Providing Cyber Security for FPGA-based Applications

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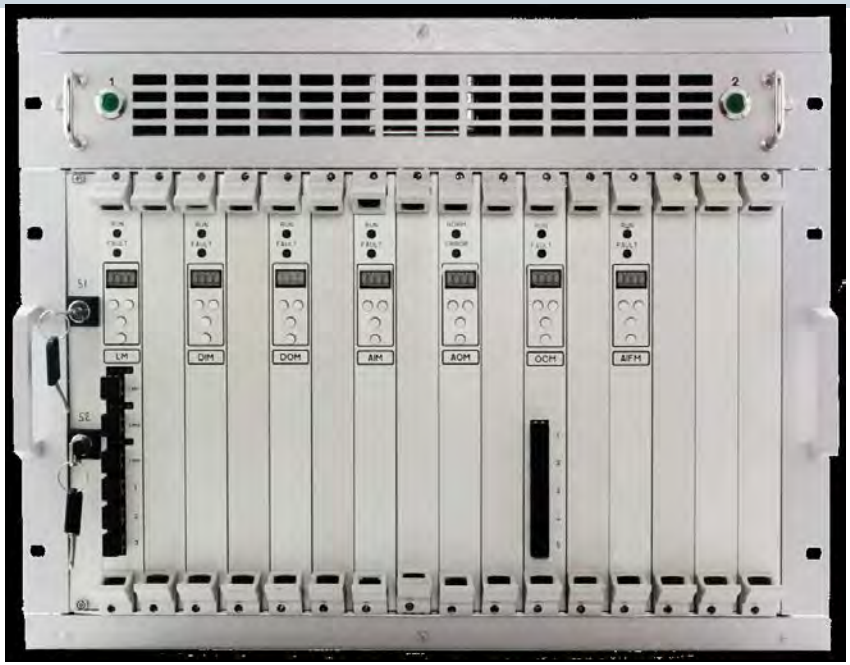
Agenda

- Introduction
- Standards Analysis
- Secure Development Environment Establishment
- RadICS Platform specific security features
- Summary

Introduction (1)

- RPC Radiy is a vendor of FPGA-based I&C Platform/Systems for NPPs
- Main product is RadICS Platform
- RadICS Platform is SIL-3 (single channel) certified as per IEC 61508:2010
- Topical Report for the Platform is under US NRC review



Introduction (2)

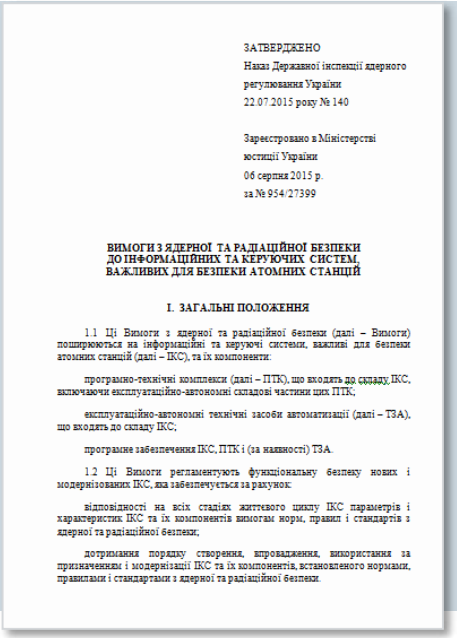
- Increasing number of security attacks on industrial safety-critical I&Cs
- COTS- components (FPGA, HW, Development Tools, SW) may have vulnerabilities
- Human factor (human errors/risks of insider attacks)
- Open systems issues (unified protocols)

Introduction (3)

Inevitable consideration of process-product approach

- ➞Life cycle of I&C Platform/Application shall consider cyber security risks during design and operation phases
- ➞I&C Platform/Application design shall provide features to minimize cyber risks
- ➞Different technologies used to implement I&C Platform/Applications have different properties with respect to cyber security

