



# CEROBEAR AEROSPACE BEARINGS

# CEROBEAR AEROSPACE BEARINGS



ROTORCRAFT



AIRCRAFT



SPACECRAFT

## OUR COMPANY

CEROBEAR's core competencies enable **CE**ramic **RO**lling **BEA**ring solutions to mechanical operating condition extremes (in temperature, load, speed, lubrication, limited space envelope, lower weight requirements, and more) to maximize reliability, life, and performance with an aim to significantly reduce total operating costs for our customers and the end-user.

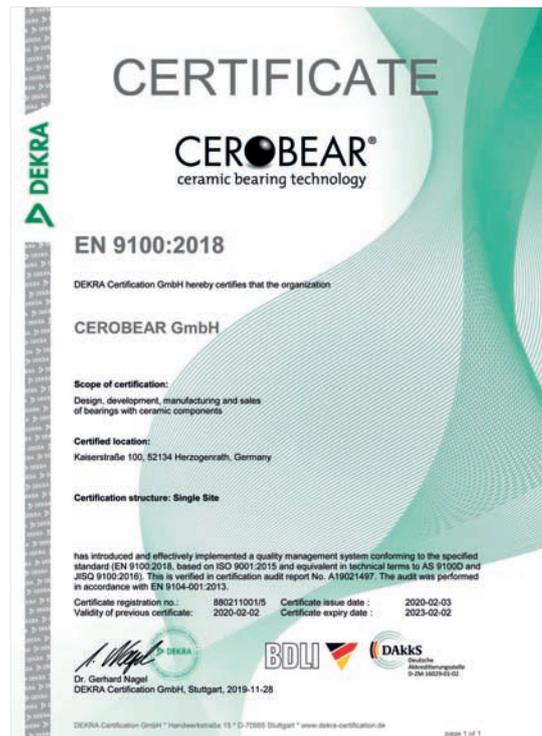
CEROBEAR GmbH was established in 1989 and operates a 42,000 square foot facility with state-of-the-art production, metrology, clean-room assembly, testing, and, R&D capabilities in Herzogenrath, Germany. Its staff of more than 130 highly skilled technical employees custom design, develop, and manufacture hybrid-ceramic, all-ceramic, and advanced all-metal rolling element bearings. The value added by CEROBEAR to every bearing is from in-house mastered production technologies such as precision hard turning (for metal), diamond grinding (for ceramic rings and rollers), five-axis milling (for bearing races and cages), ceramic component inspection, and more.

In 2013, CEROBEAR joined the MinebeaMitsumi Group headquartered in Japan. CEROBEAR is a member of the MinebeaMitsumi Aerospace Group and closely works with other rolling element bearing divisions such as NHBB and Myonic on the Aerospace market while maintaining an independent branding and unique product and service package offering.

## MANAGEMENT AND QUALITY SYSTEM

CEROBEAR's commitment to the highest quality, environmental, health and safety standards is reflected by our integrated management system. We are certified to the following international standards:

- Aerospace quality management system according to Aerospace Standard EN 9100
- Quality management system according to DIN EN ISO 9001
- Environmental management system according to DIN EN ISO 14001
- Occupational health and safety management system according to BS OHSAS 18001 / DIN EN ISO 45001
- Energy Management System according to DIN EN ISO 50001



# CEROBEAR AEROSPACE BEARINGS

## OUR PRODUCTS

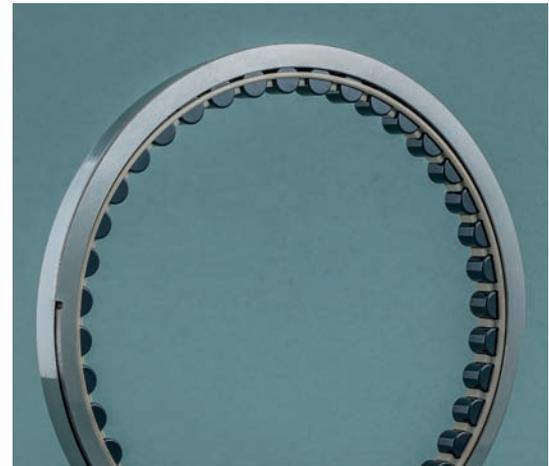
CEROBEAR manufactures a wide range of custom engineered, advanced technology ball and roller bearings of every design type in three main categories:

- Hybrid-Ceramic Bearings
- All-Ceramic Bearings
- All-Metal Bearings (for specific situations and/or special applications)

**HYBRID CERAMIC BEARINGS:** CEROBEAR makes a wide range of hybrid ceramic ball and roller bearings. In hybrid bearings, races are made of high performance steels and rolling elements from  $\text{Si}_3\text{N}_4$  ceramic. We are the only bearing company in the world that is able to make hybrid roller bearings in all roller sizes, shapes, and crown profiles due to our unique roller manufacturing process. Compared to conventional steel bearings, hybrid bearings are lighter, operate at higher speeds, generate lower friction, and require less lubrication. Since the  $\text{Si}_3\text{N}_4$  ceramic rolling elements are totally inert due to their covalently bonded crystalline structure, there is absolutely no possibility of seizure, fretting, cold welding, or adhesive wear between the rolling elements and metal raceways even in “oil-off” situations. All these benefits of  $\text{Si}_3\text{N}_4$  rolling elements result in bearings that last typically 2x to 100x longer than all-steel bearings of identical design.

**ALL-CERAMIC BEARINGS:** Made entirely from silicon nitride ( $\text{Si}_3\text{N}_4$ ) or zirconia ( $\text{ZrO}_2$ ) ceramic, CEROBEAR’s all-ceramic bearings are used for the most extreme corrosion and temperature conditions. Our all-ceramic bearings are non-magnetic, corrosion resistant, extremely hard, and much lighter than steel (>60% less). They also maintain their strength in extreme temperatures (up to 1900°F, 1038°C,) and can operate in dry conditions or with media lubrication (e.g. water).

**ALL-METAL BEARINGS:** In order to service a customer’s entire system, CEROBEAR draws upon its considerable materials experience to design and manufacture all steel ball and roller bearings in a wide range of configurations and sizes for special situations and specific applications.



## CEROBEAR AEROSPACE BEARINGS - PRODUCT + SERVICE PACKAGE OFFERING

### Rolling Element Bearing Types

#### Roller Bearings

- Cylindrical
- Tapered
- Spherical
- Tapered Double Row
- Needle
- Hour Glass
- Pure Thrust
- Geared Outer Ring
- Combined Ball and Roller

#### Ball Bearings

- Radial (Deep Groove)
- Angular Contact (15° to 60°)
- Gothic Arch (3 Point Contact)
- Gothic Arch (4 Point Contact)
- ACBB Duplex
- ACBB Super-Duplex
- ACBB Triplex
- Thin Section
- Pure Thrust
- Geared Outer Ring
- Combined Ball and Roller

## Ring Materials

- M50 (AMS 6491)
- M50 Nil (AMS 6278)
- M50 & M50 Nil - nitrided
- X30 CrMoN 15 1 (AMS 5898) - high nitrogen steel
- X40 CrMoVN 16 2 (AMS 5925) - high nitrogen steel
- AISI 440C / SAE 51440  
(AMS 5880 / AMS 5618 / AMS 5630)
- BG42 (AMS 5749)
- ASP 2062
- Ferrium 64 (AMS 6509)
- Pyrowear 53 (AMS 6308)
- Inconel 718 (AMS 5663.....)
- 100 Cr 6 / SAE 52100 (AMS 6440 / AMS 6444)
- Silicon Nitride (ASTM F2730 / ASTM F2094)
- Zirconia (Y-TZP, Mg-ZrO<sub>2</sub>...)
- and more...

## Platings & Coatings

- Silver (AMS 2410 / AMS 2412)
- Thin Dense Chromium (AMS 2438)
- Tungsten Carbide / Carbon (WC/C)
- MoS<sub>2</sub>
- Dicronite DL5
- and more...

## Bearing Sizes & Precision Level

- 0.25" (6.25mm) ID to 20" (508mm) OD
- Bearing design according to ISO or ABEC standard dimensions or fully customized
- Accuracy up to ABEC/RBEC 7 (9) corresponding to ISO class 4 (class 2)
- Accuracy up to ABEC 7F for constant section bearings
- Rollers/needles diameters from 1.5mm to 40+ mm



## Rolling Element Materials

- Silicon Nitride (ASTM F2730 / ASTM F2094)
- M50 (AMS 6491)
- AISI 440C / SAE 51440  
(AMS 5880 / AMS 5618 / AMS 5630)
- 100 Cr 6 / SAE 52100 (AMS 6440 / AMS 6444)
- Zirconia (Y-TZP)
- and more...

