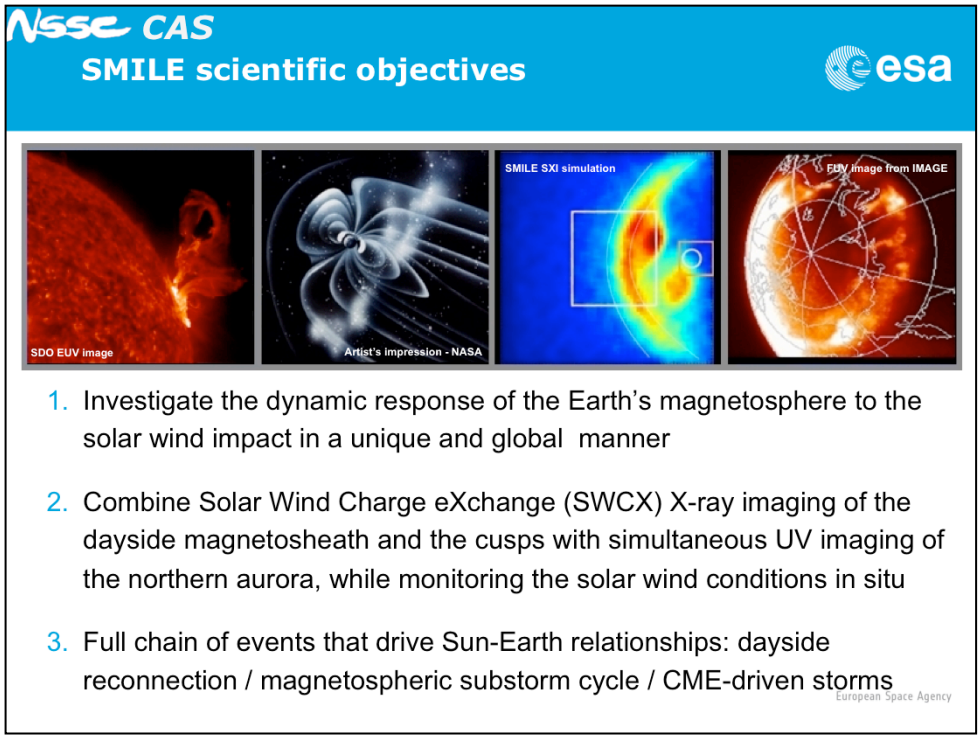
SMILE
Solar wind Magnetosphere Ionosphere Link Explorer

C. P. Escoubet[1], G. Branduardi-Raymont[2], C. Wang[3], S. Sembay[4], L. Dai[3], L. Li[3], E. Donovan[5], E. L. Spanswick[5], D. Sibeck[6], A. Read[4], D. Rebuffat[1], A. Wielders[1], J. Zheng[3], J. Romstedt[1], W. Raab[1], D. Lumb[1]

[1]*ESA/ESTEC (Netherlands)*
[2]MSSL - UCL (UK)
[3]NSSC/CAS (China)
[4]*Leicester U. (UK)*
[5]Calgary U. (Canada)
[6]GSFC (USA)

ESA-Chinese Academy of Science joint call

1. Call issued in January 2015
2. Small class mission
3. 13 proposals received
4. SMILE recommended in June 2015 by a joint European and Chinese scientific committee as candidate for a collaborative science mission

