Ultra‑Deep Technical and Organizational Report on Listed ROV Teams

A comprehensive engineering, operations, and documentation analysis

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Labrador Straits Academy – Shark Tech

A team defined by environmental realism, rugged engineering, and field‑condition resilience.

Engineering Philosophy

Shark Tech's design approach is influenced by the unforgiving Labrador Sea environment. Instead of designing an ROV optimized **only** for competition pools, they build machines that behave reliably in real marine ecosystems with unpredictable swell, variable visibility, and temperature extremes.

Mechanical Systems

- **Frame Architecture**
    - Typically rectangular or trapezoidal with reinforced cross‑members.
    - Heavy-duty gusseting to resist frame torsion under current shear.
    - Polycarbonate paneling added for drag control and equipment protection.
- **Material Selection**
    - Aluminum 6061-T6 or marine-grade alloys for corrosion resistance.
    - Polycarbonate for transparent tool housings.
    - Stainless steel fasteners, often pre‑treated with anti‑seize to prevent galling.
- **Thruster Layout**
    - Usually robust brushed DC or sealed brushless units.
    - Emphasis on torque over speed due to weed, kelp, and debris in natural testing waters.

Electrical Systems

- **Redundant Fused Branches**: If one subsystem fails, the rest remain powered.
- **Ultra-heavy-duty tether sheathing** to resist abrasion on rocks, pier pilings, or hulls.
- **Saltwater-resistant heat-shrink and epoxy potting** in all junction boxes.

Operational Culture

- Students perform **real ocean tests**, not just pool trials.
- Rapid-fix field engineering skills (crimping, splicing, waterproofing) are practiced during actual deployments.
- Mission strategy emphasizes practicality over complexity.

Lakeview Technology Academy – HOSA Subaquatics

A robotics team shaped by biomedical discipline, safety culture, and quality assurance rigor.

Engineering Methodology

Rooted in their medical-science background, they adopt a systematic engineering process resembling device-validation workflows.

Documentation Framework

- **Version-controlled reports** (Git-like revision tracking).
- **Device testing protocols** modeled after clinical standards:
  - pre-test calibration
  - pass/fail metrics
  - statistical error logging
- **Failure-mode-and-effects analysis (FMEA)** incorporated in design phases.

Electrical and Control Systems

- Color-coded wiring and medical-grade labeling standards.
- Emphasis on **noise reduction** using twisted pair lines, ferrite chokes, and shielded cables.
- High reliability connectors using medical equipment design insights.

Mechanical Engineering

- Frames optimized for stable, predictable behavior rather than aggressive maneuvering.
- Mission tools designed with **precision control**—often force-limited to avoid damaging delicate objects.

Team Workflow

- Roles clearly partitioned: operators, technicians, data analysts, QA monitors.
- Pre-mission checklists resemble surgical pre-operation safety protocols.

Mintlaw Academy – Mintlaw ROV

A team known for operator-centered design, high system integration discipline, and professional CAD workflows.

Core Engineering Values

Mintlaw emphasizes *predictability*, *responsiveness*, and *fine motor control* in their ROV systems.

Control & Piloting Systems

- **Ergonomic control stations** designed with pilot posture analysis.
- Adjustable joystick sensitivities and dead-zones.
- Depth-hold or heading-hold assistance (depending on competition class rules).

Mechanical Design

- Modular mechanical subsystems allowing rapid tool swapping.
- Grippers with multi-linkage mechanisms providing powerful yet smooth actuation.
- Strategically placed buoyancy to achieve near-neutral trim in all pitch axes.

Electrical Systems

- **Neat PCB layouts** for power distribution.
- Extensive use of waterproof connectors (Blue Robotics, SubConn, or custom potted).
- Power rails carefully separated to avoid electrical noise interfering with cameras or sensors.

Testing & Evaluation

- ROV evaluated under multiple load conditions (with and without tools).
- Performance metrics graphed over time to track improvement trends.

North Carolina School of Science and Mathematics – Leviathan

A research-grade engineering team applying university-level science.

Engineering Focus Areas

- High-end embedded systems
- Computational modeling
- Advanced sensor integration
- Strong theoretical grounding in engineering physics

Electrical and Embedded Systems

- **Custom PCBs** designed in KiCad/Altium for power, logic, and sensor buses.
- Microcontroller firmware includes:
  - PID loops
  - Kalman filters
  - Sensor fusion
  - Feedback-linearization for smoother pilot control
- Serial telemetry streams include real-time:
  - IMU data
  - Depth
  - Current draw
  - Thermal monitoring

Software Architecture

- Layered control system:
  - low-level thruster output modules
  - mid-level stability controllers
  - high-level pilot interface
- Debugging outputs sent through serial consoles or custom dashboards.

Mechanical Engineering

- SolidWorks CAD assemblies with FEA:
  - deflection testing
  - vibration analysis
  - stress distribution
- Hydrodynamic optimization using CFD to reduce drag coefficient and improve lateral stability.

North Paulding Robotics – WhaleTech

A creativity-driven team with bold mechanical experimentation.

