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# Development of 3D Synthetic Vision with network of pico-satellites

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# SATELLITE CONTEXT

- Now observing the Earth from space is performed by means of a series of satellites.
- A Pico-satellite constellation plays an important role in missions of vision and surveillance of ground.
- Spacecrafts may be threatened by the effects of external disturbances.
- Each satellite networks requires solutions to avoid threats (disturbance).

# Outline

I. Objective

II. Satellites Network

III. Choice of Architecture

IV. Application

V. Conclusion and Outlook

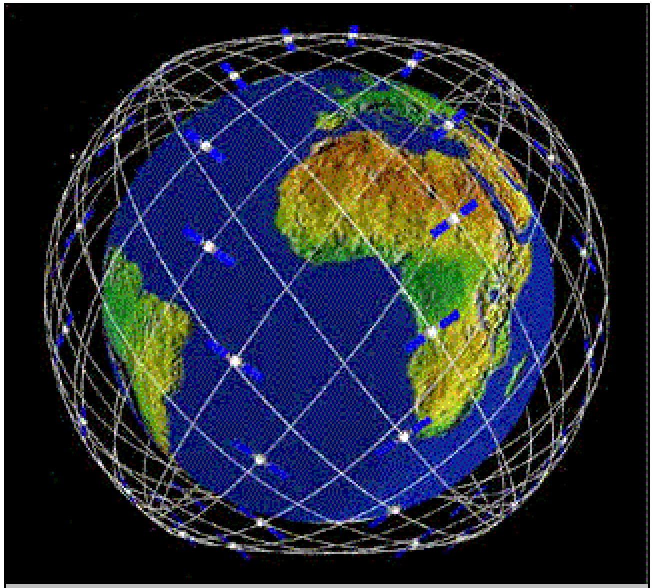
# Objective

- Perform an architecture of constellation of Pico-Satellite that meets the coverage of Tunisia:
  - desert region exploitation and monitoring .
  - fire detection, earthquake forecasts and predictions of volcanic activity…
  - Propose optimal solutions that take into account the constraints of the architecture and minimize the number of satellites covering

# Satellite Networks

## ❑ Advantages of formation flying

Several identical satellites in cooperative orbits



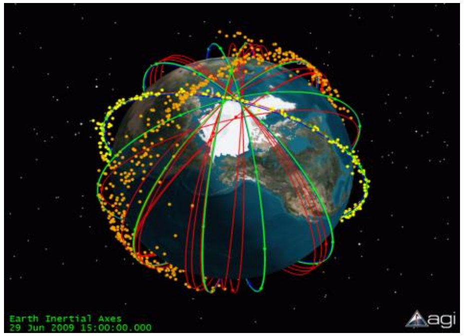
SATWEB.JPG

- Make possible new observing capabilities
- On-orbit reconfiguration within the formations offers multi-mission capability
- Reducing the size and complexity of the satellites in the formation.
- Take advantage of economies of scale
- Can reduce launch costs

## ❑ Background Issues

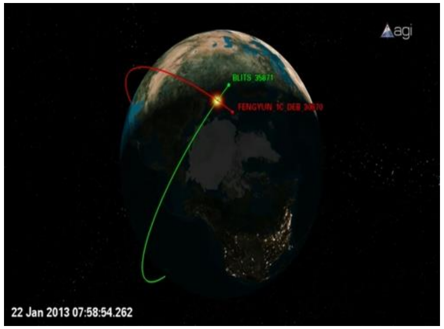
➢ Two phases of mission of Nanosatellites:

- ❖ placement on operational orbit.
- ❖ counter orbital perturbations.




