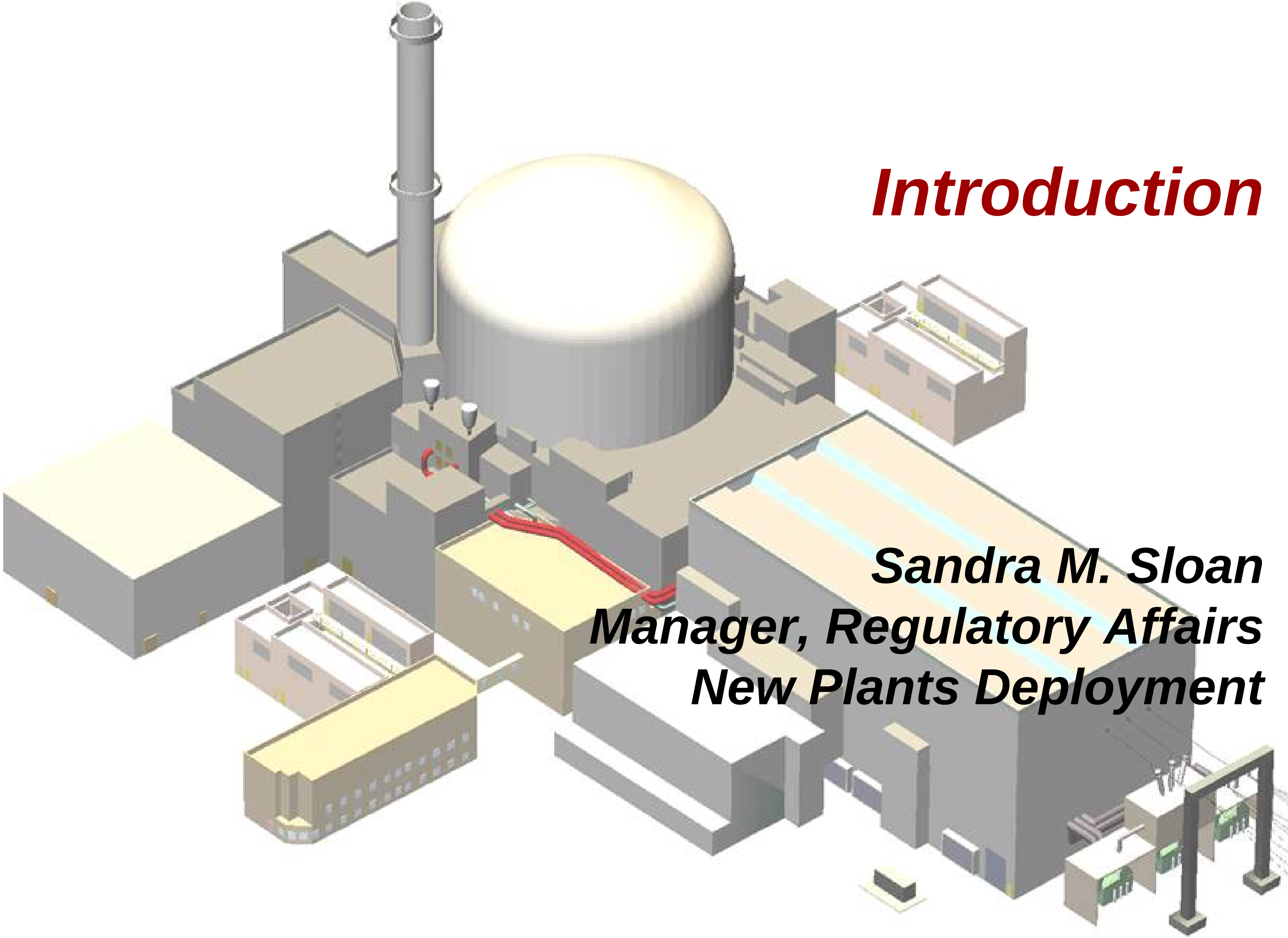
U.S. EPR Pre-Application Review Meeting: Instrument Setpoint Methodology Topical Report

