SARA: a students space initiative

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SARA is a sientific small satellite initiated, designed and assembled by students or just graduated post-students. The project lasted 3 years in an aerospace club ESIEESPACE: a club created in an engineers school ESIEE (Ecole Supérieure d'Ingénieurs en Electronique et Electrotechnique) near Paris. The purpose of SARA is to provide a long term survey of the decametric surrounding radiations above ionosphere. Datas will be used by radioastronomers for a better understanding of the jovian atmosphere. SARA has been launched on july 16 1991 thanks to ARIANE at Kourou. It weight 26Kg, look like a 35cm cube with three ten meters antennas. This project is an opportunity for a french space association to develop new ways to deal with space. SARA is also a new step in microsat designing for educationnal activities which can lead to a valuable experience to improve bigger projects.

Intoduction:

Succesfull launch !

The launch occurs successfully at Kourou by an ARIANE IV launcher (V44) along with ERS1 an 3 other microsats on july the 16th, 1991. The flight was previously planed on april but third stage engine troubles caused some delay.

At the moment SARA is functionning well . The onboard temperature monitoring shows that SARA temperature stabilizes around 7°C and that the battery voltage is nominal.

The monitoring of Jupiter will be effective after some months of technical validation concerning the temperature, the voltage battery and the galactic noise calibration.

SARA a students' space initiative

SARA is the brainchild of ESIEESPACE a french space club near Paris.

The project, from the first idea to the installation on ASAP aboard ARIANE V44, lasted 3 years. This includes everything from topic determination, mission analysis, spacecraft design, launch operations to management, mission organisation etc...

The team was composed first with 4 skilled students from ESIEE, then this team increased up to 9 for the physical completion of SARA.

The harcore of this team is the result of a 5 year experience in experimental rockets and stratospheric balloons. This very specific training inside an engineering school was determinant for the carrying out of SARA.

Some of us have a multi-scolar experience both engineering and university training.

ESIEE is an engineering school which provide an up to date technical training thanks to high technology equipements (micro-electronic clean-rooms, workstations, signal processing etc....). The SARA initiative was rapidly encouraged by the school.

The work has been done in a french association structure, which provided an unequalled effectiveness.

Our sponsorship CNES, DASSAULT AVIATION, ANVAR, MATRA let us completly free of our management and technical design. Overall they gave us the means to reach our goal.

Why to build a microsat?

Having met the success with several projects the club was looking for a more ambitious challenge than building rockets. Building a microsatellite obviously was an ambitious project. but before spending several man-year on this project, we wanted to make sure we could reasonnably succeed.

The most important thing for us to make the project look realistic was that the satellite should not have an attitude and orbit control system. Since we wanted our satellite to have some usefulness, it was a bit troublesome to find a payload to put on it.

After several months of investigation, we were proposed to put a radio-astronomy experiment aboard by the Meudon astronomers, which is part of CNRS, france's national center for scientific research.

