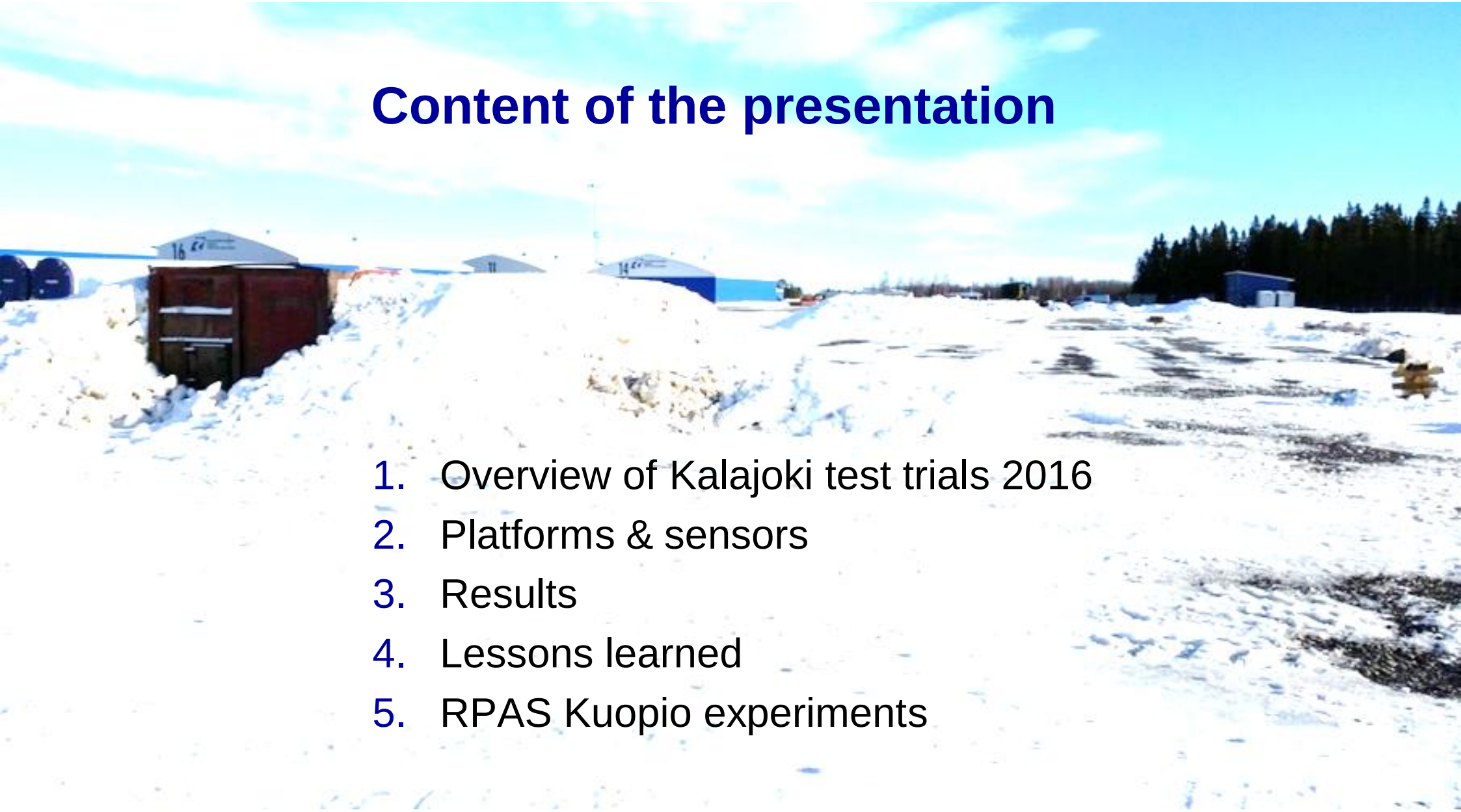
Experiences on sensor testing for oil & chemical response operations

