

# UV Cameras for Oil Spill Detection in Port Environments

## SWIPE Project

Port of Antwerp-Bruges | VITO

BELSPO STEREO Programme

28/05/2026



Els Knaeps

Project Manager - VITO



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Port of the Future Advisor – Port of Antwerp-Bruges

**Setting the scene...**



Er lekte olie in het water bij het overpompen van het ene naar het andere schip.  
Foto: Port of Antwerp-Bruges

## Olielek in Deurganckdok in haven van Antwerpen: 20 schepen besmeurd, opkuisactie zal enkele dagen duren

In het Deurganckdok in de haven van Antwerpen is er olie gelekt, toen de brandstoftank van een containerschip gevuld werd. Daardoor zijn het water, de kaaimuren en 20 schepen in het dok vervuild. Door de olievlek in te dammen, kon ze niet naar de Schelde drijven. De opruiming is volop aan de gang, maar zal meerdere dagen duren. Schepen worden omgeleid.



Foto: Port of Antwerp-Bruges

## Olie in Deurganckdok in Waaslandhaven ten vroegste woensdag opgeruimd

Het Aalsterse bedrijf Jan De Nul verwacht dat de olie in het Deurganckdok in de Waaslandhaven ten vroegste woensdag opgeruimd zal zijn. Hun baggerschip zuigt de olie op, later zal een gespecialiseerd bedrijf ze verwerken. De firma Brabo maakt de schepen schoon die in het Deurganckdok liggen voor ze verder de Schelde opvaren. Op die manier verspreidt de vervuiling zich niet.

radio2, Peggy Van de Velde  
ma 10 jun 15:54



Vorige week liep iets mis bij het vullen van een schip in het Deurganckdok. De gelekte olie heeft water, kaaimuren en een 20-tal schepen vervuild.

De Aalsterse firma Jan De Nul zuigt met een baggerschip de olie op. "Wat we zien is dat de firma Brabo stuk voor stuk de schepen schoonmaakt. Die kunnen dan het dok verlaten", legt Bart Praet van Jan De Nul uit. Op die manier breidt de vervuiling niet uit naar de Schelde. "Volgens wat we horen, is er op zee een wachtlijn met schepen voor het Deurganckdok."

# 01 | Context & Problem Statement

## The challenge

- ~50 oil spill clean-up interventions per year at POAB
- Annual cost: € 1M+ | only 40% recovered from the offender
- Major incidents running into the **tens of millions**
- +250 interventions registered 2020–2025

## Current approach: purely reactive

- Port officers detect spills by eye — no automated system exists
- Drones are part of POAB's digitization strategy since 2021

**Goal: early detection, fast response, reduced cost**

# 02 | Oil Spills in Port Environments

## Why ports are different from open sea...

- Refined oils (hydraulic, diesel, marine diesel) — not crude oil
- Thin oil films — thermal (LWIR) and SWIR methods are ineffective
- Crowded, cluttered scenes: docks, vessels, shadows, algae

## Why standard sensors fail

SWIR: no clear absorption signal in refined oils at port-typical thicknesses

SAR: insufficient surface roughness in sheltered harbour basins

Satellite: resolution too coarse for port scale

People work 24/7 — health risk requires immediate response



SAR satellite images Port of Antwerp-Bruges during oil spill

# 03 | SWIPE Project Overview

## **SWIPE: SWIR and Drones for Early Detection of Oil Spills in Ports**

Contract SR/00/400 | BELSPO STEREO IV programme

Duration: July 2022 – June 2024 (6-month extension for UV work)

### **Consortium**

Port of Antwerp-Bruges (coordinator) — Joeri Vandepierre

VITO Remote Sensing (scientific lead) — Daniel Iordache, Els Knaeps, Robrecht Moelans

University of Antwerp (physical modelling) — Bikram Koirala

### **Key pivot during project**

SWIR proved unsuitable → team reoriented to UV cameras

UV camera tested on PROGRESS vessel (Mar–May 2024, >200 GB data)