## Cage Materials

- PEEK (MIL-P-46183 TYPE 1)
- PTFE, PGM-HT, PCTFE, PI, PAI
- Steel (4340 & others)
- Bronze
- Brass
- Titanium
- Phenolic (MIL-I-24768/13)
- and more...

## Special Design Features

- Customized Outer Ring Flanges
- Anti-Rotation Features (Pins or Slots)
- Direct Oil Lube (holes & grooves)
- Extended Inner or Outer Rings
- Custom Shields & Seals; Integral Shields
- Combined Ball & Roller Bearings
- Positioning Flanges
- Flexure Cages
- Integrated Magnets/Encoder
- Puller Grooves
- Splines
- Cage and Race Platings
- Smart Bearing
- Additive Manufacturing
- and more...

## Unique Services

- Short Lead Time 12-24 Weeks typical
- Low Minimum Quantity - Typically 10 bearings
- Full Design Capability & Bearing Calculation Support
- In Depth, Simultaneous Co-Engineering Support
- Deep Application Experience by Aerospace Segment
- New Materials adapted quickly for Production Use
- Pre-Delivery Friction & Torque Testing;  
Pre-Load Measurements
- Bearing Inspection & Analysis to support customer testing

# CEROBEAR AEROSPACE BEARINGS

## THE AEROSPACE MARKET – THE CEROBEAR DIFFERENCE

CEROBEAR is highly focused on developing and growing its aerospace business because its advanced ceramic bearing technology perfectly addresses key industry trends to affordably provide:

- significant weight reduction
- increased capabilities to operate at higher temperatures and increased speeds
- improved bearing life even under increasingly challenging operating conditions including poor lubrication or „oil off“ conditions
- higher system safety and reliability
- lower total operating cost for end-users

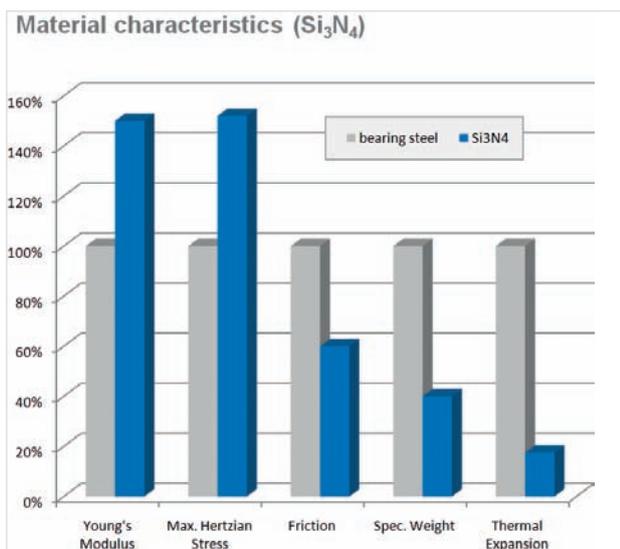


CEROBEAR is actively serving a complete range of aerospace segments and applications including: helicopters, gearboxes, transmissions, aero-engines, hot air valves, actuation systems, motors, generators, ram-air turbines, accessories, surveillance systems, space mechanisms, space propulsion systems, space guidance systems, and, much more.

For each aerospace application, CEROBEAR applies its unique business model to custom engineer a bearing solution combining the following key elements:

- **Advanced Materials:** We select the right materials to maximize life, reliability, and performance from an expansive portfolio for every part of the bearing. Specifying the right materials is a key first step derive all that is possible from a reliable design. We routinely add new materials to our portfolio to serve an application need when it's the best solution. Additively manufactured materials complement our portfolio.
- **Advanced Components:** We are able to make nearly any ball or roller bearing design required with extremely precise internal geometry to minimize contact stress and thus maximize life and reliability.
- **Simultaneous Engineering:** We work very closely with our customers to co-engineer bearing solutions from a white sheet of paper design, and/or utilize customer drawings and specifications.
- **System Integration/Special Features:** We are able to custom engineer and manufacture special bearing features to simplify integration into mechanical systems.
- **Service with Speed:** Due to our flexible, fully computerized production technology we are able to make both small quantities for testing and production volumes very quickly. Our typical delivery time is 12–24 weeks from finalized design for a first order.
- **Production Automation:** We are actively implementing Industry 4.0 standards and capabilities for factory automation for continuous improvement of consistent quality, production flexibility and efficiency.





