



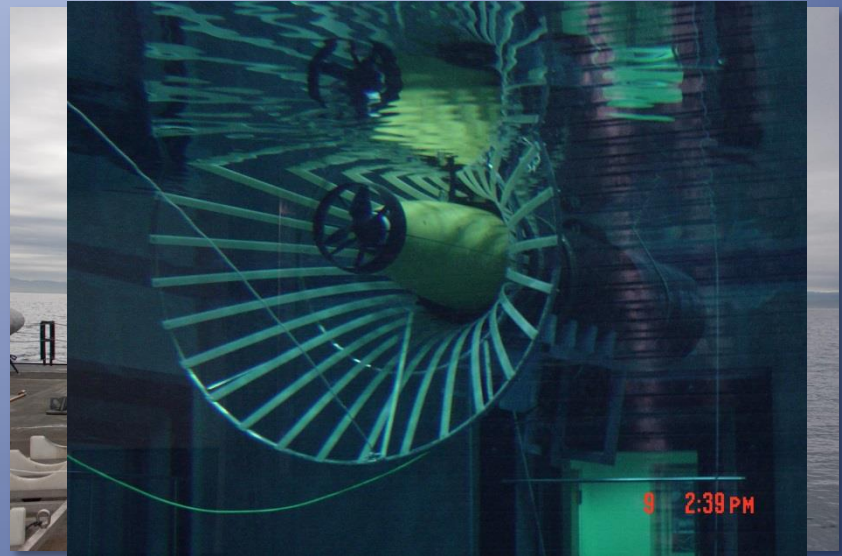
Dorado AUVs Modular Vehicles for Diverse Science Customers



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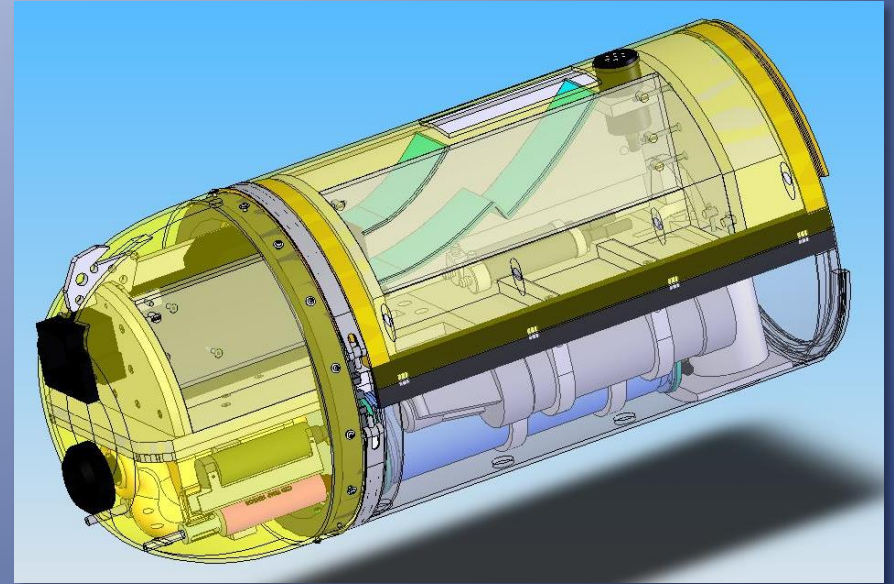
Dorado-Class AUV



- Begun as a joint development project with Bluefin Robotics in 2000
- 21 inch diameter, up to 19 feet in length
- Modular mechanical, electrical and software design
- Several different vehicle configurations:
 - Water column sampling
 - Seafloor mapping
 - Imaging
 - Docking
 - Experimental Instruments



Water Column Survey & Sampling



- 19 hour endurance at 3 knots
- Wide array of physical, chemical & bio-optical instruments
- 10 sample chambers (soon to be 20), 1.8 liter volume

