

#### **20th Anniversary of Microgravity Experiments at the Drop Tower Bremen and 25th Anniversary of ZARM**





#### ZARM FAB mbH

ZARM Drop Tower Operation and Service Company

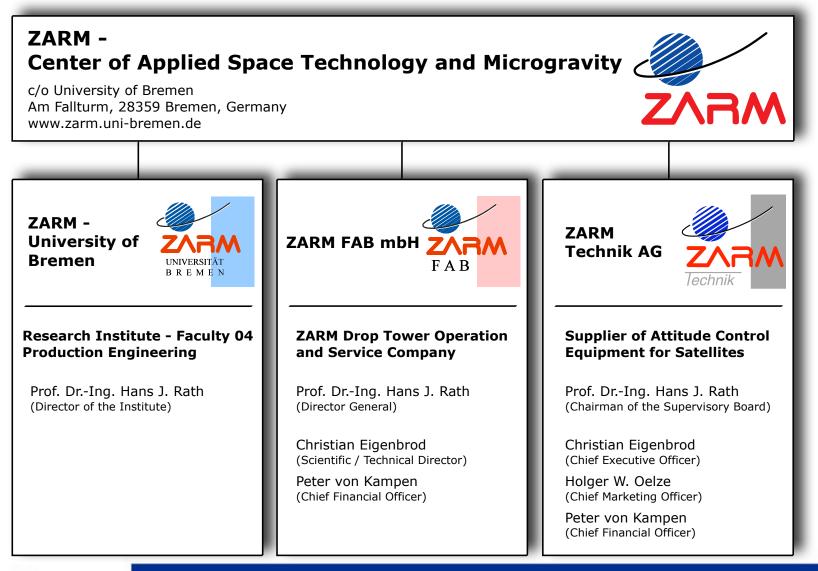
c/o University of Bremen Am Fallturm 28359 Bremen Germany