AREVA NP Inc. and the NRC
January 30, 2007

Introduction



Sandra M. Sloan
Manager, Regulatory Affairs
New Plants Deployment

Agenda

- > Introduction and meeting objectives (S. Sloan)
- > Instrument Setpoint Methodology (S. Black)
  - Introduction
  - Methodology description
  - Protection system setpoints
  - Setpoint methodology application
- > Summary and next steps (S. Sloan)

Meeting Objectives

> Provide an overview of the Instrument Setpoint Methodology Topical Report for the U.S. EPR Protection System

> Follow-up meeting from the August 31, 2006 meeting on I&C Systems Overview and Special Topics

> Provide an opportunity for early NRC feedback on the Instrument Setpoint Methodology Topical Report

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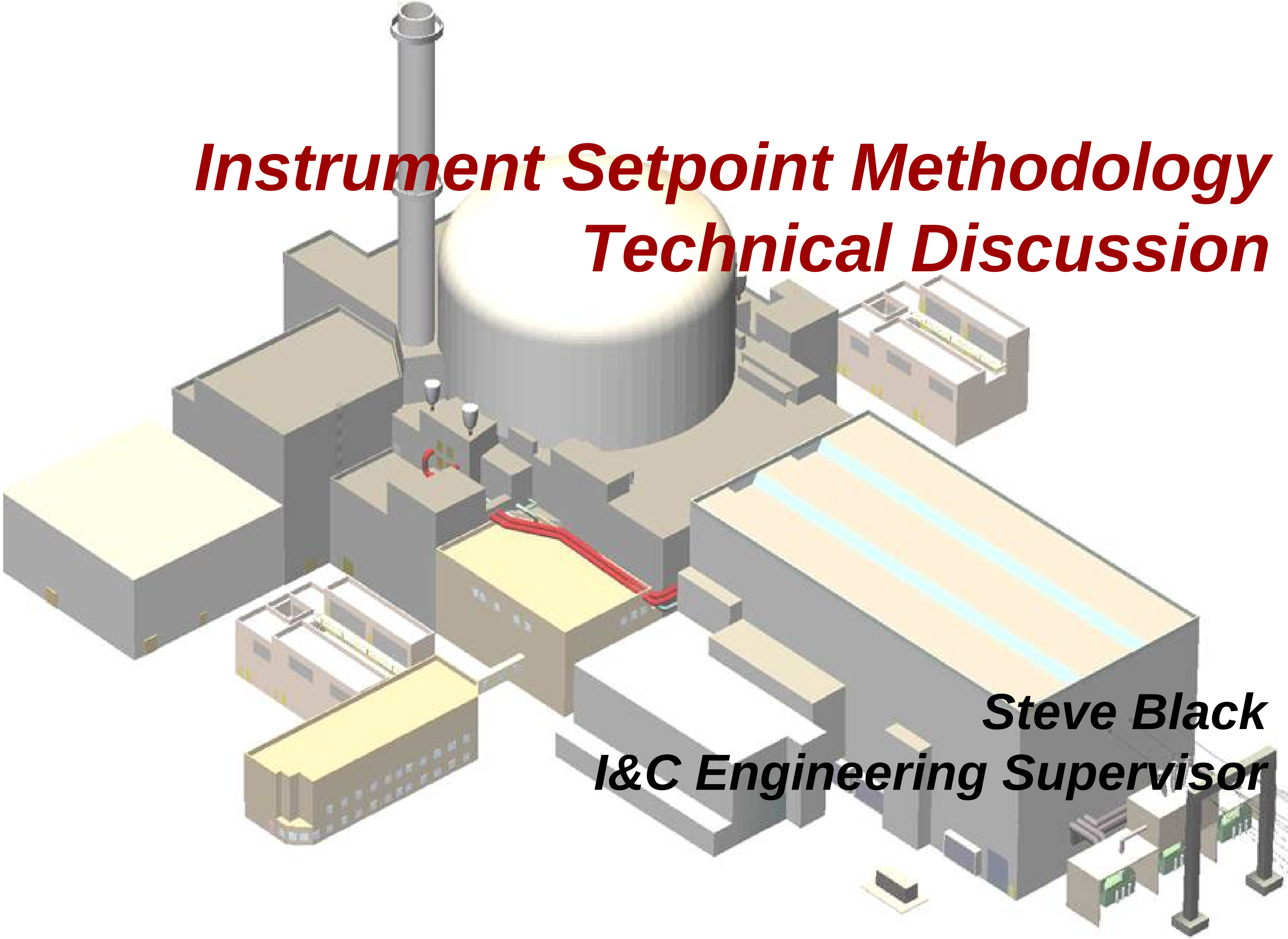
Instrument Setpoint Methodology Technical Discussion



