Breakout Discussion

at the 8th UNISEC-Global Meeting

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Ideas Generation

Some of the ideas coming out from the group…

- *Complementary or Independent GNSS System*
- *IoT constellation (with ground sensors, low power…)*
- *Remote sensing – optical systems, VIS band*
- *Remote sensing: optical (or laser) debris detection in-orbit*

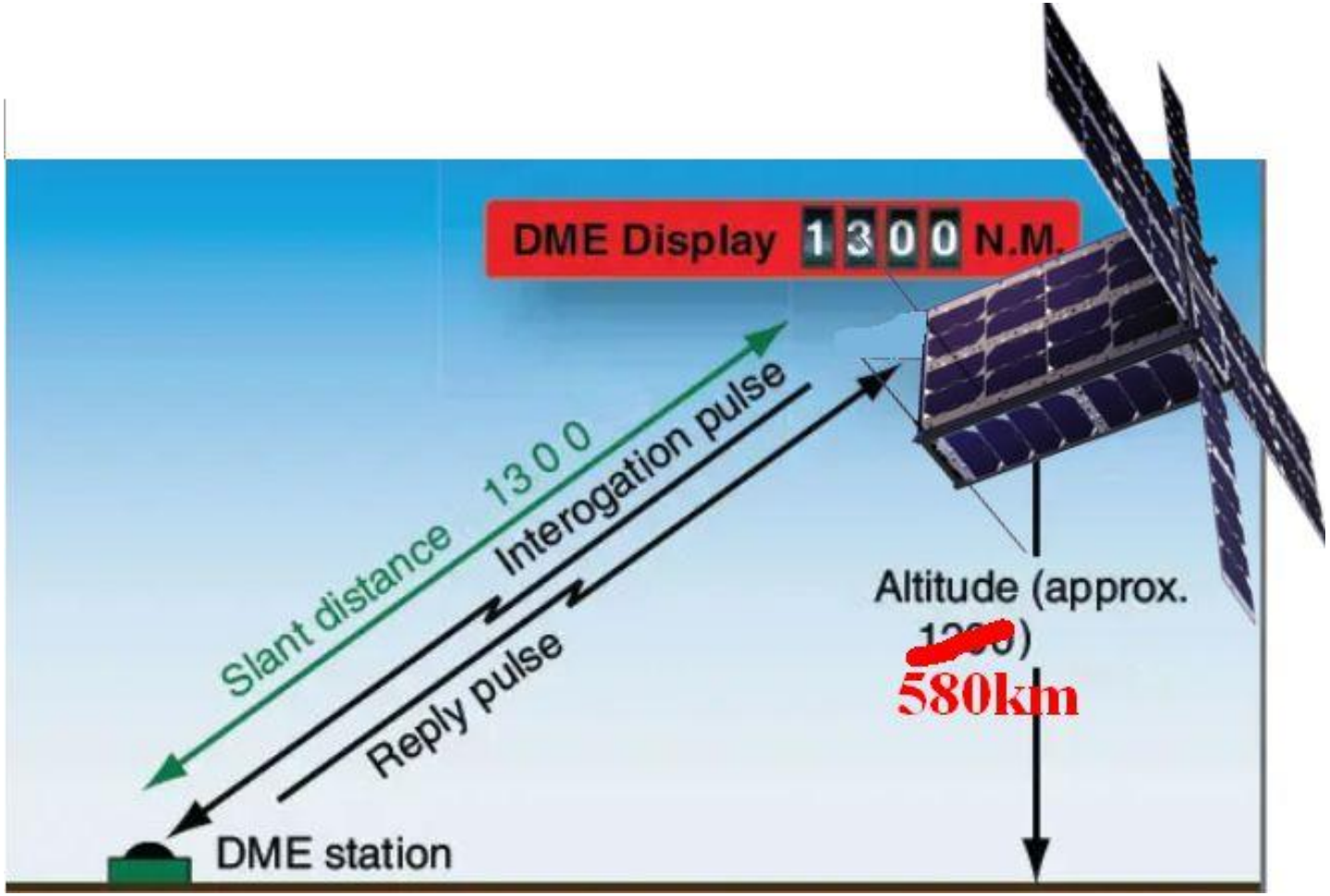
The idea: GNSS Constellation

- Independent GNSS system – always operational, not relying on governmental decisions on availability or switch-off
- The proof of concept constellation will be flying in LEO – to make it low-cost and to limit the launch costs

What makes us different?

- The on-board atomic clocks are miniaturized (CSAC technology)
- Ground-based calibration systems are simple and can be easily managed
- This calibration system is RF-based