#### www.zarm.uni-bremen.de





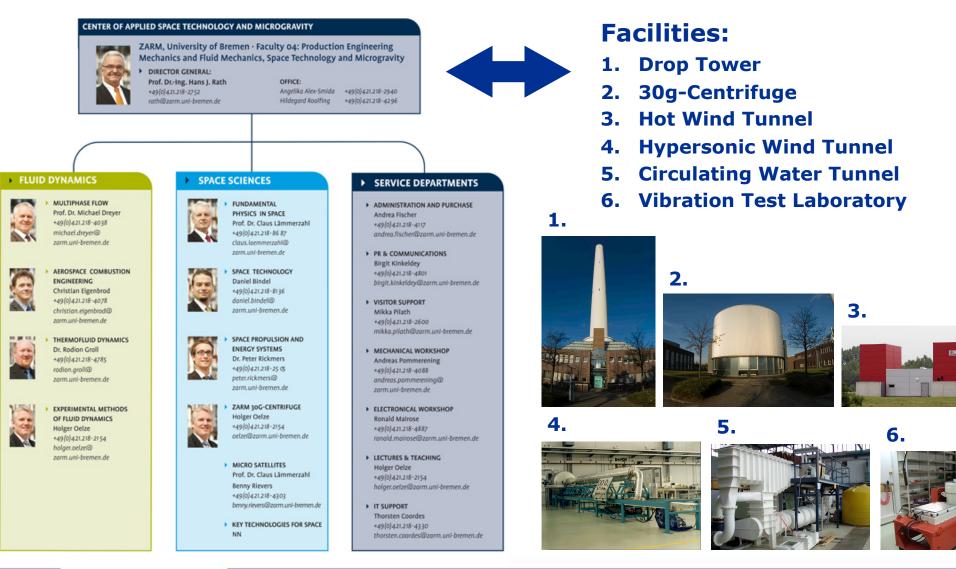
### **ZARM's Organization Plan**







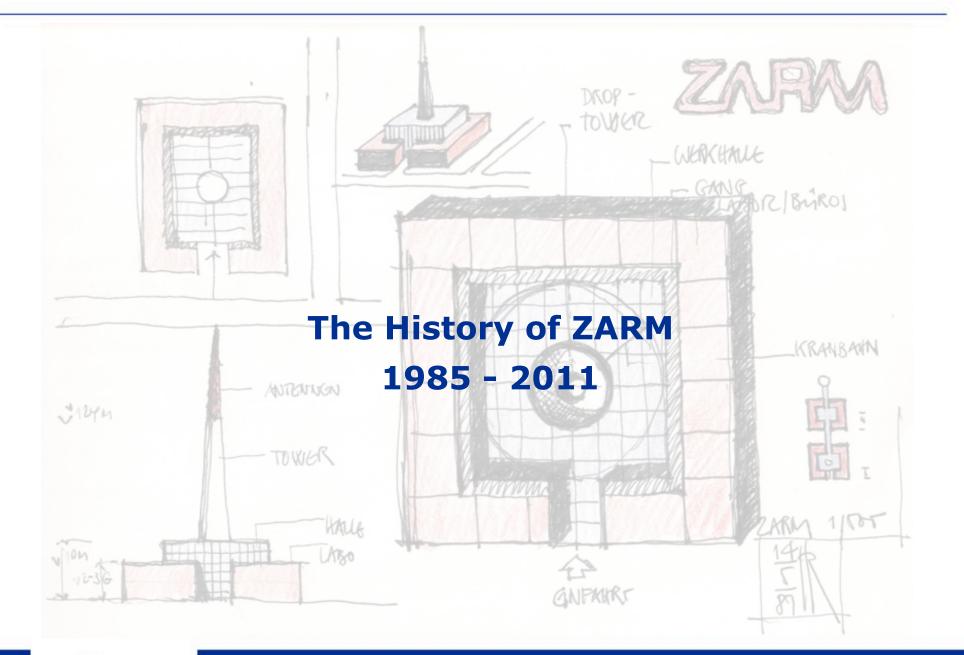
#### **ZARM's Research Institute**





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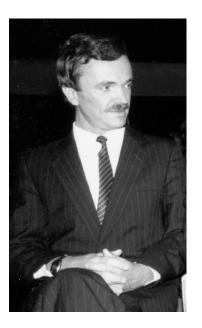
#### November, 2011 | Putrajaya, Malaysia

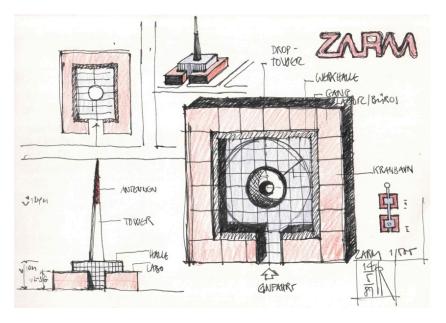






- Prof. Dr.-Ing. Hans J. Rath:
  - became Professor of Technical Mechanics and Fluid
    Mechanics at the University of Bremen in November 1981
  - drew up a draft for an "environmental and water technology institute" in 1984









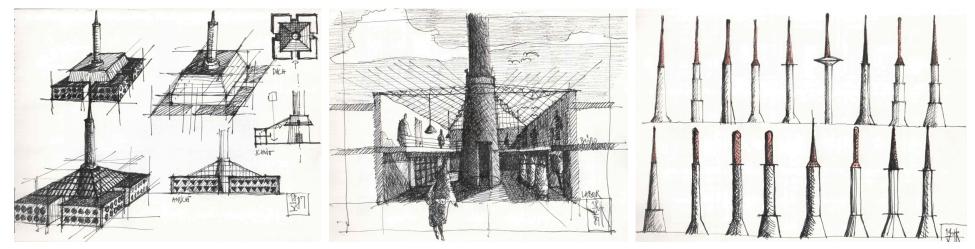


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- Christa and Manfred Fuchs:
  - met Prof. Dr.-Ing. Hans J. Rath in 1984 and had just acquired a small firm - OHB GmbH in Bremen
  - continually tried to convince Prof. Dr.-Ing. Hans J. Rath to set up something at the University of Bremen in the field of space technology...





