Evaluating Unmanned Aerial Systems (UAS) for oil spill response applications: results of recent Chevron tests and drills

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UAS applications for (offshore) oil spill response

Oil spill mapping & tracking

Coastline mapping (e.g. reconnaissance, SCAT)

Situational awareness (e.g. monitor booming)

<u>Considerations:</u>

Real-time vs post-flight analysis of data: networking, data turnaround etc…

Role of UAS within existing hierarchy of remote sensing observational approaches

Access to airspace

UAS data → actionable information for incident response

Timeline of Chevron UAS testing for oil spill response

2006

- Carpentaria, CA: offshore test of Aerovironment (AV) Raven over natural oil seeps

2007: new FAA rules on commercial ops stopped testing

2013

- Astoria, Oregon: offshore/coastal test with AV Puma
- Trieste, Italy: AV Puma test with oil spill drill

2014

- NOAA-led Santa Barbara + Vandenberg AFB, CA: offshore/coastal test with AV Puma

2015

- NOAA-led: Santa Barbara + Carpintaria, CA: offshore/coastal test of AV Puma, Lockheed Martin Indago, 3DR Solo + Spektre
- Richmond Refinery, CA: test as part of oil spill drill involving PrecisionHawk Lancaster + Indago

2016

- Richmond Refinery, CA: UAS test focused on coastal reconnaissance / SCAT

2017

- UAS test during Oceanside, CA NPREP drill
- Proposed test of UAS for BVLOS operations offshore Santa Barbara, CA

Richmond 2016 UAS for oil spill response test

- Chevron-led test with NOAA, CA state agencies, Army Corp of Engineers, East Bay Regional Parks District.
- Vendor participants: Trumbull Unmanned (flew Indago), Aerovironment (flew Puma), InSitu (2d3 Sensing), Persistent Systems
- Objectives:
  - Test UAS for assessing shoreline oiling (SCAT)
  - Test data transfer (WaveRelay) and processing software (InSitu 2d3 Tacitview)
  - Test integration of UAS data with GIS/Common Operating Pictures
  - Test UAS for night-time and offshore (vessel-based) operations

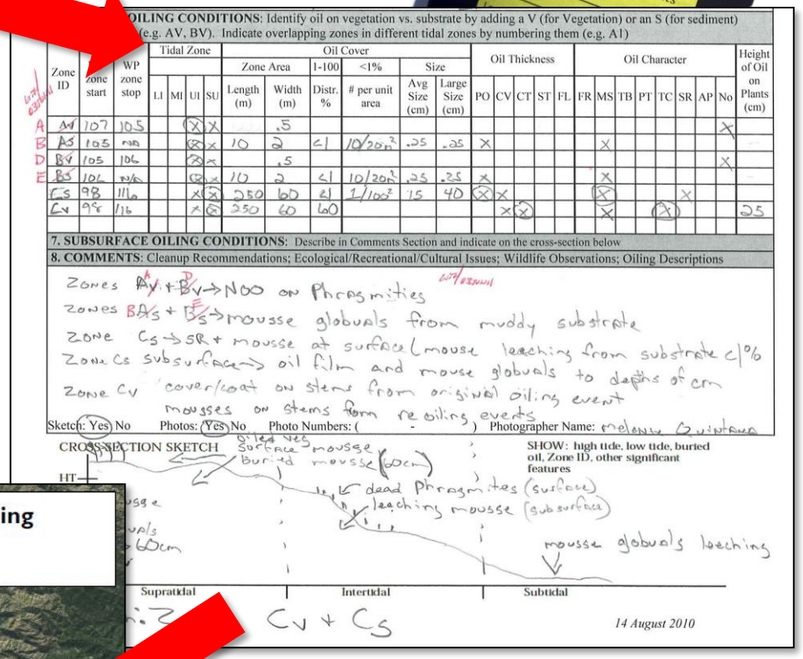

AV Puma

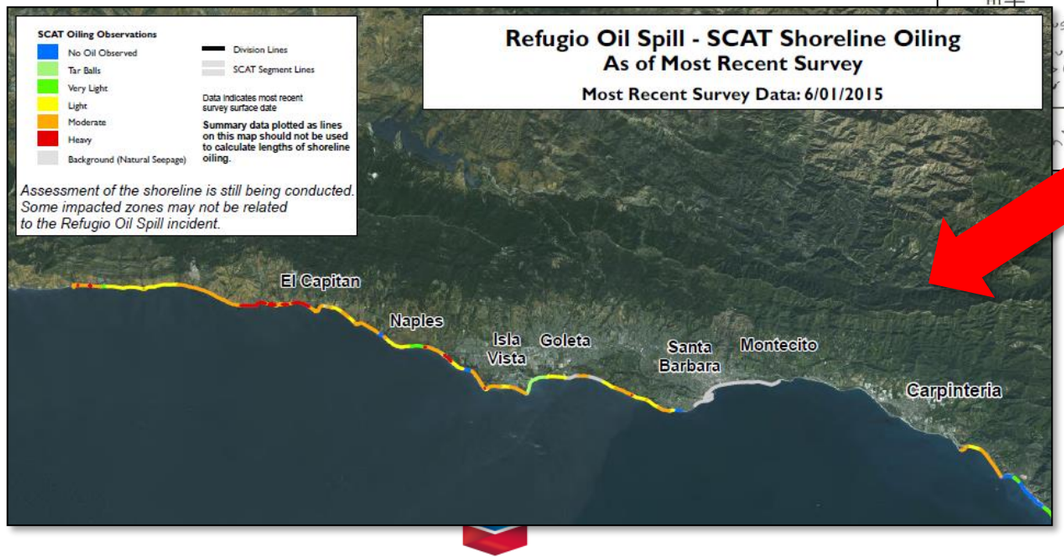

LMCO Indago

Shoreline Cleanup Assessment Technique (SCAT)