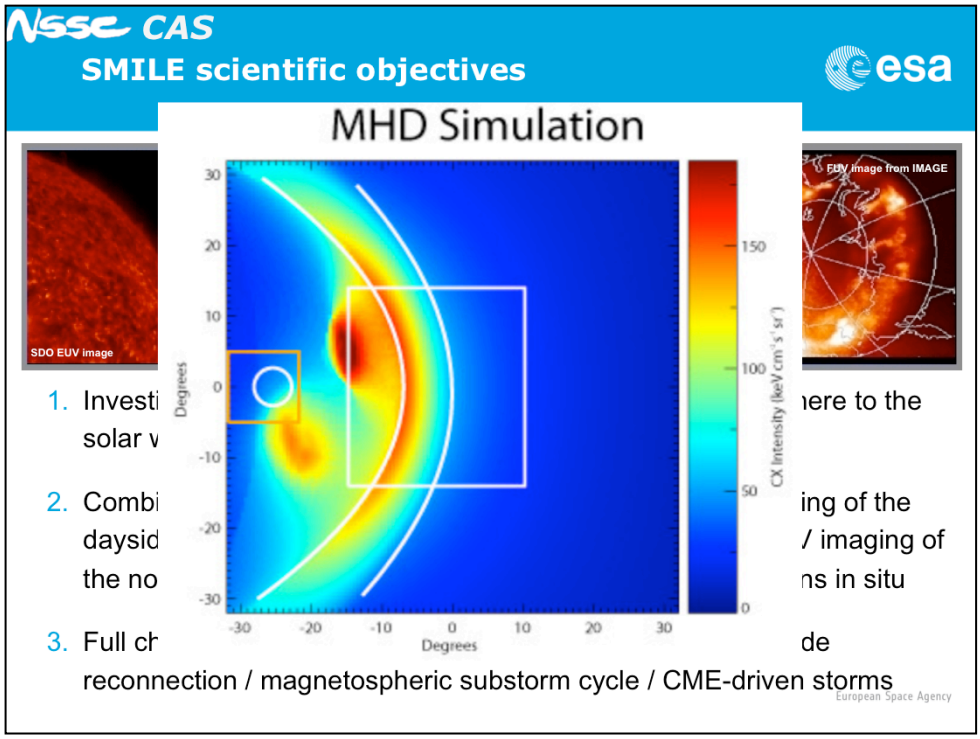


SMILE will investigate the Sun-Earth connection in a new way never attempted before.

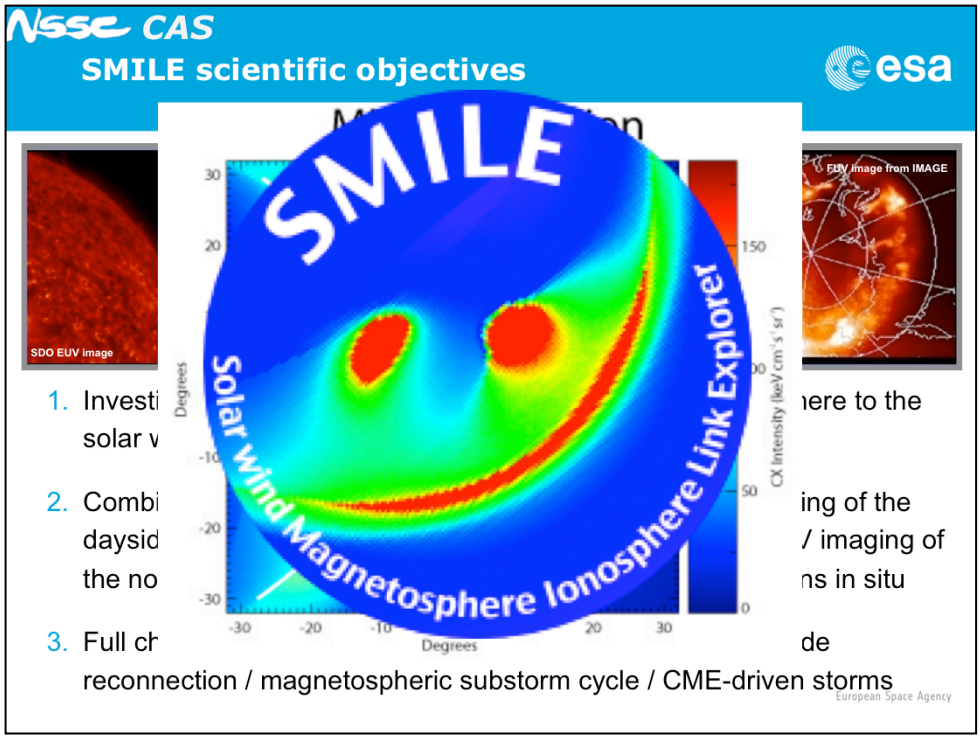
Consider the **impact of a CME** arriving at the E's magnetosphere; in this cartoon we see the **bow shock**, the **magnetopause**, the **cusps** (where solar wind particles can penetrate down to the Earth surface), and the **magnetosheath** as the region in between; it is a relatively recent discovery that **X-rays are produced** in the dayside magnetosheath and the cusps when highly charged ions of the SW interact with exospheric neutrals. The **ultimate consequences** are geomagnetic storms and particle precipitation in the aurorae.

