MAPSAR: A SMALL L-BAND SAR MISSION FOR LAND OBSERVATION

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1. ABSTRACT

This paper introduces MAPSAR (Multi-Application Purpose SAR): A new SAR (Synthetic Aperture Radar) mission for Earth Observation. MAPSAR is the result of a joint pre-phase A study conducted by INPE and DLR targeting a mission for assessment, management and monitoring of natural resources. The applicability of the sensor system was investigated for cartography, forestry, geology, geomorphology, hydrology, agriculture, disaster management, oceanography, urban studies and security. To accomplish the overall requirements, an L-band SAR has been chosen as the only payload of a small satellite. The satellite, based on INPE's Multi-Mission Platform, (MMP) is presented as well. The SAR sensor will be innovative with respect to overall mass, size and performance. The key component of the SAR instrument is the SAR antenna, which is designed as an elliptical parabolic reflector antenna with dimension of approximately 7.5 m (azimuth) x 5 m (range). L-band (high spatial resolution, quad-pol) has been selected for the SAR sensor as optimum frequency accounting for the majority of Brazilian and German user requirements. At the moment, the pre-phase A has been concluded and the phase A is planned to start in early 2003.

2. INTRODUCTION

The initiative of the joint study of a small spaceborne SAR is a consequence of a long term Brazilian-German scientific and technical cooperation that was initiated between INPE and DLR in the seventies. The decision to perform a pre-phase A study for MAPSAR was established in 2001 following several meetings in both agencies. Based on the specific and complementary experience of both partners, the sharing of the thematic responsibilities within the study was agreed. Brazil was responsible for the platform and integrated satellite analysis and Germany for the payload and orbit analysis.

3. USER REQUIREMENTS

The MAPSAR mission is tailored to optimally support the potential user groups in both countries taking into account distinct aspects of specific applications.

The consensus of the Brazilian working group was that a spaceborne SAR mission will provide a powerful new tool to acquire data and to derive important unique information of vegetated terrain of the Amazon Region. Due to the enormous scarcity of up-to-date information. which is fundamental for planning and strategic decision-making about environmental assessment, management and monitoring of natural resources in the Brazilian Amazon, the proposed small spaceborne SAR initiative should be strongly oriented to an quasi-operational ("application-oriented") system. This is dedicated to thematic mapping purposes for topography, vegetation and deforestation, geology, hydrology, etc. The MAPSAR concept should also address aspects of integration with the Brazilian "Surveillance the Amazon System" (SIVAM/SIPAM), due to the complementary nature of both sources (spaceborne/airborne) of multi-polarized and fully polarimetric L band data. Finally, although recognised in most application fields, the effects of the polarization, polarimetry and interferometry on the image information content are not well understood in some of those fields.

The Brazilian applications are of high interest for the German potential user community. Additional applications, which are of specific importance for the German user side, as biomass estimation, disaster monitoring and security complement the Brazilian disciplines. The common aim is a global biomass mapping mission covering major forests biomes of the globe (tropical and boreal). This requires the capability of polarimetric SAR interferometry for canopy height estimation which is directly related to forest biomass using allometry. The Brazilian and the German requirements have been merged resulting in the final user requirements for MAPSAR presented in Table 1.

Table 1: MAPSAR User Requirements (*priority, N.A.: not available, normal=Brazil, italic=Germany).

