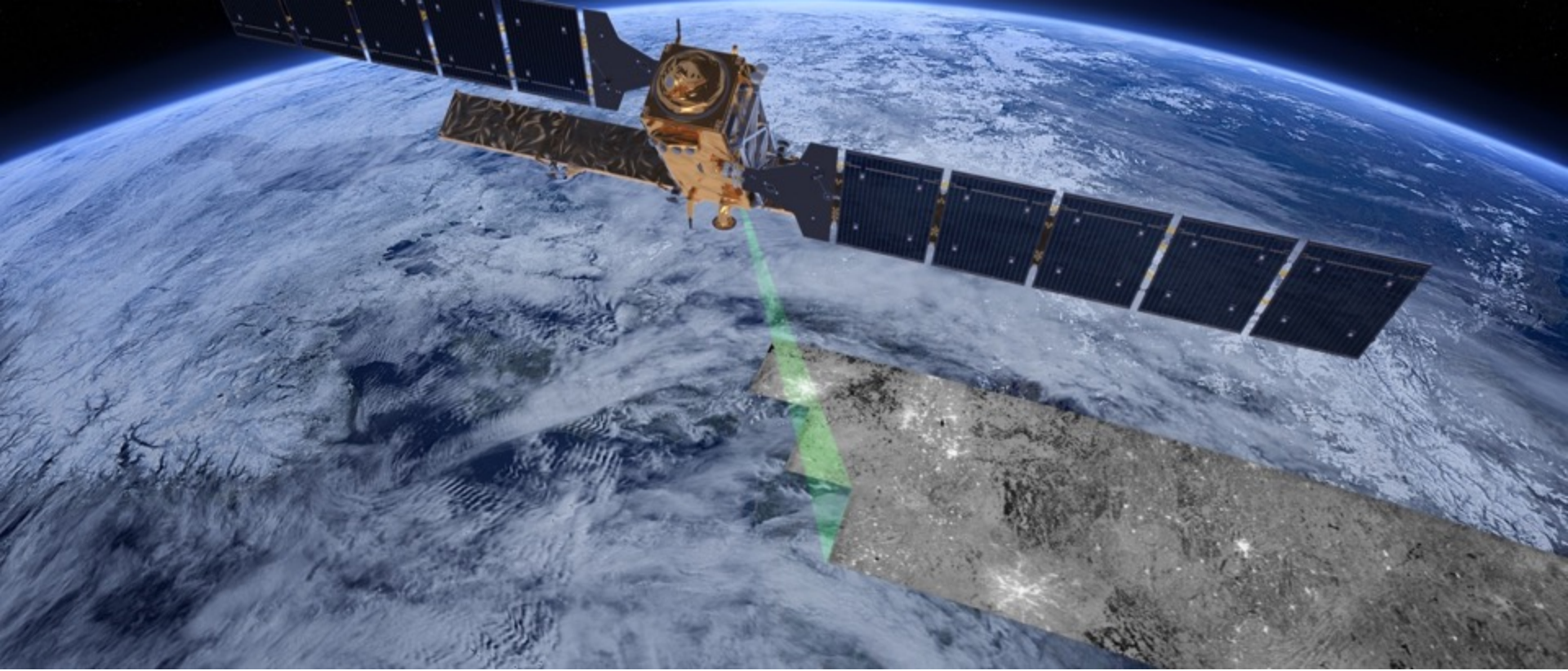


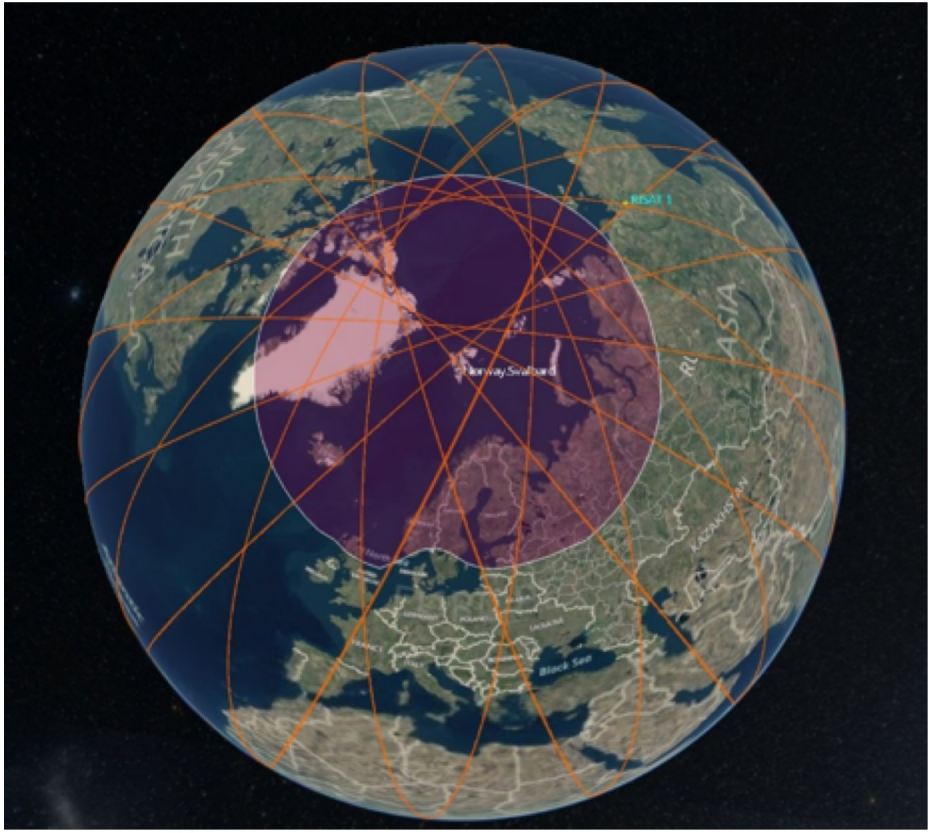
Paul Whitaker – Director of Strategy – paul@ksat.no

KSAT KONGSBERG
KONGSBERG SATELLITE SERVICES

TROMSØ 69°North, KSAT Headquarters

Svalbard –The World's Largest and Northernmost Ground Station

KONGSBERG



- 78°North
- Unique location,14 of 14 passes
- 24/7 operations
- Established 1997
- Redundant fiber cables (Tbps)
- > 50 antenna systems (3m - 13m)
- 30 employees

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Antarctica – Troll Station – Norwegian Polar Institute

KONGSBERG

- 72°S 2°E in Antarctica.
- Svalbard & Troll = access ~every 40 minutes
- Download frequency = 26 times per day per satellite (14 + 12)
- Inland location = stable climate / good weather conditions.

