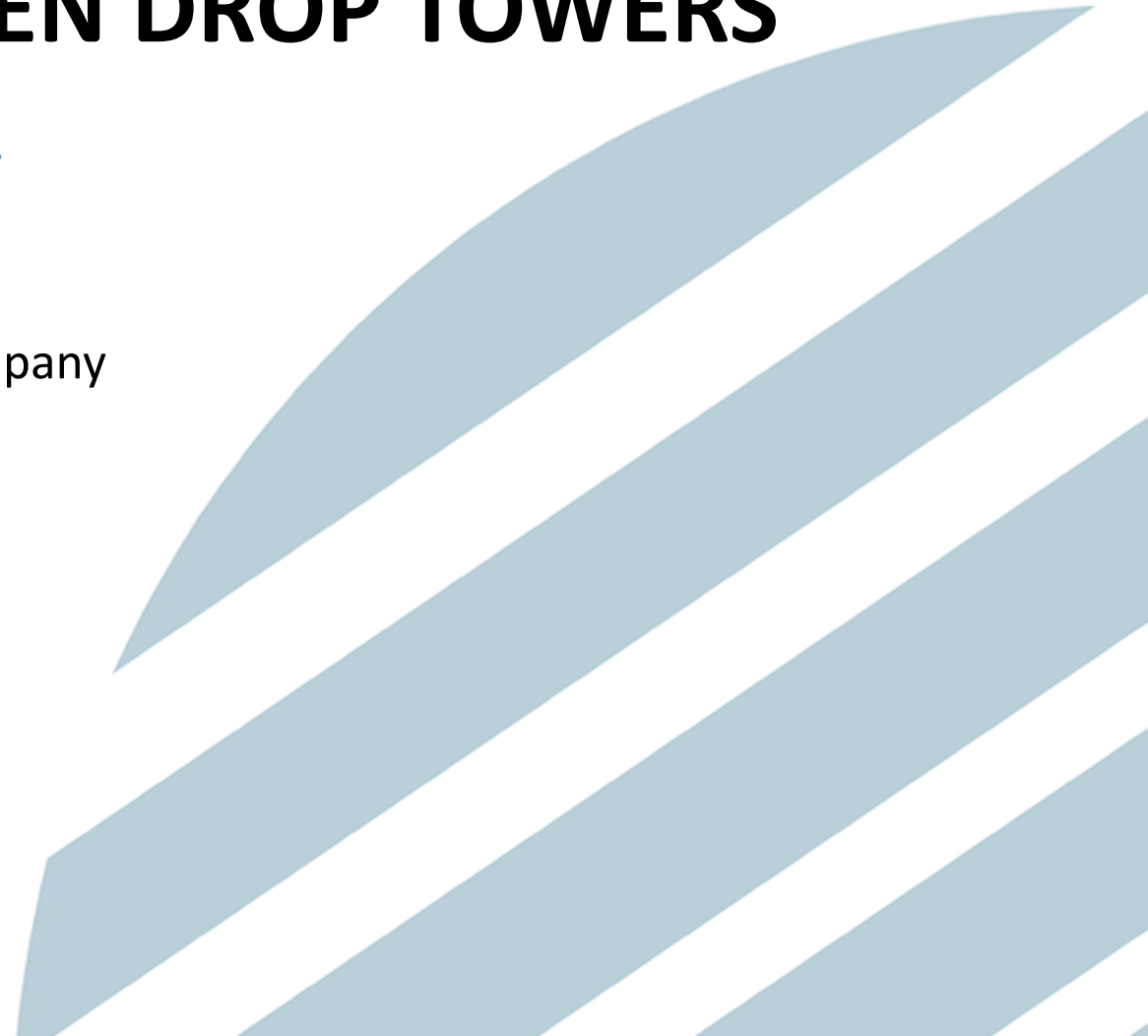


ZARM AND THE BREMEN DROP TOWERS

DROPTES – ACCESS TO SPACE FOR ALL

Dr. Merle Cornelius
ZARM Drop Tower Operation and Service Company



ZARM - Center of Applied Space Technology and Microgravity

c/o Universität Bremen
Am Fallturm 2, 28359 Bremen, Germany
www.zarm.uni-bremen.de



ZARM - University of Bremen

**Research Institute - Faculty 04
Production Engineering**

Prof. Dr. Marc Avila
(Executive Director)

- FLUID DYNAMICS
- SPACE SCIENCE
- SPACE TECHNOLOGIES
- HUMANS ON MARS

Research / Teaching

ZARM FAB mbH

**ZARM Drop Tower Operation
and Service Company**

Prof. Dr. Marc Avila
Peter von Kampen
(Executive Board)

Dr.-Ing. Thorben Könemann
(Head of Science & Operation)

Dr. Merle Cornelius
(Dep. Head of Science & Operation)

Technical Support

ZARM Technik AG

**Supplier of Attitude Control
Equipment for Satellites**

Holger W. Oelze
(Chief Executive Officer)

Peter von Kampen
(Chief Financial Officer)

Marco R. Fuchs
(Chairman of Supervisory Board)

Space Hardware



ZARM facilities beside the drop towers

Aerospace qualification and test services

HYPER-GRAVITY LAB



- ▶ 30 g centrifuge
- ▶ Mounting compatible with drop capsules
- ▶ Payload weight up to 1.5 t

