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Land Cal/Val Activities at the Mer Bleue Arctic Surrogate Simulation Site (MBASSS):

Introduction of UAV Hyperspectral to Upscale validation process

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Quality Assurance for Earth Observation,
Workshop #2 - Dec 2, 2020

NRC QA4EO-IDEAS Objective

Integration and validation of UAV hyperspectral imagery into the Bottom–Up Satellite (S2) Multispectral image data product validation approach previously developed under the IDEAS+ MBASSS project

This will fill in the spatial resolution/sampling mismatch between the field spectroscopy measurements and the airborne hyperspectral imagery.

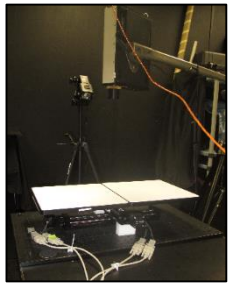
Bottom-up Approach: Satellite products validation.

Laboratory and Field Panel Calibration

Field Spectroscopy

Airborne Hyperspectral Imagery

Satellite Multispectral Imagery



Cross-calibration setup

SVC HR1024i

CASI/SASI on Twin Otter

Sentinel-2

Methodology developed and validated in IDEAS+

Bottom-up Approach: Satellite products validation.

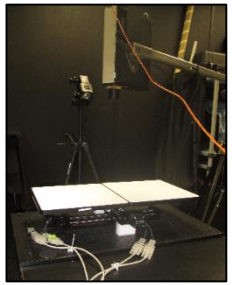
Laboratory and Field Panel Calibration

Field Spectroscopy

UAV Hyperspectral

Airborne Hyperspectral Imagery

Satellite Multispectral Imagery



Cross-calibration setup

SVC HR1024i

uCASI on Matrice 600 Pro

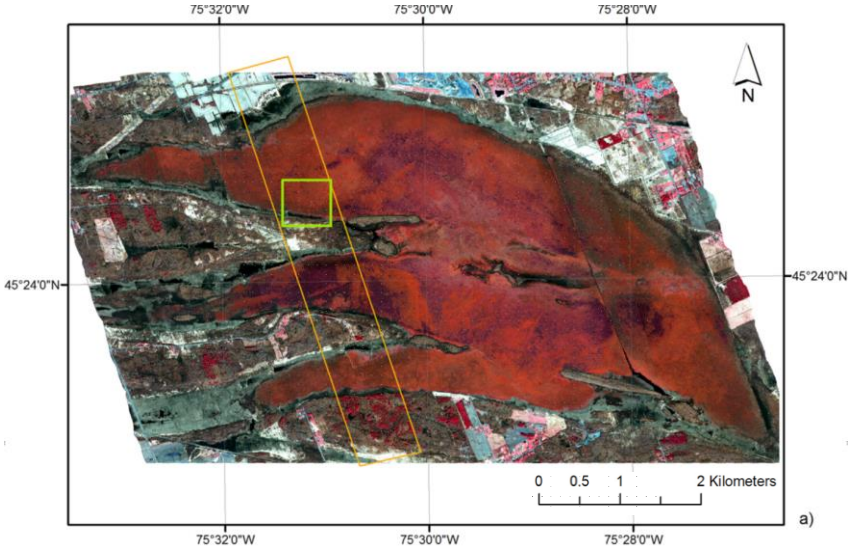
CASI/SASI on Twin Otter

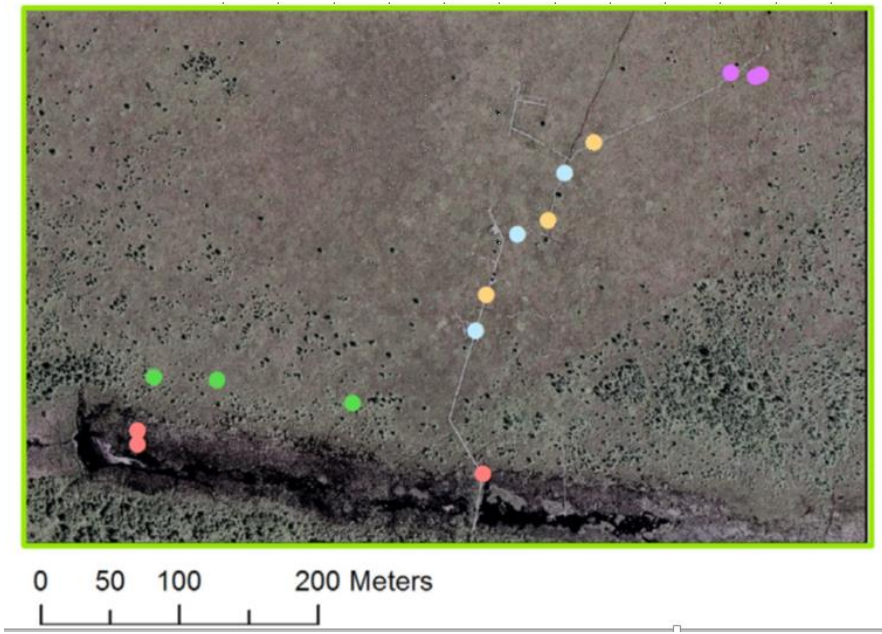
Sentinel-2

Methodology to be developed and validated in QA4EO

Study Site – Mer Bleue Peatland

- 12 flight lines / Mer Blue Mosaic
- 14 sampling sites – 6 Physiognomies



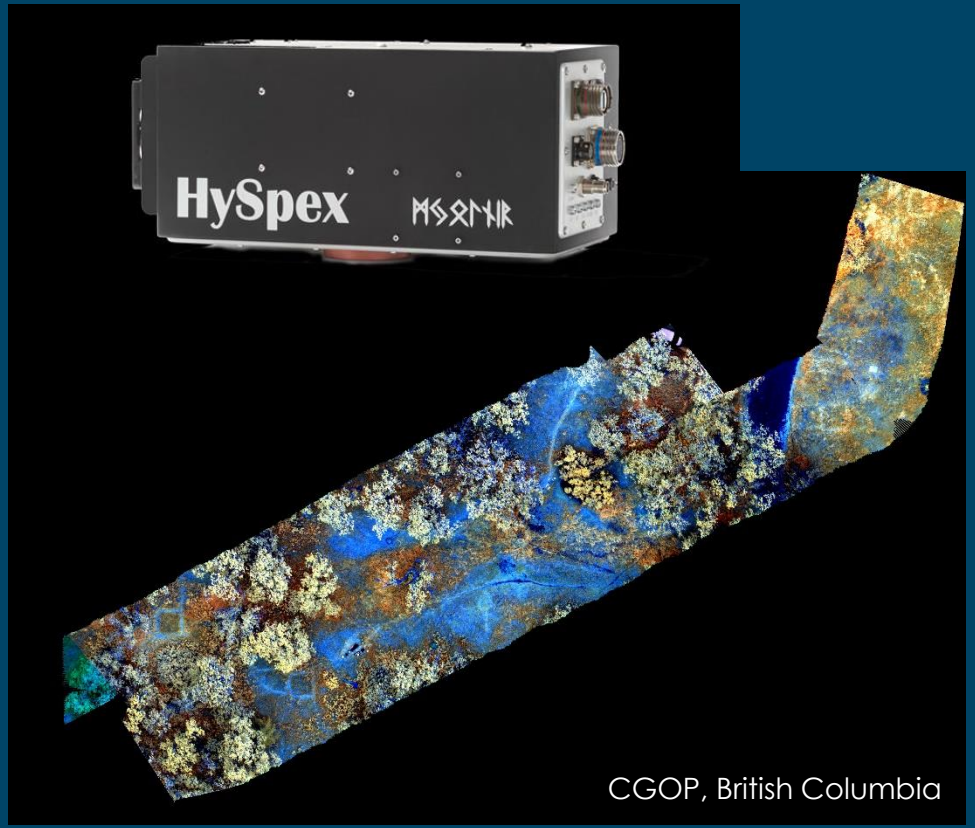


Each identified sampling location limited to 3 to 5 field spectrometry 'spot' measurements.

