

# Distributed space systems for Earth observation

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# OUTLINE

## 1. Definitions

## 2. Constellations

DMC-1

RapidEye

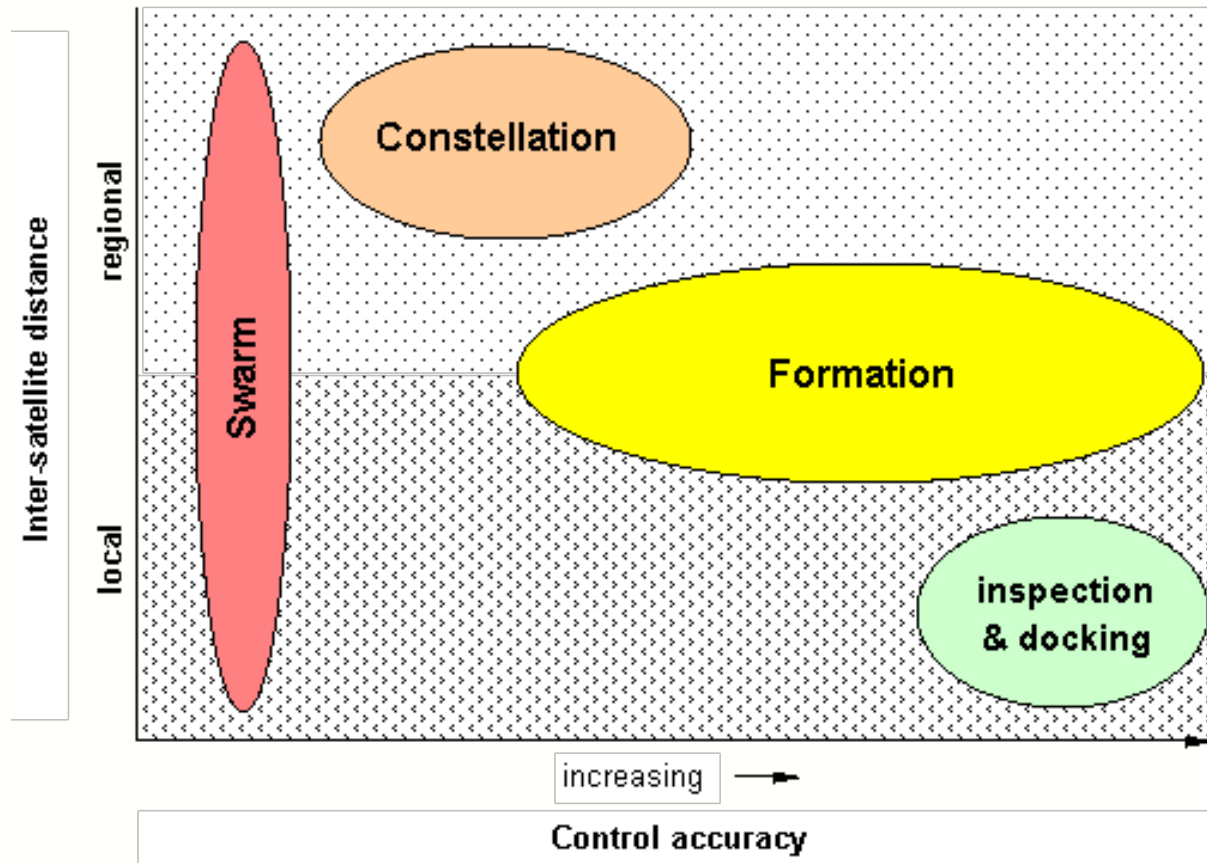
## 3. Formations

SWARM

SAC-C in Morning Train

GRACE

# Distributed space systems, requirements





# Difference of constellation and formation concepts

- A **constellation** is composed of two or more spacecraft in similar orbits with no active control by either to maintain a relative position.
- **Formation flying** involves the use of an active control scheme to maintain a relative position.

