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November 16, 2010

Document Control Desk
U.S, Nuclear Regulatory Commission
Washington, DC 20555
Attn: Mr. Duane Hardesty

Dear Mr. Hardesty,

Subject: Submittal Report on changes to the University of Florida Training Reactor (UFTR) Final Safety Analysis Report (FSAR) for the Digital Reactor Protection System Upgrade

Please find enclosed the Submittal Report on changes to the UFTR's FSAR for the Digital Reactor Protection System Upgrade. Note that the following Chapters will be revised by the UFTR Management:

- Chapter 8. Electrical Power System
- Chapter 12. Conduct of Operation
  - 12.2 Procedures;
  - 12.3 Operator Training and Requalification
  - 12.4 Emergency Plan
  - 12.5 Physical Plan

If you need further information, please do not hesitate to contact me at dhinten@ufl.edu or (352) 392-1401.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on November 16, 2010.

Sincerely,

David Hintenlang, PhD
Director of UFTR
Interim Chair of NRE

DIANA L. DAMPIER
Notary Public - State of Florida
My Comm. Expires Jul 20, 2013
Commission # DD 894207
Bonded Through National Notary Assn.

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Cc Jack Donohue, NRC
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UFTR – NRC file

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The Foundation for The Gator Nation

SUBMITTAL REPORT
To Cover Analyses of
University of Florida Training Reactor (UFTR)
Digital Reactor Protection System Upgrade

Submitted by

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First Version
November 2010

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Summary

This report contains the results of design and safety analyses performed by the University of Florida Nuclear and Radiological Engineering Department (NRE) for upgrade of the analog control/protection system of the University of Florida Training Reactor (UFTR) to two independent digital systems including the TXS Protection System and T-3000 control system. The new digital systems maintain or improve availability, reliability, safety, and efficiency of the UFTR. This will be accomplished while minimizing operations and maintenance costs. The systems will allow the UFTR to take advantage of the on-line monitoring, self testing, self diagnostics, fault tolerance, information processing, improved human-system interfaces, and higher accuracy capabilities of the new technology.

This study investigates the performance and safety margins of the proposed digital system under nominal and accident conditions. It identifies any necessary changes to the UFTR Final Safety Analysis Report (FSAR, Ref. 1), UFTR Conversion from HEU to LEU fuel (Ref. 2), and UFTR Technical Specifications (TS, Ref. 3).

1. General Description of the Facility

1.1 Introduction

This section provides an overview of the changes to the physical, nuclear and operational characteristics of the facility required by the digital system upgrade of the UFTR.

The UFTR digital system is comprised of a protection system and control system. The protection system is comprised of three blocks as shown below

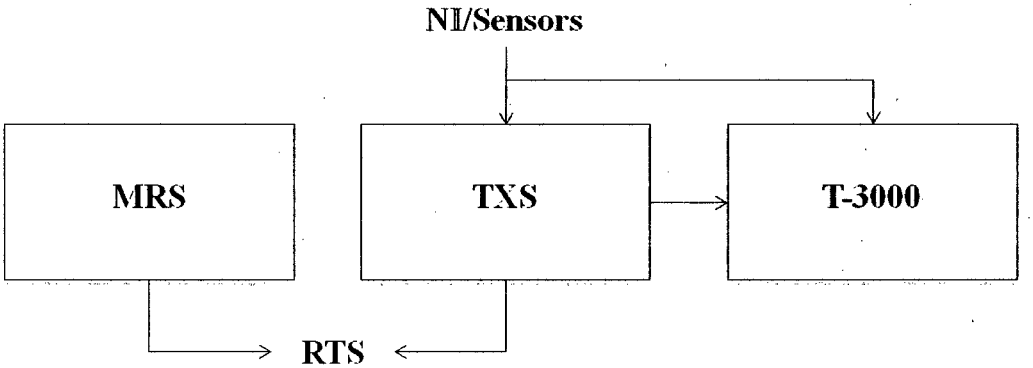

Figure 1 The UFTR Protection System

The above design is developed in order to make sure that the reactor is protected in case the TXS freezes. In this design, the T-3000 is used as an indicator, which informs the operator of the failure of the TXS, and therefore the operator will be able to shutdown the reactor through a diverse manual system, i.e., the Manual Reactor Scram - MRS.

