) will also result in a broader and continuing application of the LTH. As a first step to this, all future LTH technical reports shall be prepared and issued in English language.

The LTH is in good shape and on an attractive track. It is supported by the leading European aerospace industry companies and by the authorities. The LTH working groups appreciate to affiliate new members. Also the LTH Coordination Committee as a control and steering panel welcomes new and further representatives of aerospace industrial companies in its round. Join us as a member of a broad and well-founded knowledge base!

## **8. Volume "Mass Analysis"**

To get a better impression of the character and the technical details of the LTH reports within the volume "Mass Analysis" the following provides an excerpt of the table of contents as well as some dedicated examples of representative reports.

### **8.1 Excerpt of the Table of Contents**

0. Introduction
1. Basic Principles (except from Mass Analysis)
2. Methodology of Mass Analysis
3. Mass Control (Methodology and Basic Principles of Mass -Recording, -Control, -Tracking)
4. Total Mass (in different load status)
5. Structure
6. Propulsion System
7. Equipment (Standard Equipment, Special Equipment, Mass Deflections)
8. Payload
9. Others / Miscellaneous

## **8.2 Dedicated examples of representative current reports of the volume "Mass Analysis"**

- Moment of inertia with respect to a user-defined axis of rotation (MA 114 00-03)
- Mass and Centre of Gravity Forms for Military Aircraft (MA 211 11-01)
- Mass Main Groups and Terms of Mass, Comparison of different Mass Standards (MA 212 00-04)
- Comparison of Mass Standards, Mil-Std-1374A (USA.) vs. AIR 2001/C (France) (MA 212 00-05)
- Mass Breakdown for Cost Estimation of Aircraft, AMPR-Mass Estimation based on Mass Breakdowns according to different Mass Standards (MA 212 00-09)
- Mass Influence Coefficient (MA 230 00-02)
- Definition of an AECMA-Cost-Weight and definition of AECMA-Cost-Hours for aircraft manufacture (MA 240 00-04)
- Tolerances between calculated and weighed parts (MA 300 00-12)
- Different kind of weighing procedures and possible occurring errors (MA 311 00-04)
- Weighing of semi-rigid and rigid airships (MA 311 19-01)
- Effective moment of inertia of fuel in fighter aircraft (MA 323 00-03)
- List of Micro and Mini fixed wing UAV (MA 400 17-02)
- List of Micro and Mini rotary wing UAV (MA 400 17-03)
- Large Civil Jet Transport (MTOM > 40t), Statistical Mass Estimation (MA 401 12-01)
- Comparison Operating Mass Empty vs. Max. T.O. Mass, Transport Aircraft (MA 403 12-01)
- Specific Structure Mass vs. Year of first Flight, Ultimate Load Factor and maximum Mach-Number - Fighter and Trainer Aircraft (MA 500 11-01)
- Comparison Structure Mass without Undercarriage vs. Max. T.O. Mass, Transport Aircraft (MA 500 22-01)
- Comparison Structure Mass without Undercarriage vs. Operating Mass Empty, Transport Aircraft (MA 500 22-02)
- Comparison Wetted Area (Total) vs. Structure Mass without Undercarriage, Transport Aircraft (MA 500 22-03)
- Comparison Area Load (Total) Structure without Undercarriage / Wetted Area (Total), Transport Aircraft (MA 500 22-04)
- Wing: Statistical Mass Estimation of Landing Flaps, Transport Aircraft (MA 501 52-03)
- Comparison Fuselage Gross Area vs. Fuselage Mass, Transport Aircraft (MA 508 12-03)
- Comparison Area Load (Fuselage) Fuselage Mass/ Fuselage Gross Area, Transport Aircraft (MA 508 12-04)
- Turbine Engine and Nacelle, Transport Aircraft, Mass-relevant Data (MA 600 12-02)
- Engine Mass Estimation in the Predesign Phase (MA 600 22-01)
- Engine Internal Rotorburst Analysis (MA 600 90-01)
- Engine Mass Estimation in the Predesign Phase (MA 601 00-02)
- Thrust Reverse, Mass Relevant Data (MA 601 59-01)
- Considerations at the "More Electric Aircraft" Concept (MA 700 19-01)
- Mass estimation of Fuel Cell Systems (MA 700 19-02)
- Aircraft Gun - Fighter and Trainer Aircraft - Mass-Relevant Data (MA 707 51-01)
- Deceleration Chute Group - Military Aircraft - Statistical Mass Estimation (MA 712 21-01)
- Arresting Gear in Arresting Gear Group (MA 712 21-02)
- Wing and fuselage pylon, fighter aircraft and trainer, mass data (MA 817 11-01)
- Weapons Provisions, Pylons, Mass-relevant Data (MA 818 21-01)

In the following some dedicated pictures of weighing activities of exemplary aircraft / air vehicles are presented. These pictures also can be found in the Mass Analysis (MA) section of the LTH website ([www.lth-online.de](http://www.lth-online.de)).