- Systematic method for documenting coastline oiling conditions
- Range of attributes manually recorded: e.g. oil percent cover, oil characteristics
- SCAT data compiled into shoreline oiling summary maps → target and track cleanup
- Aerial observations for reconnaissance

SCAT team make field observations of oiled coastline



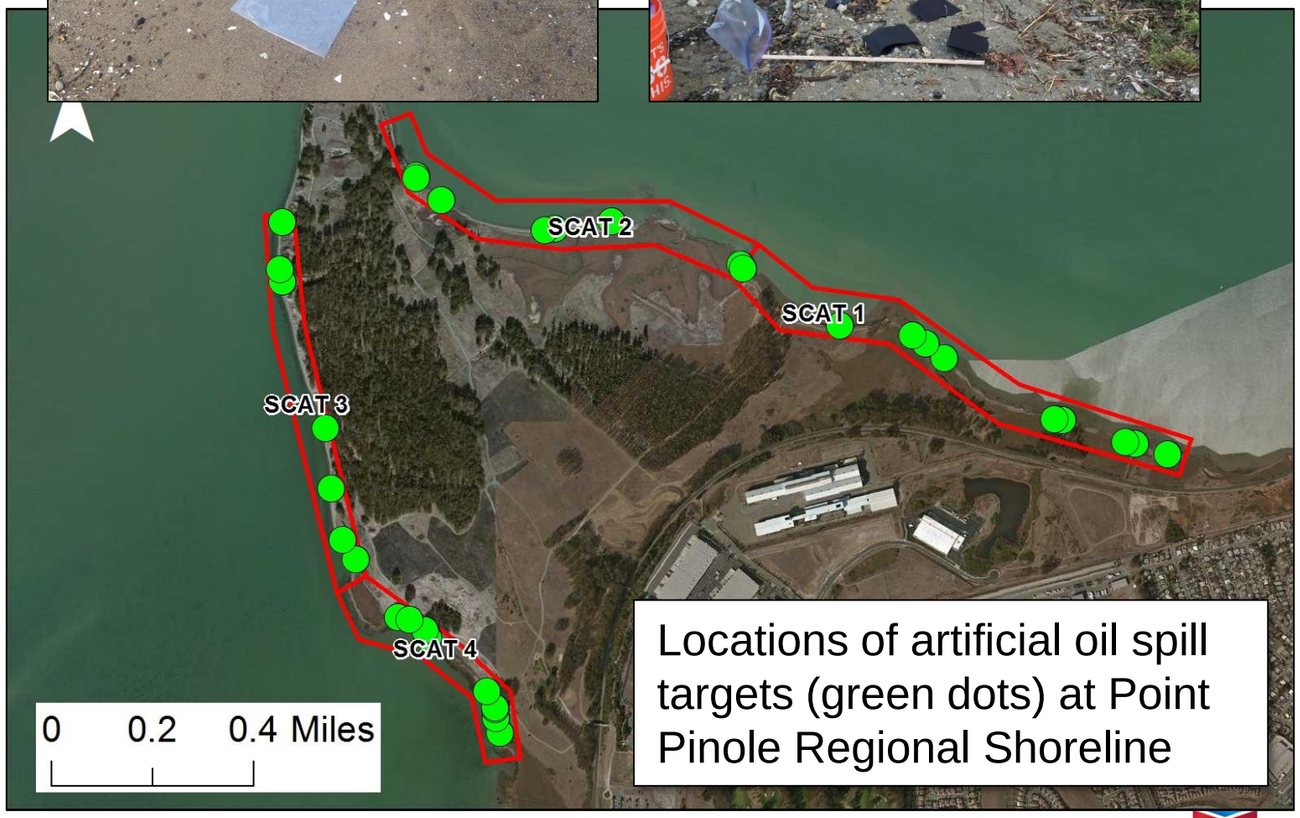


SCAT observations compiled into Shoreline Oiling Summary map at Incident Command

Testing UAS for shoreline reconnaissance/SCAT

- ‘Blind’ test of capability of UAS to locate and document artificial oil spill targets
- SCAT observers analyze video and guide flight
- Evaluate different UAS + payloads

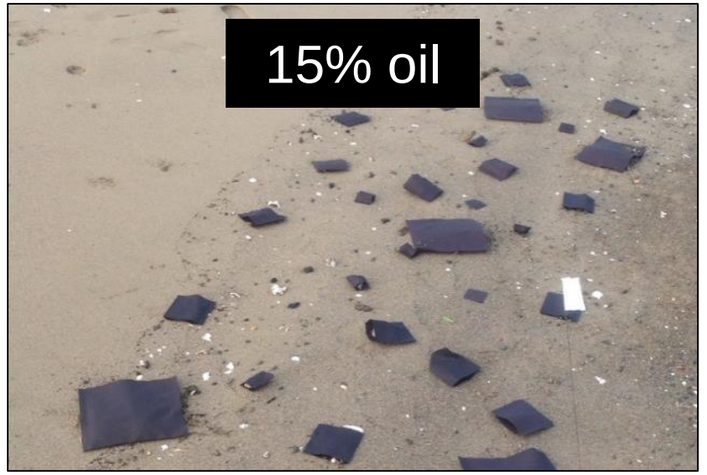
Artificial oil spill targets laid out on beaches