Si<sub>3</sub>N<sub>4</sub> vs. Steel for Rolling Elements: Extreme Hardness, Total Inertness, Lighter Weight, Lower Friction translates into superior bearing life, reliability, and performance

## ADVANCED MATERIALS

CEROBEAR's philosophy is deeply rooted in proper material selection as the primary focus of bearing design. If the material of any bearing component is deficient, then the entire bearing is deficient. After thoroughly understanding the operating conditions for an application, we then select the most optimal materials from our extensive portfolio for rings/races, rolling elements, cages, coatings, shields/seals, and lubricants. Unlike any other bearing company in the world, CEROBEAR does not limit itself in material selection.

We are able to develop, test and add new materials to our portfolio on a routine basis as required because our manufacturing processes are engineered for flexibility and adaptability. In addition, we continuously develop new products such as smart bearings and the use of additive manufacturing technologies.

### BEARING STEELS/METALS

While SAE52100 chrome steel and AISI 440C stainless steel are suitable for many applications, extreme operating conditions in aerospace applications may require the use of more advanced alloys such as BG42<sup>®</sup>, M50, M50 NiL<sup>®</sup>, M50 NiL<sup>®</sup> nitrided, and, high nitrogen steels like Cronidur<sup>®</sup> 30. These materials offer superb performance and over-rolling fatigue at high speeds, extreme temperatures, under heavy loads and in corrosive environments.

### CERAMIC ROLLING ELEMENTS - THE Si<sub>3</sub>N<sub>4</sub> ADVANTAGE

Compared to bearing steel, a properly made and inspected Si<sub>3</sub>N<sub>4</sub> rolling element provides superior operating benefits and is the cornerstone of why hybrid bearings are superior compared to conventional steel bearings. The combination of Si<sub>3</sub>N<sub>4</sub>'s very high hardness, much lower mass, total inertness, smooth running, enhanced stiffness, and, excellent rolling contact fatigue resistance leads to much longer life, higher reliability, and superior performance characteristics for hybrid bearings. The inert behavior of the Si<sub>3</sub>N<sub>4</sub> rolling element prevents cold welding and adhesive wear in the contact area with steel bearing rings. This inertness along with smooth running lowers friction and reduces internal bearing temperature which extends lubricant life.

### CAGE MATERIALS

CEROBEAR offers a wide range of cage materials. The portfolio extends from commonly used silver coated steel cages to brass, or PEEK cages and other high-tech plastic materials. PEEK is an excellent candidate for cages due to its low friction, high flexibility, wide temperature range (up to 392°F, 200°C), and manufacturability into complex designs.



# CEROBEAR AEROSPACE BEARINGS

## ADVANCED COMPONENTS

CEROBEAR has developed the capability to efficiently and rapidly produce highly complex bearing components to high precision tolerances from a wide range of materials including metals, ceramics, and plastics.

**PRECISION HARD TURNING:** CEROBEAR is the world leader in PrecisionHard Turning technology for production of hardened steel bearing components up to HRC 72. We are able to substitute grinding and honing operations of races while maintaining the highest precision and surface integrity. In addition, our hard turning creates significant benefits in quality, cost, and delivery speed. We also offer honing of raceways with our Precision Hard Turning when required by customers for the highest level of precision, geometry, and, bearing performance.

**Si<sub>3</sub>N<sub>4</sub> ROLLER FABRICATION:** Our computerized ceramic grinding technology for high precision rollers has been proven in numerous flying bearing applications in Rotorcraft, Spacecraft, and Aircraft most notably in the US Space Shuttle main engine liquid hydrogen pumps which had very extreme operating conditions and in main transmissions/gearboxes of helicopters. CEROBEAR's ability to make a very wide range of roller sizes, shapes (cylindrical, tapered, spherical, needle, and, hour-glass), and crown profiles allows for a complete design consideration for any application in which we can apply hybrid roller bearings. No other bearing company in the world has this flexibility and roller selection.

**CAGE FABRICATION:** CEROBEAR maintains a complete internal capability for cage fabrication using five-axis milling or other production methods applicable to a wide range of advanced materials and cage designs.



## SIMULTANEOUS ENGINEERING

CEROBEAR works very closely with its customers with speed and responsiveness to simultaneously engineer each bearing through every stage of the process from initial design all the way through to post-delivery follow-up including post-usage analysis for further optimization. We believe strongly that optimization of our product and success in the application system comes from true partnership with our customers. We focus on building bearings into the customer's system instead of forcing a customer to build their system around our bearings.

