Simulator Assumptions and the Path to the Dark Side

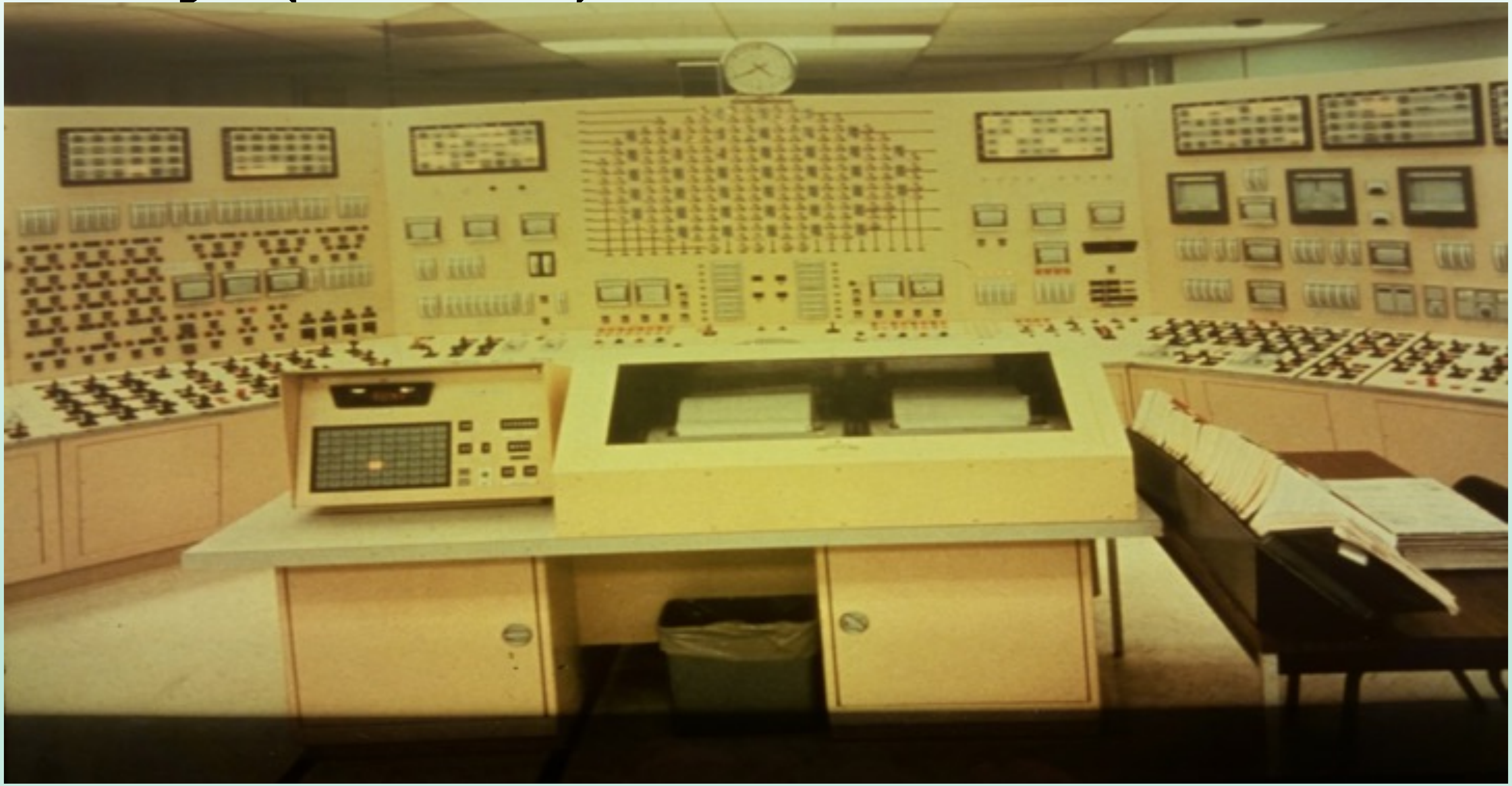
Introduction

- History.
- Grow your own Simulation Engineer.
- Assumptions:
  - State machines and Alan Turing.
  - What it means to use steady state equations.
  - Time is non-liner in the simulation environment.
- What is the impact on us?
- Questions.

