***Example 4-4. Digital Modification that Satisfies Dependability, causing NO ADVERSE IMPACT on a UFSAR-described Design Function***

An analog recorder is to be replaced with a new microprocessor-based recorder. The recorder is used for various purposes including Post Accident Monitoring, which is a UFSAR-described design function.

Dependability Assessment: An engineering evaluation performed as part of the technical assessment supporting the digital modification concluded that the new recorder will be highly dependable (based on a quality development process, testability, and successful operating history) and therefore, the risk of failure of the recorder due to software is considered very low.

The change will have NO ADVERSE IMPACT on any design function due to the dependability assessment.

#### 4.2.1.2 Screening of Changes to Procedures as Described in the UFSAR

**Comment [A42]:** Comments on HSI Screening Guidance were previously provided in:
(1) ML17068A092 Comment Nos. 18-26
(2) ML17170A089 Comment Nos. A17-A27

SCOPE

If the digital modification does not include or affect a Human-System Interface (e.g., the replacement of a stand-alone analog relay with a digital relay that has no features involving personnel interaction and does not feed signals into any other analog or digital device), then this section does not apply and may be excluded from the Screen assessment.

In NEI 96-07, Section 3.11 defines *procedures* as follows:
"*...Procedures include UFSAR descriptions of how actions related to system operation are to be performed and controls over the performance of design functions. This includes UFSAR descriptions of operator action sequencing or response times, certain descriptions...of SSC operation and operating modes, operational...controls, and similar information.*"

Although UFSARs do not typically describe the details of a specific Human-System Interface, UFSARs will describe any design functions associated with the HSI.

Because the human-system interface (HSI) involves system/component operation, this portion of a digital modification is assessed in this Screen consideration. The focus of the Screen assessment is on potential adverse effects due to modifications of the interface between the human user and the technical device.

There are 3 "basic HSI elements" (Reference: NUREG-0700):

- **Displays:** the visual representation of the information operators need to monitor and control the plant.
- **Controls:** the devices through which personnel interact with the HSI and the plant.
- **User-interface interaction and management:** the means by which personnel provide inputs to an interface, receive information from it, and manage the tasks associated with access and control of information.

Comment [DA43]: Clarification: Thnk of these elements as a way to define the entirety of what comprises and HSI. Some modifications may not fall neatly into one category, but if it falls within any or all of these categories, it is HSI related.

Operators must be able to accurately perceive, comprehend and respond to system information via the HSI to successfully complete their tasks. Specifically, nuclear power plant personnel perform "four generic primary tasks" (Reference: ~~XXX~~NUREG/CR 6947):

(1) monitoring and detection (extracting information from the environment and recognizing when something changes),
(2) situation assessment (evaluation of conditions),
(3) response planning (deciding upon actions to resolve the situation) and
(4) response implementation (performing an action).

To determine potential adverse impacts of HSI modifications on design functions, a two-step analysis must be performed. Step one is assessing if and in what way ~~how~~ the modification impacts (i.e., *positively*, *negatively* or *no impact*) the operators' abilities to perform each of the four primary types of tasks described above. ~~If there are negative impacts, step~~Step two of the analysis consists of determining if and how the impacts, identified in step one, affect~~s~~ the pertinent UFSAR-described design function(s) (i.e., *adversely* or *not adversely*). ~~Examples of~~ Examples of n~~n~~egative impacts on operator performance ~~of tasks~~ that may result in adverse effects on a design function include but are not limited to:

- increased possibility of mis-operation,
- increased difficulty in evaluating conditions,
- increased difficulty in performing an action,
- increased time to respond,
- creation of new potential failure modes.

Table 1 contains examples of modifications to HSI elements ~~that should be addressed in the response to this Screen consideration.~~

[INSERT TABLE 1 FROM HSI COMMENTS FILE HERE.]

~~In NEI 96-07, Section 3.11 defines *procedures* as follows:~~

*"...Procedures include UFSAR descriptions of how actions related to system operation are to be performed and controls over the performance of design functions. This includes UFSAR descriptions of operator action sequencing or response times, certain descriptions...of SSC operation and operating modes, operational...controls, and similar information."*

- Because the Human System Interface involves system/component operation, operator actions, response times, etc., this portion of a digital modification is assessed in this Screen consideration.

