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Paper Session I-C - MIKROBA -Mission Opportunity for Microgravity Payloads

A. Tegtmeier

K. Kretzschmar

MIKROBA - Mission Opportunity for Microgravity Payloads

A. Tegtmeier and Dr. K. Kretzschmar

Introduction

The MIKROBA-system (MIKRO-g with BAlloon drop capsules) is a new facility in the German Microgravity Programme providing reduced gravity at a level $\leq 10^{-3}$ g for time periods of approximately 57 - 60 seconds.

The drop capsule is attached to a stratospheric balloon (volume ≈ 600.000 cubic meter) and will be carried up to altitudes between 40 and 45 km.
After reaching its floating altitude the capsule will be released via telecommand.
During the free-fall inside the capsule microgravity condition is realized.
The aerodynamic drag (induced by increasing air density and velocity of the capsule especially at the end of the drop phase) is compensated by a controlable cold gas thrust system.
Parachute acitivation at altitudes between 20 and 14 km terminates the period of microgravity and guarantees a soft landing. When the main parachute is deployed at 3 km altitude the capsule tilts to horizontal position and two airbags will be inflated and damp the touch down shock.
The capsule is returned by helicopter or car to the launch site.

System description

The MIKROBA drop capsule is a rocket like cylindrical shaped body with a nosecone and a tail unit. The capsule consists of four main sections

- nose cone
- payload section
- tank module
- recovery module

A drawing of the MIKROBA capsule is shown in figure 1. The fuselage is made of 10 mm glassfiber sandwich.
The envelope of the drop capsule is

total length	6.05 m
outer diameter	0.45 m
wing-span	1.05 m
total mass	500 kg

The physical envelope of the experiment area is

length	2.00 m
diameter	0.42 m
payload mass (max)	200 kg

The nose cone houses the telemetry antenna, a rate control system (RC$) the MIKROBA instrumentation module (MIM) and the front airbag.

The payload section consists of two monocoques and can be opened along the length. During payload accommodation the MIKROBA capsule is in horizontal position allowing easy access to the open payload bay like the Shuttle (Mini-Shuttle).
The tank module contains the storage vessel for pressurized nitrogen (approx. 50 l at 250 bar N_2), the high pressure part of the cold gas thrust system, the thrust control electronics and a microgravity sensor package near the center of gravity of the overall system. An overall view of the thrust system is shown in figure 2. The adjustment of this specially for MIKROBA developed cold gas thruster follows the measured signal of the high sensitive acceleration sensor. The technical dates of the cold gas system are

Range of propulsion	0 - 500 N
Accuracy of adjustment	± 3 N at max. propulsion
Laval diameter	19 mm
Medium	Nitrogen

The recovery module contains a three stage parachute system with the first stage operating in the supersonic region. Furthermore this module contains the low pressure part (20 bar) of the thrust system with a laval's nozzle at the end and the rear airbag system.

MIKROBA Payloads

The design concept of typical MIKROBA payloads bases on autonomous experiment modules providing their own structure, power supply, timing and control electronics. The design of the MIKROBA payload section allows the accommodation of various types of experiments also those developed original for other carriers, e.g. hardware from the TEXUS or modules out of the GAS programme.
Two ways of data handling are possible:

Onboard data acquisition (e.g. solid state memory, video recorder, high speed cameras etc.)

Interface to the MIKROBA instrumentation (MIM) and real time data telemetry to ground station.

A block diagram of the onboard payload service is outlined in figure 3.

For experiment control from ground a telecommand link exists up to 14 telecommands can be routed to experiments.

A typical experiment module is mounted on a MIKROBA standard platform which is fixed to brackets in the payload bay. The experiment hardware, experiment electronics and battery packs are fixed on these platforms.
Modified designs - for example sealed experiment containers - with special features are also in use.

