FluidCam + FLUID LENSING REMOTE SENSING

EARTH SCIENCE TECHNOLOGY FORUM
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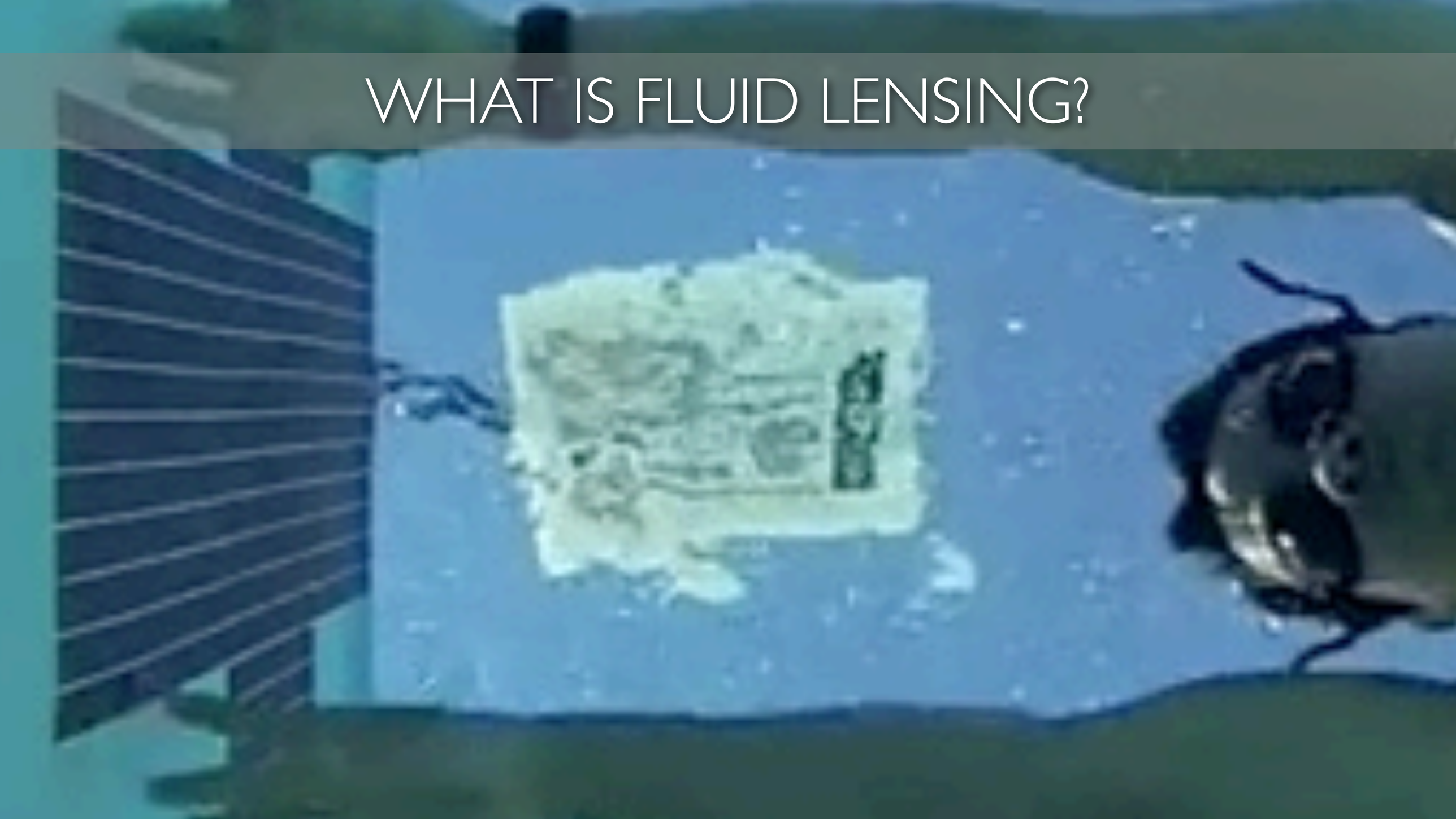
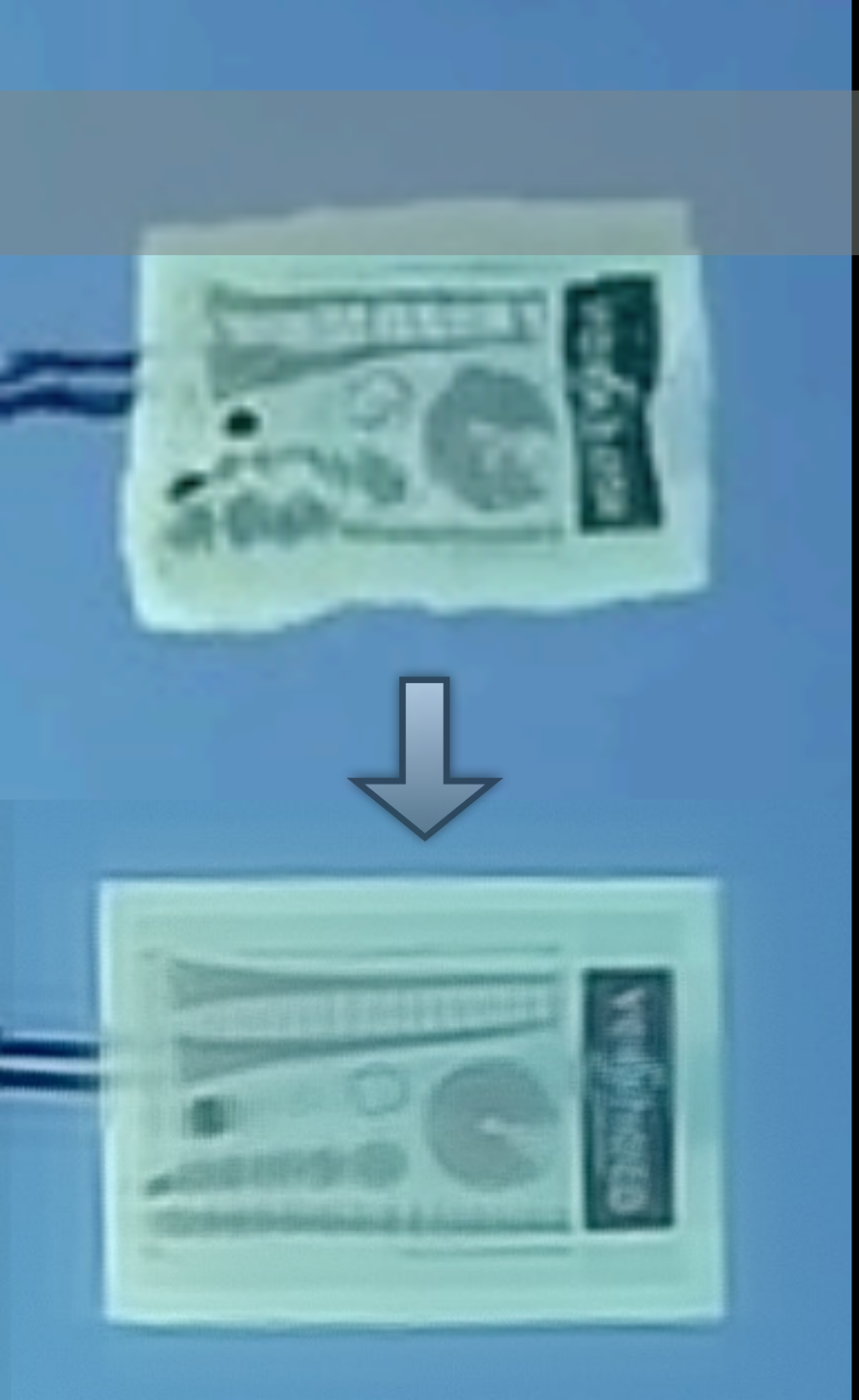
WHAT IS FLUID LENSING?



