25th anniversary
annual INCOSE
international symposium
Seattle, WA
July 13 - 16, 2015

SAND2015-5396C

Effective System Engineering Peer Reviews

Georgia Artery

Sandia National Laboratories

Outline

- Business Background
- Purpose
- Process Elements
- Process Steps
- Tool
- Benefits
- Conclusion

Business Background

- Large, complex business with proprietary design constraints
  - Limited independent technical resources
- Currently, 3 major programs are underway to develop and produce high consequence system and components.
- Corporate strategic milestone was defined to establish an engineering peer review process to support successful execution of the engineering mission space

Background

- Confusion exists between design & peer reviews
  - Absence of a clear defined peer review process adds to this confusion
- Deep technical focus required for high consequence products are needed to assure successful engineering execution
  - Evidence shows shortcuts have been taken
  - Lack of independence and follow through result in box checking
  - True benefits for a “peer review” have not been realized

Purpose

- Create a consistent process for which designs teams can benefit to improve their designs
  - Define the attributes needed for a peer review
  - Define a process to support and encourage deep technical dives
  - Propose that Peer Reviews precede Design Reviews
- Developing a systematic approach that considers independence, scope, and rigor, all tied to technical risk
  - Thorough and Repeatable Process
  - Graded Approach
  - Process to ensure observations are resolved

Risk-based tool to facilitate structure and focus of the review

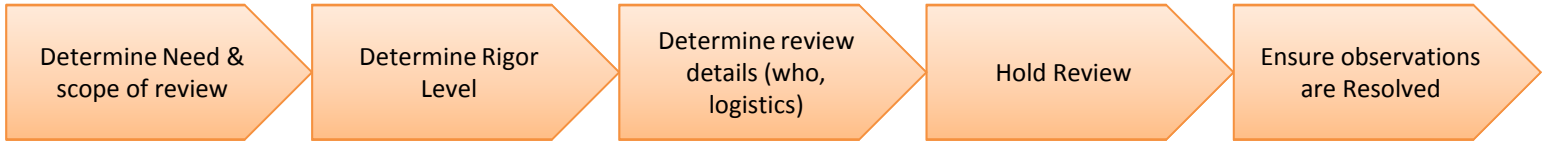
Approach

- Conduct lessons learned
- Benchmark process elements
- Define process attributes
- Socialize process
- Conduct “pilot”
- Evaluate results
- Implement new process

Proposed Process Elements

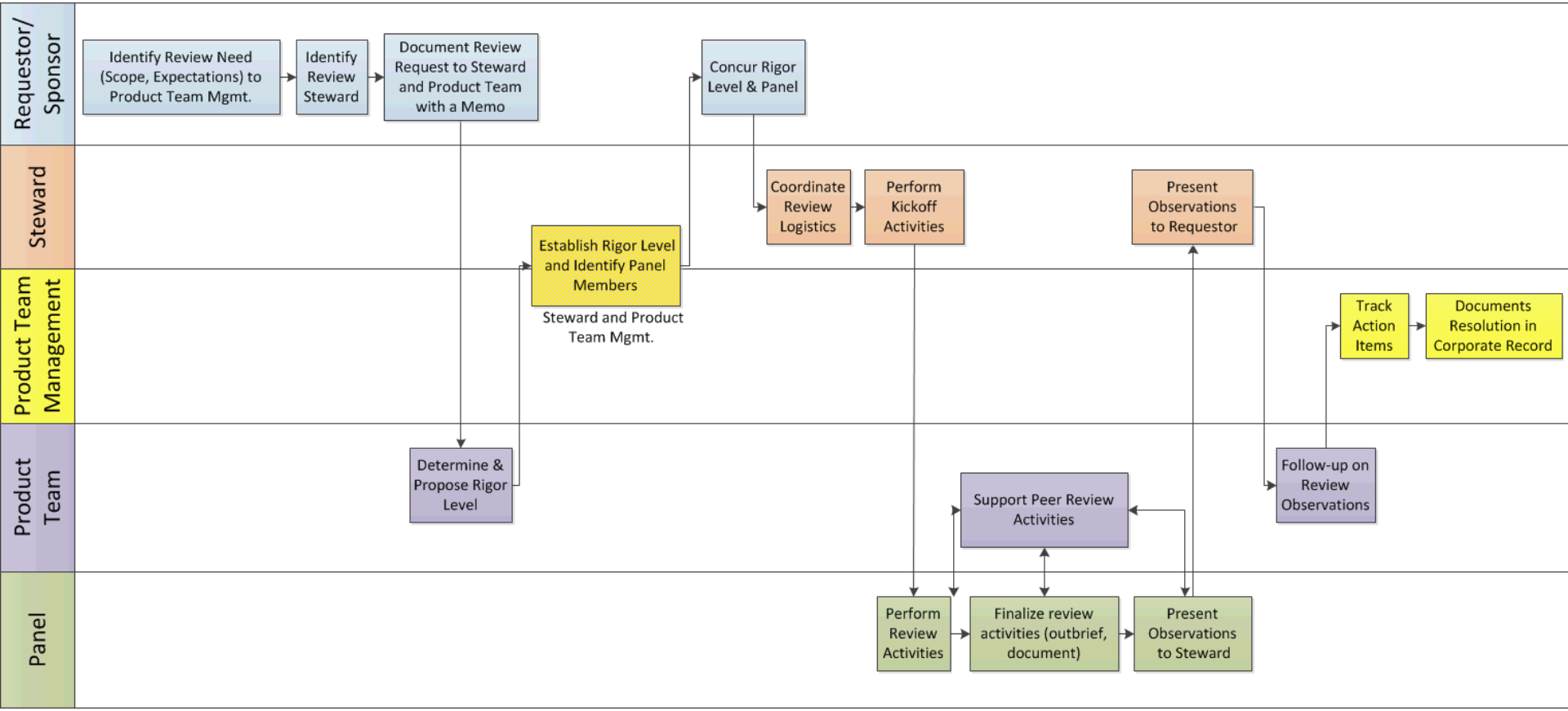
- Independence
- Rigor
- External Engagement
- Resolution
- Identification of Peers
- Systematic Process/Structure

