

Estrange capability expansion to strengthen Swedish operation in space weather

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Estrange is world-leading unique space port.
⇒ Small enhancement makes significant improvement in monitoring the **key region** for the space weather operation (80-200 km altitudes).

Idea 1: Develop a floating observatory to stay above the cloud with attitude determination $< 0.1^\circ$ (enough for all-sky camera).

Background: For space weather operation, the most important information is "**onset of the largest ionospheric activity at < 200 km**" during substorms", because it causes (i) large GIC that damages power grid and (ii) density anomaly that interrupts HF communication and GPS positioning. This "**onset**" is best predicted by monitoring optical auroral activity. Therefore, **all-sky camera placing above the cloud** improves the space weather operation significantly.

Task: Develop a floating platform that stay on the same place (Estrange) over a night during the winter season (15 LT-09 LT, or 14 UT-08 UT).

Note: Just 2 km altitude gives much higher visibility than from the ground.

Two options:

- (a) Miniature **airship** (used for surveillance at US-Mexico boundary)
⇒ *advantage:* can fly high > 2 km altitude.
Cost/time: 30-50 MSEK / 3-5 years
- (b) Unmanned air vehicle **UAV** (also investigated in Norway, Schaik, 2021)
⇒ *advantage:* easy to control the position.
Cost/time < 30 MSEK / < 3 years

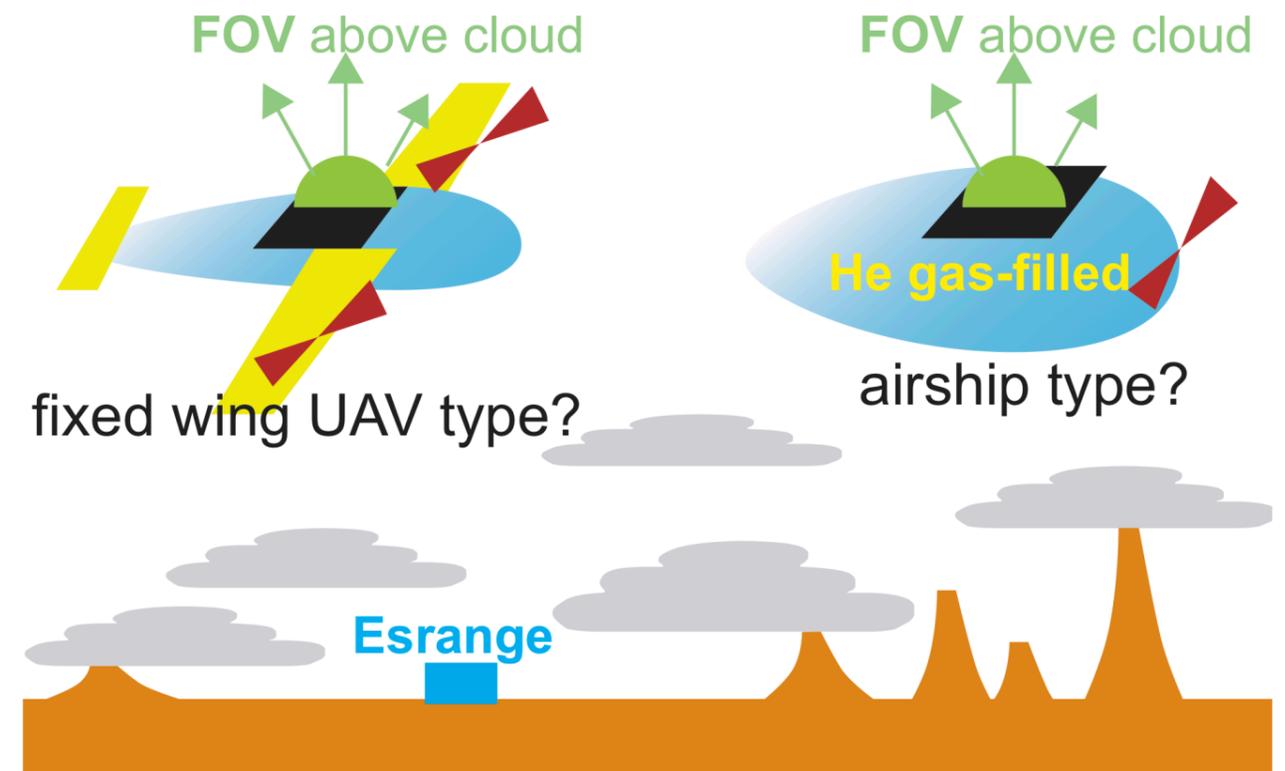
Other objects than aurora: **Mesospheric cloud** and **Stratospheric cloud**.

Why not satellite? LEO satellites (same image quality as from below) traverse the polar region too quick ⇒ need many satellites for continuous monitor of fine structure that is essential for prediction of local activity.

IRF: Expert of optical cameras and analysis program

KTH: Fixed-wing UAV research ongoing

Estrange: Best space port in the polar region for test and operation



Other merits for Sweden: (1) Estrange becomes more attractive space port for both science and tests. (2) The knowledge can also be used for hazard-monitor (avalanche, storm-cloud, wild fire, Antarctic, and worldwide volcano), and future Venus/Mars mission proposals.

Other idea 2: ESRAD renewal (unique monitoring radar for polar mesosphere in operation > 25 years). This is an independent monitor of both climate change and space weather activity. **Cost/time: 12-16 MSEK / 1-2 years.** (contact: E. Belova, IRF).

Other idea 3: Regular rocket experiments to measure the ion and neutral dynamics, which is essential for the space weather operation. SSC just gained the ability to design and conduct the experiments. **Cost/time: 50-75 MSEK / 3-5 years.** (contact: T. Sergienko, IRF).