# Lessons Learned for Modernizing Nuclear Power Plants from the Development of the Zumwalt Class Destroyer


**Jeffrey C. Joe**
Plant Modernization Pathway

**James A. Pharmer**
Naval Air Warfare Center
Training Systems Division

**Lawrence J. Hettinger**
Lawrence J.
Hettinger PhD, LLC


LWRS Program researchers have been collaborating with research colleagues from the U.S. Navy to use macro-ergonomics to help the U.S. nuclear industry proactively address future operational uncertainties. Continuous improvement of nuclear energy operations depends on the effective introduction of modern technologies—automation, advanced human-system interface concepts, remote sensing technologies, drones—and new approaches to management and operations that can effectively leverage these capabilities. Concepts and practices such as the virtual organization and integrated operations are needed, and macro-ergonomic concepts are essential to the strategic decision-making processes needed for successful plant modernization and organizational restructuring.

For virtually all commercial nuclear power plants, operations and maintenance (O&M) costs are significant contributors to the costs of plant ownership. The U.S. Navy found itself in a very similar situation in the late 1990s, experiencing similar O&M concerns, which if not addressed could affect future operational readiness.

The Navy pursued a radically new vision to replace traditionally crew-heavy platforms, a process that eventually led to the design and deployment of the USS Zumwalt class of destroyers—the *Zumwalt*, (seen in Figure 9), is the Navy's first 'optimally manned' surface combatant of its size. The *Zumwalt* was also the first of its kind to rely heavily on the performance of automated systems and significantly transformed organizational concepts.

Recently, LWRS Program researchers at Idaho National Laboratory (INL) organized and participated in four virtual conferences with U.S. Navy researchers, designers, and training personnel who were directly involved in the *Zumwalt* design process. The goal of these discussions was to explore lessons-learned from the latter that could benefit approaches to similar efforts within the nuclear energy industry.

The *Zumwalt* was a highly complex systems engineering effort, many of whose features resemble those encountered by the nuclear industry:

- **Safety-critical system** – U.S. Navy warships are inherently safety-critical both in terms of the risk of the overall mission and in the potential risks to the personal safety and well-being of sailors and others. Improving system safety and reliability are also generally viewed as key strategic warfighting advantages and objectives.
- **High reliance on automation and remote sensing** – The significant reduction in crew size from legacy destroyers to the *Zumwalt* (from approximately 350 to the *Zumwalt's* current crew size of approximately 140) without sacrifice of safety or operational capability meant that enormous amounts of 'human workload' had to be replaced with automated and expert systems— as well as remote sensing technologies for inspection and damage control.
- **Concern with operational/life cycle costs** – A significant factor underlying the *Zumwalt's* design was a desire by the U.S. Navy to control the operational and life cycle costs associated with its surface warfare fleet. According to a Government Accountability Office report (GAO-03-520), a major driver of these costs is staffing. Therefore, through significant use of automation and integrated operations, the U.S. Navy sought to design a ship that could be a more cost-effective replacement of its legacy class.
- **Desire to leverage emerging technologies to replace human workload and, improve safety and performance** – The emergence of new expert systems and automated technologies at the turn of the 21st

century was a significant driver in the U.S. Navy's decision to explore the design and development of a highly automated ship.

- **Multiple stakeholders** – Significant government presence: The *Zumwalt's* design incorporated inputs from over 1,000 sailors during its design as one means of ensuring a 'sailor-centric' design. Additionally, inputs from across the breadth of the systems engineering team – which included multiple corporations and U.S. Navy agencies – were continually solicited and incorporated into the ship's final design.

Many of the lessons learned from the *Zumwalt* experience merit serious consideration by the nuclear industry, particularly in light of the many compelling similarities between the two situations. Some of the major takeaways from our discussions were as follows:

- Organizational and cultural factors play a critical role in all levels of system design, and effectively managing their influence throughout the modernization process is vital. The *Zumwalt* design team approached the issue by including over 1,000 active duty sailors in the requirements generation, design, and test processes. "Making sure everyone is heard" was a key objective, particularly the ultimate end users—the sailors.
- In situations in which functions currently performed by humans are expected to instead be performed by technology, it is vital to verify that technical systems are able to do just that. While this change adds a supervisory role to the human, it is nevertheless critical to demonstrate that the human workload that is 'removed' with fewer personnel on staff has been effectively 'replaced' by an enabling technology and associated new processes and procedures.
- Human-in-the-loop testing and concepts of operations exercises are particularly helpful in identifying all manner of human-systems integration issues, ranging from those associated with the design of individual and shared human-systems interfaces to those related to the viability of novel organizational and operational concepts.

The *Zumwalt* design process was intended to address many similar issues and opportunities currently confronting the nuclear power industry. Faced with a need to reduce O&M costs, the U.S. Navy pursued a highly novel, culturally disruptive design process that was heavily reliant on automation, remote sensing, and other state-of-the-art technologies. The design process itself involved significant user input and a broad, human-systems integration focus that helped to counteract the effects of traditional systems engineering stove piping. These techniques and principles are at the core of the macro-ergonomic approaches that can also be used in transformative efforts in the nuclear industry.

***Figure 9. USS Zumwalt. (US Navy photo)***