RPAS as a support tool for Emergency and Response Services

Jukka Sassi, VTT

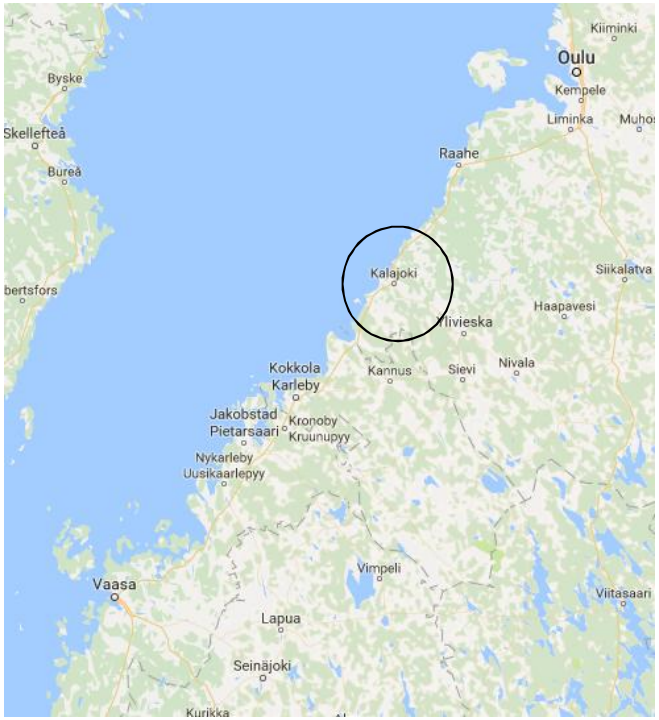
November 2, 2016, Kuopio, Finland

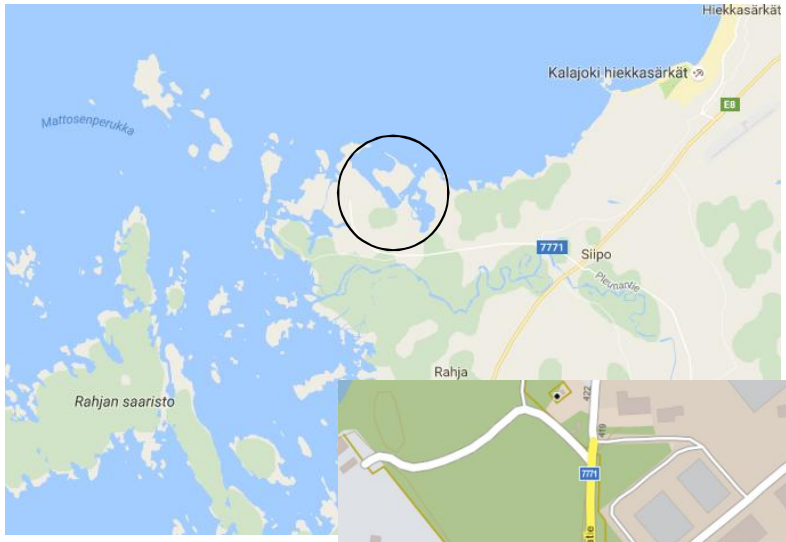
Content of the presentation

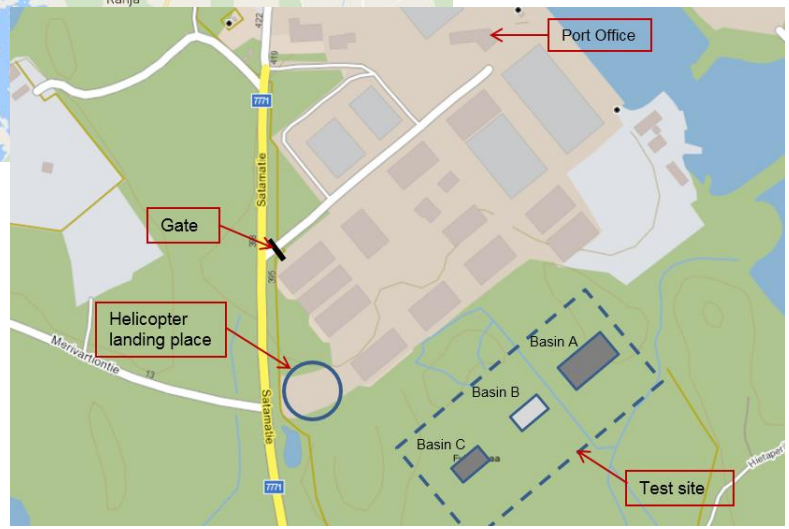


1. Overview of Kalajoki test trials 2016
2. Platforms & sensors
3. Results
4. Lessons learned
5. RPAS Kuopio experiments

Kalajoki field trials – location of test site

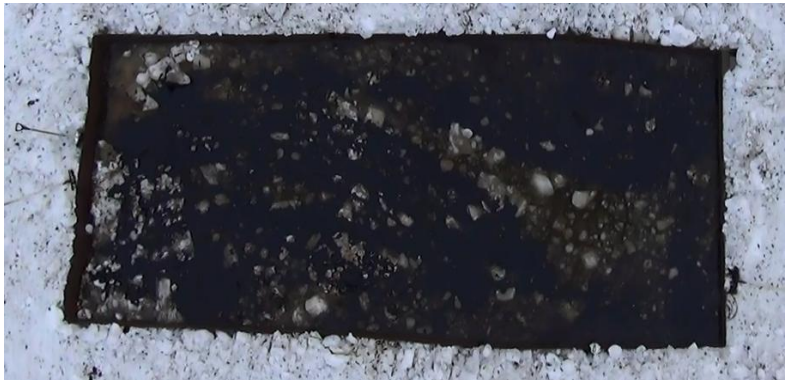






- Test site at the premises of Port of Kalajoki, 70 km north-east from Kokkola
- Field trials performed 14-15 March 2016

Test site arrangements



Basin A (60 m^2): 30% ice, 70% water, 150 l oil.

Basin C (15m^2): 70% ice, 30% water, 50 l oil.

- Three separate basins with different oil-ice-water concentrations
- Test oil: HFO180

Basin B (15m^2): 50% ice, 50% water, no oil.

Platforms

- Drone