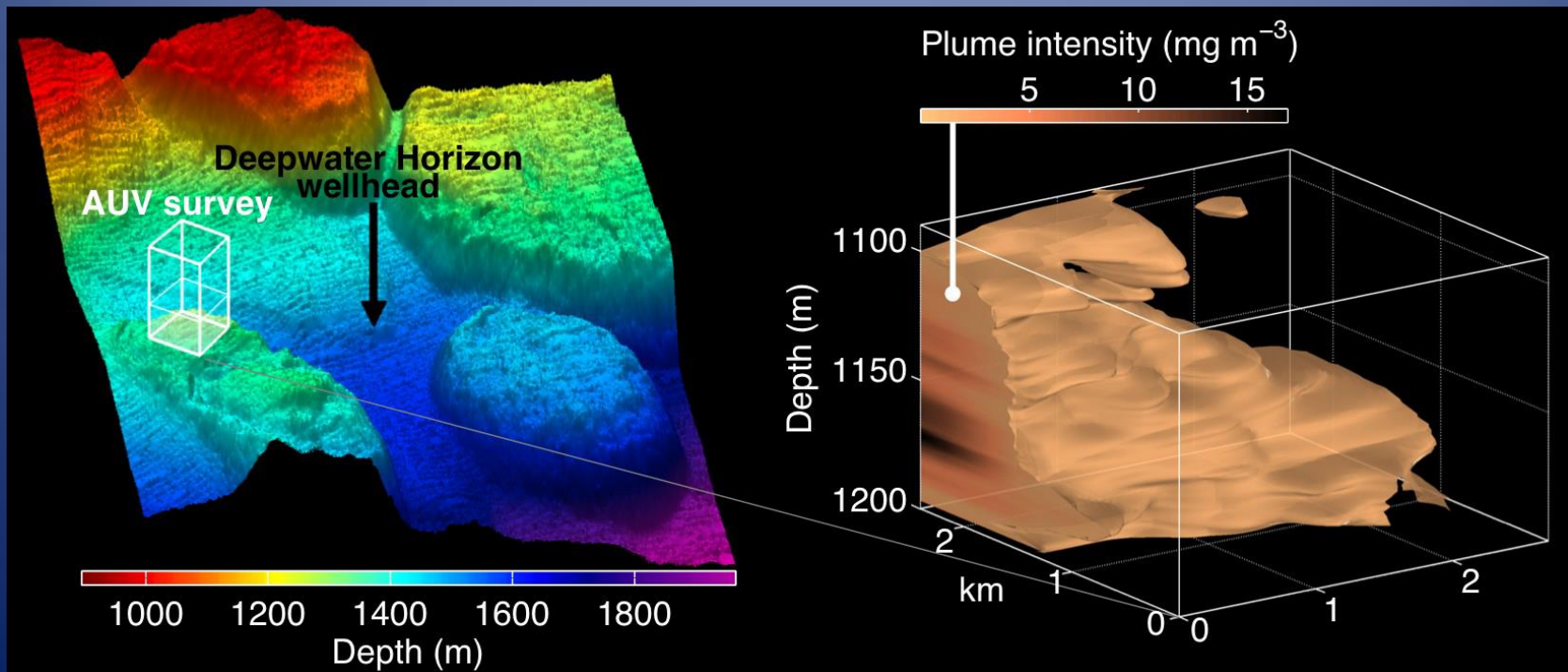




Deepwater Horizon Response Cruise



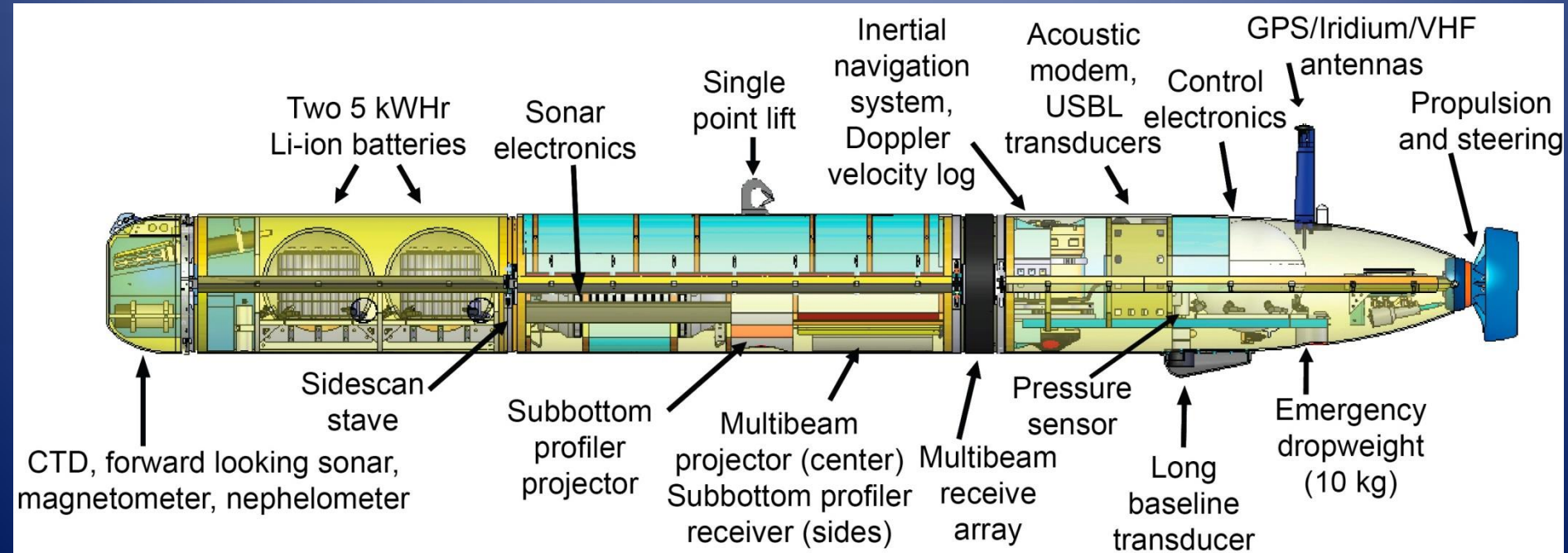
- 1 week mobilization of water column AUV and support team to GoM
- Operated from NOAA ship *Gordon Gunter* as part of joint rapid response cruise
- Adaptive sampling capability modified to precisely target hydrocarbon concentrations
- Dorado provided capability to survey large, deep plumes unreachable by other AUVs on scene and return samples for in-lab analysis





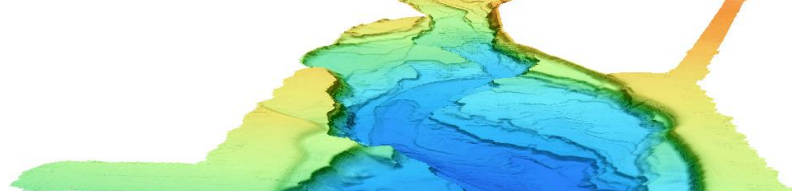
Seafloor Mapping

- 18 hour endurance at 3 knots
- 6 hour battery recharge
- Initial data products in ~5 hours after recovery
- Capable of >1m resolution bathymetry, operating at 50m altitude/200m swath
- Provides ability to operate high resolution sonars near bottom in *extreme* terrain with *high coverage rates & fast turnaround*





