KuaFu SWE Mission

ESA Thematic information day

BELSPO, 3 July 2012

Introduction

- The KuaFu Space Weather mission is proposed in cooperation with the National Space Science Centre (NSSC) under the Chinese Academy of Science (CAS).
- Unique opportunity to secure the availability of essential data required for operational Space Weather predictions as well as to address key scientific objectives;
- The substantial contribution of China to this programme will make it possible for Europe to achieve this at a fraction of the cost.
- On ESA side the programme would be financed 50 / 50 by the Science Mandatory and SSA optional programmes.

The NSSC was until recently called the CSSAR (Centre for Space Science and Applied Research)

Mission Outline

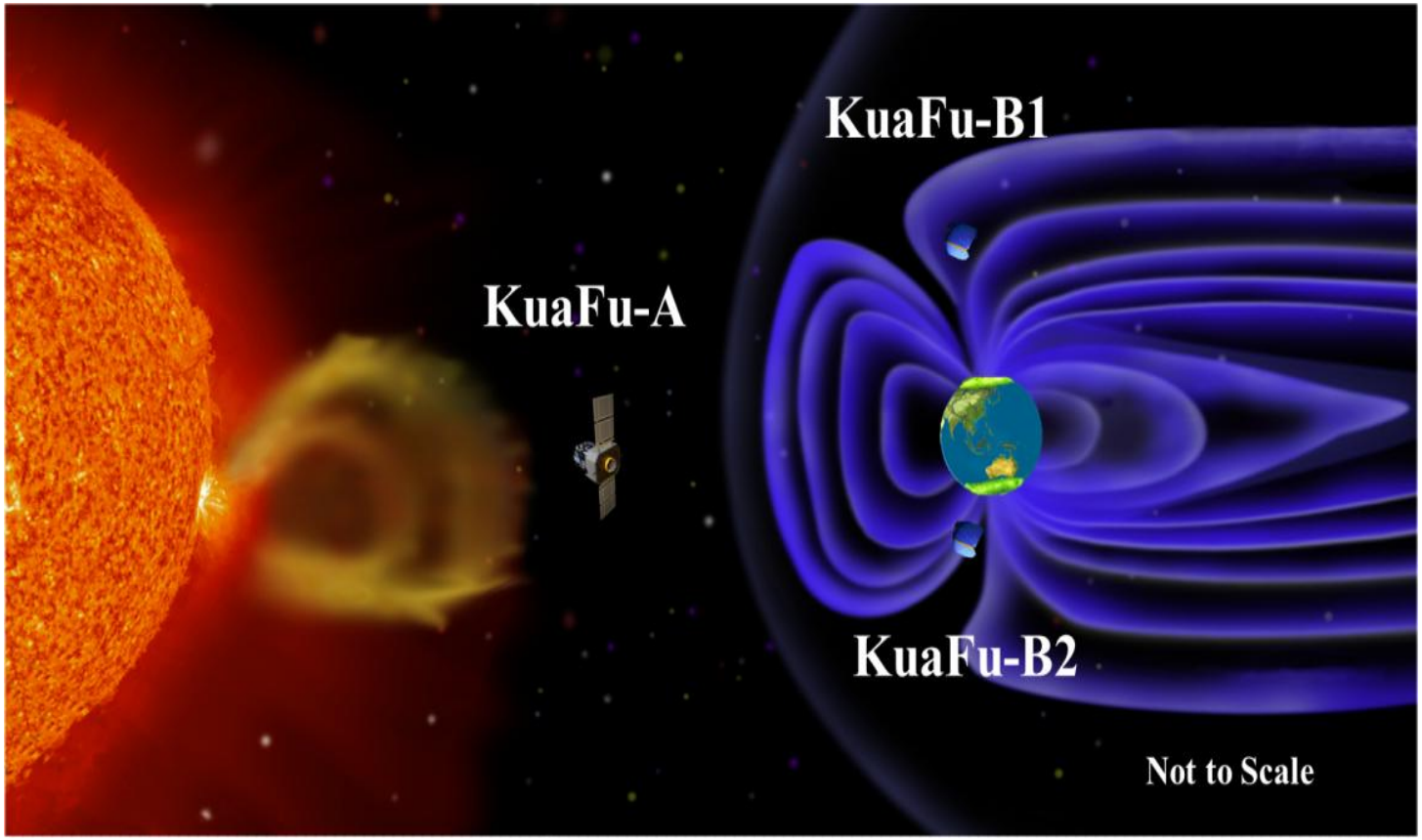


Figure 1: KuaFu Mission outline (artist impression)

KuaFu - A

- **KuaFu-A, located in a halo orbit at the Sun-Earth L1 Lagrangian point, continuously observing the Sun, providing an early warning about Coronal Mass Ejections and measurements of the Interplanetary Magnetic Field;**

- **Developed and launched (2017) under CAS responsibility; ESA will contribute with scientific instruments, mainly a Coronagraph.**

- **Operations would be shared, with Europe however taking the largest share using its Network of Stations (ESTRACK), as China does not currently have the antenna infrastructure for the essentially real-time operations that are required for the SWE monitoring.**