## ❑ Specific problems in training:

- ❖ Collision of satellites
- ❖ relative motion modeling

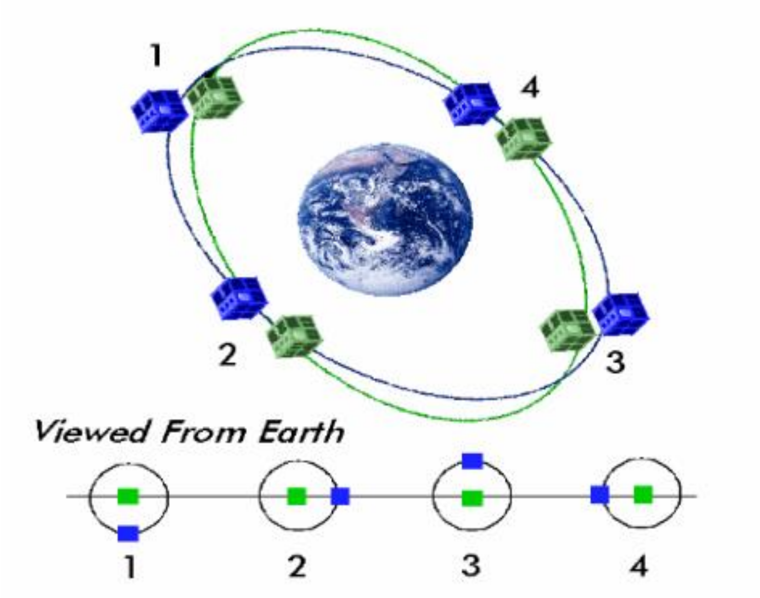


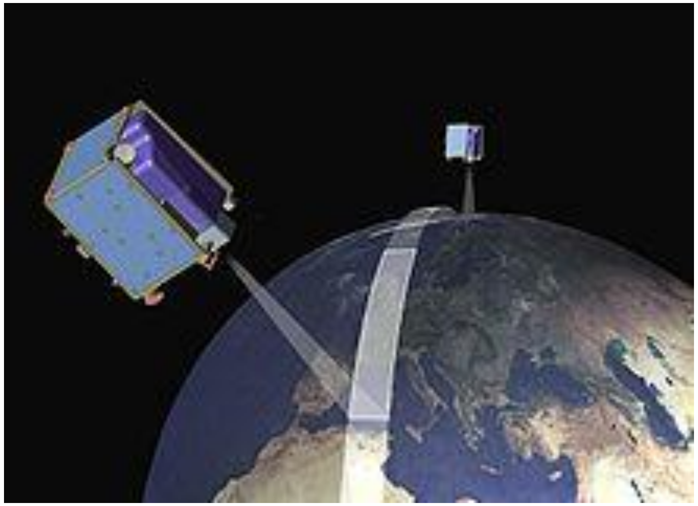

Over hundreds of thousands of pieces of this collision build a cloud in LEO

# Choice of architecture

- Architecture avoid any collision.
- Relative motion of each satellite
- Determined and fixed distance between each satellite.
  - Low dimension of training ⟶ Differential acceleration = 0
  - Relative Velocity between satellites = 0
  - Stable geometry.

✓ **Undisturbed environment with high accuracy**



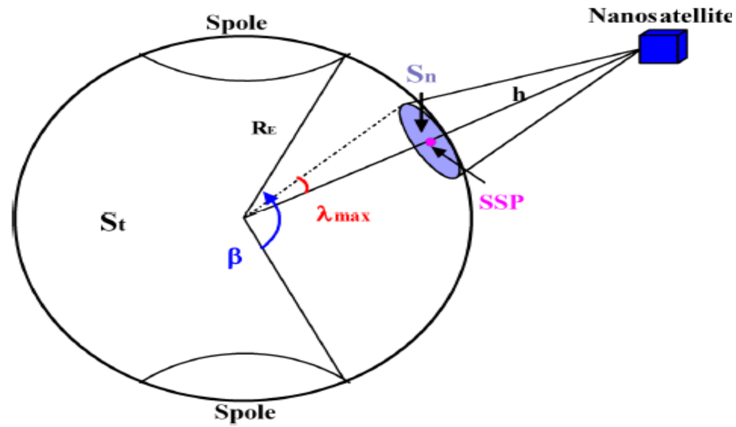



- hierarchy of authority.
- geometry of the formation does not change along the reference orbit.
- suitable for applications in meteorology and environmental.