© Airbus Operations

**Figure 4: Weighing of Airbus "Beluga"**

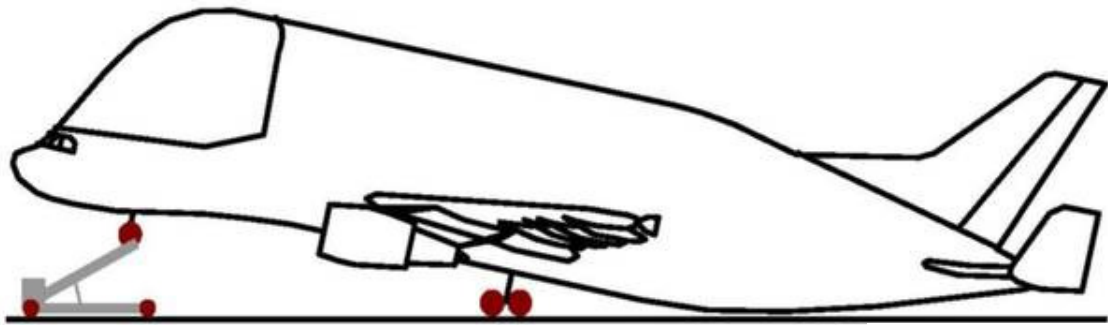


Figure 5: Weighing of Airbus "Beluga"

© Airbus Operations



© Fokker

Figure 6: Weighing of Fokker 70 Nose and Main Landing Gear Platform



© Fokker

Figure 7: Weighing of Fokker 70 Nose and Main Landing Gear Platform



Figure 8: Weighing of Eurocopter EC145



Figure 9: Weighing of Eurocopter EC145

## **9. Acknowledgement**

The author would like to thank the German Procurement Office (Bundesamt fuer Wehrtechnik und Beschaffung - BWB) and the German MoD (Bundesministerium der Verteidigung - BMVg) for their authorization and the LTH Coordination Committee for its assignment to present this paper at the 71st Annual Conference of Society of Allied Weight Engineers, Inc., Bad Gögging and Manching, Bavaria, Germany, May 05-10, 2012.

## **10. References**

- [1] Luftfahrttechnisches Handbuch (LTH), Terms of Reference, version 2008.
- [2] CD Rom "Luftfahrttechnisches Handbuch" (LTH), version 2008, volumes Aerodynamics (AD), Propulsion Technology (AT), Loads (BM), Composite Design Criteria (FL), Flight Test Engineering (FV), Mass Analysis (MA).
- [3] DVD "Handbuch Strukturberechnung" (HSB), Structural Analysis, version 2009, Fundamentals and Methods for Aeronautical Design and Analyses.
- [4] Website: [www.lth-online.de](http://www.lth-online.de).

## **Curriculum Vitae**

Birth place and date: Augsburg, Germany, January 10, 1969.

Professional Career:

1990-1994: Study of Aerospace Technology at the University of the Federal Armed Forces Germany, Munich, Certificate: Diploma, Graduate Engineer (Diplom-Ingenieur).

1994-1999: Flight Test Engineer at the German Official (Military) Flight Test Center, WTD 61, Manching, Germany (Project: Propulsion System of the Eurofighter, EJ200), Contribution to the Qualification, Certification and Verification Process.

2000-2005: Ph. D. Student and Research Assistant at the Institute for Jet Propulsion at the University of the Federal Armed Forces Germany, Munich, Certificate: Graduation to Ph. D. (Dr.-Ing.), Topic: "Investigation of the System Aspects of Stability improving Measures within Gas Turbines"

Since October 2005: company IABG, Ottobrunn, Germany

Main Topics:

- Propulsion System of the Eurofighter, EJ200: Analyses and Engine Health Monitoring (Project Manager)
- Cooperation within the UAV-/IMA-/MEA-/MEE-Study: Mission-, Propulsion System- and Power System -related
- LTH Coordination Office, Member of the Steering Board of the LTH Coordination Committee (Project Manager)
- Calculations and Analyses of Plume- and IR-Signatures (Project Manager)