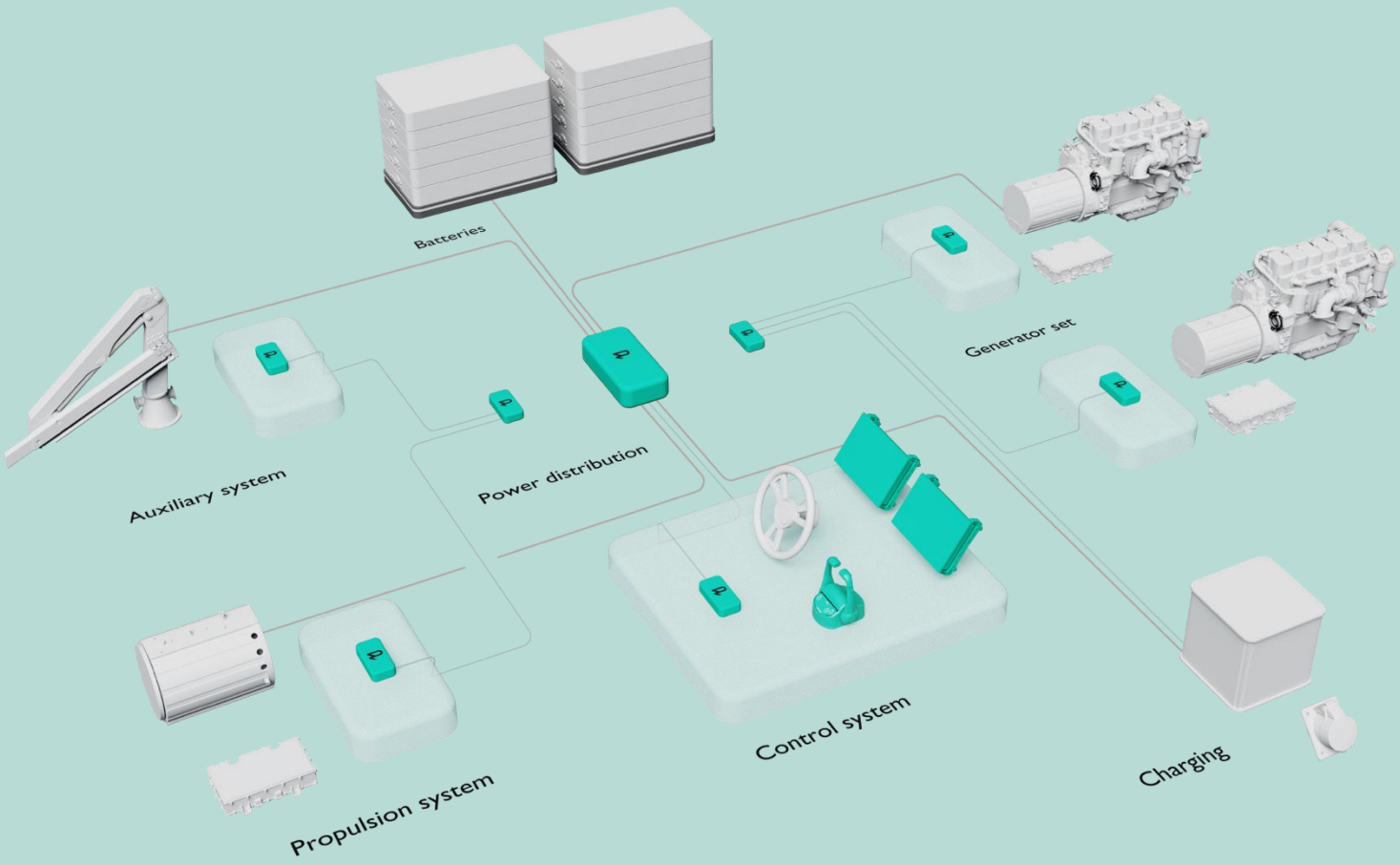
Pascal Powertrain Platform

One control platform for electric and hybrid powertrains, from a single drive to a redundant, class-compliant system. Standard control, free choice of components.