Upscaling (field to airborne) limitations

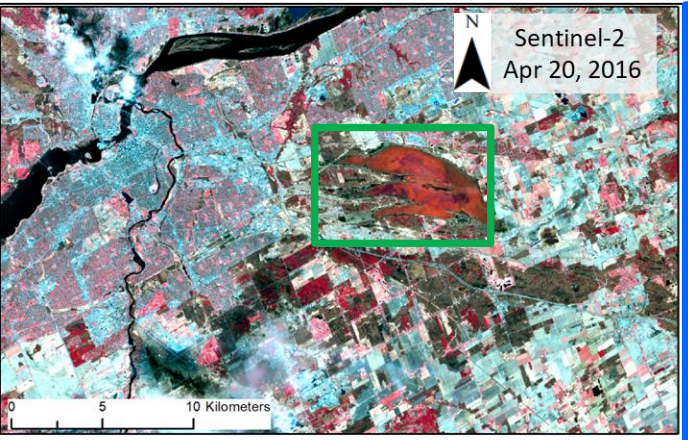
- Limited # of sample sites
- Restricted sampling site location (adjacent to boardwalk)
- Limited samples / site despite heterogeneity site (time constraints)
- Limited coverage – FOV per sample ~5 cm
- Time to access all sampling sites (temporal proximity to aircraft overpass)

