

## Lithium Upgrade Chat-GPT

Good morning, Stephan. I have a project for you. I would like to perform a Lithium Battery upgrade for Turtle. I need you to research the most up-to-date information on parts and systems. Start with sources like our web page (<https://mvturtle.net>) and Panbo (<https://panbo.com>). Don't limit yourself to those, but use trustworthy sources as manufacturer sites and forums are often wrong. The current system is three Whisper Power 200 Ah AGM batteries (40290063) for the house bank (12v) , a 200Ah AGM start bank (12v), two 200 Ah AGMs in 24v configuration for the stern thruster, and two 200Ah AGM (24v) for the bow thruster and widnlass. The 12v charger/inverter is a Magnum MS2812 2800W, with the BMK (Battery Monitoring Kit). The 24V charger is a 2430p that runs off the inverter. There are three 145W solar panels with a single Tracer MPPT charge controller.

The primary goal of the upgrade is to double or triple the useable amp hours, so we only need to run the generator at most once per day. Also, the banks should charge up while we are under way without needing to run the generator. Another primary goal is to keep the system as simple and reliable as possible. The third primary goal is to control costs. While these upgrades can be expensive, I don't want to waste money on nice-to-haves.

Some Nice-to-haves: 1. Better integration between shore power, generator, and solar charging. Right now the system is "passive" using DC voltage and combiners. 2. Replace the 24v charger that runs off AC power with DC-to-DC converters. This may be a challenge because the wire run from the lazarette, where the house bank is to the 24v bank in the bow is almost 40'. 3) Add monitoring to all of the banks, not just the house bank. 4) Potentially solve my ELCI nuisance tripping problem (See the Turtle web page).

Please produce a comprehensive plan for the upgrade.

The report should include.

1. A summary of the current state of marine lithium systems based on up-to-date sources.
2. A Recommended bill of materials including batteries (I like the Epoch 460, but am open to other brands. See the review here: <https://panbo.com/the-ultimate-lifepo4-battery-epochs-460ah-powerhouse/>), a battery management system (BMS), engine alternator, battery charger/inverter (I am partial to the Victron MultiPlus V1, but am open to others), charge controller (partial to Cerbo but open to others), battery monitor,

DC-to-DC converters, and anything else I might need. Note the need for nuance here. Some batteries have built in BMSs and not all systems will require a central controller. Also, where possible, we should continue to use existing equipment, though I suspect the charger/inverter and alternator will need to change and we will need a BMS.

3. How the system meets the three primary priorities.
4. How the lithium system is integrated with the lead-acid starter, thruster, and windlass banks (these should probably stay AGM, but open to suggestions here).
5. Trustworthy and experienced Installers in the Puget Sound region. Lithium systems are relatively new, but I know places like emerald Harbor Marine have a lot of experience.
6. Anything else I may have missed.

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## Upgrading to a Marine Lithium Battery System: Best Practices and Recommendations

### Current State of Marine Lithium Systems & Best Practices

Modern **marine lithium battery systems** (almost always LiFePO<sub>4</sub> chemistry) are increasingly popular for their higher usable capacity, lighter weight, and longer lifespan compared to lead-acid batteries . Many boat owners (sailors, trawler owners, etc.) have successfully retrofitted lithium house banks and report significant improvements in energy storage and charging efficiency. However, a lithium upgrade must be approached as a **whole-system project**, not just a battery swap . In 2022, the ABYC released standard **E-13** specifically for lithium-ion battery installations on boats, which outlines key safety and design requirements. Some **best practices** from E-13 and experienced installers include:

- **Use Only Tested Batteries with BMS:** Ensure the lithium batteries (or cells) comply with reputable safety standards (e.g. UL 1642 or UL 1973) and have a built-in or external **Battery Management System (BMS)**. A BMS is mandatory for lithium banks – it monitors cell voltages, temperatures, and currents, and will disconnect the battery to prevent unsafe conditions (overcharge, over-discharge, etc.) . Drop-in lithium batteries have internal BMSs, which is fine, but **plan for the BMS's actions**. The system should be designed so that a BMS disconnect (which should only occur in fault conditions) doesn't damage other equipment or leave you stranded . For example, alternators should not be allowed to **run into a dead bank** if a BMS disconnects – we'll address how to handle this below. Also, a BMS

disconnect is *not* a substitute for a manual battery switch; you still need a traditional disconnect switch on each bank for emergency use .

- **Define Safe Operating Limits:** Configure all charging sources (shore charger, alternator regulator, solar controller) to appropriate lithium settings so they **stay within the battery's safe operating envelope** (voltage, current, temperature) as specified by the manufacturer . Unlike lead-acid, lithium doesn't need trickle float charging and can be charged faster, but you must **not exceed the recommended bulk/absorption voltage** (typically around 14.2V–14.6V for LiFePO<sub>4</sub> 12V batteries) or the max charge current. Most lithium batteries prefer a **"bulk then float" charging regimen** with no long-term float – essentially charge to ~100% then stop or hold a lower float (~13.5V) to avoid overcharging. Adhering to the battery manufacturer's charge profile is important for both safety and to **preserve warranty** .

- **Build Redundancy and Monitoring:** Because lithium banks rely on electronic management, it's wise to have some redundancy. Many experts recommend using at least **two lithium batteries in parallel** for a house bank so that if one battery's BMS disconnects, the other battery can carry the load . Careful battery monitoring is also essential – we'll cover specific monitors, but in short you'll want a high-accuracy shunt-based monitor on the house bank to track state-of-charge (SOC) since small loads might not register on the batteries' internal gauges . Overall, taking a "system-wide" approach means upgrading charging components, protections, and monitors in tandem with the batteries for a safe and reliable result.

