The Incredible Story of the Small Scientific Satellite S^3 –A, Explorer-45

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In March 1970 I arrived in Building 11 at the Goddard Space Flight Center (GSFC) as trainee from Germany to join the Small Scientific Satellite (S^3) project.

My task was to flight-qualify a small experiment, the MOSFET degradation experiment (MOSDAM) during integration and environmental testing. The original launch date for S^3 was planned for September 1970 on a Scout-B, so I would have had a chance to participate in the launch campaign from the San Marco platform in Kenya at the Broglio Space Center of Italy within my one year stay. However this did not come about, because on December 10th 1969 the partially integrated satellite was destroyed by fire in the integration area. As investigations showed quickly, the fire was caused by a shot-circuit in a wire wrap power tool left overnight for charging.[1] Eric:]
The satellite had to be cleaned, faulty parts replaced by spares, reassembled and tested, thus the launch had to be rescheduled to early 1971.
And I also learned that this was not the first incident, hampering the progress of integrating the satellite. Before the fire– the satellite partially assembled, with its modular subsystems on breadboard and its electrical interfaces in the process of being checked out a work-crew on the floor above misread the plan and took the wrong side of the hallway, thus drilling a hole through the ceiling right above the satellite. A piece of plaster landed right beside the structure and a lot of dust coming down with it. That was the first close call for the schedule – but the integration team was able to recover fairly quickly.
I finished my training at GSFC in March 1971 with a small farewell party, but the satellite was still in the final qualification cycle.
I learned later that the launch team indeed made it to the San Marco range in 1971 however, the first launch attempt was not successful, because early during the final countdown they had no response from the satellite. When they took down the Scout and opened the shroud the crew found the satellite laying separated from the rocket in its protective cover. What had happened?
The evening before, the satellite mounted on the erected rocket a quick umbilical check was performed…and the timers for the pyros were inadvertently started and they did what they were supposed to do – they separated the satellite from the rocket.
Despite all of that, S^3 finally lifted-off on Nov. 15th 1971, 05:52:00 GMT to a highly successful mission with all the experiments working and the MOSFET experiment measuring the radiation damage as expected.

Fig. 1 SSS-A after GSFC fire [1]

Fig. 2 Rebuilt Satellite (R. Martin) [1]

The Satellite [2]

SSS-A or S-Cubed A, later designated Explorer 45 was a NASA satellite launched as part of Explorer program.

A new concept of a small satellite bus, designed to support a variety of low earth orbit payloads was implemented for S^3.

As can be seen in fig. 2, the bus consisted of an octagonal structure accommodating standardized trapezoid shaped "drawers", variable in height for housing the subsystems and designed to support interchangeable payloads of up to 85 lbs, the availability of tailorable on-board propulsion allowing weight tradeoffs. [3]

S^3 had the capability for complete inflight control of the data format through the use of an onboard set of stored program instructions. These instructions governed the collection of data and were reprogrammable via ground command. The antenna system consisted of four dipole antennas spaced 90° apart on the surface of the spacecraft cover. The satellite contained two transmitters, one for digital (PCM) data at 446 bps, and the other for either the digital data or wideband analog data from 30-Hz to 10-kHz from the AC electric field probes and from one search coil sensor. The command system handled 80 commands for controlling the spacecraft and experiment functions, as well as for flight program loads for the data processing system. The satellite power system consisted of a rechargeable battery and an array of solar cells, the liftoff weight was 52 kg.

The spin rate was about 7 rpm, and the spin axis lay in the spacecraft orbital plane which was approximately the same as the Earth's equatorial plane. The initial local time of apogee was about 21.8 hours and the line of apsides moved around toward the Sun at an initial rate of 12° per month.

The satellite was operationally turned off on 30 September 1974, after approximately 3 years of successful and productive operation.

Fig.3 San Marco, a "Texas-tower" platform in the Indian Ocean off the coast of Kenya with an erected Scout-B to be launched.

Fig. 4 The site's near-equatorial location is ideal for placing satellites into low-inclination orbits. Location: 2°56′18″S 40°12′45″E

Scientific Objectives [2]

The scientific objectives of the first small scientific satellite SSS-A, included the investigation of the Earth's equatorial ring current, the evolution of magnetic storms, time variations of the charged particles trapped in the radiation belt, and the relationship between trapped particles, the Earth's magnetic storms, and the auroras. The instrumentation of SSS-A was much like that on the Electrostatic Particle Explorer (EPE) and Interplanetary Monitoring Platform (IMP) series. SSS-A, however, was a "close-in" spacecraft, orbiting within the magnetosphere almost all of the time, in contrast to the EPEs and IMPs that swung out tens of thousands of miles in highly elliptical orbits.

In summary the three main objectives were:

- Study of the characteristics and origin of the Earth's ring current and development of the main-phase magnetic storms
- Study of the relation between magnetic storms, sub-storms, and the acceleration of charged particles within the inner magnetosphere
- Determination of the major wave-particle interaction mechanisms, directional measurements of protons, electrons, and alpha particles were made over a wide energy range, and DC and AC electric and magnetic fields were measured.

This small scientific satellite S^3 truly lived up to its name, because it had not only three SSSs in its name but it also amazing three lives.
For me, it was an important lesson: a space project may be hampered by many unforeseeable and unplannable incidents, but if the team is dedicated, highly motivated and not getting discouraged by setbacks – and lucky enough to see the project through, in the end your mission will be a success!

References

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