The G-CLASS Mission Proposal for EE10

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An overview of the G-CLASS mission concept and applications

- *A step change in temporal sampling and versatility for EO*

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1. Introduction and Overview

- What is G-CLASS?
- Snapshot of the G-CLASS science case and implementation baseline
- The Science team
- Development schedule

G-CLASS:H2O

Geosynchronous – Continental Land Atmosphere Sensing System: Water

A mission to observe and understand processes of the daily water cycle over land

G-CLASS (H2O) builds on the heritage of earlier **geosynchronous radar** mission proposals

- GeoSAT (ESA Earth Explorer 8 proposal)
- GeoSTARe (ESA Earth Explorer 9 proposal)

G-CLASS benefits from recent technical studies which have matured the mission concept including

- Radar clutter field observations and simulation – needed for E2E mission simulation
- Radio Frequency Interference assessment
- Soil moisture retrieval for high incidence angles

G-CLASS is proposed for ESA's Earth Explorer 10 call for mission ideas

- *G-CLASS is likely to be renamed as we develop the mission concept*

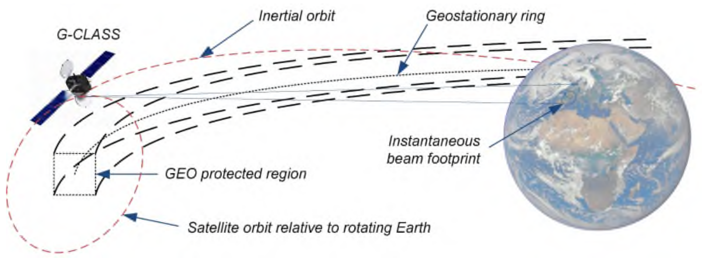
Explicit science focus on daily water cycle over land – uses the mission concept's strengths

G-CLASS mission concept

Science drivers require persistent observation of the water cycle

Persistent: use a constellation (expensive) or geosynchronous orbit (feasible, but not global)

Water cycle: use microwaves (all weather, sensitive to liquid and vapour phases of water)



Geosynchronous Radar is the G-CLASS mission concept

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G-CLASS Science Objectives

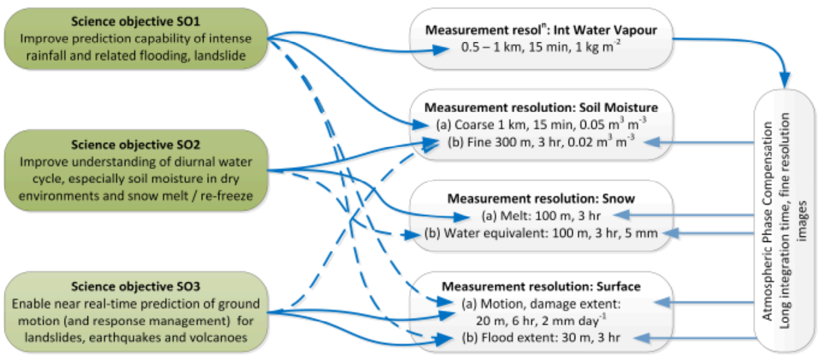
Primary science focus is the diurnal water cycle

SO1: Intense rainfall and its impact (flood, landslide)

SO2: Diurnal water cycle processes (snow melt, soil moisture)

Opportunistic science:

SO3: Ground motion – earthquakes and volcanoes



G-CLASS science objectives and related measurement needs

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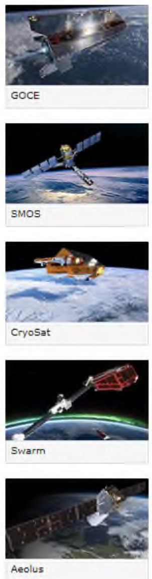
European Space Agency Earth Explorer programme



Earth Observation science-led missions

Every 2-3 years, ESA invites the European science community to propose new missions to address significant science challenges

- Core (larger) and Opportunity (smaller) missions

In September 2017 ESA invited proposals for its 10th EE mission

- Core mission (€225M for industrial costs)
- Launch expected 2027-28
- Missions must answer significant science challenge
- Provide clear societal benefits
- Innovative technology

G-CLASS was proposed for EE10 by a team of scientists with industry support

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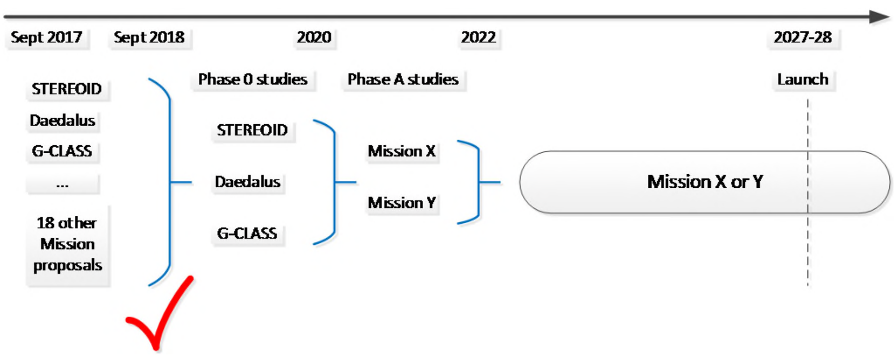
EE10 Mission Selection Process