- **Proper Installation & Safety:** Lithium batteries should be securely mounted in a dry, well-ventilated location, just like any house battery bank . Unlike flooded batteries, LiFePO<sub>4</sub> doesn't emit hydrogen, so closed boxes and venting aren't as critical, but you should still protect them from water ingress and excessive heat or cold. Many marine Li batteries (including ones recommended below) come with internal heaters to allow charging in sub-freezing conditions – a valuable feature in Puget Sound winters. Also plan for appropriate fusing and fire safety: ABYC E-13 requires a **Class T fuse or equivalent** on the lithium battery bank (many drop-in batteries actually include this internally – for example, the Epoch 460Ah has a 500A Class T fuse inside its case ). Have a fire extinguisher appropriate for electrical fires nearby as an added precaution (though LiFePO<sub>4</sub> is very stable and hard to ignite ). Lastly, consider labeling and documenting the new system thoroughly, so any future maintenance or surveys know it's a lithium setup and how it's configured.

Following these best practices will ensure your lithium upgrade is not only high-performing, but also **safe, compliant, and insurable**. Next, we'll discuss specific component recommendations and how to integrate them into your North Pacific trawler's existing system.

## **Recommended Components for the Lithium Upgrade**

Upgrading to lithium will involve selecting the right batteries and possibly updating charging equipment to match. Below is a breakdown of recommended components – from batteries and BMS to chargers, DC-DC converters, and monitors – with an eye on balancing cost, reliability, and simplicity.

- **Lithium House Batteries:** For a substantial increase in usable amp-hours, a popular choice is the **Epoch 12V 460Ah LiFePO<sub>4</sub> battery**. This is an 8D-sized lithium battery (about the size of a large AGM 8D) packing 460 Ah, with built-in heating pads, Bluetooth monitoring, and even a communication port for Victron integration . Each battery is around \$1,999 , which is a very good value per amp-hour (it also comes with an 11-year warranty and over 4000 cycle life). Two of these in parallel would give ~920 Ah (@12V) total – roughly triple the usable capacity of your current 600 Ah AGM bank (since you could safely use ~736 Ah or more of that 920 Ah, vs ~300 Ah usable from the old AGMs) . **Alternatives:** If the Epochs are hard to source or you prefer another brand, other marine-proven lithium options include **Battle Born GC3 270Ah batteries** (would need 3+ in parallel to reach similar capacity), **Victron Smart LiFePO<sub>4</sub> 200Ah modules** (very high quality, but they require an external BMS and careful setup), or **Lithionics** lithium batteries (used in many Nordhavn/Yacht installations, with excellent safety features but at a premium price). The Epoch 460Ah stands out for ticking almost every feature (high capacity, internal BMS, low-temp charging, Victron-friendly) at a reasonable cost, which is why it's been generating buzz in the boating community . Whichever battery you choose, ensure it has an **internal BMS** that disconnects on fault conditions and that it meets ABYC standards (the Epoch, for example, contains high-quality internal components and even an internal fuse for ABYC compliance ). Plan to install **2+ batteries in parallel** for redundancy so that a single battery BMS trip doesn't cut power to your whole house bank.

- **Battery Management System (BMS):** If you use drop-in lithium batteries like the Epoch or Battle Born, the BMS is internal to each battery. No separate external BMS device is needed, but you *should* take advantage of the batteries' BMS features. The Epoch batteries in particular include a **BMS CAN communication port**, which can interface with a Victron GX system (Cerbo GX, etc.) to share real-time battery data . This can be used to automate charging decisions (e.g. signal the inverter/charger to shut off if the battery is full or too cold). Whether or not you hook into a communications system, set all your chargers to profiles within the BMS limits. For example, if the battery manual says max charge 14.6V, you might set chargers to 14.2V to give a safety margin and ensure the BMS never has to step in except in emergencies. **Key BMS-related additions:** It's strongly recommended to install an **external battery monitor (shunt)** despite the internal BMS. Internal BMS gauges can sometimes miss very low current draws , leading to SOC readings that don't account for small parasitic loads. A device like the **Victron SmartShunt or BMV-712** will accurately track all current in/out of the bank and give you a reliable state-of-charge display . We will cover monitors more below, but this is part of the "BMS ecosystem" – think of it as

the human-interface to the BMS, so you can see what's going on inside those sealed batteries.

- **Inverter/Charger (Shore & Generator Charging):** Your existing Magnum **MS2812 (2800W inverter, 125A charger)** can work with lithium batteries, but it will need programming for the new charge settings. Magnum inverters allow custom charge profiles – you'd set the Absorb voltage to around 14.2V (and maybe only a short absorb time, or use the Magnum's "Battery Saver" mode to essentially float at 13.3V after reaching full charge). Many people continue using their Magnum with LiFePO<sub>4</sub> successfully by simply adjusting the DIP switches or remote settings. **Pros:** Keeping the Magnum is cost-effective (no new inverter cost) and it's a known quantity in your system; it also avoids a major rewiring of the AC system. **Cons:** Magnum is a bit dated in terms of integration – it won't communicate with the lithium BMS or other smart components, and Magnum's BMK monitor doesn't natively account for lithium's flat voltage curve (though it will still read amps and volts). If one of your goals is improved integration and monitoring (#1 Nice-to-have), you might consider upgrading to a **Victron Multiplus inverter/charger**. For example, a **Victron MultiPlus 12/3000** (3000VA inverter, ~120A charger) would be a comparable replacement. Victron's system can communicate with the batteries (via the Cerbo GX communications hub) and coordinate with solar and alternator inputs. It also has a proven lithium charging profile out of the box. That said, a new Victron MultiPlus with a GX controller will cost on the order of \$2,000+, which eats into the budget.