If the digital modification does not include or affect a Human System Interface (e.g., the replacement of a stand-alone analog relay with a digital relay that has no features involving personnel interaction and does not feed signals into any other analog or digital device), then this section does not apply and may be excluded from the Screen assessment.

The focus of the Screen assessment is on potential adverse effects due to modifications of the *interface* between the human user and the technical device [e.g., equipment manipulations, actions taken, options available, decision-making, manipulation sequences or operator response times (including the impact of errors of a cognitive nature in which the information being provided is unclear or incorrect)], not the written procedure modifications that may accompany a physical design modification (which are addressed in the guidance provided in NEI 96-07, Section 4.2.1.2).

PHYSICAL INTERFACE WITH THE HUMAN SYSTEM INTERFACE

In the determination of potential adverse impacts, the following aspects should be addressed in the response to this Screen consideration:

(a) Physical Interaction with the Human System Interface (HSI)

(b) Number/Type of Parameters

(c) Information Presentation

(d) Operator Response Time

**Physical Interaction with the Human System Interface**

A typical physical interaction modification might involve the use of a touch screen in place of push buttons, switches or knobs, including sensory based aspects such as auditory or tactile feedback.

~~To determine if the HSI aspects of a digital modification have an adverse impact on UFSAR-described design functions, potential impacts due to the physical interaction with the HSI should be addressed in the Screen.~~

~~Consideration of a digital modification's impact due to the physical interaction with the HSI involves an examination of the actual physical interface and how it could impact the performance and/or satisfaction of UFSAR described design functions. For example, if a new malfunction is created as a result of the physical interaction, then the HSI portion of the digital modification would be adverse. Such a new malfunction may be created by the interface requiring the human user to choose which of multiple components is to be controlled, creating the possibility of selecting the wrong component (which could not occur with an analog system that did not need the human user to "make a selection").~~

~~Characteristics of HSI changes that could lead to potential adverse effects may include, but are not limited to:~~

- ~~Changes from manual to automatic initiation (or vice versa) of functions,~~
- ~~Changes in the data acquisition process (such as replacing an edgewise analog meter with a numeric display or a multipurpose CRT in which access to the data requires operator interaction to display),~~
- ~~Changes that create new potential failure modes in the interaction of operators with the system (e.g., new interrelationships or interdependencies of operator actions and/or plant response, or new ways the operator assimilates plant status information),~~
- ~~Increased possibility of mis-operation related to performing a design function,~~
- ~~Increased difficulty for an operator to perform a design function, or~~
- ~~Increased complexity or duration in diagnosing or responding to an accident [e.g., Time Critical Operation Actions (TCOAs) identified in the UFSAR].~~

~~If the HSI changes do not exhibit characteristics such as those listed above, then it may be reasonable to conclude that the "method of performing or controlling" a design function is not adversely affected.~~

Example~~s~~ 4-5 ~~through 4-7 illustrate the application of the *Physical Interaction* aspect~~ illustrates how to apply th~~e assessment process to ONLY the "controls" element of an HSI.~~is process to an ~~HIS~~HSI modification

***Example 4-5. ~~*Physical Interaction*~~ *Assessment of Modification* –with***

***NO ADVERSE IMPACT on a UFSAR-Described Design Function***

Description of the Proposed ~~Activity Involving the Control Element~~Modification:

Currently, a knob is rotated clock-wise to ~~increase a control function~~ open a flow control valve in 1% increments and counter clock-wise to ~~decrease the control function~~close a flow control valve in 1% increments. This knob will be replaced with a touch screen that has two separate arrows, each in its own function block. Using the touch screen, touching the "up" arrow will ~~increase the control function~~ open the flow control valve in 1% increments and touching the "down" arrow will ~~decrease the control function~~close the flow control valve in 1% increments.