Further detail on the protection system, its design and components are provided in the UFTR-QA1-12 System Description (Ref. 12).

The UFTR control system is the T-3000, which is provided by Siemens Corporation, and has a one-way communication from the TXS system.

In support of the implementation of the new digital protection system application software, a set of documents was prepared related to the Planning and Design Analysis:

1) **Planning Documents:**
   UFTR-QA1-01 "Software Quality Assurance Plan (SQAP)," (Ref. 4)
   UFTR-QA1-02 "Software Configuration Management Plan (SCMP)," (Ref. 5)
   UFTR-QA1-03 "Software Verification and Validation Plan (SVVP)," (Ref. 6)
   UFTR-QA1-05 "Software Safety Plan (SSP)," (Ref. 7)
   UFTR-QA1-06.1 "Software Test Plan-SIVAT Plan," (Ref. 8)
   UFTR-QA1-06.2 "Factory Acceptance Test (FAT) Plan," (Ref. 9)
   UFTR-QA1-10 "Software Training Plan," (Ref. 10)
   UFTR-QA1-11 "Software Review and Audit," (Ref. 11)
   UFTR-QA1-109 "Software Library and Control," (Ref. 19)

2) **Design Analysis Documents:**

UFTR-QA1-12 "System Description," (Ref. 12)
UFTR-QA1-14 "Safety System Design Basis," (Ref. 13)
UFTR-QA1-100 "Functional Requirements Specification," (Ref. 14)
UFTR-QA1-101.1 "List of I/Os," (Ref. 15)
UFTR-QA1-102.3 "ID Coding," (Ref. 16)
UFTR-QA1-103 "Diversity and Defense-in-Depth (D3) Analysis," (Ref. 17)
UFTR-QA1-105 "TELEPERM XS Cyber Security," (Ref. 18)

1.2 Summary and Conclusions of Principal Safety Considerations

The new digital protection and control systems provide added redundancy, resulting in improved safety and control of the UFTR. The TXS system protection system consists of both hardware and software that monitors and automatically initiates protective action for the UFTR. The UFTR-QA1-103 "Diversity and Defense in Depth (D3) Analysis" (Ref. 17) shows that the upgraded digital protection system exhibits adequate diversity and defense-in-depth (D3) to address all reasonable vulnerabilities to system failure. Further, safety analysis is presented in the UFTR-QA1-14 "Safety System Design Basis" document (Ref. 13), which establishes the proposed UFTR protection system design under regulatory bases and specifies the general qualities that the resulting design will satisfy.

In Table 1, we compare the functionality of the proposed UFTR protection system, shown in Fig.1, as compared to the existing system.

Table 1 Comparison of the proposed digital and existing analog systems

Protection System Components	Required Functions of a Protection System	
	Monitoring and Indication	Reactor Trip
Existing Analog System		
Analog	**X**	**X**
Proposed Digital System		
TXS (primary)	**X**	**X**
T-3000 (redundant/diverse)	**X**	
Manual Reactor Scram (MRS) (redundant/diverse)		**X**

As indicated in the above table, for each function of the protection system, i.e. Monitoring and Indicator System (MIS) or Reactor Trip System (RTS), the proposed digital system has two diverse systems, in contrast to one system for the existing analog system. This means that the proposed digital system exceeds the reliability of the existing analog system. For further detail, see the UFTR-QA1-103 "Diversity and Defense in Depth (D3) Analysis" (Ref. 17).

1.3 Summary of Reactor Facility Changes

The major changes are the new control room and the power supply.

The Power Supply is modified by adding a UPS unit. The change improves the Reactor availability and operability of the protection system. This means the new system improves the system reliability.

The Control Room was moved to the second floor, because of the following reasons:

- More space is needed for placement of the TXS and T3000 systems and their auxiliary equipment and displays.
- Since, the control room is outside the reactor cell, there is no need for extra radiation protection for the visitors and for the reactor personnel working in this room.
- Provides better visibility of the Reactor and easier access for the visitors.
- Increase Maintainability
- Increase Reliability
- Increase Upgradeability
- Increase Operator Awareness
- Increase Operator Effectiveness
- Storage of Plant History and Trending
- New console, which provides the following:
    - Improved maintainability.
    - Enhanced information for the operator.
    - Improved human factors and ergonomics.
    - Improved reliability and operability
    - Improved educational and training capability.