**Recommendation:** If the Magnum is in good shape, keep it for now and program it for lithium – this keeps the system simple and meets your primary needs. You can always swap in a Victron MultiPlus later as an enhancement. One thing to double-check with the Magnum is the **neutral-ground bond and ELCI compatibility** (discussed later). Magnum inverters have an internal relay to bond neutral when inverting and unbond when on shore power – ensure that is functioning, as improper neutral bonding is a common cause of ELCI trips. If Magnum's quirks continue to trip the ELCI even after the 24V charger is removed, *then* you might lean toward replacing it with a Victron, which has a well-engineered transfer switch and bonding system.

- **Alternator & Regulator (Engine Charging Underway):** A major goal is to charge the lithium bank efficiently while underway, reducing the need to run the generator. This will likely require some upgrades or reconfiguration of your alternator system. Trawlers often have a single large diesel engine with at least one 12V alternator (sometimes a second alternator for dedicated charging, depending on the boat). **First, assess your current alternator:** If it's, say, a 120A alternator, note that lithium can **pull that full 120A for an extended period** (until the battery is ~80-90% full), whereas your AGM bank's acceptance tapered off much sooner. Extended high output can overheat a stock alternator. There are two main strategies to handle this with lithium:

1. **Upgrade to a high-output alternator with smart regulator.** For example, install a **Balmar 170A or 210A alternator** with a Balmar external regulator

(MC-614) or a **Wakespeed WS-500** regulator. These regulators can be programmed for LiFePO<sub>4</sub> profiles and can even tie into a BMS signal (the WS-500 can listen for a CAN-bus BMS warning from batteries like Lithionics or possibly Epoch). At the very least, a smart regulator will limit the charging voltage and can monitor alternator temperature – reducing output if the alternator starts to overheat. This setup can feed the lithium bank directly and **rapidly recharge** it while running. The downside is cost (a quality marine alternator + regulator can be \$1,500+ installed) and mechanical complexity (mounting a bigger alternator or an additional alternator on the engine).

2. **Use a DC-DC charger from the engine's start battery/alternator to the lithium house bank.** In this approach, the alternator continues to charge the 12V start battery (an AGM) as it normally would, and you install a **12V-to-12V DC-DC charger** (sometimes called a battery-to-battery charger) to funnel charge to the lithium house bank. Units like the **Victron Orion-Tr Smart 12/12-30** (30A) or **Sterling BB1260** (60A) will take power from the engine/start battery and charge the lithium to the correct voltage, limited to their rated current. This inherently prevents the alternator from being overloaded because the DC-DC acts as a **current limiter** – e.g. a 30A DC-DC will only draw ~30-40A from the alternator even if the lithium is very hungry. You can put multiple DC-DC chargers in parallel if you want more amperage; they will share the load. The DC-DC charger also provides isolation between the AGM and Li banks, meaning the voltage regime on each side can be different (it will step up or down as needed). For instance, you might program the Orion charger for a lithium profile so it outputs 14.2V to the house bank even while the start battery side might be at 14.4V or dropping to 13.6V, etc. Many DC-DC chargers have an “engine run detect” or ignition input so they only activate when the engine is on, thus avoiding draining the start battery when the engine isn't running .

**Recommendation:** Given your goal of simplicity and cost control, the **DC-DC charger route is very attractive**. It avoids messing with the alternator itself and adds a layer of protection. Essentially, your AGM start battery becomes a buffer that the alternator charges, and the DC-DC pulls from it to charge lithium. This way, the alternator always sees a battery (the AGM) and won't experience a sudden load dump if the lithium BMS disconnects . A possible configuration is a **Victron Orion-Tr Smart 12/12-30A** isolated charger (or the 12/12-50A model for more current) feeding the house bank. If 30–50A feels insufficient, you could run two Orion 30A units in parallel for ~60A charging (they are designed for parallel use) . Even 30-60A charging will significantly extend your time at anchor given lithium's depth of discharge. For example, 60A can put about 360 Ah back into the bank in a 6-hour cruise, which is a lot of usable power with LiFePO<sub>4</sub>. If you frequently do short transits and want faster charging, then invest in the alternator upgrade; but many cruisers find ~50-100A is enough to mostly recharge during normal operations. Keep in mind if you *fully* deplete the lithium bank (which is rare in practice), running the generator might still be necessary to get back to 100% – that's okay, as your priority is to reduce generator hours, not necessarily eliminate

them entirely.

- **24V Thruster/Windlass Bank Charging (DC-DC converters):** Your boat has two separate 24V AGM banks: one aft for the stern thruster (2x12V in series) and one forward for the bow thruster + windlass (2x12V in series). Currently these are charged by a **Magnum 24V charger (2430p) running off AC** from the inverter or generator. We want to eliminate that AC charger to simplify and to reduce conversion losses. The solution is to charge those 24V banks from the 12V lithium house bank using **DC-DC converters** as well. Victron makes Orion **12/24 DC-DC chargers** in various amp ratings (for example, a 12V-to-24V 15A model). Sterling Power also has a **12V-to-24V Battery-to-Battery charger (around 20A or 30A)**. By placing a DC-DC unit between the 12V house and each 24V bank, you can charge the 24V batteries whenever the house is being charged (engine running or even when the inverter/charger is on). For instance, a Victron Orion 12/24-15A will provide up to ~15A at 28.8V (so about 0.5 C for a 200Ah bank, which is fine). That's roughly  $15A \times 24V = 360W$ , which in 1 hour provides 15Ah (at 24V) to the thruster bank. Thruster and windlass use is typically intermittent, so a 15A charger can recover the charge from a few heavy thruster/windlass deployments over an hour or two. If you want faster recovery, Victron also has a 12/24-30A (about 30A, 700W). You could use one 30A unit for the bow bank and one for the stern bank. **These DC-DC chargers should be ignition-controlled**, similar to the house one, so that they run only when the engine or a charging source is active – you don't want them slowly draining the house into the thrusters when you're just sitting at anchor. The Orions have a remote on/off that you can tie to your engine's alternator field or an "engine running" signal. The idea is that under way (or when the generator is on powering the inverter/charger), the house bank is being charged and will in turn feed the 24V banks through the DC-DC units. This keeps the thruster and windlass batteries topped up **without needing the dedicated AC charger**, fulfilling nice-to-have #2. Another benefit: removing the older 24V AC charger might reduce stray ground leakage that contributed to your ELCI trips (more on this shortly).

