

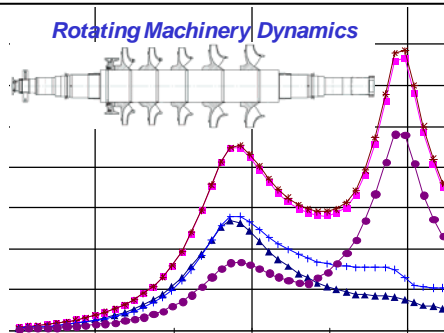


## 4-DAY SEMINAR: October 15-18, 2012, Cologne, Germany

### ROTOR DYNAMICS & BEARINGS TECHNOLOGIES

*Lateral & Torsional Vibration Analysis / Fluid-Film Bearings*

- 1<sup>st</sup> Day: Oct 15, 2012 Seminar "FLUID-FILM BEARINGS"**
- 2<sup>nd</sup> Day: Oct 16, 2012 Seminar "ROTOR DYNAMICS" (Part 1: Basics)**
- 3<sup>rd</sup> Day: Oct 17, 2012 Seminar "ROTOR DYNAMICS" (Part 2: Advanced Applications)**  
including: Unique & Specific Bearings and Machinery Problems and Solutions  
Utilizing ARMD Software for Bearings and Rotor Dynamics
- 4<sup>th</sup> Day: Oct 18, 2012 Parallel Sessions:**  
**Seminar "TORSIONAL VIBRATIONS"**  
**Workshop "ROTORDYNAMIC SOFTWARE APPLICATIONS"**



Journal & Thrust Bearings

Sponsored by:

**ARLA Maschinenteknik GmbH**  
Hansestr. 2, D-51688 Wipperfuerth, GERMANY

Tel: +49 2267 6585-0  
Fax: +49 2267 6585-70

E-mail: [info@arla.de](mailto:info@arla.de)  
Internet: [www.arla.de](http://www.arla.de)

Online Registration via:  
[www.arla.de](http://www.arla.de)



Presented by:

**RBTS, Inc.**  
**Rotor Bearing Technology & Software, Inc.**  
1041 West Bridge Street, Phoenixville, PA 19460, U.S.A.  
Internet: [www.rbts.com](http://www.rbts.com)





## About the Course

This course is presented in ENGLISH language by **Mr. Victor Obeid** (RBTS, Inc. / USA) and designed for engineers and technical managers who are involved in rotating machinery design, operation, maintenance, diagnosis, and trouble shooting, with emphasis on machinery rotor dynamics (analysis of lateral vibrations), drive train torsional vibrations and bearing systems that support, guide, and locate the rotating assembly.

The course is designed to introduce the theory and practice of vibration analysis in rotating machinery (“**Rotor Dynamics**”) from fundamental principles through present state-of-the-art analytical methodology for the solution of common, as well as, unique machinery vibration problems (for example in couplings, gears, or cracks in rotors). The discussion of special and advanced topics is planned as well.



Design consideration and application of fluid-film bearings will be discussed along with a presentation of practical examples and case histories.

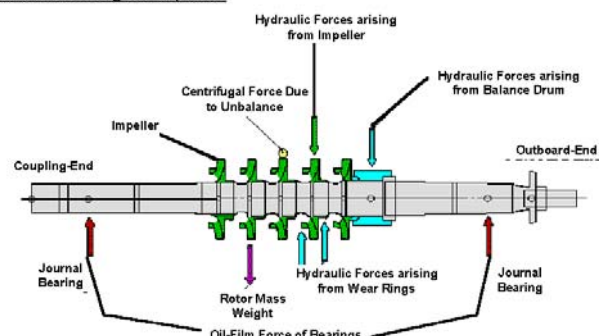
The interacting influence of bearings on the dynamic behavior (rotor dynamics) of machinery will be reviewed and illustrated by the construction of analytical models, and evaluated by PC-implemented computerized solutions. Participants are encouraged to present problems to be discussed. Informal technical sessions and workshops are intended to provide participants with adequate time to describe problems they have encountered in **BEARINGS, BEARING SYSTEMS, ROTOR DYNAMICS, and TORSIONAL VIBRATIONS**.

