Knowledge and Skills Guidelines for Oceanographic Instrumentation Technicians

Introduction

On 19-20 March 2009, a workshop was hosted by the Marine Advanced Technology Education (MATE) Center to define the occupational parameters associated with an oceanographic instrumentation technician (OIT). The workshop panel (see below) combined their individual expertise with results from a pre-workshop survey of technicians working in the marine environment (and their supervisors) to develop an occupational definition and outline the job functions and tasks for an OIT. The workshop panel also identified the knowledge, skills, and performance indicators for an OIT. Additional information collected from the panel and survey respondents included the personal characteristics, occupational titles, salary ranges, educational backgrounds, and desired course work for an OIT. An initial step in developing the knowledge and skills guidelines was defining some relevant terms related to the technology and platforms used by OITs. Commonly used sensors, instruments, platforms, tools, and related technology are included. The panel also identified the professional societies, conferences/symposiums, and professional publications that are relevant to OITs. Finally, future trends for the occupation are identified.

Workshop Participants:

Workshop Organizers: Deidre Sullivan, Shawn R. Smith, Tom Murphree, and Leslie Rosenfeld
Workshop Facilitator: Deidre Sullivan
Workshop Recorder: Jill Zande

Panel members:

Fred Bahr	CeNCOOS
Raymond Boone	National Data Buoy Center
Mark Bushnell	National Ocean Service
Lynne Butler	University of Rhode Island
Chip Haldeman	Rutgers University
Kevin Hart	Naval Oceanographic Office
Steven Hartz	University of Alaska
Cheryl Hickey	National Data Buoy Center
Mike Kelley	Monterey Bay Aquarium Research Institute
Erich Rienecker	Monterey Bay Aquarium Research Institute
Leslie Rosenfeld	Naval Postgraduate School
Shawn Smith	Florida State University
Jan van Smirren	Fugro GEOS
Phil White	NOAA Marine and Aviation Operations

Occupational Definition:

Oceanographic instrumentation technicians are responsible for the collection of oceanic and marine atmospheric observations. They collect reliable, quality data using in-situ ocean observing instrumentation to meet user needs for government, industry, academia, and the public.

Overview of the Oceanographic Instrumentation Technician

Oceanographic instrumentation technicians make possible the collection of data from the sea. The ocean is a harsh environment, and deploying and maintaining equipment there requires skilled and dedicated professionals. These individuals must be able to interface instrumentation to a wide variety of platforms including ships, moorings, drifters, autonomous underwater vehicles, etc. In many organizations, these technicians are responsible for all aspects of data collection and management, from the deployment of the instrument to the delivery of documented data to the end user. In many applications, the data is required in near real-time, so OITs may be responsible for operating data communications equipment as well. Overall, these technicians provide onshore and offshore laboratory, field, and technical support for in-situ marine instrumentation and data derived from those instruments.

Personal Characteristics of an Oceanographic Instrumentation Technician

An OIT tends to be a "jack of all trades". Often, OITs must function as their own boss, or as a one-man department, yet they also need to be able to work in a team. Successful OITs have the following characteristics:

- Ability to multitask
- Ability to work in high stress, sleep-deprived environment
- Ability to get along with others
- Ability to maintain focus
- Ability to learn from mistakes
- Willingness to seek technical advice from diverse sources
- Willingness to travel, fly, and be away from home for extended periods
- Pride in job
- Passion for the job
- Commitment to excellence in data acquisition (care about data)
- Mechanical aptitude
- Patience
- Flexibility
- Creativity
- Adaptability
- Good sense of humor

Good OITs are also:

- Organized
- Assertive
- Self-motivated

- Proactive
- Diplomatic
- Good listeners
- Physically fit
- Quick learners

Occupational Titles

Based on the workshop and survey results, the following titles are currently in use for the occupation we define here as an Oceanographic Instrumentation Technician.

- Electronics Equipment Specialist
- Engineer (oceanographic and others)
- IT Specialist
- Oceanographer
- Physical Scientist
- Electronics Technician
- Field Technician/Researcher/Service Lead
- Marine Technician
- Mooring Technician
- Oceanographic Technician
- Offshore Technician
- Physical Science Technician
- Research Technician
- Ship Technician
- Survey Technician

Salary Range

Entry level Oceanographic Instrumentation Technicians, with Associates degree and 0-5 years experience, will earn ~ $27,000 - $50,000 per year. Additional education will add to this base salary (+$5,000 - $10,000 for a Bachelors degree, +$10,000-$15,000 for a Masters degree). Salary for a senior technician (more than 15 years experience) ranges from $60,000 - $100,000.