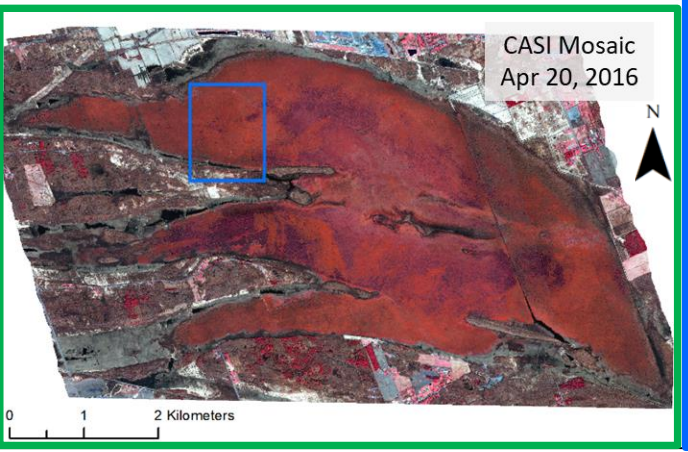
HySpex System
Mjolnir VS-620

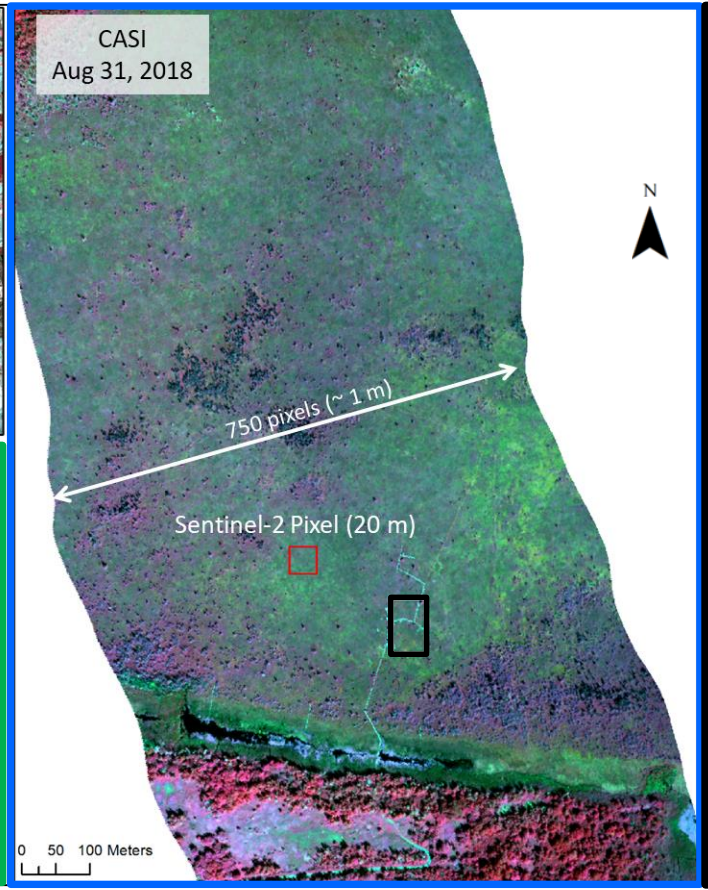


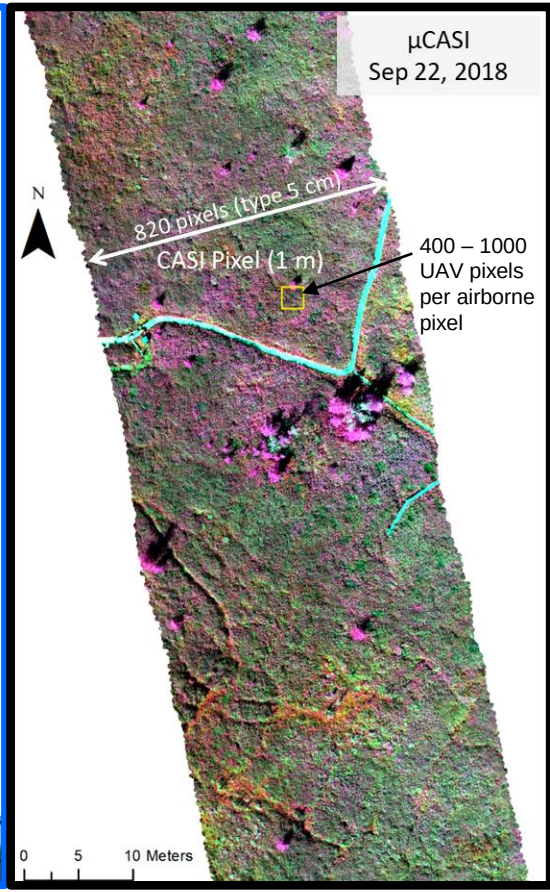
UAV-HSI: Hyspex Mjolnir VS620

	V-1240	S-620
Spectral range	400 – 1000 nm	970 – 2500 nm
Combined spectral range	400 – 2500 nm	
Spatial pixels	1240	620
Combined spatial pixels	620	
Spectral channels and sampling interval	200 bands @ 3.0 nm	300 bands @ 5.1 nm
Combined spectral channels	490	
F-number	f1.8	f1.9
FOV	20°	20°
Combined FOV	20°	
IFOV across/along track	0.27 /0.54 mrad	0.54 /0.54 mrad
Bit resolution	12 bits	16 bits
Noise floor	2.37 e^-	80 e^-
Dynamic range	4400	10000
Peak SNR (at full resolution)	> 180:1	> 900:1
Max speed (a full resolution)	285 fps	100 fps
Detector type	Silicone CCD	Mercury Cadmium Telluride (MCT) FPA
Smile and keystone	< 10% per pixel per band	
Radiometric calibration traceability	To a Physikalisch-Technische Bundesanstalt (PTB) standard	
Power consumption*	50 W	
Dimensions (l-w-h)	374 – 202 – 178 mm	
Weight*	< 6.5 kg including standard battery	