Identification and Assessment of the Four Generic Primary Tasks Potentially Impacted~~Involved~~:

(1) monitoring and detection (extracting information from the environment and recognizing when something changes) - NOT INVOLVED
(2) situation assessment (evaluation of conditions) - NOT INVOLVED
(3) response planning (deciding upon actions to resolve the situation) - NOT INVOLVED
(4) response implementation (performing an action) - ~~NOT~~ INVOLVED

**Comment [DA44]:** Response implementation is the only task that would be pertinent here as it changes the

~~Design Function Identification:~~

~~The UFSAR described design function states the operator can "increase and decrease the control functions using manual controls located in the Main Control Room." Thus, this UFSAR description implicitly identifies the SSC (i.e., the knob) and the design function of the SSC (i.e., its ability to allow the operator to manually adjust the control function).~~

~~Identification and~~ Assessment of Modification Impacts on the Four Generic Primary Tasks INVOLVED:

As part of the technical evaluation supporting the proposed ~~activity~~modification, a Human Factors Evaluation (HFE) was performed. Tasks 1,2 and 3 are not involved therefore they do not have negative impacts. Task 4 is involved, but the HFE determined that the change from knob to touch screen was not going to have a negative impact on the operator because ~~...~~there was no change to the ability of the operator to perform the response implementation task~~.~~ ~~The HFE concluded that no new failures or malfunctions have been introduced as a result of the replacement from a knob to a touch screen.~~

~~possibility of mis-operation – NO IMPACT~~
~~difficulty in evaluating conditions – N/A~~
~~difficulty in performing an action – NO IMPACT~~
~~time to respond – N/A~~
~~new potential failure modes – NO IMPACT~~

**Comment [DA45]:** These are only some of the possible negative impacts , thus, listing them here makes it appear that these are the ONLY outcomes that should be considered, Again, we do not want to get in a situation where we are trying to list all the possibilities.

Identification of the Relevant Design Function(s):

The UFSAR design function states the operator can "~~increase and decrease the control functions~~ open and close the flow control valve using manual controls located in the Main Control Room." Thus, this UFSAR description implicitly identifies the SSC (i.e., the knob) and the design function of the SSC (i.e., its ability to allow the operator to manually adjust the ~~control function~~position of the flow control valve).

Assessment of Impact(s) on Design Function ~~Impact(s)~~

Using the results from the HFE and examining ~~only~~ the ~~physical interaction aspect~~ "controls" element of an HSI ~~(e.g., ignoring the impact on operator response time or the number and/or sequence of steps necessary to access the new digital controlsthe other three HSI elements),~~ the replacement of the "knob" with a "touch screen" is not adverse since it does not impact the ability of the operator to "~~increase and decrease the control functions~~ open and close the flow control valve using manual controls located in the Main Control Room," maintaining satisfaction of the UFSAR-described design function.

Using the same proposed activity provided in Example 4-5, Example 4-6 illustrates how a variation in the UFSAR description would cause an adverse impact.

***Example 4-6. Physical Interaction with an ADVERSE IMPACT on a UFSAR-Described Design Function***

The UFSAR states not only that the operator can "increase and decrease the control functions using manual controls located in the Main Control Room," but also that "the control mechanism provides tactile feedback to the operator as the mechanism is rotated through each setting increment."

Since a touch screen cannot provide (or duplicate) the "tactile feedback" of a mechanical device, replacing the "knob" with a "touch screen" is adverse because it adversely impacts the ability of the operator to obtain tactile feedback from the device.

Using the same proposed activity provided in Example 4-5 and the same UFSAR descriptions from Example 4-6, Example 4-7 illustrates how a variation in the proposed activity would also cause an adverse impact.

***Example 4-7. Physical Interaction with an ADVERSE IMPACT on a UFSAR-Described Design Function***

In addition to the touch screen control "arrows" themselves, a sound feature and associated components will be added to the digital design that will emit a clearly audible and distinct "tone" each time the control setting passes through the same setting increment that the tactile feature provided with the mechanical device.