- **Solar Charge Controller:** You have three 145W panels (~435W) with a Tracer MPPT controller. Tracer is a brand of MPPT (likely EPEver) which usually has user-programmable settings. Check if your Tracer MPPT can be set to a custom lithium profile – many can. If yes, you can probably keep it; just program the absorption voltage to ~14.2V and float to ~13.5V (or even disable float if possible, since  $LiFePO_4$  doesn't need it). If the Tracer is not easily programmable or you want better integration, consider upgrading to a **Victron SmartSolar MPPT** (e.g. the 100/50 model, which can handle up to 700W @12V). The Victron MPPT would communicate with a Cerbo GX (if installed) and can even limit its output based on battery temperature or BMS signals when integrated. It's not a *must-have* if the current controller works, but it's a relatively modest cost item (\$300) that fits the improved integration goal. Also, think about **expanding solar** if roof space allows – an arch or pilot-house roof on a trawler can often support more panels. Even an additional 2–3 panels (bringing you to ~800–1000W) would

significantly increase your charging during sunny periods, possibly letting you go generator-free on good days. This can be a phased upgrade: get the lithium system in place first, then see if you need more solar to meet your usage.

- **Battery Monitoring & System Monitoring:** With multiple banks and new lithium chemistry, **accurate monitoring is crucial**. I recommend installing **shunt-based battery monitors on all banks**, or at least all critical ones. For the **house lithium bank**, a **Victron BMV-712 Smart monitor** (or the newer SmartShunt which is the same but without a display) is ideal. This will give you a precise readout of voltage, amps, and state-of-charge. It also has Bluetooth so you can check it on your phone, and it can integrate into a Victron Cerbo GX if you add one. For the **start battery**, a full amp-hour counter isn't as important (since the start battery is mostly always full and only discharges a tiny amount when cranking). A simple voltage monitor or the existing Magnum panel can show start battery voltage. However, since one of your nice-to-haves is *"battery monitoring for all banks"*, you might use something like a **Victron Smart Battery Sense** or BMV monitor on the start bank too, just to watch its voltage and temperature. For the **24V thruster and windlass banks**, you can also install individual voltage monitors or a dual-bank monitor. Another approach is to use a NMEA2000 monitoring system (Maretron, etc.) but that adds complexity. Keeping it simple: a Victron SmartShunt on each of the two 24V banks would let you see how much those banks cycle (likely they won't cycle deeply except when thrusters are used). If cost is a concern, you could forego shunts on the thrusters and just rely on voltmeters – but since those banks are AGM and will still behave like lead, you can infer their state by voltage pretty well (e.g. if after heavy use the 24V bank reads 24.5V at rest, it's down a bit and will charge up via DC-DC shortly). Additionally, consider a **Victron Cerbo GX** monitor/control system with a GX Touch display or use your iPad for display. The Cerbo GX is a central hub that can bring together data from the inverter/charger, MPPT, battery monitors, and even tank levels or engine data, onto one screen and online (Victron VRM portal). This definitely hits the "improved integration" goal (#1 nice-to-have) – you could see all banks' voltages, see solar input, shore/generator charging status, etc., at a glance. It's not strictly necessary for functionality, but many modern boaters love the centralized info. If budget is tight, this is a luxury – you could accomplish safe charging without it – but if you do allocate ~\$500 for Cerbo + display, it will make using and understanding the system much easier. Also, the Cerbo could potentially take in the **BMS CAN data from the Epoch batteries**, meaning it would show individual cell voltages, battery temp, and any alarm conditions coming from the batteries. That's a cutting-edge feature that not all drop-in batteries support; Epoch does, which is another reason it's a strong candidate.

- **Other Components & Gear:** A few other items you may need for the install: **Class T fuse** (if not built into the battery) or appropriate ANL fuses for the DC-DC charger outputs, etc.; **battery switches** (make sure your existing battery selector/disconnect switches can handle the higher potential current of lithium – most likely yes, since they're sized for engine cranking which is huge anyway).



**Cabling:** check that cable gauge from the batteries to inverter is sufficient (the inverter can draw ~200-250A; with lithium holding higher voltage under load, the current might be a tad *lower* for the same wattage than with AGM, but still in that range). If you end up placing lithium batteries in a different location than the old ones (for example, if space dictates moving them), ensure you use proper marine cabling and keep voltage drop low. You may also want to add a **Balmar SG200** battery monitor or similar that can handle multiple banks on one display as an alternative to multiple BMV units – but since you’re leaning Victron, sticking with all Victron sensors integrated to one system is advisable.

By selecting the components above, you’ll assemble a lithium-capable system that meets your goals: greatly expanded usable capacity, faster/more efficient charging from all sources, and robust monitoring – all while keeping the system as **simple and reliable** as possible.

