EPSC Abstracts
Vol. 8, EPSC2013-279, 2013
European Planetary Science Congress 2013

Space-based ultra-long wavelength radio observatory (low cost) – SURO-LC

Author
Richard Blott
Space Enterprise Partnerships, U K (rjb@space-enterprise-partnerships.com, +44(0)5601325706, +44(0)7894831239)
Co-authors
Prof. Dr. Ir Willem A Baan, Netherlands Institute for Radio Astronomy (NL)
Dr. Albert-Jan Boonstra, Netherlands Institute for Radio Astronomy (NL)
Dr Jan Bergman, Swedish Institute of Space Physics (SE)
Dr David Robinson, Psi-tran Ltd (UK)
Dr Doug Liddle, Surrey Satellite Technology Ltd (UK)
Dr Nimalraj Navarathinam, Surrey Satellite Technology Ltd (UK)
Dr Stuart Eves, Surrey Satellite Technology Ltd (UK)
Prof Chris Bridges, University of Surrey (Surrey Space Centre) (UK)
Prof Steven Gao, University of Kent (UK)
Dr Mark Bentum, University of Twente (NL)
Prof Alistair Forbes, National Physical Laboratory (UK)
Dr David Humphreys, National Physical laboratory (UK)
Carl-Gustaf Harroch, Novoda London Android Development Consultancy (UK).

Abstract

The mission

SURO-LC is the radio astronomer's equivalent of the first high resolution X-ray space telescopes. It opens up a largely unexplored spectral band, previously hidden from Earth, to make new discoveries in the nearby and distant universe. The proposed mission offers the first omnidirectional low frequency radio survey at high sensitivity and high resolution.

SURO-LC all-sky or rapid monitoring (for rapid solar and galactic events) operation is in the largely un-explored frequency domain between 0.1 and 70 MHz, of which the 0.1 – 30 MHz range is mostly inaccessible from earth because of ionospheric blocking and man-made radio frequency interference (RFI).

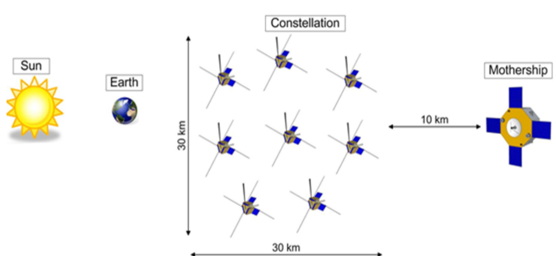

Figure 1 SURO-LC constellation deployed

SURO-LC deploys a formation of nine spacecraft in a low relative-drift Lissajous orbit at SEL2, 1.5 million km from earth in a radio clean environment. Eight spherically distributed Cubesat daughters, equipped with 3 orthogonal dipole antennas, form a distributed interferometric radio telescope. An offset mothership provides data acquisition, digital signal processing, and ground communication.

The science

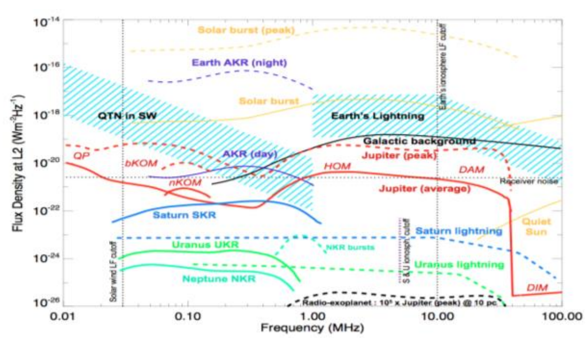

Figure 2 The low frequency spectrum at SEL2.

SURO-LC fully supports ESA's Cosmic Vision 2015-2025 uniquely using the very low radio frequencies to:

Observe the 'Dark Ages' neutral hydrogen 21-cm spin temperature up to the 'Epoch of Reionozation' to help determine the onset of star formation, the first black holes and galaxies.

