

Liquid Robotics – Field Operations

MBARI – Training, Shake-Down Cruise, Integration Test



MISSION PLAN			
Customer:	MBARI – Thom Maughan	Op Area:	Monterey Bay, within 20 miles of Moss Landing
Mission Date Range:	Sortie 1 3/26/13 – 3/26/13 Sortie 2, 3/27/13 – 4/2/13 Sortie 3, 6/5/13 – 6/6/13 Sortie 4, 6/11/13 – 6/17/13 Sortie 5, 6/20/13 – 6/28/13	Broad Mission Description:	Launch / Recovery training, Wave Glider 'Tex' shakeout mission. Integration test of 'communication hotspot', testing Wave Glider acoustic location for AUV docking.
Primary Client Contact Info:	Thom Maughan tm@mbari.org 831-775-1865	Local Authorities:	US Coast Guard District 11 Primary Phone: (415) 399-3547 Emergency Phone: (415) 399-3300 D11LNM@uscg.mil LNM Req 3/13 (5/2/13 update for 5/10-11/30) MBNMS permitting/notification via MBARI
LR Program Manager:	Ryan Carlon ryan.carlon@liquidr.com	Project Code:	113700
LR Account Rep.:	Jamie Griffith jamie.griffith@liquidr.com (509) 993-8216	LR Crew:	Sortie 1 Lorraine Anglin Field Operations Tech Liquid Robotics, Inc Lorraine.anglin@liquidr.com 619.957.9496 Sortie 2, 3, 4, 5 conducted by MBARI Thom Maughan, Paul Coenen (MBARI) [805-245-4890 thom's cell, text preferred]
LR WGOB Director:	John Appelgren john.appelgren@liquidr.com +1 408.636.4260	Desc/Qty of Wave Gliders:	☒ METOC (300 or 600hz) ☐ METOC+ (300 or 600hz) ☐ Hydrocarbon ☐ Gateway ☐ 4.0 vs. 5.8m umbilical ☐ Additional devices
Key Support Team:	Thom Maughan Project Mgr, Software Eng, WG Ops, MBARI tm@mbari.org 831-775-1865 Paul Coenen Electro-Mech Tech, WG Ops, RV Paragon Captain Brian Kieft bkieft@mbari.org Mark Chaffey chma@mbari.org	Deployment Type:	☒ Launch ☐ Training ☒ Recovery
		Special Operational Consideration:	Client operation to develop launch / recovery proficiency (with and without tow body. LR on Sortie 1 only).

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MISSION SCHEDULE / VESSEL DETAIL										
	Date	Port	Vessel				Contracted By			
Sortie 1 (launch):	130326	Moss Landing, California	RV Paragon, Paul Coenen				☒ Client, ☐ LR ☐ Other [explain]			
Sortie 1 (recover):	130326	Moss Landing, California	RV Paragon, Paul Coenen				☒ Client, ☐ LR ☐ Other [explain]			
Sortie 2 (launch):	130327	Moss Landing, California	RV Paragon, Paul Coenen				☒ Client, ☐ LR ☐ Other [explain]			
Sortie 2 (recover):	130402	Moss Landing, California	RV Paragon, Paul Coenen				☒ Client, ☐ LR ☐ Other [explain]			
Sortie 3 (launch):	130605	Moss Landing, California	Sheila B, captain tbd (Brian Kieft as contact)				☒ Client, ☐ LR ☐ Other [explain]			
Sortie 3 (recover):	130606	Moss Landing, California	Sheila B, captain tbd (Brian Kieft as contact)				☒ Client, ☐ LR ☐ Other [explain]			
Sortie 4 (launch):	130611	Moss Landing, California	RV Paragon, Paul Coenen				☒ Client, ☐ LR ☐ Other [explain]			
Sortie 4 (recover):	130617	Moss Landing, California	RV Paragon, Paul Coenen				☒ Client, ☐ LR ☐ Other [explain]			
Sortie 5 (launch):	130620	Moss Landing, California	RV Paragon, Paul Coenen				☒ Client, ☐ LR ☐ Other [explain]			
Sortie 5 (recover):	130628	Moss Landing, California	RV Paragon, Paul Coenen				☒ Client, ☐ LR ☐ Other [explain]			
Minimum hoisting specs (130 kg nominal weight in air; hoisting forces to recover will be higher; recovery typically done in two lifts... float, and then glider; each weighs ~65 kg (configuration dependent)).										
WAVE GLIDERS & WAVE GLIDER MANAGEMENT SYSTEM										
WGMS Org:	MBARI.wgms.com									
WGMS Org/Vehicle/ Performance Dashboard Preparation:	Completion date:									
WGMS Provisioning:	Submit request to LR Wave Glider Operations Center (opscenter@liquidr.com) • User name, email address, phone# (LR Account Representative authorization required)									
VEHICLE PARAMETERS										
WG1 - Configuration/Payload Sensors										
Glider Name:	AIS	Wx	WS	Light	Flag	Color	RDF Top (mhz)	RDF Bottom (mhz)	Unique ID	Security Manifest
Tex	Y	Y	Y	Y	Y	Ylw	151.635	151.623	65E51C59	Y
Tracker Name:	Tracker 87						Track Report Freq.:		24 hours	
Device Details:	Address: Hex & Dec							Port: PL1/2/3		Sub PL Pwr (Y/N)
PIB	FW ver:0393							1		N
SMC	0x2000 (8192); FW ver:							1		N
GPCTD	0x101 (257)							1		N
Active Radar Reflector	N/A							2		N
Communication Hotspot in forward payload bay	Managed by MBARI only							3		N