Educational Background

Persons entering into the occupation of an Oceanographic Instrumentation Technician can have a wide range of educational experience. Common educational backgrounds include:

Associates (2-year) degree

- Computer technology
- Electronics
- Instrumentation
- Marine science
- Marine technology

Bachelors (4-year) degree

- Computer science

- Electrical engineering
- Marine science
- Marine technology
- Mechanical engineering
- Ocean engineering
- Oceanography
- Physical / earth sciences

Masters degree

- Applied ocean science
- Computer science
- Engineering (all types)
- Hydrography
- Marine science
- Meteorology
- Ocean observing systems
- Oceanography (physical or other)
- Operational oceanography
- Physics

Basic Courses Desired

- Algebra
- Chemistry
- Communication systems
- Computer networking
- Computer programming
- Data analysis
- Data loggers and sensor integration
- Electrical engineering
- Electronics (2 courses minimum)
- Fabrication
- First aid
- Mechanics
- Meteorology
- Oceanographic instrumentation / sensors
- Oceanography
- Photo documentation
- Physics
- Project management
- Public speaking
- Scientific / working diving
- Seamanship / navigation
- Statistics
- Technical writing

- Trigonometry
- Web programming

Internships related to any of the above fields of study and/or basic course options are very beneficial for persons interested in working as an OIT.

Definitions:

The following terms are defined and used throughout this guide.

Components – instruments, positioning systems, data loggers, communications equipment, power supplies, ancillary cables, mounting hardware, etc.
Platform – physical structure on which components are deployed in field (e.g., ship, mooring, etc.)
System – Components plus deployment platform
Instrument – a sensor or collection of sensors
Sensor – technology that measures a desired parameter
Users/Customers - Persons who have commissioned / caused the data to be collected and to whom the data are to be delivered.

Components Typically Operated and Maintained by Oceanographic Instrumentation Technicians

- Environmental sensors and instruments
  - CTD/XBT/Thermosalinograph/Other CT sensors
  - Current profilers and meters (all types)
  - Standard meteorological sensors (humidity, air temperature, pressure, wind)
  - Other meteorological sensors (precipitation, lightning, CO2, cloud height or ceiling, visibility)
  - Inherent optical sensors (transmissometer, fluorometer, attenuation meter, etc.)
  - Apparent optical sensors (atmospheric radiation, PAR, radiance/irradiance sensor)
  - Water level
  - Dissolved gas (oxygen, CO2, freon)
  - Acoustic (sonar, echosounder, altimeter, sub-bottom profiler)
  - Pressure (ocean)
  - Wave sensors
  - Gravity meter
  - Magnetometer
  - Radioactivity
  - Biological sampling (video plankton recorders, UBAT)
- Position and orientation
  - GPS (e.g., DGPS, WAAS, GCGPS, RTK)
  - Compass (magnetic, gyro)
  - Chart plotters/Navigational software
  - Inertial Navigation (e.g., POS-MV)
  - Pitch/roll/heave
  - Doppler velocity log

    - Acoustic positioning system (pingers, USBL, transponders, etc.)
    - AIS (ship positioning, transponder)
    - Location finders (e.g., Radio direction finder, ARGOS beacon, IALA (visual))
- Data loggers/acquisition systems
    - COTS (commercial off the shelf) or custom design
    - Stand alone vs. networked
    - Integrated marine management systems
- Telemetry (communications)
    - Acoustic modem
    - RF (subsea, line of sight)
    - Cable (fiberoptic, copper, wave guide)
    - Infrared
    - Satellite (lower earth orbit [ARGOS, IRIDIUM], geostationary earth orbit [INMARSAT,VSAT,GOES])
    - Cell phone
    - Microwave
    - Inductive modem
- Power
    - Solar
    - Battery (primary and secondary)
    - Generator
    - Wind turbine
    - Kinetic
    - Inverter and rectifier (AC/DC)
    - UPS
- Cables/connectors
    - Wet pluggable
    - Underwater splices
- Associated equipment
    - Mounting brackets, etc.
    - Shackles, chain, wire rope (rigging)