21 proposals were submitted in March 2018

- In September 2018, three missions were selected for formal Phase 0 study (2018 – 2020): **G-CLASS**, **Daedalus** and **Stereoid**
- Mission Advisory Groups have been defined for each mission, first meet in January 2019



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2. Background to Geosynchronous Radar

Published concepts start with Tomiyasu in 1978

Initial concepts from US
- High inclination orbit, continental coverage, huge antenna, high power

European studies
- Politecnico di Milano, Cranfield, Barcelona – several mission concepts

Research in China
- Beijing Institute of Technology, Beihang University, CAST

Two broad classes of designs:
- High inclination, large antenna (10-20+ m), high power (kW RF)
- Low inclination, small – medium antenna and power, 100s of W

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European GeoSAR Studies

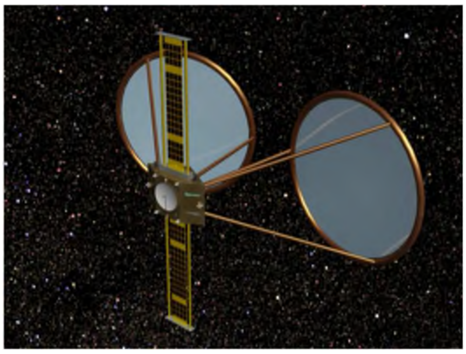
Low inclination orbits, modest antenna and power

Prati et al. (1998, Politecnico di Milano) published mission concept for passive bistatic GeoSAR using digital audio signals
- Background studies by DLR, etc. (e.g. *EUSAR 2006 Tutorial - Krieger (2006)*)

Cranfield studied complete mission design

Barcelona developed expertise in system calibration and phase compensation

ESA proposals
- GeoSAT for EE-8 (commended)
- GeoSTARe for EE-9 (unable to meet tight cost cap)



Visualisation of Cranfield GeoSAR mission concept (2006)

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Chinese GeoSAR Research and Implementation

Medium – high inclination, large antenna (?)

Chinese research teams have been active in GeoSAR research for the last decade, and have published studies on a variety of mission concepts

- Especially high inclination ones similar to the early US studies

The most active group seems to be Beijing Institute of Technology (led by Profs. Teng Long and Cheng Hu – both worked with UK groups)

- Several other Chinese universities have published useful studies too

Chinese industry (CAST – based in Beijing and Xian) is reported to be developing a GeoSAR mission due for launch ~2022

Little has been openly published, but based on studies in the literature we expect

- Satellite in a medium inclination orbit (5-20°?) focussed on Chinese mainland applications
- Large deployable antenna (15-20 m?)

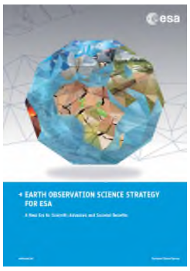
3. G-CLASS Science

Focus on the diurnal water cycle – play to GeoSAR's strengths

Opportunistic study of ground motion in general (earthquake, volcano)

1. GeoSAR's strengths
2. Diurnal water cycle
   a. Intense storms
   b. Diurnal processes
3. Ground motion

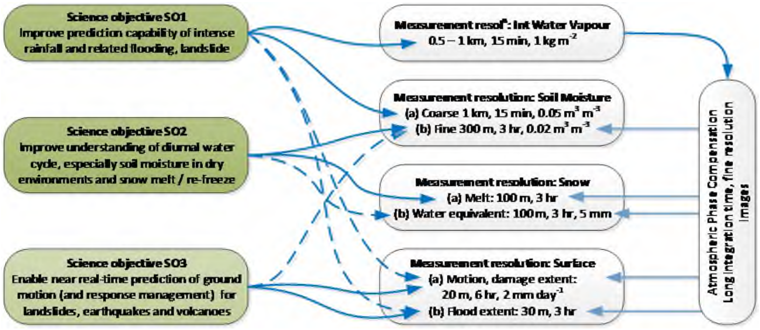
Water Cycle Science - ESA



Fundamental to life on Earth and to human society

ESA Science Strategy challenges:

- **A1, A2, A4, C3, L2, L5 and G1** (all have water cycle links),
  - E.g. A1 = Processes linking water vapour and the hydrological cycle with radiation
- Other reviews of science needs also support the diurnal water cycle goals
- **Science Objectives** and the corresponding **measurement requirements** are summarised as:



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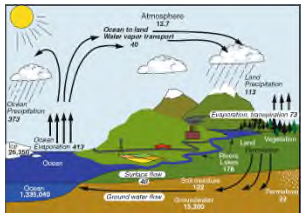
Science Case Snapshots

Water cycle (Trenberth, 2014)



Refer to the (redacted) proposal for details

Meteorology

Fine spatial and temporal resolution of atmospheric integrated water vapour support the planned fine resolution NWP – calibration, validation, initialisation

Solid Earth

Rapid response imaging of ground motion (landslides, earthquake, volcanoes) enables real-time services for the first time

Soil Moisture

Images every few hours allow diurnal changes in soil moisture to be observed directly – new insights into diurnal water cycle processes

Mountain Cryosphere

Frequent InSAR images enable new methods of estimating snow water content – important for understanding snow melt, etc.