THERMAL VACUUM LAB



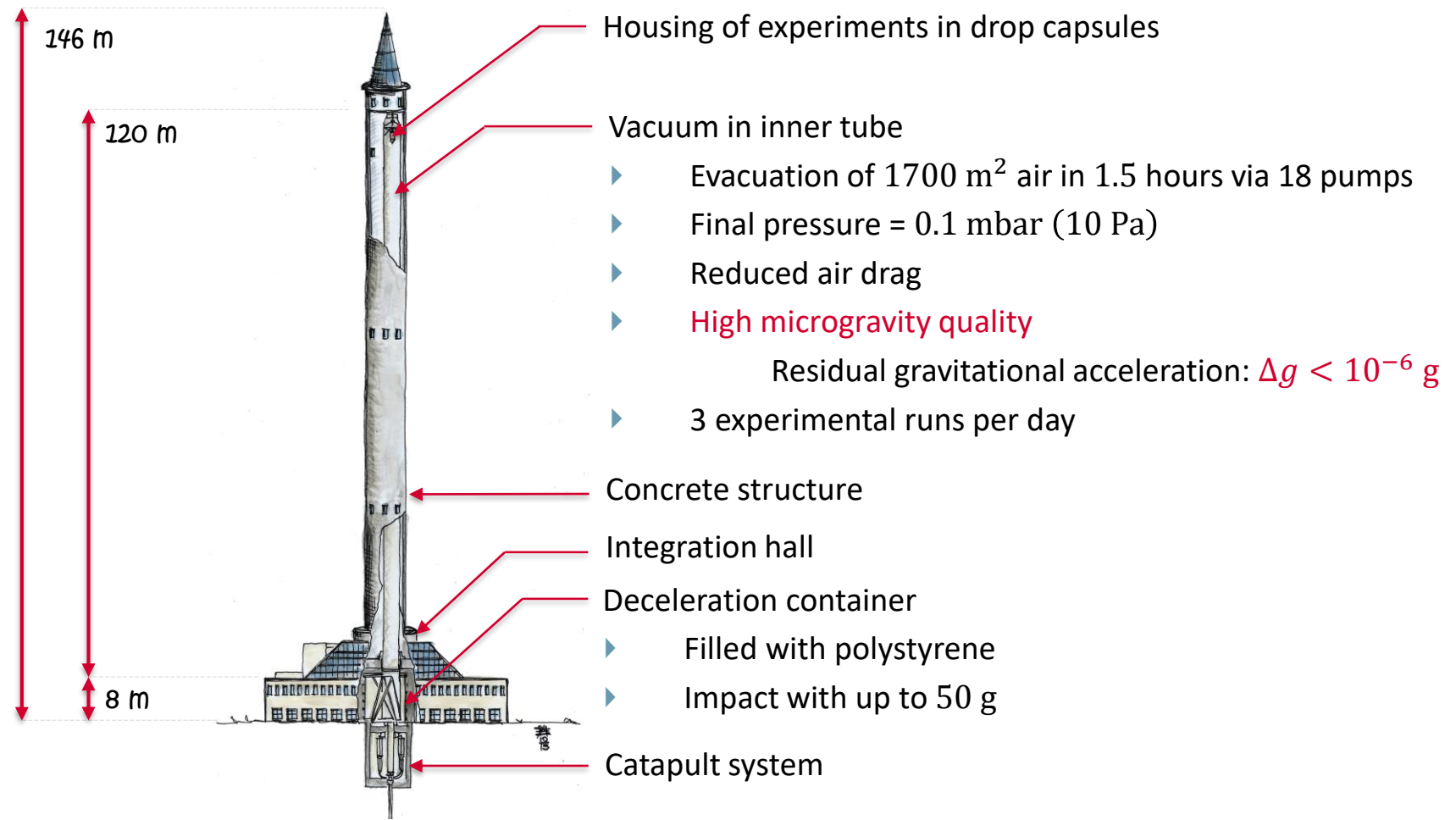
- ▶ TVC – Thermal vacuum chambers of different sizes
- ▶ TCC – Thermal cycling chamber
- ▶ TSC – Thermal shock chamber