Common Platforms

- Ships and boats (including packages lowered or towed from them)
- Moorings (surface buoys, subsurface moorings, and bottom mount platforms such as tripods)
- Surface drifters
- Profiling floats
- Autonomous / Unmanned Underwater Vehicles (AUVs/UUVs) including gliders
- Remotely operated vehicles
- Submarines/submersibles
- Offshore structures
- Fixed coastal sites (lighthouses, docks, piers etc.)
- Cabled observatories
- Aircraft

Tools Typically Used by Oceanographic Instrumentation Technicians

- Multimeter and oscilloscope
- Spectrum analyzer
- Fox and hound
- Network tools
- Serial communication
- Termination and cable crimping tools (e.g. RJ45)
- Solder station
- Hand tools
- Power tools
- Welding equipment

Professional Societies Relevant to Oceanographic Instrumentation Technicians

- American Geophysical Union (AGU)
- American Meteorological Society (AMS)
- IEEE (previously known as the Institute of Electrical and Electronics Engineers)
- Marine Technology Society (MTS)
- Society for Underwater Technology (SUT)
- The Oceanography Society (TOS)

Relevant Conferences for Oceanographic Instrumentation Technicians

- Buoy Workshop (MTS)
- Current measurement technology (IEEE)
- International Marine Technicians (INMARTECH) Symposium
- Ocean Optics
- Ocean Sciences (AGU/ASLO/TOS)
- Oceans (MTS/IEEE)
- Offshore Technology Conference
- Underwater Interventions
- Workboat Show

Important Publications for Oceanographic Instrumentation Technicians

- Bulletin of the American Meteorological Society (AMS)
- Journal of Oceanic and Atmospheric Technology (AMS)
- Marine Technology Reporter
- Ocean News and Technology
- Sea Technology
- Technical Reports (e.g., those produced by the Alliance for Coastal Technology)
- Vendor newsletters

Future Trends Likely to Affect Oceanographic Instrumentation Technicians

- Experienced workers aging out of the system
- Higher data rates and larger data volume
- Higher personnel turnover rates
- Increase in real-time data delivery
- Increase in international interaction
- Increasingly complex systems
- More autonomous platforms deployed with increasing numbers of instruments
- More computerized automation
- More data management requirements (standardization)
- More remotely controlled systems
- More technicians will be needed (numbers depend on funding)
- Technicians will need to be more versatile
- Technicians will need to be more interdisciplinary
- Technicians will need to deal with research to operations issue
- Technicians will need to function on a higher level
- Technicians will need to more frequently learn new technologies

Knowledge and Skill Overview Chart for Oceanographic Instrumentation Technicians

Job Function	**Task Areas**									
A. Apply environmental, safety, quality, and technical standards (e.g., ISO)	A1 Properly handle hazardous materials	A2 Understand and comply with established safety regulations	A3 Comply with technical and quality procedures							
B. Communicate effectively (oral and written)	B1 Produce technical and standard operating procedures (SOP)	B2 Present results	B3 Coordinate with personnel (including ship's crew)	B4 Relate problems in timely fashion	B5 Mentor less experienced personnel	B6 Interact with vendors or suppliers	B7 Maintain good customer relations			
C. Prepare for deployment	C1 Understand observational requirements	C2 Obtain permits	C3 Identify instrument requirements and select instruments	C4 Procure instruments	C5 Verify calibrations or calibrate sensors	C6 Instrument (hardware and software) setup and implementation of modifications	C7 Conduct end user acceptance test (FAT)	C8 Package and ship instruments	C9 Coordinate logistics (e.g., travel)	C10 Maintain records
D. Integrate components with platform	D1 Test instruments on site	D2 Install instruments on platform	D3 Test system end-to-end or conduct site acceptance test (SAT)							
E. Deploy and recover system	E1 Develop a deployment and recovery plan	E2 Locate site	E3 Communicate plan	E4 Implement plan	E5 Verify system operation and position	E6 Conduct post-recovery inspection and documentation				