- In September 1985:
  - founding of the Center of Applied Space Technology and Microgravity (ZARM) as a scientific entity within the University of Bremen Department of Production Engineering
- In February 1987:
  - initial planning period for the Drop Tower Bremen



Architect Prof. Horst Rosengart

www.rosengart-architekten.de





- From May 1988 to September 1989:
  - construction of the Drop Tower Bremen







- In June 1989:
  - founding of the ZARM Drop Tower Operation and Service Company (ZARM FAB mbH)
- In September 1990:
  - inauguration of the Drop Tower Bremen by the Federal
    Minister of Education and Research Dr. Heinz Riesenhuber









- In December 1993:
  - > 1,000th drop of a microgravity experiment
- In February 1994:
  - launch of BremSat from the space shuttle Discovery during the STS-60 mission and start of a one-year operation period
- In June 1995:
  - successful start of thermal convection experiment of ZARM on a Russian SS-N-18 missile aboard a submarine in the Barents Sea and safe landing in Kamchatka
- In January 1997:
  - 2,000th drop of a microgravity experiment





- In May 1997:
  - founding of ZARM-Technik GmbH a company for the development and marketing of space technology components and industry partner for scientific and technical services
- In November 1999:
  - development / construction period of the catapult system







- In April 2000:
  - > 3,000th drop of a microgravity experiment
- In August 2000:
  - start of construction works for ZARM's 30g-Centrifuge
- In June 2001:
  - start of construction works for combustion research laboratory building (hot wind tunnel)









- In October 2004:
  - 4,000th drop of a microgravity experiment
- In December 2004:
  - first test of the catapult system launched by the Federal Minister of Education and Research Edelgard Bulmahn







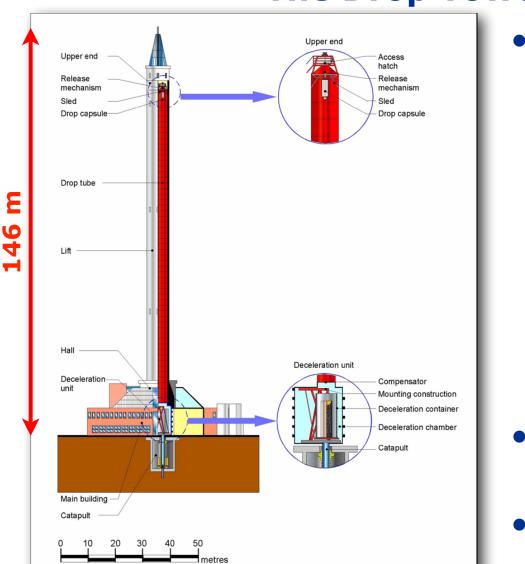
- In October 2008:
  - > 5,000th drop / catapult launch of a microgravity experiment