KuaFu - B

- KuaFu-B1 and B2, two identical small spacecraft developed and operated under ESA responsibility and launched by CAS with a LM3.

- Located in the same Molniya orbit, but phased 180 deg. apart, the KuaFu-B spacecraft will monitor the Earth magnetosphere in the polar regions and provide continuous observations of the Aurora Borealis (and Australis to some extent).

KuaFu is planned as a multi-spacecraft mission. As such the mission is capable of providing a number of critical data that are required for operational SWE services, along with data that are of direct scientific interest.

KuaFu-A spacecraft

KuaFu-A Spacecraft	
Service Module	3 – axis stabilized 0.8m High Gain antenna, low noise reaction wheels
Solar Array EOL power	> 750 W
Payload Mass:	≈ 130 kg
Payload Power:	≈ 225 W
Data Rate:	≈ 100 kbps average
Attitude Pointing:	10 arcsec accuracy
Attitude Stability:	5 arcsec/5 sec stability
Magnetic Cleanliness level:	1 nT

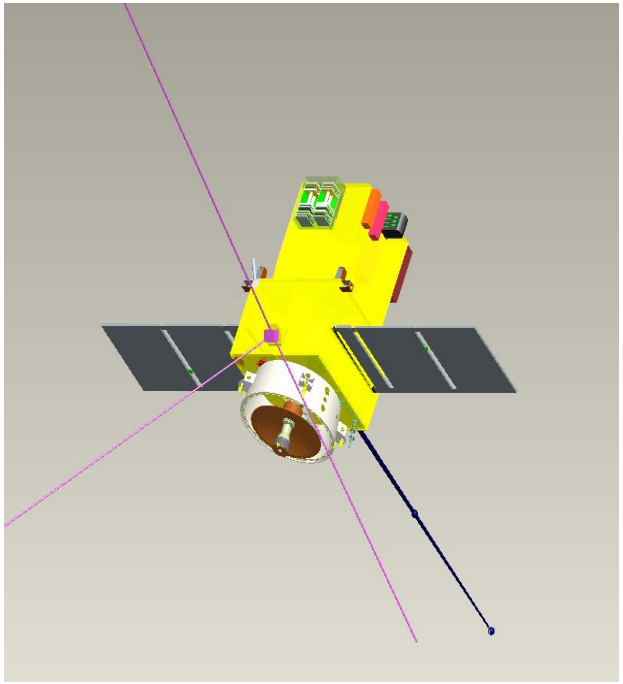


Table 1: KuaFu-A spacecraft main characteristics

KuaFu-A Model Payload

The KuaFu A current model payload consists of a number of in-situ and remote observation istruments to be provided mainly by Chinese institutes. An overview of the main characteristics of the KuaFu A payload is given in Table 2.