SERIES HYBRID | PARALLEL HYBRID | BATTERY ELECTRIC

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One control platform for every electrified vessel

Our scope is the control system: energy and power management, propulsion control, and the Integrated Automation System including hydraulics, delivered as software alone or as a complete turnkey powertrain.

Problem: every vessel becomes a new engineering project

Two things make this hard. First, the components do not speak the same language. Motors, batteries and converters each come with their own vendor, protocol and operating pattern, so making them work as one system means a custom integration job on every boat. Second, the equipment on offer was built for much larger ships and then scaled down. It is heavy, it is expensive, and systems engineering is needed for every new build.

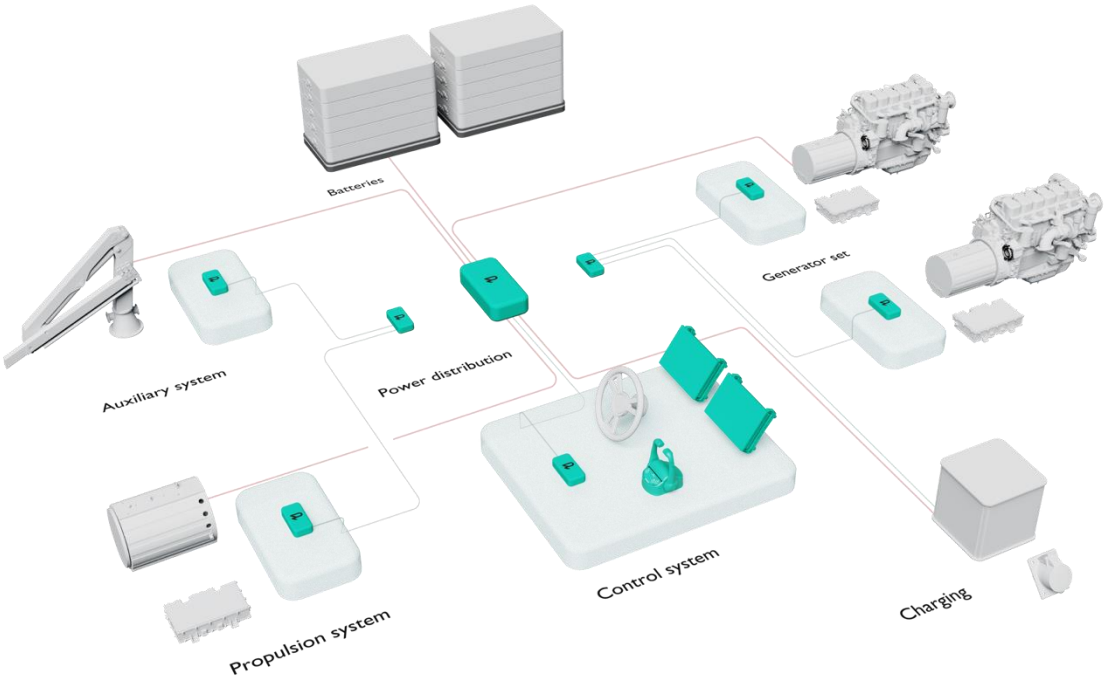
Pascal's answer: a standard control system, open to any component

One standardized, modular control platform, built for vessels where space and weight are limited. The standard part is the control layer and the interfaces. The component choice stays yours: the same platform runs third-party motors, batteries, chargers and auxiliaries in any mix. The controllers sit next to the components they serve instead of in a central cabinet, which is what keeps the system small and light. Different battery sizes and redundancy options all inside the same framework.

The delivery: configured per vessel, not engineered per vessel

Eight core functions are delivered with every configuration:

- Energy and power management,
- Propulsion and thrust control
- GenSet and grid control
- Thermal management
- IAS and hotel loads
- Safety Control
- Remote diagnostics
- Top level integration platform