# 04 | Technology Assessment: UV vs RGB

**IMPERX**  
**CHEETAH**  
RUGGEDIZED CAMERA SERIES

Front View Rear View

**P67-C2820**  
CMOS 8.1 MP  
GigE Vision® with Power over Ethernet (PoE)

**PRELIMINARY**  
Imperx C2820

The P67-C2820 provides the same robust camera design as the P6E-C2820 with an IP67 enclosure. The P67-C2820 camera features the Sony Pregius 5™ IMX487 Global Shutter CMOS sensor with a native resolution of 2856 x 2848 in a 2/3" optical format capturing images in the UV spectral range from 200 nm to 400 nm and delivering up to 14.8 frames per second with GigE Vision® Power over Ethernet (PoE) output. The Pregius 5 technology uses a stacked back-illuminated pixel structure with or without a double AR coated quartz glass window offering reduced pixel size, and quantum efficiency similar to the popular iCX407(LU) image sensor. Using the simple Gen-I-Cam™ compliant user interface, you can quickly apply image corrections to enhance recognition or quality. The C2820's flexibility, outstanding sensitivity, image quality, and speed make it suitable for a broad range of diverse and demanding applications. The IP67 rated enclosure protects the camera from dust, water and other contaminants and the wide operational temperature range makes the P67-C2820 suitable for harsh environments.

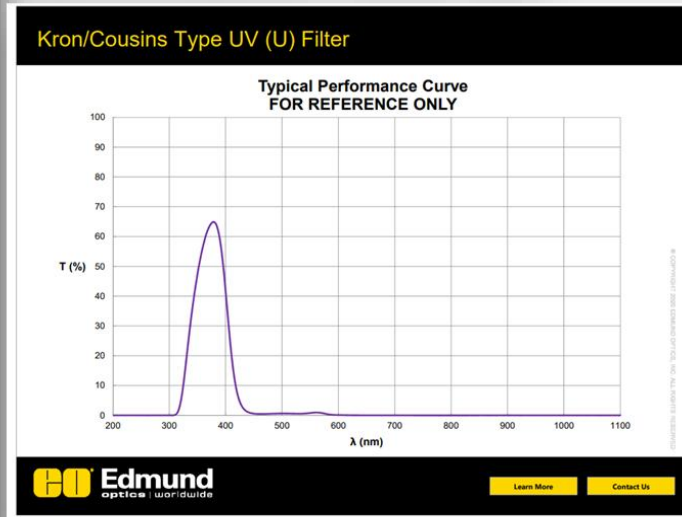
**Specifications**

Feature	Description	Feature	Description
Original Interface	GigE Vision® with Power over Ethernet (PoE)	Data Conversion	1.12% pre-programmed with Gamma 0 AC 2.11% pre-programmed with Negative LUT 3rd post conversion (static), Flat field correction C-Mount (default)
Resolution	2856 (H) x 2848 (V)	Lens Mount	12 V DC @ 0 V - 30 V; 1.5 A max @ 12 V PoE IEEE 802.3af (IEEE 802.3at)
Sensor	Sony Pregius 5 IMX487 CMOS Ultraviolet	Power Consumption	Typical 3.90 W @ 12 V PoE; 5.90 W
Sensor Format	7.8 mm (H) x 7.8 mm (V), 2/3" optical format (11.1 mm diagonal)	Camera Control	Typical 200 mA @ 12 V
Pixel Size	2.34 microns square	Size - Width/Height/Length	48.5 mm (W) x 42.0 mm (H) x 81 mm (L) partial connections and a lens tube (L)
Shutter	Global shutter (GS)	Lens Tube Dimensions	44 mm Lens tube inner diameter 44 mm Outer diameter 50 mm Length varies (see IP67 lens tubes spec sheet)
Sensor Digitization	12-bit	Weight	84 mm Lens tube inner diameter 54 mm Outer diameter 70 mm Length varies (see IP67 lens tubes spec sheet)
Frame Rate	14.8 fps (8-bits), 7.4 fps (10-bit/12-bit unpaired), 9.8 fps (10-bit/12-bit packed)	Environmental	300 (20 - 200) Hz X(1/2) 100G -30 °C to +75 °C Operating (-40 °C to +85 °C storage), +5 °C to +85 °C Storage
Dynamic Range	71 dB	Humidity	10% to 90% non-condensing - for exposure ranger than 30 minutes 100% non-condensing - for exposure up to 30 minutes
Output Bit Depth	8, 10, 12-bit	MTBF	Not Specified*
Analog/Digital Gain	Manual, Auto, 0.48 - 48 dB, 480 steps	Military Standard	MIL-STD-883C
Digital Gain	1x (0.48) to 4x (12.48) with a precision of 0.001x	Regulatory	FCC Part 15 Class A, CE, RoHS, UL94
Black Level Offset	Manual (0 - 4095), Auto		
White Balance	Manual, Auto, Once, Off		
Shutter Speed	28 µs to 1/8 s		
Exposure Control	DR Manual, Auto, External		
Regions of Interest (ROI)	2 ROI		
Binning	1x1, 2x2		
Sub-sampling	1x1, 2x2		
Trigger Inputs	External, Pulse generator, Software		
Trigger Options	Edge, Pulse width, Trigger delay, Debounce, Trigger over Ethernet		
Trigger Modes	Free run, Standard, Fast		
External Inputs/Outputs	1 In (GPIO), 2 Out (GPIO, TTL)		
Stroke Output	2 strobes, programmable position and duration		
Pulse Generator	Yes, programmable		

