U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Proposed Rule to Incorporate by Reference IEEE Std 603-2009 into 10 CFR 50.55a

August 4, 2015

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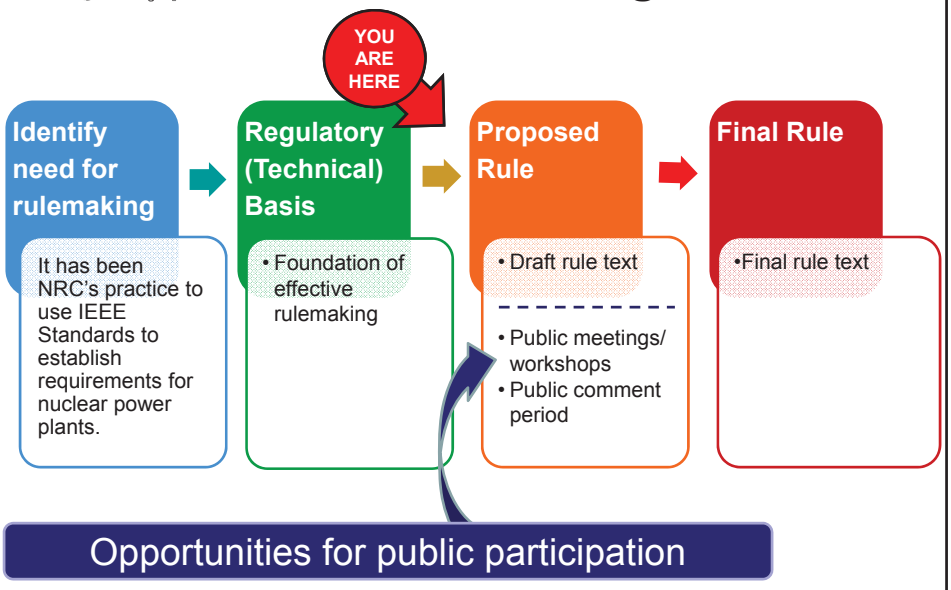
Agenda

1:00 – 1:15	Opening Remarks and Introductions
1:15 – 2:00	Overview of the Rule
2:00 – 2:45	Independence Conditions
2:45 – 2:55	Break
2:55 – 3:50	Public Discussion
3:50 – 4:00	Closing Remarks
4:00	Adjourn

Meeting Purpose

- Discuss preliminary draft proposed rule language to incorporate by reference IEEE Std 603-2009 into the NRC's regulations.
  - Available at ADAMS Accession No. ML15204A643
- Provide an opportunity for informal questions and answers about the preliminary rule language and the staff's presentation.
  - Not accepting formal comments at this time.

Rulemaking Timeline



Rulemaking for 10 CFR 50.55a

Incorporation by Reference of Institute of Electrical and Electronics Engineers Standard 603-2009
Webinar Presentation

Presented by: IEEE Std. 603 Rulemaking Working Group

Richard Stattel (NRR)
Royce Beacom (NRR)
Michael Waterman (RES)
Deanna Zhang (NRO)

Agenda

- **Describe Reasons for this Rulemaking Activity**
- **Describe changes made to IEEE Std. 603**
- **Describe Proposed Changes to Regulation**
  - **Incorporate new version of IEEE 603 2009 by reference into 10 CFR 50.55a.**
  - **Make changes to applicability of the standard**
  - **Impose new conditions on the use of IEEE 603**
- **Discuss Draft Reg. Guide to update RG 1.153 which is being issued concurrently with this rule**
- **IEEE Standards Revisions Process**
- **Questions to the Public**

Reasons for Changing the Rule

Reasons for this Rulemaking Activity

- The current IBR Standard IEEE 603-1991 has become out of date:
  - It does not address the introduction of digital technologies such as FPGA based systems into I&C safety systems
  - It does not address certain design concepts that have been made possible with digital technologies:
    - Data Communications
    - System Self Diagnostics
    - Integration of systems
    - Consolidation of Functions
- Newer I&C systems are being designed and built to the newer versions of the standard.
  - New I&C systems are designed to 1998 standard
  - Alternative Standard Evaluations required for license submittals
- There has been much discussion between the NRC staff and applicants over the existing applicability statements (Clarification of applicability is needed)