SMILE will combine X-ray and UV auroral global imaging with plasma measurement in a self consistent way.

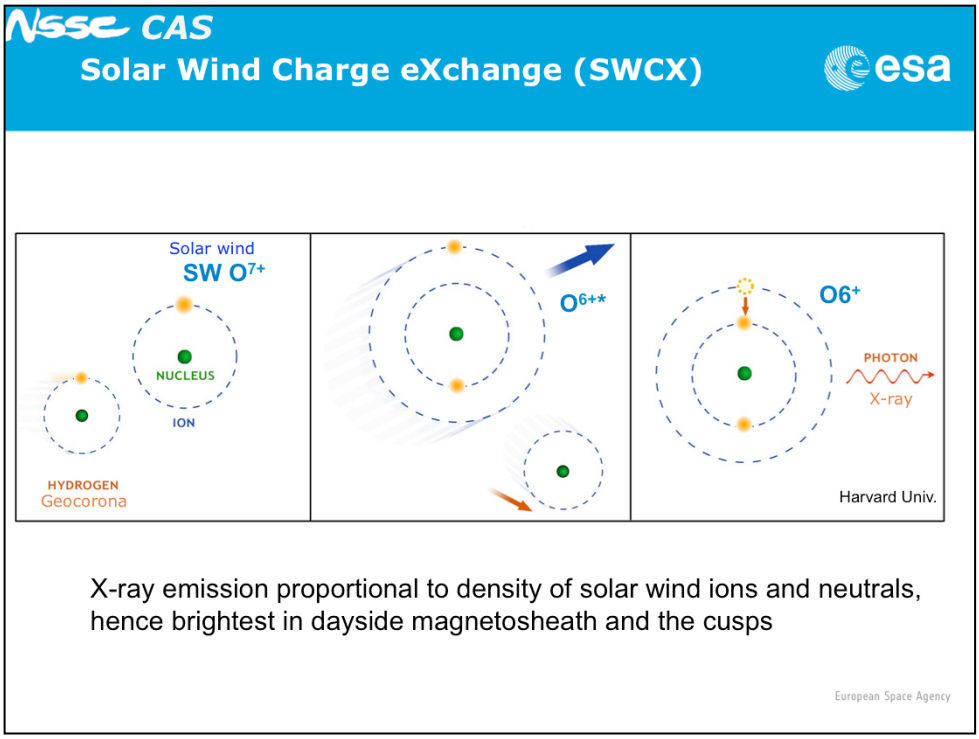
Global UV imaging was stopped with the last Polar image in April 2008.



The overlaid figure shows the MHD simulation of X-ray emissions that SMILE would see from a dawn point of view. The emissions are stronger in the magnetosheath (bow) and in the two cusps (spots). The field of view of the X-ray instrument (25x25 deg.) is shown as a white square and the auroral imager as a red square. Bow shock and magnetopause are indicated in white.