F. Operate, monitor, maintain, and trouble-shoot system	F1 Monitor instrument performance	F2 Clean instruments	F3 Identify failures	F4 Make repairs	F5 Document actions					
G. Manage and quality control data	G1 Retrieve data	G2 Back-up data files	G3 Convert raw data to end user units	G4 Visualize and scrutinize raw data	G5 Flag or edit data	G6 Transfer data and metadata				
H. Manage and maintain computers and networks	H1 Use software programs	H2 Perform system administration	H3 Perform scripting or programming	H4 Operate computer hardware						

Function A: Apply environmental, safety, quality, and technical standards (e.g. ISO)

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What oceanographic instrumentation technicians need to know and/or be able to do in order to perform this task well.
A1. Properly handle hazardous materials	• All agency rules are complied with • No incident reports • MSDS sheets are readily available • Materials are properly stored, per regulations • Materials are properly inventoried, per regulations • Appropriate containment procedures are in effect • Safety protocol is in place • Spills are cleaned up quickly and properly • All required documentation is completed	• Ability to read MSDS sheets • Knowledge of, and ability to, apply appropriate state, federal, institutional, and international regulations, such as DOT, OSHA, and IAT • Ability to respond to accidents • Knowledge of basic chemistry and hazardous materials • Knowledge of basic radioisotope safety, such as lab procedures and isolation
A2. Understand and comply with established safety regulations	• Accidents and workers' compensation claims are minimized • Safety procedures are in place and implemented • All persons are familiar with safety procedures • Safety briefings are well-documented • All required documentation is completed	• Knowledge of first aid, CPR • Seamanship/rigging skills • Situational awareness • Survival skills • Ability to make decisions quickly and effectively • Ability to conduct job safety analysis and briefings
A3. Comply with technical and quality procedures	• Complete and well-written reports are on hand when requested • Required reports and documentation are completed on time • Corrective actions are minimized	• Ability to communicate clearly, both orally and in writing • Knowledge of technical terms • Ability to meet deadlines

Function B: Communicate effectively (oral and written)

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What oceanographic instrumentation technicians need to know and/or be able to do in order to perform this task well.
B1: Produce technical and standard operating procedures (SOP)	• SOPs are in place and implemented • Equipment damage and loss is minimized • Personnel injury is minimized	• Ability to write in technical style • Knowledge of operating procedures • Knowledge of appropriate technical terms
B2: Present results	• Audience understands information presented	• Ability to effectively communicate to an audience • In-depth knowledge of the subject
B3: Coordinate with personnel (including ship's crew)	• Briefings accomplish objectives • Miscommunications are minimal • Hand signals are used properly • Debriefings provide good, positive feedback • Mission is successful	• Ability to conduct a briefing/debriefing (e.g., communicate mission and clarify terminology) • Knowledge of chain of command • Ability to use hand signals • Knowledge of platform procedures • Knowledge and ability to use wireless communications (radio)
B4: Relate problems in timely fashion	• Hazards are immediately reported	• Ability to make decisions quickly and effectively • Knowledge of chain of command • Ability to use hand signals • Knowledge and ability to use wireless communications (radio)
B5: Mentor less experienced personnel	• Trainees perform tasks correctly and efficiently • Trainees perform operations properly, with minimal assistance and oversight • Data and equipment integrity are maintained	• Knowledge of training procedures • Ability to assess trainees' skills • Ability to communicate clearly, both orally and in writing • Ability to maintain data and equipment in good condition
B6: Interact with vendors or suppliers	• Systems (hardware, software, firmware, and documentation) are current • System performance is optimized • Rapport is established and maintained • Vendor makes contact to provide updates on existing products and information about new products	• Organizational skills to keep track of updates • Interpersonal communication • Ability to conduct market research • Ability to keep abreast of current and emerging technologies

B7: Maintain good customer relations	• Customer is satisfied • Customer objective is completed • Information is recorded accurately and legibly • Logs and other records are current, correct, and well-documented	• Ability to communicate clearly, both orally and in writing • Ability to solve problems • Good customer relation skills