Application /MAPSAR parameters	Agriculture	Cartography	Disaster Monitoring	Forestry	Geology/ Geomorphology	Hydrology	Oceanography	Urban Mapping	Security
Frequency	[illegible]	L C	C *L*	L *, C *L*	L *L*	L, C *L*	C *L*	L C	*L(X)*
Polarization/ Polarimetry	quad. pol *[illegible]*	N E. *N E.*	VV, HH *quad. pol*	quad-pol. *quad. pol*	HH, HV *quad. pol*	quad. pol. *quad. pol*	quad-pol *quad. pol*	quad-pol *quad. pol*	*quad.pol*
Incidence Interval	variable [illegible]	variable(45 ° *) *(45 ° *)*	20°-30°/ 45°-60° *variable*	20°-45° *20°-45°*	large interval *large interval*	20°-45° *20°-45°*	High (45-60°) *(45-60°)*	40°-45° *variable*	*Variable*
Spatial Resolution	30 meters *[illegible]*	5 meters *3-5 meters*	30-50/15 m *3-5 meters*	10 meters *10 meters*	5 – 10 meters *3-5 meters*	10 meters *3-5 meters*	(High/Moderate) *(High/Moderate)*	5 meters *3-5 meters*	*3 meters*
Swath	[illegible]	N A. *variable*	150-350 km *variable*	100 km *variable*	40-100 Km *40-100 Km*	100 km *variable*	350km (ScanSAR & Fine Modes) *variable*	40-100 km *40-100 km*	*30 km*
Orbit Inclination	[illegible]	sun-syn *sun-syn*	sun-syn *sun-syn*	sun-syn *sun-syn*	sun-syn *sun-syn*	sun-syn *sun-syn*	sun-syn *sun-syn*	sun-syn *sun-syn*	*N.A.*
Look Direction	[illegible]	asc/desc *asc/desc*	asc/desc *asc/desc*	N . A. *asc/desc*	asc/desc *asc/desc*	asc/desc *asc/desc*	N. A. *asc/desc*	asc/desc *asc/desc*	*asc/desc*
Revisit	[illegible]	N. A.. *seasonal*	< 1 day *< 1 day*	monthly *monthly*	seasonal *seasonal*	10 –15days *< 15 days*	daily *daily*	N.A. *yearly*	*daily*
Access to data	real-time *real-time*	N A. *regularly*	real-time *real-time*	N. A. *regularly*	N. A. *regularly*	N. A. *regularly*	real-time *real-time*	N. A. *regularly*	*real-time*
Additional Requirement	- *InSAR*	stereoscopy *InSAR(opt.)*	- *InSAR*	- *InSAR*	stereoscopy *InSAR*	- *InSAR(opt.)*	raw data *InSAR*	- *InSAR (opt*	*Stereos.* *InSAR*

4. MAPSAR SATELLITE

The MAPSAR satellite utilizes a modular concept (Figure 1), consisting of a payload module and the Brazilian Multi-Mission Platform (MMP).

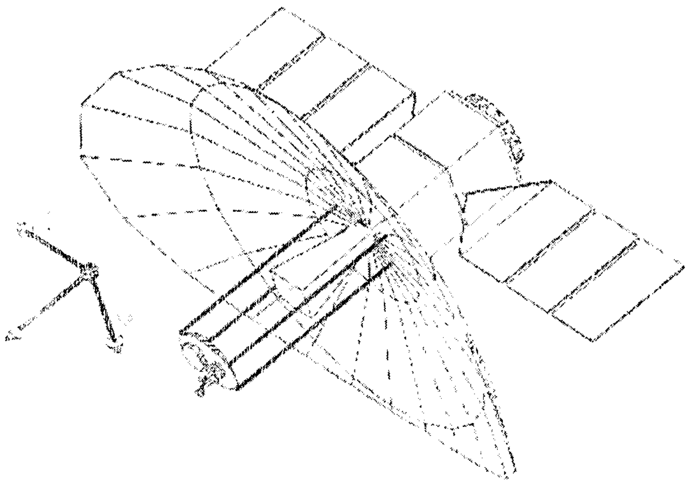

Figure 1: MAPSAR satellite constellation.

The Multi-Mission Platform concept provides for a capability to support a variety of low Earth orbit missions using the same basic three-axis stabilized platform with different payload modules. The MMP block diagram is shown in Figure 2. The MMP is already being developed by INPE and its first flight model shall be ready by the end of 2005.

