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Indian sounding rockets for material science experiments

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Abstract. The capabilities of Indian sounding rockets for conducting material science experiments are briefly described in this paper.

Keywords. Sounding rockets ; material science experiments.

1. Introduction

Sounding rockets provide one of the simplest and cheapest means of conducting material science experiments under microgravity conditions. The duration of residual accelerations $\leqslant 10^{-4}$ g during the coasting phase of the rocket can be of several minutes and is sufficiently long for conducting a number of investigations. Rocket payloads are simpler to fabricate and are less expensive to try out new ideas. Further, the turn-around time between the conception and execution of rocket experiments is typically of the order of an year in contrast to 4 to 5 years of time needed for realising a satellite experiment. Hence it is always advantageous and often desirable before one attempts to fly them on satellites. Rocket payloads in principle can be recovered and refurbished for reuse. One gets sufficient experience in conducting various space environmental tests and qualification of the experiment. Further, the safety requirements on rocket payloads are less stringent.

It is therefore clear from the above considerations that rocket experiments form a parallel and complementary activity to conduct microgravity materials research on future space missions. The Indian Space Research Organisation (ISRO) has developed a number of sounding rockets with varying capabilities that may be used for conducting a number of material science experiments in microgravity conditions. We will briefly review in this paper some of the capabilities of these rockets and outline the requirements that have to be satisfied by experimental payloads.

2. Sounding rockets of ISRO

The sounding rockets of ISRO include the Menaka series of rockets which are primarily meant for meteorological studies, the Rohini series and the Indian made Centaures for upper atmospheric investigations. Some of the salient features of these rockets are given in Table 1 (Sudhakar 1976). Menaka II,

Table 1. Salient features of ISRO sounding rockets.

Details	Type of rockets						
	Menaka II	RH-300	Cent IIB	RH-560	RH-300B	RH-560S	RH-560B
No. of stages	2	1	2	2	2	1	2
Diameter (mm)	122	305	305	561	305	561	561
Length (mm)	3778	4090	6310	7933	6465	5856	9943
Launch wt (kg)	63	369	530	1344	551	1457	2495
Typical payload weight (kg)	4·5	50	60	90	60	150	250
Spin rate (rps)	6	6	5	6·5	6	5	2·5
Apogee at 85° QE (km)	59	135	148	390	200	210	420

Centaure IIB, Rohini-300, Rohini-560 and Rohini 560S are now available for scientific experiments while the remaining are under development. The above rockets are all spin-stabilised and are unguided. Payload recovery is not available at present. This is, therefore, the major shortcoming of our rocket facilities for carrying out material processing experiments. Material science experiments however, can still be performed if one provides appropriate telemetry of data from the experiment.

Figure 1 gives a plot of the altitude *versus* payload weight capability of ISRO's sounding rockets (Sudhakar 1976). It is clear that reasonable payload weights of the order of 100 to 150 kg can be flown on Rohini 560 upto altitudes of 350–270 km. Figure 2 gives the flight duration above 110 km (at acceleration levels $> 10^{-4}$ g) *versus* payload weight for the Centaure-IIB, Rohini 560 and Rohini 560s. One finds that the Rohini 560 offers microgravity conditions to a pay-load of 110 kg for a duration of about 7 min which indeed is a reasonable time for conducting a number of material science investigations.

3. Comparison with European rockets

The Skylark rockets manufactured by the British Aerospace Corporation have been extensively used by the German-Swedish material science programme called TEXUS (Technological Experiments under Microgravity). Skylark 7 and Skylark 14 have been used for these experiments (Brown 1979). The payloads are recoverable in these cases. Figure 3 gives the apogee *versus* payload weight performance and the duration of microgravity ($\leqslant 10^{-4}$ g) conditions for the Skylark 7 and 14 rockets (Brown 1979). In table 2 we compare some of the salient features of Rohini rockets with those of Skylarks.

Once again we are led to the conclusion that the Indian rocket capabilities are comparable in performance for material science experiments to the best European rockets except for the unfortunate fact that our payloads are not recoverable.