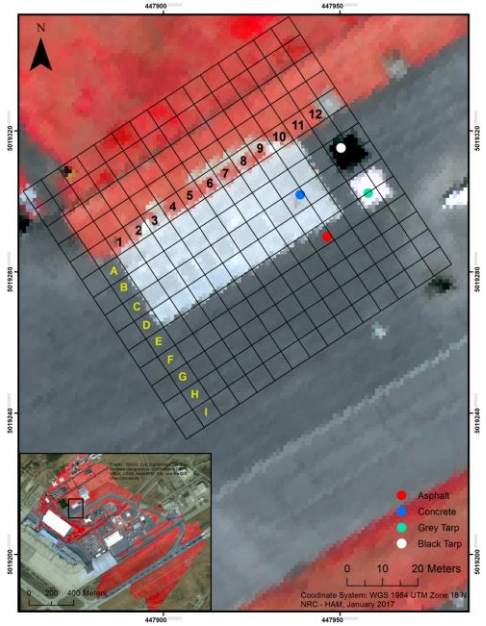

N
Sentinel-2
Apr 20, 2016
0 5 10 Kilometers


CASI Mosaic
Apr 20, 2016
N
0 1 2 Kilometers


CASI
Aug 31, 2018
N
750 pixels (~ 1 m)
Sentinel-2 Pixel (20 m)
0 50 100 Meters


µCASI
Sep 22, 2018
N
820 pixels (type 5 cm)
CASI Pixel (1 m)
400 – 1000
UAV pixels
per airborne
pixel
0 5 10 Meters

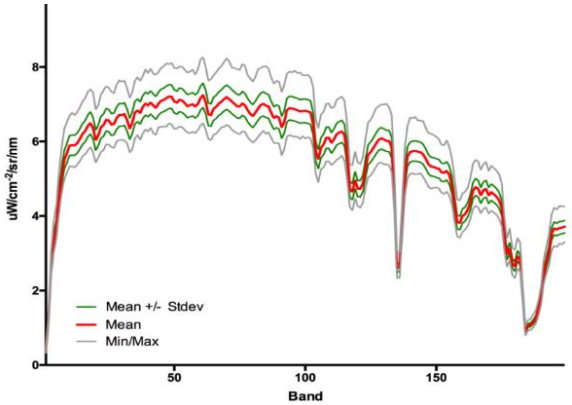
U61 Cal/Val Site



Cal/Val Support – Airborne Hyperspectral

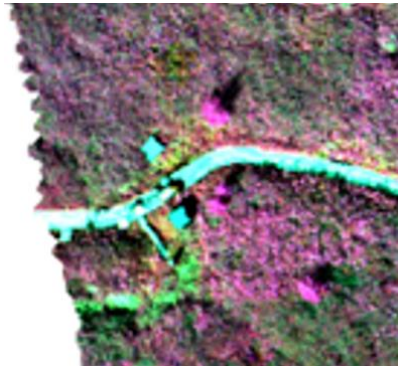
Issues of Concern

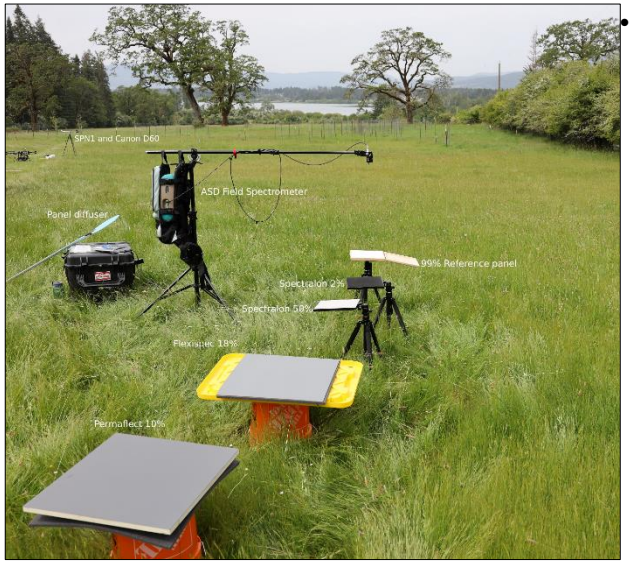
- Spatially remote from primary target
- Separate flight Line
- Large, difficult to deploy targets
  - Wind
  - Flat backing required
  - Folds in material due to stretching
  - Debris on surface
- Difficult to characterize
  - Uniformity issues require multiple field spectrometry measurements
- Manpower split between 2 sites