Objectives of Rulemaking Activity

- **The proposed rule would update the current NRC regulations to include the most recently promulgated version of IEEE Std 603-2009**

  "Criteria for Safety Systems for Nuclear Generating Stations"

  - **Define the conditions which would allow existing licensees to replace plant equipment while maintaining existing licensing basis.**
  - **Defines the conditions for which existing permit, license, certificate, standard design, and standard design approvals would be required to address the new standard in modifications and applications.**
  - **Imposes conditions upon the use of IEEE 603-2009 in the areas of system integrity, independence, maintenance bypass, and maintenance of records.**

What Changed in the Standard

The new version of the standard:

1. Addresses potential safety issues that might arise from incorporating components using advanced technologies in safety systems.
2. Contains additional and updated references and eliminates references that are no longer in effect.
3. Provides added guidance to address electromagnetic compatibility issues for I&C safety systems.
4. Adds new criteria to address the potential for common cause failures
5. Adds classification requirements for equipment not credited to perform a safety function but connected to safety-related equipment
6. Removes a requirement in section 6.7, "Maintenance bypass," for meeting the single failure criterion during maintenance activities
7. Adds a specific requirement for electrical isolation and digital communication independence between safety systems and non-safety systems

What Changed in the Standard

The new version of the standard:

1. Addresses potential safety issues that might arise from incorporating components using advanced technologies in safety systems.

Sections affected:

Definitions – Expanded the definition for “Component” to include non-hardware based system components such as software, and firmware.

Multiple references to IEEE 7-4.3.2 added to address computer and digital technology based systems. (5.3, 5.4, 5.5, 5.6.4, & 5.15)

What Changed in the Standard

The new version of the standard:

2. Contains additional and updated references and eliminates references that are no longer in effect.

Sections Affected:

Entire Standard. It is normal practice for IEEE to completely update all references within a standard as a part of the revision process.

The NRC endorses many of these referenced standards through its Regulatory Guidance documents. We therefore rely upon updates to these Reg. Guides to address standard updates.

What Changed in the Standard

The new version of the standard:

3. Provides added guidance to address electromagnetic compatibility issues for I&C safety systems.

Sections Affected:

Informative Annex B was added to the IEEE Std. 603 standard during the 1998 revision.

Section 4 “Safety System Design Basis” Item “g” includes a foot note which refers to the new EMC annex.

What Changed in the Standard

The new version of the standard:

4. Adds new criteria to address the potential for common cause failures

Sections Affected:

5.16 – Common-cause failure criteria – This new clause was added to the standard. It refers to IEEE Std. 7-4.3.2.

What Changed in the Standard

The new version of the standard:

5. Adds classification requirements for equipment not credited to perform a safety function but connected to safety-related equipment

Sections Affected:

5.6.3.1 Interconnected equipment – (Subsection of Independence Criteria)

What Changed in the Standard

The new version of the standard:

6. Removes a requirement in section 6.7, “Maintenance bypass,” for meeting the single failure criterion during maintenance activities

Sections Affected:

Section 6.7 – Maintenance Bypass - Establishes performance criteria for situations requiring systems or portions of systems to be placed in a bypass state.

EXCEPTION Clause of Section 6.7 (1991)

Maintenance Bypass (in Clause 6.7 of IEEE Std. 603-1991) Capability of a safety system to accomplish its safety function shall be retained while sense and command features equipment is in maintenance bypass. During such operation, the sense and command features **shall** continue to meet the requirements of 5.1 and 6.3.

EXCEPTION: One-out-of-two portions of the sense and command features are not required to meet 5.1 and 6.3 when one portion is rendered inoperable, provided that acceptable reliability of equipment operation is otherwise demonstrated (that is, that the period allowed for removal from service for maintenance bypass is sufficiently short to have no significantly detrimental effect on overall sense and command features availability).

EXCEPTION Clause of Section 6.7 (2009)

Maintenance Bypass (in Clause 6.7 of IEEE Std. 603-2009) Capability of a safety system to accomplish its safety function shall be retained while sense and command features equipment is in maintenance bypass. During such operation, the sense and command features **should** continue to meet the requirements of 5.1 and 6.3.