1.4 Summary of Operating License, Technical Specifications, and Procedural Changes

The main changes are reflected in the Technical Specifications and some of the operating procedures (OP's). The changes in the Technical Specifications are mainly the addition of new NIs and their impact on the reactor operation. All the OP's, especially those related to the reactor surveillance and operation will be revised and new training documents will be prepared, and new questions will be prepared for examination of operators.

1.5 Comparison with Similar Facilities Already Converted

N/A

2. Site Characteristics

The protection and control systems upgrade does not impact the site characteristics. More details about this topic can be found in Ref. 1.

3. Design of Structures, Systems, and Components

For this upgrade, we have replaced all the NI's, sensors and radiation monitors Further, the new NI's increase the diversity of monitoring the power, the thermo-couples are replaced with RTD's, which are more reliable, added one more radiation monitor, and improved monitoring the water level in the water storage tank. All the aforementioned changes improve redundancy, diversity, defense-in-depth, and consequently improve the protection and control capabilities, and also availability of the UFTR. The UFTR-QA1-12 "System Description" (Ref. 12) and the UFTR-QA1-14 "Safety System Design Basis" (Ref. 13) documents elaborate on these changes.

3.1 Design Criteria

3.1.1 Structural Design

The Control Room was moved to the second floor (See Section 1.3).

3.1.2 Overall Requirements

The protection and control systems upgrade does not impact the overall requirements. More details about this topic can be found in Ref. 1.

3.1.3 Protection of Multiple Fission Barriers

The protection and control systems upgrade does not require any changes to this section. More details about this topic can be found in Ref. 1.

3.1.4 Protection and Reactivity Control System

The existing UFTR analog protection system includes one train, which is comprised of only two safety channels comprised of NIs. Both safety channels have to be operational, because only one of the channels monitors the low power range, while both cover the high power range in a diverse manner. The proposed new UFTR digital protection system also has one safety train, but this train includes two sets of NI channels and various sensors. It is important to emphasize that the two NI channels monitor the whole power range, therefore introduce new diversity in monitoring the power.

The new digital T-3000 system is used as the reactor control system. This system not only will provide all control functions, but also provides an environment for displaying various reactor parameters and surveillance data during the reactor operations. The final installed system includes utility software for extraction of various reactor physics parameters, which are used for both confirmatory operational data and training.

3.1.5 Fluid Systems

The protection and control systems upgrade does not require any changes to this section. More details about this topic can be found in Ref. 1.

3.1.6 Confinement Design Basis

The protection and control systems upgrade does not impact the confinement design basis. More details about this topic can be found in Ref. 1.

3.1.7 Fuel Radioactivity Control

The protection and control systems upgrade does not impact the fuel radioactivity control. More details about this topic can be found in Ref. 1.

3.2 Meteorological and Water Damage

The protection and control systems upgrade does not require any changes to this section. More details about this topic can be found in Ref. 1.

3.3 Seismic Damage

The protection and control systems upgrade does not require any changes to this section. More details about this topic can be found in Ref. 1.

3.4 System and Components

The protection and control systems upgrade does not require any changes to this section. More details about this topic can be found in Ref. 1.

4. Reactor Description

4.1 Reactor Facility

The protection and control systems upgrade of the UFTR facility does not change the core configuration and fuel type. All the following aspects of the facility remain unchanged:

- Control Blades
- Neutron Reflector
- Neutron Source and Holder
- In-Core Experimental Facilities
- Reactor Tank and Biological Shielding
- Core Support Structure
- Functional Design of the Reactivity Control System

4.2 Reactor Core

The protection and control systems upgrade does not require any changes to the reactor coolant system. More details about this topic can be found in Ref. 1 and Ref 2.

5. Reactor coolant system

The protection and control systems upgrade does not require any changes to the reactor coolant system. More details about this topic can be found in Ref. 1 and Ref. 2.

6. Engineering Safety Features

The protection and control systems upgrade does not require any changes to engineering safety features. More details about this topic can be found in Ref. 1 and Ref. 2.