  - Videodrone X8 with remote control console and operator
  - Equipped with video camera
  - Operated by Air Intelligence Finland
  - Max. payload ca. 3,5 kg

- Helicopter
  - Schweizer 300, max. payload 75 kg
  - Provided by First Invest Ltd

Sensors

Company	Sensor	Platform
Air Intelligence Finland Ltd (FI)	Optris IR camera	Drone
Infradex Ltd (FI)	Workswell Wiris 640 TIR	Drone
LDI Innovation OÜ (EE)	Oil in Water Locator - OWL™	Helicopter
LDI Innovation OÜ (EE)	BlueHawk™	Handhold
NLS (FI)	VIS/NIR hyperspectral camera	Handhold
Rikola Ltd (FI)	VIS/NIR hyperspectral camera	Drone and helicopter

BlueHawk™ fluorosensor by LDI Innovation OÜ; Ø 10 cm, length 24,5 cm, weight approx. 3,8 kg

Hyperspectral camera by Rikola Ltd

Oil in Water Locator – OWL™ by LDI Innovation OÜ, 65 x 45 x 37 cm, 40 kg

Sensors (2)

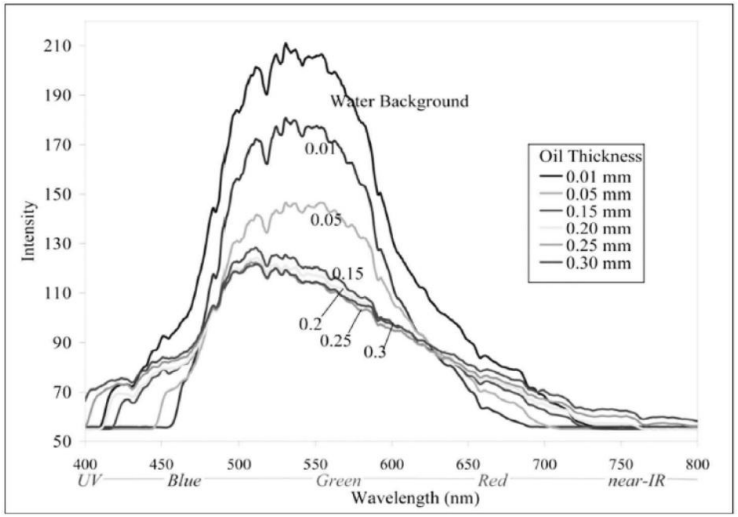
Optris PI 400 IR thermometer by Air Intelligence Finland