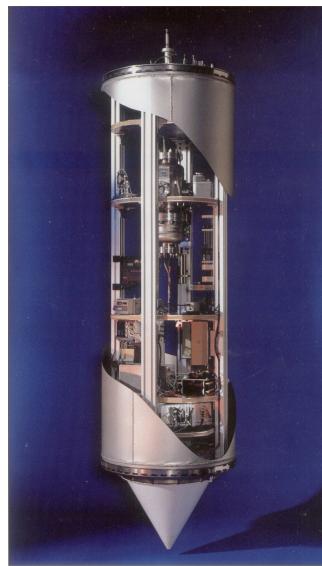
# **The Drop Tower Bremen**

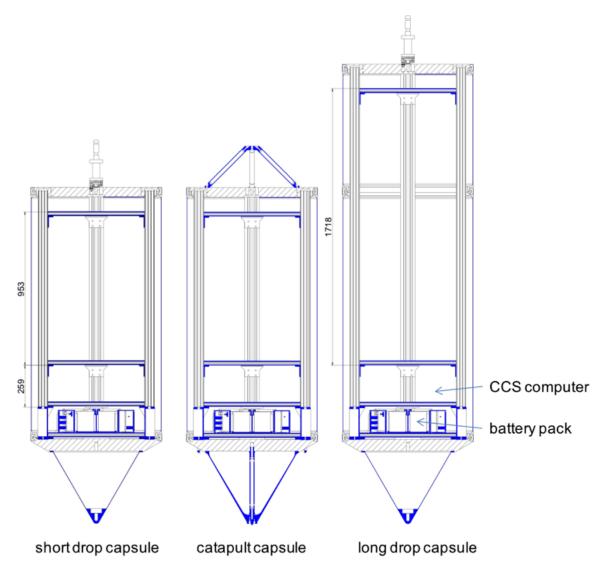
- microgravity options:
  - drop mode
    - 4.74 s weightlessness
    - high-quality **10**<sup>-6</sup> g
    - deceleration up to 50 g
    - short or long capsule
  - catapult mode
    - 9.3 s weightlessness
    - high-quality 10<sup>-6</sup> g
    - acceleration up to 30 g
    - deceleration up to 50 g
    - catapult capsule (short)
- daily campaigns (3 times per day)
- on-site experiment access and technical support



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#### **Experiment Capsule Types of the Drop Tower Bremen**