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KSAT's Growing Global Network – "New Space" Support


NASA
LANDSAT8
PLANET LABS
DOVE

Who Uses The KSAT Network?

KONGSBERG

KSAT

249 commercial non-GEO spacecraft launched in the US in 2017

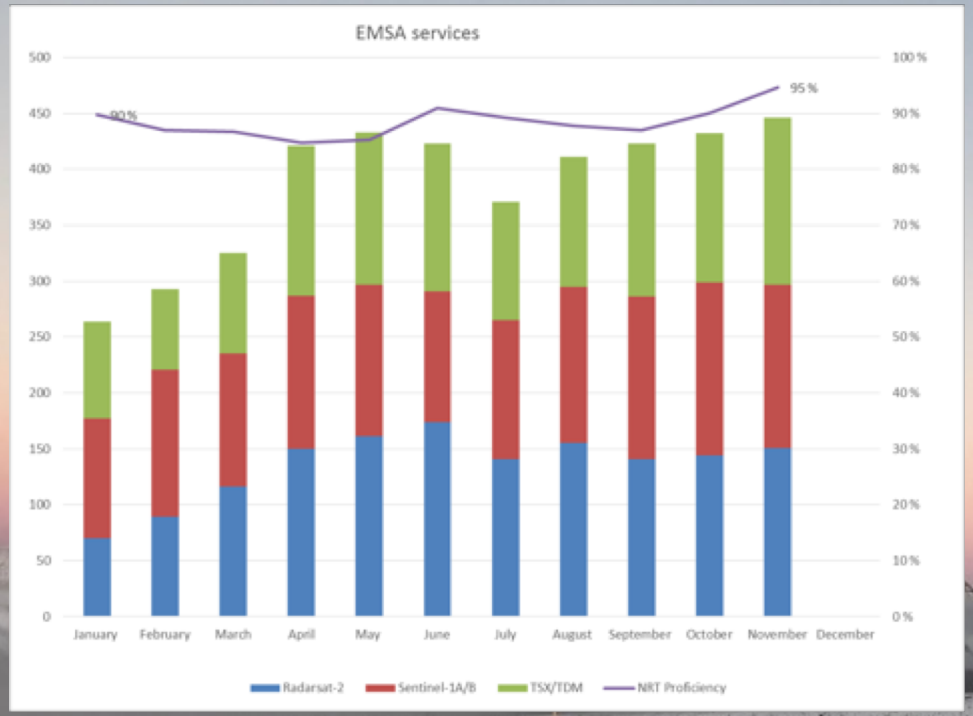
→ 243 of those spacecraft are on the KSAT network

	Percentage of Spacecraft on the KSAT Network	# of Spacecraft launched in 2017 on the KSAT Network	# of Spacecraft launched in 2017
US Commercial Spacecraft	98%	243	249
Global Commercial Spacecraft	89%	246	275

98% of the U.S. non-GEO commercial industry

Over 30,000 Satellite Passes Every Month

Example Case – Near Real Time - EMSA

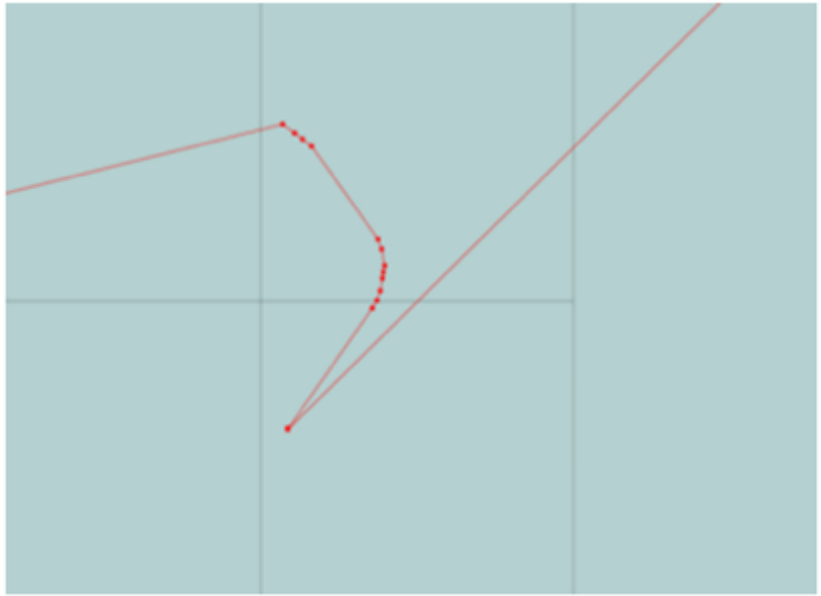


- KSAT typically delivered over 400 satellite reports per month to EMSA in 2018 (both oil spill and vessel detection)
- SAR sensor mix includes RADARSAT-2, Sentinel, TerraSAR-X
- EMSA is very strict on delivery timing –penalties for not delivering services on time (< 20 mins for notification / 30 mins for complete analysis).
- NRT proficiency has typically been 85-95%
- But our network serves more than just Europe…deliveries in Australia average less then 60 minutes from satellite pass!