### **Integration with Existing AGM Banks (Starter, Thrusters, Windlass)**

One of the trickiest parts of a partial lithium upgrade is **managing the interface between the new lithium house bank and the existing AGM banks**. The good news is you can keep those other banks in place (saving cost) and charge them in a controlled way so that each battery type is in its comfort zone. Here’s the plan for each:

- **Engine Start Battery (12V AGM):** It’s common to **keep the engine start battery as AGM or lead-acid** even when house goes lithium. Starting engines is not a big strain on capacity, and lead batteries handle engine cold cranking well. You also avoid any risk of a lithium BMS disconnect cutting power during engine start – which is rare, but starters do pull heavy current. So your 12V 200Ah AGM start can remain. How to charge it? Currently, the alternator likely charges the start battery first and then the house via an isolator or combiner. With the new setup, if you implement the **alternator-to-DC-DC strategy** described, the alternator will **feed the start battery as normal** (voltage regulated by the internal regulator, say ~14.4V). The **DC-DC charger from start to house** will activate and move some of that energy to the lithium. In this configuration, the start battery will actually stay nicely topped up (the alternator maintains it at ~100% when running), and when the engine is off, the start battery might sit around 12.8V (AGM full). We should ensure the start battery also gets charged when you are plugging into shore or running the genset: if you keep the Magnum inverter/charger, note that it likely has either a second output for charging the start battery or an “echo charge” feature. Magnum often offers an **Echo Charger** that will trickle charge the start battery from the house charger once the house is charged. If not already installed, you could add something like a **Xantrex Echo Charge** or a **Balmar Duo Charge** – these devices take a small current from the house charging source and feed the start battery, limited to e.g. 10–15A and at a safe voltage. This is *one* way. Alternatively, you could repurpose one of the small

**Orion 12/12 DC-DC units** to charge the start battery from the lithium bank whenever the lithium is being charged by shore/solar. In practice, many people rely on solar or the inverter/charger to keep the house bank up, and then a combiner relay or echo charger to keep start topped. **Important:** Do NOT leave a traditional combiner (ACR) directly connecting the lithium and start bank all the time – if engaged, the lithium at ~13.3V will constantly try to “float” the AGM start at that voltage, which could overcharge it over long periods. Instead, use a managed device (echo charger or DC-DC) that only passes current when needed and typically at a limited voltage (most echo chargers stop at 13.3V or so, which is safe for AGM). This way the start battery remains isolated except when charging is needed. In summary, the start AGM will largely take care of itself with the engine alternator and a small supplemental charger when on shore power. It also provides a nice **safety buffer** for the alternator – as mentioned, the alternator will always see the AGM battery, so its voltage won’t spike to dangerous levels even if the lithium gets full and the DC-DC stops drawing.

- **24V Thruster/Windlass Banks (AGM):** These two banks (likely ~200Ah each, at 24V) will remain dedicated to their thrusters and windlass. We will **not tie them directly to the lithium** – instead, each will be charged via a DC-DC charger from the 12V house. This keeps the lithium isolated from the high-current thruster circuits. The integration is straightforward: the **Victron Orion 12/24 chargers** will be configured for an **AGM profile** (for example, 28.8V absorption, 27.6V float) appropriate to those thruster batteries. They will only deliver current when the house voltage is above a certain threshold (indicating charge present) or when the engine is on (depending on wiring). In effect, the thruster banks will “see” a charger very similar to your old 2430p, just fed from DC instead of AC. During thruster or windlass operation, those banks deliver high amperage to the thrusters, but the house lithium isn’t directly involved, which is good for preventing large voltage sags on the house bus. After you use a thruster, the voltage in that 24V bank will dip; the Orion DC-DC will sense this (and/or the rising house voltage from alternator) and kick in to recharge it at up to ~15A or whatever it’s rated. One thing to double-check is the size of the thruster chargers: If your thruster usage is very heavy (say multiple minutes of continuous use, which is actually uncommon outside of maneuvering), you might want a larger DC-DC to replenish faster. But in most real scenarios (short bow thruster bursts while docking, windlass running for a few minutes raising anchor), a 15–20A charger will recover the charge in well under an hour. This is a reasonable trade-off to avoid needing a huge charger just for a rarely-cycled bank. **Controls:** Wire the DC-DC units with either an ignition trigger or use their built-in engine-run detection (Victron Orions can sense voltage >13.2V on the input as “engine on”). This ensures they don’t drain the house when everything is off. Also fuse both the input (12V side) and output (24V side) appropriately per the manual – these are high-power DC devices. Once set up, the thruster and windlass batteries will always be charged and ready without any manual intervention, meeting nice-to-have #2 and #3 (since you’ll monitor their voltage via your system monitor).

- **Ensuring Separation of Lithium and AGM:** The overall strategy here keeps the lithium house bank **isolated by default**. There is no always-connected parallel between Li and any lead battery. Each connection is gated by a charging device: the Orion DC-DCs or the inverter/charger or an echo charger. This is important because lithium rests at ~13.3V full and AGM at ~12.7V full; directly connecting them would cause current flow back and forth and overcharge the AGM or self-discharge the Li. By using DC-DC chargers, **each bank is charged according to its needs** – the lithium gets a lithium-specific charge curve from the alternator (via DC-DC) and solar/shore, while the AGM banks each get an AGM-specific charge from their respective devices. During discharge/use, each bank stands alone serving its loads. This approach is inherently **simple and reliable**: it behaves a lot like your current system (where the 24V banks are separate and charged by a charger when needed), except now the “charger” is fed by the house battery instead of AC.