Study low frequency heliophysics and space weather to provide unprecedented LF imaging of solar flares and CMEs in the far Solar system.

Observe extragalactic low frequencies observations to evaluate source populations' evolutional history at high redshifts, study active galactic nuclei regulating growth of accreting black holes and the nuclear star formation and detect relic radio galaxies.

Make low frequency observations of planetary radio emissions, pulsars and transients to explore major solar system planetary emissions at inaccessible frequencies from earth, provide first detections of exo-planet magnetospheric radio emissions, provide first measurements of pulse shapes and spectral properties of pulsars at low frequencies and to discover new radio transient emission behavior.

Study the 'Galactic Interstellar Medium' low frequencies to uniquely determine the structure of the 'Warm Interstellar Medium' in the local neighborhood and answer outstanding questions about the nature and origin of cosmic rays.

The technology

Low cost is achieved by using Cubesats for the daughter (sensing) satellites with android based integrated communication and navigation. They are deployed from a mini-satellite mothership. All use currently affordable, established small spacecraft engineering including Android -based integrated navigation and communication.

Sensing satellites. The sensing satellite design is based on the STRaND 3U CubeSat, (10x10x30cm) used for proto-flight STRaND-1.

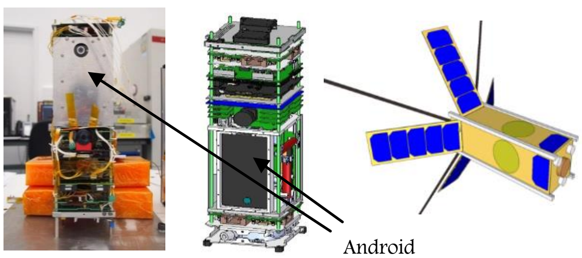

Figure 3 STRaND-1 and design modification.

The design is modified with solar panel bearing wings to give passive attitude control from the solar pressure.

Integrated communication and ranging is provided by an Android phone 'SpaceApp'. Linking is by extended range WiFi and ranging uncertainty is reduced (to the required accuracy) by a factor of 30 by multi-lateration algorithms.

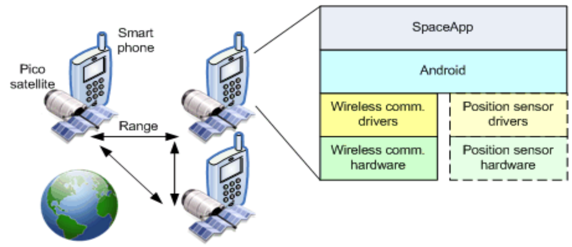

Figure 4 'SpaceApp' functional architecture

All functions and computation, including relative attitude and location are easily supported by the android 1 GHz processor. WiFi range extension is by a novel combination of software modification to hand shaking timing and high gain antennas.

Mothership. LISA Pathfinder (chemical main propulsion) is the nominal mothership platform which is compatible with a Vega launch. Modification to electric main propulsion could halve the launch wet mass and significantly raise the initial injection orbit if a longer transit time to SEL2 is accepted. The sensing satellites are mounted in rectangular dispensers on the mothership for launch and transit. Initial drift is minimised by a combination of precise manoeuvres and a novel, disturbance-free separation system using a modified standard Cubesat dispenser.

References

[1] Robinson, D., Blott, R., Forbes, A., Humphreys, D.,Bergman, J., FIRST, 2009, Explorer mission concept study, ESTEC/ contract CCN18 -19030.

[2] Boonstra et al, DARIS, 2010, Very large effective receiving antenna aperture in space, ESTEC/Contract 22108/08/NL/ST.

[3] Baan et al, SURO-LC ESA Small science mission proposal 2012.

[4] Blott R, Robinson D, Dobrosavljevic Z, Forbes A, TSB Integrated navigation and communications 'SpaceApp' study final report, 2011.