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Payload Duty Cycle Operational Notes: NA (RTE was on PL3 for sorties 1 & 2; HotSpot to be installed on PL3 for sortie 4)

Details of devices listed above:

Sensors	Make and model	Function
Fluorometer and Backscatter sensor	Wetlabs ECOBB2F	Fluorometer and Backscatter sensor for chlorophyll and turbidity-like measurements

MISSION OBJECTIVES

Study Area: Monterey Bay operating over the Canyon out of the way of nominal ship traffic between former M0 mooring location and M1 mooring location.

Aim:

- **Sortie 1** Launch and recovery training with LRI.
- **Sortie 2** Launch and recovery knowledge applied and documented by MBARI. Shake-down cruise.
- **Sortie 3** Tex will have an acoustic navigation beacon attached to the sub. The MBARI LRAUV will be locating and tracking the Beacon on Tex. Contact made with LRI WGO before and after launch by Brian Kieft bkieft@mbari.org.
- **Sortie 4**, Deployment of Tex Waveglider with integrated WiFi Hotspot in forward payload bay connected to PL3 (RTE plugged into PL2) . HotSpot will be used in coordination with Dorado AUV tended by the R/V Rachel Carson on June 12 and again on June 14 during the day from ~8am to 3:30pm local. R/V Rachel Carson will be in proximity to Tex WG however we will have situational awareness of WG position and RV Rachel Carson and will be in contact with LR WGO to insure proper vehicle safety. Changes in Tex waypoints on June 12 and June 14 will be managed by Mark Chaffey (chma@mbari.org). Contact to LR will be by Thom Maughan (tm@mbari.org) or Paul Coenen (coenen@mbari.org).
- **Sortie 5** DARPA project engineering test continued.

Legend: Operational log to record task start/end, and unplanned events.

yymmdd, hhmmz – start & end dates/times (in UTC)

unplanned events – challenges with vehicle/PL performance; special discoveries; etc...

Sortie 1: Wave Glider launch and recovery training for MBARI (Thom Maughan and Paul Coenen)

Task 1 - Deploy out of Moss Landing in the vicinity of 36 48.5538N, 121 51.0000W. Anticipate several deployment and recoveries with stock Wave Glider by Liquid Robotics operations team providing instruction and guidance and then finally observing MBARI and certifying proper operations.

[130326, 1753z Start]

Task 2 - Attempt a launch and recovery of the vehicle with tow body attached.

[130326, 2029z End]

Sortie 2: Deploy out of Moss Landing in the vicinity of 36 48.5538N, 121 51.0000W. Thom Maughan and Paul Coenen practicing and documenting wave glider launch and recovery. Vehicle to be on mission for approximately 5 days just running the GPCTD between MBM1 and MBM2. Vehicle to be recovered approximately three nm from Moss Landing at approximate coordinate 36.80935, -121.84885 at 0900 on 04/02/2013.

[130327, 1602z Start]

[130402, 1613z End]

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Sortie 3: DARPA project engineering test. Tex will hold station (loiter) and do a short line out and back with a small LRAUV in the water. Brian Kieft managing.

Task 1 - Deploy in the vicinity of 36.815, -121.826.

[yyymmdd, hhmmz Start]

Task 2 - Tex will "Hold station at waypoint" (loiter) at 36.835, -121.850.

- User interaction from MBARI (Brian Kieft) occasionally throughout the day commanding "follow fixed heading" of 300 degrees not to exceed 5km NW from above waypoint. MBARI users will likely run a reciprocal course back to the waypoint to hold station (loiter) and will not pass to the SE of above waypoint. Clear coordination with WGOC will be maintained throughout any MBARI user interactions.