Cal/Val Support – UAV Hyperspectral

In-Scene Cal/Val Site

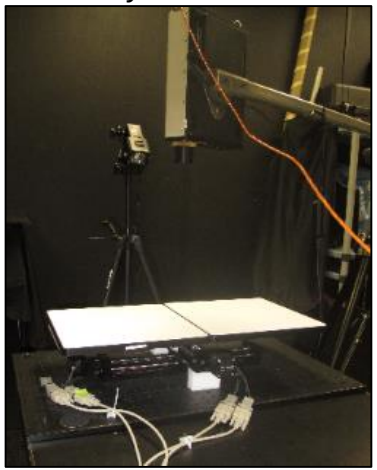


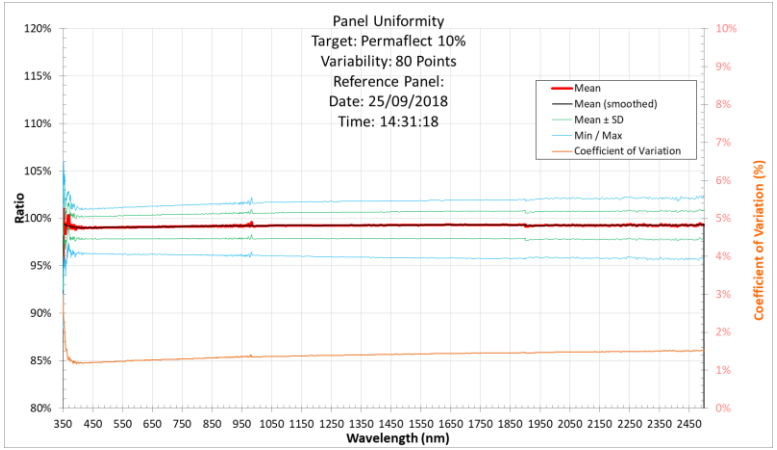


Pros

- On Site (within flight line or adjacent to)
- Single field deployment
- Small targets
- Laboratory characterization
  - Single measurement with known uniformity
- Field spectrometry
  - Focus on cal/val targets, not field spectra

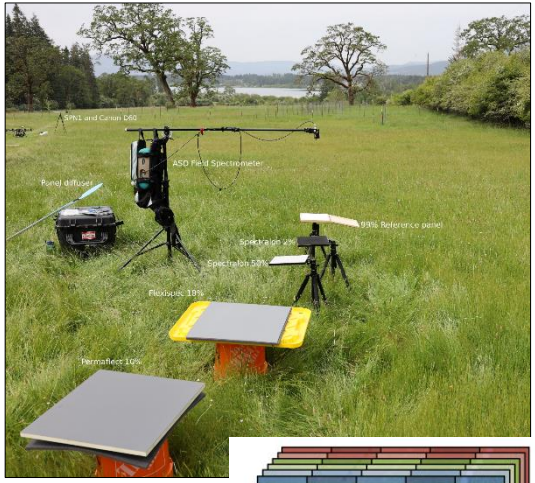
Laboratory Characterization





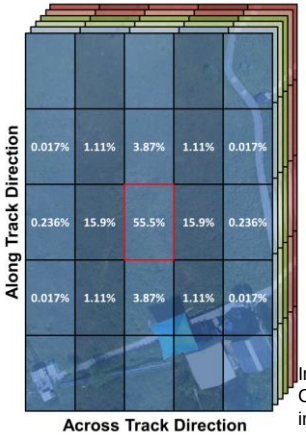
Soffer, R.J., Ifimov, G., Arroyo-Mora, J.P., & Kalacska, M. (2019). Validation of Airborne Hyperspectral Imagery from Laboratory Panel Characterization to Image Quality Assessment: Implications for an Arctic Peatland Surrogate Simulation Site. *Canadian Journal of Remote Sensing, 45*, 476-508