\*Optimization necessary depending on usage scenario including image content and contrast with scene.  
The amount of damage and the useful life of the image sensor is dependent upon the radiant power and duration. For more information, contact Imperx.

**IMPERX**  
Industrial Cameras & Imaging Systems

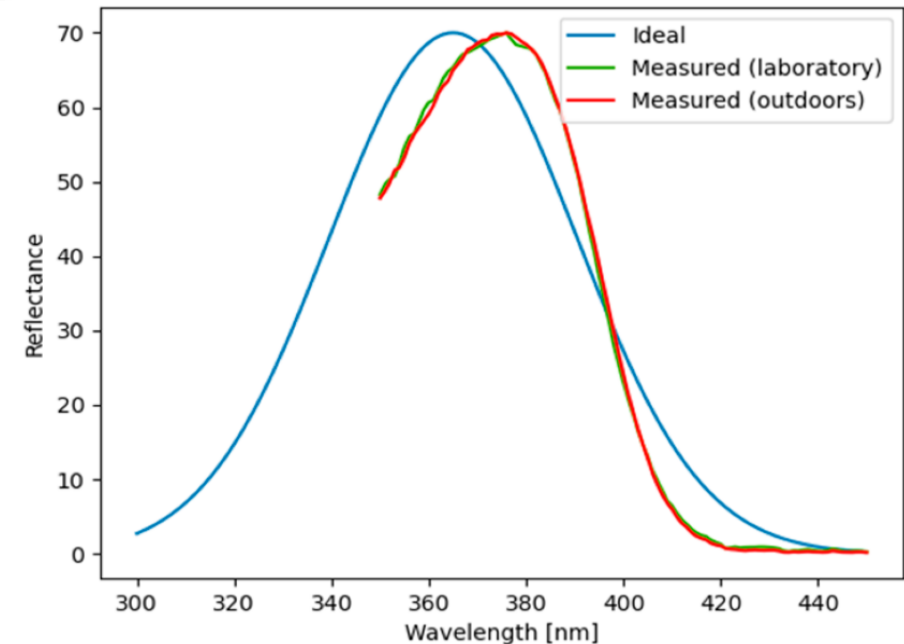
## Spectral Response Function (SRF)



central wavelength of 365 nm and a full width at half-maximum (FWHM) of 60 nm



high-resolution RLC-1212A RGB camera



UV-camera: Ruggedized camera, resistant to weather elements (IP67 rating)



# 04 | Technology Assessment: UV vs RGB



Pictures of the four oil samples.

UV and RGB cameras mounted on a common pole.