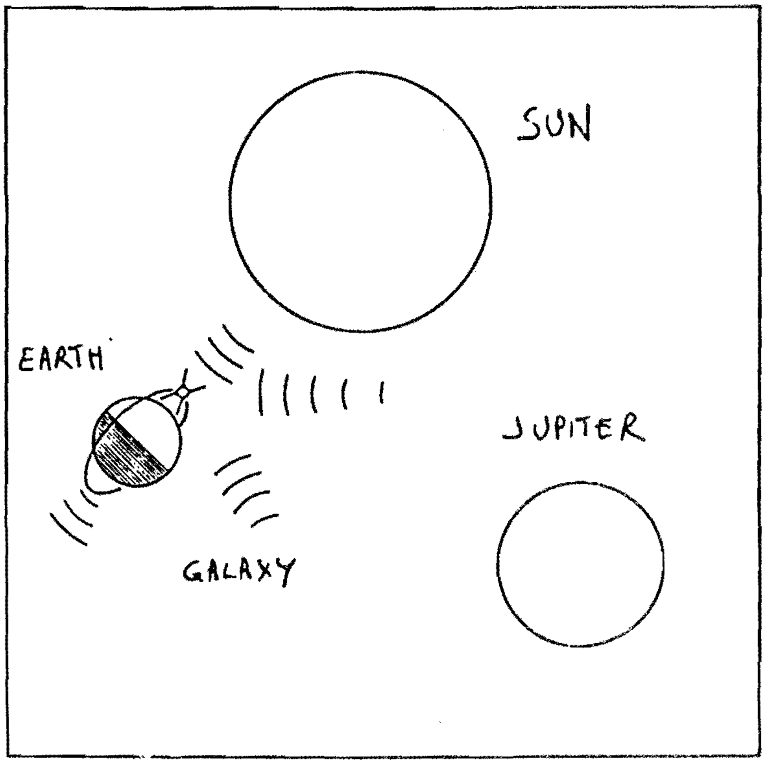

Fig. 1 The experiment

Hence the acronym: SARA, which stands for radio astronomy amateur satellite. SARA will measure the radio-waves transmitted by jupiter at frequencies between 2-15 Mhz, which do not cross through the earth's atmosphere. They are of scientific interest since they reflect phenomenons occurring in Jupiter's magnetosphere. An earth orbiting satellite is thus a way to receive them. Those waves are expected to be strong enough to be received by an omni-directionnal antenna, thus no attitude control was required.

Technical designing

SARA is the first satellite designed by ESIEESPACE. The study team of SARA was aware that it was important to make a very simple satellite to have a good chance both to succeed and overall to be credible.

Severe tradeoff were done on atitude control, telecom, thermal control and payload.

Though, each usual part of a space system design was carefully analysed sometimes more deeply as it is necessary for that kind of project.

A thermal analysis software was developped. This tool was developped to solve specific thermal problems with negligible internal radiative exchange.

The number of nodes on SARA has been limited to 38. The soft has been validated by a thermal solar simulation in a small solar thermal testing facility at CNES.

One of the main requirement for the success of the project was the possibility to fullfill the mission without precise pointing. thanks to the isotropic caracteristics of the subject rough stabilization provided by a magnet was sufficient to prevent dramatic link budget loss.

On another hand data rate telemetry link was reduced to a low rate TM (300 bauds) and a binary on off TC.

A single experiment payload makes SARA a dedicated satellite. We deviated a bit from this concept at the end of the project, because of remaining time we consider that it would be very valuable to add a temperature and a battery voltage TM technological experiment.

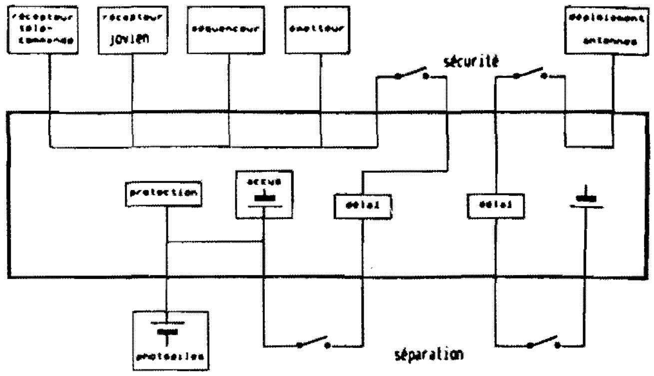

Fig. 3 The architecture of SARA

Our quality insurance policy was based on the need for the team to work in the best efficient way as possible due to the unusual amount of work for an aerospace club project. Anyone in the team knows that the part he was in charge of was essential for the success. On the other hand the goal we aimed to was highly motivating provided that the integration at Kourou was the concern of all the team and Kourou is the famous European Space Center.

As far as components are concerned it was clear that space qualified solution couldn't be a good one for us. It was important to improve our knowledge in this field. Our training of electrical engineer gives us relevant data about the specification of spaced components. Thus the project decided, due to the 10 years LEO to adopt military technology CMOS type IC.

Each specific component was discussed during frequent meetings.

Concerning the central processing unit we resist to the temptation to design an all system controled computer. This save many time debuging and the 90% functionning software syndrome was eliminated.

The mechanical structure is an all aluminium structure type for thermal and easy machining characteristics.