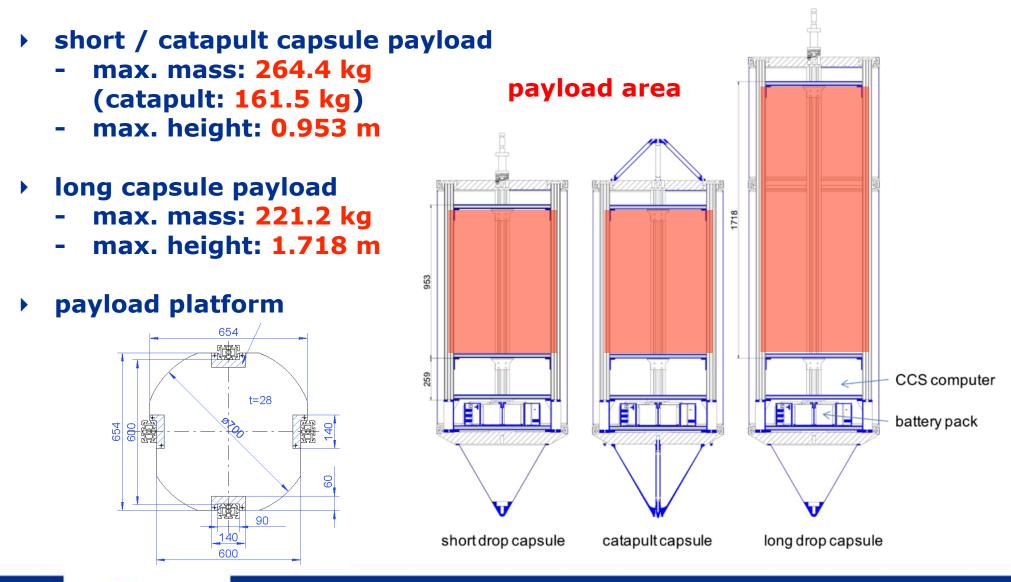








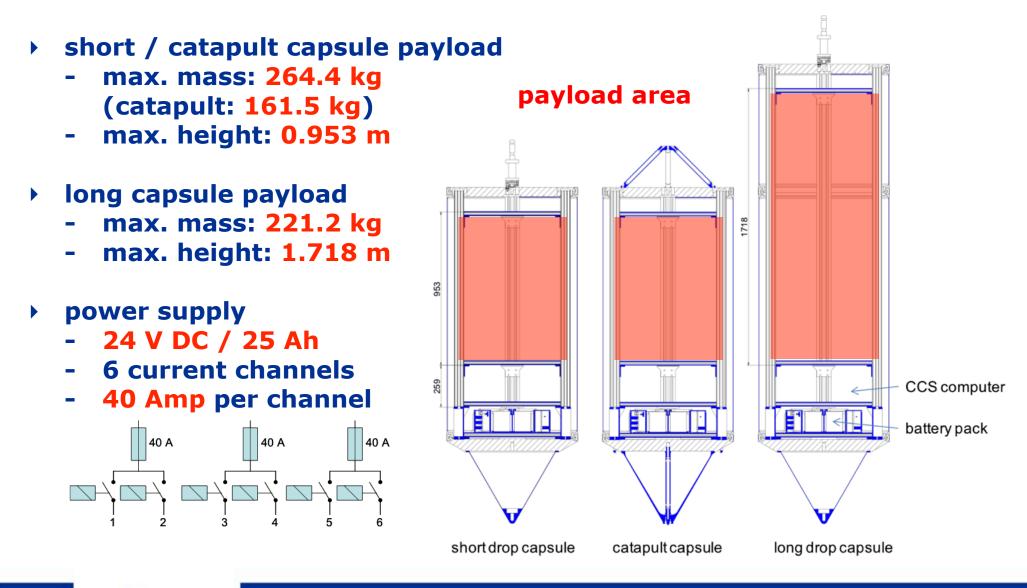
### **Capsule Payload and Battery Pack**







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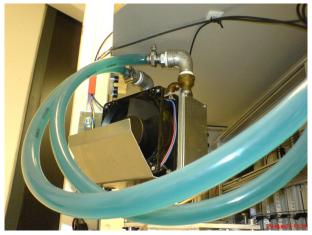


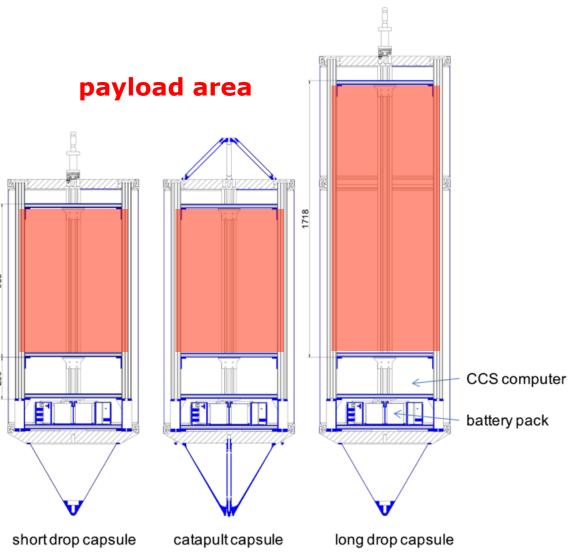




### **Environmental Conditions inside the Capsules**

- pressure-sealed capsule:
  - nominal pressure: 1 bar
- temperature in general:
  - room temperature (thermal power loss)
- thermal control on request:
  - liquid circuit thermostat (-20°C <-> +60°C)

