

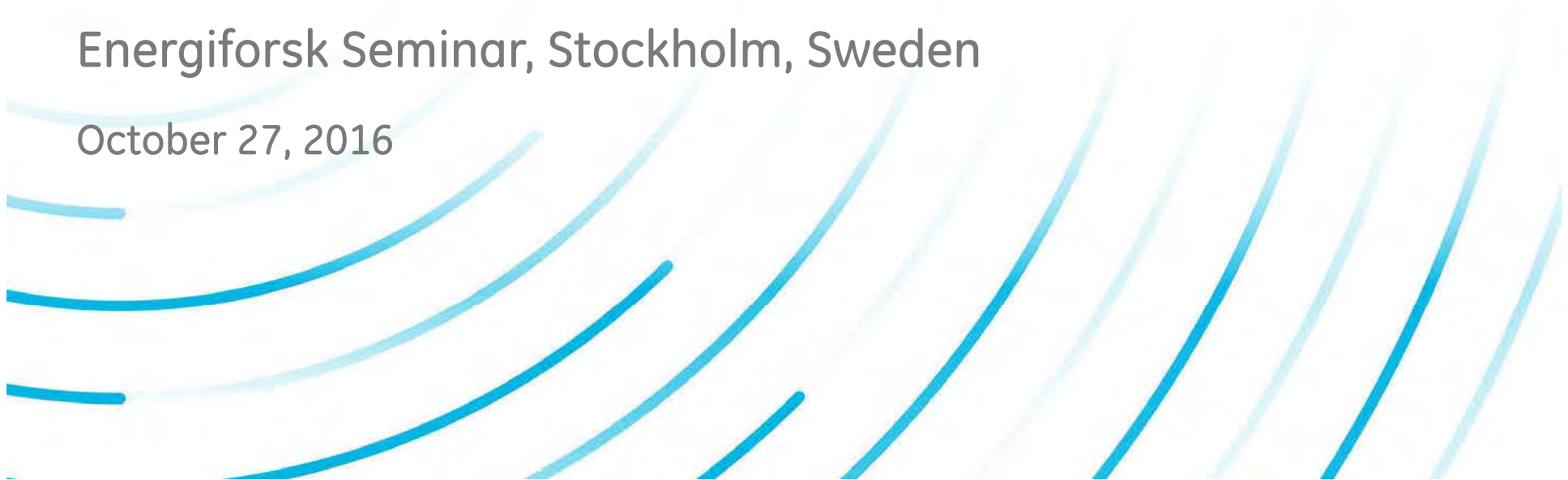


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# Insights from a Recent Analog Redesign Project

Lifetime Extension of Nuclear I&C  
Energiforsk Seminar, Stockholm, Sweden

October 27, 2016



# Agenda

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- Introduction
  - NUMAC
  - EESP
  - LRM
- NUMAC LRM Module Redesign Project
  - Goals
  - Execution
  - Results
  - Lessons Learned

# Introduction

## Nuclear Measurement Analysis & Control (NUMAC)



## Description

- Platform Since 1985
  - To resolve existing problems
    - Excessive drift due to ageing
    - Operating difficulties
    - Increased maintenance
    - Obsolescence
- Modular Design
- Fixed Program Control
- Safety and non-safety
  - LRM, TIP, WRNM, PRM, PRNM, RCMS, SFPLM, and more
- Systems upgraded in 60+ BWRs



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# Introduction

## Extended Exchange Service Program (EESP)



## Description

- Part of GE Hitachi Nuclear Energy's PARTS Asset Management Solutions
- Created to solve industry needs
- Long term partnership
- GE Hitachi (GEH) owns and manages EESP inventory
- On-demand exchange
  - Customer orders needed part
  - Part is in stock and shipped
  - Replaced part returned to GEH
  - Part is repaired or refurbished and restocked



# Introduction

## NUMAC Log Radiation Monitor (NUMAC LRM)



## Description

- First LRM installed 1986
- Safety and non-safety applications
- Gamma sensitive ionization chamber
- Six or eight decades
- Standard NUMAC femtoammeter module  
Input current range: 10 fA to 4 mA

# NUMAC LRM Module Redesign Project

## Trigger and Goals

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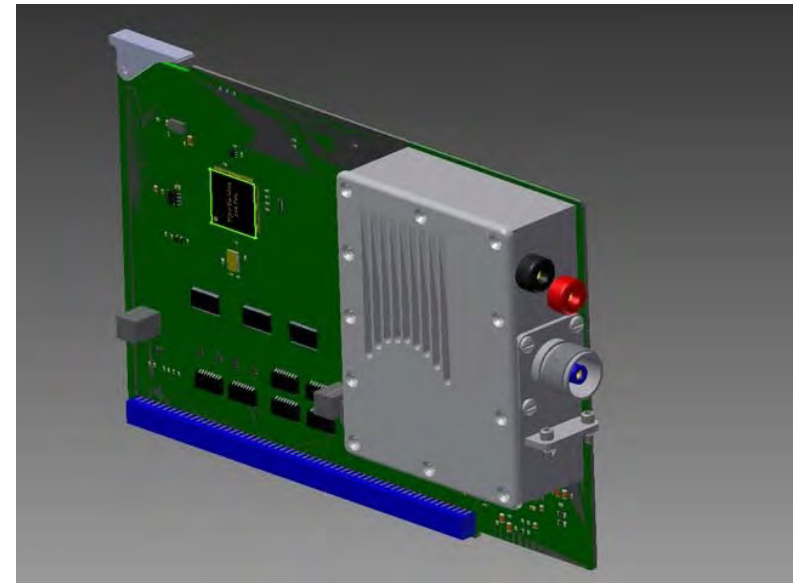
- Low EESP inventory level for the FEMTO module
- Develop a “drop-in” replacement for the FEMTO module that requires no software or hardware modifications to use
- The only required action for the customer is to recalibrate the instrument