Standards analysis



ЗАТВЕРДЖЕНО
Наказ Державної інспекції ядерного регулювання України
22.07.2015 року № 140

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ВИМОГИ З ЯДЕРНОЇ ТА РАДІАЦІЙНОЇ БЕЗПЕКИ ДО ІНФОРМАЦІЙНИХ ТА КЕРУЮЧИХ СИСТЕМ, ВАЖЛИВИХ ДЛЯ БЕЗПЕКИ АТОМНИХ СТАНЦІЙ

І. ЗАГАЛЬНІ ПОЛОЖЕННЯ

1.1 Ці Вимоги з ядерної та радіаційної безпеки (далі – Вимоги) поширюються на інформаційні та керуючі системи, важливі для безпеки атомних станцій (далі – ІКС), та їх компоненти:

програмно-технічні комплекси (далі – ПТК), що входять до складу ІКС, включаючи експлуатаційно-автономні складові частини цих ПТК;

експлуатаційно-автономні технічні засоби автоматизації (далі – ТЗА), що входять до складу ІКС;

програмне забезпечення ІКС, ПТК і (за наявності) ТЗА.

1.2 Ці Вимоги регламентують функціональну безпеку нових і модернізованих ІКС, яка забезпечується за рахунок:

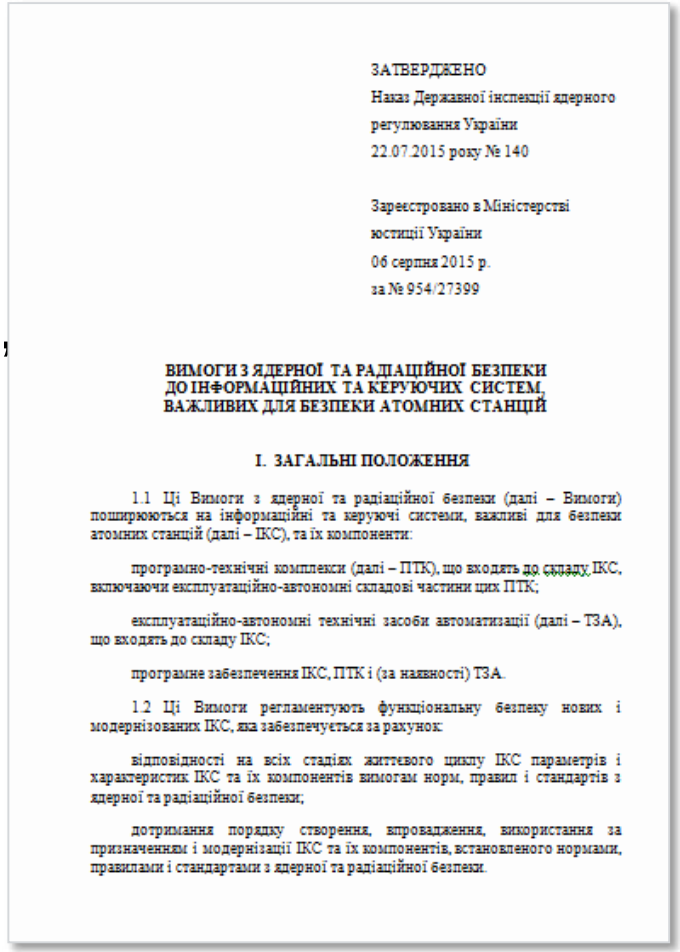
відповідності на всіх стадіях життєвого циклу ІКС параметрів і характеристик ІКС та їх компонентів вимогам норм, правил і стандартів з ядерної та радіаційної безпеки;

дотримання порядку створення, впровадження, використання за призначенням і модернізації ІКС та їх компонентів, встановленого нормами, правилами і стандартами з ядерної та радіаційної безпеки.