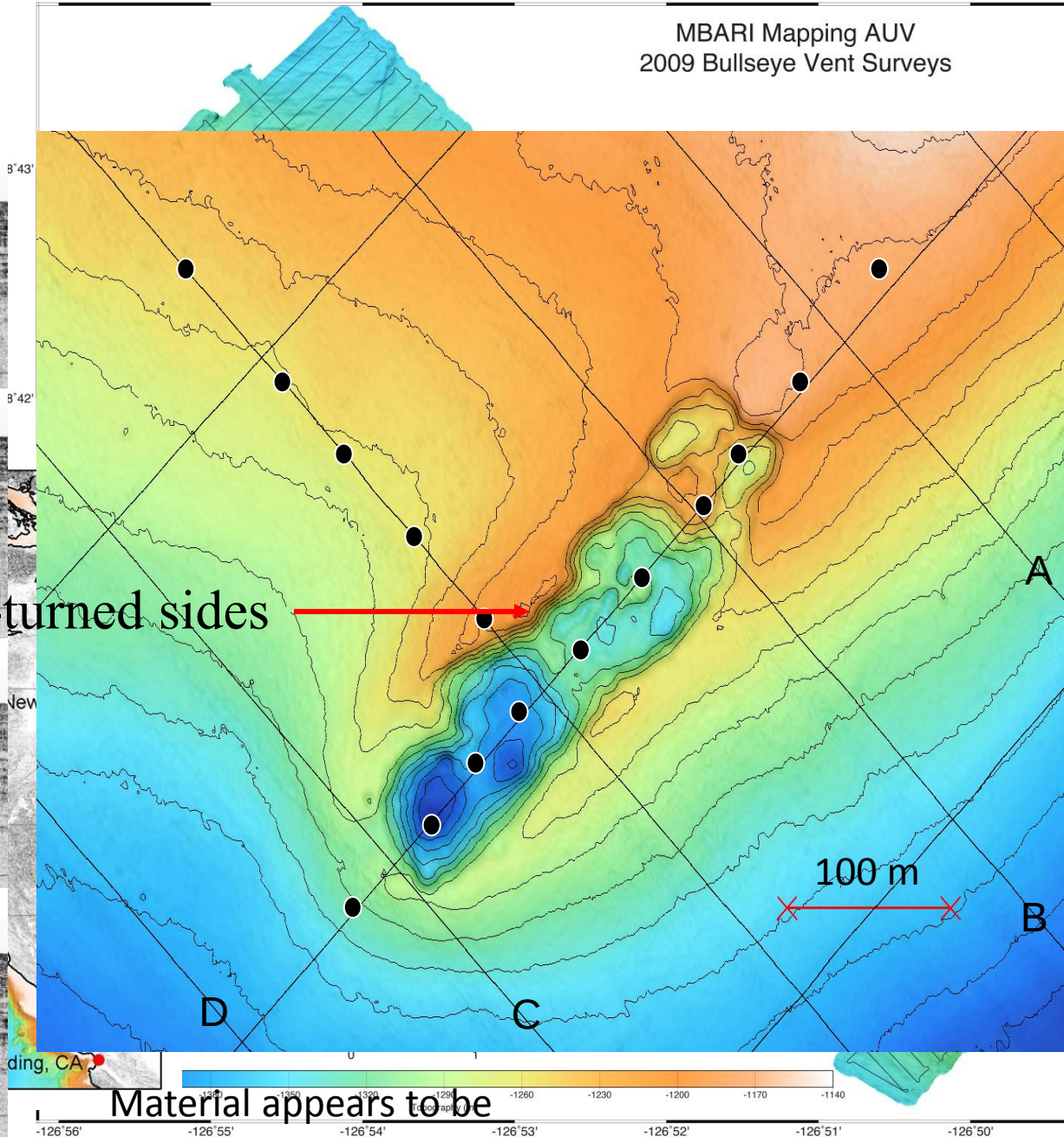
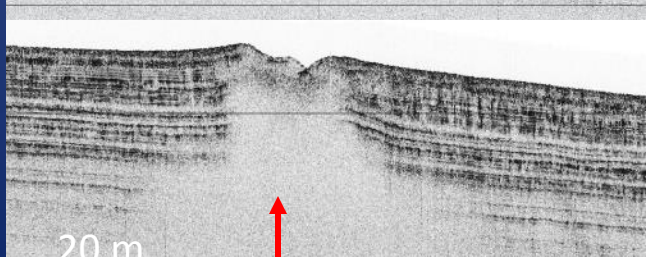
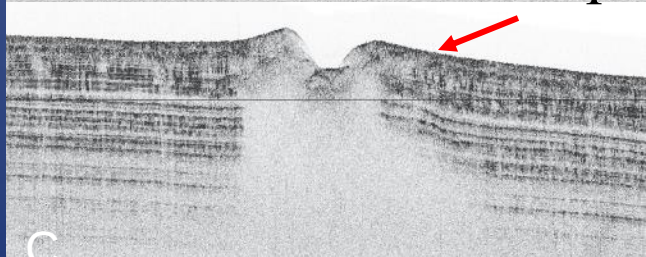
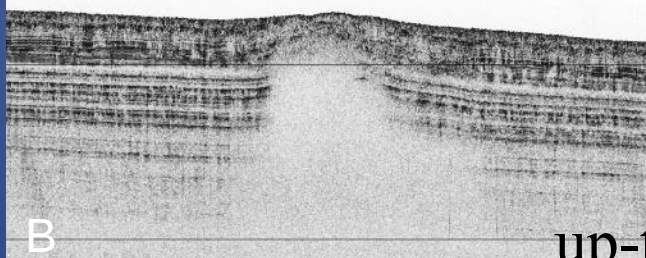
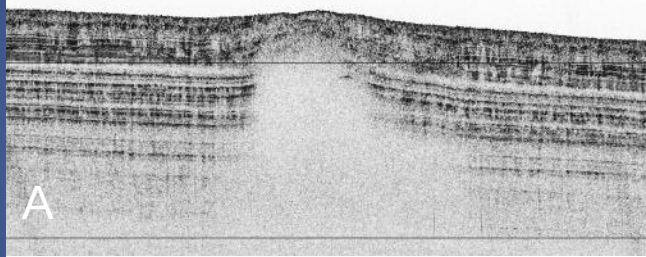
161 Successful Mapp AUV Survey Missions Since 2006.....