# NUMAC LRM Module Redesign Project

## Execution

- Analog amplifier and current converter redesigned
- New thermoelectric cooler and redesigned controller
- Digital interface realized in a Complex Programmable Logic Device (CPLD)
- Employed modern technologies such as 3D CAD/CAM and 3D printing
- Included Qualification Testing

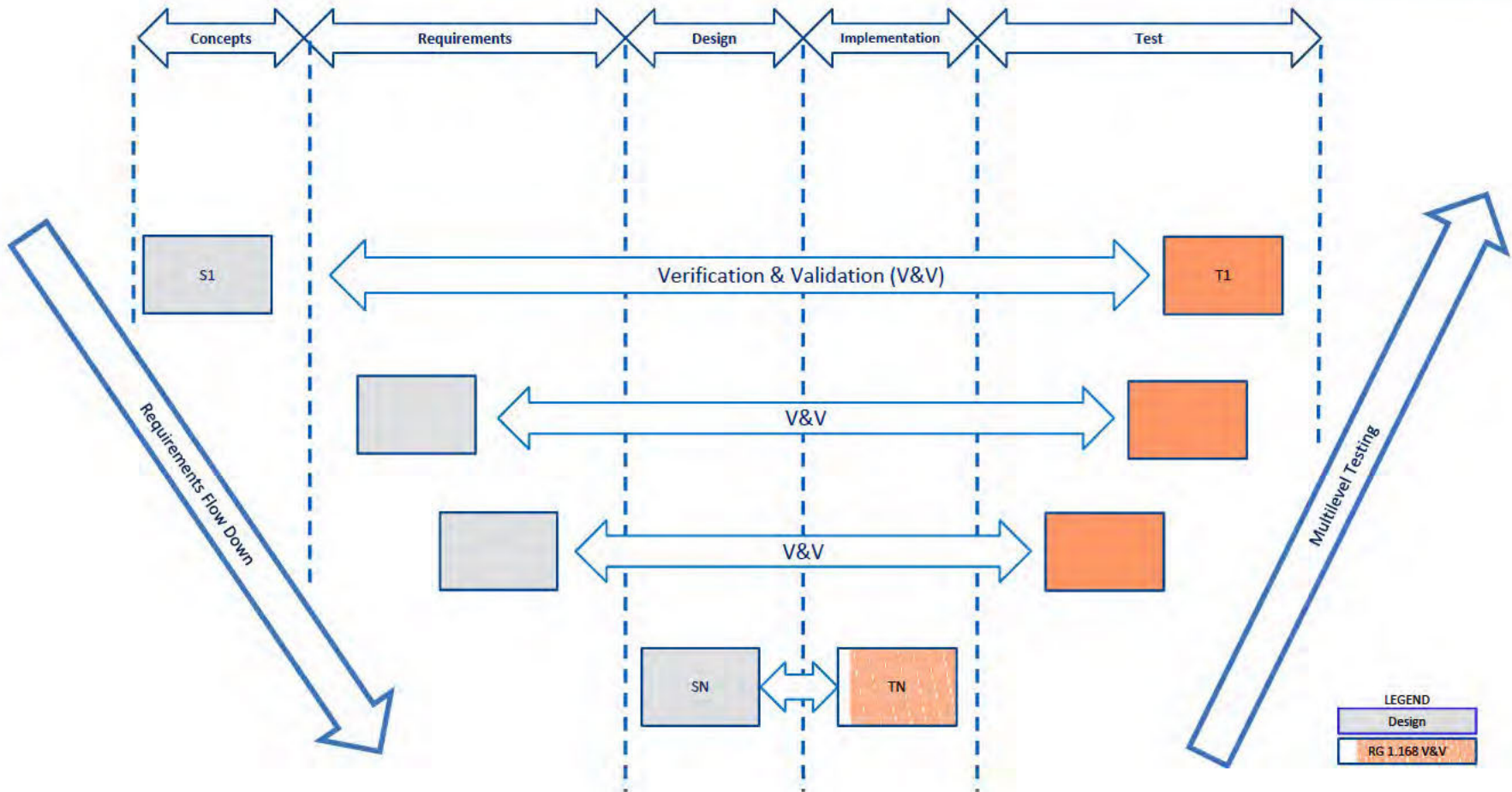
## LRM FEMTO Module



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# NUMAC LRM Module Redesign Project

CPLD Design, Verification, and Validation - Typical RG 1.152 Compliant Digital I&C Development Program





# NUMAC LRM Module Redesign Project

## Results

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- LRM instruments with the new module meet all specified performance requirements
- The new module has passed all design verification tests, including environmental and seismic qualification, as well as EMC analysis
- The new module performs with improved consistency in high humidity and high temperature environments with less maintenance compared with the existing design
- Improved accuracy
- Backwards compatible with all existing NUMAC LRM chassis configurations
- The new module is the result of EESP program and promise of GEH to maintain equipment

# NUMAC LRM Module Redesign Project

## Lessons Learned

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- Nature of this project was vastly different from typical designs in terms of the hardware design and engineering experience requirements
- Due to general lack of experience, a large amount of research and learning was done to understand the existing hardware design resulting in frequent rescheduling
- The actual timeline far exceeded any attempt at traditional scheduling and goal setting
- Use of a different approach to scheduling when research is needed to set perspective and expectations while providing better predictability

# Questions and Discussion





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