VIBRATION TEST LAB

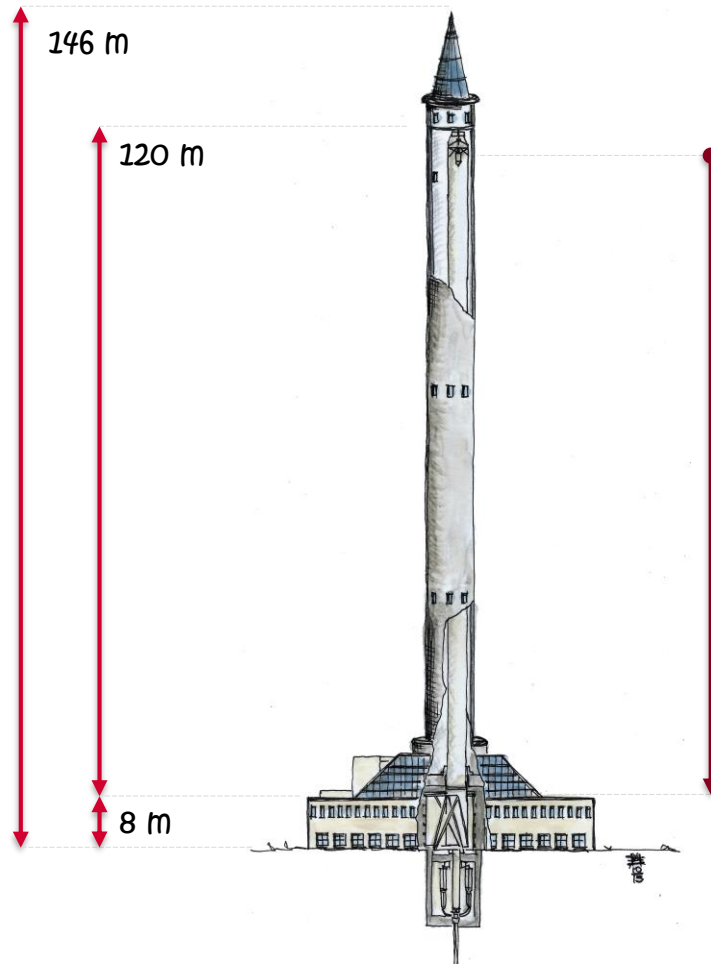


- ▶ Long Stroke Shaker
- ▶ Maximum force = 35.6 kN

Bremen Drop Tower



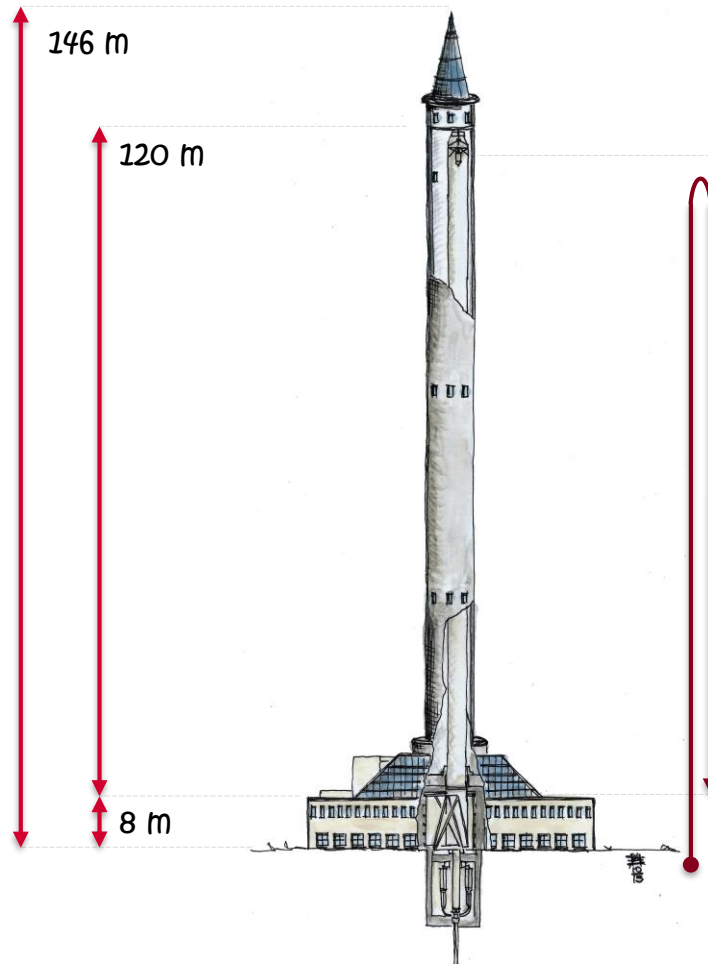
Bremen Drop Tower



DROP MODE

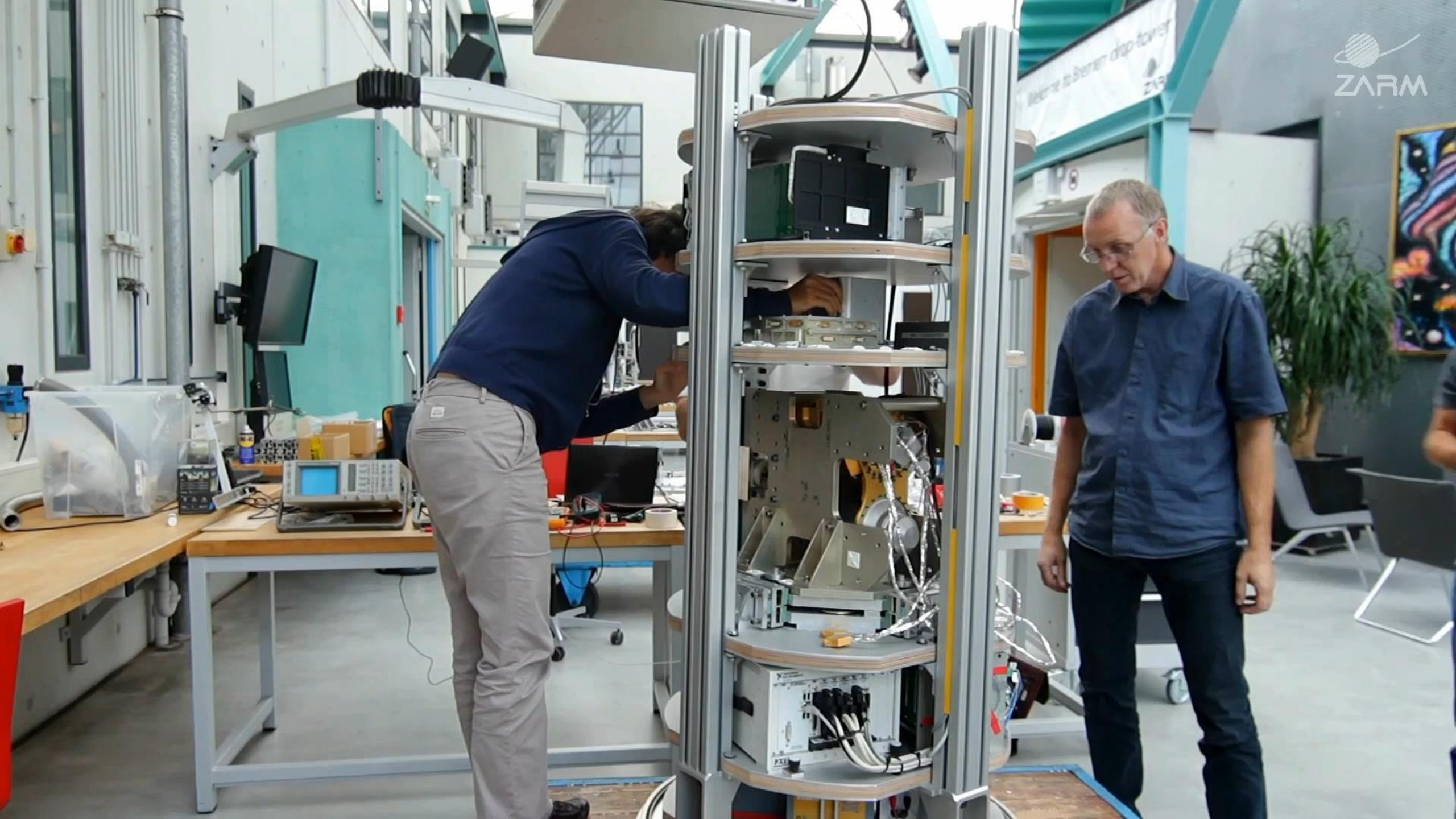
- ▶ 110m Free Fall distance
- ▶ Microgravity time **4.7 s**

