

Advanced I&C for Fault-Tolerant Supervisory Control of Small Modular Reactors

PI: Daniel G. Cole, University of Pittsburgh

Collaborators: Daniel Mossé, University of Pittsburgh

Of Pittsburgh

Program: RCD&D: Instrumentation, Control, Human, Machine Interface

ABSTRACT:

The purpose of this research is to develop advanced instrumentation and control (I&C) techniques for supervisory control of advanced small modular reactors (SMRs). This research specifically uses moltensalt reactors (MSR) for development of a supervisory control, but the technology developed here could apply to all reactor types. A significant challenge for economically viable SMRs is that staffing needs must be addressed to reduce demands for labor-intensive surveillance, testing, and inspection. At the same time, appropriate control must be maintained for safety and to meet regulatory requirements.

In this research, we will develop a supervisory control approach to enable automated control of advanced SMRs. By design the supervisory control system will be have an hierarchical, interconnected, adaptive control architecture. A considerable advantage to this architecture is that it allows subsystems to communicate with increased precision and facilitates monitoring of the processes of individual SMRs and of the plant. We will investigate the deployment of automation, monitoring, and data collection technologies to enable operation of multiple SMRs. Each SMR's controller will collect and transfer information from its sensors, optimize instructions, and transfer commands to actuators. As information is passed from the an SMR to the supervisory controller, the supervisory controller will direct their actions and manage plant processes. The information processed at the supervisory level will provide operators with the necessary information needed for reactor, module, and plant management.

In conjunction with the supervisory control effort, we will investigate techniques for fault-tolerance to maintain a safe level of operational normalcy in the presence of anomalies. This second focus is on the fault-tolerance of the supervisory control architecture, the network that supports it, and the impact of fault-tolerance on a multi-unit SMR plant. To achieve the fault-tolerance and resiliency desired for supervisory control, we architect fault tolerance at the various levels of supervisory control. The local processes will be ensured, via a backup network, that their messages will be both received by the SMR controllers. Similarly, the controllers of each SMR unit will have guaranteed transmission of messages to and from the supervisory controller.

The supervisory control system proposed here will support the operational goals of SMR concepts. This includes reduced demand for labor-intensive surveillance, testing, and inspection. The ability to monitor the plant improves surveillance enabling condition based monitoring of equipment and just-in-time maintenance. Online monitoring can be used to better track control system transients that result in reactor trip, thus avoiding undesirable reactor trips and diversion events. Finally, the system can better adapt to changing operating conditions during plant transients including load-following procedures.