[yyymmdd, hhmmz Start]

[yyymmdd, hhmmz End]

Task 3 - Calm weather recovery the morning of 6/6 or if weathered out on 6/7. Sortie contingent on final boat availability and approval to proceed by LRI with a short notice plan change (note: the Sheila frequently used for WG L&R). The Martin has also been used and may be out anyway so it will be our fallback. Recover in the vicinity of 36.815, -121.826.

[yyymmdd, hhmmz Start]

[yyymmdd, hhmmz End]

Sortie 4: Comm HotSpot testing. Hold station (loiter 100x100m box) with the RV Carson intentionally nearby on June 12 and 14 and larger AUV doing patterns around Tex. Mark Chaffey will be contacting LR in the case of Tex waypoint changes.

Task 1 – 6/10/13 Ballast Wave Glider in test tank during the morning by adding weight to the aft payload box to offset the forward payload box. Mobilize Wave Glider and gear onto the RV Paragon.

Task 2 – 6/11/13 Launch Tex from the RV Paragon or Shiela B at ~8:30am local. Tex will be in a loiter pattern at WG1 coordinates (*see Cruise Navigation Waypoints table below*).

- Deploy in the vicinity of 36.791,-121.835.

[yyymmdd, hhmmz Start]

Task 3 – Mark Chaffey will contact the WGOC, 1-888-574-4574, or by opscenter@liquidr.com if loiter position needs to change.

Task 4 – There will be at times (June 12 and June 14) close quarter operations between the RV Rachel Carson (has AIS) and Tex and this is intentional. Tex will be monitored visually and/or by radar. **MBARI requests that Liquid Robotics does not take evasive maneuvers with respect to the RV Rachel Carson.**

- The RV Paragon position is not reported via AIS, however it has a tracker on it and can be seen at odss.mbari.org.
- An AUV will be in operation in proximity to Tex and will be used in the communications testing on June 12 and June 14 (*AUV waypoints shown in Cruise Navigation Waypoints table below*).

Task 5 – 6/17/13 Tex recovery planned in the morning around 9:00am local, contingency recovery plan is 9:00am 18 June 2013.

- Recover in the vicinity of 36.791,-121.835.

[yyymmdd, hhmmz End]

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Cruise Navigation Waypoints Table:

- 1.1 Wave Glider loiter waypoint (waypoint WG1), note: the alternate position may be used depending on the location of the salmon and squid fishing fleets.
- 1.2 AUV track starting point (waypoint AUV1A).
- 1.3 AUV track ending point (waypoint AUV1G).
- 1.4 Alternate Wave Glider loiter waypoint (waypoint WG2).
- 1.5 Alternate AUV track starting point (waypoint AUV2A).
- 1.6 Alternate AUV track ending point (waypoint AUV2G).

HotSpot Cruise Waypoints

Name	Latitude	Longitude	Notes
WG1	36°46'00.00"N	121°52'00.00"W	Wave Glider loitering waypoint
WGR1	36.791	-121.835	Wave Glider recovery loiter waypoint
AUV1A	36°44'00.00"N	121°52'15.00"W	Starting AUV position 2 nm south of WG.
AUV1B	36°45'00.00"N	121°52'15.00"W	1 nm south of WG waypoint
AUV1C	36°45'30.00"N	121°52'15.00"W	0.5 nm south of WG waypoint
AUV1D	36°46'00.00"N	121°52'15.00"W	463 meters west of WG waypoint
AUV1E	36°46'30.00"N	121°52'15.00"W	0.5 nm north of WG waypoint
AUV1F	36°47'00.00"N	121°52'15.00"W	1 nm north of WG waypoint
AUV1G	36°48'00.00"N	121°52'15.00"W	Ending AUV position 2 nm north of WG.

Alternate HotSpot Cruise Waypoints (in case of salmon fleet interference with above)

Name	Latitude	Longitude	Notes
WG2	36°44'00.00"N	121°53'30.00"W	Wave Glider loitering waypoint
AUV2A	36°42'00.00"N	121°53'45.00"W	Starting AUV position 2 nm south of WG.
AUV2B	36°43'00.00"N	121°53'45.00"W	1 nm south of WG waypoint
AUV2C	36°43'30.00"N	121°53'45.00"W	0.5 nm south of WG waypoint
AUV2D	36°44'00.00"N	121°53'45.00"W	463 meters west of WG waypoint
AUV2E	36°44'30.00"N	121°53'45.00"W	0.5 nm north of WG waypoint
AUV2F	36°45'00.00"N	121°53'45.00"W	1 nm north of WG waypoint
AUV2G	36°46'00.00"N	121°53'45.00"W	Ending AUV position 2 nm north of WG.