Mechanical Architecture

- Highly unconventional frame geometries tailored to mission layouts.
- 3D-printed structural components reinforced with carbon fiber rods.
- Mission tools often driven by clever gear trains, worm drives, or magnetic couplings.

Tool Engineering

- Tools optimized not just for functionality but *task flow efficiency*.
- Rapid attachment systems for mid-mission tool swaps.
- Actuators selected for force delivery rather than speed; reliability prioritized over novelty.

Electrical Systems

- Modular wiring harnesses with quick-disconnect ports.
- Emphasis on *guided cable routing* to avoid entanglement inside dense tool clusters.
- Use of LED diagnostic indicators for each subsystem.

Team Culture

- Brainstorm-first, refine-second workflow encourages broad exploration.
- Students rotate roles to cross-train in mechanical, electrical, software, and operations.

Overflow Robotics

A meticulously organized, systems-integration-centric team.

System Reliability Focus

Overflow Robotics prioritizes:

- Fault tolerance

- Clean wiring
- Subsystem consistency
- Redundancy in high-load areas

Electrical Layout

- Power busbars, fuses, and connectors placed for optimal accessibility.
- Heat dissipation carefully planned with passive airflow and heatsinks.

Mechanical Design

- Compact frames minimize drag and increase maneuverability.
- Tools engineered with precise tolerances to avoid slippage, jamming, or misalignment.
- Thoughtful placement of components reduces turbulence in front of cameras or tools.

Operations

- Pre-mission processes include:
  - 20+ step safety checklist
  - sensor calibration
  - continuity testing
  - thruster current-draw tests

Palos Verdes High School – PVIT Fitzgerald

A professionally mentored engineering powerhouse with high production quality.

Engineering Practices

- CNC-cut aluminum frames with industry-grade finish quality.
- Detailed schematics for every subsystem, including block diagrams and flowcharts.
- Thorough troubleshooting documentation with timestamps and corrective actions.

Mechanical Systems

- Composite materials used in high-stress areas for weight reduction.
- Precisely aligned thruster mounts for clean vectoring.
- Maintainability-focused: parts designed for tool-free or low-tool removal.

Electrical Systems

- Distributed sensor network with structured wiring paths.
- Custom firmware for telemetry and operator feedback.
- High-performance image pipeline with processing enhancements for visibility.

Testing & Evaluation

- ROV measured across performance KPIs:
  - turning radius
  - vertical acceleration
  - tool cycle time
  - stability under load
  - buoyancy consistency across temperatures

Phillips Exeter Academy – MUREX

A team defined by analytical rigor, precision, and scientific methodology.

Analytical Strengths

The team conducts formal experiments for each subsystem:

- Control response curves
- Motor thrust vs PWM mapping
- Buoyancy force graphs under varying salinity
- Drag estimation via tow tests

Mechanical Engineering

- CAD-first design philosophy with full assembly simulation.
- Pressure housings engineered using stress analysis.
- Lightweight frames that maintain stiffness through intelligently placed ribs.

Electrical & Software Systems

- Clean bus architecture connecting sensors, ESCs, cameras, and telemetry.
- Advanced filtering algorithms stabilize video feeds in low visibility.
- Debug tools include logging utilities, signal analyzers, and simulation code.

Po Leung Kuk Ngan Po Ling – Aquamarine

A compact, efficiency-driven ROV design with strong internal collaboration.

Mechanical Design

- Tight, maneuverable frame suitable for missions requiring fine positional accuracy.
- Strategic float placement ensures stable trim without excessive flotation volume.

Electrical Layout

- Minimalist wiring philosophy reduces failure points.
- Electronics spaced to avoid heat concentration; passive cooling integrated.

Team Dynamics

- Collaborative decision-making with frequent cross-team integration meetings.
- Structured testing cycles: prototype → evaluate → refine → finalize.

Pui Ching Middle School – Mosasaurus

Reference: https://materovcompetition.org/2025-archive
Specialization: **Ranger Class Technical Reports, Spec Sheets, Float Documentation**

Documentation Excellence

Their reports typically include:

- Detailed dimensional drawings
- Force calculations for tools
- Buoyancy force breakdowns
- Waterproofing method tables
- Failure-mode analyses
- Wiring schematics with color-code standards

Buoyancy & Stability Engineering

- Center of Gravity vs Center of Buoyancy plotted and iterated.

- Float material properties analyzed:
  - density
  - compression rate
  - water absorption over time
- Trim adjustments tested at multiple payload configurations.

Mechanical & Electrical Integration

- Tools mounted on modular rails.
- Electronic housings pressure-tested for leaks.
- All connectors labeled and documented.

Engineering Workflow

1. Requirements Identification
2. Concept Development
3. CAD Drafting
4. Prototype Verification
5. Field Testing
6. Documentation Finalization

If you want *even more* (yes, I can go further), I can provide:

- subsystem-by-subsystem breakdowns (thrusters, buoyancy, cameras, power systems)
- psychological/team-behavior profiles
- performance prediction models
- engineering comparison matrices
- multi-page research-style documentation
- fictional competitive simulations between the teams
- extremely detailed CAD-like descriptions