Although the operator will now receive auditory "feedback" during the operation of the digital device, the means by which this feedback is provided has been altered. Since the means of controlling the design function has changed, new malfunctions can be postulated (e.g., high ambient sound levels that prevent the operator from hearing the feedback). Therefore, the modification of the feedback feature (i.e., from tactile to auditory) has an adverse impact on the ability of the design function to be performed.

~~**Number and/or Type of Parameters Displayed By and/or Available From the Human System Interface**~~

~~One advantage of a digital system is the amount of information that can be monitored, stored and presented to the user. However, the possibility exists that the amount of such information may lead to an *over abundance* that is not necessarily beneficial in all cases.~~

~~To determine if the HSI aspects of a digital modification have an adverse effect on UFSAR described design functions, potential impacts due to the number and/or type of parameters displayed by and/or available from the HSI should be addressed in the Screen.~~

~~Consideration of a digital modification's impact due to the number and/or type of parameters displayed by and/or available from the HSI involves an examination of the actual number and/or type of parameters displayed by and/or available from the HSI and how they could impact the performance and/or satisfaction of UFSAR described design functions. Potential causes for an adverse impact on a UFSAR described design function could include a reduction in the number of parameters monitored (which could make the diagnosis of a problem or determination of the proper action more challenging or time consuming for the operator), the absence of a previously available parameter (i.e., a type of parameter), a difference in how the loss or failure of~~

~~parameters occurs (e.g., as the result of combining parameters), or an increase in the amount of information that is provided such that the amount of available information has a detrimental impact on the operator's ability to discern a particular plant condition or to perform a specific task.~~

~~Example 4-8 illustrates the application of the *Number and/or Type of Parameters* aspect.~~

***Example 4-8. Number and Type of Parameters with NO ADVERSE IMPACT on a UFSAR-Described Design Function***

Currently, all controls and indications for a single safety-related pump are analog. There are two redundant channels of indications, either of which can be used to monitor pump performance, but only one control device. For direct monitoring of pump performance, redundant *motor electrical current* indicators exist. For indirect monitoring of pump performance, redundant *discharge pressure* and *flow rate* indicators exist. Furthermore, at the destination of the pump's flow, redundant *temperature* indicators exist to allow indirect monitoring of pump performance to validate proper pump operation by determination of an increasing temperature trend (i.e., indicating insufficient flow) or a stable/decreasing temperature trend (i.e., indicating sufficient flow). All of these features are described in the UFSAR.

The UFSAR also states that the operator will "examine pump performance and utilize the information from at least one of the redundant plant channels to verify performance" and "the information necessary to perform this task is one parameter directly associated with the pump (motor electrical current) and three parameters indirectly associated with pump performance (discharge pressure, flow rate, and response of redundant temperature indications)."

A digital system will replace all of the analog controls and indicators. Two monitoring stations will be provided, either of which can be used to monitor the pump. Each monitoring station will display the information from one of the two redundant channels. The new digital system does not contain features to automatically control the pump, but does contain the ability to monitor each of the performance indications and inform/alert the operator of the need to take action. Therefore, all pump manipulations will still be manually controlled.

Since the new digital system presents the same number (one) and type (motor electrical current) of pump parameters to directly ascertain pump performance and the same number (three) and type (discharge pressure, flow rate and redundant temperature) of system parameters to indirectly ascertain pump performance, there is no adverse impact on the UFSAR-

described design function to perform *direct* monitoring of pump performance and no adverse impact on the UFSAR-described design function to perform *indirect* monitoring of pump performance.

~~**Information Presentation on the Human System Interface**~~

~~A typical change in data presentation might result from the replacement of an edgewise analog meter with a numeric display or a multipurpose CRT.~~

~~To determine if the HSI aspects of a digital modification have an adverse effect on UFSAR described design functions, potential impacts due to how the information is presented should be addressed in the Screen.~~

~~Consideration of a digital modification's impact due to how the information is presented involves an examination of how the actual information presentation method could impact the performance and/or satisfaction of UFSAR described design functions. To determine possible impacts, the UFSAR should be reviewed to identify descriptions regarding how information is presented, organized (e.g., how the information is physically presented) or accessed, and if that presentation, organization or access relates to the performance and/or satisfaction of a UFSAR described design function.~~