Steve Black
I&C Engineering Supervisor

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Topical Report Format

1. Introduction
2. Methodology Description
   - Background
     - Regulatory basis
     - Statistical discussion
     - Latest industry issues
   - General Methodology
3. Protection System Setpoints
   - System inputs
   - Complex functions
4. Setpoint Methodology Application
   - Establishment of setpoints
   - Performance test acceptance criteria
   - Protection functions summary
   - Assumptions
5. Summary and Conclusions

Introduction

> **Objectives**

- **Develop an Instrument Setpoint Methodology that conforms to the latest industry guidance**
- **Ensure incorporation of applicable regulatory guidance into the Instrument Setpoint Methodology**

> **Scope**

- **Reactor trips**
- **Engineered Safety Features Actuation System (ESFAS)**

Background

> **Regulatory basis for the methodology**
- **10 CFR 50.36, Paragraph c(1)(ii)(A)**
- **GDC 13 and 20**
- **Regulatory Guide 1.105**
- **SRP Appendix 7.1-A**
- **BTP HICB-12**
- **DG-1145**

> **Statistical discussion**
- **95/95 tolerance limit**
- **Random uncertainties fall between (-)2 sigma and (+)2 sigma 95.6% of the time**

Background (continued)

- Latest industry issues
  - TSTF-493
  - ANSI/ISA-67.04.01-2006
    - ISA-RP67.04.02-2000 (under revision)
  - RIS 2006-17
  - Regulatory Guide 1.105 (under revision)

Latest Industry Issues
TSTF-493

> **Originally developed to address NRC concerns regarding technical specification requirements for limiting safety system settings**

> **Revised to address NRC concerns that the original document:**

- **Did not generically define the scope of the instruments affected**
- **Determination of as-left tolerance not adequate**

> **Currently using TSTF-493 Rev. 1 for development of topical report**

AREVA NP is monitoring the development of TSTF-493 and resolution of NRC comments

Latest Industry Issues
ANSI/ISA-67.04.01-2006

- Replaced the term Allowable Value (AV) with Performance Test Acceptance Criteria (PTAC)
- Effects expected to be present during the test will be included in the calculation of the PTAC, which are typically limited to:
  - Setting tolerance
  - Instrument uncertainties during normal operation including drift
  - Measurement and test equipment uncertainties
- Defined
  - LTSP = AL – TLU
  - NTSP = AL – TLU – Margin
- Technical specification AVs represent the upper limit of PTACs

Latest Industry Issues

RIS 2006-17

> **The Nominal Trip Setpoint (NTSP) must be equal to or more conservative than the Limiting Trip Setpoint (LTSP)**

> **AV is the limiting value of an instrument's as-found trip setting used during surveillances**

> **TSTF-493, Rev. 0 did not sufficiently address the NRC staff concern**

- **The setting tolerance band is less than or equal to the square root of the sum of the squares of reference accuracy, measurement and test equipment, and readability uncertainties**
- **The setting tolerance is included in the total loop uncertainty (TLU)**
- **The pre-defined test acceptance criteria band for the as-found value includes either the setting tolerance or the uncertainties associated with the setting tolerance band, but not both of these**

Latest Industry Issues
Regulatory Guide 1.105

> Currently under revision to address the latest issues

> AREVA NP's application of major anticipated changes

- The performance test acceptance criteria will typically use no more than the SRSS combination of the reference accuracy, measurement and test equipment error (M&TE), measurement and test equipment readability (M&TEr), and drift
- The Technical Specification AV is equal to the LTSP plus the PTAC

AREVA NP is actively monitoring changes to the industry guidance on Instrument Setpoint Methodology