Schematic drawings of experiment modules are shown in figure 4. In respect to relatively smooth mission profile during balloon flights no shaker tests with its stron impact on cost driving experiment desing requirements are necessary. Only functional, compatibility, and thermal tests are performed.
Typical data for MIKROBA experiment are

Platform diameter	0.42 m
Experiment length	≈ 0.50 m
Experiment weight	≈ 40 kg
Battery package	10 Ah/28 V

Onboard data axquisition:

- analog	32 channels
- signal input	± 10 V
- resolution (word length)	12 bit
- sampling rate	761.6 words/s
	381 words/s
	95 words/s
	3.81 words/s
- digital	36 channels

Flight Profile

After preparation and flight readiness test the MIKROBA is rolled out to the balloon launch pad. The capsule is lifted up in vertical position with its tip pointing downwards and is connected to the auxiliary balloon.
During flight preparation of the main balloon MIKROBA is under the auxiliary balloon and operates in stand-by modus.
Typcial stand-by times are between thirty minutes to one hour. The time periode between lift-off and reaching the ceiling altitude at approx. 40 km is about 3 hours.
In a case of balloon failure during ascent the MIKROBA can always recovered by a set of three emergency parachutes placed between MIKROBA and balloon.
Typical flight events are listed in table 1.

00 sec	Release drop capsule at ceiling height (40 km, v = 0 m/s) Experiment operation under reduced gravity (< 10^{-3} g)
61 sec	Activation first parachute stage (20 km, Mach 1.95, 3 g)
128 sec	Deployment second parachute stage (5 km, 160 m/s, 7 g)
158 sec	Deployment third parachute stage (3 km, 55 m/s, 6.5 g)
170 sec	Transition in horizontal position for touch down on airbags (2.7 km, 7 m/s)
550 sec	Impact, start helicopter for recovery.

Table 1 Typical Fligt Profile

After cut-off the MIKROBA from the balloon the g-level switches from 1 g to nearly zero-g. Figure 5 shows the g-level along the drop axis (x-coordinate) for the free falling capsule without thrust system. This data were performed during the first test flight of the MIKROBA 2 system. The dropping altitude for this flight without thrust compensation was 40.3 km. The g-level starts at 10^{-5} g (t = 0 s). With increasing air drag the g-level goes across 1×10^{-3} g at 21 s, 1×10^{-2} g at 33 s, and 1×10^{-1} g at 55 seconds.
The g-level in the axis perpendicular to the drop trajectory (y- and z-coordinates) from the release up to 60 seconds is in the 10^{-3} g region. Single peaks at drop times above 40 seconds exceed 1×10^{-2} g.

The next mission (MIKROBA 4) is scheduled for May '90. The system is equiped with thrust compensation and an active rudder system which damps pitch and yaw and keeps the g-level in the lateral axis below 10^{-3} g.
During air drag compensation the g-level oscillates below $\pm 10^{-3}$ g around zero-g as shown in figure 6. This micro-g characteristics with the sharp-edged transition form 1 g to zero-g, the oszillation around zero-g in conjunction with the overall smooth flight profile are indicative of this system.

At 61 seconds after release the first stage parachute decelerates the drop capsule from Mach 2 to velocities in the region Mach 0.5. The first stage parachute deployment is characterized in the acceleration spectra by a broad peak without significant maximum. Typical g-level for this section are 3 g.

At 5000 m above sea level the second stage is activated and lowers the descent to approx. 55 m/s. The deployment is characterized by a sharp asymetric peak. The g-value exceeds 7 g.

The third stage parachute is active below 3000 m altitude and terminates the drop capsule to its stationary descent of 6 - 7 m/s. The third stage is characterized by a bread nearly symmetrical peak with a maximum g-level below 7 g.

Figure 7 shows the deceleration peaks of a typical recovery sequence.

The parachute system normally is activated by a timer which starts at release. For reason of safety parachute activation can also be done redundant by telecommand and as second redundancy automatically by a baro switch at 13 km altitude.