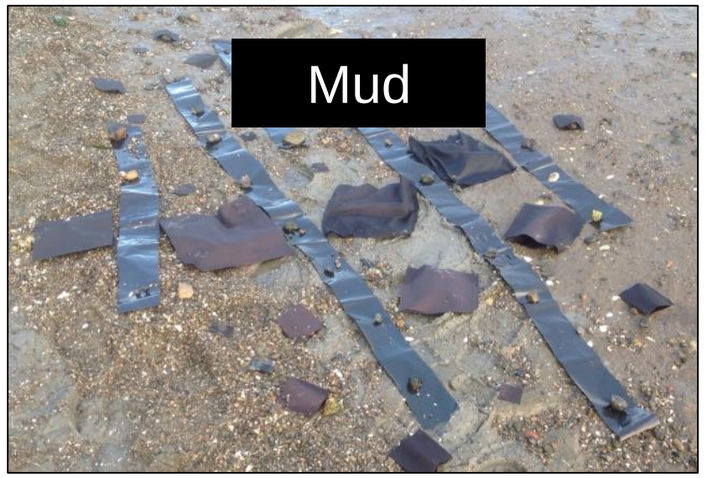


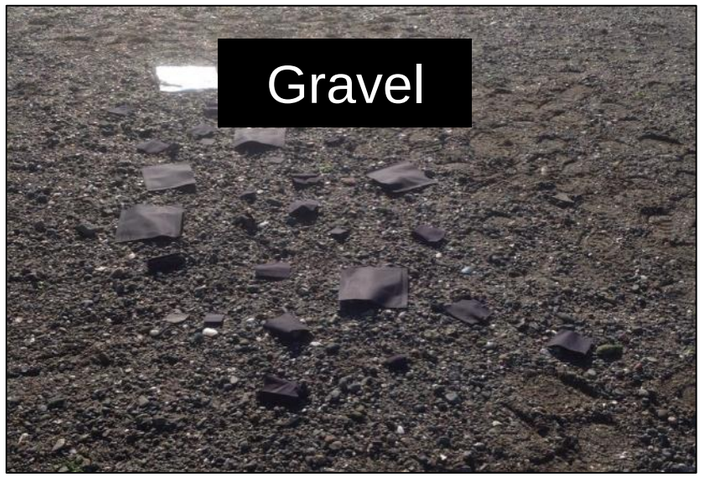
Locations of artificial oil spill targets (green dots) at Point Pinole Regional Shoreline

SCAT team analyzing Full Motion Video (FMV) from UAS

Oil spill ‘targets’







- 5 m^2 ‘patches’ made up of black plastic strips and fabric swatches
- Patches representing a range of percent coverages of oil: 5%, 15%, 30%, 50%
- Patches located on varying substrate types: sand, gravel, mud + mixtures including wrack

UAS platforms

Lockheed Martin Indago 2

Electric multirotor – 32 inch diameter

40 minute endurance, 2.5 km range

Folds to small package for easy transport

Flexible sensor package: HD video, still camera, thermal

Launch and recover from land or from vessel (drone is not waterproof)