Bingham mine

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4. GeoSAR Mission Principles

A short tutorial in GeoSAR

- Same physics as for LEO radar, but some significant differences – familiar and different

1. Radar imaging from GEO – *aperture synthesis*
2. Long integration times – *phase corrections needed*
3. Geosynchronous Orbits
4. Imaging opportunities through the day and through the year
5. What we can measure using GeoSAR – *atmosphere and surface*
6. System design trade-offs

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4.1 Aperture Synthesis in GEO

For useful along-track resolution we use synthetic aperture radar

Aperture synthesis:

1. Record the full signal (amplitude and phase) at many positions across the "aperture" to be synthesised
2. Apply phase corrections for known effects (especially change in radar position, but also any change in the atmosphere above the target, etc.)
3. Add all the phase-compensated signals numerically to form the image
    - Phase correction function is unique to each point in the image

- Note that accurate phase compensation is critical

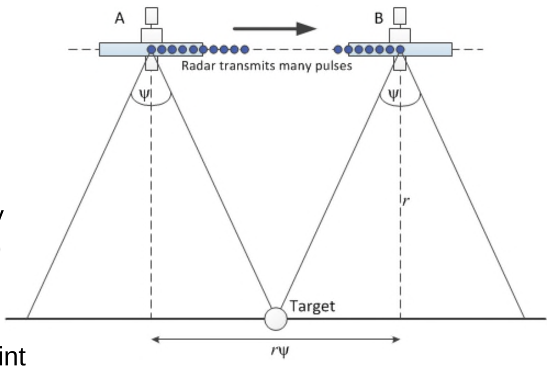

Image shows the "normal" SAR principle; GeoSAR differs – (1) synthesised aperture may be much smaller than the beamwidth, or (2) we point the beam to achieve a longer aperture

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4.2 GeoSAR Integration Times

We use long integration times (or large antennas) to compensate for the much longer range

Typical LEO SAR collects signal for ~1 s for any target on the ground

- Satellite orbit speed is ~7.5 km s^{-1}, so synthesised aperture is a few km long

In Geosynchronous orbits the speed relative to Earth is much slower than for LEO

- Depends on inclination (N-S motion) and eccentricity (E-W motion)
- Typical values are up to 1.5 km s^{-1} (high inclination) down to ~m s^{-1} (for orbits within a standard ±0.1° ITU station-keeping box for comsats)
- G-CLASS baseline assumes an E-W amplitude of 1200 km, so relative speed ≤ 44 m s^{-1}

Along-track resolution: $L_y = R\,\frac{\lambda}{2\,d_{syn}} = R\,\frac{\lambda}{2\,v\,t_{int}} \approx \frac{1.078\,.\,10^6}{v\,t_{int}}$ (SI units, C-band, typical GEO range)

E.g. v = 28 m s^{-1} (mean for G-CLASS) and t_{int} = 40 s give 1 km resolution
(400 s = 6.7 min for 100 m resolution, etc.)

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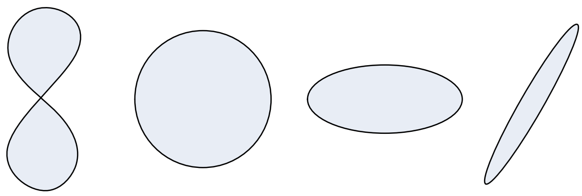
4.3 Geosynchronous Orbits

Inclination and eccentricity (and their phasing) define the relative orbit



Although the period (and orbit size) are set by being geosynchronous, orbit shape can be varied:

- Inclination: affects the north-south motion
- Eccentricity: controls the east-west motion
- Relative phase of these ~sinusoidal motions changes shape of orbit relative to Earth

Orbit relative to Earth is a closed figure with a period of 1 (sidereal) day

- No eccentricity = classical analemma ("figure-of-8")
- Can also create circle, ellipse, diagonal lines, …
- Phase relative to solar day changes through the year

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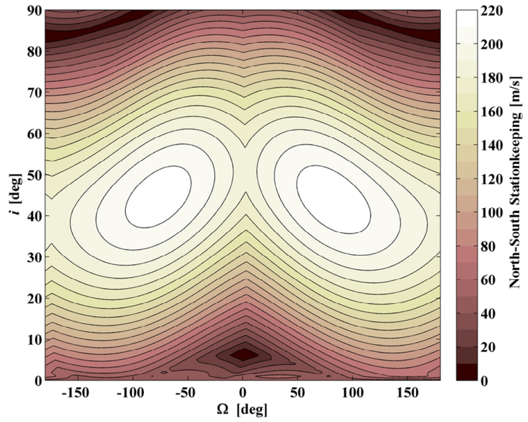
Orbit Maintenance

The main perturbation is due to Sun and Moon gravity

For low inclination orbits the manoeuvres needed are the same as for GEO comsats

- Small thrusts are needed while crossing the equatorial plane to cancel inclination drift due to Sun and Moon's gravity (~50 m s^{-1} yr^{-1})
- Electric propulsion (low thrust): ~0.14 m s^{-1} day^{-1}, or 0.1 N for two burns of 700 s (for s/c mass of 1 t)

At higher inclinations, orbit maintenance can be much more expensive



Orbit maintenance cost vs orbit inclination and RAAN (Hobbs and Sanchez, 2017)

4.4 Imaging Opportunities (Daily, Annually)

Geosynchronous orbits through the year:

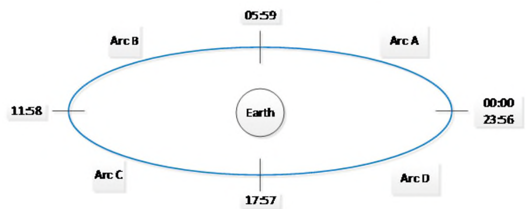
Orbit is fixed about Earth in inertial space

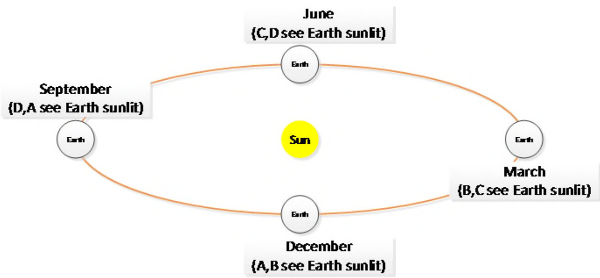
- Rotates at same speed as Earth turns on its axis

Relative to a solar day, the orbit drifts by 4 min per day, or 2 hr per month

- Operations planning must account for this drift

In particular: for SAR interferometry we must image the same area from the same part of the orbit to achieve coherence, so the imaging (solar) time drifts through the year





Imaging Opportunities (cont.)

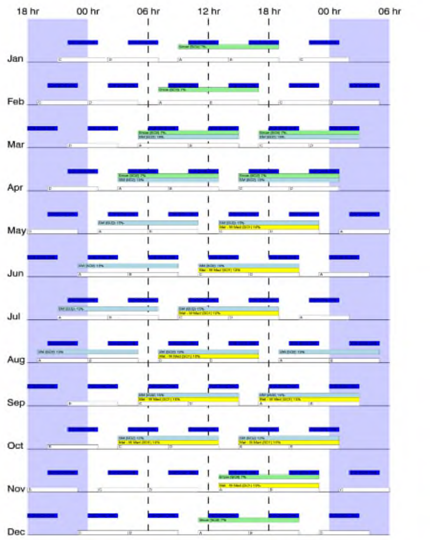
Imaging applications are fixed wrt relative orbit arcs

The EW (eccentricity) and NS (inclination) motions both have a period of 1 day and are ~sinusoidal

Satellite speed drops to 0 at the extremes of the motion and is not useful for imaging

- We have gaps (~2 hr?) every 12 hr
- Or (*but only for some orbits*) we could switch to imaging around the equator rather than to high latitudes to allow 24 hr operation

The figure shows example operations accounting for
(1) daily imaging gaps, and
(2) the annual drift of the orbit phase



Example G-CLASS operations plan

4.5 What we can measure using GeoSAR?

- Land surface and the overlying atmosphere

Long integration time:

- We only see targets which stay coherent (or which can be phase corrected)
  - We don't expect useful images over ocean or dense forest
- Incoherent targets create clutter for "nearby" targets

The atmosphere (refractive index, i.e. integrated water vapour) is observable

- For "short" integration times the atmosphere is frozen (*we assume*)
  - Becoming routine for InSAR processing (LEO)
- Today's atmosphere is estimated from a stack of previous days' images
  - May fail in extreme weather conditions (*changing too rapidly in space and time*)

Continuous imaging

- Enables direct observation of significant processes

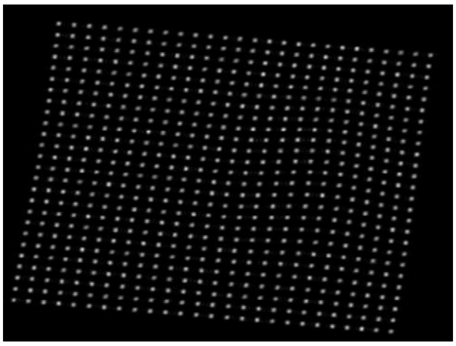
Atmospheric Humidity is Observable in Real-Time

Signal phase is affected by the optical path from radar to target

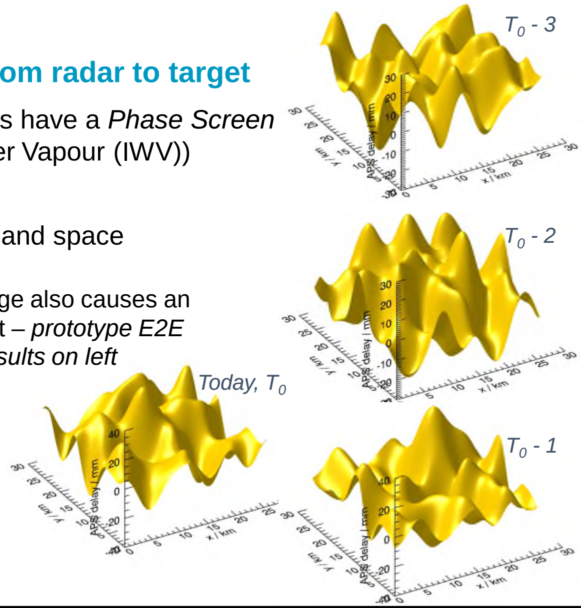
Since refractive index depends on water vapour, images have a *Phase Screen* due to integrated refractive index (i.e. Integrated Water Vapour (IWV))

- Estimated using a stack of coherent images

- GeoSAR can observe the IWV phase varying in time and space



Phase change also causes an azimuth shift – *prototype E2E simulator results on left*