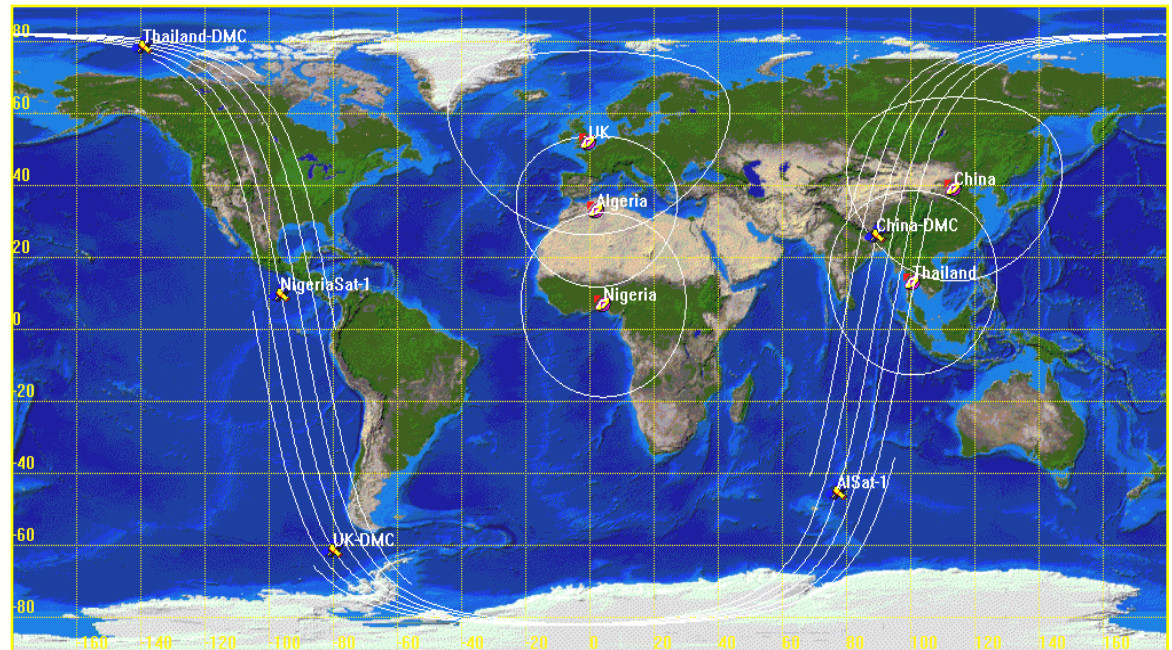


# Relative position and active control

- **Active control** scheme: the scheme can be executed in orbit or on-board, but it can also be implemented on the ground. It can be executed in real-time but it can also be implemented post-time.
- **Relative position:** The measurement of relative position can be done directly or indirectly. Direct measurement is usually applied to precisely tight formation flight while the indirect one is often used in a coarsely loose formation flight.

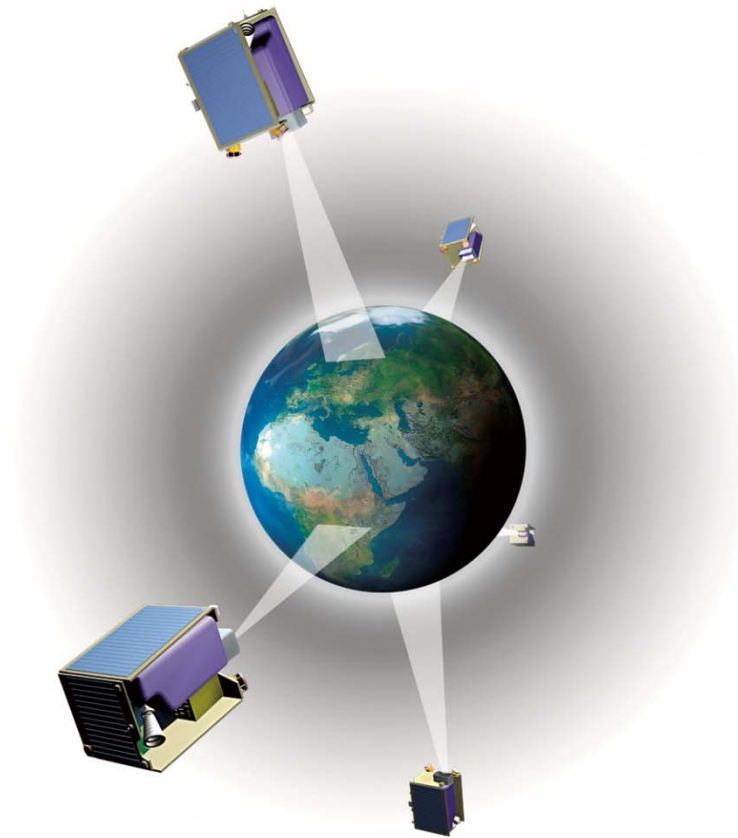
# Disaster Monitoring Constellation DMC-1