Function C: Prepare for deployment

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What oceanographic instrumentation technicians need to know and/or be able to do in order to perform this task well.
C1. Understand observational requirements	• Project plan developed and accepted	• Understanding of the project environment • Familiarity with instrument capabilities and limitations • Understanding of platform capabilities and limitations • Understanding of financial constraints • Knowledge of the scientific method
C2. Obtain permits	• Proper permit(s) obtained	• Knowledge of regulations • Knowledge of regulating authorities
C3. Identify instrument requirements and select instruments	• Proper instrument is identified and selected • Proper instrument options / configuration are specified	• Familiarity with instrument capabilities and limitations • Understanding of platform capabilities and limitations • Understanding of financial constraints • Ability to read and comprehend technical specifications • Knowledge of galvanic properties
C4. Procure instruments	• Proper instrument arrives in a timely fashion • Equipment works properly • Adequate equipment and supplies are on hand • Equipment and supplies are ordered in a timely manner • Proper inventory of equipment and supplies is maintained	• Ability to maintain an inventory of equipment and supplies • Knowledge of inventory systems • Knowledge of equipment consumption rates • Ability to locate and contact vendors and manufacturers • Knowledge of purchasing procedures • Ability to use the Internet, web browsers, and search engines • Written, oral, customer relations, and communication skills
C5. Verify calibrations or calibrate sensors	• Equipment/instrumentation functions within manufacturer's specifications • Equipment/instrumentation complies with current calibration standards • Calibration records are complete, current, and documented • Log book is current	• Familiarity with calibration procedures and standards • Ability to apply calibration according to manufacturer specifications • Ability to perform field calibrations • Maintain calibration records • Computer skills • Basic understanding of scientific notation

		• Knowledge of and ability to apply mathematical skills, including statistics, algebra, and geometry • Knowledge of sensor operation • Ability to communicate clearly, both orally and in writing
C6. Instrument (hardware and software) setup and implementation of modifications	• Instrument performs as planned	• Knowledge of electronic and mechanical test equipment • Ability to troubleshoot systems • Ability to use computer diagnostics • Ability to read schematics and mechanical drawings • Time management skills • Ability to use vendor and other supplied software • Ability to write software (an advanced skill) • Computer skills
C7. Conduct end user acceptance test (known as Factory Acceptance Test, FAT)	• End user satisfied that instrument is within specifications	• Knowledge of electronic and mechanical test equipment • Ability to troubleshoot instruments • Ability to use computer diagnostics • Ability to perform relevant computer, electronic, and mechanical repairs on equipment • Ability to communicate clearly, both orally and in writing • Maintain calibration records
C8. Package and ship instruments	• Instruments arrive on time and in working condition at anticipated cost	• Ability to pack, secure, and ship equipment/instrumentation • Knowledge of shipping procedures and time lines • Ability to operate a forklift • Knowledge of domestic and foreign customs regulations • Knowledge of export restrictions (e.g., ITAR, CCL) • Knowledge of hazmat and other shipping regulations
C9. Coordinate logistics (travel)	• All personnel arrives at intended destination on time and within budget • Travel documents obtained • Necessary immunizations and medications obtained	• Knowledge of organizational procedures and timelines • Knowledge of local customs and regulations • Ability to obtain necessary documents
C10. Maintain records	• Records are current • Information is recorded accurately and legibly • Logs are current, correct, and well-documented	• Knowledge and ability to perform record keeping • Knowledge of logs (e.g., maintenance, inventory, finance, customer, event)

Function D: Integrate components with platform

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What oceanographic instrumentation technicians need to know and/or be able to do in order to perform this task well.
D1. Test instruments on site	• Instrument performs as planned • Equipment/instrumentation functions within manufacturer's specifications under field conditions • Equipment/instrumentation complies with current calibration standards • Calibration records are complete, current, and documented • Log book is current	• Familiarity with calibration procedures and standards • Knowledge of electronic and mechanical test equipment • Computer skills • Mechanical aptitude and dexterity • Ability to communicate clearly, both orally and in writing
D2. Install instruments on platform	• Instrument and related components are appropriately positioned and properly secured • Mounting systems meet the observational and environmental requirements • Mounting system works • Proper materials are used • Operation of components meets observational requirements. • Components meets applicable standards. • Log book is filled out.	• Ability to design and fabricate mounting hardware (advanced skill) • Knowledge of proper materials to use • Knowledge of basic wiring – what equipment draws and how to get power to it • Ability to interface components • Ability to secure equipment safely • Ability to locate and comply with relevant standards, policies, applicable laws, and regulations • Ability to read schematics and mechanical drawings • Ability to obtain SCUBA dive certification • Ability to safely work at height, in confined spaces, and in other adverse conditions to secure components • Knowledge of platform layout and capabilities • Ability to operate crane • Mechanical aptitude and dexterity
D3. Test system end-to-end / conduct site acceptance test (SAT)	• System performs as planned • System functions within manufacturer's specifications under field conditions • Log books and documentation are complete	• Knowledge of electronic and mechanical test equipment • Ability to troubleshoot systems • Ability to use computer diagnostics • Ability to perform relevant computer, electronic, and mechanical repairs on the system • Computer skills • Mechanical aptitude and dexterity • Ability to communicate clearly, both orally and in writing