Workwell Wiris 640 TIR camera by Infradex Ltd

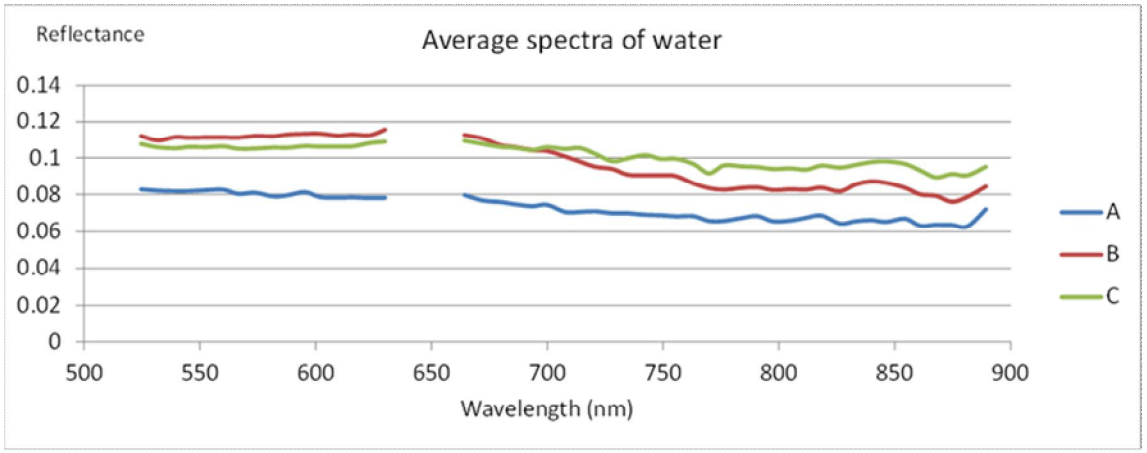
Results & observations / Blue-Hawk™

- Tests with Blue-Hawk™ (BH) were interrupted since the sensor was too heavy for drone to carry more than 10 - 20 sec, thus tested as handhold option
- According to LDI, oil detection capability of BH at distances up to 15 m have been already proved by numerous tests in its stationary installations.
- Tests confirmed that BH can be mounted in a drone
- During short flight BH transmitted signals correctly to ground PC.

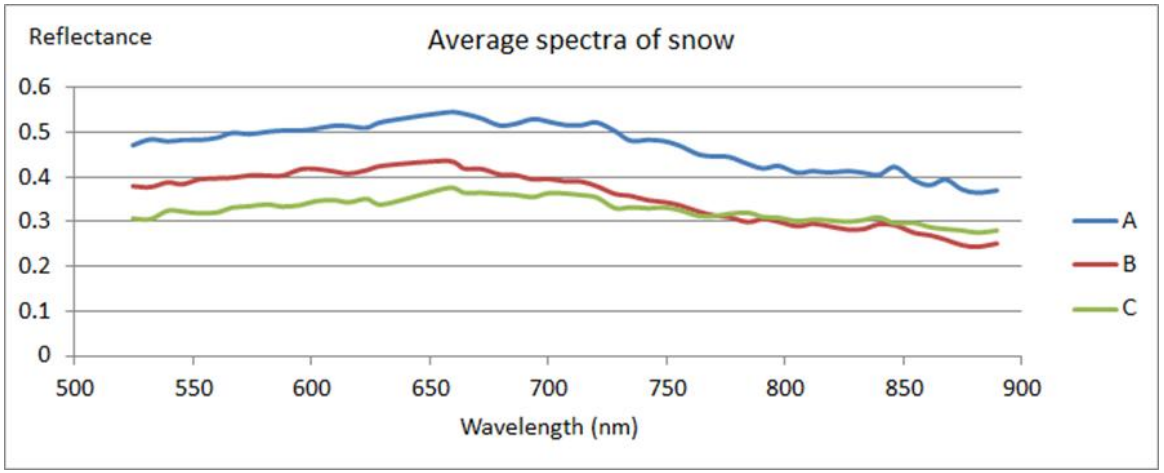
Results & observations / Hyperspectral camera