- AISat-1
- BILSAT-1
- NigeriaSat-1
- UK-DMC-1
- Beijing-1



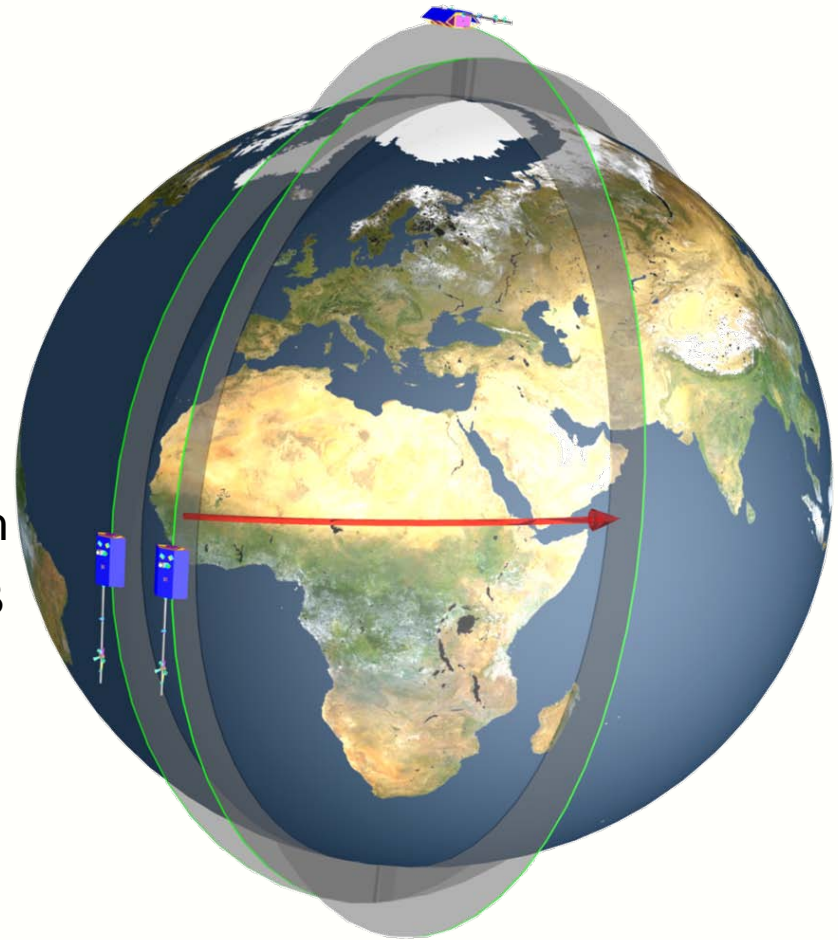
- launched with three COSMOS launchers into the same orbit

# RapidEye



# SWARM - Earth Magnetic Field Explorer

- Two Satellites at 450 – 300 km flying side-by-side with  $\sim 1.4^\circ$  separation in longitude, east-west gradient of the magnetic field
- One Satellite (C) at 530 km with an orbit plane separation to A/B of  $\sim 3-9$  h local time
- Near polar orbit
- Launch 2010





# SWARM operation





# Why Fly As A Constellation/Formation?

Constellations flying in formation form single “virtual” platforms which enable coincident observations (data fusion aspect):