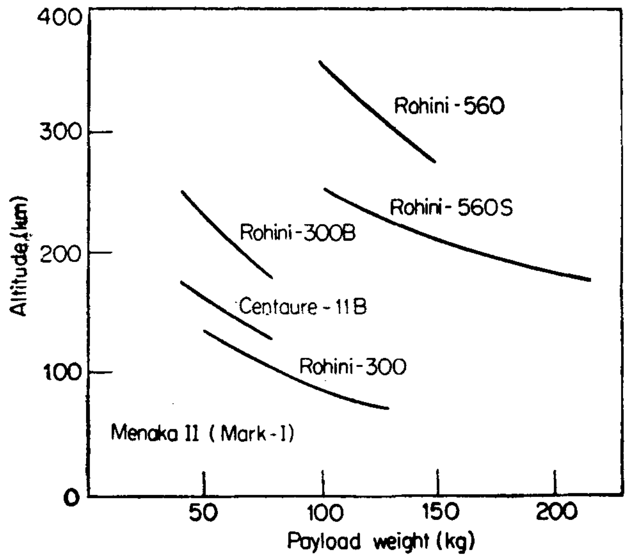


Figure 1. Comparative study of flight altitude of ISRO sounding rockets.

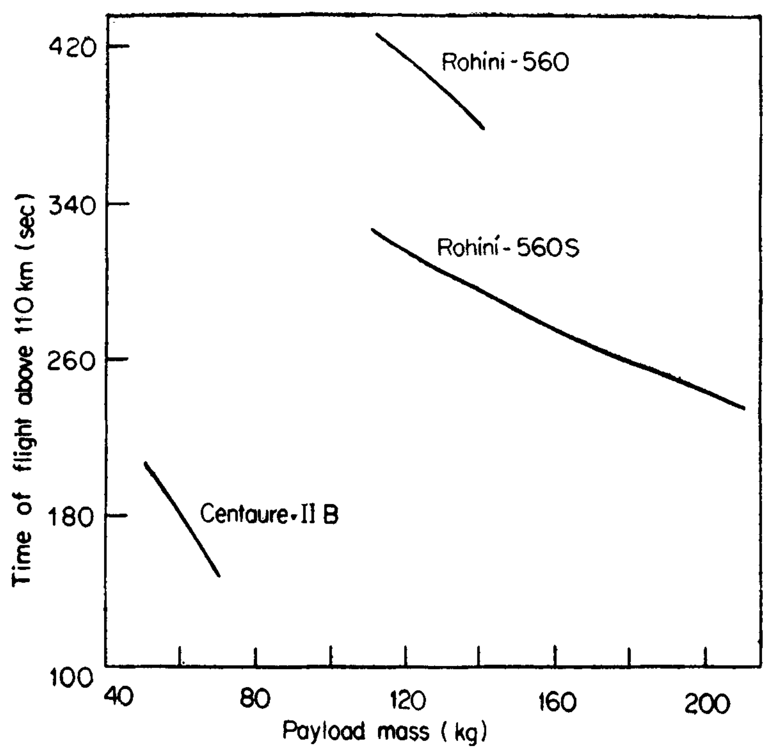
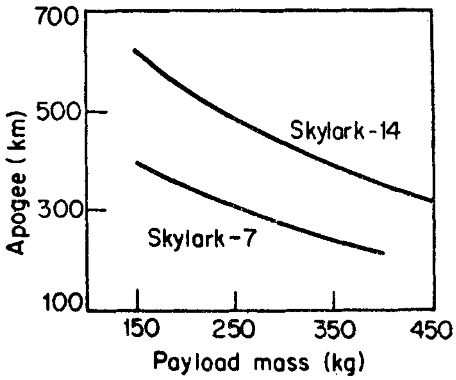
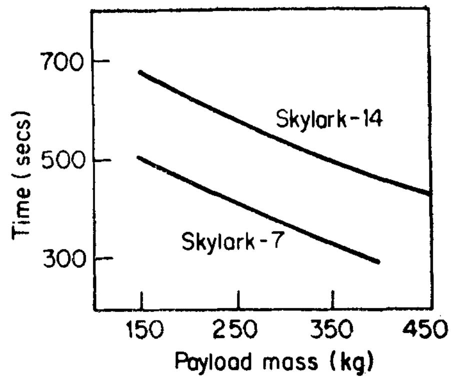


Figure 2. Comparative study of flight duration above 110 km of ISRO sounding rockets.