Figure 8 shows the MIKROBA launching schedule up to 1992.

Operational

Normally MIKROBA campaigns performed twice a year in spring and autumn. During this launch windows single or double campaigns are possible depending on inquiry. The campaigns are not restricted to a special range. Several suitable sides are available in Europe, the United States and other countries.

The MIKROBA 4 campaign in spring 1990 is already fixed. Four experiments, one combustion experiment from a student's programme and one small none microgravity piggy pack experiment which is accommodated in the gondola.
The MIKROBA 5 campaign will be performed in late summer, beginning autumn. The experiments for this flight are a droplet combustion chamber with interferometric diagnostic, and two fluid science experiments.

Conclusion

The MIKROBA drop capsule is a new microgravity facility and fills the gap between drop-towers and parabolic flight missions on one hand and sounding rockets on the other hand. For the 30 to 60 seconds microgravity range MIKROBA is the cheapest facility. The costs per kilogramm payload for a standard campaign are about 7.000,- DM.
Other advantages are:

- short access time
- easy payload integration
- no shaker tests for experiment hardware
- balloon launchers from several suitable sites in Europe, United States and other countries.

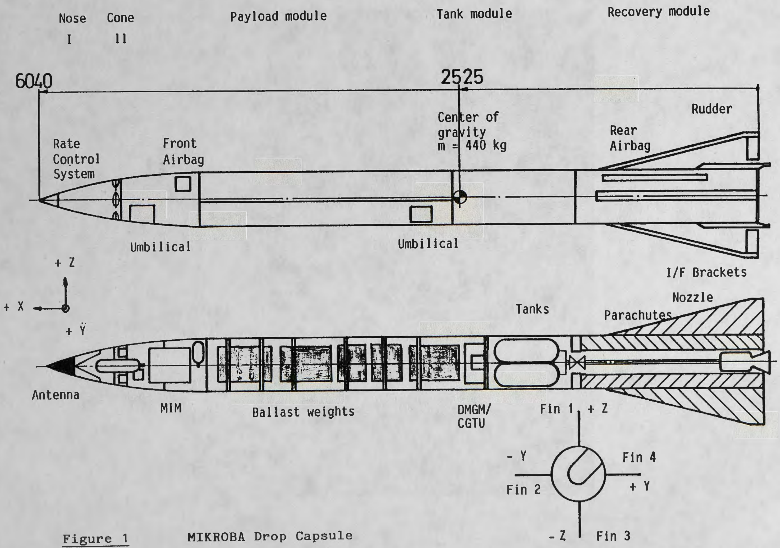


Figure 1 MIKROBA Drop Capsule

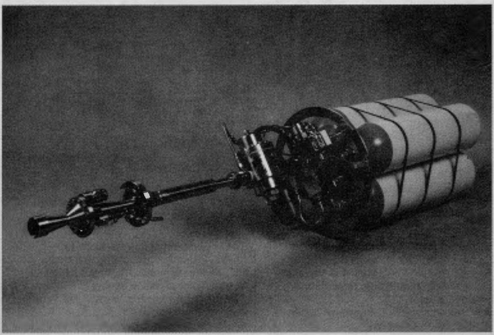
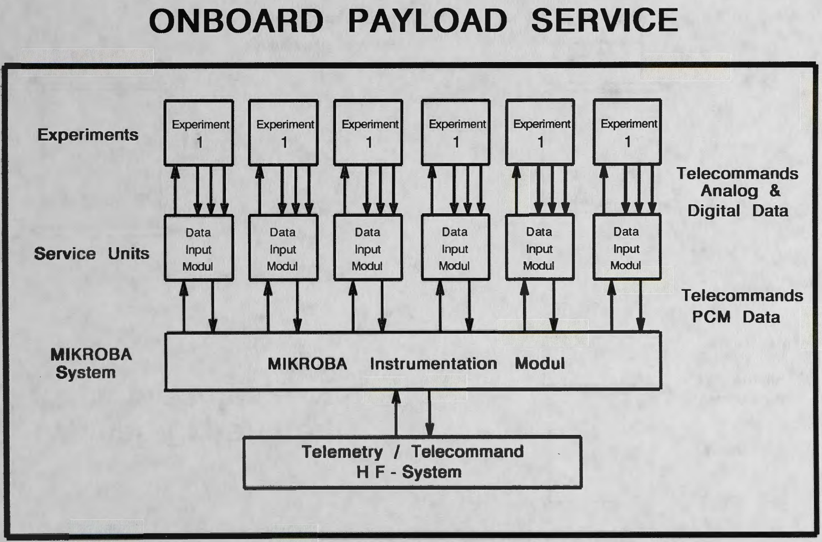