- A satellite training must have:
  - As cloakroom, on the other satellite state.
  - A control law that depends on the other member.
- Their positions are determined by the distance measuring devices DMD and GPS.
  - DMD determine their relative distances to each other
  - GPS determines their position relative to the Earth and checks the distance measured between the satellites.

# Application

## ❑ Constellation Modules



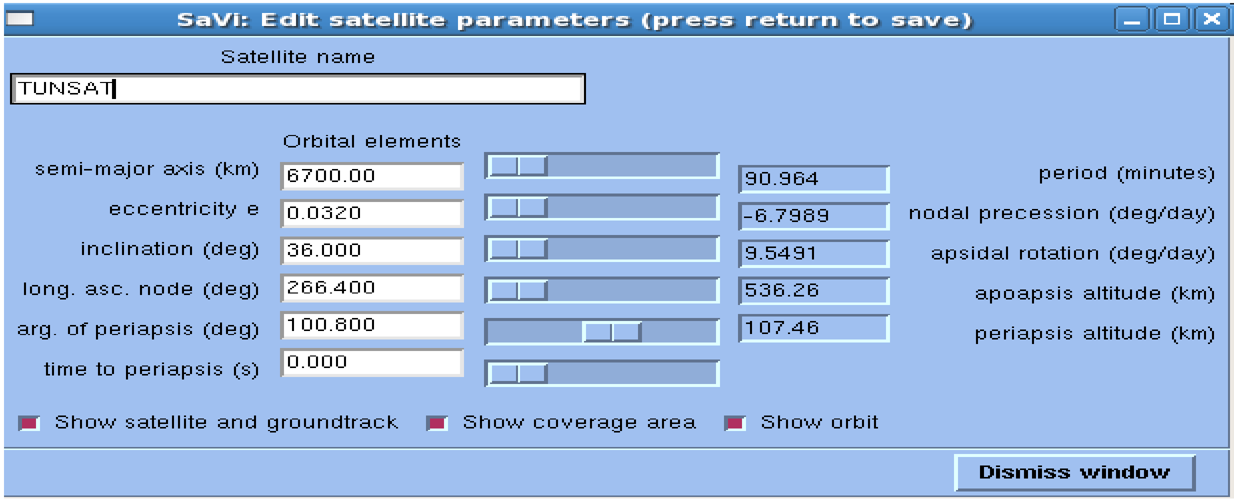

| Design vector variable | $\Sigma$ | Range |
|---|---|---|
| Constellation altitude | $\sigma 1$ | 300 Km |
| Downlink data rate | $\sigma 2$ | 140 Kbps |
| elevation angle | $\sigma 3$ | $5^\circ \leq \varepsilon \geq 10^\circ$ |

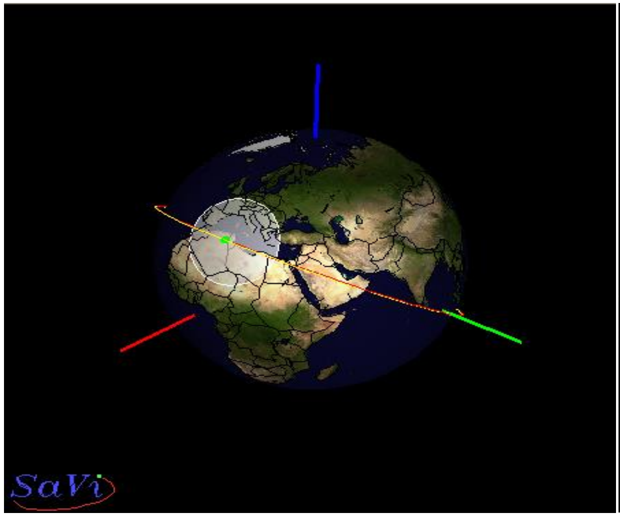
Nano-Satellite for Tunisa Coverage Design Vector