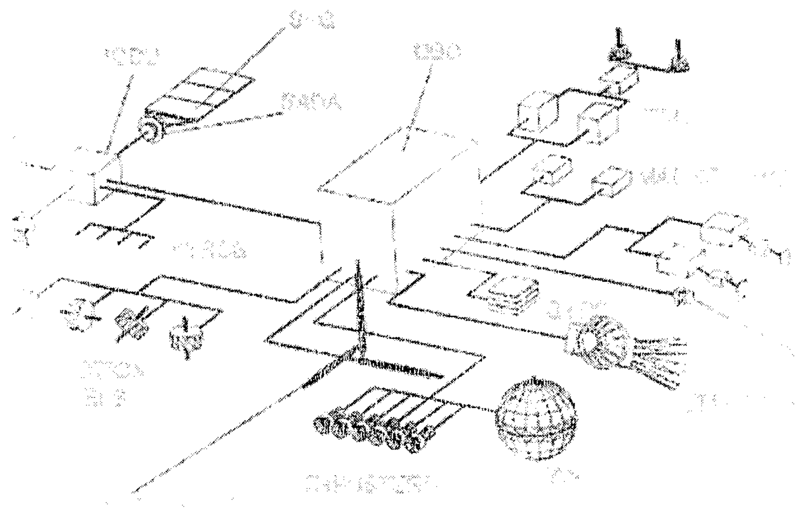

Figure 2: MMP Block Diagram.

5. SAR PAYLOAD

The MAPSAR payload module includes the SAR sensor, data storage and transmitter, mechanical structure and thermal control. The estimated payload mass is 270 kg. The payload power consumption is 750 W during operation and 120 W in stand-by. To comply with the user requirements and to provide for sufficient power generation, a dawn/dusk sun-synchronous orbit with a repeat cycle of 37 days at 620 km was chosen for this study. Based on mission simulations, this orbit shall be further optimized in the next project phases, taking into account the requirements of stereoscopic and interferometric capabilities.

A Cassegrain type antenna with a parabolic reflector was chosen for the SAR. The size of the reflector is 7.5 meters in azimuth and 5 meters in elevation. Compared to active phased-array antennas, the reflector type has lower mass and allows the use of high bandwidths and multi-polarization with less additional complexity. As a disadvantage, the reflector antenna doesn't allow electronic beam steering and ScanSAR mode. The required range of incidence angles and the left/right looking capability are achieved by tilting the whole satellite.

MAPSAR operates in three resolution modes (3m, 10m, 20m) and three polarization modes (single, dual- and quad polarization mode). A summary of important modes is shown in Table 2. The maximum instantaneous swath width in low and medium resolution mode (LR, MR) is 55 km and can be achieved in the middle of the access region.

Table 2: MAPSAR Operation Modes.

parameter	unit	HR Mode High Resolution		MR Mode Medium Resolution		LR Mode Low Resolution	
access region		near	far	near	far	near	far
geometric res.							
range	m	4,7	3	10	10	20	20
azimuth	m	3,1	3,1	10	10	20	20
incidence angle	°	20,3	47,6	20,0	48,1	20	36,7
ground swath width	km	38,3	20,5	45,1	35	43,4	28
polarization	-	SPM	SPM	DPM	DPM	QPM	QPM
pulse bandwidth	MHz	85	85	42,5	21,25	21,25	21,25
data rate	Mbps	262	300	267	300	247	249

6. CONCLUSIONS

An innovative small satellite mission with an L-band SAR was described. The study was prepared by INPE and DLR, taking into account Brazilian and German user requirements. Preliminary feasibility was demonstrated for a reflector antenna concept. A high degree of innovation is presented in the design: small SAR satellite, reflector antenna and remarkable sensor performance. The applications will take advantage of high spatial resolution L-band SAR with enhanced capabilities (polarimetry, stereoscopy, interferometry), particularly suitable for the Amazon region and Boreal forest operations. As critical items, the following are identified: antenna deployment mechanism and solid state high power amplifier. MAPSAR launch is envisaged for 2008.