Computers and computer software will be available at the course for problem-solving, and for the application of state-of-the-art computer-aided engineering of bearings and rotor dynamics. Participants will have access to the latest release of RBTS' popular “Advanced Rotating Machinery Dynamics” software package **ARM<sup>TM</sup>**.

The course can be booked as a whole, but also separately for every section. You may use **ARLA's ONLINE REGISTRATION** form that is available at the web site [www.arla.de](http://www.arla.de) (*German language*) or [www.arla-online.com](http://www.arla-online.com) (*English language*). Having registered you will receive a confirmation and also the invoice from ARLA as soon as possible. It is up to you to register your accommodation at the *Leonardo Hotel* (*Please mention "ARLA" to receive the special conditions!*). If there are any questions, please do not hesitate to contact **Dr. Andreas Laschet** or **Mr. Andreas Stoecker** at ARLA (Phone: +49 2267 6585-0, Fax: +49 2267 6585-70, E-mail: [info@arla.de](mailto:info@arla.de)). Note: The program (subjects / schedule) may change according to customer's wishes.



Radial forces Acting on Pump Rotor



## Day 1 - FLUID-FILM BEARINGS

1<sup>st</sup> Day: October 15, 2012 (MONDAY, 09:00 – 17:00)

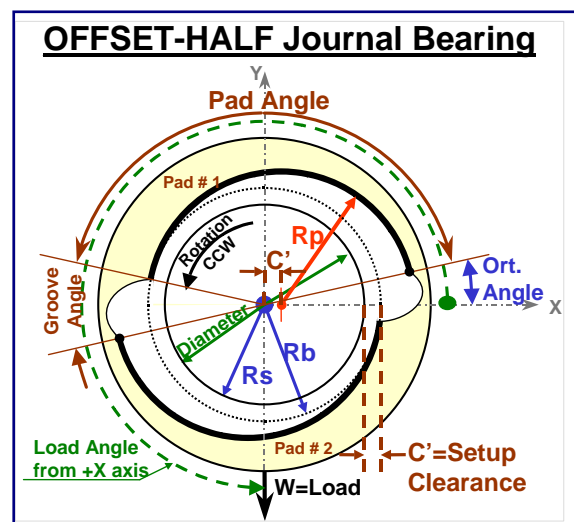
◆ This session is presented in a simple way to understand the technology of **sliding surface bearings** so that participants with or without previous knowledge benefit from the presentation and can apply it immediately in their profession. It is an introduction to BEARINGS, the vital tribological elements of rotating machinery that support, guide, and locate the rotating assembly beginning with their fundamental principles of operation through computer-implemented evaluations of their operational performance characteristics and limitations. Design considerations and applications of sliding surface and rolling element bearings with emphasis on HYDRODYNAMICALLY lubricated fluid-film bearings will be discussed along with presentations of practical examples and case histories.

### INTRODUCTION TO BEARINGS

- Functional Roll
- The Two Primary Classes
- Noteworthy Differences between the Two Classes of Bearings

### SLIDING SURFACE BEARINGS

- Fundamentals
- Types and Definitions
- Load Support Mechanisms
- Modes of Lubrication
- Frictional Response Characteristics
- Terms and Concepts of Hydrodynamic Lubrication and its Requirements
- Terms and Concepts of Hydrostatic-Hybrid Lubrication and its Requirements
- Lubricant Temperature/Viscosity Dependent Properties and Heat Balance Effects
- Turbomachinery Hydrodynamic Bearing Types, Performance, and Dynamic Characteristics
- Oil Whirl / Whip
- Advantages / Disadvantages
- Costs



### FLUID-FILM BEARING TYPES AND APPLICATIONS

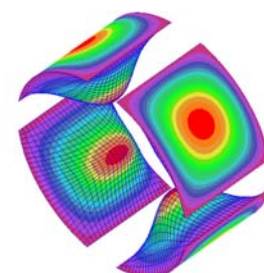
- Fixed & Tilting Pad Geometries
- Journal, Thrust & Conical