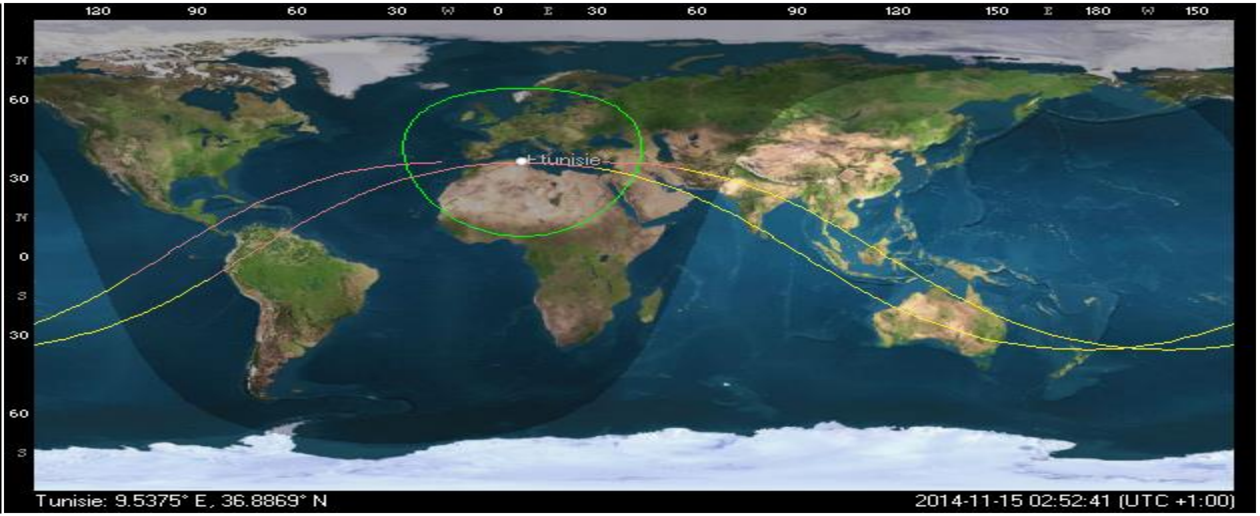
| Constant vector variable | $\Gamma$ | Value |
|---|---|---|
| Latitude | $\gamma 1$ | 34° |
| Inclination angle | $\gamma 2$ | 36° |
| β angle | $\gamma 3$ | 56° |