Aerovironment Puma

Electric fixed wing – 9’2” wing-span

3.5 hours endurance, 15 km range

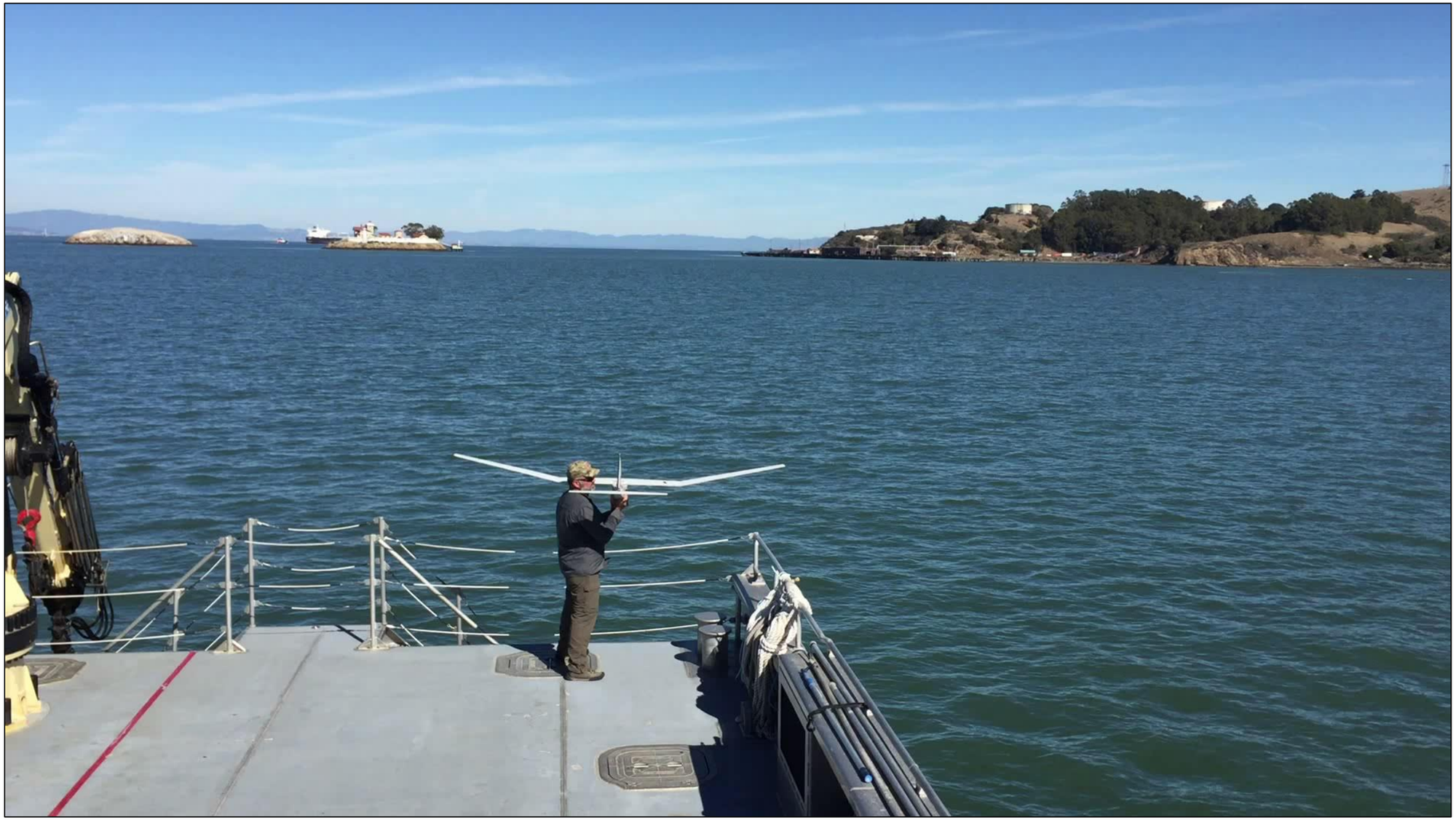
Transported in large pelican case

Flexible sensor package: HD video, still camera, thermal, low-light camera

Launch from land or vessel, recover on land or from water (waterproof)

Indago – launch and recovery