## SYSTEM ENGINEERING/SPECIAL FEATURES

To fully support customer needs, CEROBEAR engages in bearing customization to integrate our bearing solution into the complete mechanical system. We find a way to uniquely integrate a bearing solution for simplicity, performance, reliability, and affordability. Our engineers optimize the internal geometry and design of every bearing to minimize contact stress and maximize performance. In addition, we routinely incorporate a variety of special features such as anti-rotation devices, flanges, integrated threads and much more.



## AEROSPACE MARKET SEGMENTS SERVED

CEROBEAR serves a wide range of aerospace applications to maximize life, increase reliability, reduce weight, and optimize performance which results in lower total operating cost for end-users.

We serve four main Aerospace Market Segments: **Aero-Engines; Helicopter-Vertical Flight; Space; and, Accessories.**

### AERO-ENGINES

For the Aero-Engine market segment, we serve 3 sub-segments including: **Main-Shaft for Propulsion** (Engines), **Main-Shaft for Non-Propulsion** (APU's, Generators for electric aircraft, etc), and, **Accessory Gearboxes.**

CEROBEAR hybrid bearings provide a wide range of benefits for Aero-Engine applications. The use of ceramic rolling elements offers a considerable amount of weight saving for high speed applications in addition to longer life from lower friction and less wear. This weight savings can be increased further by using PEEK cages for gearboxes where application conditions allow. CEROBEAR also exactly adapts inner bearing geometry to the application requirements to minimize contact stress. CEROBEAR's production technology allows complex bearing designs which allows a higher degree of integration of the bearings into the system reducing part count and increasing simplicity. This also includes the use of case hardened materials like M50-NiL for bearing life improvement or specific design like flexure ring geometries. If beneficial the Heat treatment and carburizing process will be adapted to give the best performance for the specific application.



The use of Si<sub>3</sub>N<sub>4</sub> ceramic rolling elements offers extraordinary bearing performance under oil-off conditions in gearboxes and engines. In grease lubricated gearbox bearings, the lifetime of the grease can be prolonged resulting in a longer service life for the bearings which increases the time between re-greasing intervals and can even allow “for life” lubrication.

### HELICOPTER-VERTICAL FLIGHT

For the Helicopter-Vertical Flight market segment, we serve four sub-segments including: **Gearboxes-Transmissions-Drive Train, Rotor Systems, Heli-Specific Accessories,** and, **eVTOL.**

CEROBEAR's hybrid ceramic ball and roller bearings provide resistance to poor lubrication conditions and longer running time in oil off situations increasing the safety margin in case of critical lubrication conditions; Ceramic rolling elements also provide more wear resistance and lower friction which extends lubricant life; Light Weight Si<sub>3</sub>N<sub>4</sub> rolling elements are a great benefit for transmissions close to the center-line of a helicopter main rotor. The use of PEEK cages allows further weight savings where maximum application conditions allow for it.

Complex and integrated bearing designs allow to reduce the number of parts used in a transmission or gearbox and thus simplify assembly and reduce tolerance stack ups. Integral gear design for planetary bearings reduce the mass of the rotating planetary and allow for more design flexibility.

For grease lubricated bearings the re-greasing intervals can be extended significantly by using ceramic rolling elements reducing the overall maintenance requirements.



# CEROBEAR AEROSPACE BEARINGS

## SPACE

For the Space market segment, we serve 3 sub-segments including: **Mechanisms, Propulsion Systems, and Guidance Systems**. CEROBEAR's Aerospace Heritage began in early 2000 with the first flight of ceramic cylindrical rollers in the bearings of the USA Space Shuttle's main engine liquid hydrogen pumps. Performing flawlessly for nearly 40 missions, the ceramic rollers operated at 36,200 rpm in temperatures of -423°F (-253°C) while being lubricated by only liquid hydrogen. CEROBEAR's solution improved the time between overhaul for the engines by a factor of 12 (increasing life, reducing costs), while increasing payload by 9% (increasing performance and lower total operating costs), and reducing maintenance hours between missions from 1000 hours to <50 hours (reducing total operating costs). CEROBEAR has also supplied a large variety of mechanisms bearings for many commercial satellite programs as well as directly to ESA, NASA, JAXA or ISRO.