Figure 2 Cold Gas Thrust System



<u>Figure 3</u> MIKROBA Onboard Data Handling

Figure 4 MIKROBA Experiment Modules

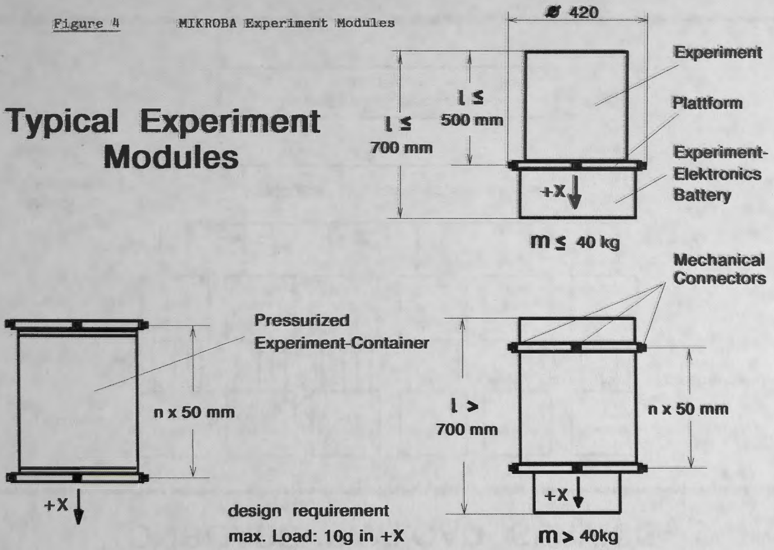


Figure 5 G-Level during Drop without Thrust Compensation

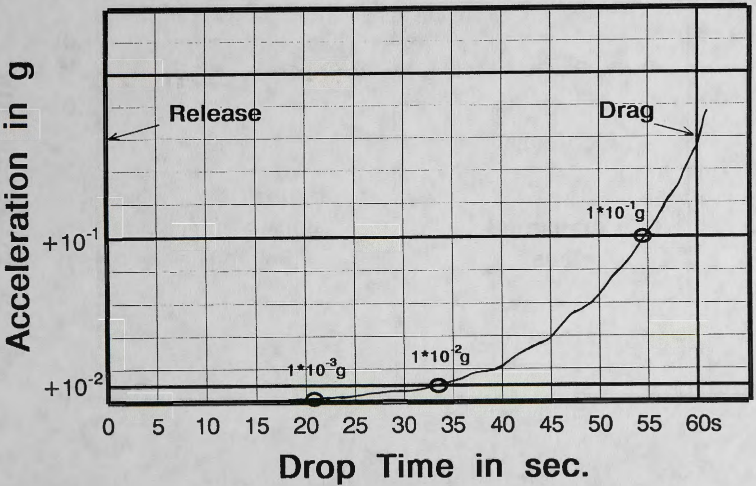
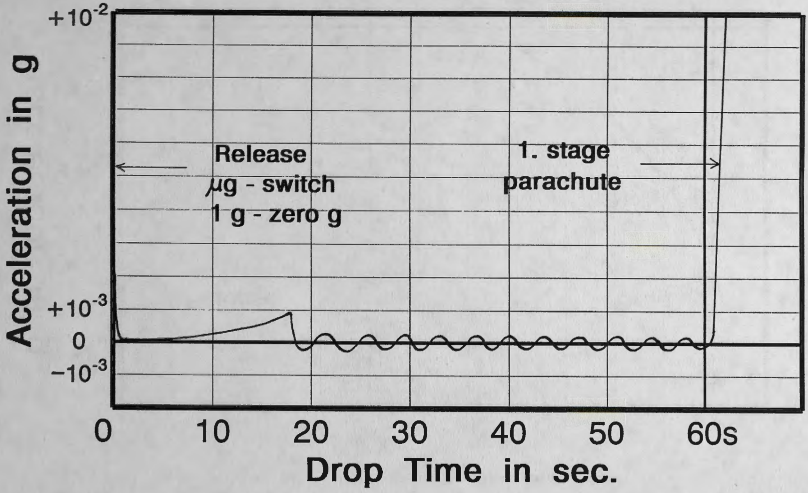