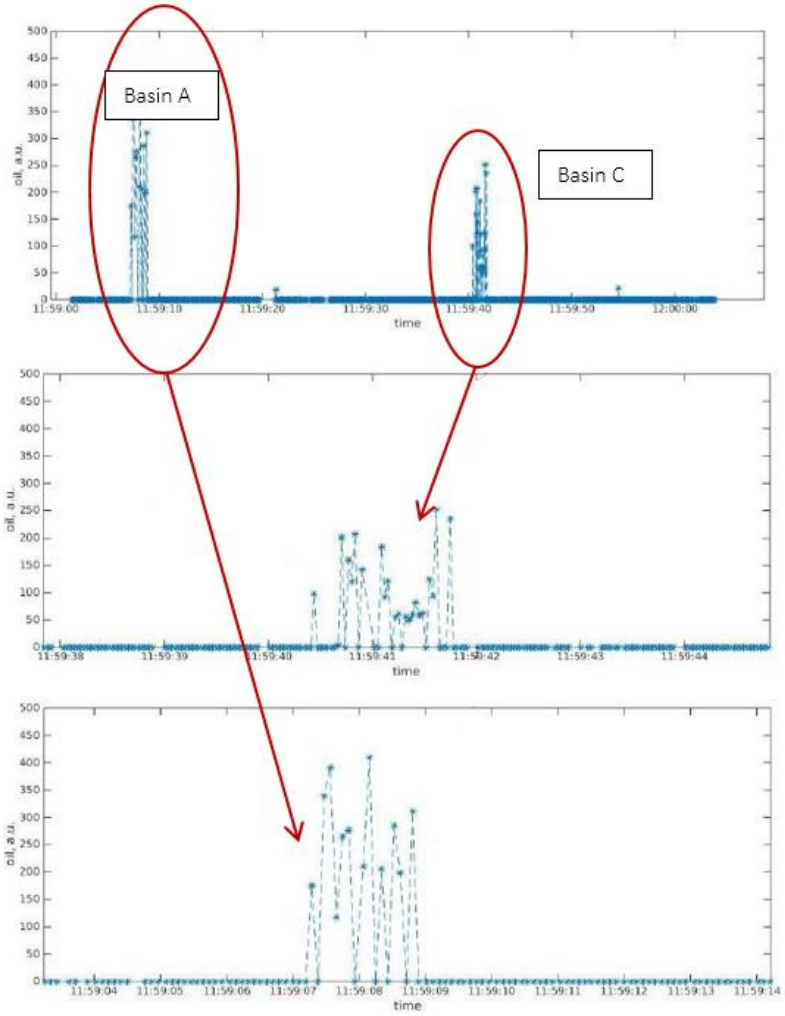
(Ref.: Svejkovsky et al, 2012)



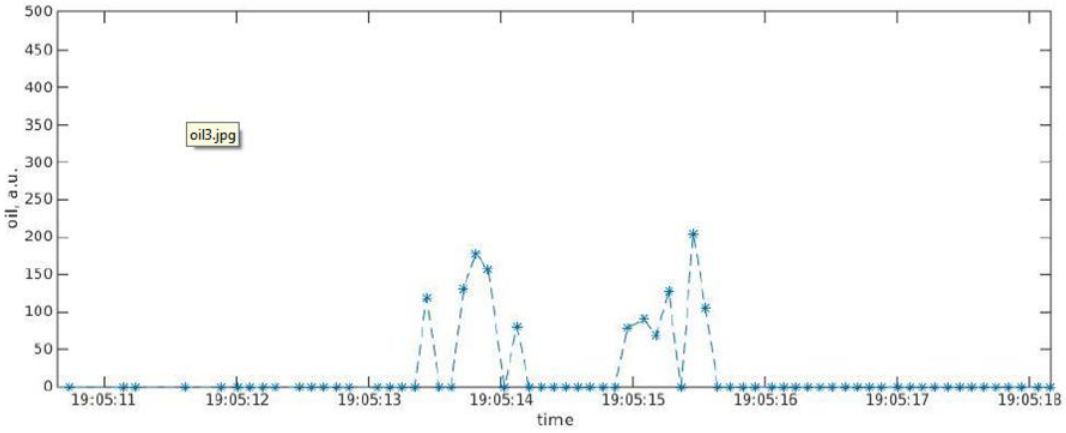
- Presence of oil can be noticed in reflectance values; in oil-free surfaces decline is more evident
- Different ice concentrations in basins may have influenced on result



