Mission Design Review 15/12/17

Follow-up 20/12/17

Element	Requirement	Justification
Target Area	30x30 km^2 along Norway's coast	Should be at least this size in an envelope of 100x100 km^2
Subjects	HABs, phytoplankton, oil, plumes	Detecting ocean color signatures that indicate biology or dissolved matter to be coordinated with UAVs, USVs, AUVs
Orbit	500 km SSO (RAAN ca. 83.3 or 228.3 deg)	Depends on launcher. Altitude can be 450-550 km. Trade-off between cost and availability. RAAN=228.3 deg is priority.
Repeat cycle	Max. ca. 7 days	107 revs/day
Launch	In Q4 2019 or Q1 2020 satisfying above two requirements	
Thermal	Withstand temperature gradients at terminators (shadow-to-sun)	15 deg C/s?
Radiation (total dose)	10kRad	Must also withstand dose rate: 0.01 Gy /s or lower (ISO19683:2017(E))
Spectral Range	400-800 nm (5 nm resolution)	Based on hyperspectral imager specifications
# Images	3 per day	Number of images per day, based on 3 revisits of target areas
Spatial Resolution	<300 m	Based on exposure time of 31 FPS
GSD	<50 m	Theoretically we should achieve GSD=40 m, depends on ADCS precision capability.
Image Resolution	<100 m	Images should have less than 100 m resolution that have undergone fusion of pixels (deconvolution)
Data Levels (Nominal)	Level 4 and Level 2	Operational (full compression; signature detection) and scientific data (radiometrically calibrated; only lossless spatial compr.)
Data Levels (Upon Request)	Level 1a, 1b, 3	Level 0 may be reconstructed from 1a. See definitions online.
Mapping Error	<100 m	Relative error. Must be less than desired final image resolution. Both along-track and cross-track requirement.
Pointing Accuracy	0.01 deg (2σ)	Less stringent on communications pointing (especially if equipped with S-band patch antenna - 1 deg error for downlink. Expect "fully" stacked ADCS.

Orbit Knowledge	<10 m	Minimize this. Based on already available space-flown GPS
Slew rate	1 deg/s	Need this to achieve desired GSD and overlapping pixels
Energy	>12 Wh available for 1/3 passes. 36 Wh total.	Need this much energy to do at least three images consecutively. Includes imaging operations, uplink and downlink. Based on calculated energy budget.
Radio-link	S-band (down), UHF (up), S-band (up?)	Baseline to have S-band TX down and UHF up. If more feasible, then S-band RX for uplink is also suggested.
Ground Stations	NTNU (UHF+S-band), KSAT (S-band)	More available ground stations in University of Porto and potential partners
Downlink Data	25 Mbit-94Mbit	Data range to be downlinked
S/C lifetime	3 years	
Cost Budget	<5 MNOK for 1 mission with 3U (<8 MNOK for 6U or 2x3U)	This cost includes operations, training, integration, testing, HW, SW and launch

Do you want the mission to be (slide 5-10, 11-13):

- ☑ Science Driven (ocean color)
- ~~☐ Also use for land remote sensing (agriculture/deforestation etc.)~~
- ☑ Technology Demonstration
- ~~☐ N/A~~

Both tech demonstrator and science driven. Need to push requirements for technology/optics.

Target Area Size (baseline) (slide 16):

- ☑ 30x30 km^2
- ☑ 50x30 km^2
- ☑ 100x100 km^2
- ~~☐ 1000x1000 km^2~~
- ~~☐ N/A~~
- ~~☐ Need further reference/justification~~

Narrow field of view and small targets are sought.

Coordinate ASAP with AUV people for coordinated campaigns motivation (slide 19 & 20):

- ☑ Yes
- ~~☐ No~~
- ~~☐ N/A~~
- ~~☐ Need further reference/justification~~

A couple checked for the last option “Need further reference/justification”: Answer is that we should also coordinate with them regarding what they want to measure in the campaigns, expected results from AUVs (in terms of samples and underwater hyperspectral imaging). We have much to learn from them. This is essence of our concept and we should start talking with them soon. Should also coordinate with the UAV, USV folks and Marine Robotics. Coordinating with USV is easiest.