Peer Review Process Steps



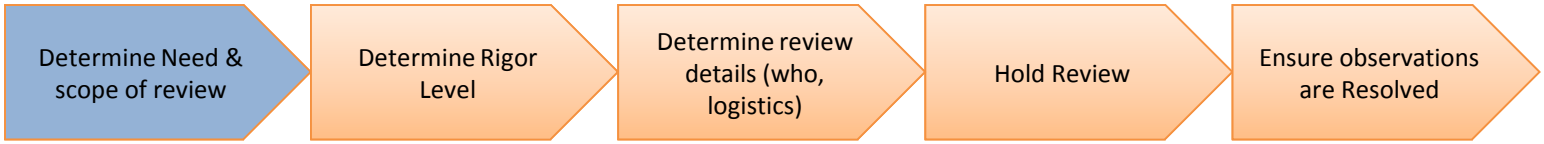
- Identify peer review is needed & determine scope of review
- Determine rigor level by evaluating criticality (likelihood indicator) and consequence
- Determine review details
  - Establish constraints on execution of peer review (time, $, classification, etc...)
  - Determine what knobs can be turned to execute the review (depth, who, ...)
- Hold the review
- Ensure review results get acted on

Peer Review Process



Cleared Defined Roles and Responsibilities is key to review execution

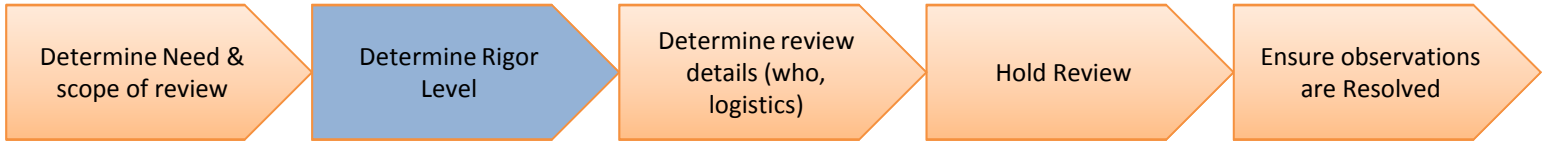
Determine Scope of Review



- Is the design approach new?
- Is there a new technology or material that is being used?
- Are there safety architecture concerns?
- Are there functional performance areas that are of concern?
- Are there areas of margin/uncertainty that need review?
- Are there high risk sub-components included in the design?
- Are there Nonconformance reports or field returns on legacy components that may lead to further review by a peer team?

Peer Reviews can be initiated at any time in the life-cycle

Likelihood / Consequence Tool



Step 2: Utilize the Likelihood and Consequence Tool to assess Rigor Level for Review

Technical Issues (Click Cell to Obtain More Information)	Please Enter Answer/Concern Level by Clicking on Cell and Using Dropdown List
Are there requirements of concern? Are there functional or performance areas of concern?	Yes/High Concern
Is there new technology that is being used? Is the design approach new? Is there a history of issues on legacy design or process?	Minor Concern
Are there any new process approaches? Are there major process changes? Have there been materials changes?	No/No Concern
Is the necessary information for the design or process difficult to obtain?	No/No Concern
Is the design or process highly complex?	Yes/High Concern
Are there qualification concerns?	No/No Concern
Are there high-risk components included in the design? Is the design or process highly dependent on other things being achieved?	No/No Concern