Metallic containers

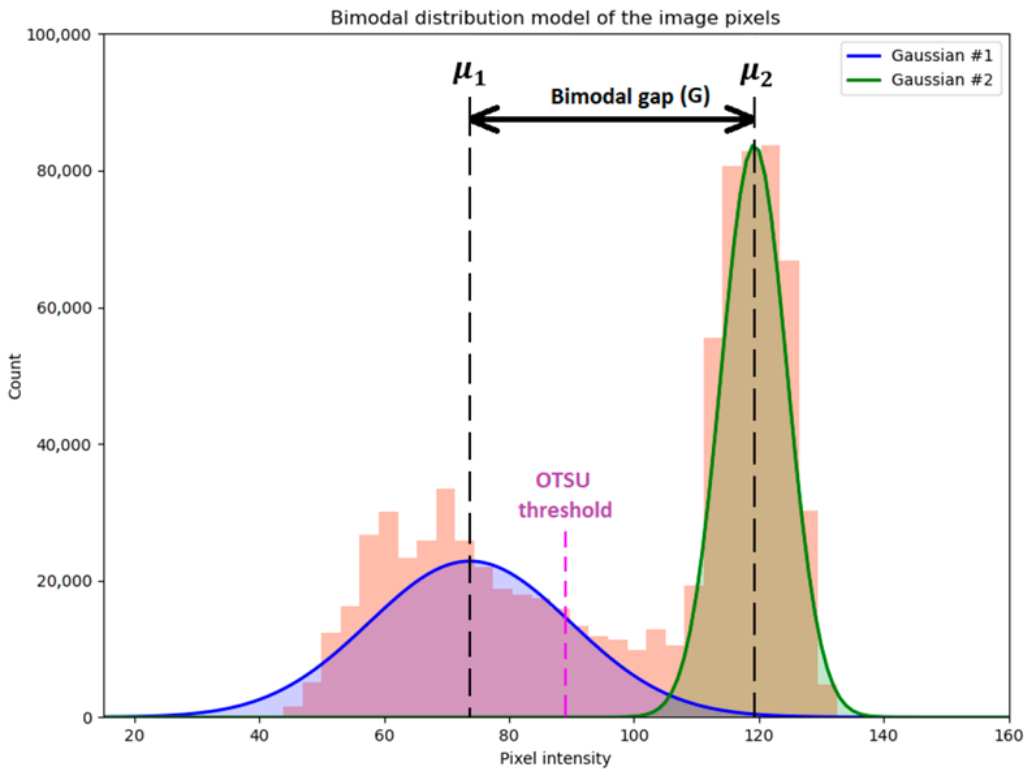


Table 1. Experiments performed on 27 February 2024.

Oil Type	Identifier	Viewing Angle	Observations
H (hydraulic)	H_NN	NN	Cloudy, regular wind
	H_45	45	Sunny, mild wind
	H_45R	45_Rotation	Sunny, mild wind
	H_30	30	Sunny, mild wind, sun glint
U (used)	U_NN	NN	Cloudy, regular wind
	U_45	45	Sunny, mild wind
	U_30	30	Sunny, mild wind, sun glint
D (diesel)	D_NN	NN	Cloudy, regular wind
	D_45	45	Mixed sky, mild wind
	D_30	30	Sunny, mild wind, sun glint
M (marine diesel)	M_NN	NN	Cloudy, regular wind
	M_45	45	Sunny, mild wind
	M_30	30	Sunny, mild wind, sun glint

# 05 | Experimental Results

class separability between the classes “water” and “oil”



Identifier	Image Type (Spectral Band/Transformation)				
	UV	Blue	Green	Red	Gray
H_NN	$G, \eta, M$				
H_45	$G, \eta$	$M$			
H_45R	$G, \eta$	$M$			
H_30	$(G), \eta, M$	$G$	$(G)$	$(G)$	$(G)$
U_NN				$G, \eta, M$	
U_45	$G, \eta, M$				
U_30	$G, \eta, M$				
D_NN	$(G)$	$(G), M$	$G$	$(G), \eta$	$(G)$
D_45	$G, \eta, M$				
D_30	$G, \eta, M$	$(G)$	$(G)$	$(G)$	$(G)$
M_NN	$G$	$M$		$\eta$	
M_45	$G, M$			$\eta$	
M_30	$(\eta), M$	$G$	$(G)$	$\eta$	$(G)$

Metric #1: Bimodal gap ( $G$ )

Metric #2: Normalized between-class variance ( $\eta$ )

Metric #3: Mutual information ( $M$ )

# 05 | Experimental Results

Bottom and shadow effects in RGB and UV images for a near-nadir viewing: (a) UV image. (b) RGB image. (c) Classification map of the UV image. (d) Classification map of the RGB image