7. Instrumentation and control

The proposed TXS protection system includes one safety train of several signals, which are processed by an Acquisition and Processing (AQP) processor, and the processed data are sent to the Main Control Room (MCR) and the Gateway (GW). The GW provides one-way communication with the T-3000 control system. Fig. 2 shows the proposed TXS system.

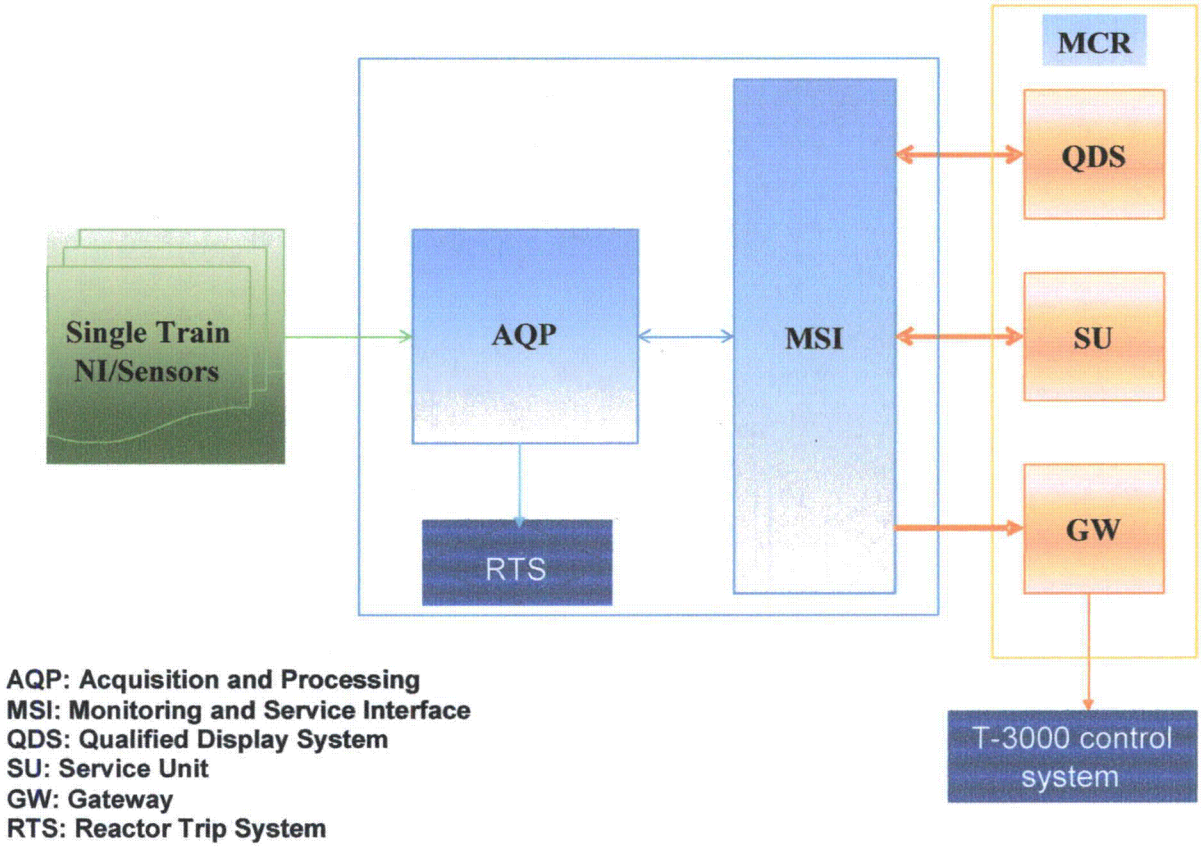

Figure 2 Proposed TXS System

Table 2 lists the signals monitored within the above proposed one-train TXS system. Note that the components designated with (*) refer to new NIs or sensors considered for the new system.