3 Key Sensor Types in Fisheries Monitoring

KONGSBERG

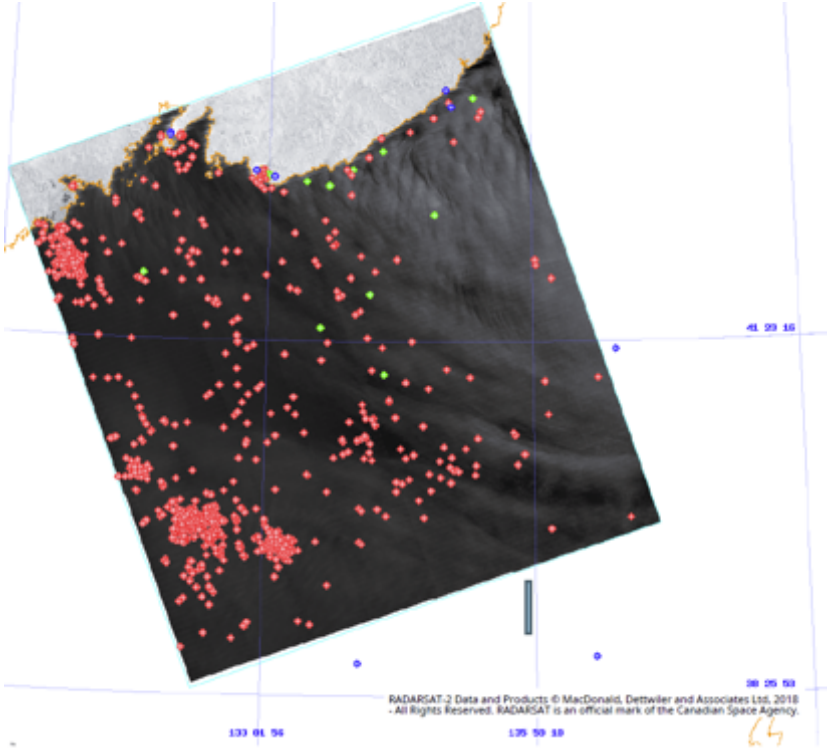
Satellite AIS



3 Key Sensor Types in Fisheries Monitoring

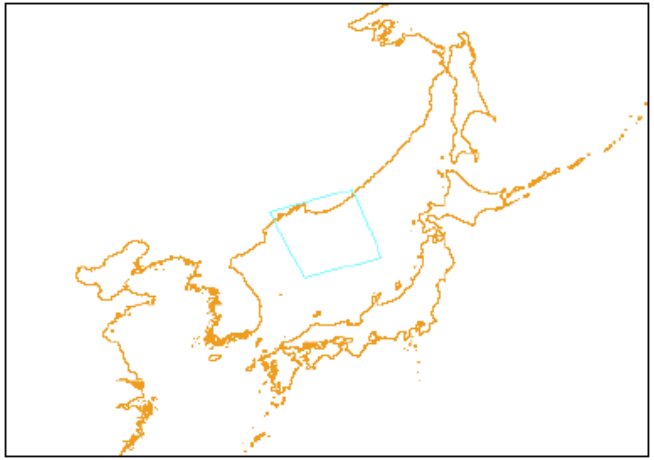
KONGSBERG

Satellite AIS



Example from July 15, 2018

- 12 vessels seen on AIS*
- 1,061 vessels seen with SAR



*Satellite AIS from Norwegian sources – indicative only

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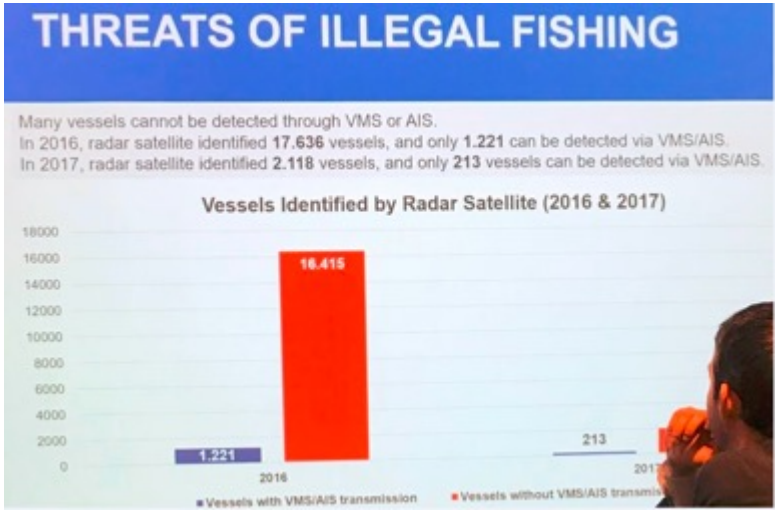
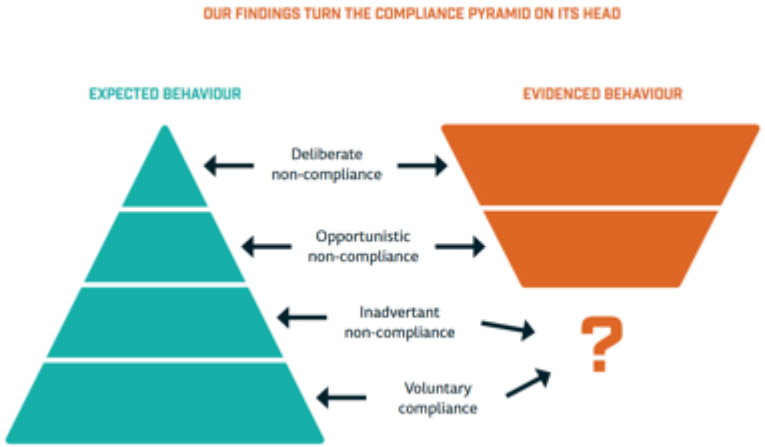
3 Key Sensor Types in Fisheries Monitoring

KONGSBERG

Satellite AIS



Presentation of Mr. Mas Achmad Santosa, Coordinator for Special Advisors, Presidential Task Force to Combat Illegal Fishing - Arctic Frontiers, Tromsø Norway, January 24th 2018



Stop Illegal Fishing (2017) FISH-i Africa: Our Future. Gaborone, Botswana - September 27, 2017

https://stopillegalfishing.com/wp-content/uploads/2017/09/FISH-i_Africa_Our_future_WEB.pdf

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3 Key Sensor Types in Fisheries Monitoring

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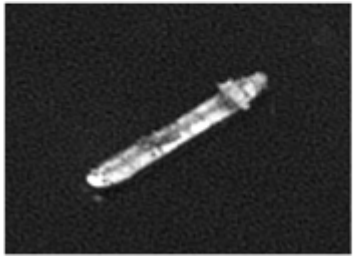
Optical Imagery

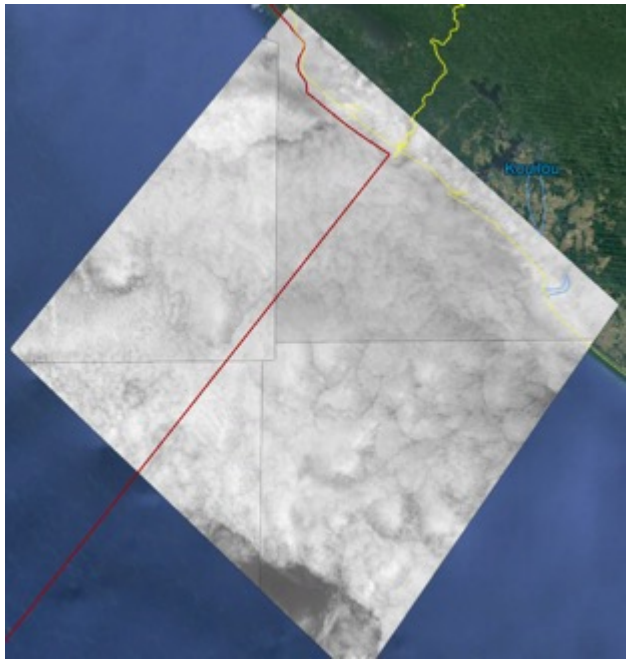
Track 1

Date of the shot :	2017-05-12T09:04:32Z
Latitude :	03°53'06" S
Longitude :	010°55'46" E
Confidence :	PROBABLE
Speed :	STOPPED
Type (STANAG) :	TMO (Merchant ship, tanker)
Length :	237.0 m
Width :	31.0 m
Heading :	230.0°
Comment :	Anchored
Track Pointing Type :	Full