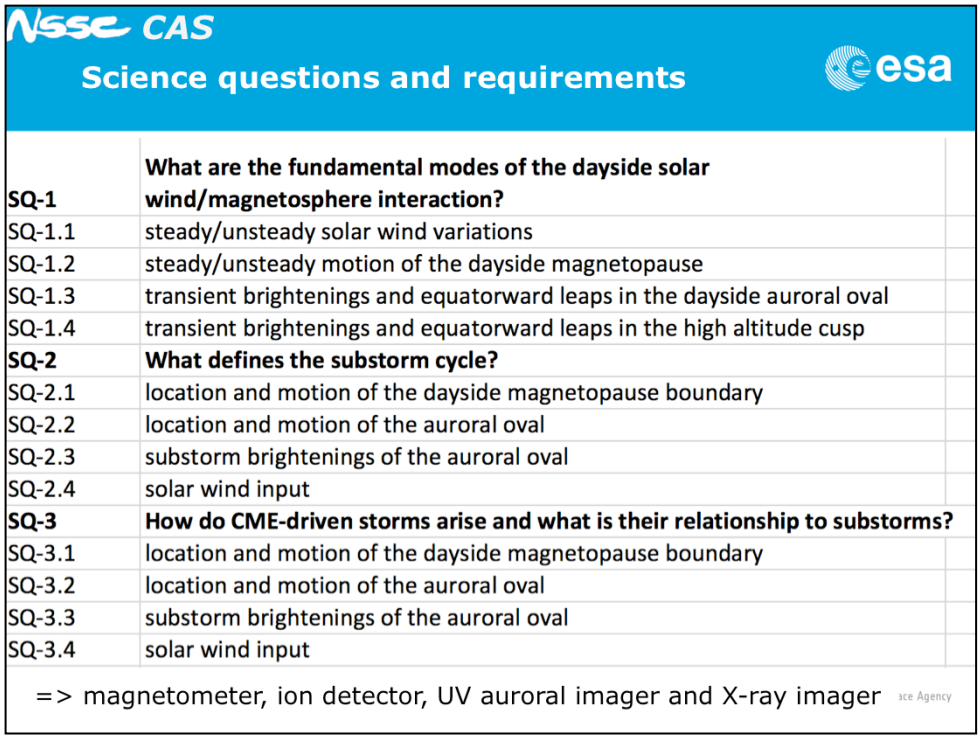


Smile logo derived from the simulation



Solar wind charge exchange process:

1. A highly ionised solar wind ions O7+ interact with an atom of hydrogen from the Earth geocorona (left diagram).
2. The O7+ pick-up the electron from H atom and become O6+ in an exited state (middle diagram).
3. 3. H atom become a proton (middle diagram).
4. O6+ emits a soft X ray and reaches a more stable state (right diagram)..

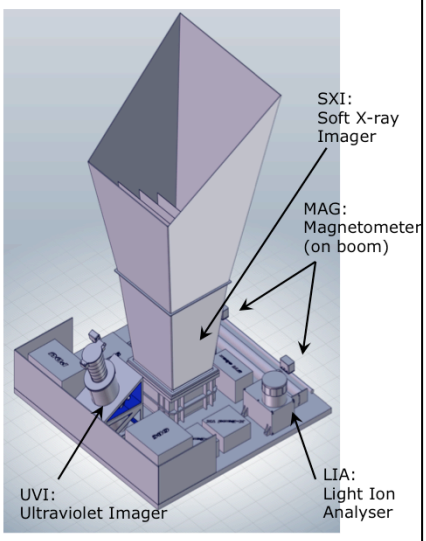


SMILE 3 scientific questions and top science requirements derived from these questions.

Instrument necessary to achieved this objectives lister at the bottom

SMILE instruments

1. LIA (Light Ion Analyser) is a top-hat analyser for detection of protons and alphas. Energy range 50 eV-20 keV. **PI: L. Dai, NSSC, CAS, China**
2. MAG (Magnetometer) is a flux-gate magnetometer with two sensors on a 2.5m boom. **PI: L. Li, NSSC, CAS, China**
3. SXI is a wide field lobster-eye 0.2-5 keV X-ray imager. CCD detectors. 25 x 25 degree FOV. **PI: S. Sembay, Leicester, UK**
4. UVI (UV imager) is a four mirror imager in the range 155-175 nm. CMOS detector. **PI: E. Donovan, Calgary, Canada**



The 4 instrument details, including Pis (left)

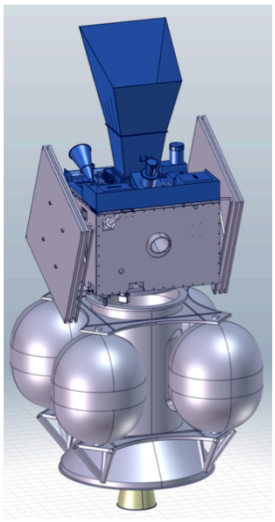
Their location on the payload module (right)

NSSC CAS

SMILE: collaboration between ESA and China

esa

1. ESA responsibilities:
    a. Payload module (see right figure)
    b. Launch (shared Soyuz, Vega or other launcher)
2. China responsibilities:
    a. Service module (power, pointing)
    b. Propulsion module (to reach 5000 km x 19 earth radii polar orbit)
    c. Ion detector and Magnetometer
3. ESA and China share operations