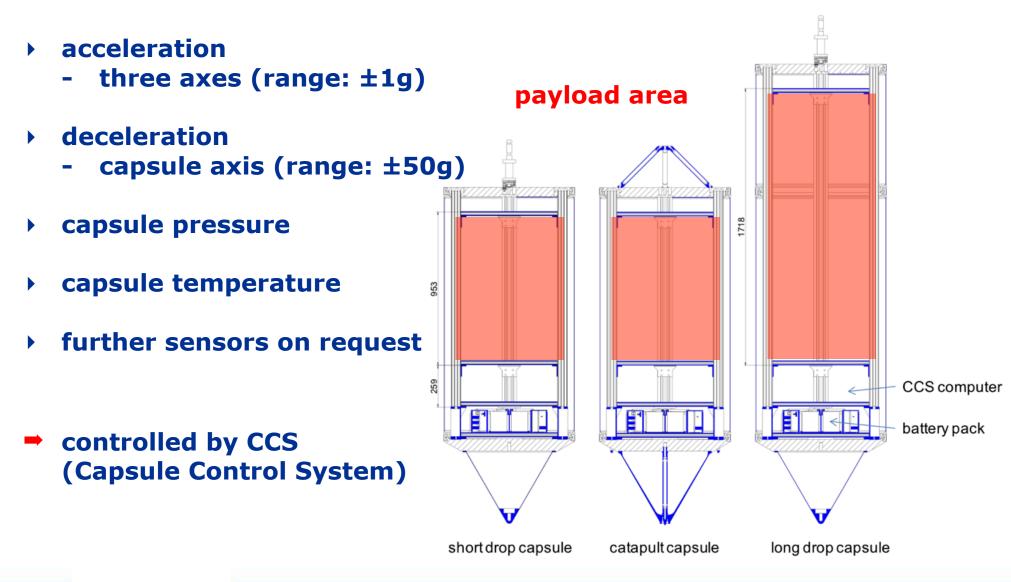








### **Standard on-board Sensor Pack**







# **Capsule Control System (CCS)**

- National Instruments(TM) Real Time PXI System:
  - to remote control the microgravity experiment via LabView(TM)
  - using analogue and digital I/O channels at the Interface Board (data rates: 5 kHz on fast, 100 Hz on slow I/O channels)
  - to save experiment data on the password-secure user account
- radio telemetry/telecommand system via an on-board WLAN-unit



**NI Real Time PXI System** 



Interface Board (SMA, D-Sub)





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• experiment capsule preparation before drop/catapult launch:



capsule cover closing



capsule cover lid closing



capsule nose cone assembling



• experiment capsule preparation before drop/catapult launch:



winch for lifting the drop capsule to the top

- 1.5 h for the evacuation of the vacuum tube
- residual pressure of 0.1 mbar inside vacuum tube



exp. capsule on catapult piston





#### • experiment control from ZARM's Ground Control Station:













• experiment capsule recovery after drop/catapult launch:



capsule inside deceleration container

- 0.5 h for the ventilation of the vacuum tube and for the capsule recovery

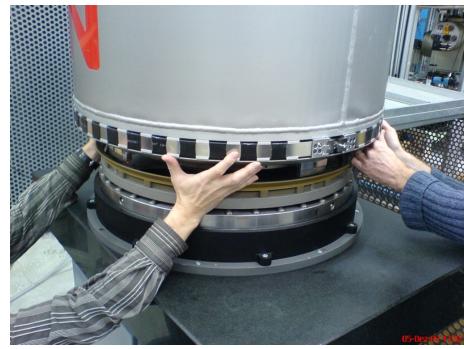


available at integration area





special capsule preparation for catapult experiments:



- catapult capsule balancing once before campaign start
- to center the mass distribution for catapult capsule alignment



ZARM's taring device



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**Consulting Logistic Support** Accommodation Integration/Operation

Over 20 Years Experience of Handling Microgravity Experiments





**Consulting Logistic Support** Accommodation Integration/Operation

- Over 20 Years Experience of Handling Microgravity Experiments
- special capsule equipment for drop tower experiments:
  - ▶ thermal liquid heating and cooling circuit (-20°C ↔ +60°C)
  - non-standard power supply (DC Voltage, up to 100 Amp)
  - regulated vent line to release gases out of the experiment
  - color CCD-cameras and problem-specific lenses DVCam(TM)
  - digital high-performance video system:



- Photron Fastcam MC2(TM) 2GB
  - 3 control devices / 6 heads
  - monochrome or color images
  - 512 x 512 pixel resolution
  - frame rates up to 10,000





**Consulting Logistic Support** Accommodation Integration/Operation

- Over 20 Years Experience of Handling Microgravity Experiments
- special capsule equipment for drop tower experiments:
  - on-board microgravity centrifuge:



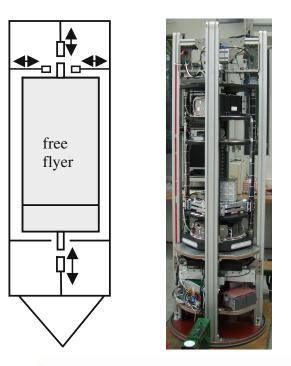
- for accelerations between 1g and 0g
- not applicable for catapult operation