History

- Roots in the Aviation Simulator Industry.
  - Link, Singer-Link, L3 Comunications (now L3 Technologies), GE Apollo Systems, TRAX EPRI, GSE, … really too many players to mention.
  - Original testing terminology found there too.
  - The BWR Nuclear Power Plant Simulator
    - Dick Mills (4 Papers)
    - Walter Cronkite and the CBS Evening News (NRC inspector comment “Good enough”)
- ISA77.20 and ANSI 3.5 (1985).
- Art to Engineering.

History (cont.)



GENERAL ELECTRIC

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SUMMARY This report documents the development and analyses of the digital dynamic models developed for the Nuclear Power Plant Simulator.

These models provide the functional capability of determining the plant's dynamic response. They specify the mathematical procedures and sequences of real time calculation which will be implemented on a GE/PAC 4020 process computer in the facility.

These models simulate the dynamic characteristics of the single cycle boiling water reactor (SCBWR)/turbine systems with associated control and pertinent balance of plant equipment necessary for operator training.

The various parameters and physical configurations of the plant modelled are determined for the Dresden II 810 MW nuclear power plant. The basic equations and techniques employed, however, are equally applicable to dynamic simulation of any similar type ...

RETURN TO GRIDLEY

ELECTRIC UTILITY ENGINEERING OPERATION

Grow your own Simulation Engineer

- Three input areas. Engineers, Operators, Computer Science (Engineering).
- Then OJT for all the other areas.
- Years of development. But junior engineers become contributors early on in there area in which they have been trained.
- But you need a wide variety of projects to keep people involved and training them worthwhile.
- Therefore not all organization are good candidates to do this.
- Talbot's rule of thumb 80% internal, 20% specialized, for large organizations.

State Machine Alan Turing

- This is for computer science GEEKs (because I am one)
- S x P➔S*
  - Where:
  - S is the Complete state of the machine.
  - P is the Process that acts on the state.
  - S* is the resulting State of the machine after the Process.
- Dick Mills "My Momma Dun Told me Not to Use Common as Scratchpad." and Asynchronies Processes.
  - Flash, simulator dark, simulator stall (TTY bell).
  - Only happened every 100 to 200 hours of operation.

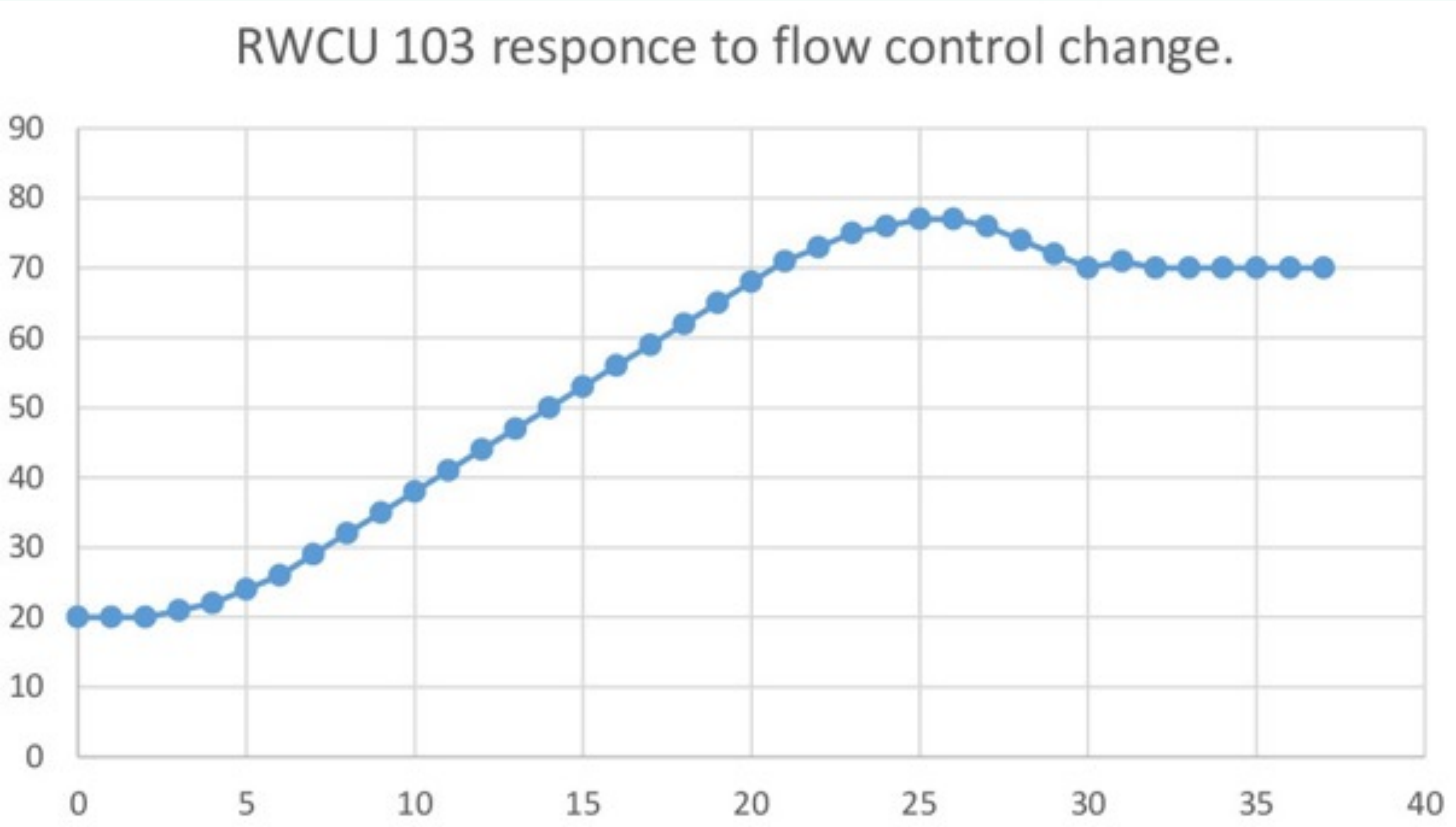
State Machine Alan Turing (cont.)