Table 2 List of signals within the proposed one-train TXS system (parameter, device, type of signal & monitoring region)

Parameter	Device	AI[c]	DI[d]	Monitoring Region
Full power range	*FC[a], IC[b]	2	-	Core
Full power range	*BF3, IC	2	-	Core
Temperature	*Resistive TD	10	-	core, primary, secondary
Flow Rate	Flow Rate Monitor (FRM)	2	2	primary, secondary
Water Level	Water Level Monitor* (WLM)	2	1	Core, storage tank*, shield tank
Area Radiation Level	Area Radiation Monitor (ARM)	4	4	east, north, south, west*
Fan Availability	Fan Monitor (FM)	1	2	Core ventilation, stack dilution, stack dilution RPM

[a]Fission Chamber; [b]Ion Chamber; [c]AI, Analog Input; [d]DI, Digital Input

It is important to note that the new system has two diverse sets of instrumentation for measuring the whole range of power. Further, within the system, for increased reliability, RTD's are used in lieu of thermocouples.

The diverse set of signals within the new safety train shall improve defense-in-depth of the protection system, i.e., TXS, and therefore, the safety and reliability of the UFTR. Table 3 summarizes how different segments of the reactor are monitored by the proposed diverse set of sensors.

Table 3 Proposed Diverse Monitoring of different regions of the UFTR

Sensor/Monitor	Core	Primary	Secondary	Reactor Cell	Confinement
FC+BF3	✓				
IC	✓				
RTD	✓	✓	✓		
FRM	✓	✓	✓		
WLM	✓	✓			
ARM				✓	✓
FM				✓	✓

The above table indicates that each segment of the reactor is monitored at least by two diverse sensors.

Fig. 3 shows the network diagram corresponding to the above proposed TXS system (Fig. 1), and Figs. 4 and 5 provide schematics of two cabinets for housing different components of the proposed TXS system.