Track 3

Date of the shot :	2017-05-12T09:04:32Z
Latitude :	03°56'20" S
Longitude :	010°53'22" E
Confidence :	PROBABLE
Speed :	STOPPED
Type (STANAG) :	TMT (Merchant ship, tug, ocean-going)
Length :	53.0 m
Width :	11.0 m
Heading :	23.0°
Comment :	MPSV
Track Pointing Type :	Full



KSAT can now provide high resolution optical imagery in near real time…but can't make the sun shine

KSAT

3 Key Sensor Types in Fisheries Monitoring

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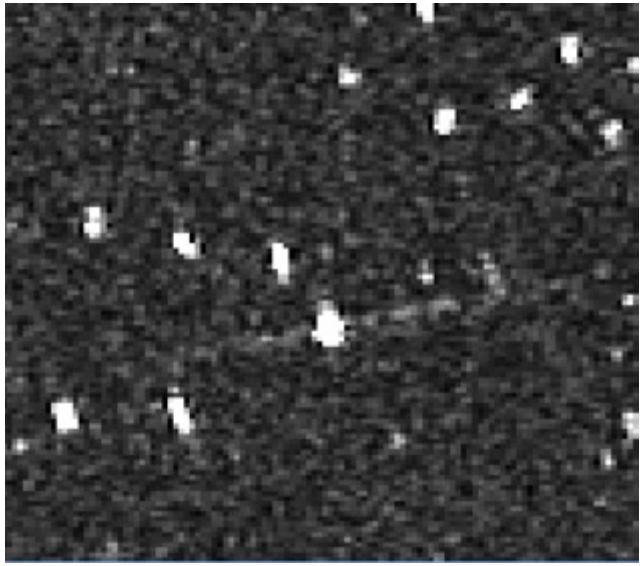
Synthetic Aperture Radar (SAR)*

RADARSAT-2	COSMO-SkyMed 1-4	SENTINEL-1a+1b	TerraSAR-X /TanDEM-X	RISAT-1	PAZ
					
In-House Processing					Launching 2018



*Gaofen-3 (C-Band Chinese SAR) is expected to be operational by end of February for NRT delivery
* PAZ is on orbit now in calibration – expected to be operational by Q1 2019

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Why So Much SAR?

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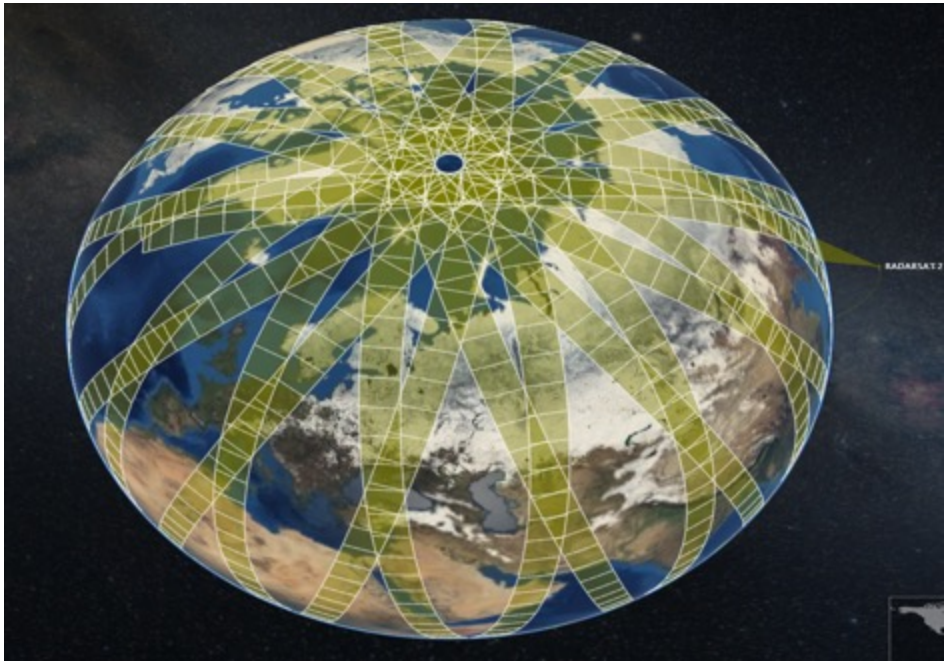