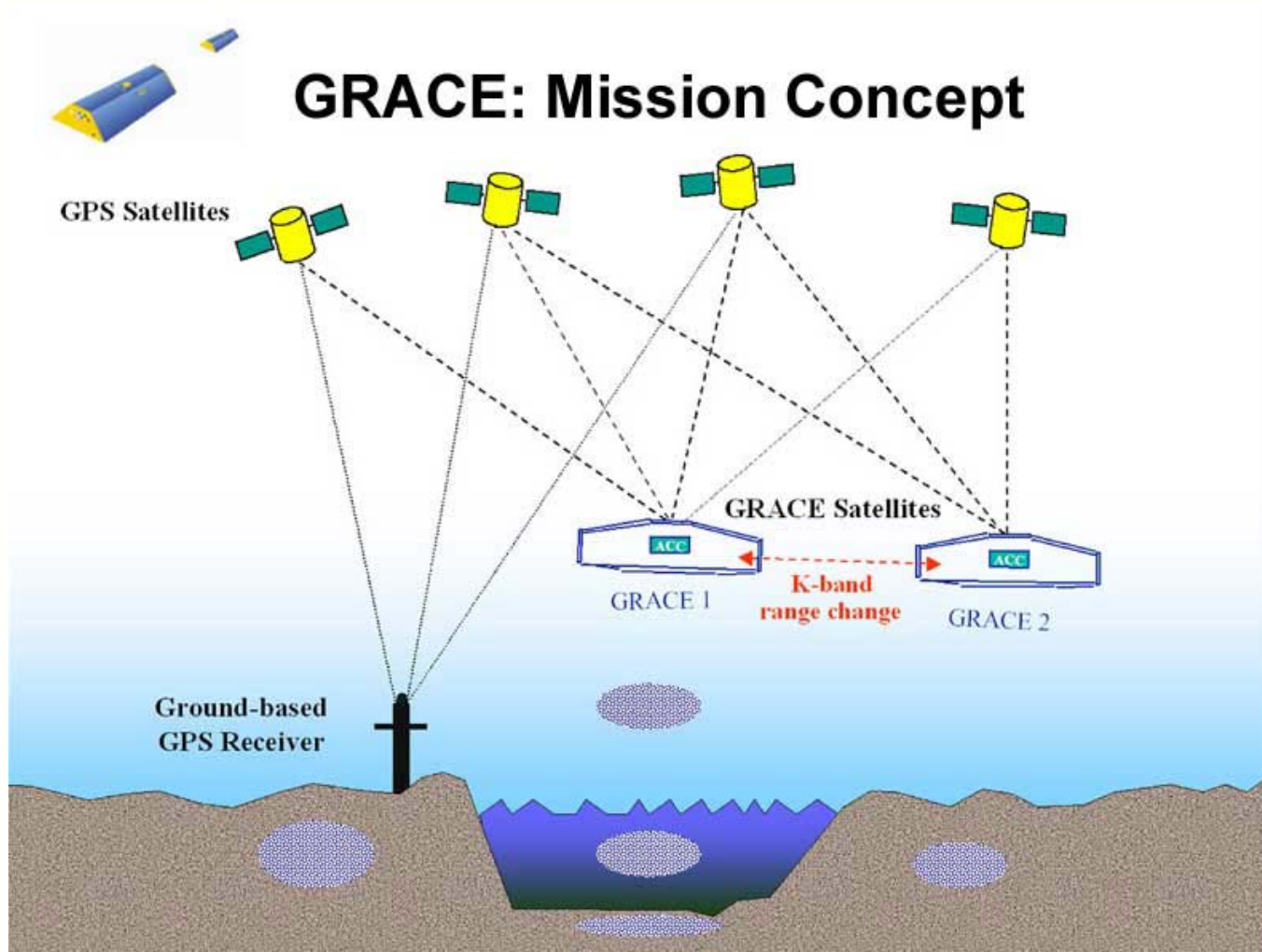
- Increase synergy between satellites; Instruments on multiple satellites can observe the same scene at about the same time,
- Facilitate coordinated validation and calibration efforts, and