2009 Surveys of Hydrate Deposits

MBARI Mapping AUV
2009 Bullseye Vent Surveys



Material appears to be missing from depression?

blanking - gas?



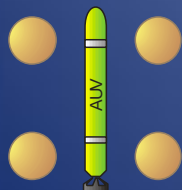
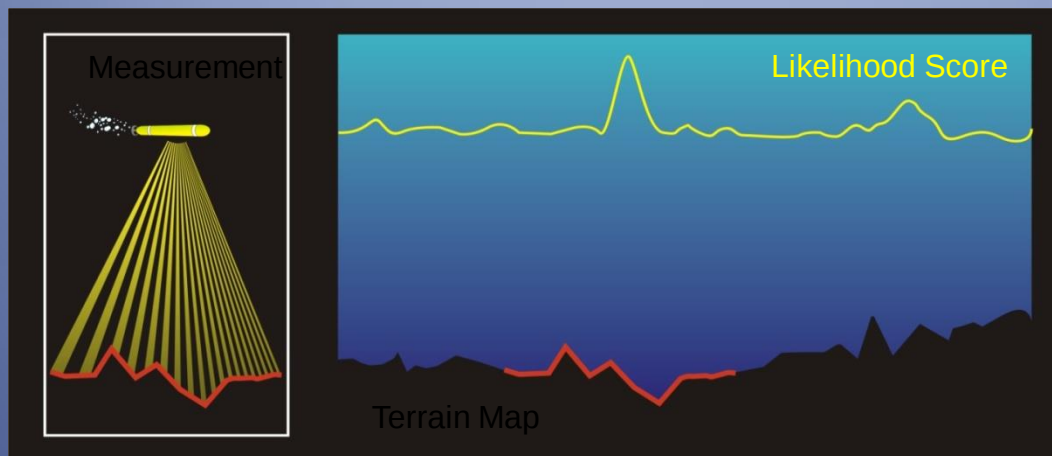
Processing Issues Particular to Swath Data Collected Using Underwater Platforms

- Vehicle navigation is low precision relative to the lateral resolution of the seafloor mapping data
- Mapping sonars on underwater vehicles are subject to interference problems due to propulsion and other active sonars
- Vehicle depth derives from pressure measurements
 - Pressure can be impacted by surface waves – observed in shallow surveys (vehicle depths < 50 m)
 - Deep pressure sensors can be noisy relative to the sonar's vertical precision
- Tides matter in every survey

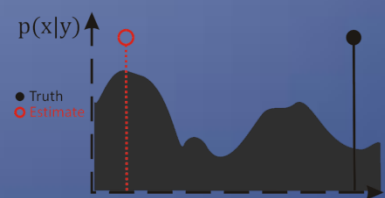
and if the vehicle doesn't come back,
there are no data to process....