Standards Analysis and Requirements Profile

Ukrainian Normative Documents (1)

- Ukrainian normative document NP 306.2.202 "Nuclear and Radiation Safety Requirements for I&C Systems Important to NPP Safety", issued in 2015, contains umbrella requirements to establishment of secure environment
- In particular, Section 6 of Chapter IV contains requirements to protection from unauthorized access during operation
- Section 4 of Chapter VIII contains relevant requirements to software



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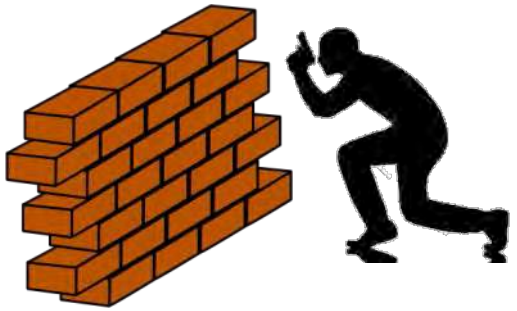
Standards Analysis and Requirements Profile

Ukrainian Normative Documents (2)

Recommended measures from NP 306.2.202:



➞ Physical protection

➞ Protection from unauthorized software, databases and archives modification

Standards Analysis and Requirements Profile

Ukrainian Normative Documents (3)

Recommended measures from NP 306.2.202 (cont'd):

➞ Protection from unauthorized commands from control rooms

➞ Immediate personnel notification on any unauthorized access attempts

Standards Analysis and Requirements Profile

Ukrainian Normative Documents (4)

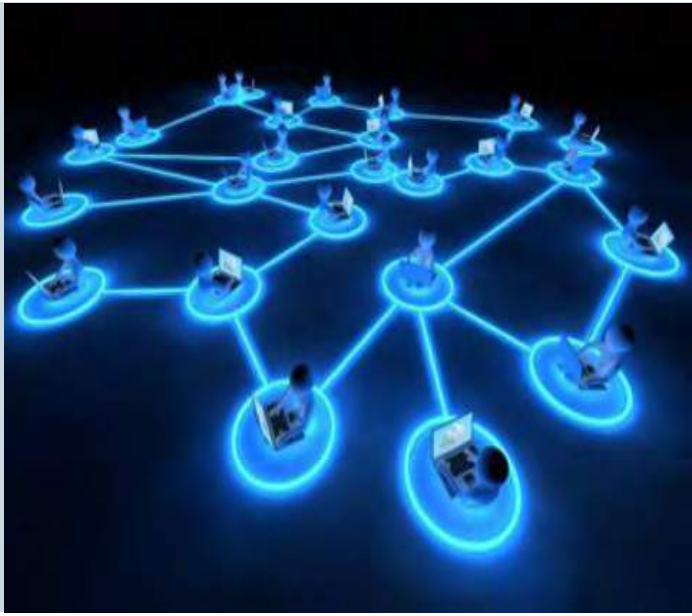
- Requirements in NP 306.2.202 are quite generic and can be used only as umbrella requirements to be fulfilled in quality management system
- Also, secure development environment issues aren't covered
- Therefore, relevant NRC and IEC standards were used as guidance during the process of secure development environment establishment:

  - RG 1.152-2011, "Criteria for use of computers in safety systems of Nuclear Power Plants";

  - RG 5.71-2010, "Cyber security programs for nuclear facilities"

  - IEC 62645, "Nuclear power plants - Instrumentation and control systems - Requirements for security programs for computer-based systems"

Secure Development Environment (SDE) Establishment



Main elements of I&C cybersecurity ensuring (1). QMS

➞With respect to cyber security issues our QMS includes:

– procedures and guidelines on cybersecurity ensuring (who, how, when-stages). It defines approach for creation of secure development environment and its further operation. It provides guidance for designing digital systems (both hardware and software) to ensure that they are free from vulnerabilities that could affect the reliability of the system;