NOTE: For portions of the sense and command features that cannot meet the requirements of 5.1 and 6.3 when in maintenance bypass, acceptable reliability of equipment operation shall be demonstrated (e.g., that the period allowed for removal from service for maintenance bypass is sufficiently short, or additional measures are taken, or both, to ensure there is no significant detrimental effect on overall sense and command feature availability).

What Changed in the Standard

The new version of the standard:

7. Adds a specific requirement for electrical isolation and digital communication independence between safety systems and non-safety systems

Sections Affected:

5.6.3.1 – Interconnected Equipment – Added the following sentence:

"Isolation devices shall ensure electrical isolation and digital communication independence."

5.6.4 – Detailed Criteria – Added reference to IEEE 7-4.3.2 for criteria on separation and isolation of data processing functions of interconnected computers.

What is Changing in the Regulations

The proposed Rule:

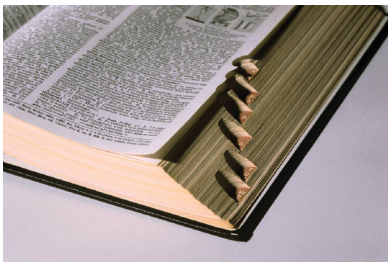
1. Provides definitions for several terms used in various standards and within the proposed regulation.

2. Establishes conditions for applicability of the new and previously incorporated versions of the standard.

3. Imposes several conditions for the use of IEEE Std. 603 2009.

4. Retains the incorporation by reference for IEEE Std. 279-1971, IEEE Std. 603-1991, and the IEEE Std. 603-1991 correction sheet dated January 30, 1995.

New Definitions



Definitions Provided in FRN

1. Terms Defined in FRN

- Protection System / Safety System
- Best Estimate
- Current Reactors
- Data Communication
- Defense-in-depth
- Diversity
- Function / Functionality
- Hardwired Connections
- New Reactors
- Physical Mechanism
- Predictable
- Repeatable
- Safety Benefit
- Safety Function
- Safety System Function
- Signal Sharing
- Support(s) the Safety Function

What is Changing in the Regulations

2. Establishes conditions for applicability of the new and previously incorporated versions of the standard.

Construction Permit, Standard Design Certification, Combined License, or Manufacturing License Issue Date	10 CFR 50.55a(h)(2) Paragraph	Standard Applicability[1]
Nuclear power plant construction permits issued before January 1, 1971	**(h)(2)(i)**	Licensing Basis IEEE Std 603-1991[2]
Nuclear power plant construction permits issued on or after January 1, 1971 and before May 13, 1999	**(h)(2)(ii)**	IEEE Std 279-1971 IEEE Std 603-1991
Standard design certifications issued before May 13, 1999	**(h)(2)(iii)**	IEEE Std 279-1971
Standard design certifications issued on or after May 13, 1999, but before 30 days after **[THE EFFECTIVE DATE OF THE RULE]**	**(h)(2)(iv)**	IEEE Std 603-1991
Standard design certifications issued 30 days after **[THE EFFECTIVE DATE OF THE RULE]**	**(h)(2)(v)**	IEEE Std 603-2009
Applications submitted 30 days after [EFFECTIVE DATE OF THIS RULE] for nuclear power plant construction permits and operating licenses under 10 CFR part 50.	**(h)(2)(vi)**	
Nuclear power plant combined licenses and manufacturing licenses under 10 CFR part 52 issued 30 days after **[THE EFFECTIVE DATE OF THE RULE]**	**(h)(2)(vii)** Referenced SDC[3] issued before 30 days after **[THE EFFECTIVE DATE OF THE RULE]**	IEEE Std 279-1971 IEEE Std 603-1991
	(h)(2)(vii) Referenced SDC[3] issued 30 days after **[THE EFFECTIVE DATE OF THE RULE]**	IEEE Std 603-2009

Examples of modifications and replacements of components, functions, and systems

Example	Modification or Replacement Example	Was Functionality, Technology, Independence strategy, or Diversity strategy changed?				Applicable Standard
		F	T	I	D	
1	Power supply replaced in one power train division	N	N	N	N	Licensing Basis Standard
2	Pressure measurement instrumentation replaced with new pressure measurement instrumentation in all four channels of the protection system	N	N	N	N	
3	DNBR safety function replaced with improved DNBR safety function	N	N	N	N	
4	Added functionality to DNBR safety function to allow manual selection of one of four channels of input data for each DNBR channel	Y	N	Y	N	IEEE Std 603-2009 (subject to the conditions in paragraph (h)(4) through (h)(7))
5	Modified a protection system with components based on a different technology	N	Y	N	N	
6	Modified channels or divisions such that independence was changed	N	N	Y	N	
7	Modified a safety function such that protection system diversity strategy was changed	Y	N	N	Y	