Bremen Drop Tower



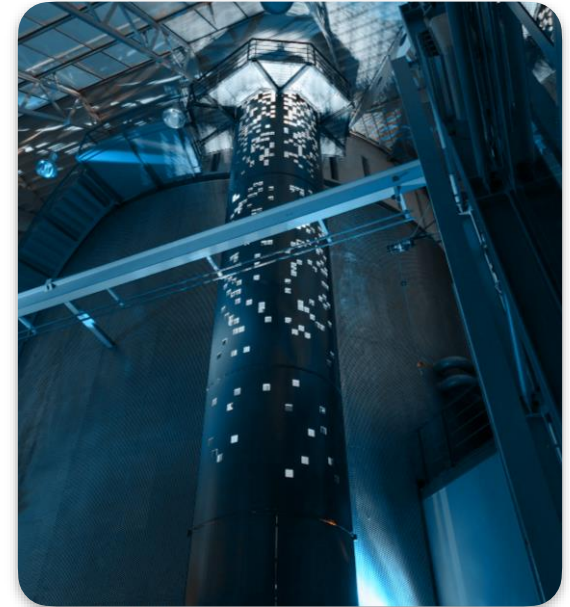
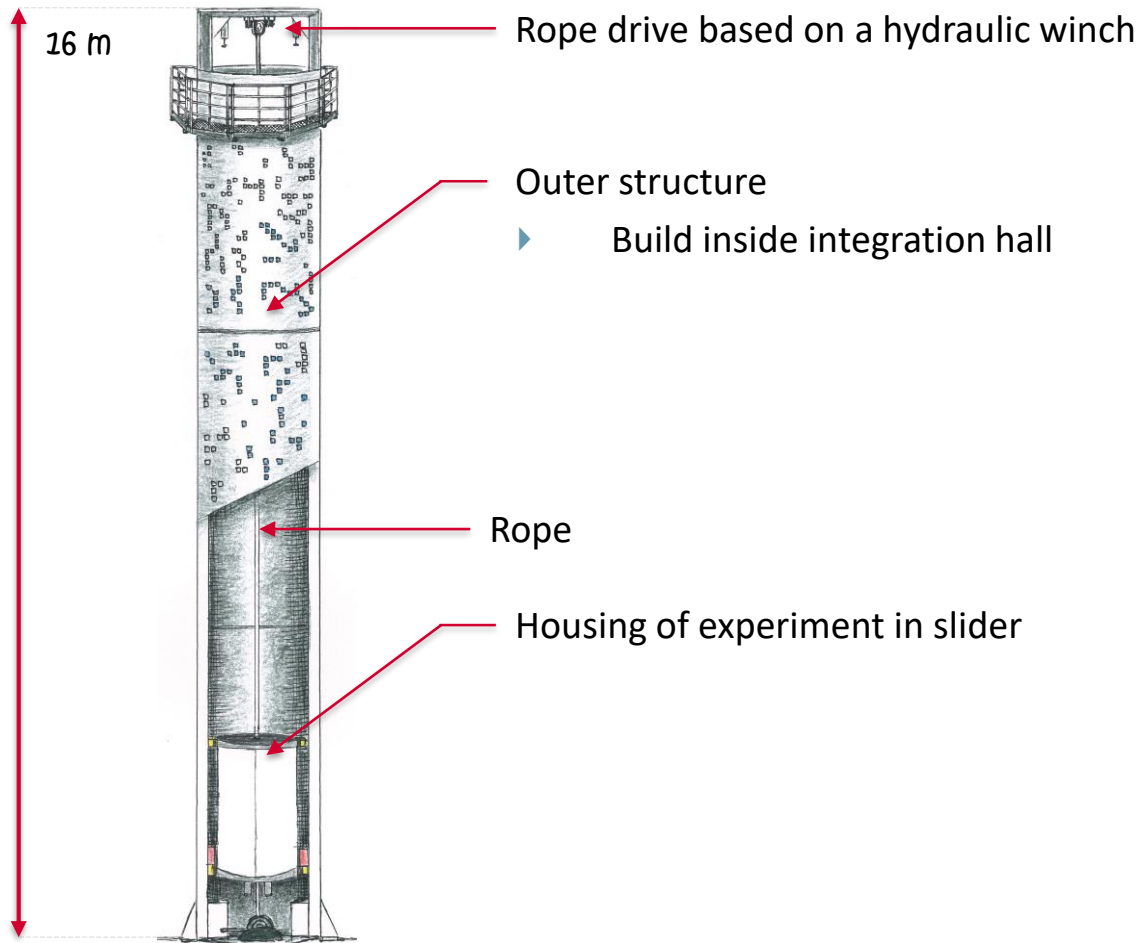
CATAPULT MODE