General Methodology

$$CU = [(PM_R)^2 + (PE)^2 + (RA_{SENSOR})^2 + (DR_{SENSOR})^2 + (TE_{SENSOR})^2 + (SP_{SENSOR})^2 + (ARE_{SENSOR})^2 + (SE_{SENSOR})^2 + (ATE_{SENSOR})^2 + (CT_{SENSOR})^2 + (MTE_{SENSOR})^2 + (DR_{DPS})^2 + (TE_{DPS})^2 + (CT_{DPS})^2 + (MTE_{DPS})^2]^{½} + PM_B + IR_B + B$$

(Note: The above equation is for example only and may not be all inclusive.)

where:

CU	=	Channel Uncertainty
PM_R	=	Process Measurement Uncertainty (random)
PE	=	Primary Element
RA_{SENSOR}	=	Sensor Reference Accuracy
DR_{SENSOR}	=	Sensor Drift
TE_{SENSOR}	=	Sensor Temperature Effect
SP_{SENSOR}	=	Sensor Static Pressure Effect
ARE_{SENSOR}	=	Sensor Accident Radiation Effect
SE_{SENSOR}	=	Sensor Seismic Effect
ATE_{SENSOR}	=	Sensor Accident Temperature Effect
CT_{SENSOR}	=	Sensor Calibration Tolerance
MTE_{SENSOR}	=	Sensor Measurement and Test Equipment
DR_{DPS}	=	Digital Protection System Drift Effect
TE_{DPS}	=	Digital Protection System Temperature Effect
CT_{DPS}	=	Digital Protection System Calibration Tolerance
MTE_{DPS}	=	Digital Protection System Measurement and Test Equipment
PM_B	=	Process Measurement Uncertainty (bias)
IR_B	=	Insulation Resistance Effects (bias)
B	=	Bias (others)

The above equation is aligned with ISA-RP67.04.02-2000 Annex L example calculations

General Methodology (continued)

> Typical sensor effects

- Normal conditions
  - RA_{SENSOR}
  - DR_{SENSOR}
  - TE_{SENSOR}
  - CT_{SENSOR}
  - MTE_{SENSOR}
- Accident conditions (harsh environment)
  - RA_{SENSOR}
  - DR_{SENSOR}
  - ARE_{SENSOR}
  - ATE_{SENSOR}
  - CT_{SENSOR}
  - MTE_{SENSOR}

> Digital protection system racks

- Normal conditions only
  - DR_{DPS}
  - TE_{DPS}
  - CT_{DPS}
  - MTE_{DPS}

Protection System Setpoints

System Inputs

- Scope
  - Reactor trip
  - ESFAS
- Provide a list of all inputs to the protection system
- Provide tables for each input to identify
  - Applicable uncertainties for consideration
  - Error combination methodology for each function
  - Protection functions for each input (i.e., Reactor Trip, ESFAS)

Aligns with Owner's Group Activities

Protection System Setpoints

Examples of Tables

> **The following slides provide examples of specific uncertainty equations for different setpoints:**

- **Trips under normal conditions**
- **Trips under accident conditions (e.g., harsh environment)**

(Note: Protection functions that are required to mitigate an event causing a harsh environment use "A" to designate accident conditions.)

> **Methodology is illustrated by use of "x.xx" and "0"**

- **"x.xx" - applicable error terms**
- **"0" - non-applicable error terms**

Example of Table - Normal Conditions

RT on High PRZ Pressure

Normal Environment	Uncertainty (% Span)
Process & Misc Effects	
Process Measurement (PM)	0
Primary Element (PE)	0
Insulation Resistance Error (IR_B)	0
Sensor	
Sensor Reference Accuracy (RA_{SENSOR})	± x.xx
Sensor Drift (DR_{SENSOR})	± x.xx
Sensor Temperature Effect (TE_{SENSOR})	± x.xx
Sensor Static Pressure Effect (SP_{SENSOR})	0
Sensor Accident Radiation Effect (ARE_{SENSOR})	0
Sensor Seismic Effect (SE_{SENSOR})	0
Sensor Accident Temperature Effect (ATE_{SENSOR})	0
Sensor Calibration Tolerance (CT_{SENSOR})	± x.xx
Sensor Measurement and Test Equipment (MTE_{SENSOR})	± x.xx
Digital Protection System (DPS)	
DPS Drift (DR_{DPS})	± x.xx
DPS Temperature Effect (TE_{DPS})	± x.xx
DPS Calibration Tolerance (CT_{DPS})	± x.xx
DPS Measurement and Test Equipment (MTE_{DPS})	± x.xx