What is Changing in the Regulations

3. Imposes several conditions for the use of IEEE 603 2009.

Regulations Affected:

50.55a(h)(4) – Amplify “System Integrity” requirements
50.55a(h)(5) – Amplify “Independence” requirements
50.55a(h)(6) – Correct reference, “Checking Operational Availability.”
50.55a(h)(7) – Clarify requirements for use of “Maintenance Bypass”
50.55a(h)(8) – Provide requirement for “documentation”

System Integrity

50.55a(h)(4) – Amplify “System Integrity” requirements

Applicable Section of IEEE 603:
Section 5.5 “System Integrity”

New requirement added:

In order to assure the integrity and reliable operation of safety systems, safety functions shall be designed to operate in a predictable and repeatable manner.

Independence

Independence

50.55a(h)(5) – Amplify “Independence” requirements

Applicable Section of IEEE 603:
Section 5.6 “Independence”

i. Provides requirements for applicants to address independence among redundant portions of safety systems.
ii. Provides requirements for applicants to address independence between safety systems and other systems.
iii. Detailed Criteria: Clarifies requirements that apply to section 5.6 of IEEE Std. 603-2009.

Independence

50.55a(h)(5) – Amplify “Independence” requirements

i. Provides requirements for applicants to address independence among redundant portions of safety systems.

Criteria Applies to System Architecture

Imposes new requirement for applicant to perform analysis activity to address the following:

1) Safety system internal and external hazards,
2) Extent of interconnectivity between redundant portions of the safety system, and
3) Impact of failures or degradation in one portion of a safety system on the ability of redundant safety system portions to accomplish the safety functions.

Independence

50.55a(h)(5) – Amplify “Independence” requirements

ii. Provides requirements for applicants to address independence between safety systems and other systems.

Criteria Applies to System Architecture

Imposes new requirement for applicant to perform analysis activity to address the following:

1) Hazards posed by other systems on the safety system,
2) Extent of interconnectivity between the safety system and other systems, and
3) Impact of failures or degradation in other systems on the ability of the safety system to accomplish the safety functions.

Independence

50.55a(h)(5) – Amplify “Independence” requirements

iii.Clarifies requirements that apply to section 5.6 of IEEE Std. 603-2009.

Provides Detailed Criteria for the application of Independence Criteria.

A. Independence of Signal Processing
B. Fault Detection Criteria
C. Current Reactor Independence Criteria
D. New Reactor Independence Criteria

Independence

50.55a(h)(5) – Amplify “Independence” requirements

A. Signals between redundant safety divisions and signals from a non-safety-related system to a safety division must be processed in a manner that does not impair the safety functions of any safety system division.

Independence

50.55a(h)(5) – Amplify “Independence” requirements

B. Safety system divisions must detect and mitigate signal faults and failures received from outside the safety system division in a manner that does not impair the safety system safety functions of the division.

Independence

50.55a(h)(5) – Amplify “Independence” requirements

C. For current reactors, communications or signals from outside the safety division during operation must support safety or provide a safety benefit.

Independence

D. For new reactors,

I. Data communications between safety and non-safety systems must be one-way, enforced by a physical mechanism, from safety to non-safety systems while the affected portion of the safety system is in operation.

II. Signals between redundant portions of safety systems may be shared only if the signals are required to perform a safety function.

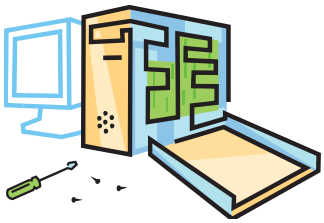
III. A safety system may receive signals from non-safety systems while the safety system is in operation only if the received signal supports diversity and automatic anticipatory reactor trip functions. These signals must be transmitted over a hardwired connection using means other than data communication.