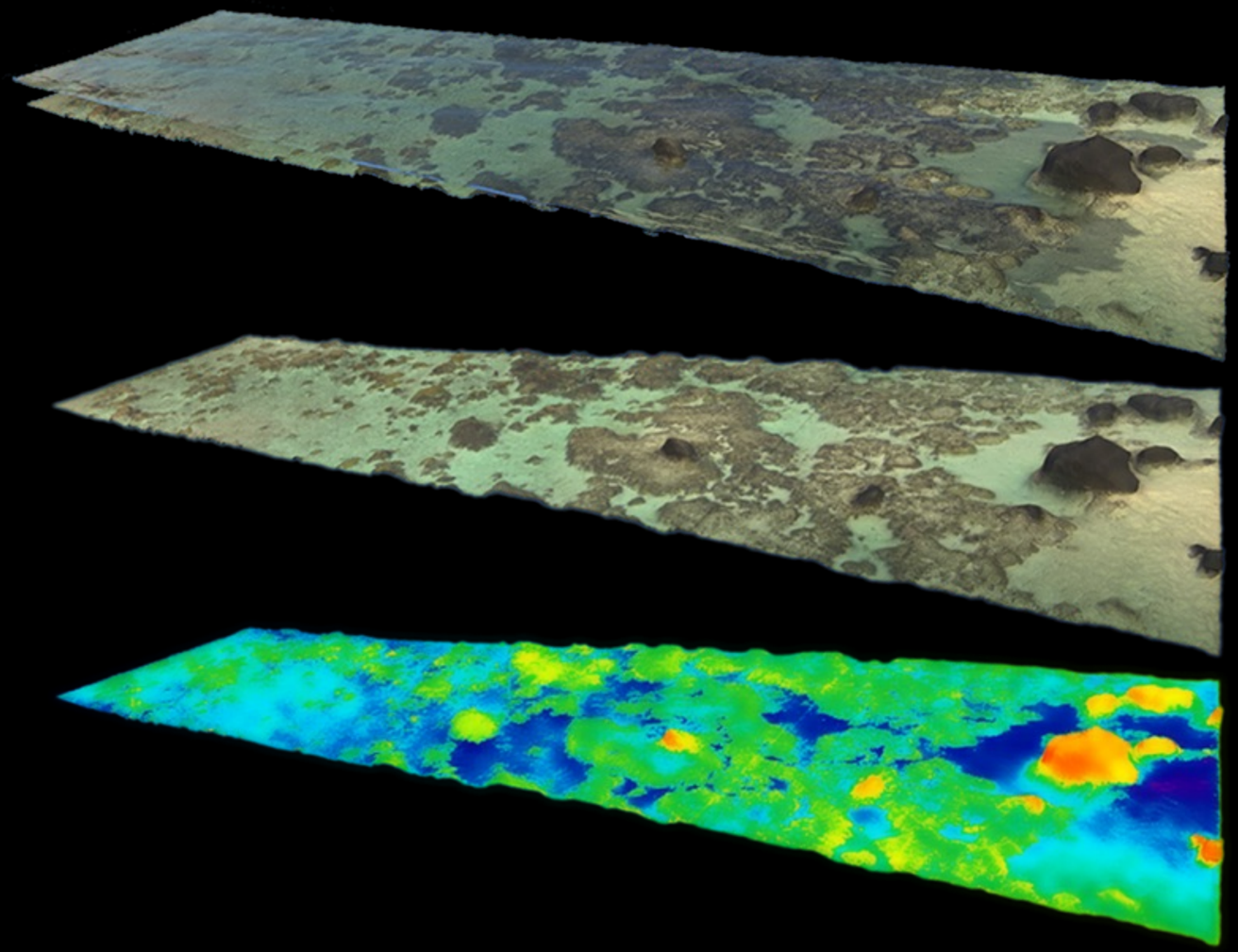


FLUID LENSING

Fluid Lensing leverages optofluidic interactions, computational imaging and fluid models to **remove optical distortions** and significantly **enhance the angular resolution** of an otherwise underpowered optical system.

Fluid Lensing works to **image underwater objects** in visible wavelengths by exploiting time-varying optical lensing events caused by refractive distortions from travelling surface waves over the ocean. Fluid-lensed processed images can be effectively used for accurate **3D reconstruction** using structure from motion and typically exceed diffraction-limited performance depending on the setup, SNR restraints and fluid properties.

FluidCam INSTRUMENT MEASUREMENTS



Raw data from FluidCam

On-board Fluid Lensing Processing

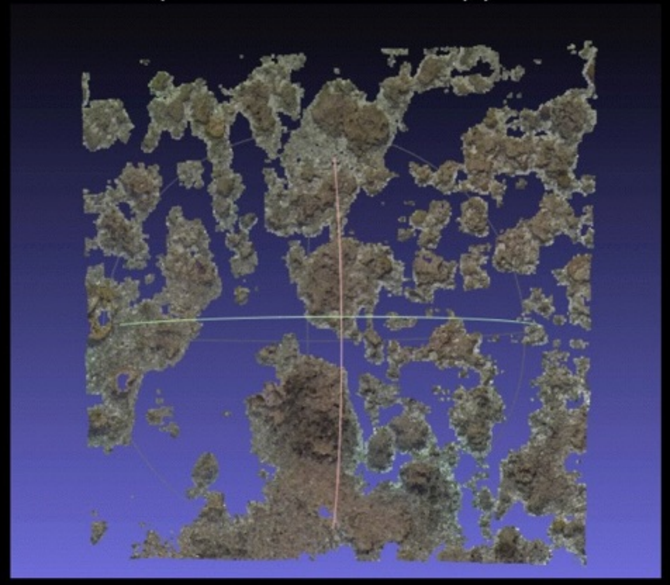
Bathymetry & high-res 2D orthophoto output

Fluid Lensing processing pipeline and output results. Actual data from American Samoa imaging campaign. (Chirayath, Bieri and Instrella, Fluid Lensing and Applications to Automated Biosphere Assessment in American Samoa 2015)