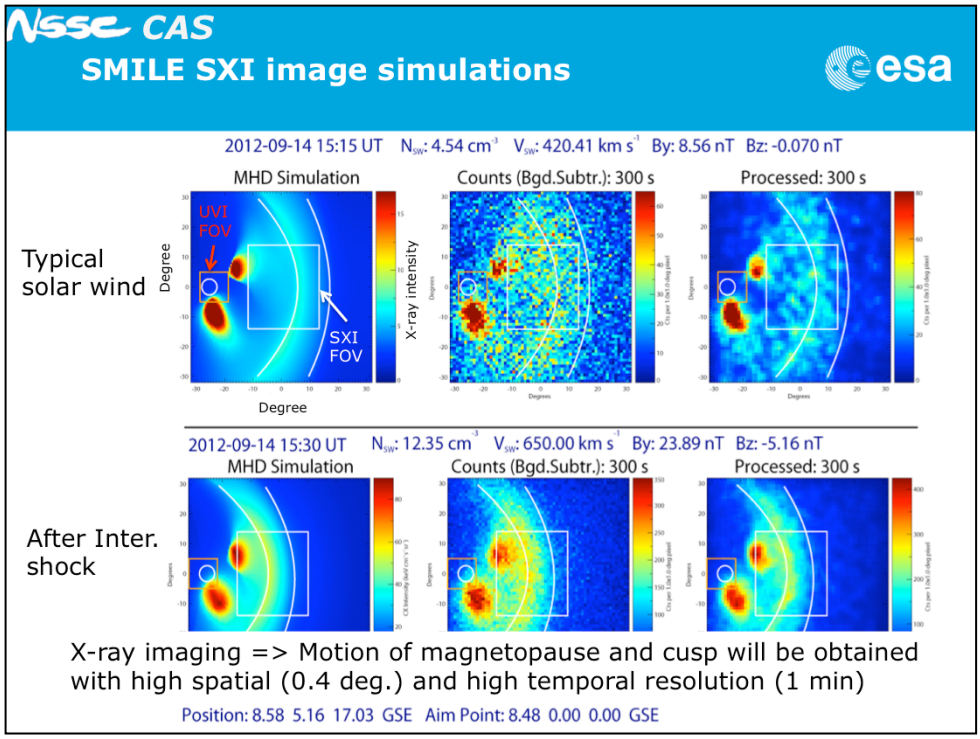


European Space Agency

SMILE is a joint ESA-China Academy of Science mission

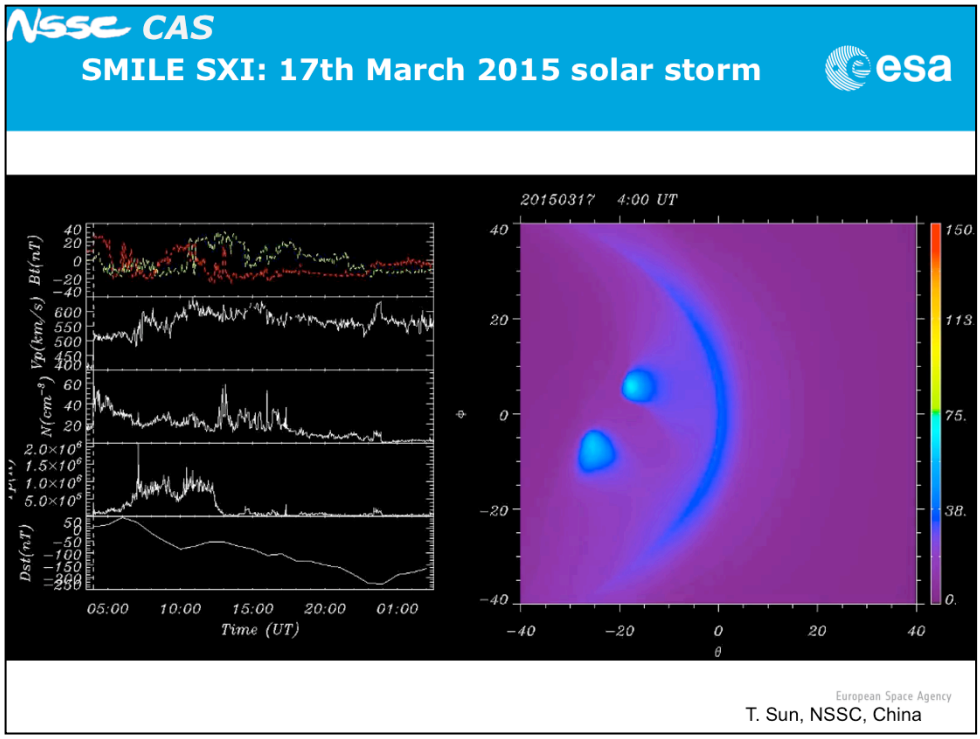
The sharing of responsibilities is listed below (left)