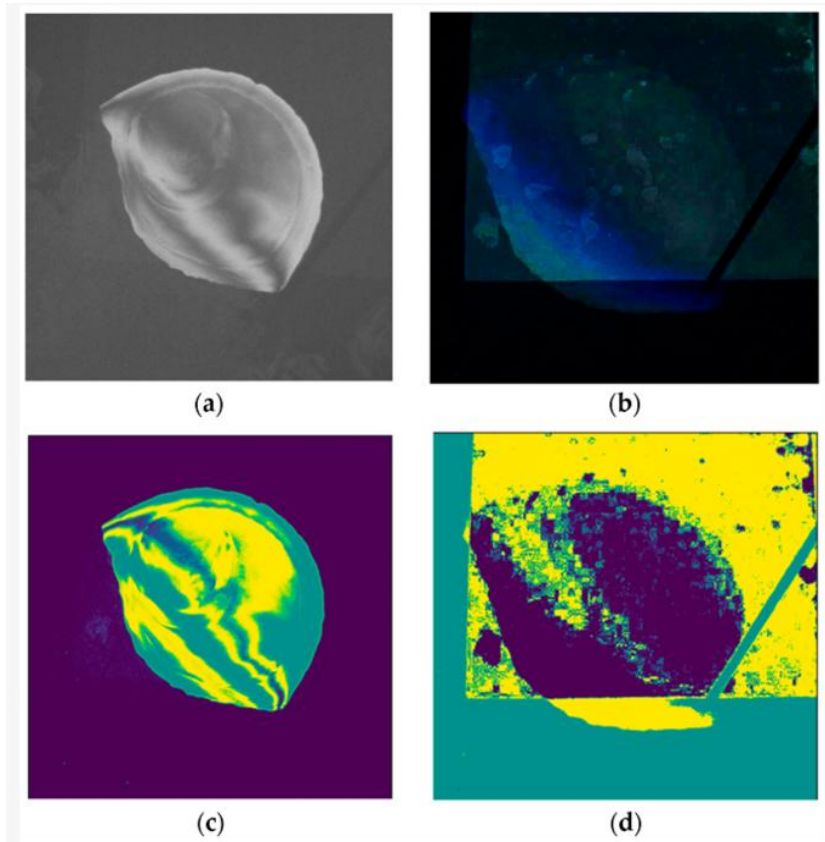
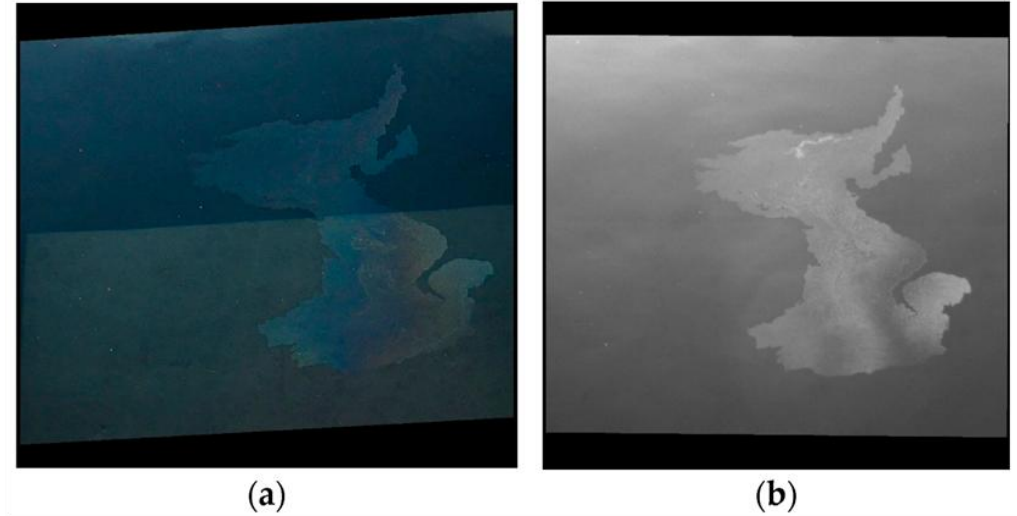


Illustration of bottom effects: (a) RGB image; (b) UV image

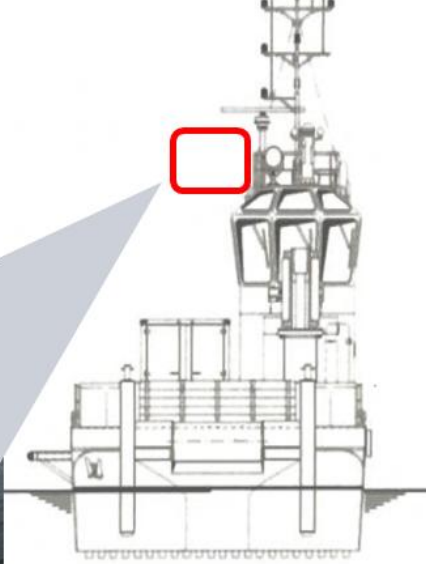


rotation experiment on 27 February 2024. One RGB-UV pair is shown for each of the six positions (top: RGB; bottom: UV).