Puma launch



Puma recovery

Analysis of UAS FMV feeds on ACE vessel

Oil ‘target’ identification from UAS video feed

Oil spill ‘target’ identification from UAS

Field photo of 30% ‘oil’ patch on sandy beach with wrack

Indago FMV

Puma FMV

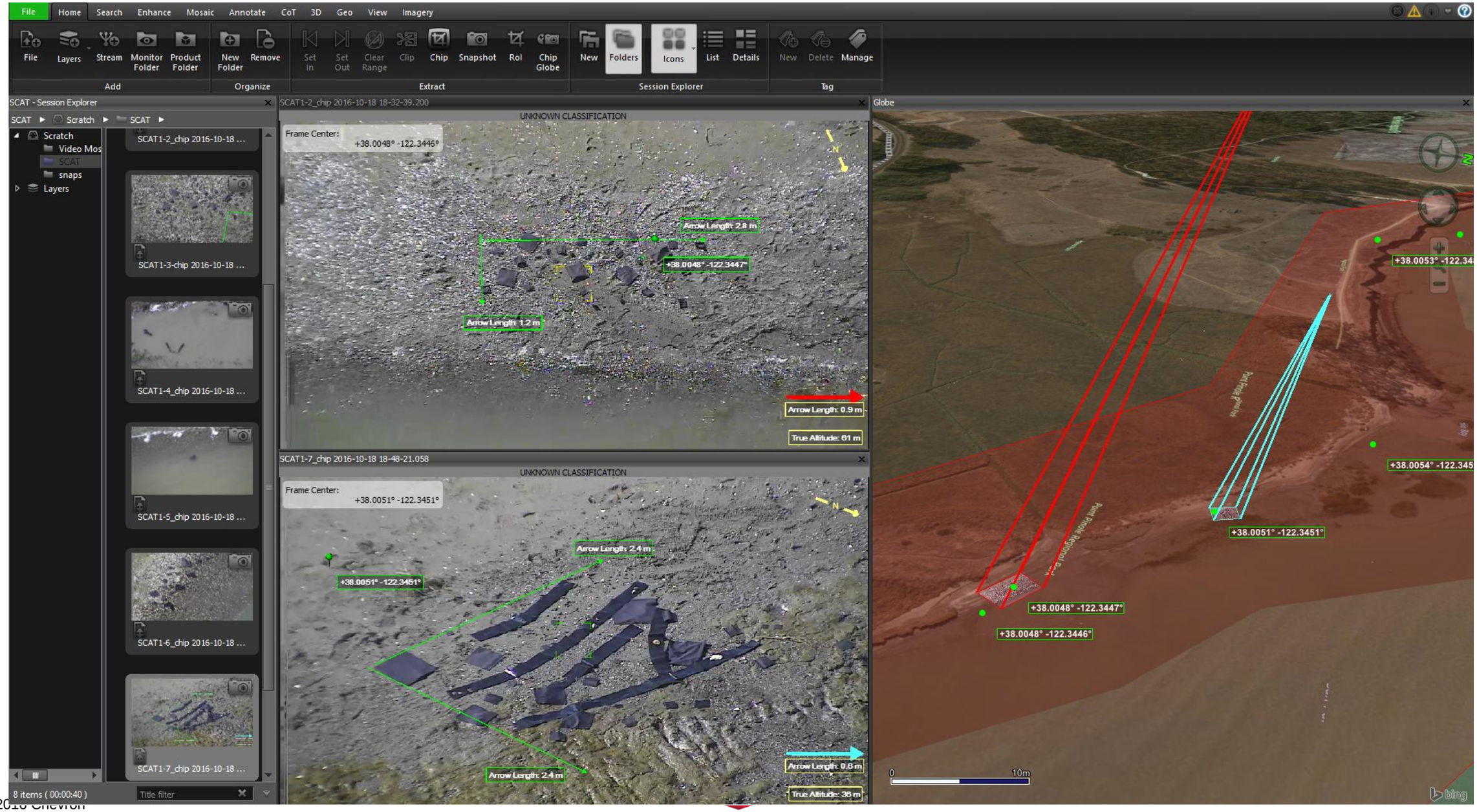
Oil spill ‘target’ identification from UAS

