Battelle, Pacific Northwest Division, Management & Operating Contractor of the U.S. Department of Energy’s Pacific Northwest National Laboratory (PNNL), requires two (2) High-Throughput Automation Systems. This equipment is anticipated to accelerate R&D on multiple battery chemistries, including aqueous and non-aqueous systems.

The systems must be capable of multiple workflows, necessitating a variety of deck elements. Such workflows shall achieve the following experiments at a minimum: 1.) preparing mixtures for the solubility determination of organic and inorganic materials ranging from mM to M concentrations in both aqueous and non-aqueous mixtures, 2.) preparation of multi-component electrolyte solutions (aqueous and non-aqueous) and slurry mixtures, 3.) automated synthesis procedures for organic and inorganic materials. The system shall be capable of interfacing with third party instruments. The system shall be flexible, and capable of modification of the functions and deck elements for future changes in research needs. The two systems, referred to as System A (a system for predominately aqueous work) and System B (a system for exclusively non-aqueous work) shall deviate as described in Sections 1.9, 1.10, 1.14 and 1.15.

1. **Instrument Specification**

1.1 Both systems shall be capable of gravimetric dispensing of solids and liquids, with a lower range of at least 5 mg or less and up to or greater than 20 g.

1.1.1 Gravimetric dispensing must allow for a many-to-many function, with at least 24 hoppers to be utilized by the robot at once.

1.1.2 Gravimetric dispensing must be capable for both single vial additions as well as full plate additions.

1.2 Both systems shall be capable of volumetric dispensing of liquids and solvents, with a lower range of at least 50 µL or less and up to or greater than 25 mL.

1.2.1 Volumetric dispensing must provide an option for the use of disposable positive displacement tips. (ranging from at least 10 µL to up to 10 mL).

1.2.2 Volumetric dispensing must provide an option for syringe aspirated liquid additions from on-deck sources.

1.2.3 Volumetric dispensing must provide an option for syringe aspirated liquid additions from off-deck sources.

1.3 Both systems shall be capable of multiple options for sample agitation, including vortex mixing, magnetic stirring, and mechanical stirring to accommodate flexibility in sample mixing approaches.

1.4 Both systems shall be capable of performing capping/decapping or crimping/decrimping functions.
1.5 Both systems shall be capable of heating and cooling samples between a range of at least −10 °C or less and up to or greater than +100 °C.

1.6 Both systems shall be capable of performing heating/cooling functions concurrent with sample agitation, as described above.

1.7 Both systems shall be capable of handling highly viscous liquids, as well as thick slurries containing undissolved material and performing filtration of these slurries.

1.8 Both systems shall be capable of performing sample filtrations under positive pressure to avoid evaporation issues which occur with vacuum filtration. For solubility studies a saturated solution with undissolved material will require filtration: filtered sample volumes should be at least 0.25 mL, or whatever volume is necessary for subsequent volumetric removal of 0.05-0.2 mL of the resultant filtrate from the receiving vessel using the system’s liquid transfer apparatus.

1.9 System A shall be capable of performing synthetic reactions under a variety of conditions and allowing both parallel synthesis and screening of reaction conditions. Available reaction vessel volumes shall range from at least 10 mL or less and up to or greater than 100 mL. System A shall be capable of heating and cooling reaction mixtures between a range of at least −20 °C or less and up to or greater than +200 °C under an inert atmosphere established within the reaction vessel(s) and capable of reflux, and with available procedures such as reaction sampling, filtration and solvent evaporation.

1.10 System B shall be capable of homogenizing small volumes (<50 mL and as low as 10 mL) of viscous electrode slurry mixtures with viscosities of up to 6000 cP. System shall be capable of performing at least 4 slurry preparations concurrently (or number of vessels contained in a module to occupy a single section of deck space). The system shall be capable of providing a cooling/heating function for each vessel to maintain the temperature of the slurry between a range of at least −10 °C or less and up to or greater than +200 °C.

1.11 Both systems shall be capable of removing aliquots from sample vials and transferring to other samples vials, as well as performing dilution of the sample aliquot.

1.11.1 Sample transferring must be able to be done with the use of a piercing tip as well as provide a capping/uncapping option.

1.12 Both systems shall be able to store sample vials for multiple day periods, and then resume manipulations on the samples.

1.13 Space on the system that is not occupied by elements/reactors/features necessary for the above functions shall serve as sample storage space.

1.14 System A shall be capable of performing manipulations within a housing that may be closed and that can variably be filled with ambient atmosphere or can be purged with nitrogen from a “house nitrogen” supply to perform chemistry with moderate oxygen sensitivity. This housing shall keep the system readily accessible to the user. Housing unit shall have the appropriate plumbing to be connected to a laboratory ventilation system.

1.15 System B shall be contained within a stainless steel, closed-loop recirculating glovebox to be used under an argon atmosphere, capable of <1 ppm of oxygen and water, with at least 4 gloveports and industry standard antechambers for transfer into/out of the glovebox. Glovebox will possess at least 1 linear meter of space that is not occupied by the automation.
system to allow for manual manipulations and storage. Glovebox will be supplied with all standard equipment from the manufacturer needed for operation, including all oxygen/water/pressure sensors, touch screen display, lighting system, shelving, recirculating blower, catalyst, and pressure control systems.

1.16 Both systems must have user friendly software that allows for flexibility in robotic workflow design and data storage.

1.16.1 The Offeror shall provide 4 computers with the systems. Two instrument control computers with the ability to have an instrument specific VLAN. One virtual database computer for data storage and experimental designs. One server computer that allows for multiple users to log on simultaneously and act as a go-between between the instruments and the database.

1.16.2 Unique experimental designs must be stored on a searchable database to allow for sample tracking.

1.16.3 Workflows for the instruments must be customizable by the operator.

1.16.4 Data collected from the instruments and third party instruments must be stored on a searchable database.

1.17 Offer shall provide a sufficient “Starter Kit” of consumables to contain: 500 of each various sized disposable vials and caps, 25 of each various sized re-usable vials (if re-usable option is available), 25 total racks of the various sized pipette tips, and 3 of each of the variously sized vial array holders.