Orbit (slide 26):

- ☑ SSO
- ☐ ~~ISS (upon opportunity to launch free through NASA Ames -but no observing in Norway)~~
- ☐ ~~Other orbit – would like to see more~~
- ☐ ~~Decrease orbit altitude (higher resolution)~~
- ☐ ~~Increase orbit altitude (larger coverage and power)~~
- ☑ N/A – It is good as it is
- ☐ ~~Need further reference/justification~~

It will be SSO, preferably stay at baseline orbit altitude of 500 km. Most people agree here. Some have said that they don't know enough and clouds may be an issue: answer is that SSO has benefit of same lighting conditions every day and is highly available for launches. SSO is also preferable for observations in the North and Norway. Clouds is something we cannot control.

Orbit Concept 1 (North-South Pass) (slide 29):

- ☑ Go
- ☐ ~~No-Go~~
- ☐ ~~N/A~~
- ☐ ~~Need further reference/justification~~

Some checked for "Need further reference/justification": Answer this is contingent upon launcher – although much more available orbit. Some also said it depends on use of ground stations outside – it does not – since ground stations are flexible and not the main driver for orbit choice. Depends on launcher we choose. If we choose a launcher – we know what we get from the analysis presented in the slides. Analysis showed what observations we may get – this concept is more flexible in number of observations but not totally dedicated to Norway. So I leave it at "Go".

Orbit Concept 2 (South-North Pass) (slide 30):

- ☑ Go
- ☐ ~~No-Go~~
- ☐ ~~N/A~~
- ☐ ~~Need further reference/justification~~

Some checked for "Need further reference/justification": Answer this is probably the most scientifically and useful orbit for mapping all Norway and chance of detection. Some also said it depends on use of ground stations outside Norway – it does not – since ground stations are flexible and not the main driver for orbit choice. Depends on launcher we choose. If we choose a launcher – we know what we get from the analysis presented in the slides. This concept is more dedicated to Norway (covers all of the coastline). CONCLUSION: This is a first priority configuration.

Which launcher (in Table below) should we aim for (in terms of time and orbit type) (slide 36)?

- ☑ Insert option(s) here: 8,9 or 10
- ☐ ~~N/A~~
- ☐ ~~Need further reference/justification~~

Option	Date	Where	Orbit Type
~~1~~	~~Q2 2018~~	~~N/A (not US)~~	~~550 km SSO~~
~~2~~	~~Q2 2018~~	~~USA~~	~~500 km SSO~~
~~3~~	~~Q2 2018~~	~~N/A (not US)~~	~~450 km SSO~~
~~4~~	~~Q3 2018~~	~~N/A (not US)~~	~~550 km SSO~~
~~5~~	~~Q4 2018~~	~~N/A (not US)~~	~~536 km SSO~~
~~6~~	~~Q4 2019~~	~~N/A (not US)~~	~~500 km SSO~~
~~7~~	~~H2 2019~~	~~Russia~~	~~450-600 km SSO~~
8 ✓	Q4 2019	Europe	500-700 km SSO
9 ✓	Q4 2019	Europe	450-600 km SSO
10 ✓	Q1 2020	Europe	500-700 km SSO

Table: launchers (source: https://www.isispace.nl/launch-services/; http://spaceflight.com/schedule-pricing/)

Most people agree here. However, some have said that we need to plan the payload deadline first: answer launch should be coordinated 12 months prior to launch – i.e. we need to set strict deadline – as this is our final goal. Most have said early 2020. Should also check with NASA and ESA University Programs.

What processing levels should be employed onboard (slide 50)?

- ☐ ~~Only lossless spatial compression~~
- ☐ ~~Lossless spatial compression + spectral signature detection (algorithm TBD)~~
- ☑ Lossless spatial compression + spectral signature detection (algorithm TBD) + radiometric calib + geometric calib
- ☐ ~~N/A~~
- ☐ ~~Need further reference/justification~~

Only a few answered this but choice indicated above. Full on-board processing it is.

Which data level products should be nominal for end user (slide 51)?