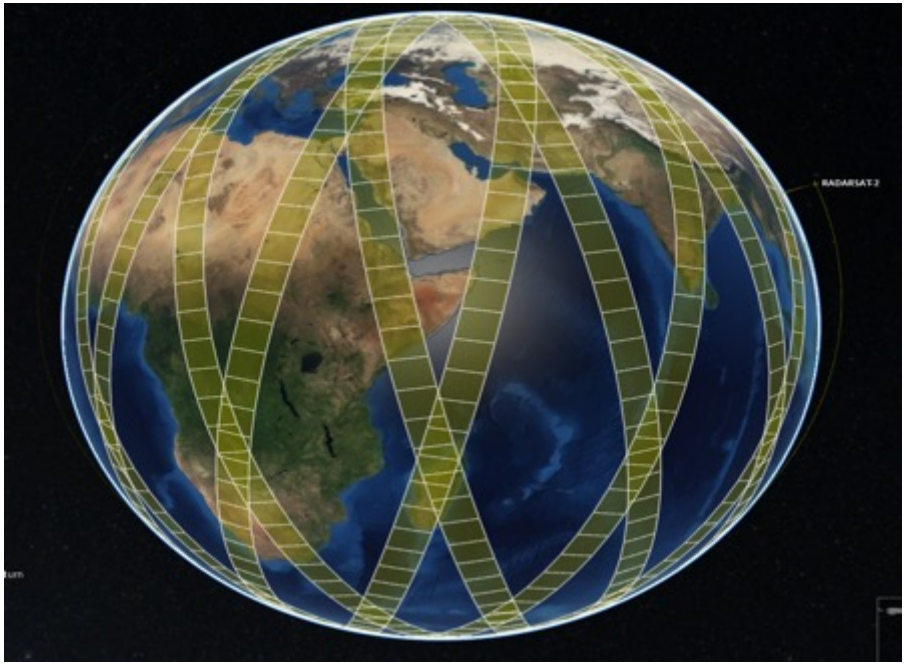

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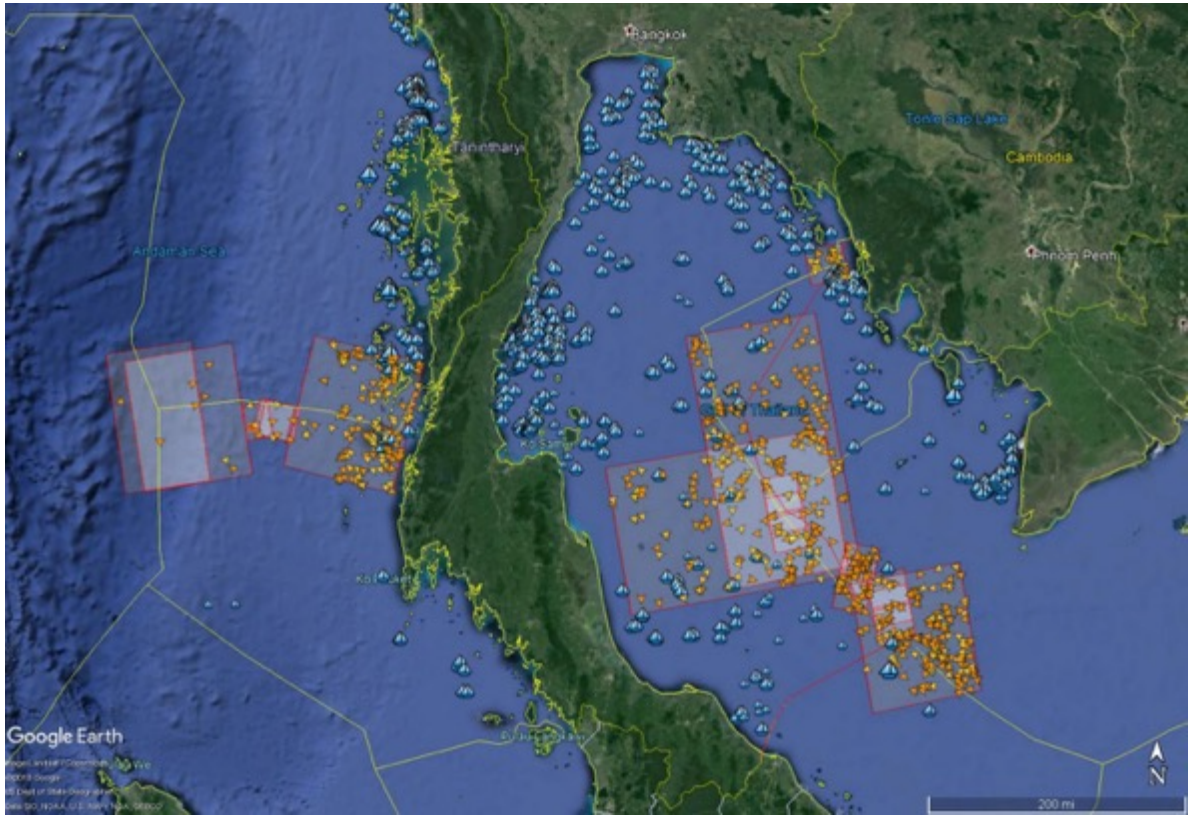
Thailand Example - Multi-Mission NRT



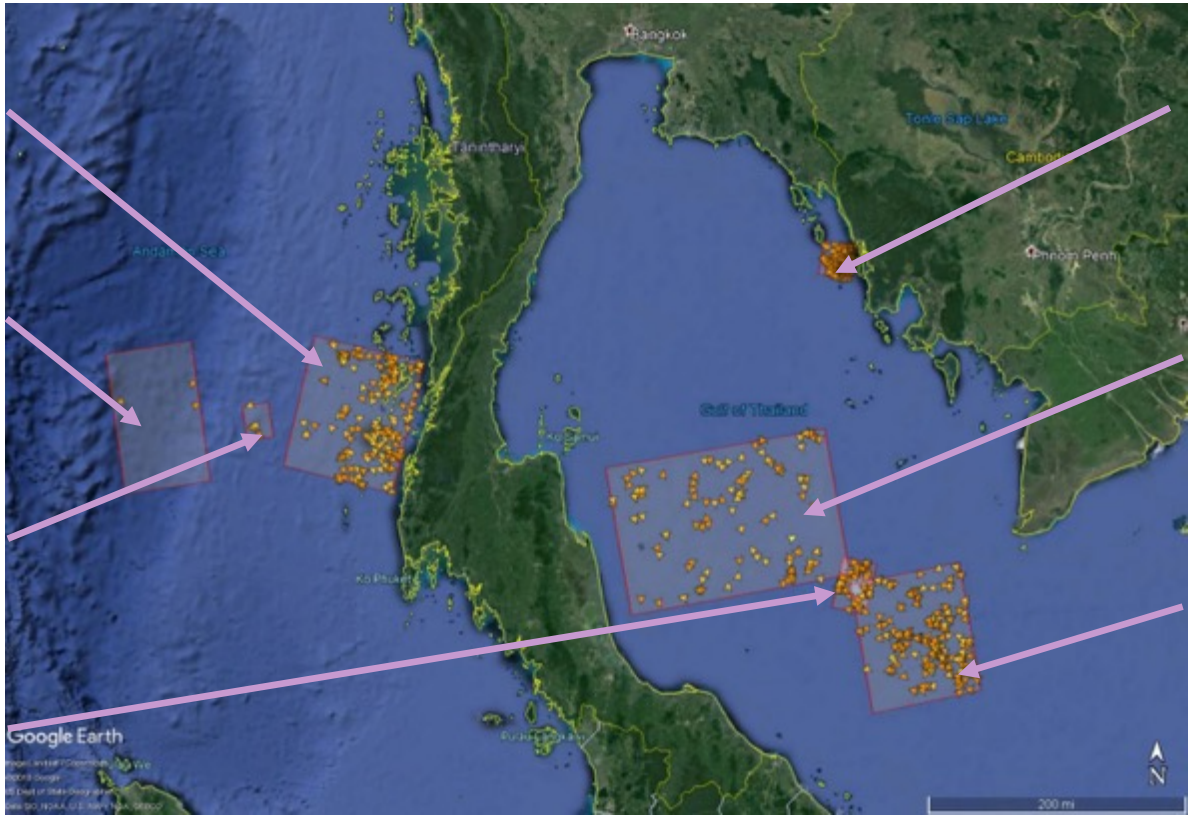
Thailand Example - Multi-Mission NRT

RADARSAT-2
(~ 8 m
Sept 26 – 23:12 UTC)

