**Esrange capability expansion to strengthen Swedish operation in space weather**

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Esrange 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° (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 (Esrange) 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 potions:**
(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

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

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**Other merits for Sweden:** (1) Esrange 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).