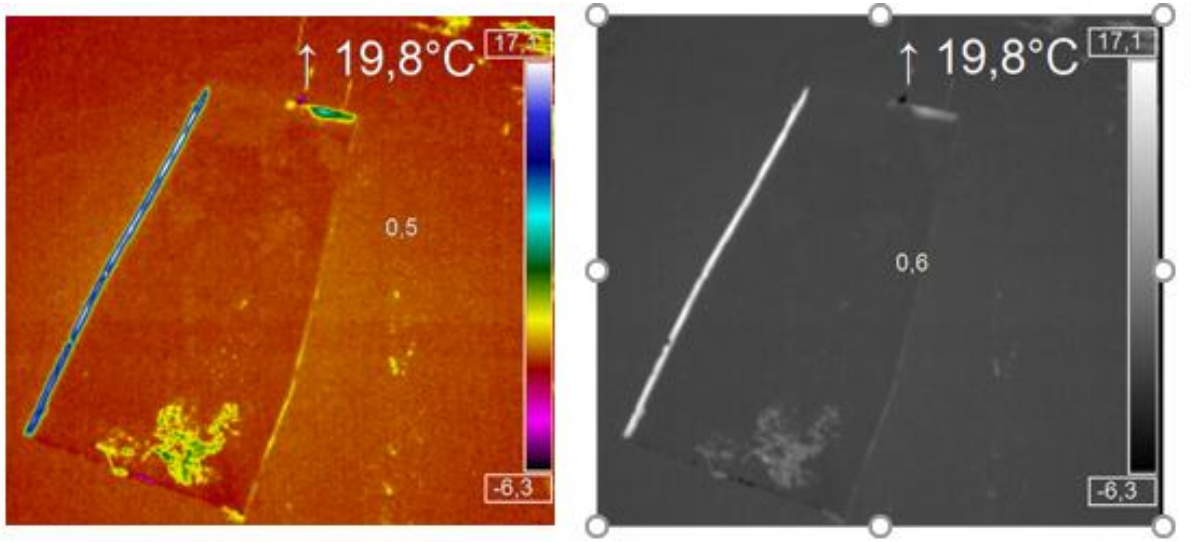
Results & observations / OWL



- Left (daylight): results indicate that first set of non-zero readings corresponds to first crossing of oil target at 11:59:07.
- Another overflight at 11:59:41 also corresponded to oil target.
- Below (nighttime): two peaks correspond to oil readings from basins A and C while basin B did not generate any readings as there was no oil present