Spacecraft composite including the payload paltform (top in blue), the Service module (middle) and the propulsion module. Total mass is around 2 tons

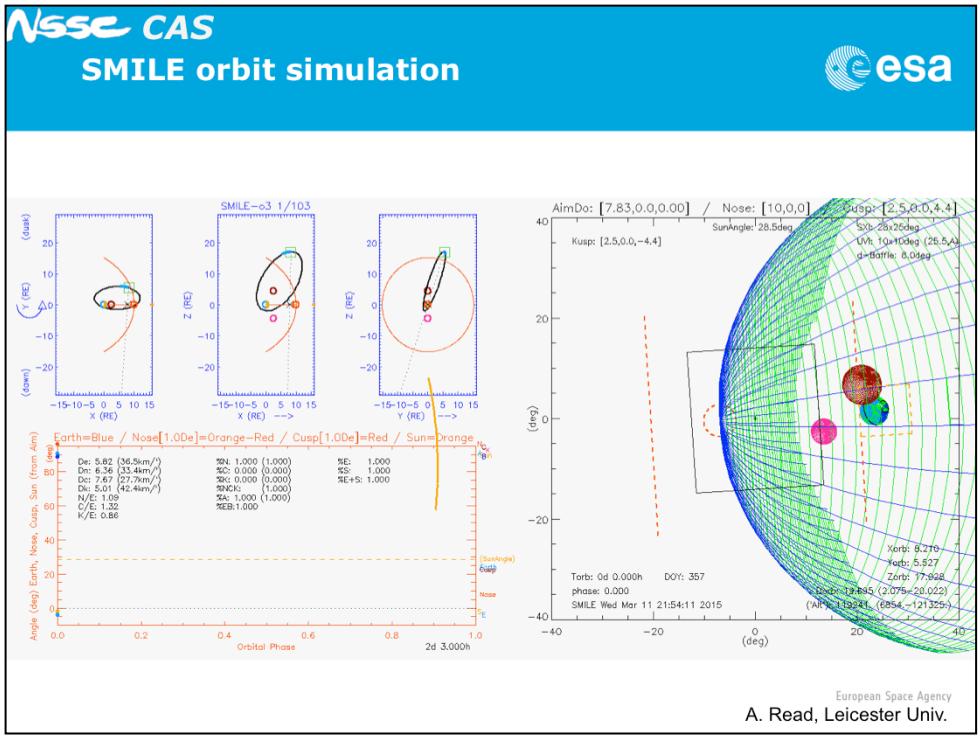


Simulation of X-ray imaging for typical solar wind (N=4.5 cm-3 V=420 km/s and By=8.5 nT) top diagrams and

After arrival of an interplanetary shock (N=12.3 cm-3 V=650 km/s and By=24 nT) bottom diagrams



Simulation of X-ray emissions during the solar storm of 17 March 2015. Note this is a movie



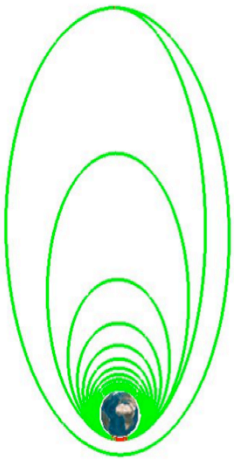
Simulaton of orbit (top left), field of views of the X-ray and UV imaging (right diagram) and target regions (bottom left diagram). Note this is a movie.