CEROBEAR bearings for space applications are customized and perfectly adapted to a long service life with highest accuracy and low friction. We make bearings for High Speed applications for Guidance Systems (flywheels, momentum wheels, control momentum gyros), Low Speed applications for Mechanisms (dry running and wet lubricated), and, Propulsion Systems (turbo-pumps with cryogenic media lubrication, or, rocket propellant liquid). For low speed bearings, which are typically used in space mechanisms, space qualified materials and coatings are available. For very special requirements, new materials like enhanced bearing steel and ceramic are also applied. Due to the special requirements for space bearings (vacuum, high launch loads, long lifetime and reliability without maintenance) each bearing is customized and manufactured on order. In all cases, we work closely with system designers to meet all requirements for performance and life.

CEROBEAR's space heritage goes back 20 years with a long list of missions and programs using a wide range of bearing types and materials proven both heritage and next-generation.



## ACCESSORIES

For the Accessories market segment, we serve a wide range of sub-segments including: **Hot Air Valves, Surveillance Systems, Actuators, Starters, Generators, Motors, Ram Air Turbines, Pumps, Landing Gear, and, much more**. CEROBEAR's wide ranging advanced material portfolio, application specific design expertise, and ability to make all types of ball and roller bearing in hybrid-ceramic, all-metal, and, all-ceramic options provides our customers the right solution for their specific application.

In **Hot Air Valves**, for example, bearings currently operate at high temperatures (up to 1000°F, 538°C) and for the next generation of valves, the temperatures are expected to be even higher (1300°F, 704°C). To operate under such extreme temperatures as well as typically high loads with shaft bending, CEROBEAR hybrid bearings are designed with high temperature metals including BG42® or other high temperature metal rings plus Si<sub>3</sub>N<sub>4</sub> rolling elements, and high temperature cages to enable a dry running reliable solution.

For **Surveillance Systems**, for example, high precision, light loads, and limited space are typical. CEROBEAR's constant section bearings serve these needs. A customized solution with integrated flanges minimizes the number of parts, simplifies the assembly and provides excellent bearing performance in terms of stiffness, runout, and friction.



For **Starters**, for example, which are oil splash lubricated, hybrid ceramic ball and roller bearings provide poor lubrication resistance, wear resistance, high acceleration/skidding tolerance, weight savings through integrated bearing designs, weight savings through selected materials, and, weight savings through geared outer rings for planetary roller bearings.

For **Actuators**, for example, hybrid bearings provide a more regular and lower friction torque which reduces the power consumption and increases the reliability. Even at difficult lubricating conditions ceramic rolling elements prevent a bearing from jamming which is an important requirement of electromechanical actuation used for flight control or other critical applications.



ROTORCRAFT



AIRCRAFT



SPACECRAFT



We welcome your enquiries from around the world and look forward to hearing from you.

For more information on CEROBEAR and our unique technology and products, please contact us:

CEROBEAR GmbH  
Kaiserstr. 100  
52134 Herzogenrath  
GERMANY

Phone: +49 2407 95 56 - 0  
Fax: +49 2407 96 22 4  
Email: [cb-sales@cerobear.com](mailto:cb-sales@cerobear.com)  
[www.cerobear.com](http://www.cerobear.com)

03/2020

#### **CEROBEAR North American Sales:**

Tony Tagliavore  
Business Development Manager  
Aerospace Market  
[tony.tagliavore@cerobear.com](mailto:tony.tagliavore@cerobear.com)  
Phone: +1 719 2376859

#### **in Israel:**

Frank Agencies  
Moshe Frank  
[frank\\_ag@frank.co.il](mailto:frank_ag@frank.co.il)  
Phone: +972 3 5441 941

#### **CEROBEAR European Sales:**

Bernd Reuter  
Sales Manager Aerospace Europe  
[bernd.reuter@cerobear.com](mailto:bernd.reuter@cerobear.com)  
Phone: +49 171 540 85 58

#### **Rest of the World:**

Tony Tagliavore  
Business Development Manager  
Aerospace Market  
[tony.tagliavore@cerobear.com](mailto:tony.tagliavore@cerobear.com)  
Phone: +1 719 2376859

CEROBEAR is part of MinebeaMitsumi Aerospace.  
For further Aerospace products of the MinebeaMitsumi group please visit:  
[minebeamitsumi-aerospace.com](http://minebeamitsumi-aerospace.com)