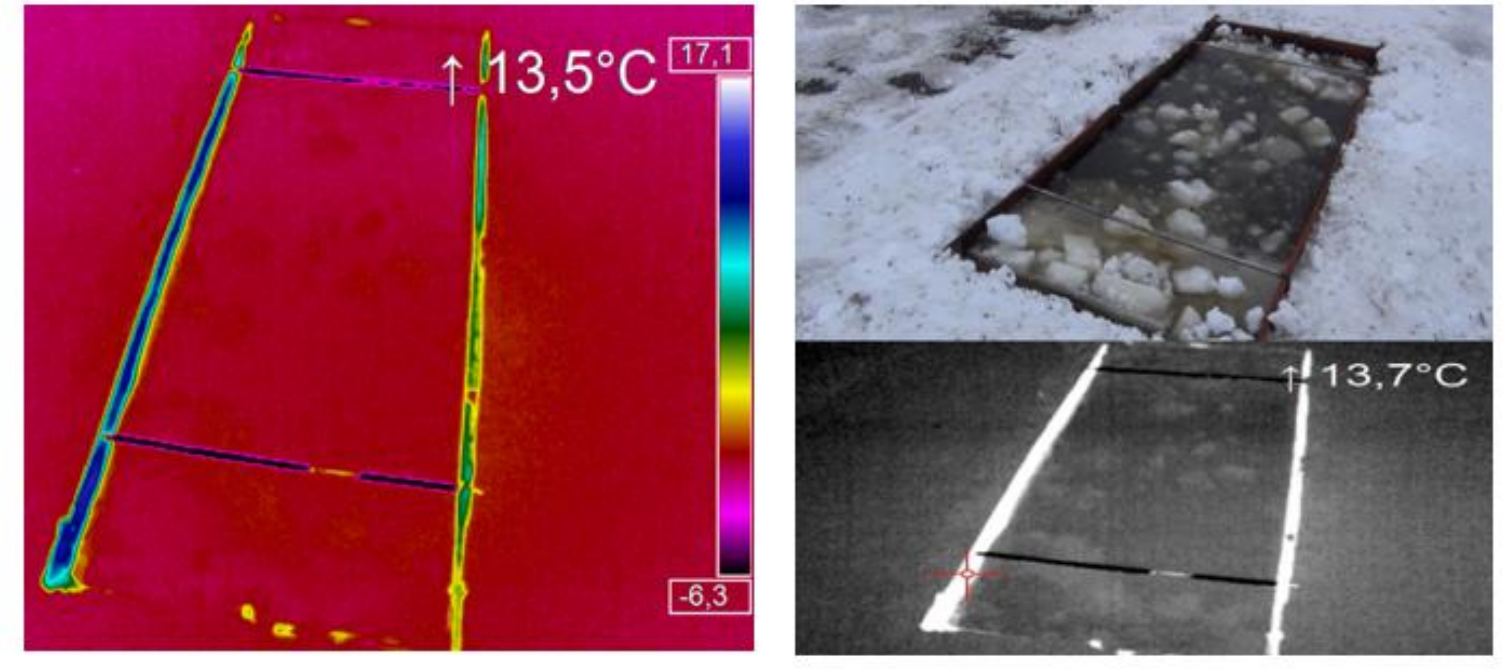


Results & observations / Optris IR thermometer



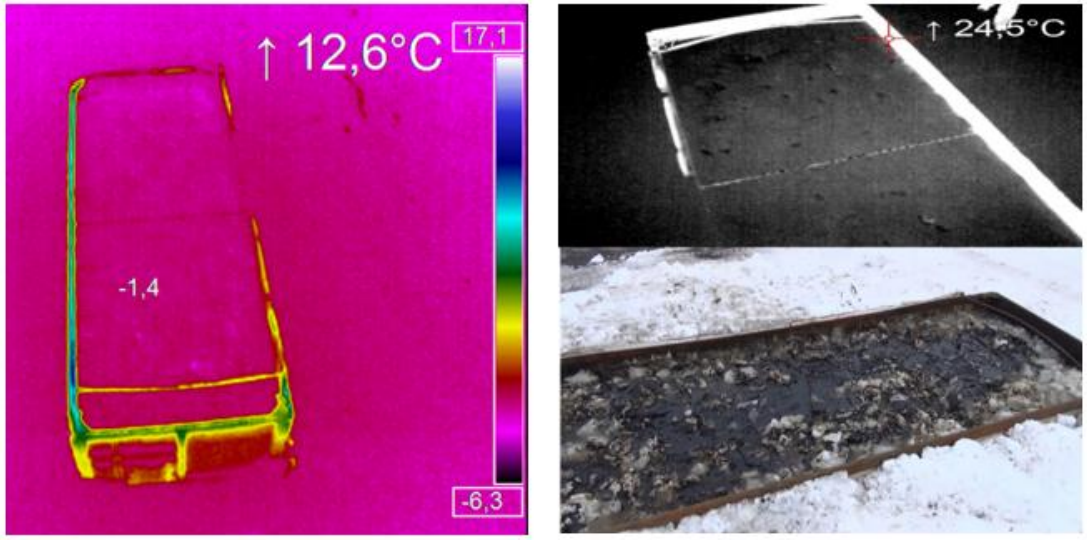
- Optris IR thermometer image from basin A illustrated with two different color palette
- Interestingly Optris detected hardly any oil in other parts of basin A

Results & observations / Optris IR thermometer (2)