Figure 6 G-Level during Drop with Thrust Compensation



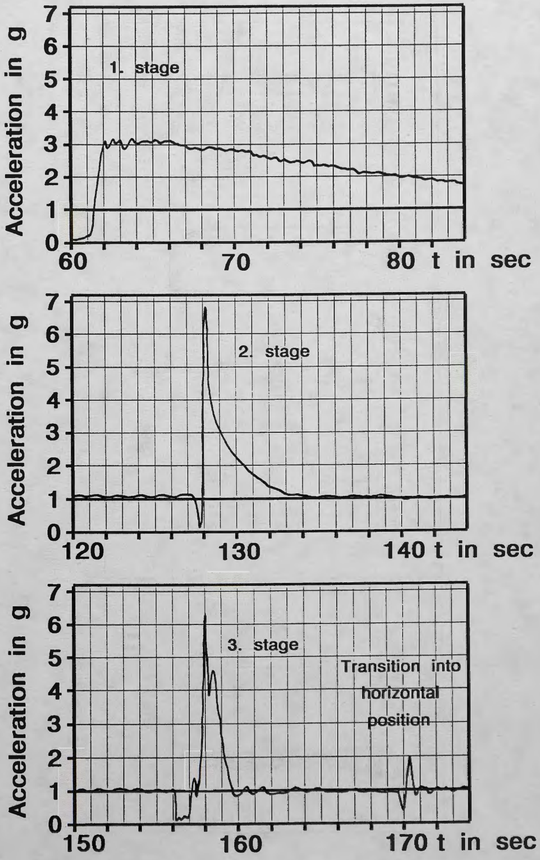
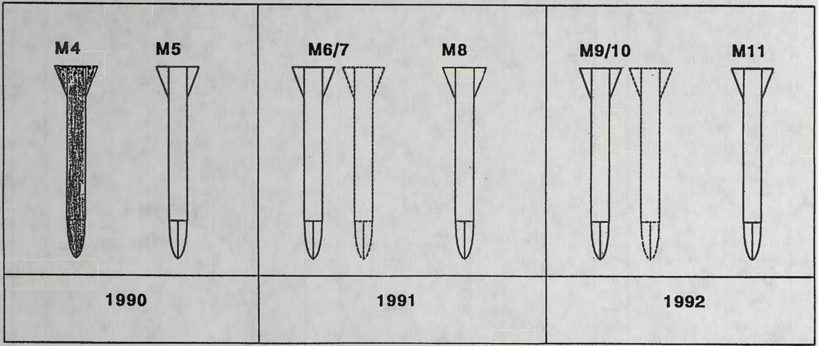


Figure 7 MIKROBA Parachute Sequence



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<u>Figure 8</u> MIKROBA Launching Programme