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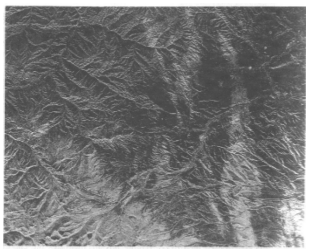
Radar Imaging from GEO

Significant Innovation in Earth Observation

– Several to many images per day
– Interferometry on 24 hr baseline (*possibly even twice daily*)

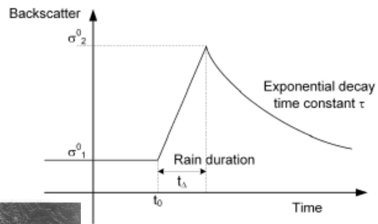
Dramatic improvement in temporal sampling and mission versatility

- Example: variation of surface backscatter over hours:



SeaSAR image showing bright rain streaks (Harris, 1987)

Model of backscatter variation with time due to rain



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“Software-defined” Imaging

Imaged area and resolution is ~decoupled from the orbit

Imaging is controlled by pointing the satellite

- Choose ~any region from the Earth disk as a target area
- Dwell for long enough to obtain the required synthetic aperture length for the desired azimuth resolution

All this is controlled purely by satellite attitude, *almost* independent of the orbit

- Slews require reaction wheels – no extra fuel used
- Adjacent areas can be imaged using a continuous smooth slew (with very low angular rates – few degrees in 10s of minutes)

Example image swaths, chosen for specific applications (footprint ~400 km)

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4.6 System Design Trade-offs

Wavelength and orbit are critical decisions

Wavelength

- Atmospheric effects (ionosphere and / or troposphere perturbations)
- Surface coherence (longer wavelength implies better coherence)

- Orbit
  - ITU regulations control comsat operations and frequency use (small relative orbit, long integration times, moderate antenna size and transmitter power, less coverage)
  - Larger orbits imply shorter integration time, larger antenna, more coverage, …
- Other important tradeoffs
  - Choice of application / application priorities
  - Antenna technology, use of polarisation, propulsion, beam steering, …

Some of these are still under discussion

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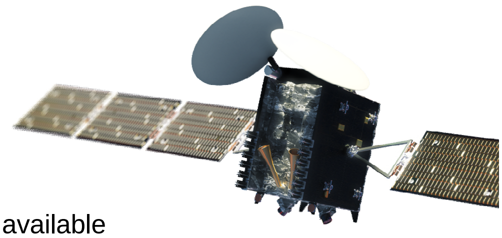
5. Mission Implementation Baseline

Draws on the mission implementation baseline proposed for EE10

1. Satellite
2. Launch
3. Orbit-raising
4. Payload
5. Antenna and beam pattern
6. Performance estimation
7. Operations concepts

5.1 Standard Small GEO Bus



SSTL VAMP GEO s/c (SSTL)

Expect to use a standard small GEO bus

Several European manufacturers have small GEO satellites available

- Use standard bus where possible for low mission cost

Required performance

- Electric propulsion for orbit-raising
- 1 - 2 kW electrical power for payload
- Compatible with deployable antennas of 3 – 10 m diameter
- Payload mass: few hundred kg
- Downlink <100 Mbit s^{-1}
- Compatible with expected operations – repeated slews to target application areas, etc.

OHB's Hispasat small GEO s/c under test (ESA)

5.2 Launch

EE10 baseline is Vega-C

Vega launch on 1 Aug 2017

ESA identifies the EE10 baseline launcher as Vega-C

- Normally used for launch to LEO
- Vega-C is a development due in service for EE10 with increased launch capacity (mass and volume)
- E.g. 2200 kg to 700 km Sun-sync LEO

Ariane 62 is also a possible launcher and could deliver to GTO

- Probably use a shared launch to reduce cost

5.3 GEO Orbit Acquisition

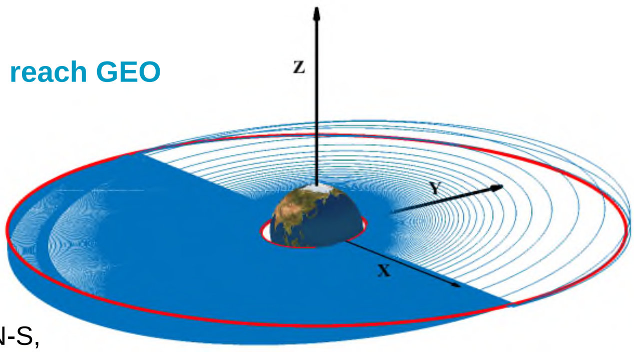
Using electric propulsion orbit raising to reach GEO

Launch to LEO with Vega C

- Electric propulsion to raise orbit to GEO
- Far more mass-efficient than chemical propulsion, but takes 6-9 months
- Delivers ~1 tonne to GEO
- Operational orbit (*orbit baseline:* 600 km N-S, 1200 km E-W)

Option for Ariane 62 launch to GTO (or GEO?)