- ▶ Launch on vertical parabola
- ▶ Microgravity time **9.3 s**

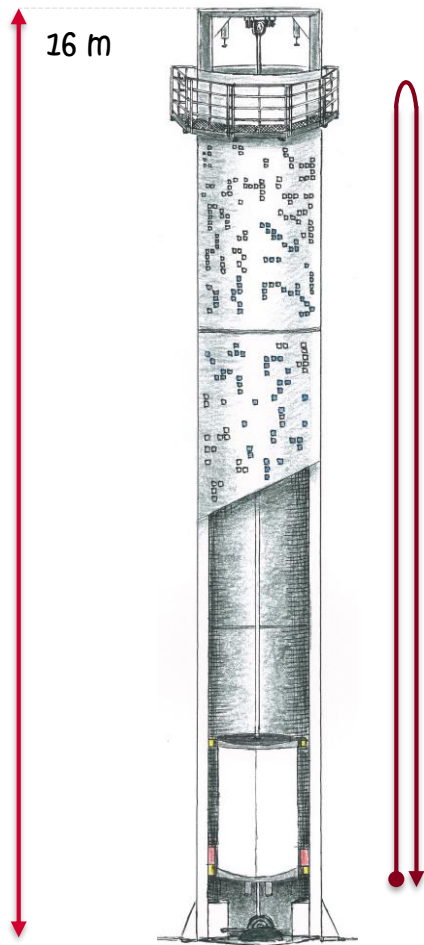


Welcome to better drop-tower
ZARM

GraviTower Bremen Pro

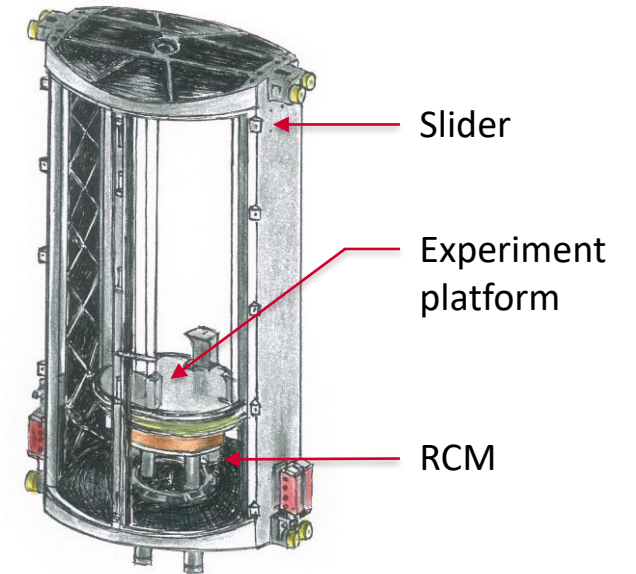


GraviTower Bremen Pro

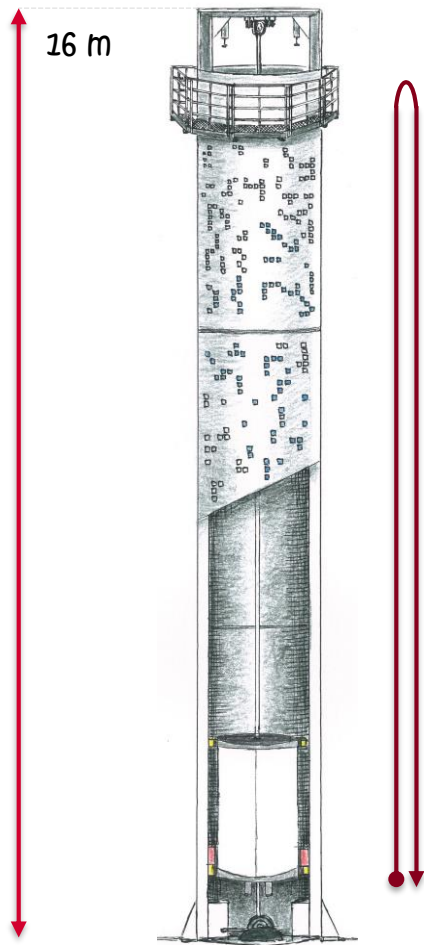


ACCELERATION ON VERTICAL PARABOLA

- ▶ Decoupling experiment capsule from slider via *Release Caging Mechanism (RCM)*
 - ▶ Slider acts as an air shield
 - ▶ No vacuum needed
 - ▶ High microgravity quality ($\Delta g < 10^{-4}g$)
 - ▶ High repetition rate of up to 960 runs per day



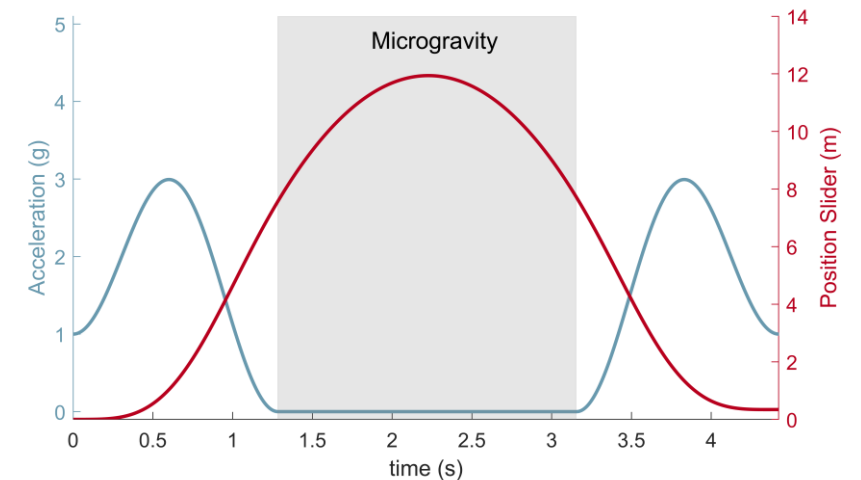
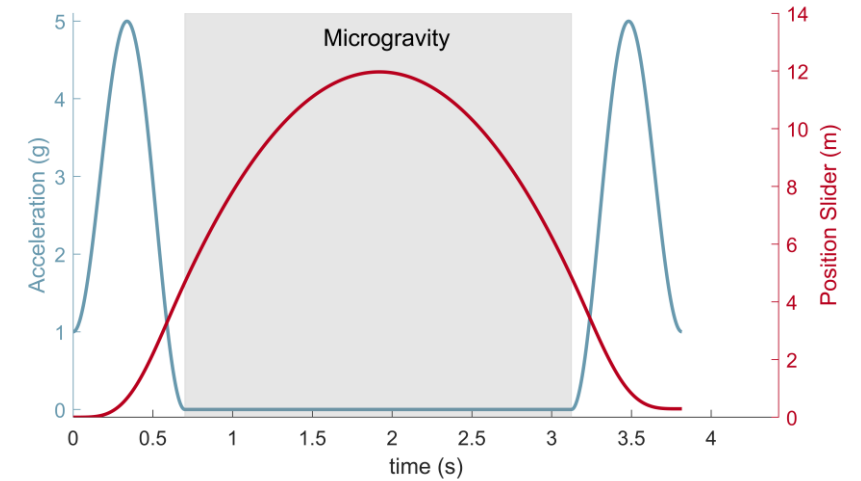
GraviTower Bremen Pro



ACCELERATION ON VERTICAL PARABOLA

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 - ▶ High repetition rate of up to 960 runs per day

- ▶ Customize flight parabola to experimental requirements
 - ▶ 4 g acceleration → microgravity time = 2.5 s
 - ▶ 2 g acceleration → microgravity time = 1.9 s





GraviTower Bremen Pro

FUTURE OPERATION MODES

- ▶ Partial gravity
 - ▶ Like gravitational acceleration of **Moon and Mars**
 - ▶ Important in the field of human exploration and technical development
- ▶ g-vectoring
 - ▶ Changing gravitational acceleration during flight phase

