The power wires are usually considered part of the power distribution system, and the signal wires or optical fibers are usually considered part of the navigation and control systems, but the tether still warrants consideration as its own system because there are a number of issues, including length, strength, durability, drag, buoyancy, flexibility, and storage/deployment/retrieval that are distinctly tether-specific.

2.6. Strategy E: Use the Design Spiral

You'll quickly learn that one of the greatest challenges in designing, building, and maintaining an underwater vehicle (or any other complex system) is that interactions between systems within the supersystem complicate design and repair. Often it seems as though fixing or improving one part of the system creates a whole new set of problems in other parts of the system, leading to tremendous delays and frustration.

For example, you might discover that your ROV is underpowered, so you decide to use bigger thrusters. Fine, but by moving to bigger thrusters, you have also increased vehicle weight and placed additional demands on the power system. To compensate, you must change the ballast and increase the capacities of the power supply and thruster control circuitry. All of that costs a lot more money, which means you won't be able to afford that nice camera upgrade you were hoping for. Just remember that in systems, everything affects everything else.

The **design spiral** is a strategy for confronting this type of problem throughout the design phase of a project. It takes advantage of the natural hierarchical structure of systems by allowing you to focus on the right system level at the right time, yet acknowledges that there are interactions within and among levels that must be taken into account.

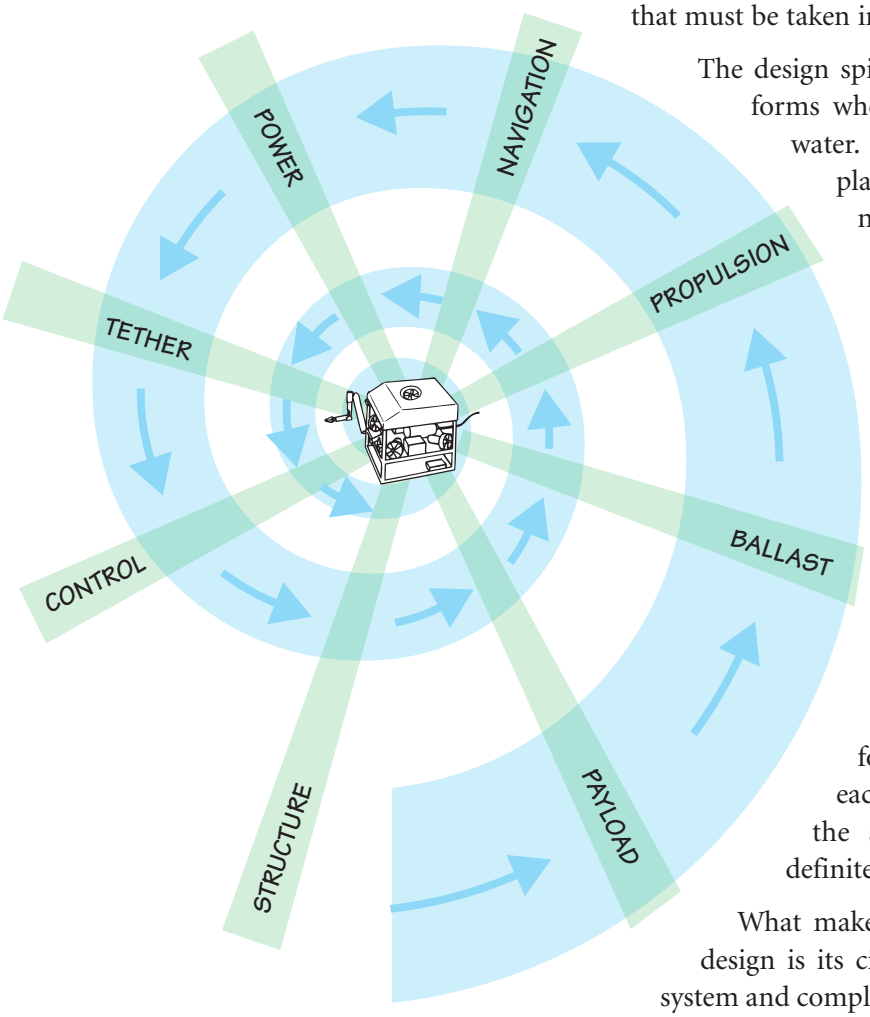

Figure 2.13: Design Spiral

In the design spiral, each system gets revisited again and again, each time with more precise knowledge of the other systems. Ultimately the process converges on the final vehicle design.

The design spiral is like the vortex of swirling water that forms when you pull the plug on a bathtub full of water. It spirals round and round, passing near places it has visited before, but always a little narrower and more focused than on previous passes.

The vortex is wide at the top, where it starts. Similarly, at the beginning of any project, the options are wide open. There is usually an undisciplined mass of ideas and data as well as a wide range of possible options for solving tricky technical problems. But as soon as you start making firm decisions about any particular system, the options begin to narrow, just like the vortex. Deciding on a thruster type determines the power necessary to propel the vehicle, and that narrows the list of options available for controlling that power. As you address each round of technical solutions in your design, the spiral tightens and plans become more definite.

What makes the design spiral so powerful in systems design is its circular nature. Instead of starting with one system and completing its design before moving on to the next