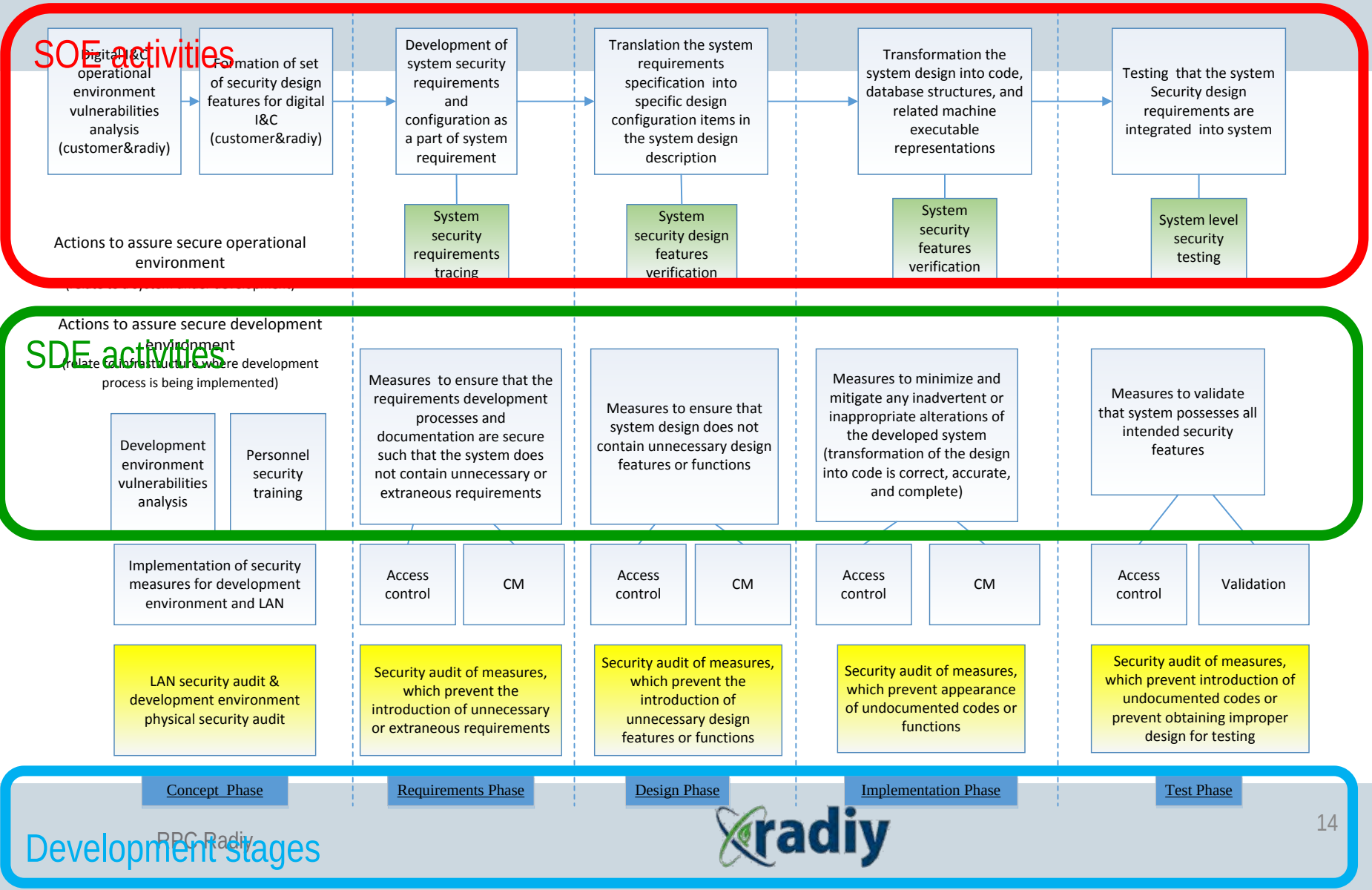
– company policy, aimed at development of secure applications;

– staff training program.