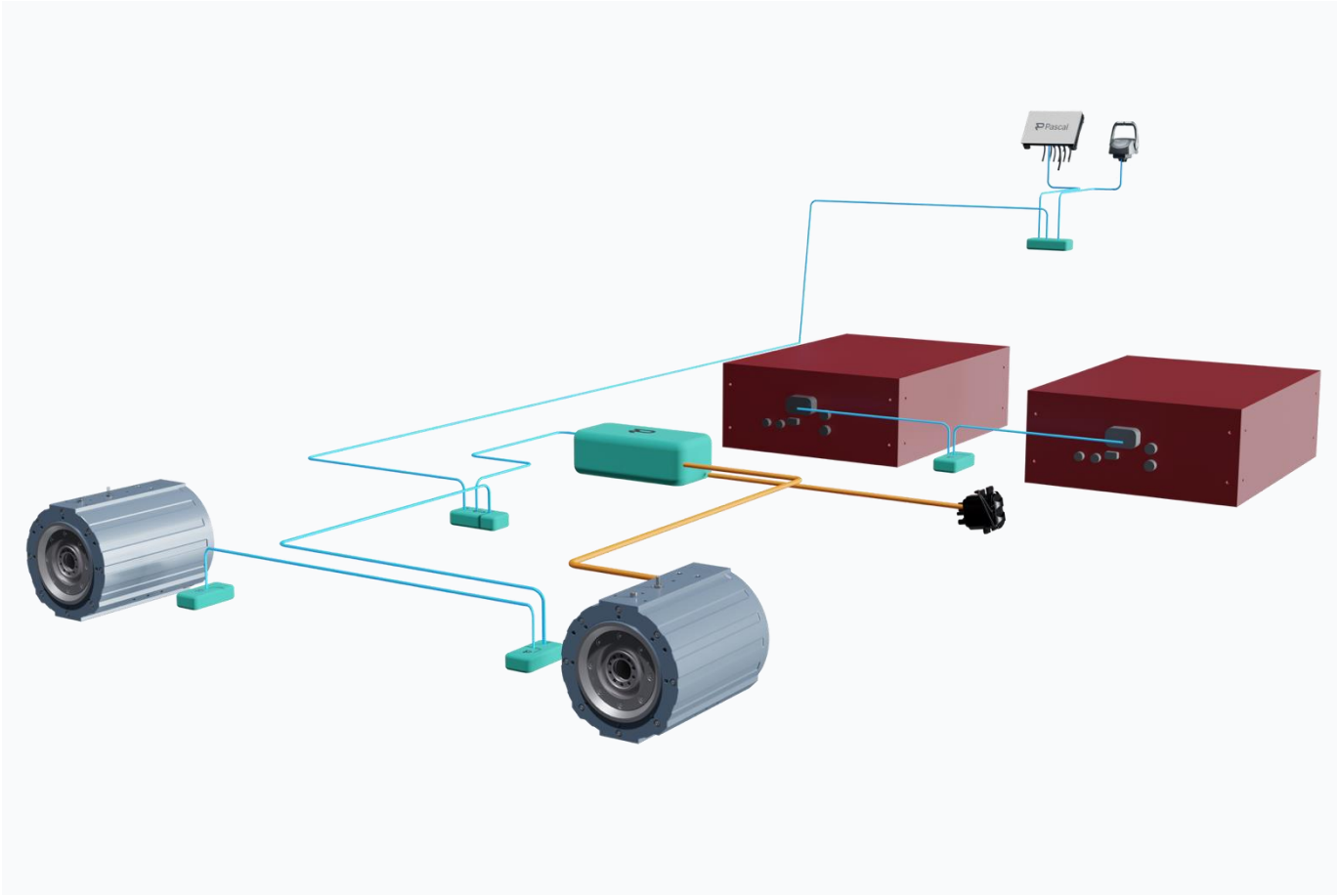
One platform tying batteries, generators, propulsion motors, auxiliaries and charging into a single managed architecture.

Core Powertrain Platform

Controls energy flow between battery packs and main propulsors, and between every other onboard source and consumer.

Pascal delivers a full control system as one integrated package: controllers, power electronics and power distribution units. The platform supports both fully electric and hybrid operation, and scales in the number of consumers and in energy content.

The architecture is scalable across vessel sizes and power levels, and transferable both regulatorily and in terms of capacity to larger and smaller vessels. Controllers sit at the components they serve. The boat carries only the control hardware it needs, as a plug-and-play system tailored to the vessel.