Sortie 5: (Follow on to Sortie 3) DARPA project engineering test continued. Hold station (loiter 100x100m box) with commands issued from Kieft. **Possible tow body with acoustic modem... to be confirmed by Thom prior to deployment.**

Task 1 - Deploy in the vicinity of 36.791,-121.835. Contact to LR will be by Thom Maughan (tm@mbari.org) or Paul Coenen (coenen@mbari.org). Launch planned for 6/20/13 (dependent on RV Paragon availability).

[yyymmdd, hhmmz Start]

Task 2 - Tex will loiter at 36.835, -121.850. Operations with LRAUV are June 24-27 with course changes from MBARI to LR by Brian Kieft.

[yyymmdd, hhmmz Start]

[yyymmdd, hhmmz End]

Task 3 - Recover in the vicinity of 36.791,-121.835 on 6/28/13

[yyymmdd, hhmmz End]

Mission Deviation Log (if applicable)

[dates requested/vetted/decision/execution, requestor, narrative, detailed coordinates].

DELIVERABLES

Mission Plan Authorization: Deployment authorization pending completion of: WGMS org/vehicle/performance dashboard readiness, pre-launch validation, confirmation of vessel/launch crew readiness, provision of outstanding

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data highlighted yellow within this plan.

LR Field Resource Logistics/Operations Kit: LR Field Ops representative to accompany MBARI on Sortie 1.

Pre-Launch: Core systems, sensor calibration verification, Ops and safety review preceding each sortie.

Training: Training conducted 3/26/13. Sortie 1 and 2 are primarily for training of MBARI personnel Thom Maughan and Paul Coenen.

Sea Acceptance Tests (SAT): See Sortie 2 and 3.

Freight Forwarding Logistics: Vehicles and required materials transported via truck from LRI Sunnyvale to port of departure.

Field Replaceable Units (FRUs/Spares): NA.

Proposed Sea Trials: See Sortie 2 and 3.

Data: Client determined.

Reports: Post-deployment; mission operations; post-recovery.

- Post-deployment - authored by LR deployment resource; distributed to WGOC (mission/case record), and Field Operations; possible expanded distribution to effect quality improvement initiatives.
- Post-recovery - authored by LR recovery resource; distributed to WGOC (mission/case record), and Field Operations; possible expanded distribution to effect quality improvement initiatives.

Communications: Use of Project Team roster indicated in opening section.

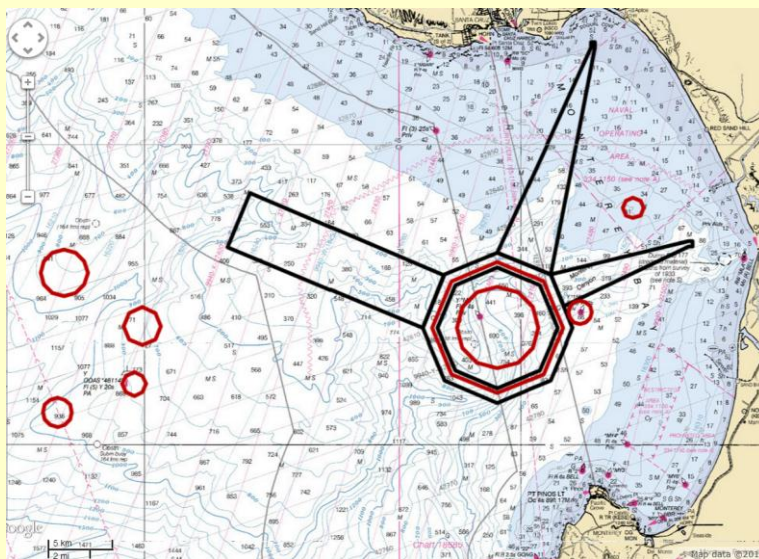
- *In case of an emergency refer to the emergency escalation diagram on the last page.*

WGMS offices (Wave Glider Operations Center): LR HQ in Sunnyvale will pilot Wave Glider and update Mission Plan as necessary. Client engagement requires acknowledgement by WGOC and client, prefer text messaging, email, or voice. Text to WGOC via opscenter@liquidr.com; text to MBARI based on number specified by MBARI.

Post-Recovery: Client determined.