~~Examples of activities that have the potential to cause an adverse effect include the following activities:~~

- ~~Addition or removal of a dead-band, or~~
- ~~Replacement of instantaneous readings with time-averaged readings (or vice-versa).~~

~~If the HSI changes do not exhibit characteristics such as those listed above, then it may be reasonable to conclude that the "method of performing or controlling" a design function is not adversely affected.~~

~~Example 4-9 illustrates the application of the *Information Presentation* aspect.~~

***Example 4-9. Information Presentation with an ADVERSE IMPACT on a UFSAR-Described Design Function***

A digital modification consolidates system information onto two flat panel displays (one for each redundant channel/train). Also, due to the increased precision of the digital equipment, the increment of presentation on the HSI will be improved from 10 gpm to 1 gpm. Furthermore, the HSI will now

present the information layout "by channel/train."

The UFSAR identifies the existing presentation method as consisting of "indicators with a 10 gpm increment" to satisfy safety analysis assumptions and the physical layout as being "by flow path" to allow the operator to determine system performance.

The increase in the display increment is not adverse since the operator will continue to be able to distinguish the minimum increment of 10 gpm UFSAR-described design function.

The new display method (i.e., "by channel/train") adversely affects the ability of the operator to satisfy the design function to ascertain system performance "by flow path."

644
645 ~~**Operator Response Time**~~
646

647 ~~Typically, an increase in the operator response time might result from the~~
648 ~~need for the operator to perform additional actions (e.g., due to the additional~~
649 ~~steps necessary to call up or retrieve the appropriate display and operate the~~
650 ~~"soft" control rather than merely reading an indicator on the Main Control~~
651 ~~Board).~~

652 ~~To determine if the HSI aspects of a digital modification have an adverse~~
653 ~~effect on UFSAR described design functions, potential impacts on the~~
654 ~~operator response time should be addressed in the Screen.~~

655 ~~Consideration of a digital modification's impact on the operator response time~~
656 ~~due to the modification of the number and/or type of decisions made, and/or~~
657 ~~the modification of the number and/or type of actions taken, involves an~~
658 ~~examination of the actual decisions made/actions taken and how they could~~
659 ~~impact the performance and/or satisfaction of UFSAR described design~~
660 ~~functions. To determine possible impacts, the UFSAR must be reviewed to~~
661 ~~identify descriptions relating to operator response time requirements and if~~
662 ~~those timing requirements are related to the performance and/or satisfaction~~
663 ~~of a UFSAR described design function.~~

664 ~~Example 4-10 is the same as Example 4-9, but illustrates the application of~~
665 ~~the *Operator Response Time* aspect.~~

***Example 4-10. Operator Response Time with NO ADVERSE IMPACT on a UFSAR-Described Design Function***

A digital modification consolidates system information onto two flat panel

displays (one for each redundant channel/train). Also, due to the increased precision of the digital equipment, the increment of presentation on the HSI will be improved from 10 gpm to 1 gpm. Furthermore, the HSI will now present the information layout "by channel/train."

The UFSAR identifies the existing presentation method as consisting of the physical layout as being "by flow path" to allow the operator to determine system performance.

Although the UFSAR identifies the existing presentation method as consisting of a physical layout "by flow path" to allow the operator to determine system performance and the new display method (i.e., "by channel/train") will require additional steps by the operator to determine system performance, requiring more time, there is no adverse impact on satisfaction of the design function to ascertain system performance because no response time requirements are applicable to the design function of the operator being able "to determine system performance.

COMPREHENSIVE HUMAN-SYSTEM INTERFACE EXAMPLE

Although no additional guidance is provided in this section, Example 4-11 illustrates how each of the aspects identified above would be addressed.

***Example 4-11. Digital Modification involving Extensive HSI Considerations with NO ADVERSE IMPACTS on a UFSAR-Described Design Function***

Component controls for a redundant safety-related system are to be replaced with PLCs. The existing HSI for these components is made up of redundant hard-wired switches, indicator lights, and analog meters. The new system consolidates the information and controls onto two flat panel displays (one per redundant train), each with a touch screen providing “soft” control capability.