IV. Applicants for design certifications, standard design approvals, or manufacturing licenses who propose an alternative under 10 CFR 50.55a(z) for complying with the requirement in paragraph (h)(5) above for data communications independence shall identify direct or indirect communication pathways to safety systems from other systems.

Independence

- Proposed paragraph (h)(5)(iv) imposes additional requirements on the applicant of design certifications, standard design approvals, and manufacturing licenses if they propose an alternative approach to the independence conditions imposed in the proposed rule. Specifically, these applicants would need to identify:
  - Any direct pathways from other systems (e.g. direct connections from non-safety systems to safety systems).
  - Indirect pathways from non-safety systems to safety systems (e.g. networked connections from non-safety systems to safety systems).
- This additional requirement facilitates the identification of interdependences and failure modes in the alternative design.

System Maintenance / Testing



Maintenance Bypass

50.55a(h)(6) – Correct reference, “Checking the operational availability.”

Applicable Section of IEEE 603:
Section 6.5.1.b “Retaining safety function capability during maintenance bypass.”

The constraints referenced in IEEE Std. 603-2009 Section 6.5.1.b shall be the constraints described in section 6.7, “Maintenance Bypass.”

Maintenance Bypass

IEEE 279:

Channel Bypass or Removal from Operation. The system shall be designed to permit any one channel to **be maintained**, and when required, tested or calibrated during power operation without initiating a protective action at the systems level. During such operation the active parts of the system shall of themselves continue to meet the single failure criterion.

IEEE 603:

Means shall be provided for checking, with a high degree of confidence, the operational availability of each sense and command feature input sensor required for a safety function during reactor operation. This may be accomplished in various ways; for example:

a)By perturbing the monitored variable,

b)Within the constraints **of 6.6**, by introducing and varying, as appropriate, a substitute input to the sensor of the same nature as the measured variable, or

c)By cross-checking between channels that bear a known relationship to each other and that have readouts available..

Maintenance Bypass

50.55a(h)(7) – Clarify requirements for use of “Maintenance Bypass”

Applicable Section of IEEE 603:

Section 6.7 “Maintenance Bypass.”

The maintenance bypass requirements stated in Section 6.7 of IEEE Std. 603 1991 shall be met instead of the requirements stated in Section 6.7 of IEEE Std. 603-2009.

Documentation

Documentation to Support Compliance

50.55a(h)(8) – Documentation supporting compliance

Applicants and licensees shall develop and maintain documentation, analyses, and design details demonstrating compliance with paragraphs (h)(2) through (h)(7) of this section.

Alternatives

Alternatives Clause 10 CFR 50.55a(z)

50.55a(z)

(z) Alternatives to codes and standards requirements. Proposed alternatives to the requirements of paragraphs (b), (c), (d), (e), (f), (g), and (h) of this section or portions thereof may be used when authorized by the Director, Office of Nuclear Reactor Regulation, or Director, Office of New Reactors, as appropriate. The applicant or licensee shall demonstrate that:

(1) Acceptable level of quality and safety. The proposed alternative would provide an acceptable level of quality and safety; or

(2) Hardship without a compensating increase in quality and safety. Compliance with the specified requirements of this section would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Draft Reg. Guide 1.153

Draft Regulatory Guide (DG)-1251 (RG 1.153,

"Criteria for the Power, Instrumentation, and Control Portions of Safety Systems for Nuclear Power Plants,"

Provides additional guidance for implementing the requirements of the rule. This Guide is based upon the discussion in the FRN, and does not modify the scope of 50.55a(h).

Questions for Public

Questions to the Public

1. How frequently should the NRC conduct rulemaking to incorporate by reference the IEEE Std 603 into § 50.55a(h)?
2. What would be a reasonable compliance period for applications or license amendments? For example, should the NRC allow 6 months after publication of a final rule amending § 50.55a(h) before license applications or amendments submitted to the NRC be required to follow the new requirements?
3. Licensees could replace protection systems or safety systems using new functionality or technology over an extended period (e.g., over several refueling outages). At what point in this extended period of modification should the NRC require the protection system or safety system to meet the requirements stated in IEEE Std 603-2009 and the correction sheet dated March 10, 2015? Further, should the NRC also require the parts of the protection system or safety system that were added or modified up to that point to meet the requirements stated in IEEE Std 603-2009 and the correction sheet dated March 10, 2015?
4. Will the proposed independence requirements (§ 50.55a(h)(5)) provide more regulatory certainty for new and current reactor I&C designs? Are there better regulatory criteria to achieve independence than those being proposed? What additional guidance is necessary to implement the proposed criteria?