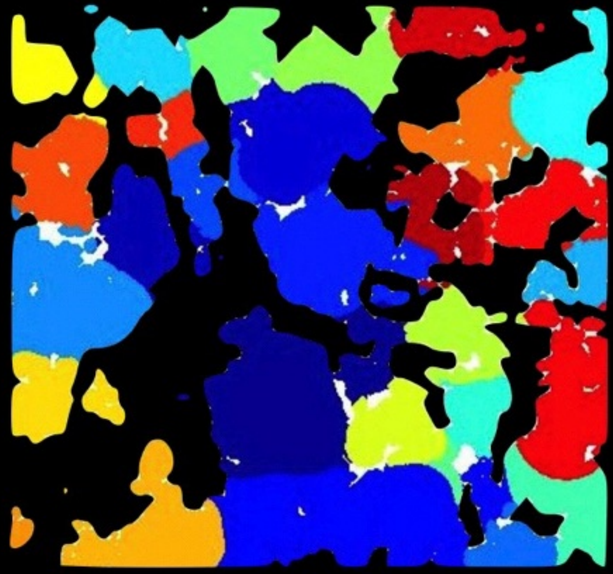
FluidCam SCIENCE

original 3D fluid lensed solution

organic vs inorganic structure (98.7% accuracy)



automated species ID (85% accuracy)



Fluid-Lensing-based, computational optical imagers for 3D mapping and high-resolution remote sensing of shallow underwater coastal targets have been demonstrated in the past. Using Fluid Lensing with commercial cameras flown on a sUAV, large areas of at-risk reefs were imaged in American Samoa (2013) and Hamelin Pool, Western Australia (2014) at sub-cm resolution with cm-scale 3D reconstruction. The resulting high-resolution datasets allowed for large-scale automated species identification, morphology studies and reef ecosystem characterization for these shallow marine biospheres, of crucial importance to understanding climate change's impact on coastal zones, global oxygen production and carbon sequestration.

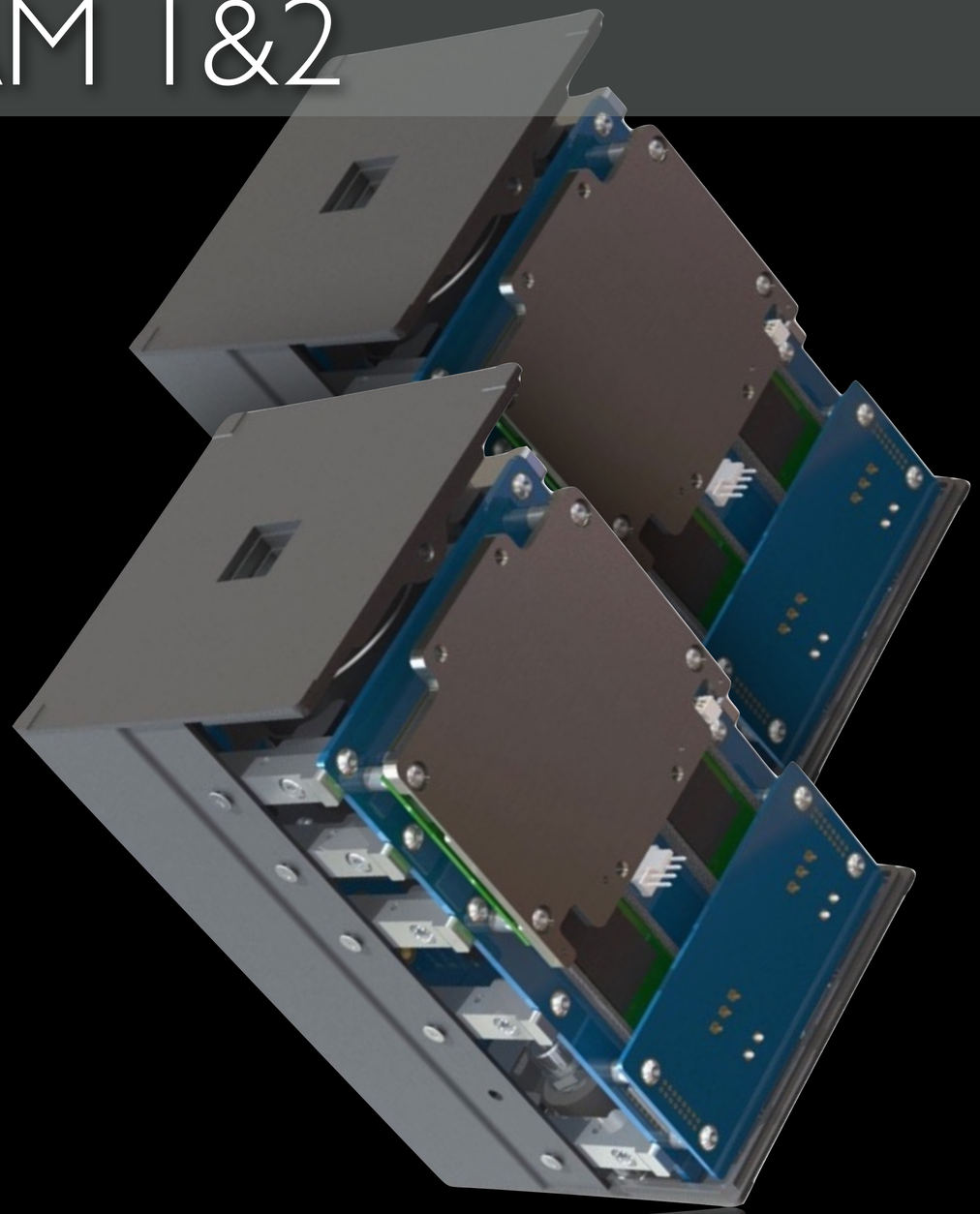
FluidCam ESTO FLUIDCAM 1&2

Overview:

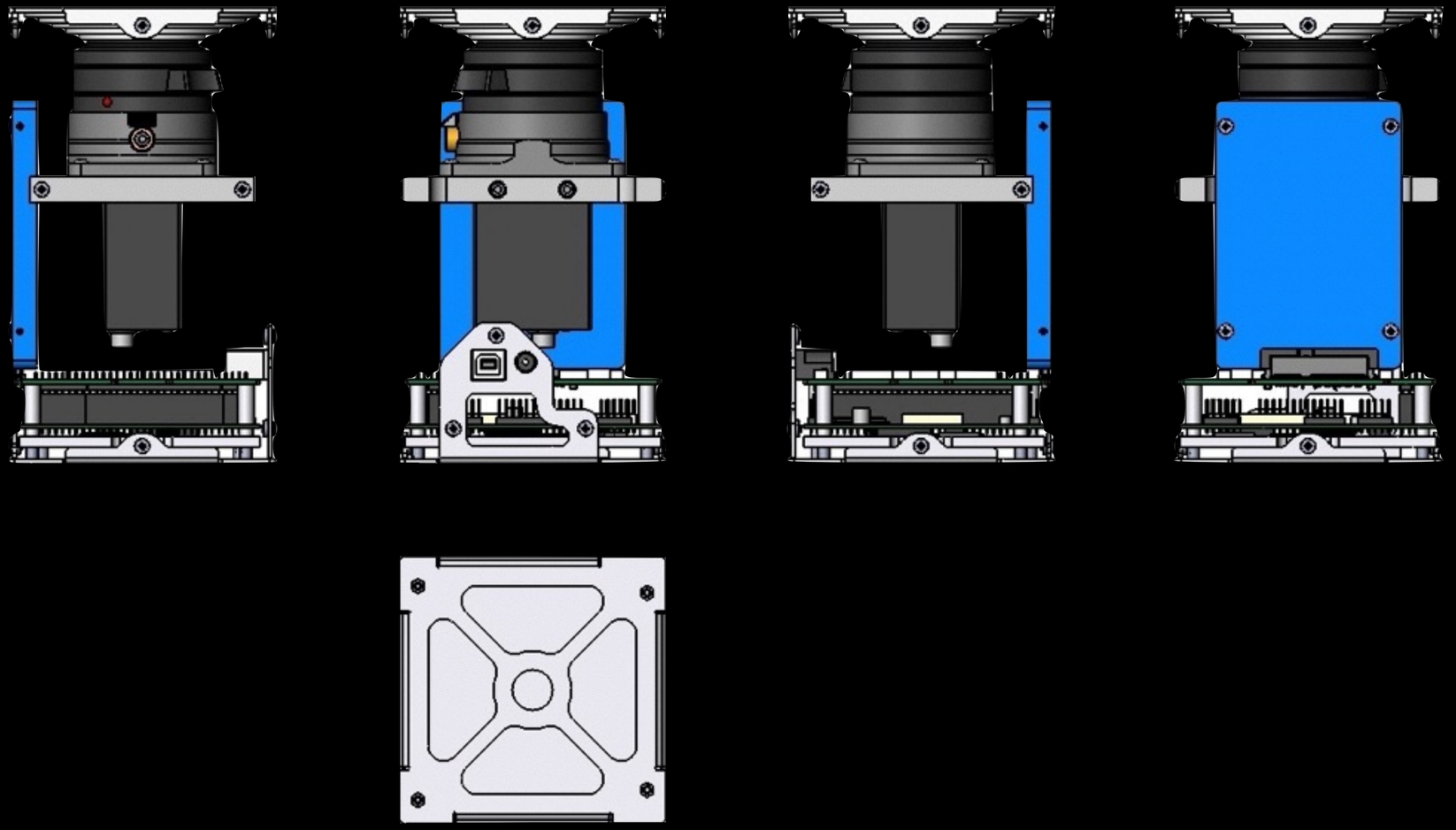
- $0.2M project selected March 2014 to develop 2 Fluid Lensing instruments, FluidCams
- Delivered February 28, 2015
- 1.5U CubeSat payload architecture
- 2 x next-generation FluidCams (visible & NIR)