Loop Accuracy

$CU = [(RA_{SENSOR})^2 + (DR_{SENSOR})^2 + (TE_{SENSOR})^2 + (CT_{SENSOR})^2 + (MTE_{SENSOR})^2 + (DR_{DPS})^2 + (TE_{DPS})^2 + (CT_{DPS})^2 + (MTE_{DPS})^2]^{½}$

$CU = [(x.xx)^2 + (x.xx)^2 + (x.xx)^2 + (x.xx)^2 + (x.xx)^2 + (x.xx)^2 + (x.xx)^2 + (x.xx)^2 + (x.xx)^2]^{½}$

$CU = x.xx_{Random}$

CU = x.xx% span

Example of Table - Accident Conditions

RT on Low PRZ Pressure (A), RT on Low DNBR(A), Safety Injection Signal on Low-Low PRZ Pressure (A)

Harsh Environment	Uncertainty (% Span)
Process & Misc Effects	
Process Measurement (PM)	0
Primary Element (PE)	0
Insulation Resistance Error (IR_B)	+ x.xx
Sensor	
Sensor Reference Accuracy (RA_{SENSOR})	± x.xx
Sensor Drift (DR_{SENSOR})	± x.xx
Sensor Temperature Effect (TE_{SENSOR})	0
Sensor Static Pressure Effect (SP_{SENSOR})	0
Sensor Accident Radiation Effect (ARE_{SENSOR})	± x.xx
Sensor Seismic Effect (SE_{SENSOR})	0
Sensor Accident Temperature Effect (ATE_{SENSOR})	± x.xx
Sensor Calibration Tolerance (CT_{SENSOR})	± x.xx
Sensor Measurement and Test Equipment (MTE_{SENSOR})	± x.xx
Digital Protection System (DPS)	
DPS Drift (DR_{DPS})	± x.xx
DPS Temperature Effect (TE_{DPS})	± x.xx
DPS Calibration Tolerance (CT_{DPS})	± x.xx
DPS Measurement and Test Equipment (MTE_{DPS})	± x.xx

Loop Accuracy

$$CU = [(RA_{SENSOR})^2 + (DR_{SENSOR})^2 + (ARE_{SENSOR})^2 + (ATE_{SENSOR})^2 + (CT_{SENSOR})^2 + (MTE_{SENSOR})^2 + (DR_{DPS})^2 + (TE_{DPS})^2 + (CT_{DPS})^2 + (MTE_{DPS})^2]^{1/2} + IR_B$$

$$CU = [(x.xx)^2 + (x.xx)^2 + (x.xx)^2 + (x.xx)^2 + (x.xx)^2 + (x.xx)^2 + (x.xx)^2 + (x.xx)^2 + (x.xx)^2 + (x.xx)^2]^{1/2} + x.xx_{Bias}$$

$$CU = x.xx_{Random} + x.xx_{Bias}$$

$$CU = x.xx\% \text{ span}$$

Protection System Setpoints

Complex Functions

> **Characteristics of complex functions**
- **Consist of multiple inputs**
- **In most cases are not combined solely using the SRSS method**
- **Often contain complex algorithms in the digital protection system such that other statistical methodologies are more appropriate for the error analysis**

Protection System Setpoints

Complex Functions (continued)

> This topical report addresses the following complex protection functions

- SIS Actuation on ΔPsat
- Rod Position Indication

> Uncertainties are determined using partial derivatives

Use of partial derivatives is in accordance with ISA-RP67.04.02-2000 Annex K

Protection System Setpoints

Complex Functions (continued)

> The following complex functions will be addressed in a separate report

- Departure from Nucleate Boiling Ratio (DNBR)
- High Linear Power Density (HLPD)
  - Included in the above two analysis is the uncertainty of the Self Powered Neutron Detectors (SPNDs)
- High Core Power Level (HCPL)/Low Saturation Margin
- Anti-dilution