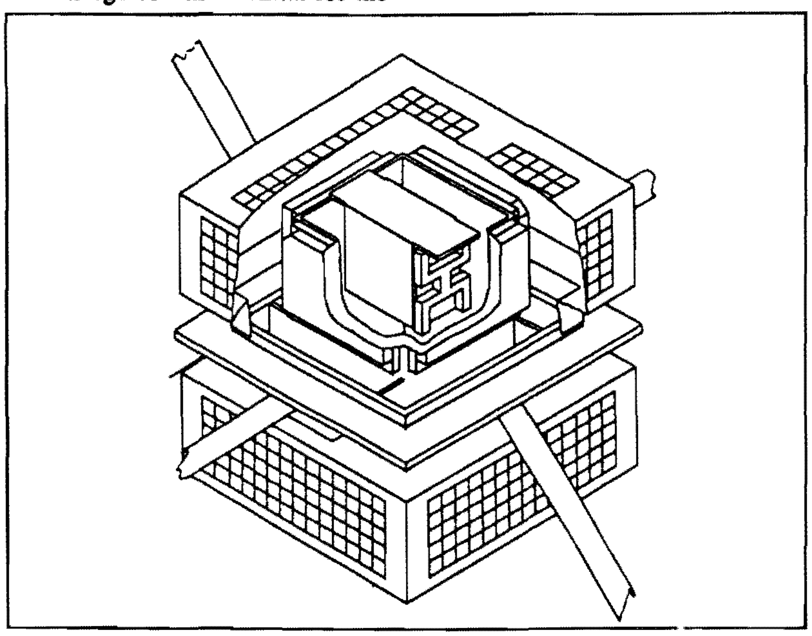

Fig. 4 The mechanical structure

The solar generator and the battery was a difficult point to solve due to the long mission duration requirement. We couldn't avoid to use professional batteries, but we were able to develop solar panelsthem from Si cells assembly to the installation on SARA.

ESIEESPACE team thanks to this project acquire the capacity to deal with space constraints. These constraints ranges from old habits due to the aging of many devices used by space engineers to the natural constraint of piggyback qualification, space environnement, operationnal and industrial life.

It is possible to reduce space sytem cost in relaxing the space qualification constraints on components when it is not justified. Also small system can undertake money saving management but overall small space system managers must maintain a complete technical mastering.

Realisation

When designing the plateform, the leading requirement was to ensure the battery a proper working temperature, whatever the satellite's attitude would be with respect to the sun and the earth. This was met by a highly symmetrical design: a cube with all side having the same colour, and by tying the equipements plateform equally to the centers of four opposite edges, thus averaging the temperatures of the sides. Also, all sides were equally covered with photocells.

Easy access to all pieces of equipement was highly prized; as a result we were able to assemble SARA entirely within 90 min.

The mechanical design was greatly simplified because on ARIANE we pay for a place onboard rather than for each kilogram. This allowed us to oversize many parts, saving much time of drawing, calculations and machining.

All mechanical parts and electronic equipements were home-made, mainly because this is part of the enjoyement given by amateur's project.

SARA passed the various tests without problems: vibration tests (mandatory to fly on Ariane) thermal tests in a vacuum solar facility (needed because of the delicate thermal design of the spacecrafts and also to show that SARA resistance to the depressurisation).

Budget, sponsoring

SARA has been done with very low funding. The total cost of this project is 3244 kF, roughly 0.6 M$ launch included, this total take into account only direct cost (no wages).

Outgoing		k$	Incoming	k$
SARA hardware		203.6		
Mecanic			ESIEE budget	2
	aluminium	6.6		
	various	1.6		
Electronic			Matra MHS components	4
	components	13.3	ESIEE budget	1
	printed circuits	1.6	RTC	2
Pyro		20	DASSAULT AVIATION	
			bolt cutter	20
Solar cells		115	SAT	115
Cover glass		8	Pilkington	9
Battery		35	SAFT	35
Painting		1.5		
Bonding		1		
Earth station		29	DART computer	6
antennas		3.5		
receiver		2.5		
recorder,decoder		6		
Travelling expenses		17		
Tests and launching		268		
	tests			
	vibrations	34	MATRA	34
	vaccum thermal	34	CNES	34
Launching		200	CNES	200
Miscealeanous		46		
Editing		5	ESIEE	0.5
Maquette		2.5		
Crate		2.5		
Special equipements		34	developement system	3
secretary		2		
			ANVAR	9
			DASSAULT AVIATION	76
TOTAL		550		550

Conclusion

It is important to recall that ASAP is at the moment the easiest way to put lightsats (<50kg) into orbit. This facility highlights that exciting experiments can be developped at low cost and very rapidly.

Also, microsats like SARA are the way to create highly competent teams in order to develop more ambitious space systems.

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