Applications:

- High-resolution imaging through fluid boundaries, turbulent media & transients
- Dual purpose UAV & CubeSat payloads
- Marine, subsurface imaging
- 3D imaging, DEM, high temporal resolution, mesAMIS



ESTO FLUIDCAM 1&2 DESIGN



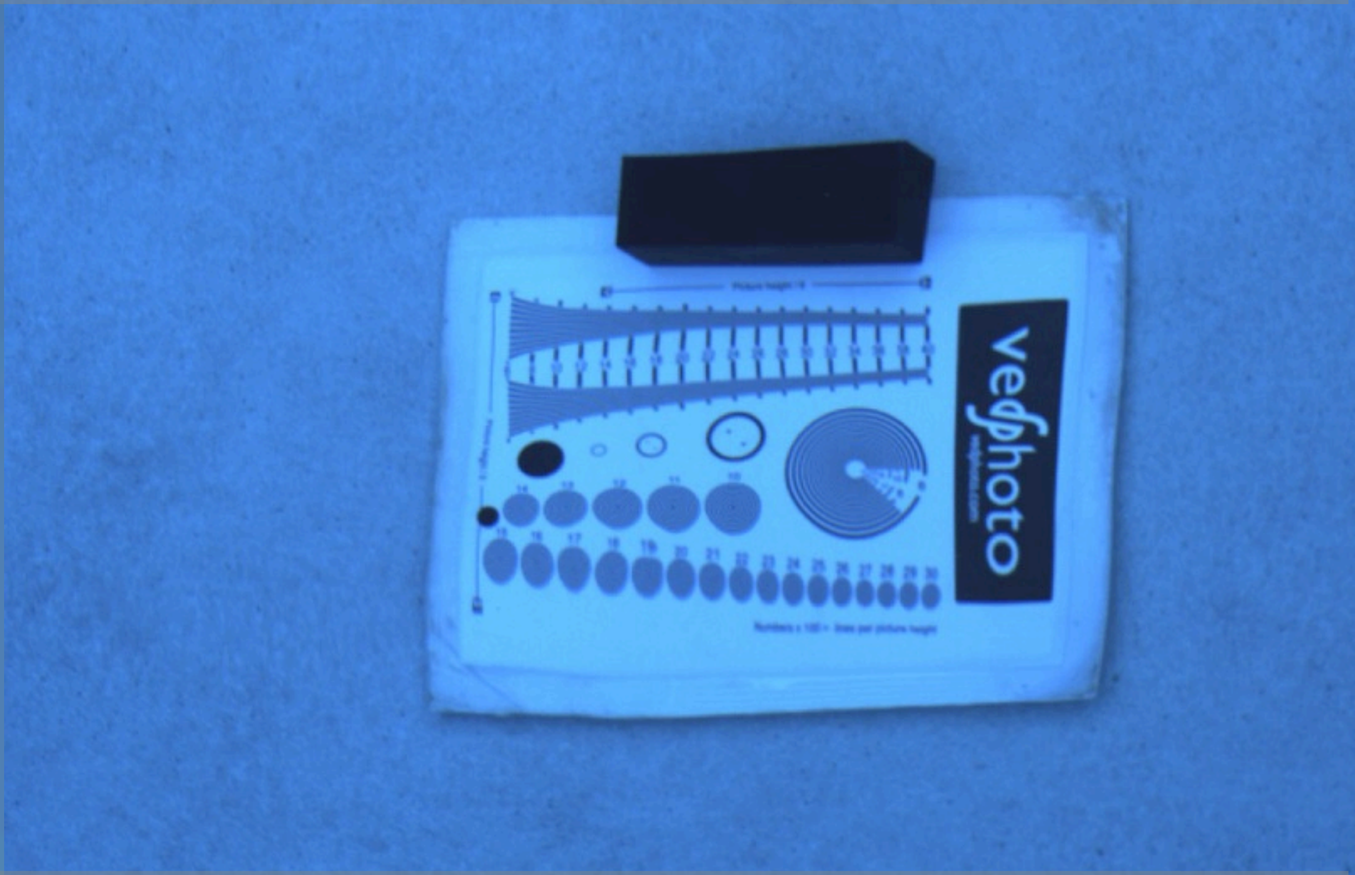
Novel hardware requirements imposed by the Fluid Lensing algorithms pushed the boundaries of commercially available hardware. To be useful in modern marine research, a new combined optical and computational design was needed that would be amenable for deployment on aircraft and in space to cover larger swaths of geographically isolated regions at regular intervals.

FluidCam 1&2 were designed with the highest bandwidth and processing capabilities that exist on CubeSats to date.