Methodology Application
Establishment of Setpoints

> **Increasing process**

LTSP	= AL – CU
NTSP	= AL – CU – Margin

> **Decreasing process**

LTSP	= AL + CU
NTSP	= AL + CU + Margin

where:

AL	= Analytical Limit
CU	= Channel Uncertainty
LTSP	= Limiting Trip Setpoint
NTSP	= Nominal Trip Setpoint

Consistent with NRC guidance in RIS 2006-17

Methodology Application
Performance Test Acceptance Criteria (PTAC)

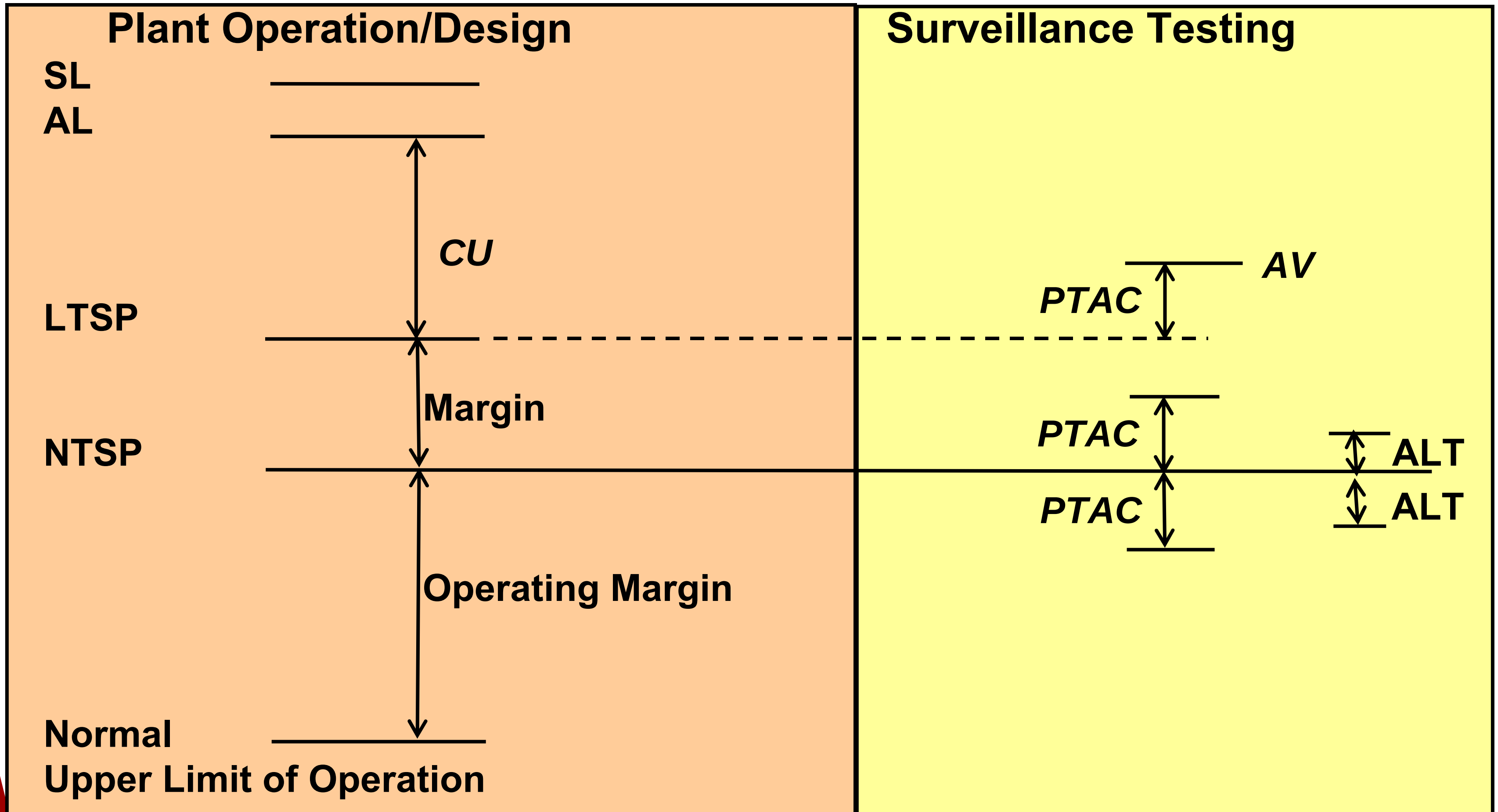
> Digital protection system (DPS) racks
- $PTAC_{DPS} = [(RA_{DPS\ Module1})^2 + (RA_{DPS\ Module2})^2 + (\ldots\ldots)^2 + (M\&TE)^2 + (M\&TEr)^2]^{1/2}$