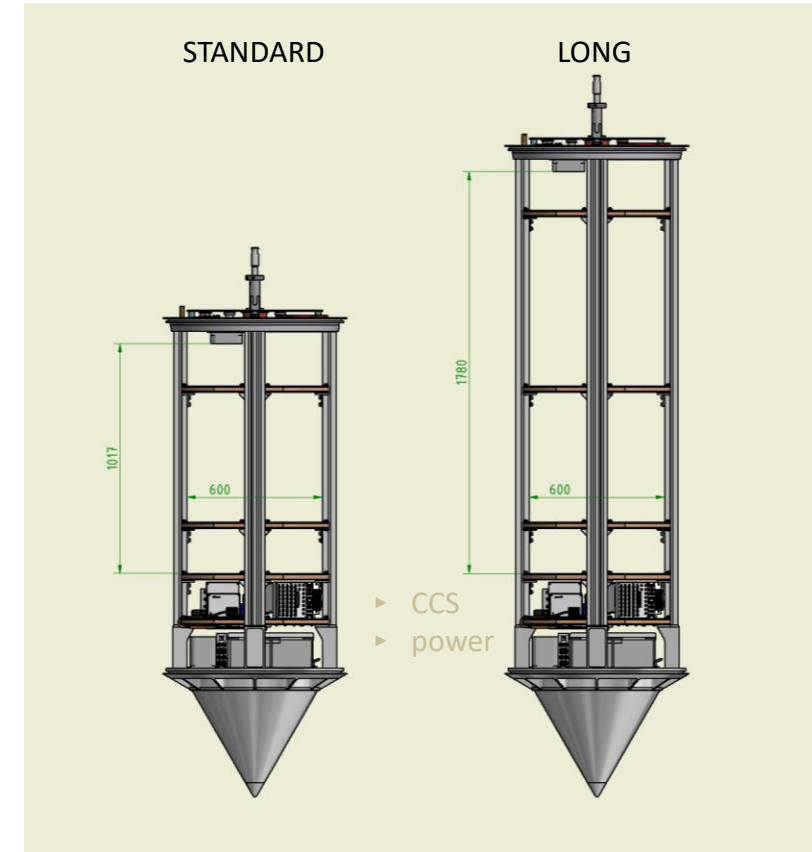


How to drop!

► Requirements and Constraints

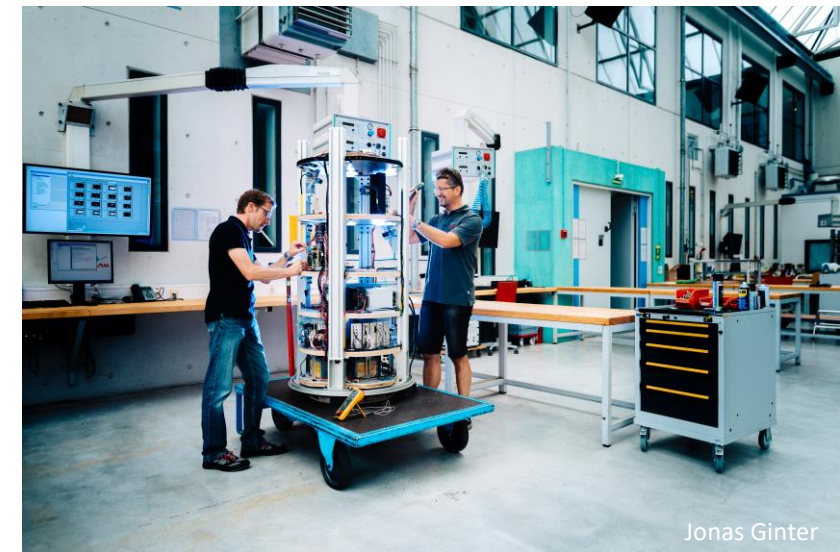
	Drop		Catapult	GraviTower
Capsule type	Long	Standard		
Max. payload height (hard limit)	1.780 m	1.017 m		
Max. payload width (hard limit)	600 mm			
Max. payload mass	265 kg	225 kg	165 kg	265 kg
Max. point load	50 kg			

- Standard capsule suited for drop, catapult and GraviTower operation
- Capsule equipment
 - Capsule Control System (experimental control, triggering, data acquisition)
 - Power supply
- Setup designed to withstand impact of 50 g (+ 50 g safety margin)



How to drop!