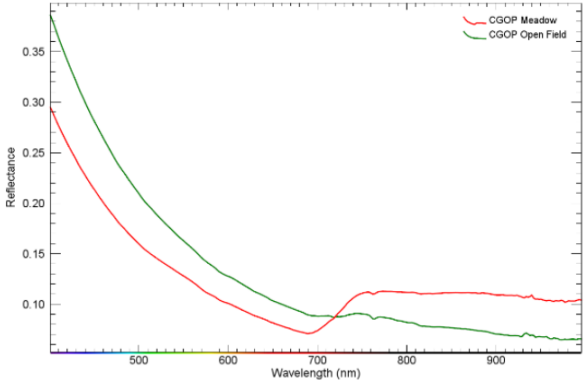
Cal/Val Support – UAV Hyperspectral



Issues of Concern

- Despite availability of lab characterization, measurements under field conditions still required
  - nBCRF only known for 99% Spectralon
- Target Location
  - Impact of in-scattering objects
- Cal/Val Target Selection
  - Material (Spectralon?, Permaflect?)
  - Reflectance levels
    - Maximum radiometric separation
    - Will 50% saturate?
  - Panel Size
    - # of pixels in UAV imagery
    - Energy distribution
- Number of targets
  - Calibration targets - 2 (brightest (50%)and darkest (50%)
  - Validation targets - ≥ 2 (10%, 18%, 30%)





Inamdar, D., Kalacska, M., Leblanc, G., & Arroyo-Mora, J.P. (2020). Characterizing and Mitigating Sensor Generated Spatial Correlations in Airborne Hyperspectral Imaging Data. *Remote Sensing, 12*, 641

Project Timeline

- Covid19 lock down
  - Delay of 1 year for primary data acquisition activity.
    - NRC Airborne activities shut down for 6 months
  - Primary impact
    - reduced period available to perform the data analysis
    - increased preparation time

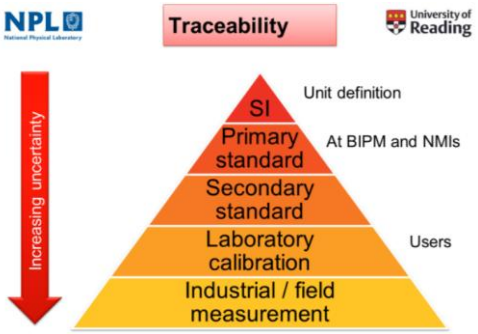
	Original	Delayed (Covid19)
Field work planning and preparations	April – June ‘20	Nov. – June ’21
Shake down flights	June ’20	June ’21
Data acquisition activities (S2 coordination)	**June (late) - July (early), ’20**	**June (late) - July (early) ’21**
Data Preprocessing	Sept. – Oct. ’20	Aug. – Sept. ’21
Data Analysis	Oct. ‘20 – Feb. ’22	Sept. ‘21 – Feb. ’22
Preliminary Report	March ’22	March ’22
Final Report	April ’22	April ‘22

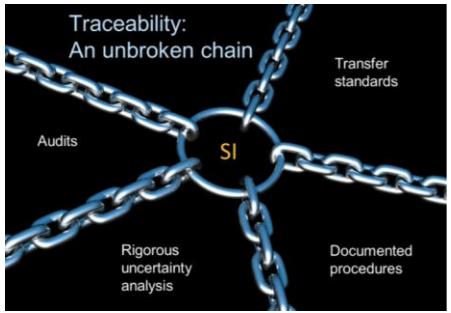
Proposed scope expansion through CCN proposal under consideration:

Collaboration with NPL (Niall Origo) and WUR (Benjamin Brede -TBC)

1) Development of an uncertainty budgets which accounts for the full procedure chain in the upscaling validation process of multispectral satellite reflectance data product traceable to a national standard.