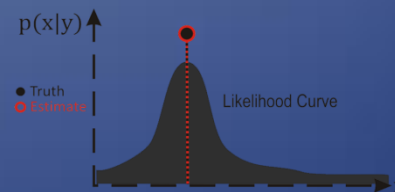
Terrain-Relative Navigation



**Non-parametric filtering
methods due to multi-
modal distributions**



**Doppler Velocity Log (DVL)
sonar used for correlation**

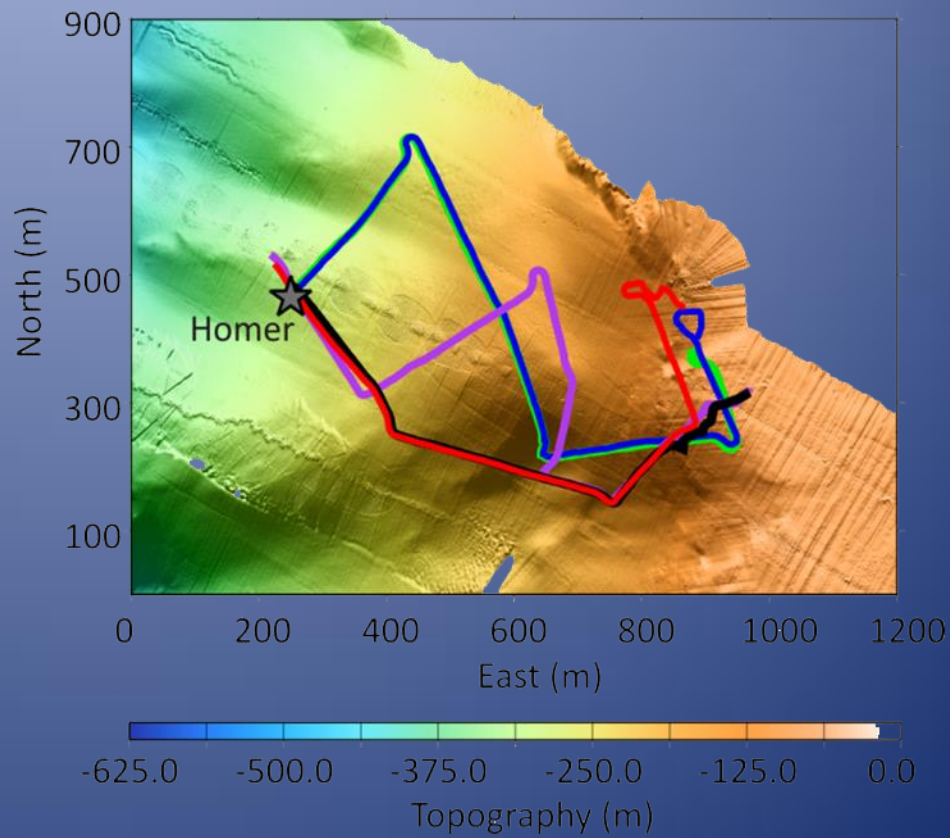
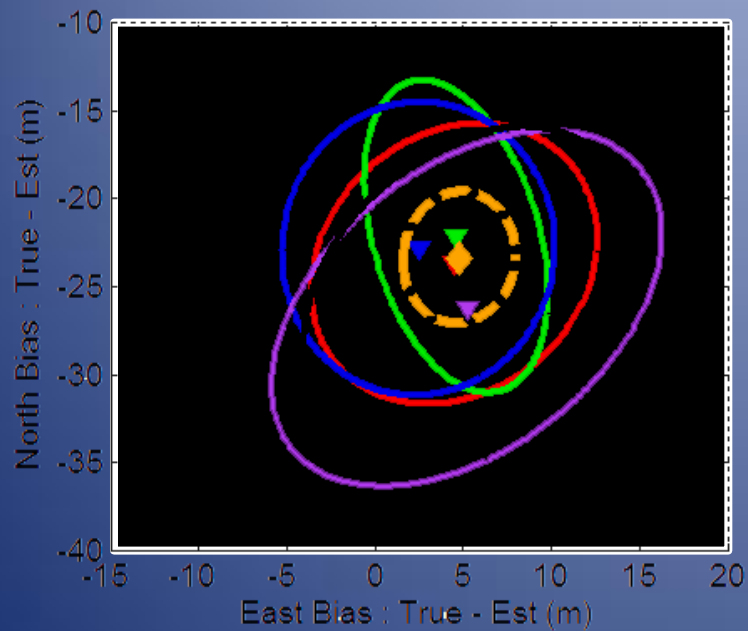




Georeferencing Errors

Repeat runs at Soquel Canyon

TRN Homer Location Estimates:





Conclusions

- AUV hardware and sensors becoming more of a commodity technology
 - Complex sonar systems, modular battery technology are a great example of this
- Increasing emphasis on endurance and onboard intelligence and sensor processing
 - Real-time adaptation to bio-optical sensors and sonars
 - Active navigation and complex obstacle avoidance
 - Intervention & autonomous manipulation are poised to become a reality