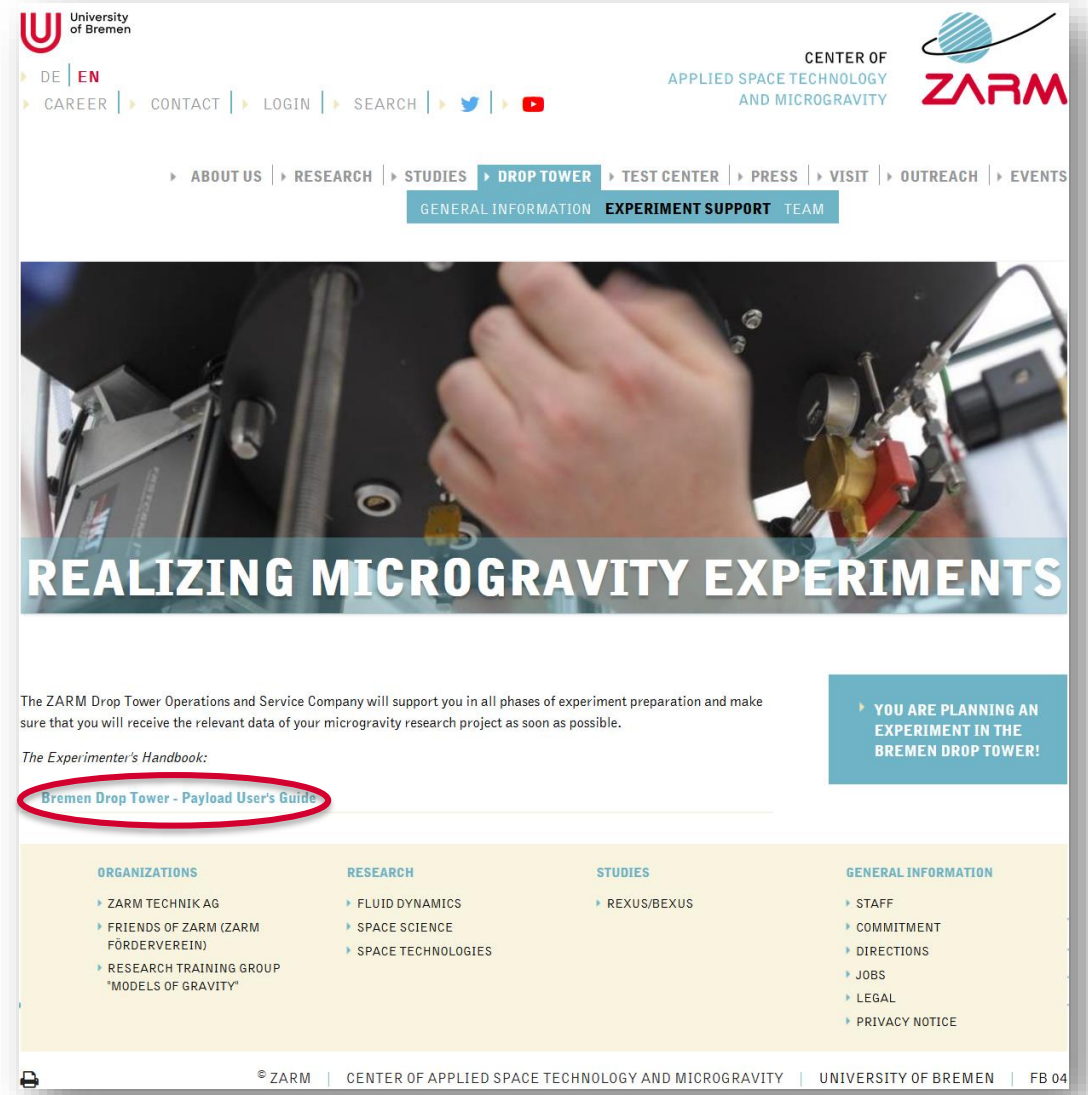
- ▶ Service provided by ZARM and the engineering team
 - ▶ Mechanical and electrical integration of the experiment into the capsule
 - ▶ NI-LabView software interface and data acquisition
 - ▶ Experimental control via standard network connection (Wi-Fi and Trulifi)
- ▶ Provided equipment
 - ▶ High-speed camera systems: Phantom Miro / Photron FASTCAM
 - ▶ Lenses and illumination systems
 - ▶ Non-standard power supply
 - ▶ Vacuum pumps (rotary vane pumps, turbo molecular pumps)



ZARM Website:

➡ zarm.uni-bremen.de/

Bremen Drop Tower – Payload User's Guide



The screenshot shows the ZARM website homepage. At the top left is the University of Bremen logo. To its right are navigation links for DE, EN, CAREER, CONTACT, LOGIN, SEARCH, and social media icons for Twitter and YouTube. Further right is the ZARM logo and the text 'CENTER OF APPLIED SPACE TECHNOLOGY AND MICROGRAVITY'. Below this is a secondary navigation bar with links for ABOUT US, RESEARCH, STUDIES, DROP TOWER (highlighted), TEST CENTER, PRESS, VISIT, OUTREACH, and EVENTS. Underneath 'DROP TOWER' are sub-links for GENERAL INFORMATION, EXPERIMENT SUPPORT (highlighted), and TEAM. The main header image shows a person's hands working on a piece of equipment, with the text 'REALIZING MICROGRAVITY EXPERIMENTS' overlaid. Below the image, a paragraph states: 'The ZARM Drop Tower Operations and Service Company will support you in all phases of experiment preparation and make sure that you will receive the relevant data of your microgravity research project as soon as possible.' To the right of this text is a blue box with the text 'YOU ARE PLANNING AN EXPERIMENT IN THE BREMEN DROP TOWER!'. Below the paragraph is the heading 'The Experimenter's Handbook:' followed by a list of links. The link 'Bremen Drop Tower - Payload User's Guide' is circled in red. At the bottom of the page is a footer with a printer icon, the copyright notice '© ZARM | CENTER OF APPLIED SPACE TECHNOLOGY AND MICROGRAVITY | UNIVERSITY OF BREMEN | FB 04'.

University of Bremen

DE | EN

CAREER | CONTACT | LOGIN | SEARCH | TWITTER | YOUTUBE

CENTER OF APPLIED SPACE TECHNOLOGY AND MICROGRAVITY

ZARM

ABOUT US | RESEARCH | STUDIES | DROP TOWER | TEST CENTER | PRESS | VISIT | OUTREACH | EVENTS

GENERAL INFORMATION | EXPERIMENT SUPPORT | TEAM

REALIZING MICROGRAVITY EXPERIMENTS

The ZARM Drop Tower Operations and Service Company will support you in all phases of experiment preparation and make sure that you will receive the relevant data of your microgravity research project as soon as possible.

YOU ARE PLANNING AN EXPERIMENT IN THE BREMEN DROP TOWER!

The Experimenter's Handbook:

- Bremen Drop Tower - Payload User's Guide**

ORGANIZATIONS

- ZARM TECHNIK AG
- FRIENDS OF ZARM (ZARM FÖRDERVEREIN)
- RESEARCH TRAINING GROUP "MODELS OF GRAVITY"