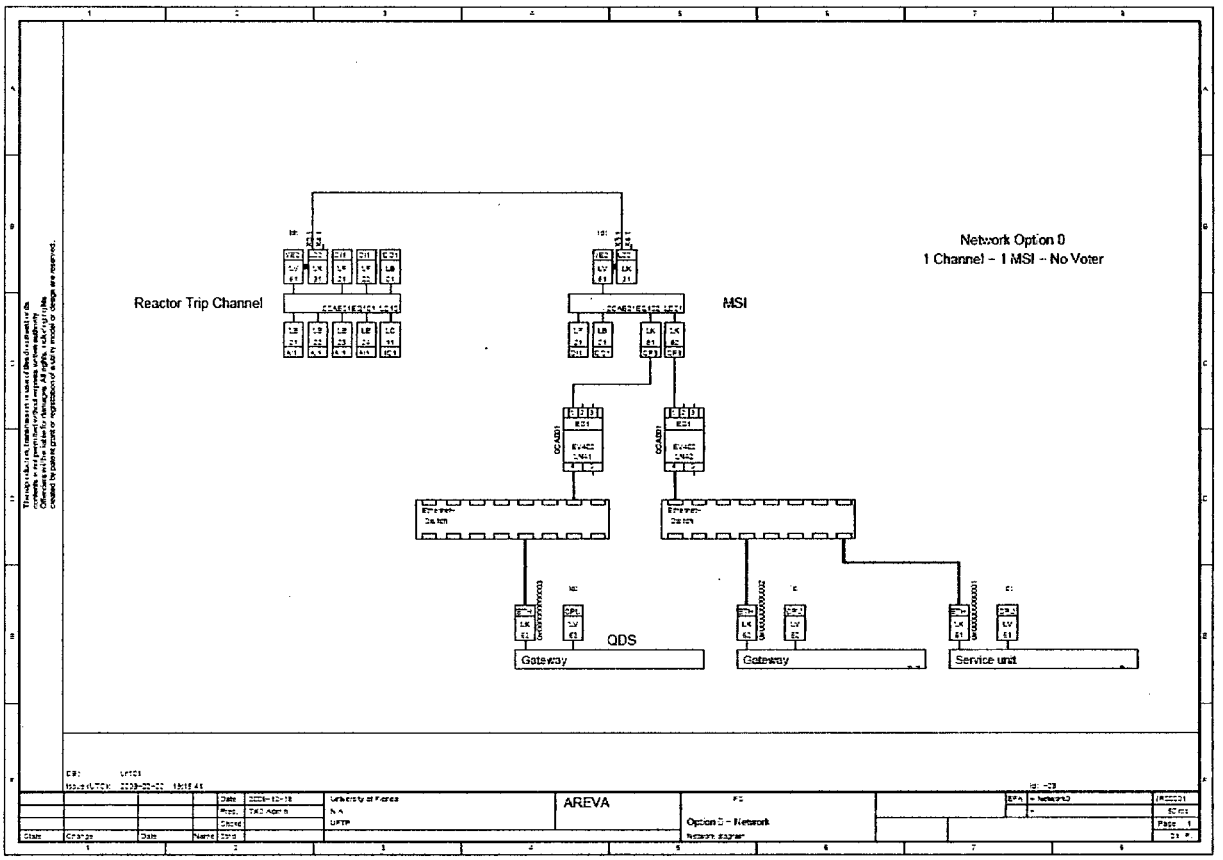

Figure 3 TXS System Network Diagram

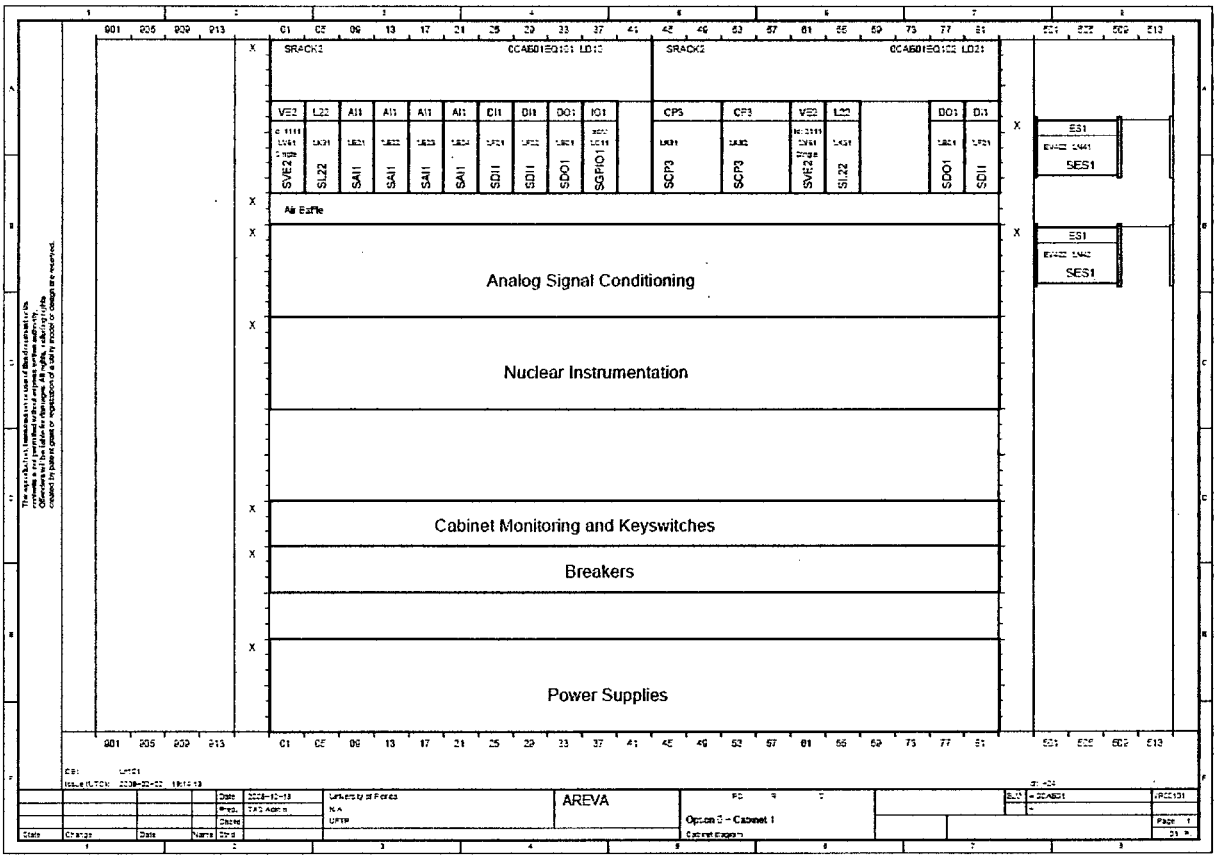

Figure 4 UFTR TXS Cabinet 1 (Including AQP, NI signal processing)