Questions to the Public

5. How likely is it that applicants and licensees will use the alternative process (as provided in § 50.55a(z)) associated with the new requirements for "independence" (IEEE Std 603-2009, section 5.6)? In what respects would alternatives be sought and what would be the basis for seeking the alternatives?
6. Will the proposed rule language act to limit different design solutions to address independence? If yes, what is the net impact on plant safety?
7. Will the added requirements and restrictions on digital communications independence discourage the nuclear industry from using available technologies to enhance safety system performance or replace aging and obsolete safety systems?
8. Will different requirements for digital system independence for new and current reactors lead to inconsistencies between reactor designs that will impact safety or the ability of the NRC to effectively carry out inspections or regulatory reviews?
9. IEEE Std 603-2009, Clause 5.16, "Common-cause failure criteria," does not provide specific requirements for addressing common-cause failure and the proposed rule does not provide requirements in this area. Should the NRC provide requirements within the final rule addressing common-cause failure criteria?

Questions to the Public

10. The Commission provided defense-in-depth and diversity criteria to address potential common-cause failures in the Staff Requirements Memorandum to SECY-93-087. These criteria are used by the staff in their licensing reviews in accordance with Branch Technical Position 7-19, "Guidance for Evaluation of Diversity and Defense-in-Depth in Digital Computer-Based Instrumentation and Control Systems," of NUREG-0800, "Standard Review Plan." Should these criteria be included in this rulemaking, or should other criteria be included?
11. Given that (1) the Staff Requirements Memorandum to SECY-93-087 was originally written to address advanced reactors (i.e., design certifications under review at that time); (2) new and operating reactors face different I&C challenges such as analog-to-digital upgrades; and (3) defense-in-depth and diversity analyses can promote better understanding, particularly for new and first-of-a-kind reactor designs having little to no operating history, if the common cause failure criteria is included in the rule, should it be applicable to new reactors only?

END

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Safety Case for Independence Conditions in Proposed 10 CFR 50.55a Rule

Deanna Zhang
US NRC
August 4, 2015

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Acronyms

- ART: Anticipatory Reactor Trip
- CFR: Code of Federal Regulations
- D3: Diversity and Defense-in-Depth
- IEEE: Institute for Electrical and Electronics Engineering
- FAD: Final Actuation Device
- HMI: Human Machine Interface
- Std: Standard

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Objective

This presentation provides an overview of the safety case for the independence requirements for new reactors within the draft public version of the 10 CFR 50.55a rule, which in part incorporates by reference IEEE Std 603-2009.

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Agenda

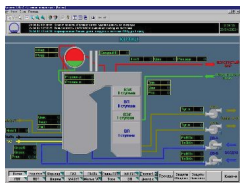
- Background on 10 CFR 50.55a Rulemaking
- Digital Technology Benefits and Failure Modes
- Safety Principle of Independence
- Proposed Rule Independence Conditions
  - New Reactor Independence Conditions
- Safety Case for New Reactor Independence Conditions
- Implementation of Independence Conditions
- Summary and Conclusion

10 CFR 50.55a Rulemaking

- Existing 10 CFR 50.55a(h) rule incorporates by reference IEEE Std 603-1991 and IEEE Std 279-1971.
- Proposed 10 CFR 50.55a rule
  - Incorporation by reference of IEEE Std 603-2009
  - Applicability requirements
  - Inclusion of requirements on predictable and repeatable behavior of safety systems
  - Amplification of the independence section of IEEE Std 603-2009, which includes a bifurcated independence requirements for current and new reactors.

Digital Technology Benefits

- Digital technology provides additional flexibility and functionality in the safety and non-safety functions.



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Potential for New Digital Failure Modes

- Latent failures that could lead to common cause failures.
- Potential for propagation of failures due to increased interconnections.
- Potential for unknown interdependencies, to be created due to added complexity which may create unexpected conditions that could lead to systematic failures.
- Operating experience at domestic and international nuclear power plants has demonstrated that design and implementation errors can adversely impact the safety of complex and highly interconnected I&C designs.