- ☐ ~~Level 0/Level 1a~~
- ☐ ~~Level 1b~~
- ☑ Level 2
- ☐ ~~Level 3~~
- ☑ Level 4
- ☐ ~~N/A~~
- ☐ ~~Need further reference/justification~~

Everyone who answered agrees on “Level 2” and “Level 4”.

Ground Stations (slide 55):

- [x] NTNU Trondheim
- [x] KSAT Svalbard
- [ ] ~~More~~
- [ ] ~~N/A~~
- [ ] ~~Need further reference/justification~~

This is baseline. Most agree. Both orbit concepts need a Northern Ground station to fulfil the "immediate" response in a coordinated observation (30 min max). Either uplink or downlink. Other Ground stations can be *added* to baseline, but we stay flexible here. KSAT and NTNU Trondheim are decided, at least NTNU Trondheim to have full control of download or upload as it also is our mission control.

Software-Defined Radio (slide 23):

- [ ] ~~Go~~
- [x] No-Go
- [ ] ~~N/A~~
- [ ] ~~Need further reference/justification~~

This is set as No-Go until mission is created and implementable/useful for HSI first-flight mission. Also if 6U is chosen, then SDR will be implemented. However, this is purely a HSI mission. Most people said for 2nd mission.

S-band Uplink (replace UHF) (slide 58):

- [ ] ~~Go~~
- [x] No-Go
- [ ] ~~N/A~~
- [x] Need further reference/justification

TBD. Potentially No-Go since it depends on bus provider. Not everyone has S-band RX.

Communicate directly with UAVs/USVs/AUVs through UHF (slide 23):

- [ ] ~~Go~~
- [x] No-Go
- [ ] ~~N/A~~
- [ ] ~~Need further reference/justification~~

Feasible, but most said "No-Go". Depends if we choose S-band only for the bus. However it is a No-Go, since comms. will go through mission control. Not essential.

Payload Design(slide 60):

- [x] Vote for increase in aperture
- [x] Vote for change in design (general)
- [ ] ~~N/A~~
- [x] Need further reference/justification

Most agree on increase in aperture. I also vote for change in design, strongly advise at least exploring the idea. Some said "Need further reference/justification": I assume that given that current prototypes and lens aperture are sufficient in performance then we may go with that.

Payload Manufacturing Pipeline (slide 61):

- [x] Go
- [ ] ~~No-Go~~
- [ ] ~~N/A~~
- [ ] ~~Need further reference/justification~~

Most agree.

Payload Testing Pipeline (slide 62):

- [x] Go
- [ ] ~~No-Go~~
- [ ] ~~N/A~~
- [ ] ~~Need further reference/justification~~

Most agree.

Add another camera (RGB) to the payload? (slide 60):

- [x] Go
- [ ] ~~No-Go~~
- [ ] ~~N/A~~
- [ ] ~~Need further reference/justification~~

Most agree.

What S/C bus size (slide 71):

- [x] 3U
- [ ] ~~6U (will include SDR)~~
- [ ] ~~N/A~~
- [ ] ~~Need further reference/justification~~

We shall push for 3U. However, if very costly and bad performance, then 6U will be chosen (if cheaper) and will include SDR.

Requirements for observing a target (size and subject) + downlink (slide 16 & 72):

- [ ] ~~Relax them! Too ambitious!~~
- [ ] ~~Aim higher! Not ambitious enough!~~
- [x] Relax them a bit
- [ ] ~~Aim a bit higher~~
- [x] They are fine

Pointing requirements should be slightly relaxed. Flexibility in viewing conditions (no strict requirements) should be employed.

What should next mission in the SmallSat pipeline be?:

- [ ] ~~Altimetry~~
- [ ] Micro-SAR
- [x] SDR
- [x] Hyperspectral Imager 2
- [ ] ~~Purely experimental~~
- [ ] IR camera
- [ ] ~~N/A~~
- [ ] ~~Need further reference/justification~~

Very different opinions here. However, if pipeline is the goal and higher revisits of targets, then a constellation with similar payloads is necessary. Hyperspectral Imager 2 doubles the chance of detection and enables us to monitor dynamics better. SDR is also to be the next mission if it is not on first-flight.