FluidCam EXPERIMENTAL RESULTS

FLUIDCAM COMPARISON TO PREVIOUS INSTRUMENT

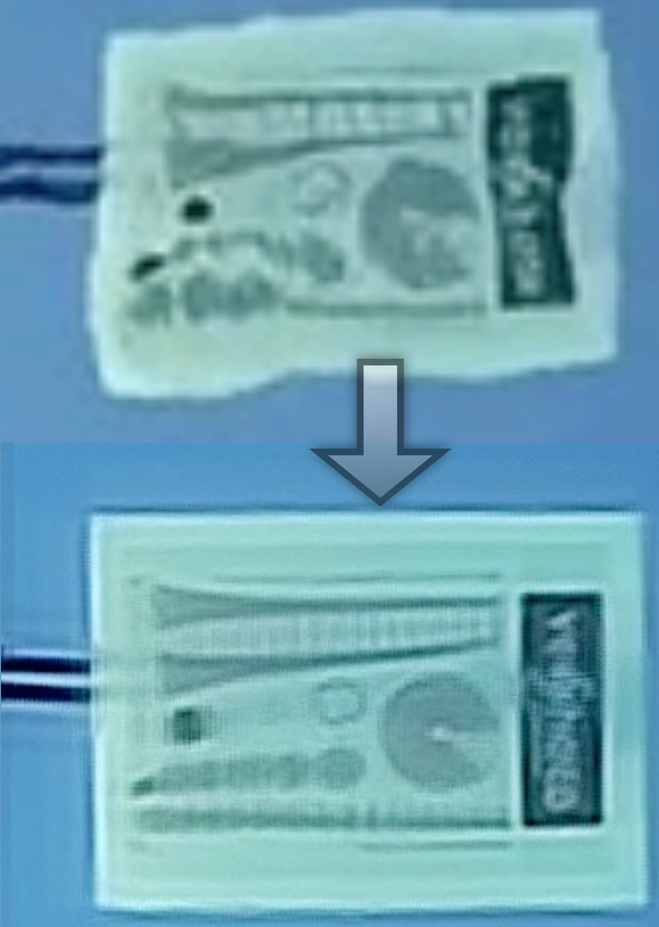
Raw frame close up (60Hz, 0.7MP) from previous instrument in pool test (~10 ft depth, ~10ft surface to camera)



Raw frame close up (90Hz, 4MP) from FluidCam 1 in pool test (~10 ft depth, ~10ft surface to camera)

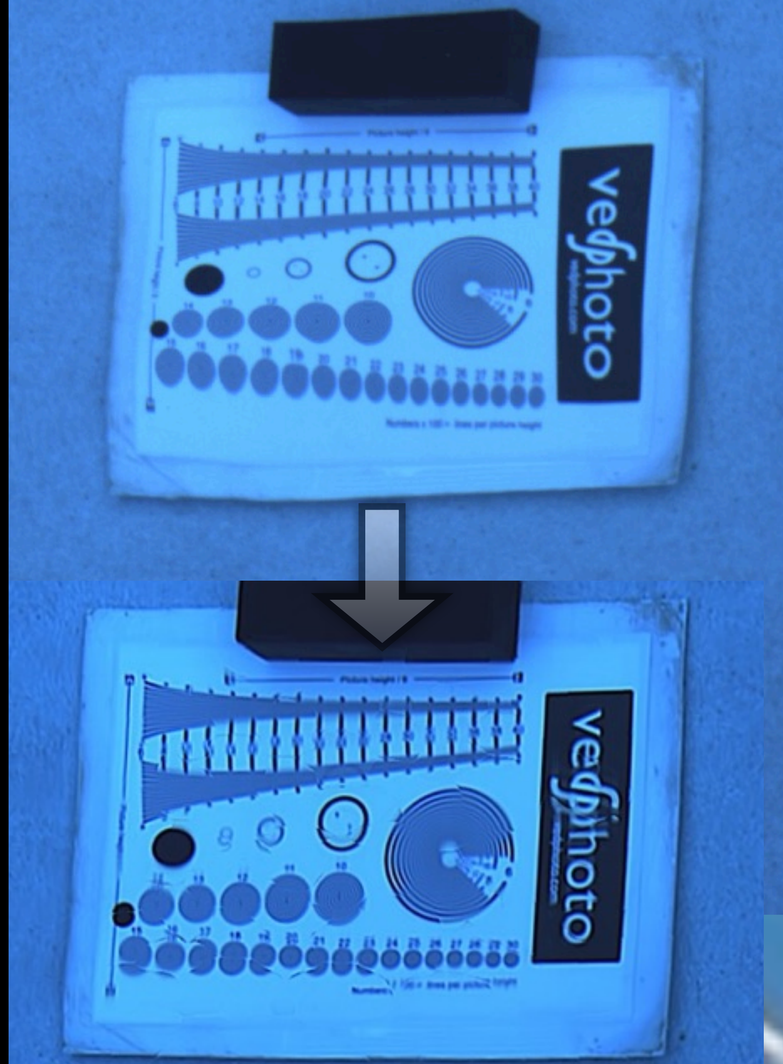
FLUIDCAM COMPARISON TO PREVIOUS INSTRUMENT

Previous FluidCam



FluidCam 1&2 offer more than a 10x improvement over previous Fluid Lensing instruments in resolution and data bandwidth, provide enhanced spectral range in the NIR and all processing can be done on-board the instrument - a novel capability.