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Independence

- Fundamental principle for the design of safety-critical systems.
- Ensure that a safety division can accomplish its safety functions without adverse influence from outside the division.
- Communications independence addresses potential failures and interdependencies (both known and unknown) between interconnected plant systems.
- Minimize the propagation of errors.

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Proposed Rule Independence Conditions

- Address independence between
  - Redundant portions of safety systems.
  - Safety systems and other systems.
- Analyze
  - Safety system internal and external hazards.
  - Extent of interconnectivity.
  - Impact of failures and degradation.

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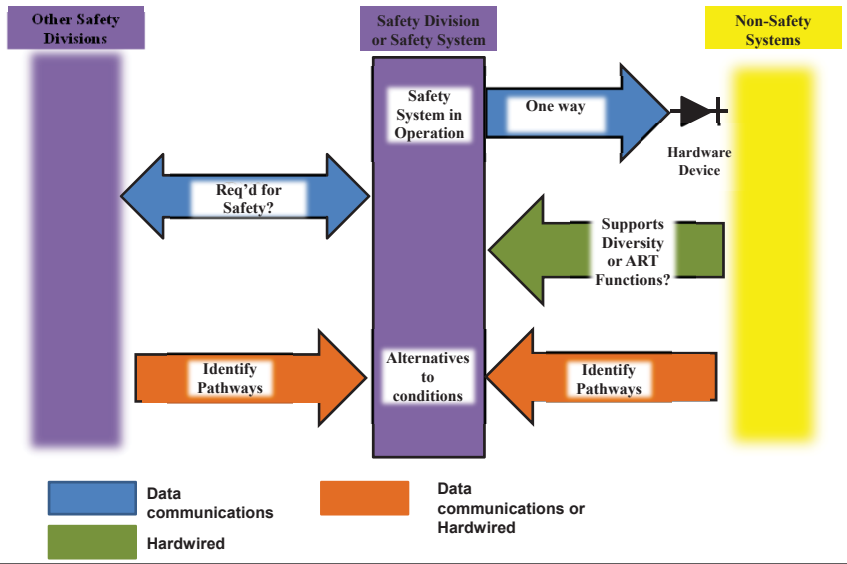
Independence Conditions for New Reactors



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Safety Case

- Limit potential hazards to safety division due to:
  - Unintended behavior of non-safety systems.
  - Propagation of faults from non-safety systems and other safety divisions.
- Elimination of certain potential hazards through hardware architectural design.
- Reduce unnecessary complexity of safety system design.

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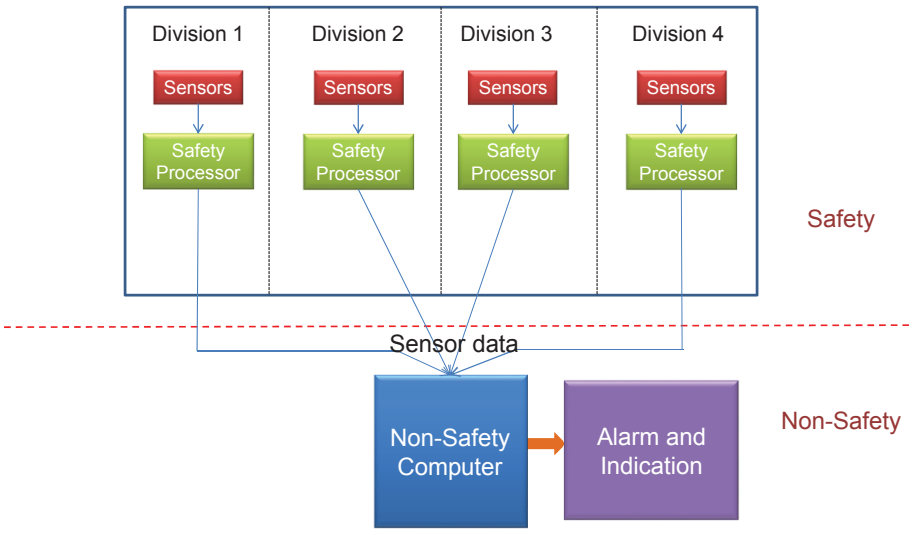
Safety Case Continued

- Allows for certain cases where data communication is necessary to support safety function or diversity and defense-in-depth functions:
  - Interdivisional communication for coincidence voting.
  - Hardwired signals to support D3 or ART functions.