No	Instrument	Notes
1	Lyman alpha imager	CAS interest
2	Coronagraph	TBC, open to European interest
3	Fluxgate Magnetometer	CAS interest
4	Plasma Instrument	TBC, open to European interest
5	Hard X-ray/Gamma-ray spectrometer	CAS interest
6	Solar High-Energy Proton Detector	CAS interest
7	Solar High-Energy Electron Detector	CAS interest
8	Solar High-Energy Ion Detector	CAS interest
9	Solar electron-proton telescope	Possible spare of Stereo instrument
10	Digital Absolute Radiometer (Solar Irradiance Measurement)	Potential Interest from Switzerland

. Table 2: KuaFu-A Model payload

KuaFu-B Mission

The KuaFu-B mission consists of two small (identical) satellites placed on the same Molniya orbit by a CAS provided launcher, the two spacecraft will be phased 180 degree apart allowing monitoring of both the North and South poles.

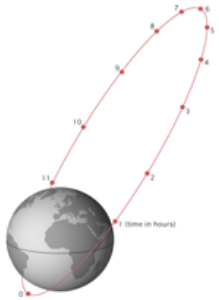
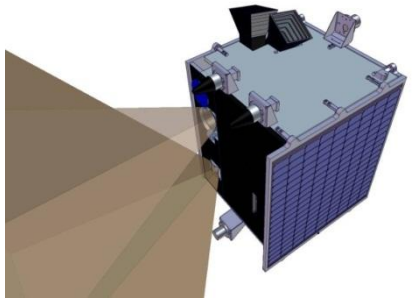
Mission Description				
Architecture	2 identical spacecraft into identical orbit but phased by 180 deg.			
Launch	Long March 3B in dual launch configuration.			
Launch Date	As early as 4th quarter 2018			
Launch Orbit	Identical to final orbit except the two spacecraft are at zero phasing			
Operation	Orbit	Type:	Quasi-Molniya	
		Perigee Radius:	1.8 R_E	
		Apogee Radius:	7 R_E	
		Arg. of Perigee:	270 deg	
		Inclination:	63.4 deg	
		Period:	13.0 hr	
		RAAN:	-90 deg	
		Max. Eclipse duration:	1.1 hr	
	Duration: 4 years nominal with possible extension			

Table 3. KuaFu-B Mission Description

Spacecraft technical baseline

- During a pre-Phase A study conducted in March 2012, several European platforms have been assessed as possible candidates for the KuaFu-B mission.
- As a reference a design based on the Proba V platform, modified with a new propulsion system derived from the Proba 3 Coronagraph spacecraft, has been selected as baseline.



KuaFu-B Spacecraft	
Service Module	3 – axis stabilized 4 reaction wheels
Power Generation	3 body-mounted solar panels
Payload Mass:	22 kg
Payload Power:	30 W
Payload Data Volume (per s/c):	9.7 Gbit / 24 hrs downlinked
Communications	X-band horn MGA S-band LGAs
Pointing Accuracy:	< 1 arcmin (1-sig)
Pointing Knowledge	5 arcsec (1-sig)
Propulsion:	Monoprop hydrazine, 4.5 L tank 4+4 1N thrusters