Tandem-X
(ScanSAR – 19 m
Sept 28 – 11:48 UTC)

Cosmo-SkyMed
(Stripmap – 5 m
Sept 27 – 23:45 UTC)

Cosmo-SkyMed
(Stripmap – 5 m
Sept 28 – 10:37 UTC)

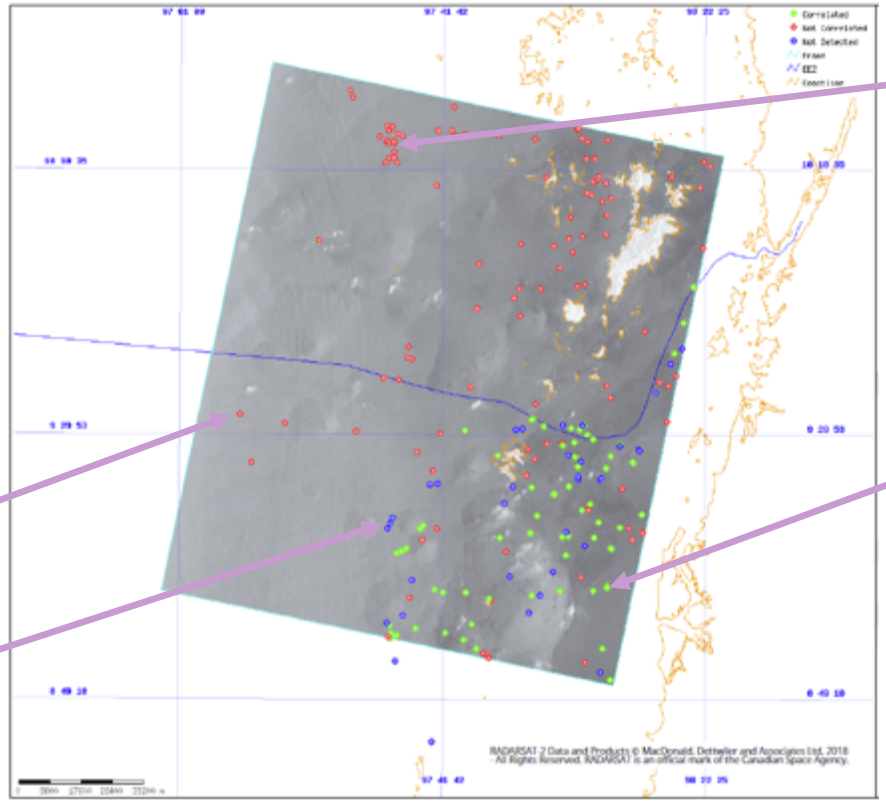


Cosmo-SkyMed
(Stripmap – 5 m
Sept 28 – 10:36 UTC)

Sentinel 1A
(IW ~ 22 m
Sept 26 – 11:27 UTC)

RADARSAT-2
(~ 8 m
Sept 28 – 11:23 UTC)

Thailand Example - VMS Correlation – September 26, 2018



Myanmar EEZ – no Thai VMS

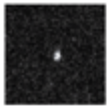
Uncorrelated vessels – possibly non-compliant with VMS

Undetected vessels in SAR – many small, wooden hulls

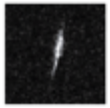
Vessels correlated with SAR / VMS

Example Report Details

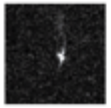
Position	09°59'43"N 097°22'21"E	Confidence	1.0
Heading(SAR)	002		
Length(SAR)	122 m		
Width(SAR)	23 m		



Position	10°22'43"N 097°27'04"E	Confidence	0.8
Heading(SAR)	224		
Length(SAR)	49 m		
Width(SAR)	10 m		

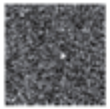


Position	09°49'17"N 097°46'58"E	Confidence	1.0
Heading(SAR)	003		
Length(SAR)	207 m		
Width(SAR)	35 m		



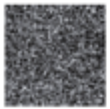
Position	10°11'56"N 096°22'13"E	Confidence	1.0
Heading(SAR)	312		
Length(SAR)	84 m		
Width(SAR)	33 m		

Position	09°26'09"N 097°55'57"E	Confidence	0.5
Heading(SAR)	022		
Length(SAR)	59 m		
Width(SAR)	16 m		



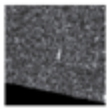
Position	09°27'40"N 097°54'56"E	Confidence	0.8
Heading(SAR)	012		
Length(SAR)	37 m		
Width(SAR)	19 m		

Position	09°28'39"N 097°57'51"E	Confidence	0.5
Heading(SAR)	048		
Length(SAR)	26 m		
Width(SAR)	12 m		



Position	09°23'41"N 097°54'44"E	Confidence	0.5
Heading(SAR)	192		
Length(SAR)	37 m		
Width(SAR)	16 m		

Position	09°34'40"N 097°56'03"E	Confidence	0.5
Heading(SAR)	026		
Length(SAR)	43 m		
Width(SAR)	16 m		



Position	09°58'49"N 097°33'24"E	Confidence	0.8
Heading(SAR)	025		
Length(SAR)	70 m		
Width(SAR)	21 m		