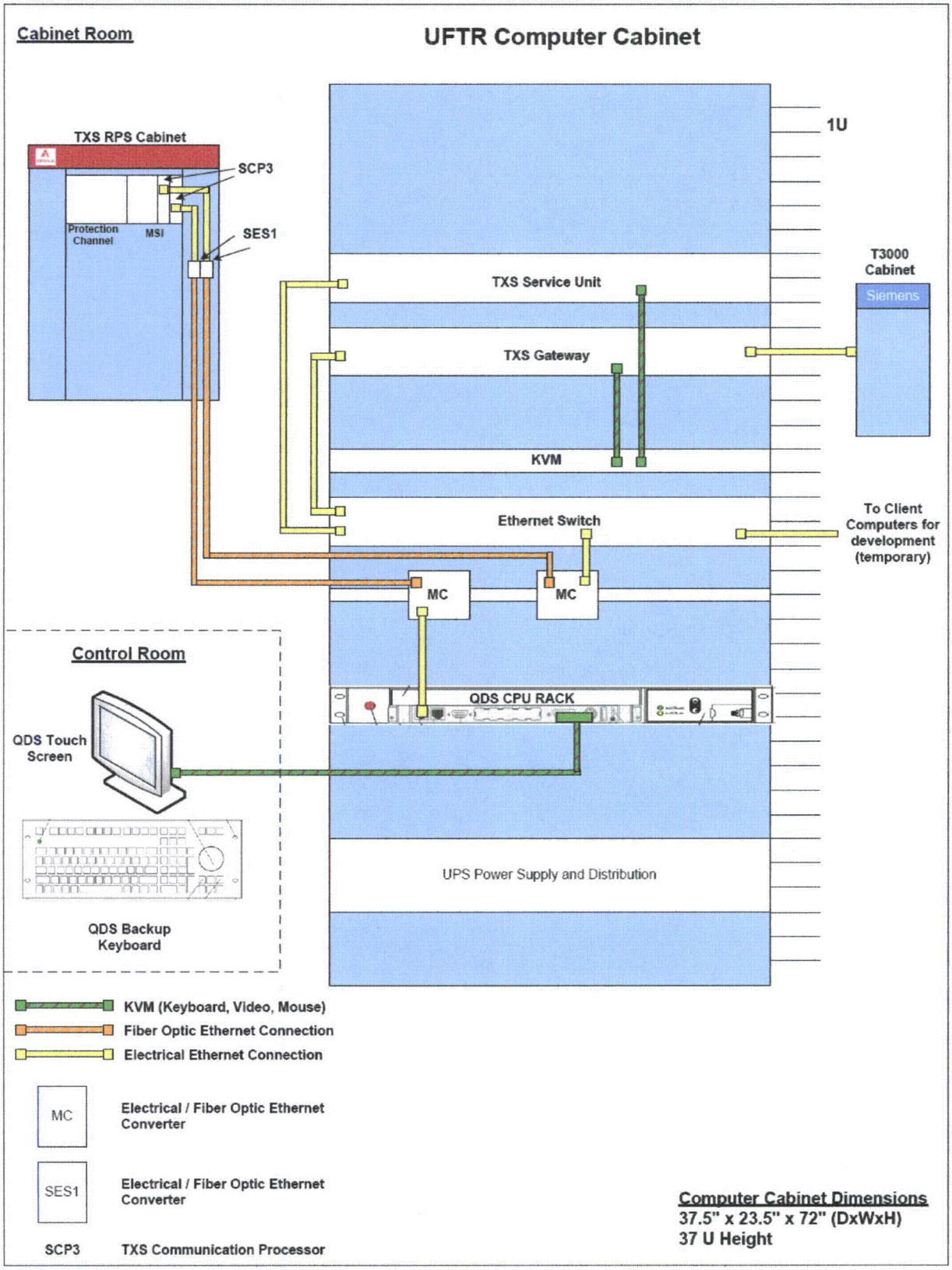

Figure 5 UFTR TXS Cabinet 2 (Including SU, GW, MSI, &QDS)

Finally, the T-3000 system is used as the reactor control system. This system not only will provide all the necessary control functions, but also provides an environment for displaying various reactor parameters and surveillance data during the reactor operations. The final installed system includes utility software for extraction of various reactor physics parameters, which are used for both confirmatory operational data and training.