RESEARCH

- FLUID DYNAMICS
- SPACE SCIENCE
- SPACE TECHNOLOGIES

STUDIES

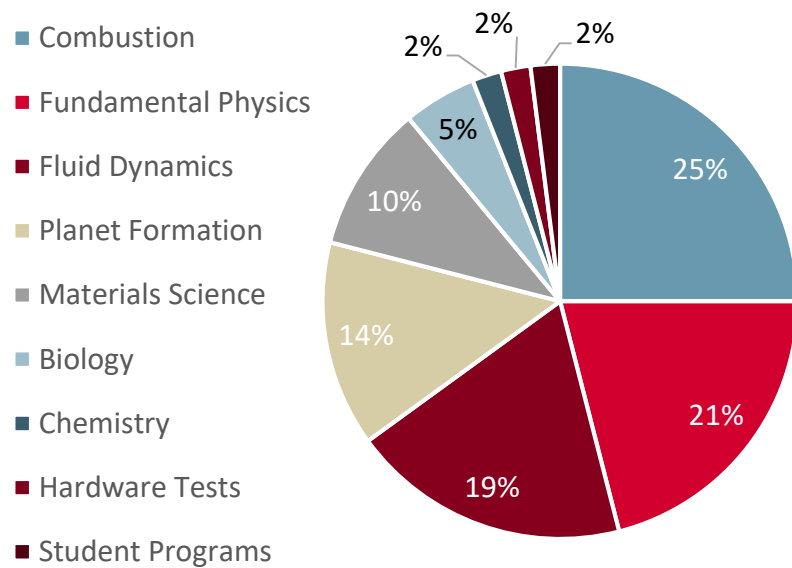
- REXUS/BEXUS

GENERAL INFORMATION

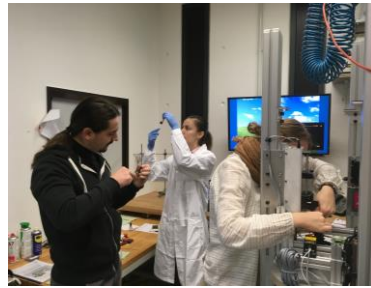
- STAFF
- COMMITMENT
- DIRECTIONS
- JOBS
- LEGAL
- PRIVACY NOTICE

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What to drop?



- ▶ Scientific experiments in various research field
- ▶ Hardware tests for space missions
- ▶ Student programs
 - ▶ DropTES
 - ▶ REXUS/BEXUS
 - ▶ PETRI



- ▶ ZARM contribution to DropTES since 2014
 - ▶ Experiments in the fields of science and technology developing
8. Round 2022 – **Universidad de Antioquia** (Columbia)
 7. Round 2020 – **Universidad Católica Boliviana San Pablo** (Bolivia)
 6. Round 2019 – **Politecnico de Milano** (Italy)
 5. Round 2018 – **University of Bucharest**
and **Politehnica University of Bucharest** (Romania)
 4. Round 2017 – **Warsaw University of Technology** (Poland)
 3. Round 2016 – **Instituto Tecnológico de Costa Rica**
and **Universidad de Costa Rica** (Costa Rica)
 2. Round 2015 – **Universidad Católica Boliviana San Pablo** (Bolivia)
 1. Round 2014 – **German Jordanian University** (Jordan)

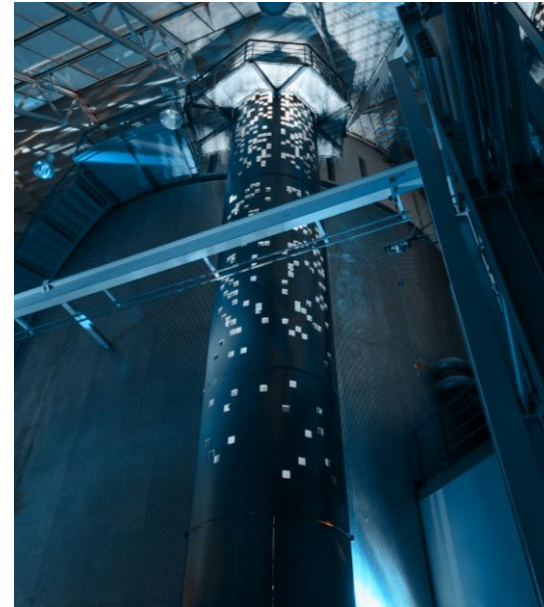
Conclusion

- ▶ The Bremen drop towers are microgravity labs for research and technology tests
→ Stepping stones into space



DROP TOWER

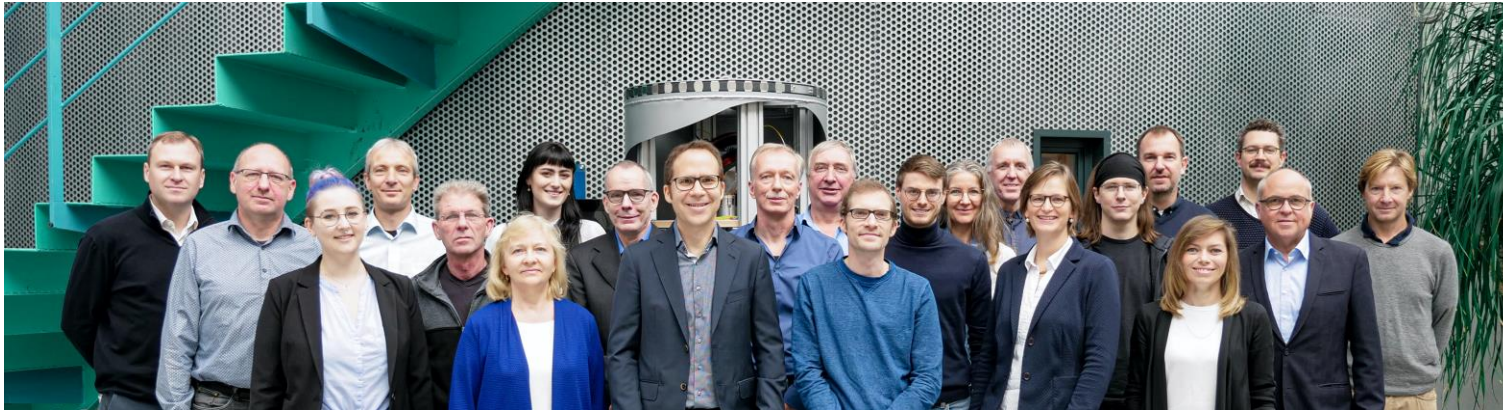
- ▶ Up to 9.3s in weightlessness
- ▶ High microgravity quality
- ▶ 3 experiments per day



GRAVITOWER BREMEN PRO

- ▶ Up to 2.5s in weightlessness
- ▶ Up to 960 experiments per day
- ▶ Partial-gravity option

Thank you!



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 zarm.uni-bremen.de/

Acknowledgements