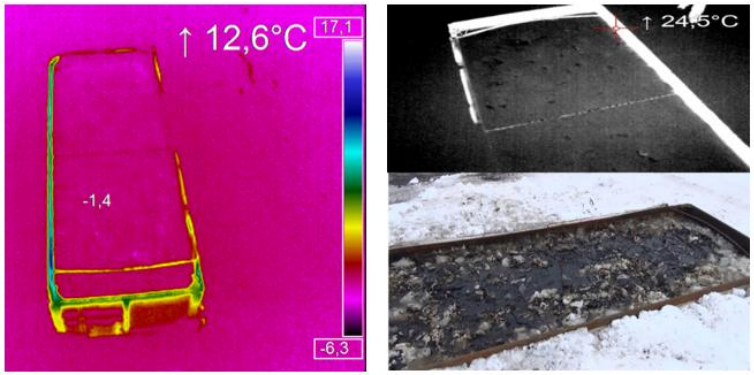
- Apparently no oil detected in basin B but temperature difference between water and ice was observed

Results & observations / Optris IR thermometer (3)



- No detection of any oil in basin C although there was oil
- No difference between the basin and the packed snow surrounding the basin
- Confusing since plenty of oil present in basin and difference between packed snow and oil/ice the in basin was visually apparent

Results & observations / Optris IR thermometer (4)



Possible reasons for false readings:

- Time used for the imaging of one basin (average of one minute) might have been too short for oil detection since only thickest layer of oil was detected
- Angle of IR camera toward basins might not have been optimum for oil detection in prevailing conditions
- If possible different imaging angles could have been tried to find out best possible angle
- Target areas should have been larger

Technology evaluation summary / Expected detection performance

Technology	Among Pack Ice Ice concentration < 30%	30-60%	>60%	On ice	Under ice / snow or encapsulated	Low visibility Blowing snow	Darkness	Rain or fog
VIS, MS, UV, Hyperspectral							Active systems	
TIR								
MWR								
SAR, SLAR Marine radar								
GPR								
LFS								
TDL								
LURSOT								
LiDAR								
Acoustic								
NMR								
Dogs								

(Ref.: Puestow et al, 2013)

Lessons learned / Drone

- Moderate wind conditions favorable to drone and flying operations could be performed as planned
- Wind limit for drone around 10 m/s while harder wind speeds causes exceeding of rectification limits of gimbal causing poor image quality
- Maximum payload around 3,5 kg since 3,8 kg was too heavy for a longer (> 20 sec) period of flying time
- Operator must have a direct unaided eye contact to drone
- Attention must be payed to charging of batteries in order to avoid additional interruptions during monitoring sessions

Lessons learned / Helicopter

- Some challenges to hit targets in fairly small basins, especially when flying in higher altitudes (not a problem in a real case due to larger target area)
- Heavier helicopter would enable more space for sensors and sensor operators, downside higher operational costs
- In case when operational area is more than 300 m from shoreline helicopter must be equipped with floats -> limits use of sensors due to obstacle caused by floats on both sides of helicopter

Lessons learned / Sensors

- Blue-Hawk™:
  - Sensor was too heavy for drone but could be used as handhold
  - Previous experiments conducted by LDI Innovation OÜ with stationary installations have indicated that sensor isa capable to detect oil up to 15 m distance

- Hyperspectral camera:
  - Spectral ranges from water samples could be classified with good accuracy
  - However, it was not clear if distinguishable differences in spectral ranges were caused by different ice-water concentrations in basins
  - Especially presence of ice made classification challenging

- OWL™:
  - Detected oil in both basins and confirmed that technology is suitable for a helicopter platform
  - When operating in dark conditions, UV target light needed in assisting pilot and operator to hit target area

Lessons learned / General

- Platform operator should have a basic understanding of sensors' operation principle in order to be able to operate it properly and interpret collected data
- Sensor operators and observers should be aware of limitations and basic operational principals of utilized technology in order to be able to provide reliable and accurate interpretation of measured data -> crucial in cases when operators and/or observers are not from companies providing sensor technology
- Limitations of platforms in question must be addressed beforehand

RPAS Field trials @ Kuopio, Nov. 1, 2016

- Test site of Emergency Services College
- Two different drones: Videodrone X8 (max. payload ca. 3,5 kg) & Airborne Heavy Lift KX-8 (max. payload 7 kg)

- Chemicals: acids, hydrocarbons & ammonia
- Detectors: ChemPro100i, Dräger detector tubes & Aeromon Ltd.

RPAS Field trials @ Kuopio, Nov. 1, 2016 (2)

THANK YOU!

jukka.sassi@vtt.fi