Position 1	Position 2	Position 3	Position 4	Position 5	Position 6

# 06 | Real-World Validation — PROGRESS Vessel

- System attached to monkey bridge of multicat “Progress”
- Autonomous system + remote access
  - Multiple raspberry pi
  - Storage on multiple HDD
  - 4G + wifi
  - Influence water / dirt & vibrations!!

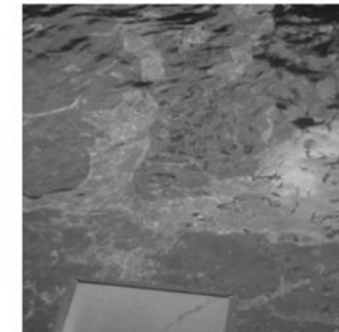


**Table 6.** Numbers of available and used images for the three considered dates.

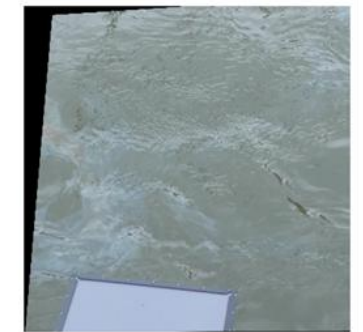
Date	Time Range	#RGB Images	#UV Images	#Image Pairs Used
12 March 2024	13:16:46–14:33:05	12	5	3
21 May 2024	14:01:51–16:17:50	18	8	3
22 May 2024	10:02:03–12:16:38	19	9	4



(a)



(b)



(c)

(a) Example of an RGB image. (b) Example of corresponding UV image. (c) Preprocessed RGB image

# 06 | Real-World Validation — PROGRESS Vessel

Discriminative metrics computed for real-world imagery. The grey cells indicate the best performing bands, and values highlighted in bold indicate bands whose performance is close to the best one.

Metric #1: Bimodal gap ( $G$ )

Metric #2: Normalized between-class variance ( $\eta$ )

Metric #3: Mutual information ( $M$ )

Metric	Date	Image Type (Spectral Band/Transformation)				
		UV	Blue	Green	Red	Gray
$G$	12 March 2024	0	33	49	52	48
	21 May 2024	0	<b>2</b>	23	32	23
	22 May 2024	0	17	38	49	39
$\eta$	12 March 2024	0	-82	-89	-89	-88
	21 May 2024	0	-56	-73	-75	-72
	22 May 2024	0	-85	-91	-94	-92
$M$	12 March 2024	0	34	31	25	46
	21 May 2024	0	-18	<b>-4</b>	<b>2</b>	<b>2</b>
	22 May 2024	0	<b>-5</b>	<b>-10</b>	<b>-7</b>	<b>8</b>

## 07 | Conclusions

- Experiments in controlled environment showed that UV camera is superior to RGB cameras
- Analysis of real-world images confirmed the conclusions
- Other classes were not considered (e.g. vessel passing by), water constituents were not considered -> new experiments from drone
- Separability test -> development of detection algorithms

# 08 | Operational Requirements (1/2)

## Desired target service model

- Drone-as-a-service network | 24/7 availability | 500+ flights/month
- Oil spill detection as part of standard drone inspection program

## Two detection modes

- Autonomous patrol: drone self-detects spill
- Alert-triggered: port worker notifies emergency ops centre

# 08 | Operational Requirements (2/2)

## Desired processing phases

1. Initial detection: <2 min after drone arrival
2. Live monitoring: drone hovers above spill
3. Post-processing: detailed analysis <1h after data upload

# Conclusions & Next Steps



Port of  
Antwerp  
Bruges

EU General Regulation 2017 in relation to port state

Validated in certified equipment AISD (air-water interface)