ESTO FluidCam Color

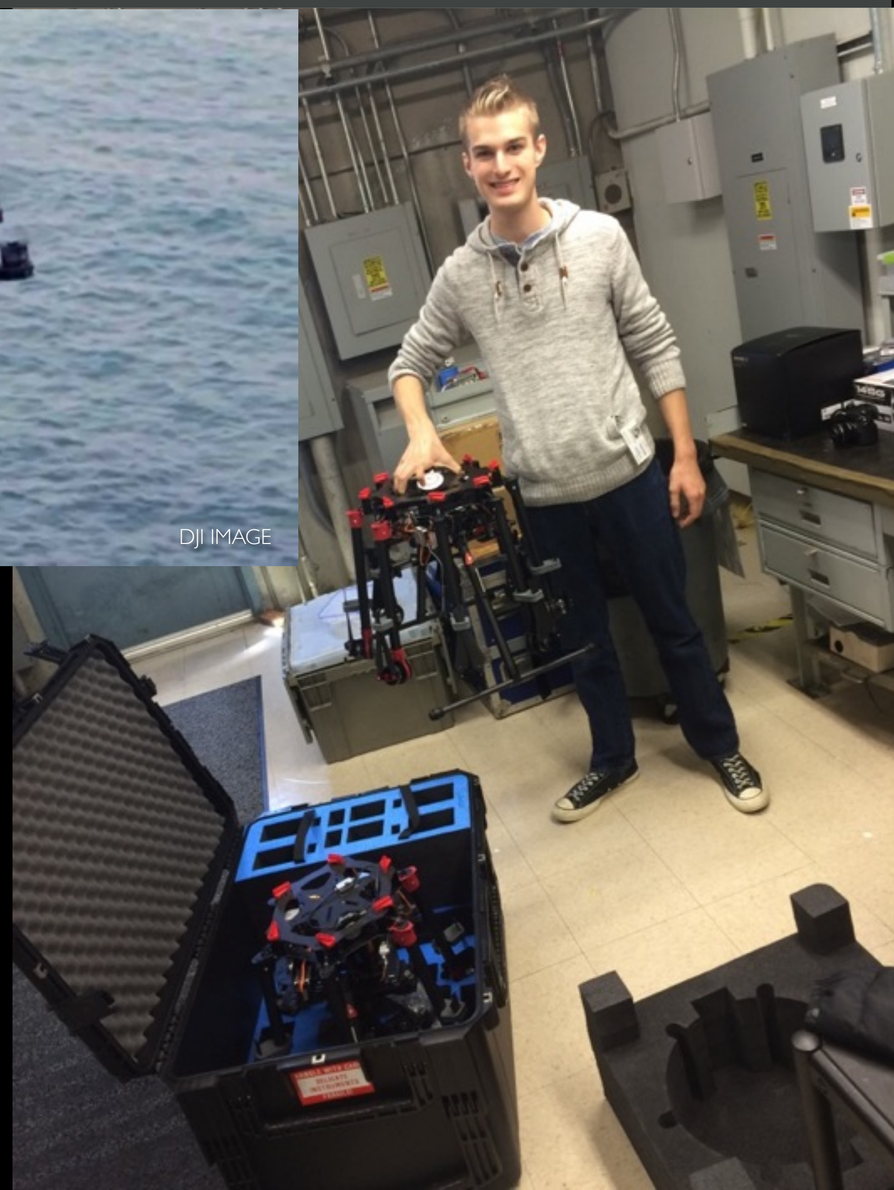


FluidCam NEXT-GEN FLUIDCAM UAVS

- 2 sUAS multi-copter platforms built in collaboration with Stanford University (May 2015)

Slated Campaigns:

- Automated cetacean detection & 3D imaging **(Aug 2015)**
- Samoa fringing reef mapping **(Nov. 2015), NSF**
- SF Bay Turbidity (NSF) **December 2015**
- LiDAR vs FluidCam DEM comparison over terrestrial target, USGS (2015)



FluidCam NEW FLUIDCAM UAVS

Built in collaboration with Stanford University

Offer 10x the resolution and pointing precision of previous Fluid Lensing system for future mapping campaigns

Custom designed for FluidCam 1&2

THANK YOU!

online @

www.nasa.gov/ames/fluidlensing

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next @

AGU (December 2015)

4 peer-reviewed journal papers (2015)