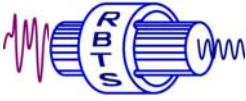
### BEARINGS STATE-OF-THE-ART TECHNOLOGY

- Advanced Technology Presentation & Demonstration
- Summary of Course Content and Application of Bearings Technologies

### WORKSHOP & TRAINING

- Participants' Systems
- Group Discussion





## Day 2 & 3 - ROTOR DYNAMICS

2<sup>nd</sup> Day: October 16, 2012 (TUESDAY, 09:00 – 17:00)

Part 1: Basics

3<sup>rd</sup> Day: October 17, 2012 (WEDNESDAY, 09:00 – 17:00)

Part 2: Applications

◆ This session is presented in a simple way to understand the "**ROTOR DYNAMICS**" technology so that participants with or without previous knowledge benefit from the presentation and can apply it immediately in their profession. Commonly used terminology in the industry such as critical speed, mode shapes (rigid body and bending), stability, bearing whirl/whip, phase angle, critical damping, gyroscopic effects, unbalance, API-amplification factors & required separation margins, etc. will be discussed and illustrated throughout the course by the presentation of practical examples and case histories. The course handout includes sufficient details to be used as a reference including a tutorial section on rotor dynamic fundamentals and terminology. The next day covers subjects on advanced applications in rotor dynamics.

**INTRODUCTION & OVERVIEW** includes the presentation of real life vibration problems and cost/time effective corrective actions taken as a solution

### ROTOR DYNAMICS INTRODUCTION & APPLICATION

- **Basics** on Machinery Vibrations
- **Forces in Rotating Machinery**, Bearings, Cavitation, Imbalance, Hydraulic, Aerodynamic
- **Basics & Application** of Rotor Dynamics
- **Shaft Dynamics & Response** Controlling Mechanisms, Balancing, and API Requirements
- **Modeling**: Shaft, Disks, Rolling Element & Fluid-Film Bearings, Couplings, Seals, Housings
- **Analysis**: Damped & Undamped Rotor Stability, Natural Frequencies, Mode Shapes, Stability & Critical Speed Maps, and Responses

### ROTOR DYNAMICS DETAILED CASE HISTORY

- **Step-by-Step Rotor-Bearing System Modeling**, Analysis, and Problem Solution by the Introduction of Rotor Dynamics Software and its Application to a Rotor-Bearing System
- **Bearing Interaction** with the Rotating Assembly, Oil-Whirl/Whip Phenomena, Rotor-Bearing Response, and Stability Illustrations
- **Brief Section on Torsional Modeling and Analysis** of Drive Trains illustrated by Presentation and Solution of Problems associated with Synchronous/Induction Motor Startup Transients and Reciprocating Equipment Steady-State Operation

### STATE-OF-THE-ART TECHNOLOGY PRESENTATION & DEMONSTRATION

- Advanced Technology Presentation & Demonstration
- Summary of Course Content and Application of Rotating Machinery Dynamics Technologies

### WORKSHOP & TRAINING

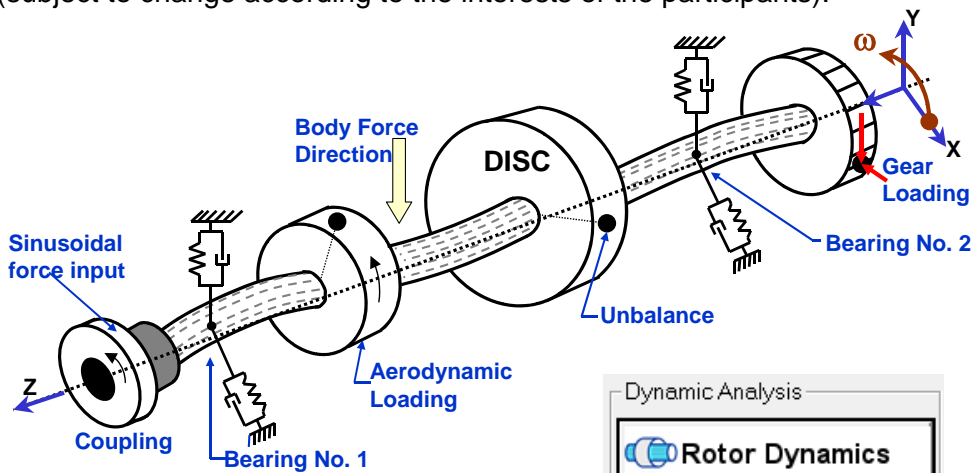
- Participants' Systems & Discussing Problems in the Group

◆ During the session, numerous real life case histories will be presented to illustrate the technology and its application to rotating machinery failure analysis and troubleshooting of common, as well as, unique vibration problems.