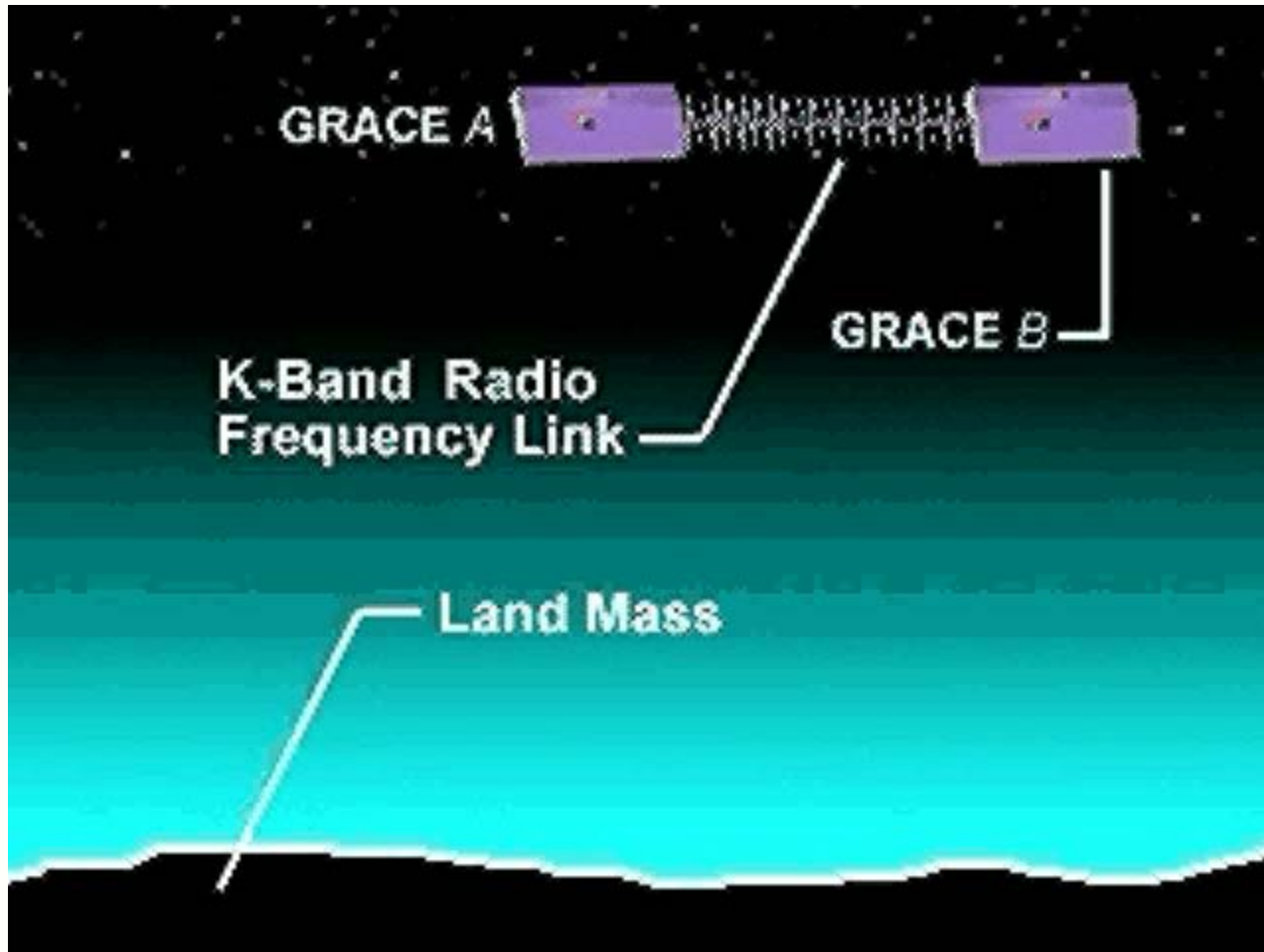
*“The sum is greater than the parts...”*

# Morning train



# GRACE – Mission concept







# Advantages of constellations & formations

- Increase of time resolution and daily coverage depending on the number of satellites within a constellation
- Substitution of complex satellite systems (or complementing them) using different (distributed) instruments on small satellite platforms making use of data fusion in formations
- Easy replacement of a satellite within a constellation or formation due to the relative low costs of a single satellite
- Soft degradation of the system performance caused by the malfunction of one satellite of a constellation