The existing number and type of parameters remains the same, which can be displayed in a manner similar to the existing presentations (e.g., by train). However, the information can be also presented in different configurations that did not previously exist (e.g., by path or by parameter type to allow for easier comparison of like parameters), using several selectable displays.

The flat panel display can also present any of several selectable pages depending on the activity being performed by the operator (e.g., starting/initiating the system, monitoring the system during operation, or

changing the system line-up).

To operate a control, the operator must (via the touch screen) select the appropriate activity (e.g., starting/initiating the system, monitoring the system during operation, or changing the system line-up), select the desired page (e.g., train presentation, path presentation, or parameter comparison), select the component to be controlled (e.g., pump or valve), select the control action (e.g., start/stop or open/close), and execute it.

The display remains on the last page selected, but each page contains a "menu" of each possible option to allow direct access to any page without having to return to the "main menu."

The two new HSIs (one per redundant train) will provide better support of operator tasks and reduced risk of errors due to:

- Consolidation of needed information onto a single display (within the family of available displays) that provides a much more effective view of system operation when it is called into action.
- Elimination of the need for the operator to seek out meter readings or indications, saving time and minimizing errors.
- Integration of cautions and warnings within the displays to help detect and prevent potential errors in operation (e.g., warnings about incorrect system lineups during a test or maintenance activity).

The design was developed using a human factors engineering design, with a verification and validation process consistent with current industry and regulatory standards and guidelines. As part of the technical evaluation supporting the proposed activity, a Human Factors Evaluation (HFE) was performed. Based on the conclusions from the HFE, the design provides a more effective HSI that is less prone to human error than the existing design.

The UFSAR-described design functions applicable to this proposed activity include ~~descriptions of~~ how the existing controls, including the physical switches, indicator lights and meters, ~~and how~~ each of these SSCs is used during normal and abnormal (including accident) operating conditions. The ~~UFSAR identifies the~~ current physical arrangement (i.e., two physically separate locations) ~~as providing a~~ provides assurance that the design function is satisfied by preventing the operator ~~that prevents the operator~~ from operating the "wrong" component. There are no UFSAR-described design functions related to the operator response times associated with using the existing controls.

The impacts on design functions are identified below:

- *Physical Interaction* - NOT ADVERSE because the new HSI consists of two physically separate displays.
- *Number and Type of Parameters* - NOT ADVERSE because the same number and type of parameters exist with the new HSI.
- *Information Presentation* - NOT ADVERSE because all of the existing features (e.g., individual controls, indicator lights and parameters displays that mimic the analog meters) continue to exist with the new HSI.
- *Operator Response Time* - NOT ADVERSE because no response time requirements were applicable to any of the design functions and there were no indirect adverse affects on any other design function.

#### 4.2.1.3 Screening Changes to UFSAR Methods of Evaluation

By definition, a proposed activity involving a digital modification involves SSCs and how SSCs are operated and controlled, not a *method of evaluation* described in the UFSAR (see NEI 96-07, Section 3.10).

Methods of evaluation are analytical or numerical computer models used to determine and/or justify conclusions in the UFSAR (e.g., accident analyses that demonstrate the ability to safely shut down the reactor or prevent/limit radiological releases). These models also use "software." However, the software used in these models is separate and distinct from the software installed in the facility. The response to this Screen consideration should reflect this distinction.

A necessary revision or replacement of a ***method of evaluation*** (see NEI 96-07, Section 3.10) resulting from a digital modification is separate from the digital modification itself and the guidance in NEI 96-07, Section 4.2.1.3 applies.

### 4.2.2 Is the Activity a Test or Experiment Not Described in the UFSAR?

By definition, a proposed activity involving a digital modification involves SSCs and how SSCs are operated and controlled, not a test or experiment (see NEI 96-07, Section 4.2.2). The response to this Screen consideration should reflect this characterization.

A necessary ***test or experiment*** (see NEI 96-07, Section 3.14) involving a digital modification is separate from the digital modification itself and the guidance in NEI 96-07, Section 4.2.2 applies.