> Sensor calibration
- $PTAC_{SENSOR} = [(RA)^2 + (M\&TE)^2 + (M\&TEr)^2 + (DR)^2]^{1/2}$

> Total loop calibration
- $PTAC_{LOOP} = [(RA)^2 + (M\&TE)^2 + (M\&TEr)^2 + (DR)^2 + (RA_{DPS\ Module1})^2 + (RA_{DPS\ Module2})^2 + (\ldots\ldots)^2]^{1/2}$

Methodology Application

Setpoint Relationship Illustration



(Note: This illustration is for an increasing trip.)

Methodology Application
Protection Functions

Example of a Protection Functions Summary Table

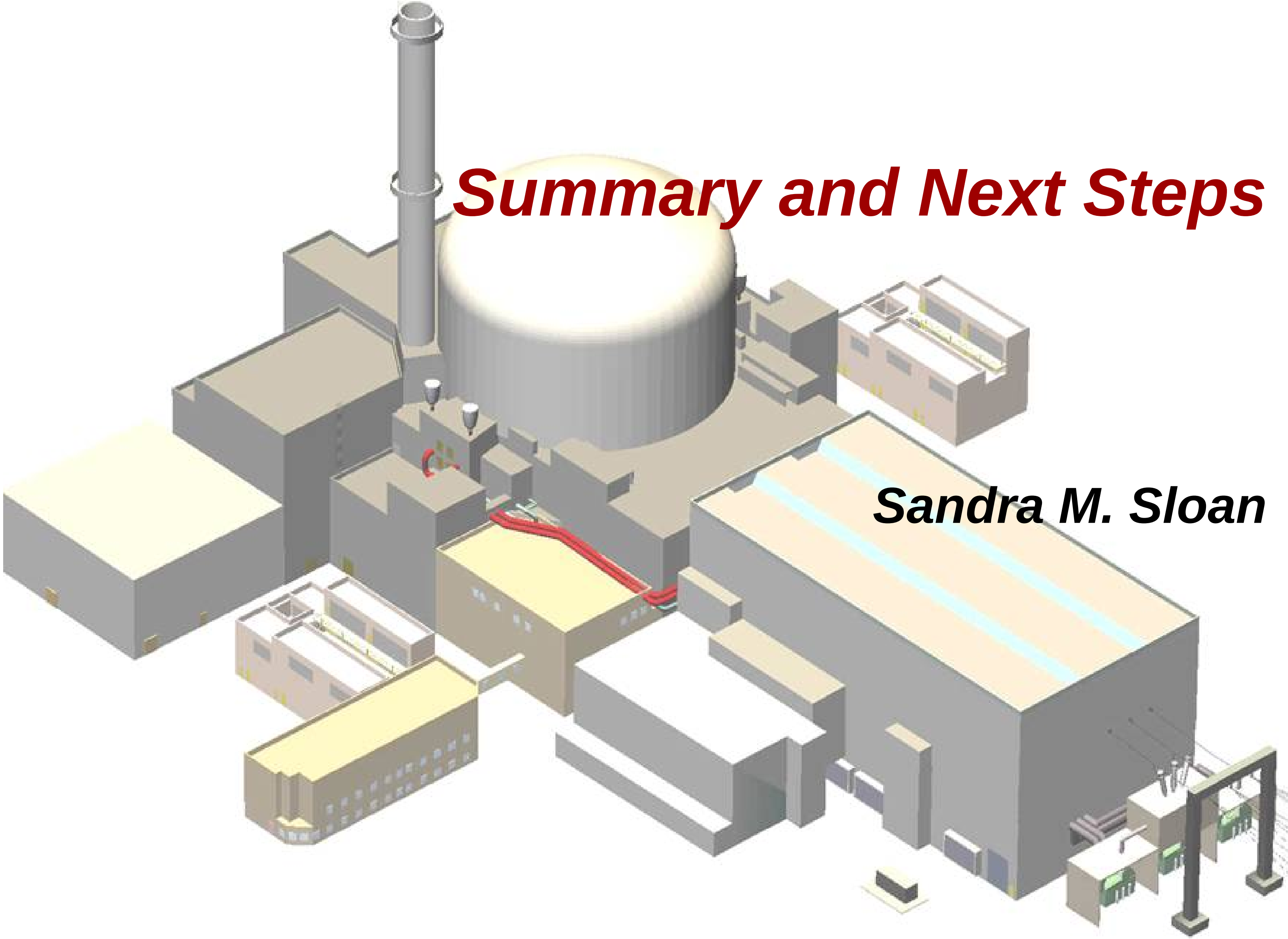
Note: Protection functions that are required to mitigate an event causing a harsh environment use "A" to designate accident conditions.