COURSE ARCHITECTURE

Overall Operating Area:



Close-Ups of Course

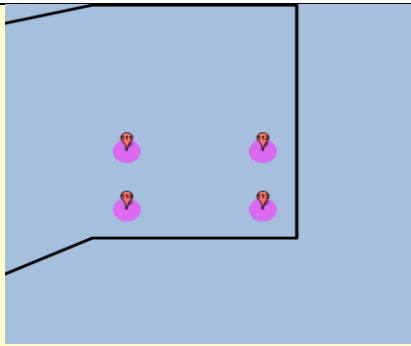
Deployment/Recovery Area

Buoy MBM1 Orbit

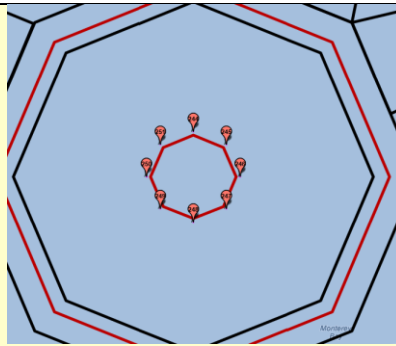
Buoy 46044 Orbit

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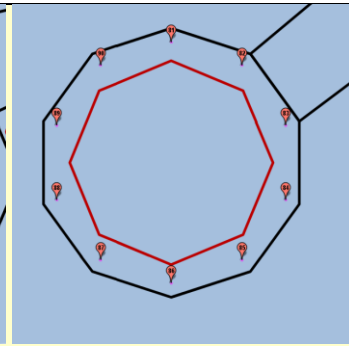
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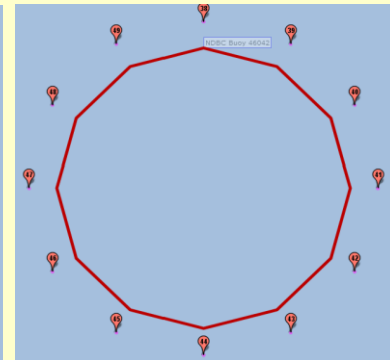
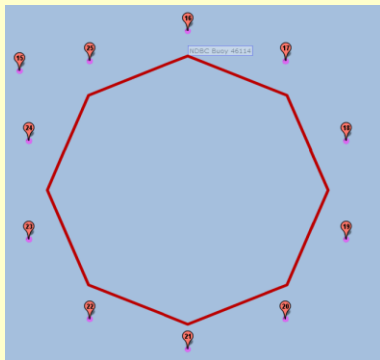
Buoy 46114 Orbit



Buoy MBM2 Orbit



Buoy 46042 Orbit



OPERATIONAL AREA DESCRIPTION

Loiter Areas: Operating areas for deployment, vehicle performance and sensor correlative data observations, and recovery operations.

Transit Lanes: Swim lanes between operating areas circumventing hazards to navigation.

- Shipping safety fairways intersecting transit lanes traversed under heightened observation.
- Transit lanes established at >1nm distance from known hazards to navigation where possible.

Operation Polygons: Defined operational areas structured within a Wave Glider to notify pilots of “out-of-bounds” operating conditions.

- Inclusion boundaries alert pilots of unplanned operating area departures. Containment boundaries typically established during near shore or known hazard operations.
- Exclusion boundaries alert pilots of unplanned encroachment of undesired operating areas.
 - Buoy station boundaries established at published watch circles (minimum safe operating distance). Unspecified watch circles established at radius equivalent to buoy depth.
 - Other surface expression boundaries (i.e., platforms) established at 1nm radius.
 - Wave Glider operations in less than 10 fathoms of water are avoided.
 - Exclusion boundaries established when course intersects Shipping Safety Fairways to alert pilots for heightened awareness.

ENVIRONMENTAL

Bathymetry: Vehicle will be operating within the Monterey Bay where depth drops off quickly after about the 60 fathom line to several hundred fathoms due to Monterey Canyon. Vehicle should not go any shallower than the 10 fathom line.