◆ Attendees, who are interested in more details concerning the extensive and elaborate analysis of **TORSIONAL VIBRATIONS**, should book the extra special seminar on the 4<sup>th</sup> day as well.

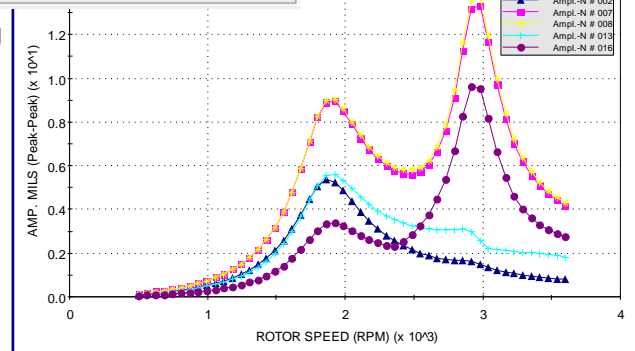
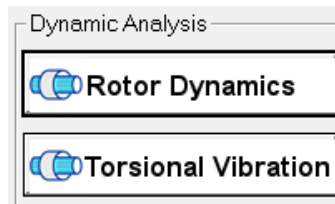
◆ Building on the 1<sup>st</sup> and 2<sup>nd</sup> seminar day, the 3<sup>rd</sup> day will also bring the technology together by the **demonstration and application of advanced software to bearings and rotor dynamics problems**. Unique and specific problems will be presented and its solution illustrated in details. Selected participants problems brought-up during the course may be utilized, as case histories and its analysis and solution will be demonstrated. An open discussion is planned at the end of the day.

Software utilized in the session may include the following items (subject to change according to the interests of the participants).



## ROTOR DYNAMICS SOFTWARE

- Introduction & Capabilities
- Shaft, Bearings, Housing & Pedestal Modeling
- Input Map and Variables Description
- Menus, Forms and Graphics
- Sample Problems
- Output Description and Interpretations of Results
- Optional Hands-On Program Operation & Integration with Bearing Modules



## FLUID-FILM BEARINGS SOFTWARE

- Introduction & Capabilities
- Bearings Modeling
- Input Map and Variables Description
- Menus, Forms and Graphics
- Sample Problems
- Output Description and Interpretations of Results
- Optional Hands-On Program Operation & Application for Parametric Evaluation and Bearing Performance to such Effects as Clearance, Lubricant, Temperature, Load, Speed, Flow, Pressure, etc.



## Day 4 – Special Seminar TORSIONAL VIBRATIONS

**4<sup>th</sup> Day: October 18, 2012 (THURSDAY, 09:00 – 16:00)**

◆ This is a special seminar and will give interested participants more depth into the basics on **TORSIONAL VIBRATIONS** including case studies and applications in rotating machinery supported by computer simulation methods. This session will be presented by **Dr. Andreas Laschet** (ARLA Maschinentechnik GmbH, Germany). This course is recommended as additional session of the previous days. The seminar will cover the following subjects:

### MODEL GENERATION

- Introduction & Problem Description
- Getting the "Right" Parameters
- Model Structures (Straight, Branched, Intermeshed Systems)

### ANALYSIS OF EXCITABILITY

- Natural Frequencies
- Modes and Interpretation of System Sensitivity, Model Refinement
- CAMPBELL Diagram & Discussing the Relevant Excitations

### SIMULATION METHODS

- Simulation in the Time Domain
- Simulation in the Frequency Domain (Steady-State)
- Analysis of the System Response & Discussing Case Studies