- **Future Consideration – Thruster/Windlass to Lithium?:** You didn’t explicitly ask to convert the thruster banks to lithium, and it’s not necessary at this time. Some boaters do eventually replace thruster batteries with lithium or supercapacitor banks to save weight and improve voltage under load. However, thrusters draw extremely high currents for short times, and that can be harsh on a lithium BMS (you’d need batteries that can handle e.g. 500-600A spikes). It also adds cost and complexity (you’d need two more lithium batteries in series to make 24V, likely with special BMS arrangements). Given your goals (cost control, simplicity), sticking with AGM for those high-amp systems is perfectly reasonable. The AGM can supply huge surge currents and their lifespan is mostly preserved since they are in float most of the time. So our integration strategy focuses on **charging them properly** from the new system, rather than replacing them.

In summary, by using dedicated DC-DC chargers and smart charging logic, your new lithium house bank will **coexist peacefully with the AGM start and thruster banks**. Each bank will be charged optimally and kept isolated when not charging. This ensures longevity for all batteries and avoids the pitfalls of mixing chemistries on one circuit. It also adds a level of redundancy – e.g. if the lithium ever went offline, your engine start battery and thruster batteries are still lead-acid and can operate critical systems (engine, thrusters) independently. This integration plan addresses research need #3 and keeps the system **simple, robust, and safe**.

## **Addressing ELCI Tripping and AC Integration Issues**

Nuisance tripping of the **ELCI (Equipment Leakage Circuit Interrupter)** on your boat can be frustrating, and it’s often a sign of a small ground fault or bonding issue in the AC system. Inverters/chargers are frequently the culprit. Your ELCI (similar to a GFCI but for the whole boat) will trip if it senses an imbalance of just 30 mA or so between hot and neutral – meaning some current is leaking to ground. Here’s how the lithium upgrade and some tweaks can solve or mitigate

this:

- **Remove the 24V AC Charger:** By eliminating the old 24V “2430p” AC charger, we remove one device that was connected to AC shore power. Many older chargers (or lower-cost ones) have filters or insulation that can leak a small current to ground. If that charger was on the output of your inverter, it also created a scenario where inverter AC was feeding a device that is grounded to the DC system – a recipe for ground-loop leakage. The new **DC-DC chargers replace this AC device**, so once you physically disconnect and remove the 24V charger, re-test your shore power ELCI. There’s a good chance the nuisance trips will decrease or stop. This addresses nice-to-have #4 partly, by removing a suspect component.

- **Inverter Neutral/Ground Bonding:** The Magnum inverter/charger, like all marine inverters, should bond neutral-to-ground internally **only when it is in invert mode**, and open that bond when on shore power pass-through . If that timing or function fails, it can trip an ELCI the moment you plug into shore . Ensure the Magnum is wired correctly per the manual: the AC input ground should be tied to ship’s ground, same for AC output ground; the neutral on the output should **ONLY** be bonded to ground when inverting. Magnum uses an automatic relay for this. Sometimes if an inverter was mis-wired (for example, if someone inadvertently created a second neutral-ground bond in the AC panel), the ELCI will catch it. One diagnostic: *Does the ELCI trip only when the inverter is connected/enabled?* From what you’ve said, it sounds like yes (it tripped and the inverter had a fault code ). After removing the 24V charger, if trips persist, try temporarily disconnecting the Magnum’s AC input/output and see if shore stays on (this was done in one case on a boat – isolating the inverter stopped the trips ). If that’s the case, the Magnum or its wiring is at fault. A properly installed inverter will *not* trip an ELCI. Sometimes the fix is as simple as adding a switch or breaker to completely isolate the inverter’s output when on shore power (Magnum actually sells an automatic relay device for this scenario, or one can manually switch off the inverter output when plugging in). The goal is to ensure there is **only one neutral-ground bond** on the boat at any time (at the source – either at the generator or inverter when they create power, or at shore pedestal when on shore). Work with an electrician to trace and correct any stray bonds.

- **Galvanic Isolator / Bonding System:** Another angle: ELCIs can trip if a **galvanic isolator** is failing or if there is DC leakage to ground. Since you mention nuisance trips, check the galvanic isolator on your shore ground (if installed). Some isolators have monitoring circuits (to show if they fail short or open) that can sometimes confuse sensitive ELCIs. If in doubt, a safe (though more costly) fix is to install an **Isolation Transformer** instead of relying on an ELCI+GI. An isolation transformer will completely isolate your boat’s AC from the shore ground, essentially eliminating ground-current trips (because there is no direct path for current to leak to actual earth ground – the boat becomes its own “island” power system). Many larger trawlers have isolation transformers for exactly this reason, and for corrosion protection. They do cost ~\$1,000-1,500 and weigh a lot, so it’s a

non-trivial addition. But it *will* solve nuisance tripping in virtually all cases. If budget allows as a later upgrade, it's the gold standard solution for shore power issues. In the meantime, focus on the simpler fixes: remove the suspect charger, ensure inverter bonding is correct, and have an ABYC electrician **megger test** or use a clamp meter on your AC circuits to see if any small leakage exists on appliances, water heater, etc.

- **Shore Power and Charging Integration:** As part of the lithium upgrade, you might also consider **upgrading the shore power inlet or main breaker** if it's older. ELCIs can nuisance trip if connections are corroded (causing impedance that fools the sensor). A fresh 30A inlet or ensuring all AC neutrals and grounds are clean and tight might help. Also verify your **ELCI breaker itself** is functioning properly; sometimes older ones become too sensitive or erratic. Given that your boat is a North Pacific trawler, it likely has a fairly modern electrical system, but it's worth a check. The lithium system itself doesn't inherently cause ELCI issues – in fact, it might reduce them because the new system likely has fewer continuous AC loads (the batteries will be charged faster and longer periods on inverter/charger may be reduced).

- **Generator Integration:** Don't forget to configure the generator's charger output (likely through the Magnum) for lithium as well. The generator should not cause ELCI issues since it's onboard (it will have its own neutral-ground bond internally usually). But ensure the generator's neutral is floating when on shore power, etc. It's typically handled by the transfer switch in the Magnum or your AC panel.