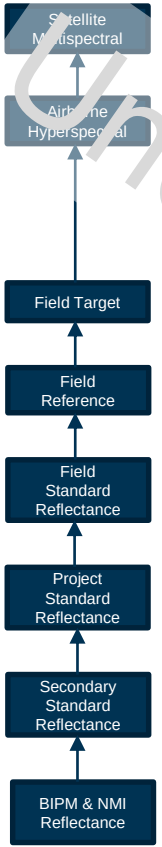
2) Development of a Best Practices protocols for consideration in the application of UAV-hyperspectral for surface reflectance validation and assessment of traceability.



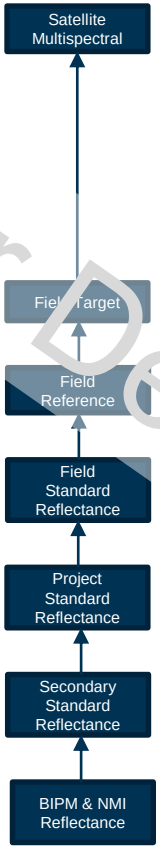


Courtesy Nigel Fox (NPL)

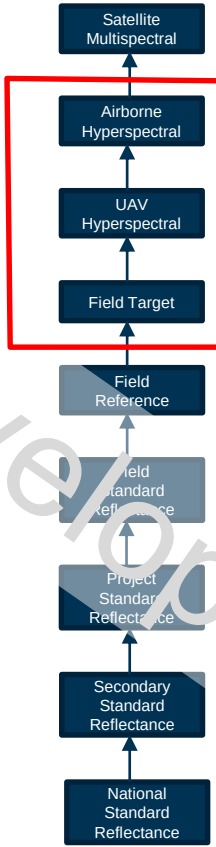
Origo, N., Gorroño, J., Ryder, J., Nightingale, J., & Bialek, A. (2020). Fiducial Reference Measurements for validation of Sentinel-2 and Proba-V surface reflectance products. *Remote Sensing of Environment, 241*, 111690



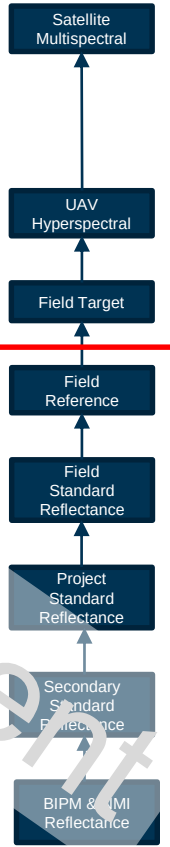
Scenario 1
(IDEAS+ Approach)



Scenario 2
Origo (NPL) 2020
(No UAV or Airborne)



Scenario 3
QA4EO Approach



Scenario 4

(no Airborne)

MBPO LPV Super-Site Development

- **Mer Bleue Identified 2 years ago as LPV Super Site**
- **To be managed by the MBPO (McGill University)**
- **Funding sources to cover additional instrumentation and maintenance being developed (beyond the scope of this project)**

- **Current capabilities:**
  - Airborne/UAV hyperspectral imagery
  - Sentinel-2, Landsat 8/9, MODIS imagery
  - Flux tower (CO_2 and Meteorological measurements - FLUXNET)
  - Methane flux chambers
  - Water Table Depths
  - Ground Temperature
  - **Albedo Tower measurements - validated Landsat 8 Albedo available**

- **Capabilities under development:**
  - Cimel Sun photometer (Aeronet)
  - Land surface temperature
  - Albedo Tower measurements in support of MODIS, and VIIRS Albedo product (TBD) – Crystal Schaaf

THANK YOU!

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