Skylark Apogee performance



Skylark experiment time at 10^{-4} g

Figure 3. Study of performances of Skylark 7 and Skylark 14.

Table 2. Rohini and Skylarks—A comparison.

Features	Rohini 560	Rohini 560S	Skylark 7	Skylark 14
1. Typical payload dimensions				
Diameter (mm)	305	561	440	440
Length (mm)	1730	2000	4200	4200
2. Maximum payload weight (kg)	150	220	400	450
3. Apogee for 150 kg payload (km)	280	220	400	620
4. Time of flight under microgravity (10^{-4} g) (sec.)	240	150	505	680
5. Payload recovery	No	No	Yes	Yes

4. Get-away specials on ISRO rockets

NASA has announced the availability of opportunities for flying small, autonomous payloads in most of the future shuttle flights. These are called Get-away specials (GAS) and are expected to offer the most economical method of carrying out autonomous experiments in space. The experimental volume and maximum allowable weight are specified by NASA. Of the available options, the two with volumes of $0 \cdot 04 m^3$ and $0 \cdot 07$ m^3 with maximum masses of $27 \cdot 3$ kg and $45 \cdot 4$ kg respectively can be flown for trial experiments on ISRO's rockets. Each shuttle flight can accommodate an average of four GAS payloads and hence the flight opportunities are considerably greater for GAS than for spacelab experiments. The GAS payload should contain the experiment, its electronics, photography, battery pack, data storage, interface with the shuttle, the experiment programme timer, thermal control and an accelerometer for recording the g levels. In other words, it is essentially a mini-satellite. Trial flights of GAS payloads on rockets are therefore a desirable, parallel and complementary activity to their final flight on the shuttle.

Table 3. Typical specifications for qualification of payloads.

	Frequency Range (HZ)	Amplitude or level	Sweep rate (Octaves/min.)
	10–35	1·5 mm	2
	35–90	4·0 g	2
	90–500	9·0 g	1
	500–2000	6·0 g	2
1. Vibration	Sinusoidal (along ZZ axis)		
2. Spin	6 rps for 3 min		
3. Vacuum	10^{-4} to 10^{-6} Torr for 30 min		
4. Acceleration	25 g for 2 min		
5. Shock	50 g for 10 milli sec. (half sinusoidal)		
6. Temperature	70° C for 10 min		

5. Requirements on experimental payloads

All payloads that are to be flown on ISRO sounding rockets have to be subjected to space environmental tests as per the specifications laid down by the management office of the Rohini sounding rocket programme of Vikram Sarabhai Space Centre in Trivandrum. A typical test specification that applies to the prototype of an experiment is given in table 3 (Sudhakar 1976).

The Thumba Equatorial Rocket Launching Station (TERLS) provides a number of facilities to experimenters. These facilities include complete FM/FM telemetry system conforming to IRIG standards and channels, trasmitters with 1·5 and 4·5 watts power at 225–260 MHz frequency, sequences, magnetometers and sun sensors for aspect determination, 500 MHz tone receiver, house keeping sensors such as accelerometers, pressure pick-ups and temperature sensors, timers, S- and C-band radar transponders, telecommand systems for experiment operational requirements, pyrodevices, nose cone ejection facility, door-ejection and payload separation systems. The ground support facilities at TERLS include two FM/FM telemetry stations conforming to IRIG standards, a COTAL LV–300 radar tracking station, DOVAP tracking, meteorological support for launch and a number of other facilities such as computers, inter-communication links, photography etc.

Scientists wishing to use ISRO sounding rockets for material science experiments may contact the Scientific Secretary, ISRO Head Quarters, Cauvery Bhavan, District Office Road, Bangalore 560 009, for rocket allotment, and the programme Manager, Rohini Sounding Rocket Programme, Vikram Sarabhai Space Centre, Trivandrum 695 022, for any special requirements and launch support.

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