In short, **resolving the ELCI tripping** will involve cleaning up the AC side of the system. Removing the old charger is a big first step. After the lithium conversion, systematically test shore power with various devices (inverter on/off, etc.). If it still trips, enlist a marine electrician to identify the leakage path. It's often something like a fridge or water heater with a tiny ground fault. Given your symptoms, I suspect the Magnum + 24V charger setup was the primary issue. The new configuration, if properly installed, should be **fully ABYC-compliant and ELCI-friendly**. Do make sure your installer or electrician double-checks everything against **ABYC E-11 (AC systems)** and E-13. This will not only stop the nuisance trips but ensure safety (no stray AC on hull/ground that could cause corrosion or shock hazards).

## **Recommended ABYC-Certified Installers in Puget Sound**

Upgrading to a lithium-based system is complex, and having an **experienced ABYC-certified installer** involved is highly recommended – even if you do some work yourself, an expert can review plans or do final connections to ensure everything is correct. In the Puget Sound region (Seattle area), here are a few well-regarded options:

- **Emerald Harbor Marine (Seattle)** – A longstanding marine systems

installer known for high-quality electrical work on cruising boats and yachts. They are familiar with inverter systems, lithium batteries, and custom alternator setups. Many Nordhavn and trawler owners use Emerald Harbor for complex projects. Expect professional results (and pricing to match). The original poster on a forum even mentioned considering them, which attests to their reputation.

- **CSR Marine (Seattle/Ballard)** – CSR is a full-service boat yard that also has ABYC-certified electricians. They have done lithium battery installs. As you noted, they are on the expensive side, but they have a broad capability (fiberglass, mechanical, electrical all in one place). For a big job like this, they can handle all aspects, from mounting batteries securely to rewiring alternators. Their organized project management might justify the cost if you want a turn-key solution.

- **S3 Maritime (Seattle)** – S3 is known for marine electronics and electrical systems on larger yachts. They **"fixate on Victron"** (i.e. they prefer Victron equipment) , which could be good if you decide to go the Victron route for inverter/charger and MPPT. They have experience with lithium upgrades and can do system design. They are reported to be expensive as well, but very knowledgeable. One user mentioned that asking questions and negotiating with them helped align the project scope to his budget , so they may work with you to prioritize changes (for example, only doing the battery and charger install, but leaving your existing gear in place if you want).

- **Sarah's Shipshape Services (Seattle)** – An independent ABYC-certified marine electrician (Sarah is ABYC certified in marine electrical) who *specializes in Victron systems and LiFePO<sub>4</sub> batteries* . This is a smaller outfit which could be more budget-friendly and flexible on custom projects. Being a Victron specialist, she can integrate the Cerbo GX, MPPTs, etc., and has experience with lithium retrofits on cruising boats. Her company is relatively new (founded 2022) but has garnered good word-of-mouth in the local boating community for doing high-quality, compliant work.

- **Monkey Fist Marine (Seattle)** – Another local company with ABYC-certified techs. They advertise expertise in **inverter/charger systems and batteries (including lithium)** . They could handle an upgrade like this end-to-end. Their rates are around \$145/hr per their site, which is standard. They also hold ABYC certs in corrosion and marine systems , which might be useful for solving that ELCI/ground issue.

- **Others / North Sound** – If you are based nearer to Everett/Anacortes, there are individuals like **Steve Tiefisher (Anacortes Yacht Repair)** or firms like Pacific Yacht Systems (in Vancouver, BC) that consult on projects in the NW. In Seattle, asking at **Fisheries Supply** for recommended freelancers is a good tip – as one forum user said, *"I know there are some good independents, ask at Fisheries."* This can turn up a qualified electrician who maybe isn't widely advertised but has done many lithium boat projects. Just be sure to vet that **they truly know lithium systems** – unfortunately, some electricians claim to know but aren't up to date (for example, one "old salt" electrician didn't realize an AGM charge profile is actually acceptable for many Li batteries and gave incorrect

advice ). So when interviewing an installer, ask specifically about their experience with LiFePO<sub>4</sub>, BMS, DC-DC chargers, etc. A good sign is if they talk about having done recent lithium projects or mention adherence to ABYC E-13, rather than dismissing it.

Given the scope (house bank + integration + alternator/DC-DC + monitors), you might even choose a **hybrid approach**: hire an expert for the critical high-power wiring and configuration, but do some of the simpler tasks yourself (like installing battery monitors or running wires to the DC-DC units, etc.). This can save labor costs and still ensure the main system is sound. Most of the companies above would be amenable to working with a semi-DIY owner.

Always communicate the **goals and constraints** clearly: that you want a safe, ABYC-compliant install, but also want to reuse as much existing equipment as makes sense to stay near the \$20k budget. Some high-end installers may initially quote a “gold standard” system (replacing *everything* – alternators, inverter, all batteries including start/thruster) which can easily top \$30k . Make sure they understand you want the **most bang for the buck** – e.g., upgrade the house bank to lithium and make necessary changes, but not a full rewiring of the entire boat. There is often room to prioritize what gets replaced vs. what can be retained. A knowledgeable installer will also discuss your cruising profile (e.g. daily anchor-outs vs. marina stays) and can tailor the system accordingly – it sounds like you want to anchor out and minimize genset runtime, so emphasize that.

In the Puget Sound area, all of the above have the credentials; the difference will come down to scheduling and budget. **Emerald Harbor** and **S3** will likely deliver top-notch results but at higher cost. **Independent specialists (Sarah’s Shipshape, Monkey Fist)** might be more hands-on with you and cheaper on labor. Since reliability is paramount, don’t just go with the cheapest – go with someone who instills confidence and has proven lithium experience.