Field photo of 5% ‘oil’ patch on sandy beach with wrack

Indago FMV

Puma FMV

Analysis and annotation of FMV streams using TacitView



Workflow

- UAS pilot deploys UAS to predefined shoreline segments
- UAS pilot + sensor operator proceed to ‘scan’ shoreline with oversight from SCAT observer
- SCAT observer analyses UAS video in real-time (on-screen, FPV goggles, or through map interface)
- SCAT observer identifies oil ‘patch’:
  - Communicates with UAS pilot + sensor operator to ‘hold + zoom’
  - Image still is recorded by UAS pilot
  - SCAT observer makes observations with support from 2d3 analyst in real-time
  - SCAT observer gives OK for UAS pilot to proceed
- UAS lands: image stills downloaded and packaged with SCAT observations for delivery to IC?

How well did we do at finding the oil targets?

Distribution %	Targets	Detected
5	8	3
15	8	6
30	**8**	**8**
50	6	4

*

Predominant Substrate

sand	**16**	**13**
gravel	13	8
mud	1	0

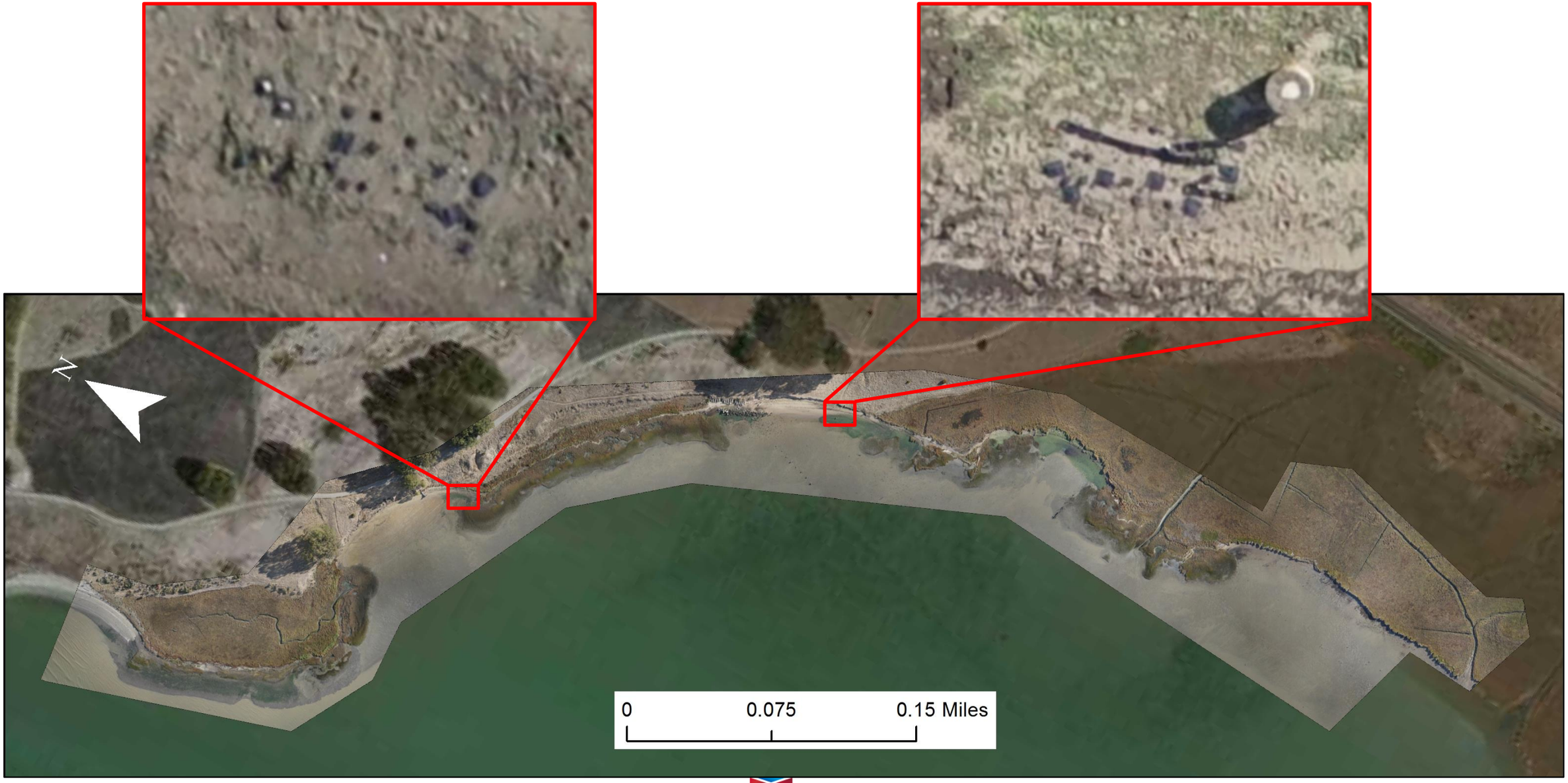
**

* both on Day 1

** 2 of the 3 on Day 1

- 70% of oil ‘targets’ identified over ~5 miles coastline
- Less success with lower % oil coverages + non-sandy beach

Mosaicked still imagery



Outcomes of UAS/SCAT tests

- Bit of a learning curve!
- UAS pilots + SCAT observers worked well together → repeatable workflow for analysis of video
- Capabilities of multirotor vs fixed-wing UAS
- Enhanced capabilities of zoom sensors: discriminate oil from wrack
- Successful onshore + offshore UAS deployments
- Video vs orthoimagery for recon/SCAT?
- Next steps:
  - Develop guidance or job aid on use of UAS for SCAT?
  - Streamline how UAS stills + annotations are distributed to IC and COP

VR from UAS

3DR Solo with downward facing 180° field of view VR video camera

Video's 'stitched' post flight to create immersive VR viewable with Oculus Rift, Google Cardboard etc…

https://www.youtube.com/watch?v=98DktXoACrQ

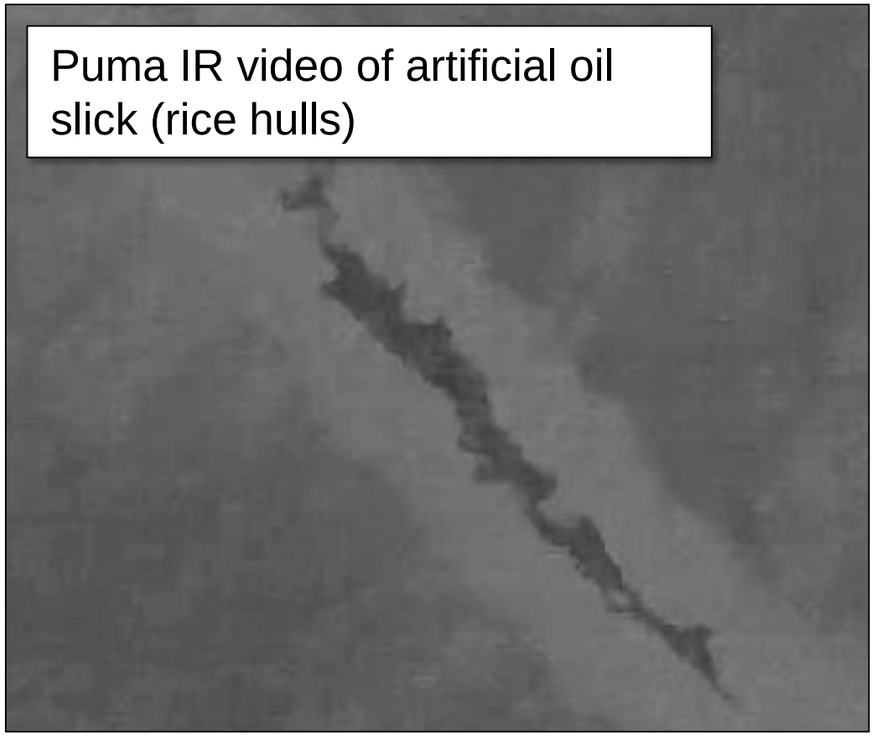
https://www.youtube.com/watch?v=4HpIfyEM9co