Function E: Deploy and recover system

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What oceanographic instrumentation technicians need to know and/or be able to do in order to perform this task well.
E1. Develop a deployment and recovery plan	• SOPs and safety considerations incorporated • Plan is executable with available personnel • Contingency plans are included	• Knowledge of rigging equipment (e.g., shackles, eyes, snatch blocks, bridles, slings) • Knowledge of salvage equipment • Knowledge of trigonometry • Knowledge of physics • Knowledge of ship's procedures • Knowledge of chain of command • Knowledge of safety procedures
E2. Locate site	• Site meets mission and permit requirements	• Knowledge of navigation systems • Knowledge of trigonometry (visual sighting) • Ability to communicate with ship's crew • Knowledge of surveying • Knowledge of environmental conditions • Knowledge of platform limitations • Ability to come up with contingency plan on short notice
E3. Communicate plan	• Team goals are accomplished • Mission is successful • Communications are clear and concise • Scientists are well-informed as to the capabilities and limitations of the platform • All parties are informed of plan of action, time line, and individual roles • Platform operator has been briefed on scientific mission	• Ability to communicate clearly, both orally and in writing • Ability to conduct briefings • Ability to solve problems • Knowledge of chain of command • Knowledge of platform procedures • Ability to use hand signals • Ability to focus on team goals • Ability to get along with fellow team members
E4. Implement plan	• Knots, gear, and rigging equipment are used properly • Rigging is accomplished safely, correctly, and in a timely manner • Items are moved or secured safely and without damage • Hand signals are used properly • Personal floatation devices and safety gear are used properly • Environmental concerns are addressed adequately	• Knowledge of rigging equipment (e.g., shackles, eyes, snatch blocks, bridles, slings) • Knowledge of salvage equipment • Knowledge of trigonometry • Knowledge of physics • Ability to operate launch and recovery equipment (e.g., pelican hooks, happy hooker ring) • Ability to operate winches, cranes, and frames safely • Ability to operate a forklift • Knowledge of seamanship, rigging, knot tying

	• Overhead loads and other hazards are assessed properly	• Ability to use of hand signals • Understanding of, and ability to, apply safety protocols • Ability to recognize unsafe conditions and react swiftly and appropriately • Ability to operate small boats
E5. Verify system operation and position	• System in position and data coming through (if applicable)	• Knowledge of navigation systems • Computer/software skills • Knowledge of system communication protocols (e.g., satellite telemetry, RF, cabled, etc.)
E6. Conduct post-recovery inspection and documentation	• Component condition properly assessed and noted • Mission completed successfully • Documentation completed	• Ability to operate photo and video documentation equipment • Knowledge and ability to perform record keeping