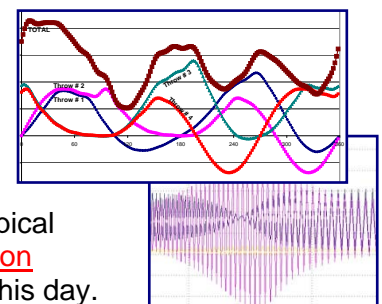
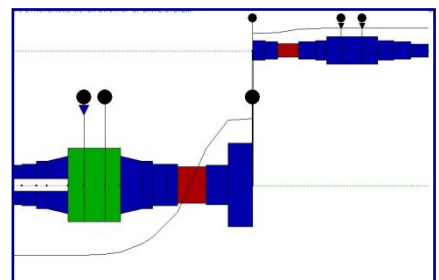
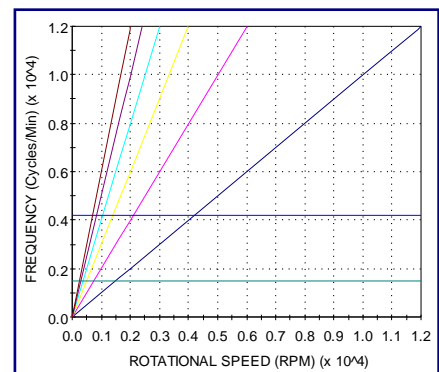
### SYSTEM EVALUATION

- Evaluation Methods
- Correlation with Measurements
- Identification of Dynamic Effects & Machine Diagnosis
- Planning Further Steps towards System Optimization

### APPLICATIONS

- TVA (Torsional Vibration Analysis) of a Total Drive System
- Drivelines with Reciprocating Engines & Reciprocating Compressors
- Electrical Effects (due to Motor Start-Up, Short Circuits, Synchronous Motor Dynamics, etc.)
- Non-linear System Behavior, Influence of Non-linear Effects (like Gear Dynamics, Friction Hystereses, Rubber Influence in Flexible Couplings, Backlash & Impacts, etc.)
- Presentation of Computer Results

- **Note:** It is planned that at **15:00 – 16:00** (approx.) the participants of the rotordynamic workshop (see the description of this parallel session on *Page 7*) will join this course in order to discuss some typical practical examples presented by **Mr. Victor Obeid**. A **final discussion** with special "TVA Questions & Answers" is planned at the end of this day.





## Day 4 – Workshop Rotordynamic Software Applications

**4<sup>th</sup> Day: October 18, 2012 (THURSDAY, 09:00 – 16:00)**

◆ This workshop is planned for participants who are interested in the detailed modeling and analysis of rotor bearing systems and their interactions utilizing the **ARMD Software V5.7**. Participants can bring their own rotating machinery problems to be presented and discussed in an open session, watch a problem developed and solved, or use the software and create their own models and perform the analysis of their interest. Time will be allocated to discuss FAQs and some details of the ARMD software, which has been used to solve the seminar sample problems. This workshop will be presented by **Mr. Victor Obeid (RBTS, USA)**. The workshop will mainly cover the following subjects:

### MODEL GENERATION

- Introduction & Problem Description
- Getting The "Right" Parameters
- Dividing The Rotating Machine Into Components For Modeling And Integration
- Verification Of Constructed Model

### ROTOR/BEARING SIMULATION

- Deflection & Load Calculations
- Bearing Performance And The Generation Of Dynamic Coefficients (Stiffness And Damping)
- System Natural Frequency, Mode Shapes And Stability Calculations
- Critical Speed Map Generation
- Stability Map (CAMPBELL Diagram)
- Synchronous Unbalance Response
- Non-Synchronous Time Transient Response