Nssc CAS
Mission Profile

esa

Launch option 1
- Dual launch with Soyuz used as reference from Kourou with Main Passenger determining the launch date into SSO 700 km; inclination 98.2 degrees

Launch option 2
- Single launch with Vega–C from Kourou into ~70 deg inclined orbit of either;
  - 700 km circular
  - 200 by 720 km orbit

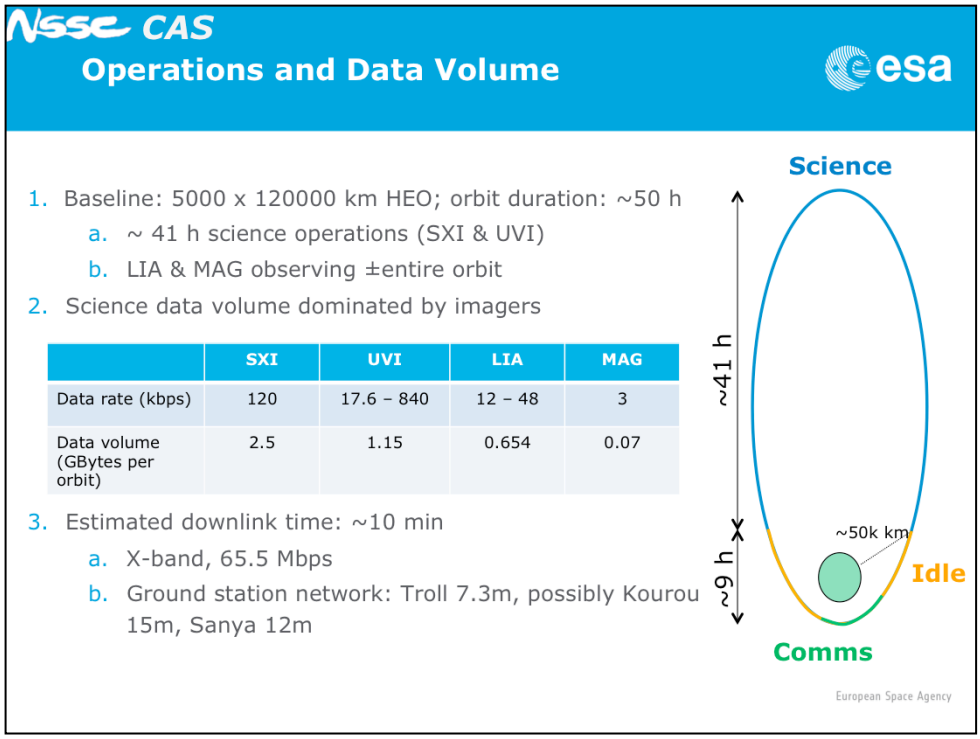


Final orbit:
- Option 1 launch:
  - 98.2 degree inclined polar orbit with 5000 km by 19 Re orbit, argument of perigee ~270 degree
- Option 2 launch:
  - 70 deg inclined orbit 5000 km by 19 Re orbit, argument of perigee ~270 degree
- No change of inclination with respect to injection orbit
- Delta-V is about 3 km/s from 700km orbit to HEO orbit to be performed by the Propulsion Module

End of Life
- Decaying orbit within 25 years (Space Debris regulation)

European Space Agency

Launchers options (right) and final orbits (right)



Science operations and communications during an orbit. The imaging instruments are switch-off in the radiations belts (orange segment)

SMILE milestones

1. Concurrent Design Facility (CDF) study (Oct. 15) with common sessions with Chinese CDF
2. Mission selected by ESA Science Programme Committee (Nov. 15)
3. Study phase (2 years)
4. ESA invitation to tender to industry for payload module (Jul. 16)
5. Mission adoption (4th quarter 2017)
6. Implementation phase (4 years)
7. Launch end 2021

Conclusion

1. X-rays from the magnetosphere: from 'unwanted background' for X-ray astrophysical observatories to diagnostic tool of Sun-Earth relation
2. SMILE will trace and link processes of solar wind injection with those acting on charged particles precipitating into the cusps and the aurora
3. Outreach: great interest for new magnetosphere imaging
4. Cooperation with China: SMILE is a showcase, building on Double Star experience