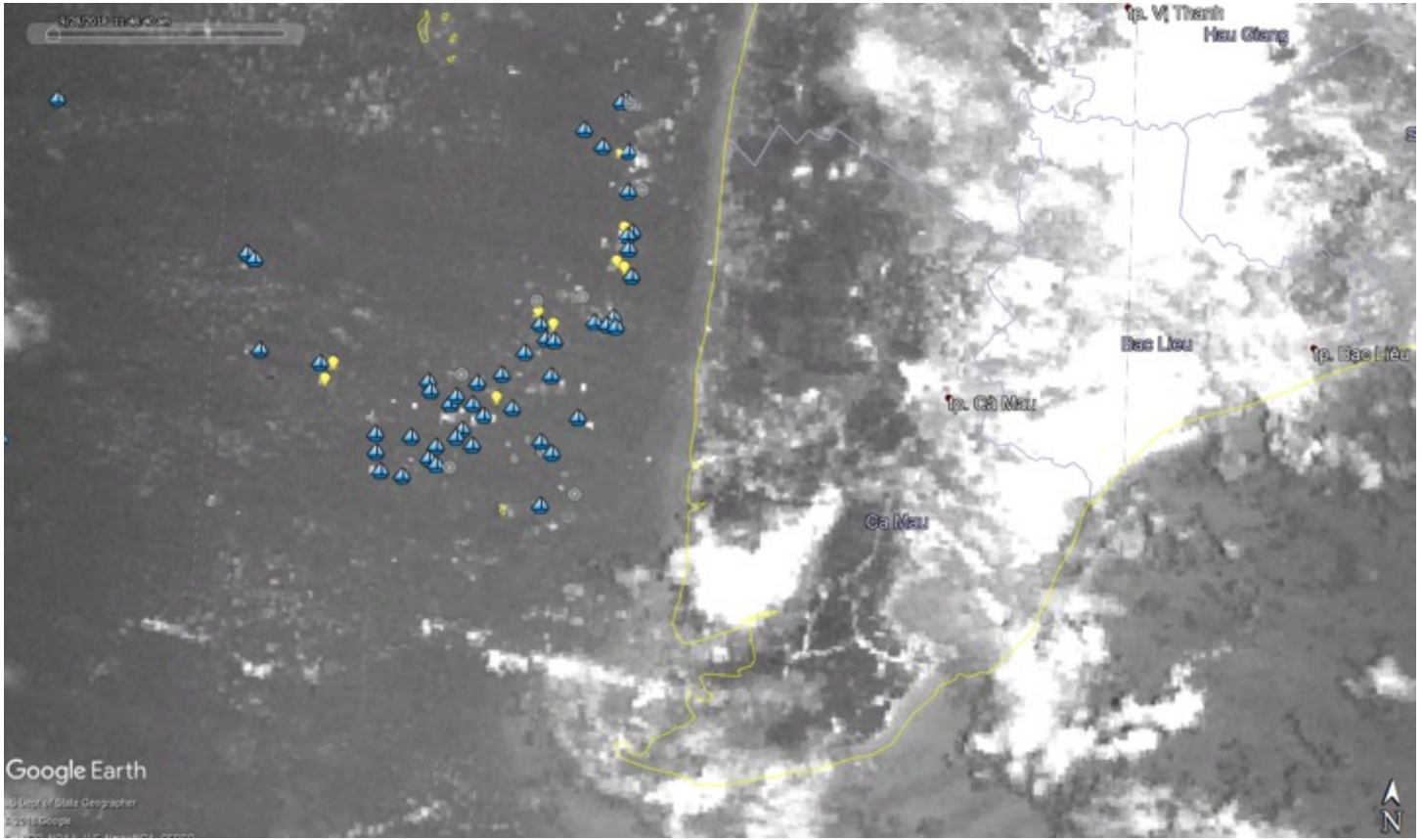
Position	09°04'46"N 097°36'35"E	Confidence	0.8
Heading(SAR)	008		
Length(SAR)	89 m		
Width(SAR)	7 m		

Position	09°48'05"N 097°53'43"E	Confidence	0.5
Heading(SAR)	048		
Length(SAR)	26 m		
Width(SAR)	16 m		

Position	09°52'18"N 097°56'48"E	Confidence	0.5
Heading(SAR)	001		
Length(SAR)	59 m		
Width(SAR)	16 m		

Position	09°52'43"N 096°02'28"E	Confidence	0.8
Heading(SAR)	175		
Length(SAR)	93 m		
Width(SAR)	19 m		

VIIRS - Visible Infrared Imaging Radiometer – September 28



And Of Course, We See More Than Just Boats…

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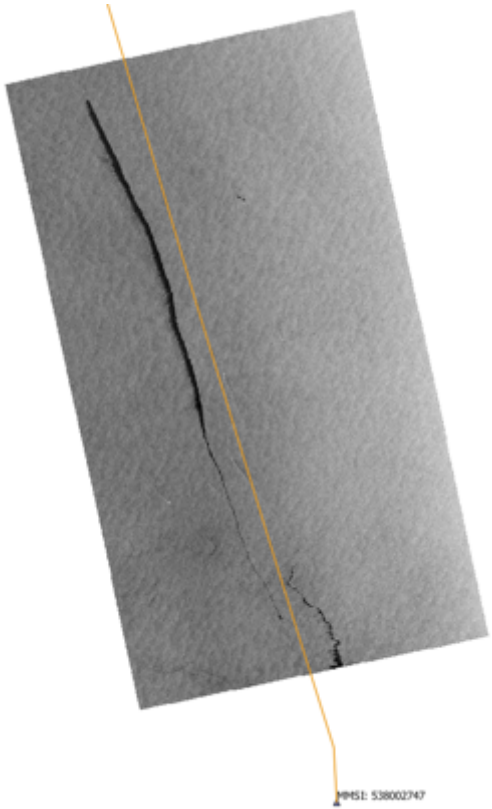


2 Spill Detection

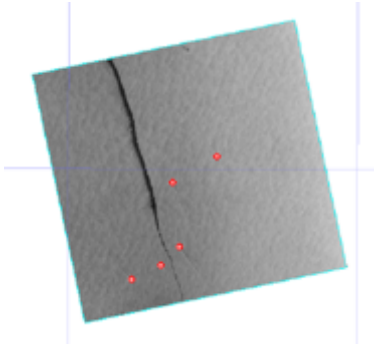
Detection			
Detection Time	**Central Position**		**Category**
2018-09-26 22:38:20.1	07°39'19"N 103°23'54"E		A
Area	**Length**	**Width**	**Orientation**
9.17 km²	34.30 km	2.01 km	339.93°

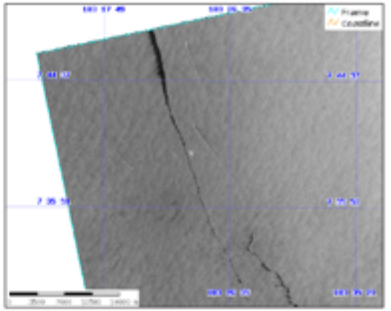
Classification			
Shape	linear feathered	Contrast	strong
Outline	fragmented	Edge	variable
Wind related	no match	Texture	smooth
Possible source	likely source		
Repeated observation	false		
Natural slicks in vicinity	false		