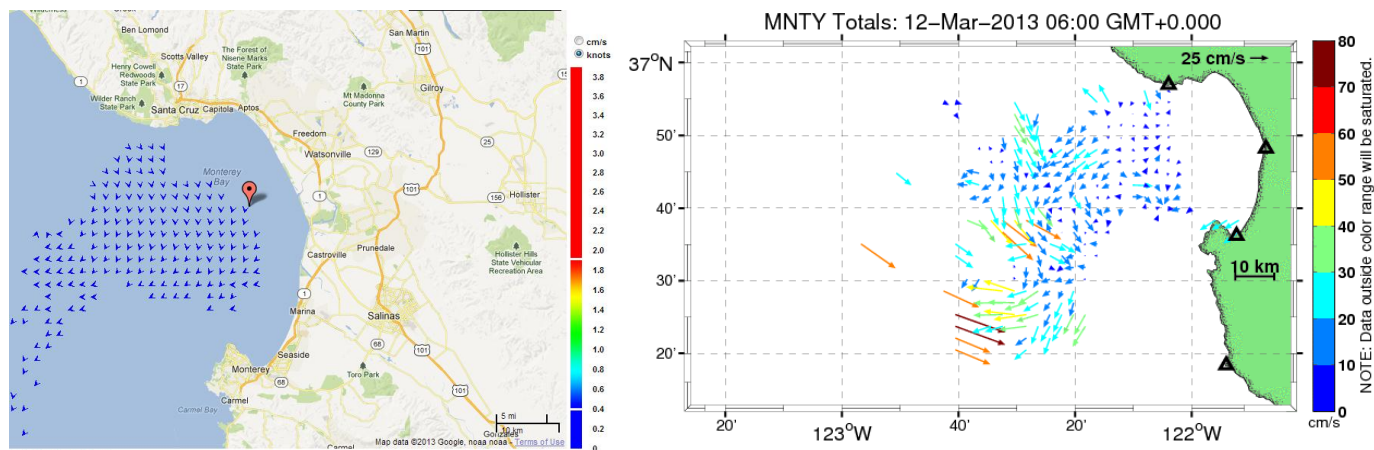
Wind/Waves: Entering windy season presently (March-October), should expect daily onshore breezes by the afternoon (local time) of around 10-20 knots. Wind direction is variable, but Northerly bias dominates. Expect slow swells, average waves of 5-10 ft with periods of 10-14 seconds.

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Currents/Eddies: Currents within the Monterey Bay can be expected to be less than 1 knot.



Tides: Semi-Diurnal tides. Effect on vehicle should be negligible in this area.

Solar: Occasional storms/rain and fog may affect solar charging, but otherwise should have sufficient sunlight for day-to-day operations. Rainy season is drawing to a close, so the number of cloudy days should become less frequent as we move into Spring. Approximately 13-14 hrs of daylight this time of year.

Variable	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Insolation, kWh/m ² /day	2.21	3.16	4.54	5.91	6.87	7.41	7.08	6.36	5.18	3.84	2.62	1.99
Clearness, 0 - 1	0.48	0.52	0.57	0.60	0.62	0.64	0.63	0.62	0.60	0.57	0.52	0.47
Temperature, °C	9.95	10.21	11.43	13.68	17.04	20.36	22.07	21.68	20.51	17.91	12.98	9.98
Wind speed, m/s	4.21	4.59	4.96	4.99	5.37	5.46	5.16	4.75	4.48	4.06	4.18	4.29
Precipitation, mm	156	128	119	57	12	4	2	3	10	36	109	125
Wet days, d	9.2	8.7	9.9	5.9	2.2	0.8	0.6	0.7	1.5	3.5	7.7	8.8

These data were obtained from the NASA Langley Research Center Atmospheric Science Data Center; New et al. 2002

Notes: [Help](#). [Change preferences](#).

POTENTIAL ISSUES / CONCERNS

Bathymetry: Do not operate below 10 fathom line.

Wind/Waves/Currents/Eddies/Tides: Nominal

Solar/Magnetic Declination: NA

Hazards to Navigation: Crab pots and other fishing gear pose a significant risk (Nov-June). Kelp clusters adrift may entangle the wave glider. Close attention should be paid to vehicle speed through water and navigational authority.

Vessel Traffic Density: Minimal within the MEP Monterey Bay area; some small boat traffic should be expected.

Political Interests (ITAR, EAR, Maritime Zones and Boundaries): Operating within the Monterey Bay National Marine Sanctuary

PILOTING TASKS

Things To Look For:	Probable Response:	When to Escalate:
Event Notifications	Navigate (evasion, drift management); observe power management criteria; take corrective action; report accordingly	- Unsafe operation conditions - Course change required