Nighttime UAS operations

IR video fed into TacitView

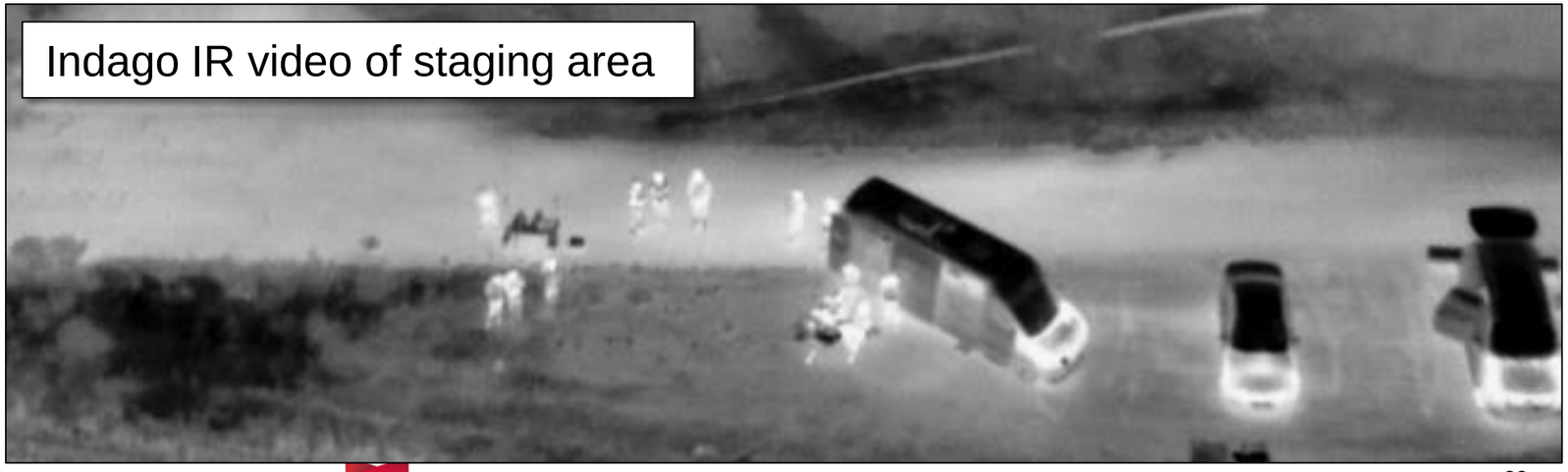
Puma IR video of Dept Fish/Wildlife boat

Puma IR video of artificial oil slick (rice hulls)



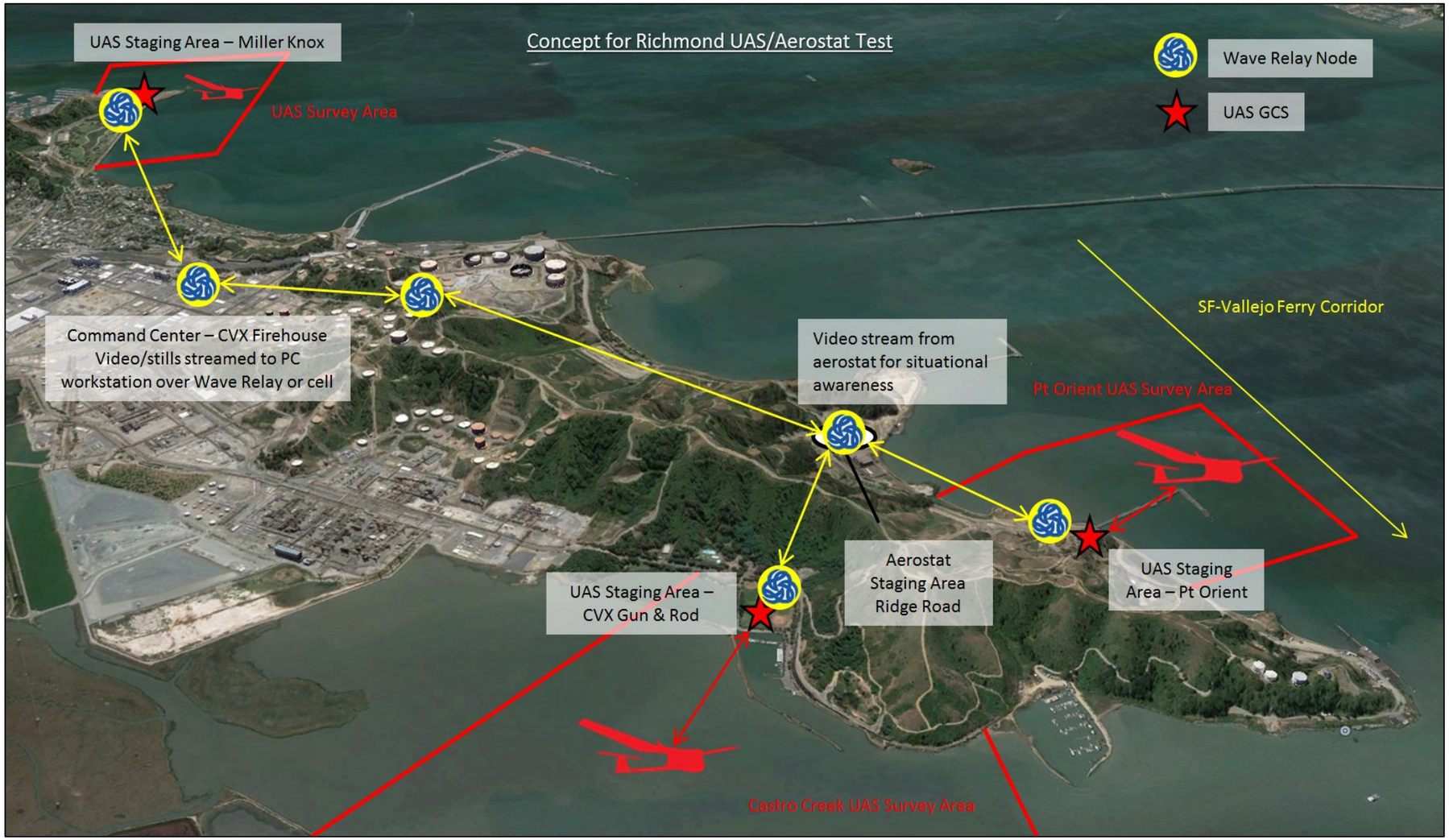
Indago launch

Indago IR video of staging area



Testing UAS data push into incident command

- WaveRelay™ Mobile Ad-hoc Networking (MANET) radios
- Push video back to Incident Command Post
- Interference issues