### INTERPRETATION OF RESULTS

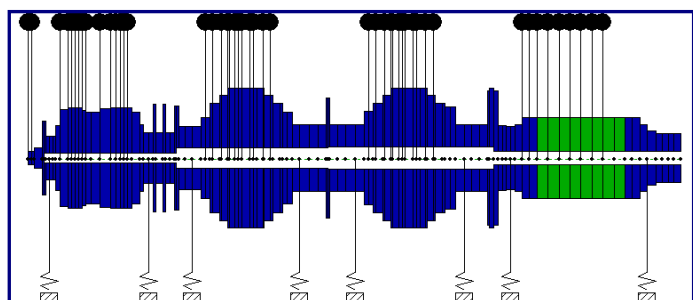
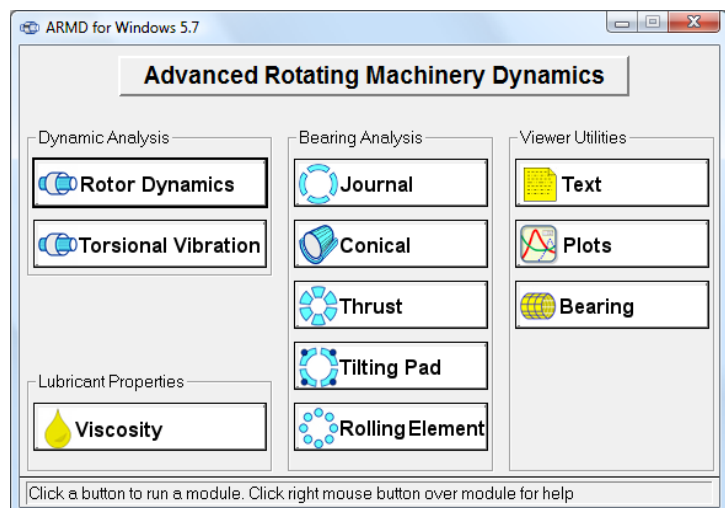
- Acceptable Bearing Performance
- Rotating Machinery Dynamic Performance And Cost Effective Corrective Action
- Comparison/Correlation Of Calculated & Measured Machinery Dynamic Performance

### APPLICATIONS

- Participants' Problems  
(if available early before the seminar starts)
- Group/Instructor Sample Problem

### DISCUSSING SPECIAL "TVA" STUDIES

- Presenting Special TVA Applications  
(planned for 15:00 – 16:00 during the parallel TVA course, see Page 6)





## About RBTS & ARLA

### RBTS: A Tradition in Engineering Excellence

Established in 1986, RBTS (USA) offers professional engineering services in rotating machinery dynamics, bearing systems, and structural engineering. RBTS' principals bring a versatile, yet highly specialized perspective to the solution of commonplace as well as unique engineering problems.

As an international leader in the design and development of software for rotating machinery dynamics, bearings, and seals, RBTS offers expertise in advanced rotor dynamic technologies. The engineering software, **Advanced Rotating Machinery Dynamics (ARMD™)** is currently in use by major corporations worldwide. Through its state-of-the-art software and service programs, RBTS provides computer-assisted technologies to companies to help them "test" the performance of rotating machinery during development and analyze machine failure in operation. Consulting services are available to supplement computer programs and for highly complex or unique machinery.

Through its principals, RBTS offers more than 60 years of combined experience. Senior consultants from these and other engineering fields also work with RBTS. Together, the RBTS network provides the most comprehensive engineering expertise available.

RBTS takes an integrated approach to problem solving, analyzing the entire project to determine the impact of each component. Again, the collective expertise of RBTS' professionals means that the clients receive both generalized as well as specialized consultation. Further information: [www.rbts.com](http://www.rbts.com)

### ARLA: From Tradition to Further Progress

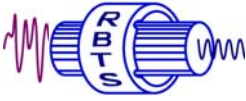
In 1918 Arnold Laschet (senior) set up a company in Essen (Germany), specialized in mechanical and electrical engineering, design of tools, fixtures, jigs, gears, devices, special machine tools, and made-to-order production. After World War II, his two sons Arnold and Guenther Laschet took over the management of his company. Since then the products, which have always been linked to the name of ARLA (abbreviation of the senior's name Arnold Laschet), have been continually developed and distributed.