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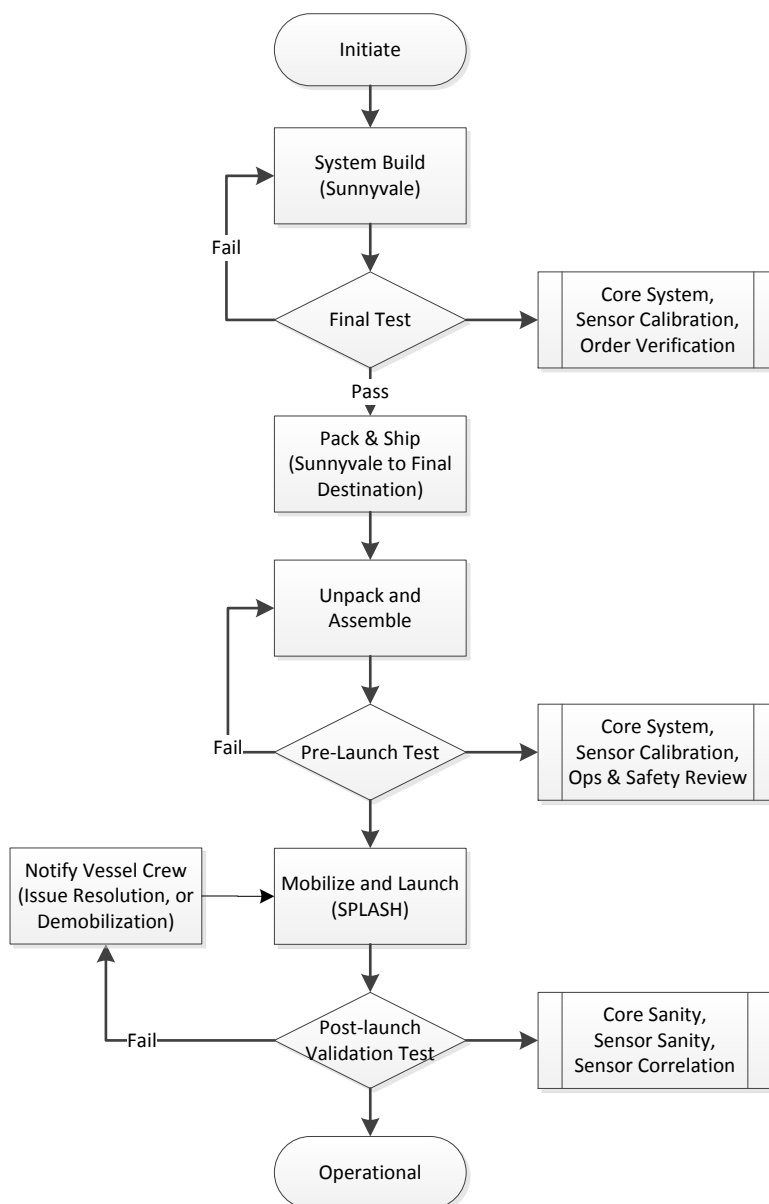


• Power Management	• Light: Launch/recovery/emergency use only • Telemetry: 5min standard, 10min (250wh), 15min (200wh - auto adjust controlled), 20min (150wh), 30min (100wh) ○ Consider glider position (AIS notification diminished at TRR >5min). • Water Speed Sensor: Off at 250wh • Payloads: Adj sample rate, or off at <200wh • Weather Station: Off at 150wh • AIS and Radar Target Enhancer: Off at 100wh ○ Consider glider position (no AIS and risk of power loss). • Move to Safe Harbor: At 50wh <i>* Restore power in reverse order +25wh</i> (Increase thresholds by 100Wh when entering periods of deteriorating weather forecasts)	• Notify Program Manager if total available power reaches 300Wh • If course change required
RISK ASSESSMENT		
Refer to Wave Glider Risk Assessment addendum.		
EMERGENCY EQUIPMENT RETREIVAL		
If escalation warrants emergency retrieval of a Wave Glider, local authorities are notified and Marine Operations is engaged to coordinate search and recovery operations.		
RESOURCES		
For access to Mission Support Specialists (piloting resources), please contact the Liquid Robotics Wave Glider Operations Center at +1 408. 636.4205, or email opscenter@liquidr.com .		
AUTHORIZATIONS		
Sales Engineer: Jamie Griffith	WGOC Director: John Appelgren	
Program Manager: Ryan Carlon	VP Operations: Keith Kreider	
VP Sales: Francois Leroy	Chief Operations Officer: Steve Springsteel	