Further information about the system are provided in the following documents: UFTR-QA1-12 "System Description," (Ref. 12), UFTR-QA1-14 "Safety System Design Basis," (Ref. 13), and UFTR-QA1-100 "Functional Requirements Specifications" (Ref. 17).

8. Electrical power system

The Power Supply is modified and information has to be provided by the reactor management. The new power supply includes UPS, which contribute to improved operability and reliability of the TXS protection and T-3000 control systems. It also improves the availability of the UFTR.

9. Auxiliary system

The protection and control systems upgrade does not impact the auxiliary system. More details about this topic can be found in Ref. 1.

10. Experimental Facility and utilization

The protection and control systems upgrade does not require any changes to experimental facility and utilization of UFTR. More details about this topic can be found in Ref. 1 and Ref. 2.

11. Radiation Protection and Radioactive Waste Management

The protection and control systems upgrade does not require any changes to the radiation protection and radioactive waste management of UFTR facility. More details about this topic can be found in Ref. 1 and Ref. 2.

12. Conduct of Operation

12.1 Organization and Staff Qualification

The protection and control systems upgrade does not require any changes on the organization and staff qualification. More details about this topic can be found in Ref. 1.

12.2 Procedures

This section has to be completed by the UFTR management.

12.3 Operator Training and Re-qualification

This section has to be completed by the UFTR management.

12.4 Emergency Plan

The change of the location of the control room will require some changes to the Emergency Planning document. This has to be provided by the UFTR management.

12.5 Physical Security

This section has to be completed by the UFTR management.

12.6 Reactor Reload and Startup Plan

The protection and control systems upgrade does not require any changes to the reactor reload and startup plan. More details about this topic can be found in Ref. 1.

13. Accident Analysis

The protection and control systems upgrade does not introduce any new accident scenarios. More details about this topic can be found in Ref. 1 and Ref. 2.

14. Technical Specifications

The protection and control systems upgrade, and the changes in NI's and sensors and their operation will require changes in the UFTR TS (Ref. 3). The main sections affected are presented in Table 4:

Table 4 List of the TS sections affected by the UFTR changes

Chapter	Section	Subsection	Comment
3. Limiting Conditions for Operations (LCO)	3.2 Reactor Control and Safety Systems		
	3.4 Radiation Monitoring Systems and Radioactive Effluents	3.4.1 Aerial Radiation Monitors and Air Particulate Detectors	
	3.10 UFTR Shield Tank		Change is only necessary if a new device were to be installed,
4. Surveillance Requirements	4.2 Reactor Control and Safety Systems		

15. Other License Considerations

The necessary documentation of reactor parameters and status will be provided after the installation of the new protection and control systems.

References

1. Diaz and Vernetson, "Final Safety Analysis Report (FSAR)," 1981 updated to Rev. 11, University of Florida, 1998.
2. A. Haghighat, "Submittal Report to Cover Analyses of UFTR Conversion from HEU to LEU Fuel," Second Version, August 2009.
3. UFTR Technical Specification (TS)
4. UFTR-QA1-01 "Software Quality Assurance Plan (SQAP)"
5. UFTR-QA1-02 "Software Configuration Management Plan (SCMP)"
6. UFTR-QA1-03 "Software Verification and Validation Plan (SVVP)"
7. UFTR-QA1-05 "Software Safety Plan (SSP)"
8. UFTR-QA1-06.1 "Software Test Plan-SIVAT Plan"
9. UFTR-QA1-06.2 "Factory Acceptance Test (FAT) Plan"
10. UFTR-QA1-10 "Software Training Plan"
11. UFTR-QA1-11 "Software Review and Audit"
12. UFTR-QA1-12 "System Description,"
13. UFTR-QA1-14 "Safety System Design Basis"
14. UFTR-QA1-100 "Functional Requirements Specification"
15. UFTR-QA1-101.1 "List of I/Os"
16. UFTR-QA1-102.3 "ID Coding"
17. UFTR-QA1-103 "Diversity and Defense-in-Depth (D3) Analysis"
18. UFTR-QA1-105 "TELEPERM XS Cyber Security"
19. UFTR-QA1-109 "Software Library and Control"