The further growth of the family-owned business led to splitting the company into two independent entities in 1984. At this time, Guenther Laschet and his son Dr.-Ing. Andreas Laschet set up their own new company **ARLA Maschinentechnik GmbH** in Kuerten, a small town near Cologne. In 2002 the company moved to a new location in Wipperfuert. The name "*Maschinentechnik*" stands for *machine & technology*: machine products, technical software, engineering services, and consulting.

ARLA Maschinentechnik GmbH and its highly qualified staff aim at further developing, testing and selling their own **ARLA® Machine Products** (CNC machining units, complete endworking machines for pipes & tubes & shafts, concentric clamping systems). Another important field of activities covers engineering services, technical software products and also software and hardware systems for computer simulation and virtual engineering (**ARLA® Engineering**). ARLA uses state-of-the-art computer simulation software packages and advanced engineering tools to calculate the dynamic behavior (torsional & lateral vibrations) of drive systems. Typical applications are found in all rotating machinery, particularly in vehicles (cars, trucks), ships, aircrafts, turbo machinery, and further applications referring to power transmission engineering.

To be able to meet the increasing demands made on the simulation of vibrations, ARLA started a [close cooperation with RBTS, Inc. \(USA\)](#) to offer the rotordynamics software **ARMD™** and the accompanying engineering services in Europe and worldwide.

Since ARLA is both software developer and professional user, there is always a reference to practical use and customer-near verification of this kind of computer simulation. Worldwide, a lot of customers in R&D and testing departments use the software with great success. Customer-dedicated training courses and consultancies (also supported by web based conferences like *WebEx*) complete the range of products and services. See also the long list of ARLA's references and publications in the engineering domain on ARLA's web site [www.arla.de](http://www.arla.de) or [www.arla-online.com](http://www.arla-online.com).



Registration

Please fill in this form per person and fax it to: +49 2267 6585-70. It is better that you REGISTER ONLINE. Please go to www.arla.de or www.arla-online.com. The INVOICE is issued by ARLA in EUR currency.

Last (Family) Name + Academic Title:
First Name(s):
Job Title: Dept.
Company Name:
Company Address:
Zip (Postal) Code & City:
Country:
VAT IdNo. (necessary for companies from EU)
Phone:
Email Address:

Personal and company name (including city, country) will appear on the name badge and the attendee list. The course and literature language is ENGLISH only. Please provide us with your INVOICE address, if it is not the same as above. Changes or modifications of the program may be possible according to the requests from the participants.

You may book single days. Please tick the boxes for registration. For the total course (4 days) we offer favorable price conditions which you read below.

- Day 1 1-Day Seminar FLUID-FILM BEARINGS Monday October 15, 2012 – 09:00-17:00
Day 2+3 2-Day Seminar ROTOR DYNAMICS, Part 1+2 Tuesday October 16, 2012 – 09:00-17:00 Wednesday October 17, 2012 – 09:00-17:00
Day 4 \*) 1-Day Seminar TORSIONAL VIBRATIONS Thursday October 18, 2012 – 09:00-16:00
Day 4 \*) 1-Day Workshop ROTORDYNAMIC SOFTWARE Thursday October 18, 2012 – 09:00-16:00

\*) The 2 sessions on the 4th day (Thursday) are parallel sessions. Please register for 1 session only.

The prices as mentioned below include the participation of 1 attendee, 1 set of literature, beverages during the breaks, and lunch. German or private participants should notice the following important tax information: 19 % German VAT (value added tax) must be added to the yellow marked prices. Hotel accommodation is paid by yourself. Please also notice our attached effective "ARLA Seminar Terms & Conditions" which are separately available as download using the following link: http://www.arla.de/download/info/ARLA-Seminar-Terms.pdf

Table with 2 columns: Duration (1 day, 2 days, 3 days, 4 days) and Price (EUR 640,00, EUR 1.200,00, EUR 1.600,00, EUR 1.950,00)

In order to plan this seminar, we appreciate your registration as soon as possible.