- This only simplifies the orbit acquisition (but probably adds to cost)



Example low-thrust transfer from LEO to GEO

5.4 Payload

C-band radar payload

Current baseline for the payload assumes transmitted RF power of 300 – 400 W

Compact polarimetry seems to offer valuable extra information at minimal system cost

- Transmit circularly-polarised signals; receive both linear polarisations
- Being used for the Radarsat Constellation Mission

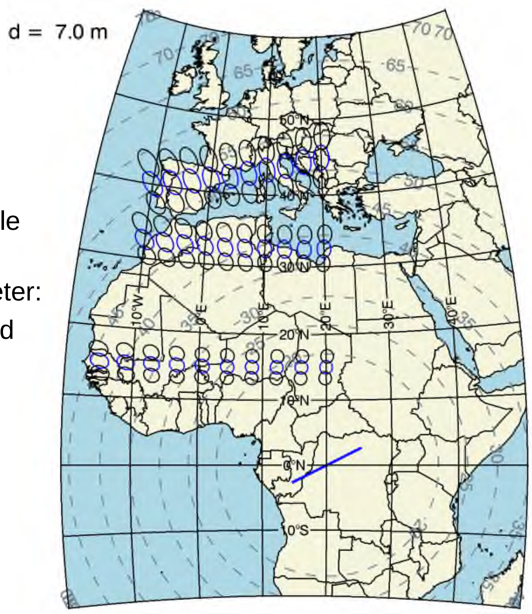
GeoSAR radars tend to operate at low prf (~100 Hz rather than >1 kHz)

A simple feed-horn array enables extra geographical coverage if we have SNR margin

- Expect signal margin for low incidence angles; less likely at the far limits of coverage
- Ideally use 4-8 electronically switchable spot-beams
- High-power RF switch technology (and cost?) may limit the number of feed-horns

More RF power allows us to make better measurements

5.5 Antenna and Beam Pattern



Antenna

- Proposal baseline is a 7 m diameter (European) deployable antenna
- Several groups are developing European deployable antennas; require TRL 5 by end of phase B1
- GeoSAR is feasible with antennas of 3-15 m diameter:
  - Larger antennas improve SNR / allow increased geographical coverage (related to orbit)
  - Smaller antennas may improve immunity to interference (longer t_{int}, so can exclude noise without losing the whole image)

Beam pattern

- Sweep EW with overlapping spots aligned NS to improve coverage

5.6 Performance Estimation

Current estimates of performance use standard community references to quantify key parameters

- WMO OSCAR database for user requirements (e.g. soil moisture, snow water equivalent)
- Ulaby and Dobson data for surface backscatter (vs band, landcover, incidence, polarisation)
- Consider several beam positions (near, mid, far)

Simplifications:

- No clutter or interference
- Hypothetical landscape

Next steps

- Domain expert critique of user requirements
- Include clutter

Science → geophysical data → radar data → system design

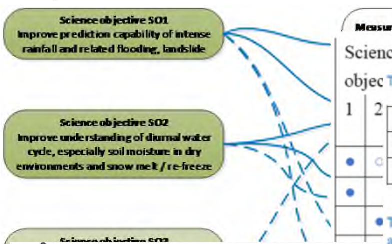


Table 8: Assumed parameter values for system performance calculations.

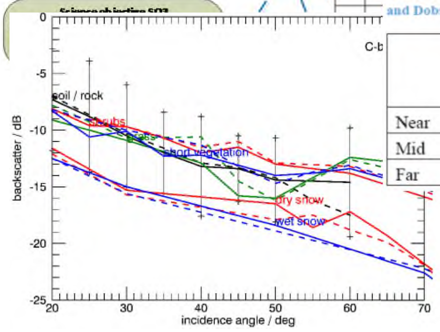
Wavelength / mm	56	Mean Tx RF power / W	300	Noise figure / dB	4.0
Surface temp. / K	300	Antenna diameter / m	7	Ant. efficiency (2-way)	0.7

Objective 1	Objective 2	Objective 3	Measurand	Resolutions	Looks (x,y,T)	Required NE σ^0 (dB) Near	Mid	Far	Predicted NEσ^0 (dB) Near	Mid	Far
●			SM (coarse)	1 km, 0.25 hr	10,1,10	-15.5	-19.4	-23.0	-28.0	-26.0	-23.4
	●	○	SM (fine)	300 m, 3 hr	7,5,18	-15.5	-19.4	-23.0	-24.1	-22.1	-19.4
	●		Snow melt	100 m, 3 hr	1,1,1	-20.6	-23.9	-27.2	-31.0	-29.0	-26.4
○		●	Flood extent	20 m, 6 hr	1,1,1	-15.1	-19.0	-20.2	-24.1	-22.1	-19.4

(a) Backscatter performance requirements (dual polarisation is assumed for soil moisture, single polarisation for snow melt and flood extent; the backscatter requirement includes a 5 dB margin to allow for surface variability)

Objective 1	Objective 2	Objective 3	Measurand	Resolutions	Avg	Level 1 Data Quality	Req. SNR (abs, dB)	Predicted SNR (dB) Near	Mid	Far
●	○	○	IWV (SVeg)	500 m, 15 min	1	$\delta\phi_z = 1.46$ rad	1,0	22.9	17.0	13.2
	○		SWE (DryS)	100 m, 3 hr	1	$\delta\phi_z = -1.0$ rad	1,0	10.5	6.8	-0.5
○		●	Surface (S&R)	20 m, 6 hr	7	$\delta\phi_z = 0.25$ rad	16/7,3.6	12.8	6.9	0.6