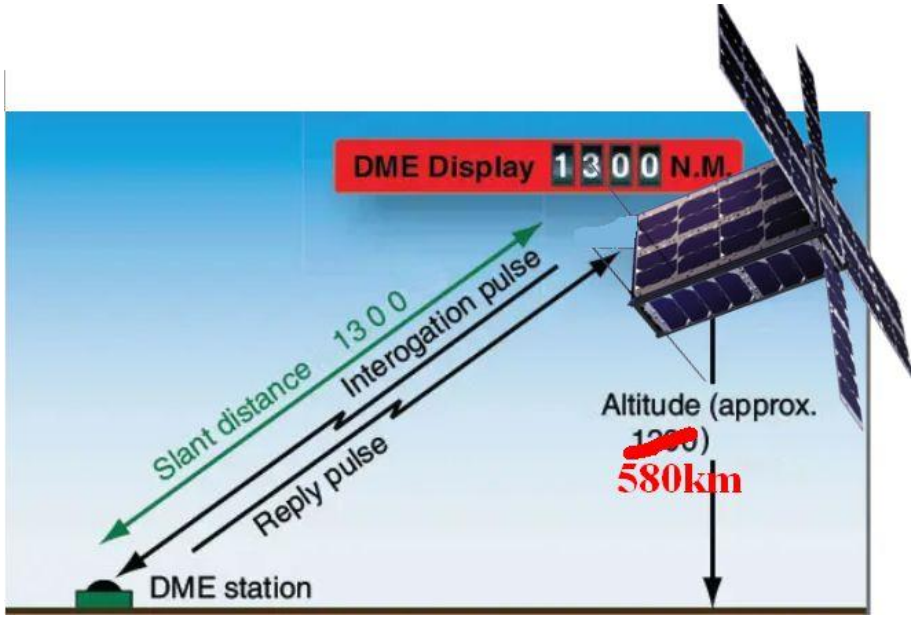
Concept of operations



The 2U payload

- The advantage of using an SDR-based system gives the possibility to use the payload for multiple objectives, such as:
  - Internet-of-Things. The calibration stations can be used as IoT nodes for ground instrumentation etc.
  - Disaster monitoring: besides having a positioning system which is **always available**, alternative operational modes focusing on disaster monitoring can be available, including inter-satellite link exploitation

The idea: ground calibration stations



- The system exploits ground-based calibration stations at known locations
- The stations can be used both for satellite position and ephemeris calibration and for rough positioning (see next slide)
- The stations can gather data through small sensors and act as IoT nodes

Positioning alternatives

1. Testbed for LEO-based GNSS: providing a test environment to verify the technologies and techniques required, such as:
    1. Higher Doppler to be compensated
    2. Visibility of multiple satellites: how to achieve this with LEO?
    3. How do I make the positioning algorithm converge in LEO?
2. Rough positioning using the on-ground calibration station
    1. Knowledge of satellite position: making it precise through autonomous calibration
    2. Rough positioning of ground nodes with respect to the satellite – just 1 satellite and 1 ground node with active RF communication

Special payloads (1U)

Every country participating to the Group has a specialized payload of 1 CubeSat Unit:

- Nepal: **ADS-B repeater** for air traffic monitoring
- Kazakhstan: **VIS + IR camera** for water resources management
- Türkiye: **Experimental miniaturized rubidium atomic clock** – technology demonstrator for new GNSS features + **experimental high resolution camera**
- South Africa: **Real time radiation monitoring payload** – prediction of UV index?
- Italy: **Educational payload** – “easy” amateur radio digipeater for Italian middle and high school students – to make them passionate about space

Satellite Constellation limitations

1. Low Earth Orbit: general purpose electronics are ok, launches are available (reducing costs), ground nodes performances can be low enough
2. Global coverage is needed: UNISEC is made by many nations and we like to aim at disaster monitoring worldwide
3. Four satellites in view on any place covered by the service (traditional GNSS with spherical positioning) – it conditions the number of satellites
4. Not too large separation distance to allow inter-satellite link and to make it feasible with general purpose communication systems

Constellation: General requirements

1. Inclination: Most of the world's population lives between + and – 60 degrees of latitude: polar orbits are not strictly needed. **Proposal: 65 degrees inclination** for main planes, to mix with polar orbits if needed
2. Altitude needs **not to interfere with new mega-constellations**: let's stay higher than Starlink! Proposal: 580 km high orbit
3. **Inter-satellite link needs not to cross the Earth's atmosphere** – We need minimum 8 satellites per plane. Inter-satellite distance with 8 satellites is 5000 km.
4. For traditional positioning schemes we will need **20 degrees separation (roughly) among planes**, that makes it **16 satellites and 9 planes = 144 satellites!** (**TOO MANY!)** So the implementation plan is:

5. **Proof of concept at LEO – with limited number of satellites – 6-8**
6. **Implementation in MEO – with less satellites (ideally 24-32 as for GPS)**

Constellation: Satellite bus requirements

1. **Fine temperature control** for the oscillators and atomic clocks: +/- 3 degrees
2. **Doppler compensation**: to be done for signal correlation
3. **Memory**: no heavy constraints on size, but many write/delete cycles, better solid state memories, and good data handling
4. **Mass**: main payload will be around 2.5 kg, that does not appear to be a problem
5. **Battery size**: shall support the mission for 10 years, roughly 135 Whr
6. **Power budget positive with constantly on active thermal systems and 25-35 W atomic clock**: doable with deployable panels (75W), not body mounted
7. **Communication at relatively slant range** (both to ground and inter-satellite) probably with omni antennas
8. **Pointing:** probably ok with 1-5 degrees accuracy, not very limiting

Not familiar with satellite technologies? Not a problem.

Level 1: Host and operate the calibration stations!
All UNISEC Countries are called to host it and practice with calibration

Level 2: Host the ground stations and control the satellites!
After practicing with calibration, you can build the ground stations and operate!

Level 3: Build the satellites!
You can contribute to the next generations of the satellites after practicing with levels 1 and 2

Thank you for your attention!

- Paolo Marzioli, Italy
- Arno Barnard, South Africa
- Alim Rüstem Aslan, Türkiye
- Ersin Makas, Türkiye
- Sudip Bhattrai, Nepal
- Onur Öztekin, Türkiye
- Baris Beynek, Türkiye
- Alisher Aden, Kazakhstan