# Location & Accommodation

The seminar will take place at the following hotel:

**Leonardo Hotel Köln**  
 Waldecker Str. 11-15  
 51065 Köln (Cologne) - GERMANY  
 Telephone: +49 221 6709-0  
 Fax: +49 221 6709-321  
 Email: [reservations.koeln@leonardo-hotels.com](mailto:reservations.koeln@leonardo-hotels.com)  
 Internet: [www.leonardo-hotels.com](http://www.leonardo-hotels.com)



The hotel is in the city of **Cologne** (Köln) in the west part of Germany and very close to the urban motorway (extension of the **A4**), exit "Köln-Buchforst" (see the road map on the following page). Due to other events which take place during the same period of time (like conventions, trade fairs, shows), we recommend to book your hotel room **as soon as possible**. Please book your room **directly via the a.m. Email address** to get your special room rates. The reservation is guaranteed if you communicate your credit card details to the reservation manager of the hotel (usually via Fax). The contact partners at the hotel are: **Ms. Arendsen** (Phone +49 221 6709 340) or **Ms. Weis** (Phone: +49 221 6709 715) The reduced conditions can only be granted by mentioning the **reservation code "ARLA"**.

The **special ARLA room rate** incl. breakfast, service, VAT (local city tax extra) is:

**EUR 79.00** for a single room per night  
earliest check-in at the arrival day: 15:00 (03:00 p.m.)  
latest check-out at the departure day: 12:00 (noon)

All 165 comfort rooms, 11 superior rooms, and 2 junior suites are equipped with bath, shower, WC, hairdryer, minibar, radio, TV with national and international programs, 1-2 telephones with ISDN (digital) and analog connections, WLAN and an individually adjustable full air-conditioning system. The hotel has 14 smoker rooms. Laundry services are from Monday to Friday. 4 hotel rooms are suitable for handicapped persons. The rooms are equipped with a connecting door to a neighbor room and can be easily accessed with a wheelchair. A free safe deposit box is available at the reception. If you arrive by car, use one of the 90 parking spaces of the hotel (EUR 10.00 / day). More information are available at the hotel web site [www.leonardo-hotels.com](http://www.leonardo-hotels.com) in many languages (German, English, French, Spanish, Italian, Chinese, etc.).



## How to get there?



### BY CAR

**From the NORTH direction:** *from North-East: A1 to Leverkusen intersection or from North: A3 from Oberhausen, from there via the A3 in the direction of Frankfurt to Cologne-East (Köln-Ost) intersection, then via the urban motorway in the direction of Cologne city centre / downtown (Köln-Zentrum), take Köln-Buchforst exit.*

**From the SOUTH direction:** *A3 to Cologne-East (Köln-Ost) intersection, then via the urban motorway in the direction of Cologne city centre (Köln-Zentrum), take Köln-Buchforst exit.*

**From the WEST direction:** *A4 to Dreieck Heumar (junction), then take the urban motorway in the direction of Cologne city centre (Köln-Zentrum), take Köln-Buchforst exit.*

**From the EAST direction:** *A4 in the direction of Cologne city centre (Köln-Zentrum) - you do not leave the motorway because it automatically runs in the urban motorway, take Köln-Buchforst exit*

### BY TRAIN

There is a **S train station** about 400 m away (**Köln-Buchforst**). The **international central (main) station** is 4 km away. There is a very fast connection (less than 1 hour) from Cologne city to Frankfurt airport.

### FROM GERMAN AIRPORTS TO THE LEONARDO HOTEL KÖLN (COLOGNE)

**Cologne/Bonn Airport:** *By taxi* approx. 15-20 minutes. There is also a *direct railway connection S13* which goes every 20 minutes from Cologne/Bonn Airport railway station to the Deutz/Messe and Cologne Central Station, from there you take a taxi to the hotel.

**Düsseldorf Airport:** *By taxi* approx. 20-30 minutes, or you better take the *railway* to Cologne Central Station, and from there a taxi to the hotel.

**Frankfurt/Main Airport:** Arrival at Deutz/Messe Station or Cologne Central Station less than 1 hour by **ICE** (*intercity express train*), from there you take a taxi to the hotel.



*Come to Germany, come to Cologne (Köln) and attend the*

**9<sup>th</sup> International Seminar (October 15-18, 2012)  
"ROTOR DYNAMICS & BEARINGS"**

*... in close cooperation between RBTS and ARLA*