500 KG LIGHTER

15 m electric ferry, 200 kWh, against conventional integration. Same architecture, same components.

NO CENTRAL CABINETS

Small units that fit where there is space, instead of one cabinet that needs a compartment of its own.

NO BESPOKE SCHEMATICS

Configured per vessel from standard modules.

Core system functions

The following eight functions are delivered with every vessel and every configuration.

Energy and power management

Manages the energy flow between the various onboard sources and consumers, ensuring all components are kept within their operational limits and adhere to the limitations set by batteries, generators and shore connection.

Propulsion and thrust control

Communication and control of motors and inverters powering the vessel's prime movers and thrusters. From throttle lever to shaft, ensuring that they operate within their nominal limits and adhere to the system available power.

GenSet and grid control

For hybrid vessels, control of the generator output to ensure that the energy flow within the vessel DC grid supports the intended operation while staying within operational limits of batteries, propulsion units, and other large consumers.

Thermal management

Integrated thermal management of batteries and propulsion units. Pascal delivers complete systems or interfaces and controls systems specified by yard or designer, and supports engineering so components stay within thermal limits in hot and cold climates.

IAS: hotel and auxiliary loads

Supply of power to AC and LVDC switchboards in single and redundant configurations, and direct power to larger consumers on a case-by-case basis.

Safety

Monitors and controls safety instrumentation and equipment in the battery compartment, so potentially dangerous conditions are detected and mitigated as early as possible.

Remote diagnostics and connectivity

All systems are delivered with a secure remote connection. This carries both streaming of operational data made available to your existing cloud environment or Pascal's, and security and functional updates to be remotely installed onboard. The system is designed to comply with the forthcoming EU Cyber Resilience Act.

Integration

Bringing the selected components into one working system: implementing the interfaces towards each vendor's equipment, tuning the control behaviour to the operational profile, and commissioning the vessel through harbour and sea trials with the documentation the yard and class society need.

The building blocks (1/2)

Two of the four elements in every installation. Control sits at the components, spread through the boat rather than gathered in one cabinet.

Vessel Control Unit



Where the control system runs. Holds the vessel power and energy budget, the operating modes, and the coordination of every controller on the network. DNV type approved.

- **Operating modes**. The vessel runs as a defined set of states, with the entry and exit conditions for every transition specified in the platform. The state machine holds what is permitted in each state: available power, which sources and consumers may run, and the state a fault falls back to.
- **Mode changeover**. Between normal operating modes without interruption in propulsion, steering or power generation.
- **Configuration**. The vessel application is set up by configuration, from the standard platform.
- **Unit data**. Approx. 200 x 200 x 45 mm, ~2 kg, IP69K, rated for minus 40 to plus 85 degrees C. Supply 9 to 32 V DC off the vessel 12 or 24 V system.
- **Redundancy**. Redundant installations run two units on separately routed feeds, either one able to run the boat alone.

Controllers



Control units placed at the equipment they serve: propulsion, batteries, GenSet, charging, thermal and auxiliary systems. They connect to the platform through standardized connectors, and the role of each one is set in configuration.

- **Placed at the component**. Sensor and actuator wiring stays local to the equipment it serves. Fewer meters of cable, less weight, and no cabinet to find space for.
- **Standardized, marine approved connectors**. 3-8 connectors per unit, keyed and labelled. No termination work on site and no loose wiring.
- **Local control**. Controllers run smaller auxiliary loads directly, such as cooling pumps, valves, fans and lighting, without going through the Vessel Control Unit. Outputs are digital, PWM capable where a load needs proportional control, and inputs read sensor values at the component.
- **Unit data**. IP67, Typically 300 x 150 x 60 mm, 1 to 2 kg.
- **New components**. The interface to specific makes and models is a software module. Supporting a new vendor or variations is a change to that module. The controllers, the network and the rest of the control system stay as they are.
- **Contained faults**. CAN networks running at different baud rates are bridged with optocoupled outputs, so a fault on one network cannot propagate to another.

The building blocks (2/2)

The other two elements: what the operator works with, and what ties the system together.

HMI

User friendly and unified operation, monitoring and alarms in one panel.