Conclusions

- UAS have significant potential to support reconnaissance + SCAT: further testing/drilling, improve efficiency of UAS operations + guidance/job-aid development?
- Continue focus on specific UAS oil spill applications + testing hardware, software etc…
- Successful UAS Proof-of-concepts → Guidance → Drill
- Continue working airspace issues
- Better industry collaboration on UAS for oil spill response moving forward?

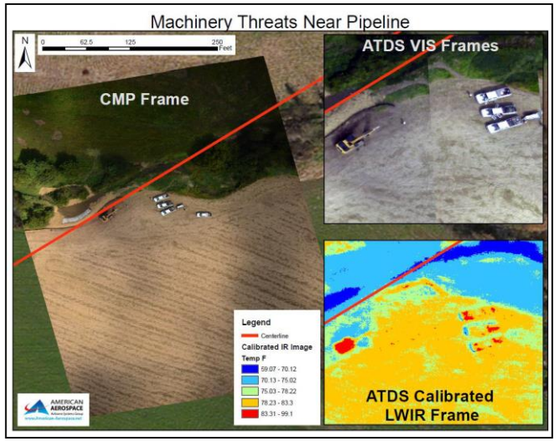
2017 UAS drills and tests

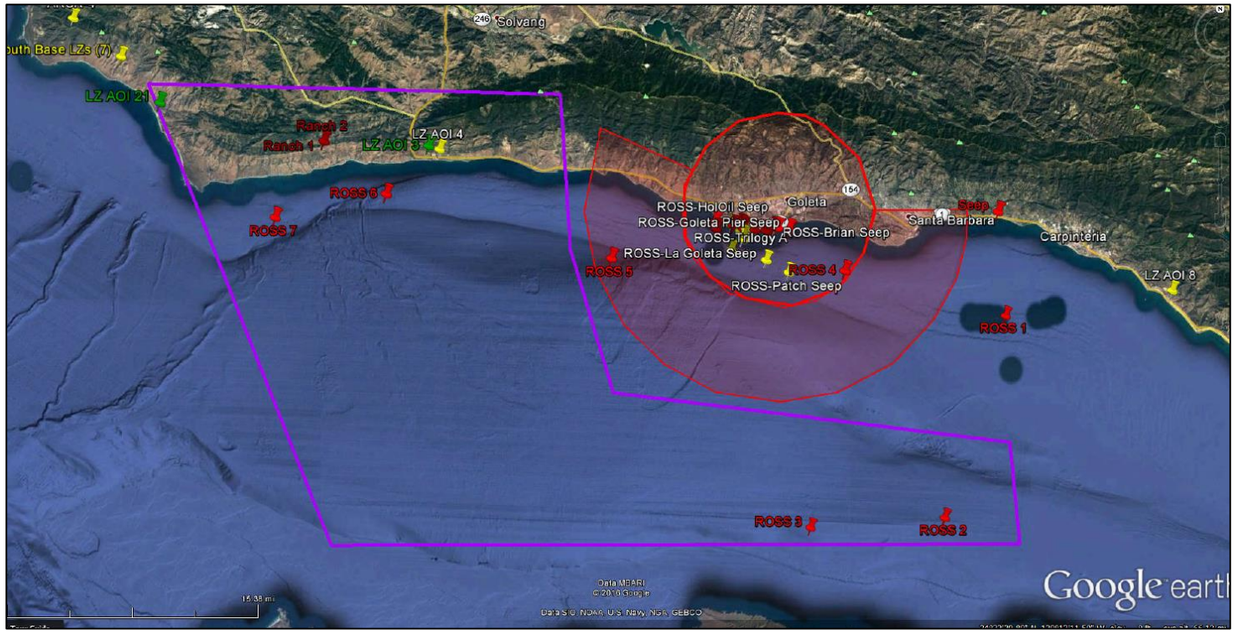
<u>Oceanside NPREP drill – May 2017:</u>

- UAS aerial imaging for pre-SCAT: determine extent of debris for pre-clean treatment
- UAS video surveillance of boom deployment

<u>Santa Barbara BVLOS/extended duration UAS test, late summer 2017</u>:

- Larger fixed-wing UAS with heavier payload capabilities + extended range
- Real-time high resolution multispectral imagery
- Potential for deploying other sensors
- COA for SB channel seeps area





	"333 Class"	BLOS UAS
Payload Capacity	2 to 25 lbs	50-150 lbs
Endurance	~1 hour	10+ hours
Range	½ mile	1,000 miles
Ceiling	8,000 ft	24,000'

Acknowledgements to project team + partners

- Chevron: Dan Tydingco, Nathan Marx, Will Gala,
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- Aerovironment: Kevin Hand
- InSitu / 2d3 Sensing: John Leipper

Thankyou! Questions?