**Consulting Logistic Support** Accommodation Integration/Operation

- Over 20 Years Experience of Handling Microgravity Experiments
- special capsule equipment for drop tower experiments:
  - on-board free-flyer system:



- for residual accelerations below 10<sup>-6</sup>g (10<sup>-7</sup>g)
- not applicable for catapult operation





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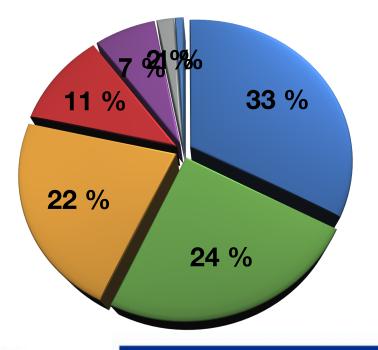






#### **Microgravity Experiments at ZARM's Drop Tower**

- Since the Start of Operation of the Drop Tower Bremen:
  - over 6000 drops / catapult launches have been performed
  - more than 150 different experiment types have been integrated
  - collaborations with experimenters from 42 countries
- Research Fields of performed Microgravity Experiments:



- Combustion
  Astrophysics / Planetology
  Fundamental Physics
  Fluid Dynamics
  Biology
  Materials Sciences
  Chemistry / Technological Tests
- Supported by DLR and ESA



# **Microgravity Experiments at ZARM's Drop Tower**

- Combustion:
  - ▶ propellant tests (fossil or synthetic fuels) → BIOSPRAY
- Astrophysics:
  - ▶ planetary formation (collision experiments) → ICAPS (ISS)
- Fundamental Physics:
  - ▶ quantum optics (Bose-Einstein condensation) → QUANTUS
  - ▶ general relativity (equivalence principle) → MICROSCOPE
- Fluid Dynamics:
  - ▶ multiphase flow (capillary channel flow) → CCF (ISS)
- Biology:
  - spinning movements (fish experiments) → SpinMov
- Materials Sciences:
  - Fire safety on spacecrafts (combustion properties) → CPM
- Technological Tests:
  - ▶ asteroid mission (soil samples) → Hayabusa-2 (DLR/JAXA)





# Microgravity Experiments at ZARM's Drop Tower How to Apply for Drop Tower Experiments?

- National Research Programs:
  - supported by German Aerospace Center (DLR)
    - via DLR Space Administration
      - -> Microgravtiy Research and Life Sciences Program DLR

#### or

- International Research Programs:
  - supported by European Space Agency (ESA)
    - via ESA Human Spaceflight Research
      - -> Continuously Open Research Announcement (CORA)
    - via ESA Education (for students)
      - -> "Drop Your Thesis!" Program

#### or

Collaboration with DLR- or ESA-funded Scientific Institute ZAF





# - ZARM's Future Technology -A Next Generation Drop Tower System



Center of Applied Space Technology and Microgravity

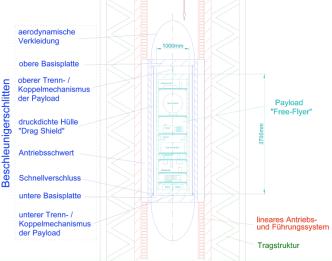
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#### **Project "SFB" - Rapid Drop Tower Bremen**

- Foreseen Key Features:
  - Inear accelerator drive with max. accel. of 4 g (adjustable)
  - min. operation time of 5 s with max. payload mass of 1000 kg
  - high experiment repetition rates of 100 launches per day
  - > 2 operation modes -> microgravity or reduced gravity
    - microgravity mode: high-quality weightlessness @ 10<sup>-6</sup> g
    - reduced gravity mode: residual accel. between 0.1 0.4 g incl. gravity of Mars and Moon
  - double capsule system:
    drag shield / free-flyer capsule
  - payload size (free-flyer capsule):
    height 3.7 m / width 1.0 m







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#### **Thank You for Your Attention**





#### www.zarm.uni-bremen.de