- **Mode based operation.** The operator picks a mode, such as transit, charge or standby, and the system handles power allocation, thermal limits, protection limits and faults underneath. No separate panel per system, and no manual coordination between them.
- **One view.** Propulsion, energy, charging, auxiliaries and alarms together: operating mode, system status, drive status, propeller speed, state of charge and power, as ISO 16315 requires for combined combustion and electric propulsion.
- **Branding.** For OEM and volume deliveries the interface is styled to the customer's visual identity.

Wiring Harness

Pre-terminated harness connecting the Vessel Control Unit, controllers, sensors and actuators.

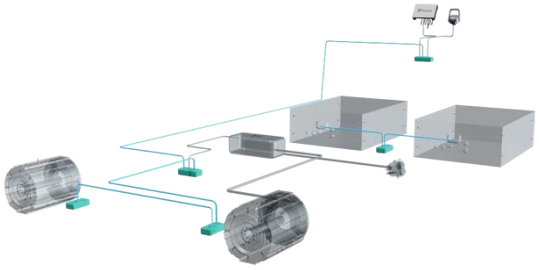


- **Routed from the vessel 3D model.** Standard modular lengths are selected against the model, so routing, length and weight are settled before production starts. EMC segregation and the rest of the routing rules are applied in the model, so every hull is wired the same way and the compliance work is done before anyone is on board with a cable in hand.
- **No work on site.** Delivered pre-terminated, which takes on-site termination and the wiring errors that come with it out of the build.
- **Marine grade and documented.** Marine-grade cable and connectors, individually labelled, delivered with connector mapping and as-built documentation, so integration with third-party motors, inverters and batteries is straightforward.
- **Short local runs.** Because the controllers sit at their components, the runs are short and local.

Scope of delivery

Three different models exist because yards and owners differ in how much of the value chain they want to own. The control platform is always included, and the scope can extend to a complete turnkey delivery with all documentation and FAT before shipment. In every case, Pascal is accountable for the control, performance and safety of the integrated system.

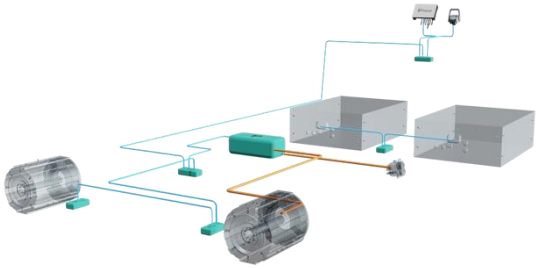
CONTROL PLATFORM



The cost-efficient option: Pascal delivers the control platform: software, controllers and wiring harness. The customer supplies motors, inverters, batteries and power distribution cabling. Pascal makes all components talk together in one integrated system. All deliveries include Pascal's cloud suite: operational data streaming, remote diagnostics and updates at vessel and fleet level, compliant with the EU Cyber Resilience Act.

- CONTROL SOFTWARE
- CONTROLLERS
- WIRING HARNESS
- HMI
- CLOUD SUITE

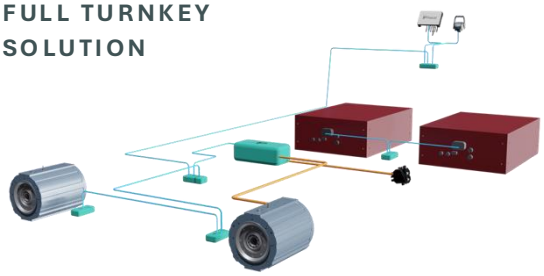
CONTROL + HV DISTRIBUTION



Pascal additionally supplies high-voltage power distribution units with fuses, charging contactors and isolation monitoring, as well as pre-terminated high-voltage cables tailored to your specific vessel. Through our configuration tools we can quickly distribute components in 3D by simply uploading your vessel model and automatically retrieve relevant cable lengths for all components with the correct connectors sent to production.

- INCLUDES CONTROL PLATFORM
- PRE-TERMINATED HV CABLES
- HV DISTRIBUTION HUBS

FULL TURNKEY SOLUTION



Pascal delivers a full turnkey solution ready to install, with batteries, chargers and motors from Pascal's approved suppliers. The system can be optimized for performance, speed, cost, or redundancy.