## **Additional Considerations and Conclusion**

Finally, a few extra points to consider as you move forward with the upgrade:

- **Total Cost and Phased Upgrades:** With a target budget of \$20K, you’ll need to be strategic. The biggest single cost will be the lithium batteries themselves (expect \$4K–\$6K for two or three large batteries). After that, labor is usually the next big chunk. To stay on budget, prioritize *must-haves* (sufficient battery capacity, proper charging devices, safety equipment) over *nice-to-haves* (like a full Victron integration or new alternator) if needed. The good news is you can do this upgrade in stages: for example, install the lithium bank, DC-DC chargers, and basic monitoring now (perhaps \$12-15K total), and see how the system performs. If you find the alternator is struggling or you really want remote monitoring, you can invest in a second alternator or Cerbo GX later. There’s no

part of the plan that *absolutely* precludes adding more later – just leave expansion room (spare breakers, a mounting spot for a future second alternator or solar charge controller, etc.). The end-goal is achievable within budget by leveraging much of your existing infrastructure (Magnum inverter, current alternator, AGM thrusters) and only adding what's necessary to make it lithium-ready.

- **Wiring and Equipment Placement:** Lithium batteries can often be smaller and lighter for the same usable capacity. Ensure the new batteries can be mounted securely where the old ones were, or if they're a different size/shape, modify the battery trays/straps accordingly. Lithium 8D batteries like the Epoch 460Ah weigh around 120 lbs each (lighter than 3 x 8D AGMs, but still heavy) – make sure the floor or shelf can support them. Because they are sealed, they could even be mounted on their side if needed (check manufacturer specs). Also plan the layout for DC-DC chargers and fuses – these devices can be mounted near your electrical distribution panel or close to the batteries they charge. They do generate some heat at full power, so keep them in a ventilated space (engine room or a machinery space is fine, as they're ignition protected).

- **Balancing Loads and Charging:** Once installed, you may need to tweak charge settings after observing the system. For example, if you find the alternator (through the DC-DC) is overcharging the lithium (unlikely if set right) or not providing enough, adjust the DC-DC output limit or the alternator regulator (if using one). Likewise, watch how the thruster DC-DCs perform – if the bow battery isn't fully charging on short runs, you might increase the current or turn on the charger manually via a switch before using the bow thruster (some people do this: energize the DC-DC to "top off" the bow bank just before heavy use). These are fine-tuning details that a good monitoring setup will reveal.

- **Lithium Usage Habits:** Enjoy the fact that you can discharge deeper without harm – but it's still wise for longevity to avoid 100% discharge regularly. Many  $\text{LiFePO}_4$  users actually size their bank so that they normally use only 20-50% of it in a day, which appears to be your plan (double or triple capacity to reduce generator run time to once a day or less). That will be easy on the batteries and they'll likely last well beyond 10 years. You might decide to only charge them to 90% most of the time (since going to 100% isn't necessary every cycle), which further extends life. These settings can be adjusted in your charger – e.g., float at 13.6V so the batteries rest ~95% charged instead of holding 100% all the time. It's a subtle point, but something to discuss with your installer or research in manufacturer guidelines.

- **Safety and Certification:** After the install, it could be beneficial to get a **marine surveyor or ABYC technician to sign off** on the system (especially if your insurance requires it due to the lithium). Show that all components are UL-listed for marine use, all cables are marine-grade, fusing is correct, and the install follows ABYC E-13 recommendations. The components we've discussed (Epoch batteries, Victron chargers, etc.) do meet the intent of ABYC standards as long as installed per their manuals. Documenting the system (a wiring diagram, list of



equipment and model numbers) will be very useful for future troubleshooting or when selling the boat.

By implementing the above plan, you will dramatically improve your North Pacific trawler's electrical capacity and efficiency. You can expect on the order of 700+ amp-hours of usable 12V power, meaning running the fridge, lights, navigation electronics, and even some inverter loads through the day and night with only a short generator charge or a decent engine run. Charging will be faster and more effective: the solar panels will more meaningfully extend your time off-grid, and the alternator (via DC-DC or upgrade) will pour energy into the house bank whenever you're underway. All of this while **maintaining reliability** – critical systems like engine start and thrusters stay on proven AGM banks (kept charged via the new system), and you have multiple layers of protection (BMS, fuses, disconnects) guarding against failures.

In summary, the **upgrade goals** will be met as follows: you'll double or triple your usable amp-hours (lithium's depth of discharge and efficiency accomplish this), you'll be able to charge all banks effectively under way without the generator (via alternator->DC-DC charging and solar input), and the system will remain straightforward – each piece (alternator, shore charger, solar, DC-DC units) has a clear role. The budget is kept in check by reusing major items (Magnum inverter, existing alternator with DC-DC assist, existing AGM for start/thrusters) and focusing spending on the new lithium batteries and a few key electronics. The **nice-to-haves** are addressed: shore/gen/solar integration will be smoother with matching charge profiles (and potentially a Victron Cerbo for oversight), the 24V charger is replaced with efficient DC-DC converters, you'll have full visibility into all banks with new monitors, and the pesky ELCI trips should be resolved by the cleaner electrical setup .

This is a cutting-edge but proven approach – in fact, many 2020+ model cruising boats are shipping with very similar configurations (lithium house, DC-DC chargers for engine and thruster banks, smart monitoring). By following current best practices and using quality components, you'll ensure your trawler's electrical system is ready for the demands of long-term cruising with minimal generator dependency. Enjoy the freedom of quiet anchorages and the peace of mind that comes with a robust, up-to-date power system!