Main elements of cybersecurity ensuring (2). Who ensures security

Lifecycle phase (RG 1.152)	System design process stage	Responsibility in this procedure
Concepts	Pre-Development and Planning	End-user, IT manager, Application Design Bureaus and Independent V&V Department
Requirements	Requirements Specification (SW/HW/HMI)	Design Bureaus, Independent V&V Department and QAPM
Design	HW, SW Design	Design Bureaus, Independent V&V Department and QAPM
Implementation	Implementation	Design Bureaus, Independent V&V Department and QAPM
Test	Integration; Validation and FAT	Independent V&V Department and QAPM
Installation, checkout, and acceptance testing	Installation	Technical Support and Maintenance Group and QAPM with turnover to the system user
Operation	Operation and Maintenance	End-user
Maintenance		End-user
Retirement	Not Applicable	End-user

The general scheme of the process approach to the implementation of secure design and operation environment



SDE at Concept Phase

- SDE activities:

- Vulnerabilities analysis for development environment (DE).
- Implementation and audit of security measures related to DE:
    1) Network security hardening (isolated network);
    2) Physical Access Control;
    3) System and Communications Protection;
    4) Identification and Authentication;
    5) Document and Software storage security;
    6) Removable Media usage control;
- Personnel training

SDE at Requirements Phase

- SDE task:

- Measures to ensure that the requirements defined during this phase do not contain unnecessary or extraneous requirements. Cyber Security requirements shall be considered also.

- SDE activities:

- Implementation and audit of phase-specific security measures to prevent the introduction of unnecessary or extraneous requirements (*configuration management, access control, tracing, review and comments, security audit*)

SDE at Design Phase

- SDE task:

- Measures to ensure that system design does not contain unnecessary design features or functions which might compromise cyber security

- SDE activities:

- Implementation and audit of phase-specific security measures to prevent the introduction of unnecessary design features or functions (*tracing*, *configuration management, access control, review and comments, security audit*)

SDE at Implementation Phase

- SDE task:

- Measures to minimize and mitigate any inadvertent or inappropriate alterations of the developed system (transformation of the design into code is correct, accurate, complete and doesn't contain unnecessary functionality)

- SDE activities:

- Implementation and audit of phase-specific security measures to prevent appearance of undocumented codes or functions (*static code analysis and review*, *positive and negative functional testing*, *configuration management, access control, etc.*)

SDE at
Test Phase

- SDE task:

- To validate that system possesses all intended security features

- SDE activities:

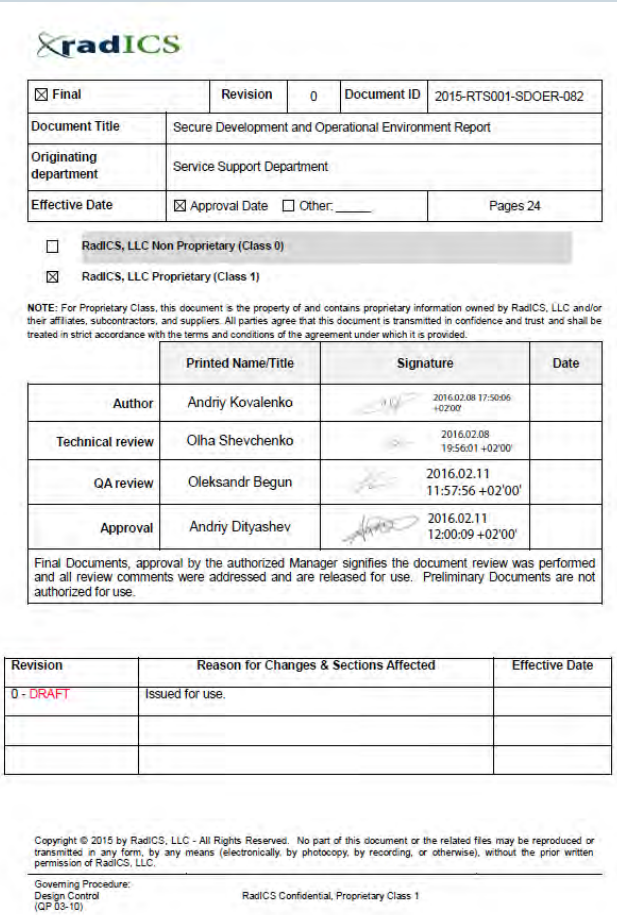
- System security features validation

(*validation testing*, *configuration management, access control*)