- INCLUDES CONTROL SOFTWARE + HV DISTRIBUTION
- MOTORS & INVERTERS
- BATTERIES & CHARGERS
- ++

VENDOR FLEXIBILITY

Pascal integrates with leading marine component suppliers. The control system and DC distribution interface with third-party batteries, motors and inverters according to your preferences, or Pascal can suggest and supply a fully specified, pre-validated package for your vessel, with route- and operational simulations for your specific vessel to confirm it meets your operational requirements.

Application segments

The same platform, configured in four different ways. Pascal's platform is not limited to these four configurations; they're illustrations of what's possible.

SEGMENT	VESSEL TYPES	CONFIGURATION	CAPACITIES	CLASS
I · Single drive powertrain	Leisure craft, port duty, crew transfer and small ferries under 12 passengers	Battery electric, single non-redundant propulsion line with charger and shore connection (CCS2 or direct grid connection) plus 12/24V supply for onboard consumers	5–800 kW total system power, including fast charging above 300kW; 50–500 kWh battery pack size	Recreational Craft Directive and ES-TRIN, with declaration of conformity
II · OEM programmes	In collaboration with client, tailoring the platform to vessel series or specific equipment	Bespoke control units to complete system deliveries, GUI in the client's brand	Defined per programme	Including the forthcoming EU Cyber Resilience Act
III · Workboats and ferries	Workboats, cargo vessels and passenger ferries in commercial service	Hybrid or full electric; redundant twin DC switchboards with bus tie	10–500 kW per propulsion unit; 200–1,000 kWh battery pack size	DNV, ES-TRIN, Norwegian Maritime Authorities
IV · Project-based complex vessels	One-off vessels: multiple propulsors, thrusters, large battery installations	Series or parallel hybrid with redundant drive sections	Scales horizontally by adding units	DNV redundancy type R1, ES-TRIN independent power sources; FMEA support

ONE PLATFORM

Every segment runs the same control platform and the same core system functions. What changes is the number of units on the bus, system capacity, and redundancy level. The four are illustrations, not limits.

System architecture

The core powertrain system stays fixed. Everything around it is configured to the vessel: how far the redundancy goes, how large the system grows, and which components it talks to.

Redundancy

TAILORED TO THE OPERATION

The platform can be configured with redundancy on multiple levels, so the level matches the exact operation of the vessel and its regulatory framework.

- **Control.** Dual controllers, so no single error can impair the operability of the system.
- **Network.** Single line, ring bus or double communication network, so no single problem renders the entire system inoperational.
- **Power.** Standardized high voltage power distribution units installed in parallel with bus ties, so no downstream defect can leave the vessel without propulsion or maneuverability.

Scalability

ANY SIZE, ANY OPERATION

Universal component interfaces and a scalable control network mean the system can be configured for vessels of any size and any operation. Any number of propulsion and thruster units, shore connections and battery sizes integrate into the same system.

The modular design also keeps the vessel future friendly: a larger battery pack or another auxiliary system can be added tomorrow without a complete system redesign or extensive modification. Just add another unit.

Universal interfaces

ANY COMPONENT, ANY VENDOR

The platform offers universally compatible hardware interfaces towards all components and subsystems and can therefore be used to integrate any kind of component into our integrated system. Standardized interfaces mean high quality and low risk in the production phase, and the simplest possible route to integrating complex systems: reliable, cost-efficient solutions that are easy to service with a simple spare part strategy.

Inverters and drives | Batteries | Onboard chargers | DC/DC converters | Heat pumps | Hydraulic Power Units | and many more

Tell us your operational profile. We will give you the optimized system.

Pascal engages while the vessel's duty cycle is still being defined, and recommends the configuration that wins on cost, performance and/or operability.

Hydrodynamicists, naval architects, system architects and power system engineers in house, supporting customers through every part of the project lifecycle: from early concept and operational profiling to engineering, commissioning and operation.

Hydrodynamics | Naval architecture | System architecture | Power systems

PASCAL TECHNOLOGIES

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ENQUIRIES

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QUESTIONS AND PROJECTS

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