Implementation of Independence Conditions for New Reactors

- Many functionality that supports plant reliability and availability can still be achieved.
- Supports use of digital technology in both safety and non-safety systems.
- Selective design choices will facilitate implementation of digital technology while supporting conformance to proposed independence conditions.

Interdivisional Sensor Checks



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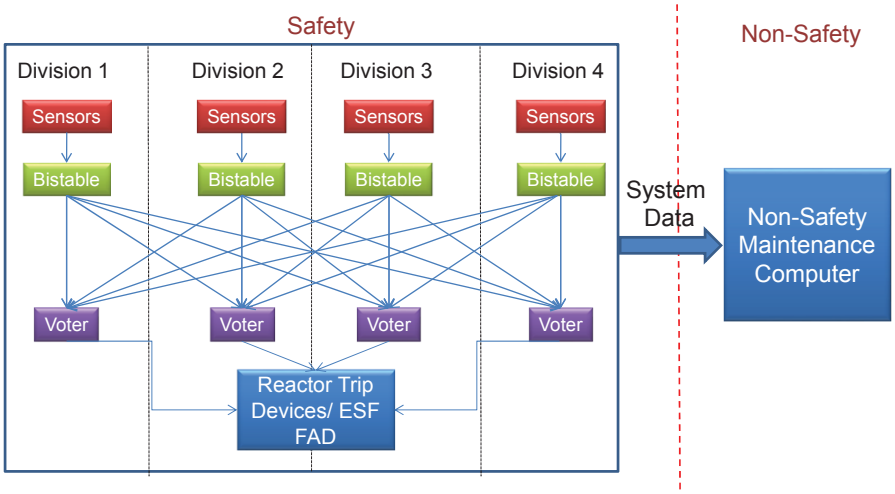
Continuous Diagnostics



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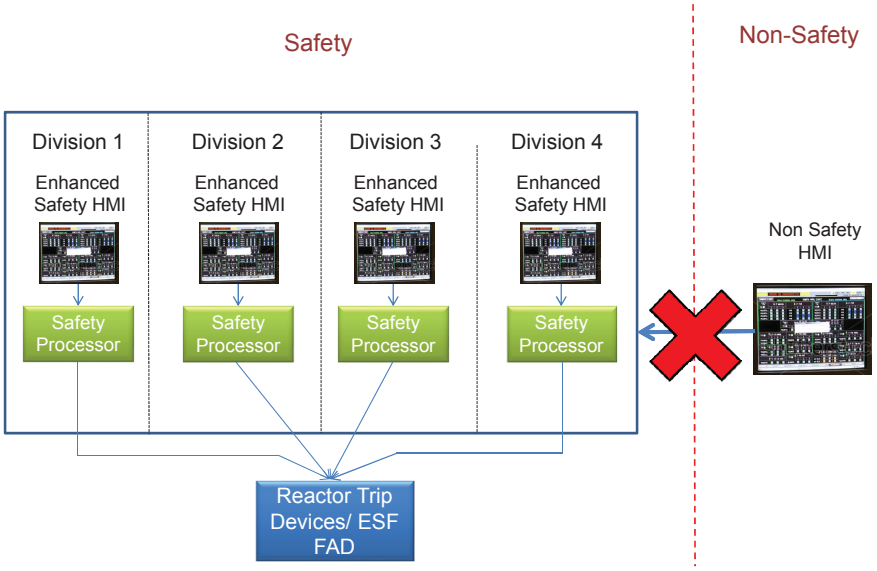
Enhanced Safety-Related Human Machine Interface



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Summary and Conclusion

- Proposed rule to incorporate by reference IEEE Std 603-2009 with additional conditions.
- Conditions on data communications independence for new reactors intend to limit potential hazards to safety systems.
- Many functionality that supports plant reliability and availability can still be achieved through selective design considerations.
- Proposed rule will be reviewed by the Commission prior to issuance for public comment

Next Steps

- Commission review of draft proposed rule
- Publish proposed rule in the *Federal Register*
- Public comment period
- NRC staff develops draft final rule
- Commission review of draft final rule
- Publish final rule in the *Federal Register*

How to get involved

Search for docket ID NRC-2011-0089

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