(b) Interferometric phase performance requirements including 5 dB margin for surface backscatter variability ($\delta\phi_z$ > 1 rad is treated as $\delta\phi_z = 1$ rad for SNR)



5.7 Operations Concept

Anticipate mission phases: start with experiments, transition to routine observations

Now compiling a detailed list of observation requirements

- Geographical area, measurand, resolution, repeat period, etc.
- Time of day and months through the year

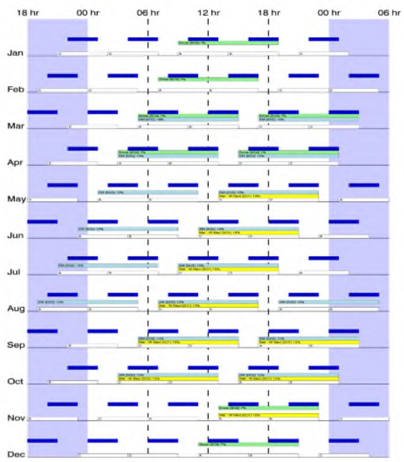
Initial plans combine science campaigns and programmed observations

Constraints:

- Orbit phasing
- Can't be everywhere all the time

Versatility creates complications!

- Likely to adopt standardised observations in later phases



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Quantifying the coverage rate

Imaging modes can be programmed responsively:

- Resolution and target area depend on pointing and slew-rate

Proposed orbit has typical speed relative to Earth ~20 m s^{-1}

- Resolve ~1 km from GEO in ~1 min integration time (C-band, synthetic aperture / min = 1.2 km)
  - New image every minute (1 km resolution)
  - … or every 10 min (100 m resolution)

Spot beam diameter ~300 km (7 m diameter)

- Slew at 300 km min^{-1} for 1 km resolution
- Slew at 30 km min^{-1} (1800 km hr^{-1}) for 100 m resolution

Beam can use overlapping spots aligned N-S

Point and slew using reaction wheels – no fuel used

G-CLASS imaging modes ~decoupled from orbit

G-CLASS potential coverage

Example actual Sentinel 1A+1B coverage in 24 hr (250 km swath)

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6. Societal Benefits

ESA was today congratulated for the services provided by its latest mission G-CLASS. Images from G-CLASS helped emergency staff predict the development of floods so that citizens were evacuated safely in advance of the water's rise. G-CLASS had allowed meteorologists to forecast the detailed track of the storm that caused all the damage, and the first signs of the landslide which closed the railway and main road from the west also came from G-CLASS. "Our citizens never knew how useful space could be." was how the mayor summed up the city's review of the Great Storm of 2028 for ESA.

A strength of G-CLASS is its ability to provide significant societal benefits

1. SO1: Intense storms, mitigate weather impacts
2. SO2: Water resource management – agriculture, etc.
3. SO3: Ground motion monitoring becomes real-time
4. Africa
   a) Much better coverage than Sentinel-1
   b) Region is poor in surface infrastructure so space makes a difference

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G-CLASS Applications

Exceptionally versatile

Intense storms:

Frequent imaging of region ~1000 km across

IWV and soil moisture

Diurnal Water cycle:

Soil moisture

Snowmelt

Solid Earth

Landslides

Earthquake, volcano, …

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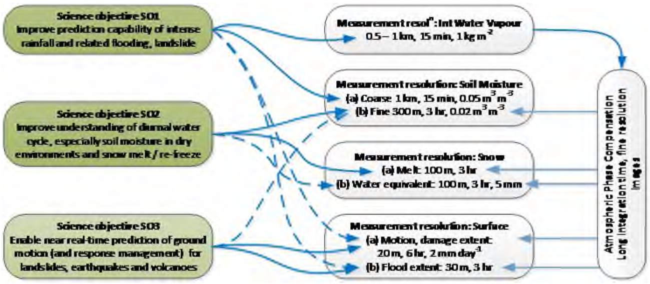
ESA Evaluation Criteria



ESA Research Objectives for EO

Advances in **EO Science**

- Direct observation of IWV over land at fine spatial and temporal resolution
- Simultaneous observation of “surface wetness” and overlying atmospheric humidity
- Revolutionary improvement in temporal sampling – directly observe processes on hour – day timescale

G-CLASS enables several clear **societal benefits**

- Improved short-term and high resolution weather forecasts
- Much improved disaster response
- More accurate flood monitoring
- Indirect benefits – agriculture, health and pest monitoring

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EO for Africa

A GEO satellite is ideally placed to serve Africa

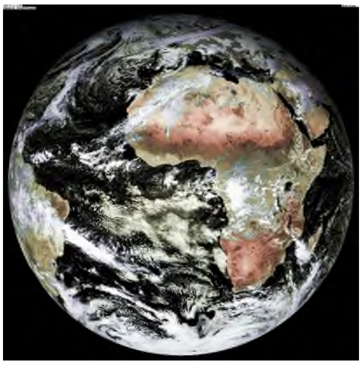
There are significant needs for improved services for Africa over the next few decades

- Lack of surface infrastructure means that space-based services add even more value

A GEO satellite:

- Can vastly improve coverage of Africa
- Target specific areas at key moments (~rainy seasons, monsoon periods, etc.)
- Support both government and commercial services

UK has significant relevant expertise



Meteosat image from GEO

Sentinel-1A+B coverage of Africa is 1 image per 12 days; LEO coverage is generally good near the poles and poor at low latitudes

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7. Our Challenges

Research and development priorities during Phase 0

Development challenges exist in several areas to validate the operational concept and to optimise performance

1. Science
2. Societal benefits
3. Principle
4. Implementation

Challenges: Science and Impact

Science

1. Understand science drivers for Africa
2. Solid justification (in all application areas) for
   a) Science case and quantified measurement needs
   b) Link from geophysical observables to the payload measurand(s)
3. Ability to observe intense storms (how rapidly can the atmosphere change and we still see it?)