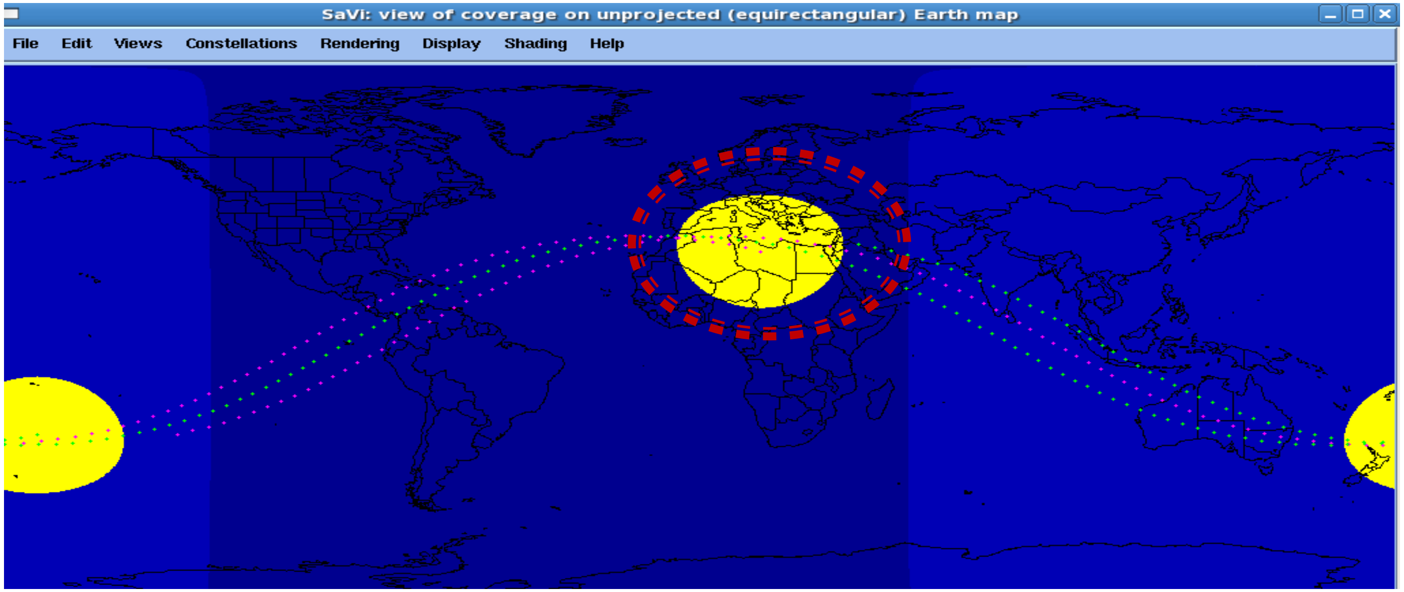
Nano-Satellite for Tunisa Coverage Constant Vector

# ❑ orbital parameters

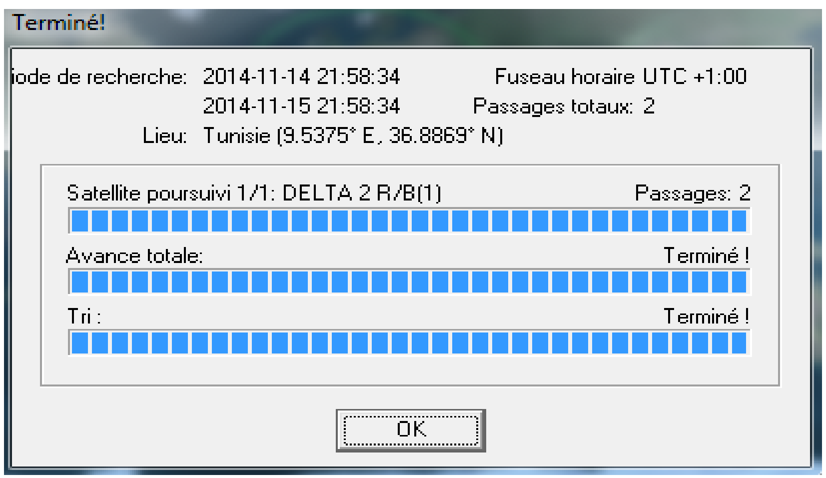





## Nano-Satellite for Tunisa Coverage




| | |
|---|---|
| Number of Nano-satellites | 2 Sats |
| Earth central angle ($\lambda_{max}$) | 14,94° |
| Maximum time in view ($T_{max}$) | 7,51 min |
| Orbital Period | 9h |
| Number of orbit per day | 2 |

## Outputs of Nano-Satellite for Tunisa Coverage

µEi

# Conclusion and Outlook

## ❑ Conclusion

- Review of some problems in LEO satellite networks.
- Find an architecture of satellites network that can interact with the most problems.

## ❑ Outlook

- Discuss the best architecture of Leader-Follower for the best coverage of the earth (one or two Orbits).
- Sizing coverage area

# Thank You!

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