Structure of SDE Report

Contains description for more than 60 security controls:

- System design features for security
  - ➞ Physical Access Controls
  - ➞ Electronic Access Controls
  - ➞ Software Alteration Controls
  - ➞ Deterministic Performance Controls
- Development processes for security



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☒ Final	Revision	0	Document ID	2015-RTS001-SDOER-082
Document Title	Secure Development and Operational Environment Report			
Originating department	Service Support Department			
Effective Date	☒ Approval Date ☐ Other: ____			Pages 24

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Author	Andriy Kovalenko	2016.02.08 17:50:06 +02'00'	
Technical review	Olha Shevchenko	2016.02.08 19:56:01 +02'00'	
QA review	Oleksandr Begun	2016.02.11 11:57:56 +02'00'	
Approval	Andriy Dityashev	2016.02.11 12:00:09 +02'00'	

Final Documents, approval by the authorized Manager signifies the document review was performed and all review comments were addressed and are released for use. Preliminary Documents are not authorized for use.

Revision	Reason for Changes & Sections Affected	Effective Date
0 - DRAFT	Issued for use.	

RadICS Platform specific cyber security features

FPGA technology advantages

- There are no known viruses and malware designed to attack HDL coded configurations; FPGA-based platforms have a simple and structured design, therefore the corresponding V&V processes performed at each stage of design are more likely detect the presence of potential threats and malicious design;
- FPGAs do not use operating systems which could be the target of potential cyber attacks
- FPGA programming and reprogramming can be done only through a special interface. It is impossible to connect common storage media or communication devices that could infect the control logic code, as was the case in the Stuxnet attack.
- FPGA chips itself may contain vulnerabilities. So it's extremely recommended to use chips which presents on the market more then 3 years without changing their revision (e.g. floorplan)

FPGA technology vulnerabilities

- Configuration cloning;
- Reverse Engineering;
- Tampering;
- Spoofing;
- Attack from the field;

Some of security controls implemented in I&C systems based on the RadICS Platform (1)

- Physical locks on equipment cabinets
- It's not possible to reconfigure modules during operation (remotely or locally - need to extract module(s) from chassis)
- It's not possible to reconfigure modules (EPCS, EEPROM(s), CPLD Flash) using standard vendor programmer (special converter needed)
- Watchdog (based on diverse technology) checks FPGA configuration process and all FPGA supply voltages levels (switch-off FPGA power supply)
- Partial configuration is not allowed by the platform design

Some of security controls implemented in I&C systems based on the RadICS Platform (2)

- FGPA's configuration integrity fully (using chip's vendor and proprietary techniques) checked during module startup period and continuously during operation
- FPGA's configuration UID easily verifiable (local display, MATS display)
- Only point-to-point safety communications (no rings, no broadcast) with
- Proprietary protocol
- Self-diagnostic of interfaces helps to detect intrusion (data corruption\modification will be detected)
- One-way communication interfaces to external systems

Some of security controls implemented in I&C systems based on the RadICS Platform (3)

- Interfaces used for the modification of the set-points are de-energized during normal operation. Requires two-steps authorization
- Local indication provides all information to check that plant data and diagnostic monitoring system provide correct data for operator
- Full control of design. Home-made source code. No 3-rd party IP cores in the Platform Level. Source code available for audit by independent entities.
- Manuals are issued with supplied I&C systems to encourage operation and maintenance personnel to implement security measures

Summary

- Providing cyber security is an important business process of the company. It takes into account the specifics of the company, its resources and technologies.
- The process of cybersecurity is implemented within the QMS. Secure development environment is a must.
- Secure I&C system development is a joint responsibility of developer/manufacturer and customer. It should be based on the process-product approach

Thank you for your attention!

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