Societal Benefits

1. Identify relevant benefits
2. Evidence to justify our claims

Additional experiment campaigns and research are expected during Phase 0

Challenges (2)

Mission Concept

1. Phase compensation
   a) Orbit drift
   b) Clock drift
   c) Atmospheric Phase Screen dynamics
2. Interference (RFI, LEO SAR)
3. Clutter (APS partial compensation, moving targets)
4. System design
5. End-to-End Simulation

Work is underway on all these areas but further progress is needed during Phase 0

Challenges (3)

Implementation

1. Choice of orbit
2. System design
3. Deployable antenna
4. Orbit-raising (inc. confident costing)
5. Payload (e.g. RF power available, polarimetry)
6. Feed-horn array and RF switching
7. Cost modelling and cost reduction
8. Operations (ground data processing, archiving, satellite utilization)
9. Phase compensation as an operational process (e.g. auto-focus, calibration targets)

Much of this work needs industry expertise – costs, understanding technology constraints

Some overlaps with research groups, e.g. phase compensation, system design

8. Summary and Conclusions

An overview of the G-CLASS mission concept and applications

1. Summary
   - Science
   - Implementation
   - Programme and future development
2. Technology demonstration / risk reduction opportunities
3. Conclusions

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G-CLASS:H2O summary

A mission to observe and understand processes of the daily water cycle over land

Science case has been identified which uses the strengths of geosynchronous radar

- Science objectives in three main areas:
  - o Meteorology – short-term, local scale weather forecasting
  - o Diurnal water cycle (hydrology, mountain cryosphere)
  - o Solid Earth science is also enabled; transform post-event analysis to ~real-time
- Anticipate other science too (e.g. ionosphere)

Clear connection between science objectives and the mission design

- Significant societal benefits (extreme weather, floods, water resources, agriculture, …)
- Geographical coverage: Europe, parts of Africa (low latitude cover much improved)

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Summary – the Implementation

Implementation: mainly proven technology – novelty is largely in the system design

- Science: extends many standard LEO products; new services expected (temporal sampling)
- Feasible with existing technology (*but we'd like more power and a bigger antenna*)
- *Many challenges remain – phase compensation, ITU, clutter & interference, cost*

Opportunities for more sophisticated imaging modes, especially if further satellites are launched

- MIMO, graceful degradation, etc.

ESA now starting Phase 0 studies (2 parallel industry teams, to summer 2020)

A Chinese GeoSAR in 2022 could help convince ESA and demonstrate technologies

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Passive Bistatic GeoSAR

Potential Technology Demonstrator

PB GeoSAR concept discussed by Prati et al. (1998) and Krieger (2006)

Conclusions are similar to a recent Cranfield & Birmingham study, except

- Increased use of digital transmissions and technology (e.g. SDR) improves the technical feasibility
- We identify potentially useful applications at ~1 km spatial resolution

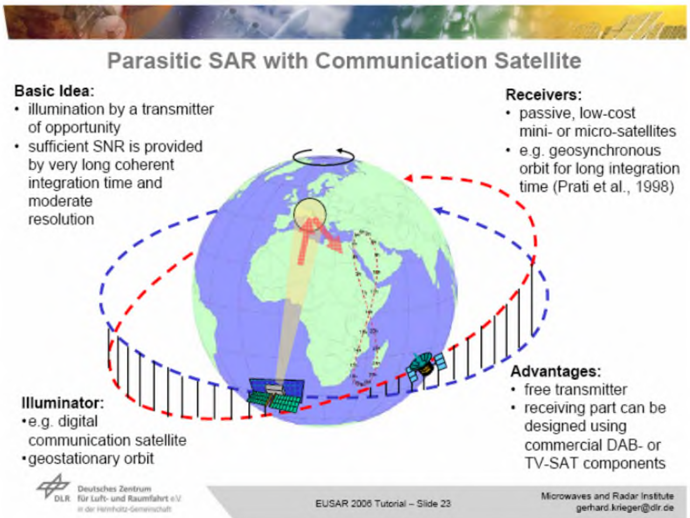

Image: EUSAR 2006 Tutorial - Krieger (2006)

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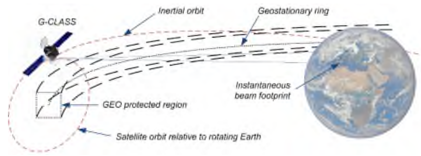
Conclusions



G-CLASS is an exciting opportunity for Europe to develop an innovative EO system expected to have important scientific and societal benefits

- Science focus is the diurnal water cycle over land
- Implementation is based on existing technology, with an innovative system design
- Mission cost is an important challenge
- Broad and direct societal benefits, especially for Africa
- Complements LEO Earth observation
- Challenges identified: most affect the level of performance, not feasibility

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Thank you for your attention

Any questions?

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