- Dick Mills "My Momma Dun Told me Not to Use Common as Scratchpad." and Asynchronies Processes. (Continued)
  - Finally found that it was on Panel 7 because Mr. Mills felt a flash of heat.
  - The software engineer (wanting to conserve memory) at the beginning of the software set all the light bits and then calculated which lights to turn off.
  - The GPAC 4020 I/O process would run and catch the I/O common in that state.
  - The electrical transient was sufficient to cause I/O cabinet problems and drum fault.
  - Expansion of local memory for scratchpad fixed the problem.

Steady State Equations

- Start with the general Thermal Hydraulic Equations
- Make assumptions to get to the STEADY STATE Equation.
- As long as we keep the time step small we can get the dynamic response from the steady state equations.
- BUT underlying assumption the change in each control volume is small during any time step.
- Rule of Thumb (shout out to Peter Andersen) V_c>>Max(W_f)*KdelT.
- Why Worry? Because something will always come along and disturb the system.

Steady State Equations (cont.)



Steady State Equations (cont.)

- Turbine Control Valves.
- Other control systems may impact the sensed control parameter (steam driven pumps in the feed water systems).
- Piece wise valve curves used in valve modeling.
- Second order differential with other control elements.

Non-liner Time

- Inherent in the basic functions of simulation is dealing with discontinuous time (Initialize, Run, Freeze, Backtrack, Replay, …).
- Distributed Control Systems are inherently liner time systems. Look at how they handle failure on the real systems.
- Stimulation, Emulation, and Virtual Simulation. Each solution had a hand in development of how this simulator executive interfaced with the controls.
- Repeatability standards are a fact of the environment for testing the simulation.

Non-liner Time (cont.)

- The Challenge:
  - Recall the “Aged” 100 % power condition and run the same heat balance graphs on the simulator.
  - Upset the plant to auto initiate a plant trip.
  - Freeze the simulator and recall, one time and one time only, the “Aged” 100% power condition. Run the simulation, recording the same 100% steady state data from the simulation acceptance test.
  - Compare the data recorded with the acceptance test data if there is no difference then you’ve passed the challenge. The more interesting question that some of us may have to answer, is what caused by plant trip?

Non-liner Time

- If you are in the state of not having passed, ask your controls engineer at plant where do the process blocks carry out their computation?
- Draw careful parallels between where and how execution occurs in the real plant and where and how execution occurs in your stimulation, emulation, or virtual simulation of the control system. Is the complete state being saved?
- If you change what is being saved ensure you run the real time test again.

What is the impact on us?

- There is history to stumble over in our industry, but don’t let it keep you from innovating.
- Large organizations need to look toward their input path of senior personnel.
- Keeping your eyes on basic assumptions, can save you a lot of pain and heartache in your projects.
- Planning how to use and maintain the simulator may be a more important question to ask while working up to procurement.

Questions

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