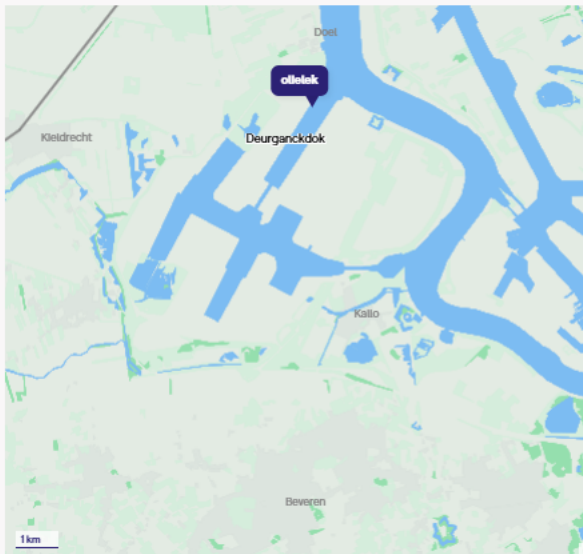
## Olie vrij ver verspreid

De Berendrechtsluis blijft **gestremd** door de aanwezigheid van oliestierten, de Zandvlietluis zou weer opengaan. Beide sluisen liggen zo'n 3 kilometer stroomafwaarts van de bron van het lek. Dat wil zeggen dat de olie zich afgelopen nacht vrij ver heeft verspreid. In de omgeving van het lek bevinden zich heel wat natuurgebieden, zoals de Doelpolder en het Verdrongen Land van Saeftinghe.

"Er wordt rekening gehouden met mogelijke impact op de omliggende natuurgebieden", aldus Port of Antwerp-Bruges. "De zorg voor onze omgeving is een absolute prioriteit. We zetten dan ook alles op alles om de operationele en ecologische schade tot een minimum te beperken."

De haven heeft een vliegtuig ingezet om de schade in kaart te brengen.

### Lekkend schip in haven van Antwerpen



vrt nws

Regio Haven Antwerpen

## 320 besmeurde vogels geteld na olie lek in Antwerpse haven, ook minder vissen gespot

Artikel luisteren | 4min



Vrijwilligers troffen op rechteroever besmeurde kuikens aan.

Het Instituut voor Natuur- en Bosonderzoek heeft 320 vogels gevonden die besmeurd door olie, zowel op rechter- als linkeroever van de Schelde. Dat komt door een olie lek Deurganckdok in de Antwerpse haven vorige donderdag. Ze vonden ook 2 dode vogels en minder vissen gespot. "De cijfers zijn een zware onderschatting van het totaal getroffen vogels", zegt Koen Van Muylem van het INBO.

Mathieu Verstichel, Johanna Van Doninck

do 16 apr. 18u23

Binnenland Economie

## Scheepvaartverkeer van en naar Schelde gedeeltelijk heropgestart na olie lek in Waaslandhaven

Artikel luisteren | 4min

Meer info



De olie lek is vanuit het Deurganckdok utgedeind naar de steiger van de Waterbus in Lillo.

Het scheepvaartverkeer van en naar de Schelde is gedeeltelijk heropgestart na het olie lek van afgelopen nacht. Het incident gebeurde aan het Deurganckdok. Het lek is intussen gedicht, maar de olie heeft zich wel verspreid. Hoeveel olie in het water is terechtgekomen, is nog niet duidelijk. De Haven van Antwerpen zal wellicht pas zaterdag opnieuw open kunnen gaan.

Helena De Bouver, Belga

vr 10 apr. 08u57

update: vr 10 apr. 22u00



# New drone images: UV and RGB oblique images



# New drone images: UV and RGB NADIR images



# Deep-Dive: UV Camera Proof-of-Concept

## Next steps

### 1 Payload Integration

- Temporary UV + RGB/VNIR integration on drone (DJI M300 or generic platform)
- Two options: UV + multispectral VNIR (generic) OR UV + RGB for DJI M300
- VITO develops & loans payload; PoAB decides platform in consultation

### 2 Field Flights

- 2–3 flights over active oil spill incidents in the port
- Simultaneous UV and RGB capture for direct comparison
- VITO advises on flight parameters and camera orientation
- Goal: representative drone imagery in real port conditions

### 3 Analysis & Decision

- Visual & statistical evaluation (same methodology as SWIPE)
- Key question: does UV add detection value over RGB alone?
- If NO → proceed with RGB only; if YES → scale up UV integration

**Thank you!**