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APPENDIX

Related Workflow: Build to Operations

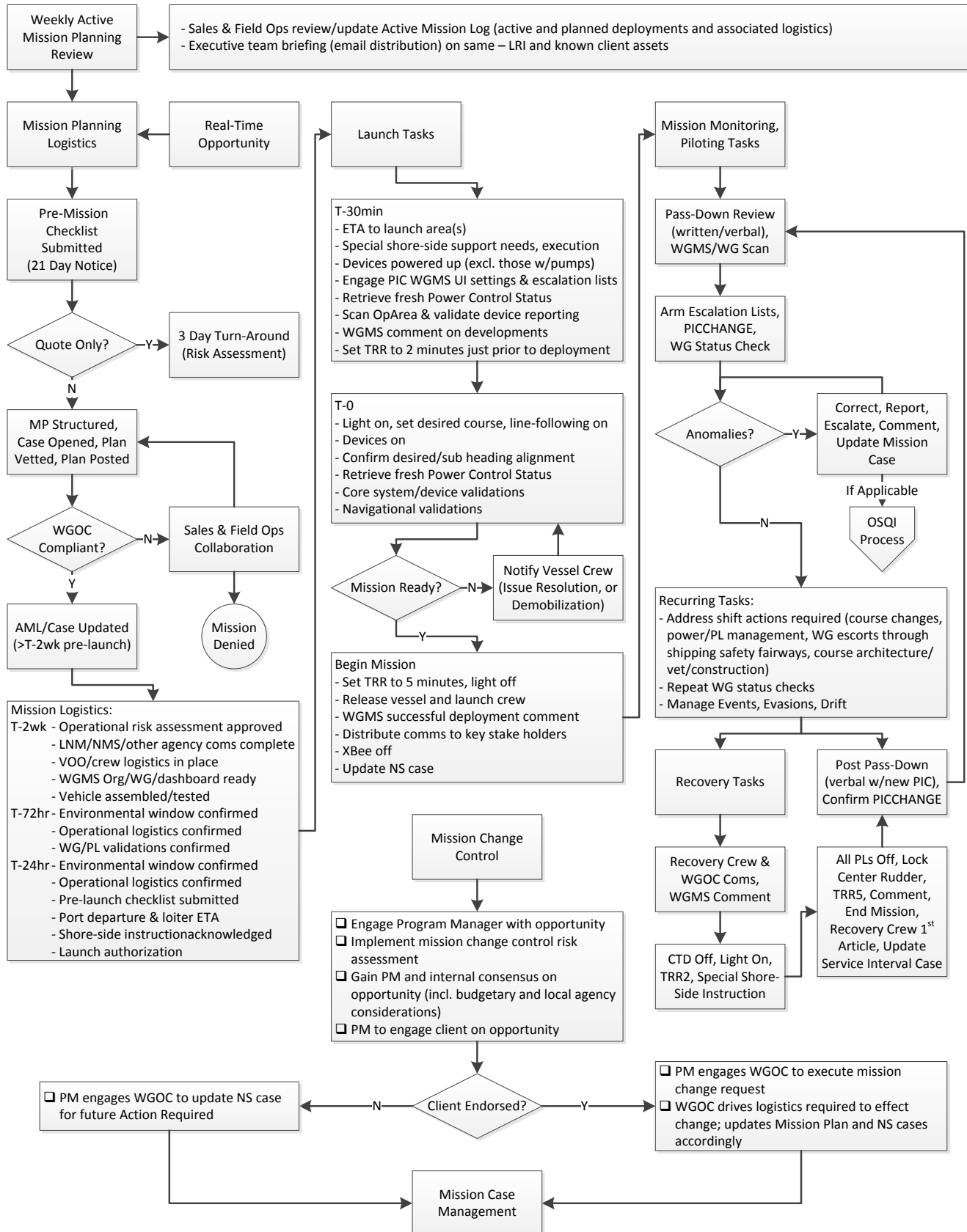


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Mission Planning Logistics

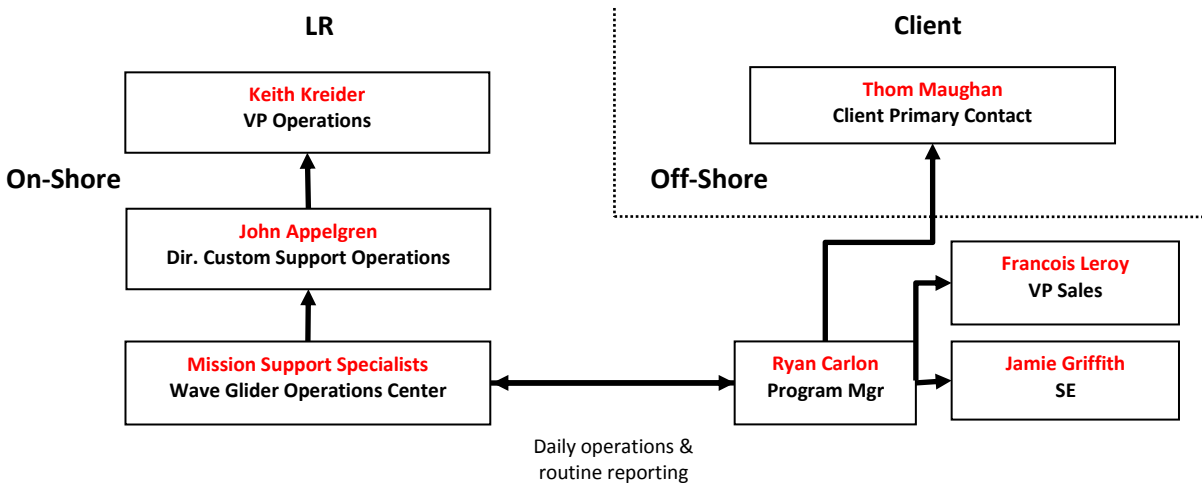


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Day to Day Interfaces



Emergency Escalation