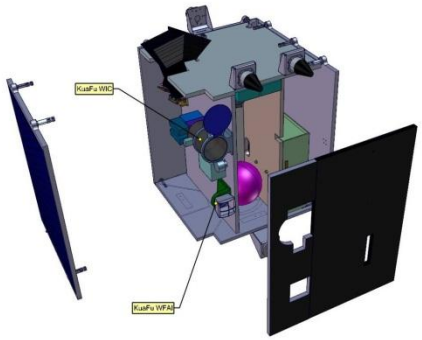


Table 4. KuaFu-B Spacecraft

KuaFu-B Model Payload

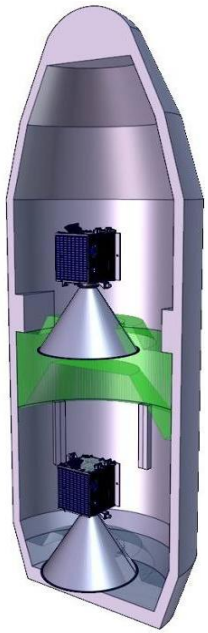
Characteristic	Wide Field Auroral Imager (Perigee Imager)	Wideband Imaging Camera
Instrument Acronym	WFAI	WIC
Description	Wide field FUV imager for auroral observations primarily at perigee (1.8 Re geocentric) and apogee (for low resolution auroral oval measurements)	Auroral Imaging primarily at apogee (7 Re geocentric) and at perigee (to cover the auroral oval partially)
Heritage	MIXS (BepiColombo), DE-1, ROSAT	WIC from the US IMAGE mission
Detector type	MCP optics – photon-counting detector	MCP intensified CCD
Measurement Range(s)	140-180 nm (FUV)	140 -190 nm (FUV)
Measurement Resolution/Accuracy	Spatial resolution 40 km at 0.8 Re altitude (angular resolution: 14 arcmin)	Spatial resolution at apogee 100 km, angular resolution: 0.13 degrees and 6 km at perigee
Field of View (per package)	44 by 44 degrees	17 by 17 degrees
Cadence	1 image per 10 seconds	1 image per 10 seconds
Mass per package	3 kg (excluding DPU)	5 kg (excluding DPU)
Power per package	10 W (excluding DPU)	4 W (excluding DPU)
Assumed shielding	Shielding mass assumed: 1.1 kg	Shielding mass assumed: 1.1 kg

Table 5: KuaFu-B Model Payload (main instruments)

CAS has expressed interest to provide instrument (s) for the mission.

KuaFu-B Launcher

- The two KuaFu-B spacecraft will be launched by a single Long March 3B (LM-3B) provided by China.
- CAS is also expected to provide the special launch adapter for the Proba small interface diameter (330mm). This will open the market of small platforms for the LM-3B launcher. The separation system (clamp band) will be provided by ESA.
- The LM-3B vehicle is capable of delivering both 200 kg spacecraft into the desired orbit.
- Based on currently known performances of the upper stage, the launcher would not be able to perform the required 180° phasing between the two spacecraft. This needs to be performed by the spacecraft



KuaFu-B Spacecraft

- Within the framework of the Science Programme, ESA has carried out in March 2012 a “Phase 0” CDF study of KuaFu-B mission to assess feasibility and costs. The study has confirmed that the KuaFu-B mission can be implemented making use of small satellite platforms available in Europe.

- After evaluating the KuaFu-B mission requirements, a first assessment of the existing European platforms (Proba, Myriade, SSTL, Prisma, TET) has been performed. The conclusion was that in any case design modifications are required.

- The study then focused on Proba 3, Proba V and Myriade (old and New Generation) as potential candidates expected to require the least modifications.

KuaFu-B design drivers

The platform design has been reviewed taking into account system development, technology and operational aspects. Main critical areas identified are:

- ITAR restricted technology: KuaFu shall be ITAR free to comply with current US export regulations given that the baseline launcher is Long March 3B (China). Potential ITAR components need replacement and/or local redesign.

- Radiation environment: Low cost LEO platforms need to be upgraded to cope with the level of radiation typical of the Molniya orbits. Use of rad-hard EEE components and / or additional shielding are required.

Conclusions

- KuaFu is a unique opportunity to implement an operational system of SWE services for a fraction of a cost.
- The mission provides as well important scientific data (replacing the ageing SOHO spacecraft).
- The KuaFu mission is part of a Programme Proposal to be submitted for approval at the coming CM 2012.
- Presented by CAS as a “package deal”. It will be the first broad ESA - China cooperation project, beyond the Double Star mission.