Input Parameter	Protection Function	AL	CU		LTSP	NTSP	AV
			Random	Bias			
Pressurizer Pressure Input	RT on Low PRZ Pressure (A)	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	RT on High PRZ Pressure	x.xx	x.xx	-	x.xx	x.xx	x.xx
	RT on Low DNBR (A)	-	x.xx	x.xx	-	-	-
	SIS on Low-Low PRZ Pressure (A)	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
Pressurizer Level Input	RT on High PRZ Level	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
	Shutdown CVCS Charging Line	x.xx	x.xx	x.xx	x.xx	x.xx	x.xx
Others	………………………….						

Setpoint Methodology Conclusion

- AREVA NP's instrument setpoint methodology meets regulatory requirements and is aligned with latest industry guidance
- Scope of this topical report includes reactor trips and ESFAS
  - Other complex functions will be addressed in a separate report
- The topical report will address trips for both normal and accident conditions

Summary and Next Steps



Sandra M. Sloan

Summary

> **The Instrument Setpoint Methodology:**
  - **Complies with regulatory requirements**
  - **Considers latest developments**
    - **ANSI/ISA-67.04-01-2006**
    - **RIS 2006-17**
    - **TSTF-493 Rev. 1**

> **This type of interaction helps us understand NRC expectations and thus produce a high-quality DC submittal**

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Next Steps

- AREVA NP will submit the Instrument Setpoint Methodology Topical Report in March 2007
- Next meetings:
  - February 22, 2007: Digital Protection System Design Topical Report pre-submittal
  - AREVA NP proposes a May 2007 Instrument Setpoint Methodology Topical Report post-submittal meeting

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Abbreviations and Acronyms

AL	Analytical Limit
ALT	As-left Tolerance
ARE	Accident Radiation Effect
ATE	Accident Temperature Effect
AV	Allowable Value
B	Bias
CT	Calibration Tolerance
CU	Channel Uncertainty
CVCS	Chemical and Volume Control System
DNBR	Departure from Nucleate Boiling Ratio
DPS	Digital Protection System
DR	Drift
EPR	Evolutionary Power Reactor
ESFAS	Engineered Safety Features Actuation System
HCPL	High Core Power Level
HLPD	High Linear Power Density
I&C	Instrumentation and Controls
IR	Insulation Resistance Error

Abbreviations and Acronyms (Continued)

>	LTSP	Limiting Trip Setpoint
>	M&TE	Measurement and Test Equipment
>	M&TEr	Measurement and Test Equipment Readability
>	NTSP	Nominal Trip Setpoint
>	PE	Primary Element
>	PM	Process Measurement Uncertainty
>	PRZ	Pressurizer
>	PTAC	Performance Test Acceptance Criteria
>	RA	Reference Accuracy
>	SE	Seismic Effect
>	SIS	Safety Injection Signal
>	SL	Safety Limit
>	SP	Static Pressure Effect
>	SPND	Self Powered Neutron Detectors
>	SRSS	Square Root Sum of the Squares
>	TE	Temperature Effect
>	TLU	Total Loop Uncertainty