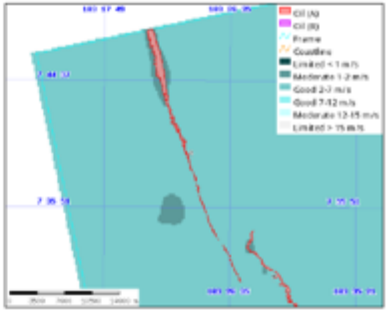
Met-ocean data		
Type	**Value**	**Source**
ncmatic	2.0 m/s from 219.8°	SAR ocean wind

Comment
N/A

Possible sources				
Position	**Object Name**	**MMSI**	**Type**	**Confidence**
06°49'35"N 103°34'36"E	CAPE FRANKLIN	538002747	VESSEL	1.0







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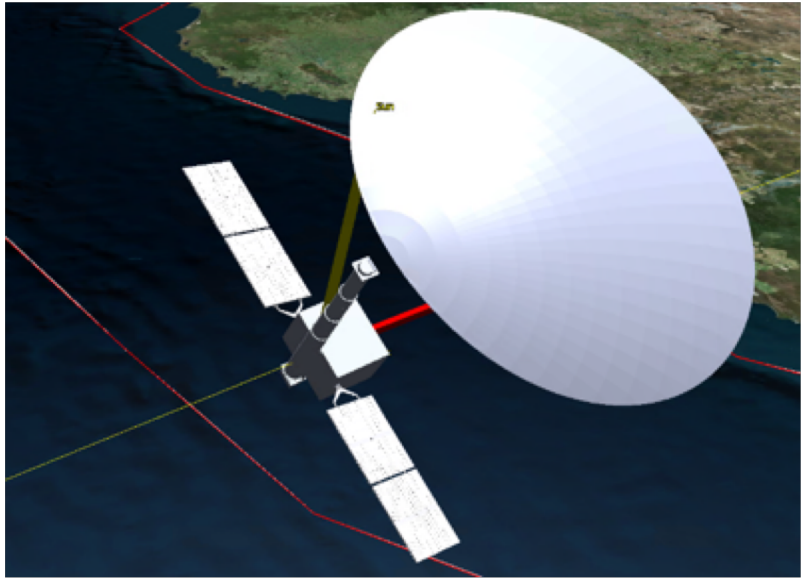
Coming Soon…MicroSAR

KONGSBERG

- Constellation of ~10 small SAR satellites optimized for ship detection
- Simultaneous AIS and SAR
- KSAT's local ground station network
- Features:
  - Resolution
    - 2m x 4m resolution
    - Improved detection capability
    - Possibility for classification
  - Coverage:
    - > 200 km swath width
    - Minimum 10% duty cycle (equivalent to 4000 km total swath length)
  - Temporal resolution
    - Constellation of satellites optimized for low revisit time at AOIs
    - < 3 hours average revisit globally with approximately 10 satellites
  - Latency
    - Downlink at first ground station after acquisition
    - Local processing / detection at (every) ground station
    - Maximum 30 minutes between acquisition and service delivery

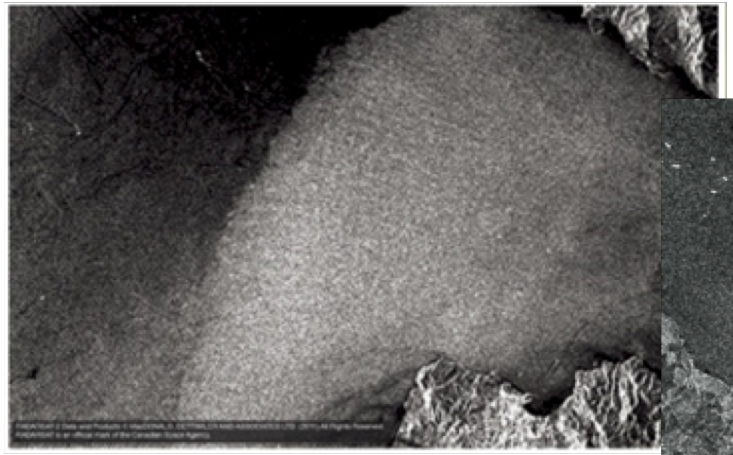


- Optimized high data rate down link (up to 6 Gb/s)
- Goal is to use < 60 minutes from order reception to satellite command upload and 45 to 90 minutes between order and image acquisition

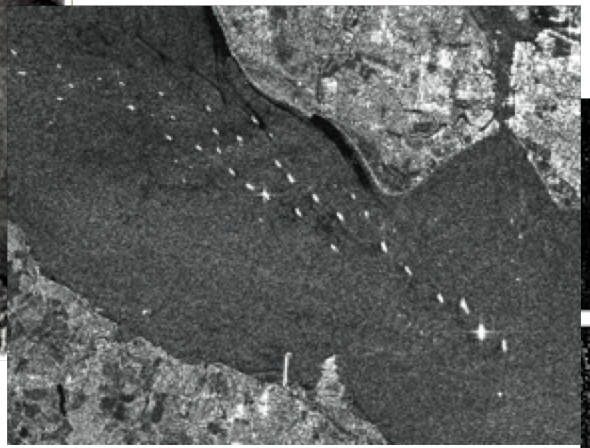
KSAT

SPACE NORWAY

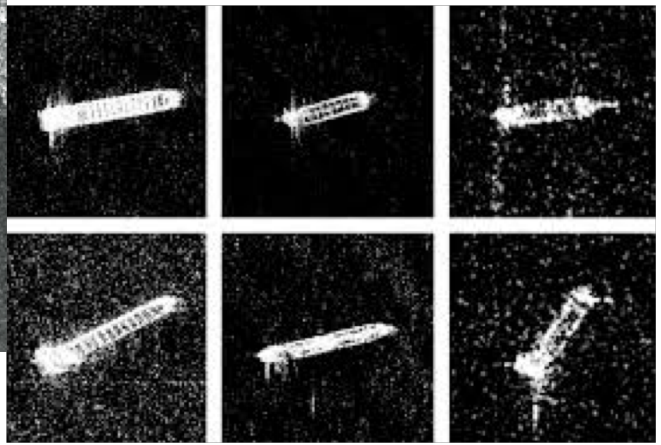
Quick Aside: Why High resolution For Ship Detection?



- 40-50 m resolution (ScanSAR)
- ”Simple” amplitude detection
- Ships are single pixel or small ”dot”
- False positives: Any floating object + noise



- 10-15 m resolution (Strip Map)
- ”Simple” amplitude detection
- Can differentiate between small /large
- But still some false positives / erroneous lengths



- 3-4 m resolution (Parallel SAR):
- Full feature discrimination
- Improved detection
- Classification possible


PAUL@KSAT.NO