Function F: Operate, monitor, maintain, and troubleshoot system

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What oceanographic instrumentation technicians need to know and/or be able to do in order to perform this task well.
F1. Monitor instrument performance	• Problems are identified in a timely manner • Results are within expected limits • Data is validated (e.g. inter-comparison between sensors)	• Ability to communicate clearly, both orally and in writing • Computer/software skills • Knowledge of system and environment • Data visualization and analysis skills
F2. Clean instruments	• Scheduled cleaning is performed • Environmental regulations are followed • Data quality is maintained • Sensor meets or exceeds expected life span	• Ability to delegate • Knowledge of hazardous materials regulations • Knowledge of appropriate materials and methods
F3. Identify failures	• Correct test equipment is chosen for each task • Test equipment is used properly to accomplish required task(s) • Tests are conducted in a safe manner • Test and measurement data are used to troubleshoot and resolve problems successfully	• Knowledge of, and ability to, use electronic and mechanical test equipment (e.g., oscilloscope, megohmeter, multimeter) • Ability to determine proper equipment for test • Ability to troubleshoot systems • Ability to use computer diagnostics software • Ability to inspect components (e.g., for corrosion, wear, damage) • Knowledge of system and environment • Data visualization and analysis skills • Ability to make and use flow charts • Ability to read schematics and mechanical drawings • Computer/software skills
F4. Make repairs	• Relevant repairs are coordinated with manufacturer • Repairs are completed safely (lockout, tagout), correctly, and in a timely manner • System demonstrates increased reliability • Equipment is returned to working condition • Logs are current	• Ability to perform relevant computer, electronic, and mechanical repairs on equipment • Ability to replace parts to board level • Knowledge of basic electronics • Ability to solder • Ability to take apart and rebuild instruments • Knowledge of safety (lockout, tagout) procedures • Ability to read schematics and mechanical drawing • Time management skills
F5. Document actions	• Problem and solution clearly documented, disseminated, and filed	• Ability to communicate clearly, both orally and with technical writing

Function G: Manage and quality control data

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What oceanographic instrumentation technicians need to know and/or be able to do in order to perform this task well.
G1. Retrieve data	• Data recovered from instruments successfully • Files are properly named • Documentation is completed	• Ability to operate vendor or other software • Ability to interface equipment • Ability to operate telemetry equipment
G2. Back-up data files	• Data stored on appropriate media with sufficient copies to meet observational requirements • All data arrive at "home base" in good order	• Computer skills
G3. Convert raw data to end user units	• Data is converted properly	• Computer skills • Ability to operate vendor or other software • Ability to apply computer scripting • Knowledge of software programming
G4. Visualize and scrutinize raw data	• Plots created are clear and well documented (e.g., axes are labeled, correct units are used). • Potential problems are correctly identified • Anomalies are properly identified • Interesting physical features are correctly identified	• See G3 • Understanding of visualizations • Knowledge of environment (e.g., oceanography, meteorology, chemistry, physics) • Understanding of instrument performance in environment
G5. Flag or edit data	• Suspect data are flagged correctly • Invalid data are properly rejected • Anomalous data are properly documented • Data quality objectives meet observational requirements	• See G4
G6. Transfer data and metadata	• Data distribution requirements are met in a timely manner • Metadata allows data discovery • Data are transferred to archive as per observational requirements • Documentation of data transmittal is accurate and complete	• Computer skills • Ability to post data and/or metadata to appropriate electronic for a (e.g. the web, data servers)

Function H: Manage and maintain computers and networks

TASK	Performance Indicators How do we know when the task is performed well?	Technical Knowledge and Skills What oceanographic instrumentation technicians need to know and/or be able to do in order to perform this task well.
H1. Use software programs	• Appropriate software is selected for each task • Desired end product is efficiently created	• Ability to use relevant software (e.g., Matlab, SQL [databases], Microsoft Office, GIS, CAD, Lab-view, VNC, Ocean data viewer) • Ability to learn new software
H2. Perform system administration	• System functions within specifications • System operates with high reliability • Maintenance is performed on schedule • Log books are current and legible • Multiple systems are interfaced successfully • Scientific data are recorded, backed up, and made accessible • Customers are satisfied	• Knowledge of, and ability to, install and maintain operating systems (Windows, LINUX, MacOS), software, hardware, and networks • Knowledge of, and ability to, troubleshoot/repair operating systems, software, hardware, and networks • Ability to write clear, concise log entries • Knowledge of incremental back-up techniques • Knowledge of storage media (e.g., DVD) • Knowledge of computer security • Ability to use TCP/IP, UDP, etc. • Understanding of file structures and permissions
H3. Perform scripting or programming	• Program performs planned tasks • Program is well documented • Source code is provided	• Knowledge of scripting languages, such as JavaScript, PHP, • Knowledge of programming languages, such as Java, C, Matlab, PERL • Knowledge of web languages., such as HTML, XML • Ability to document program/source code in clear, concise language • Knowledge of version control
H4. Operate computer hardware	• Operates correctly • Uninterrupted operation • Instruments properly interfaced to computer	• Ability to install components • Knowledge of interface ports • Knowledge of power budgets and UPS's • Knowledge of basic electronics