Programmatic Issues (Click Cell to Obtain More Information)	Please Enter Answer/Concern Level by Clicking on Cell and Using Dropdown List
Is the level of experience of design team of concern?	No/No Concern
Is anything on a critical path?	No/No Concern
Is the funding or funding profile of concern?	No/No Concern
Are there conditions of Program, program obstacles, or program constraints (i.e., use COTS, provide commonality, really long lifetime….) that are of concern?	No/No Concern
Is the program sufficiently ready?	No/No Concern

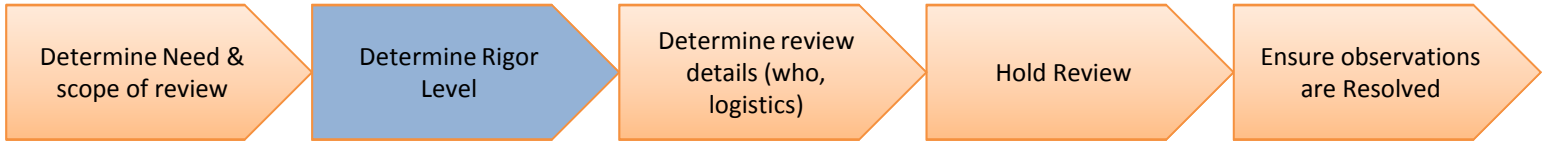
System Impact* (Click Cell to Obtain More Information)	Please Enter Answer/Concern Level by Clicking on Cell and Using Dropdown List
Are there concerns about stakeholder perceptions, political and/or social factors, if the design does fails or does not meet its performance requirements?	High/Critical
What is the time impact if design cannot be realized when needed?	Moderate/Major
What is the cost impact if design cannot be realized when needed?	Low/Minor

*Note: If design in used in multiple systems, please consult with all system owners.

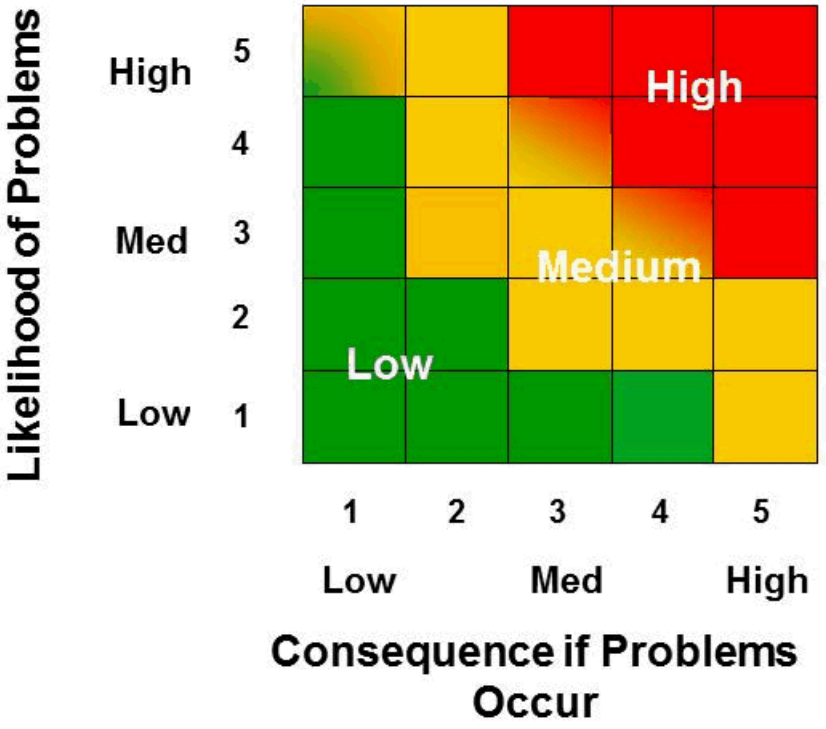
Likelihood for Problems	4

Consequence	3

Determine review rigor level

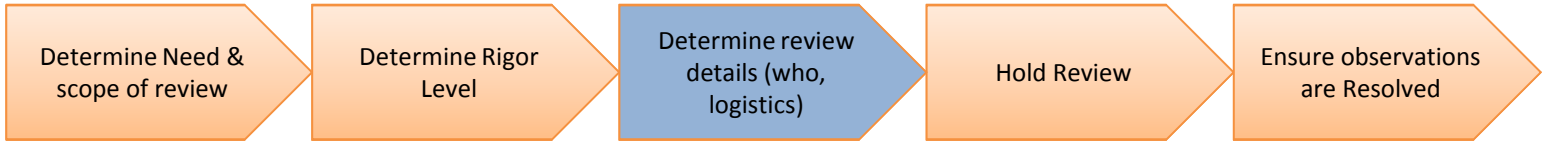


- **Use Tool to evaluate:**
  - Level of likelihood of problems
  - Level of consequence if problems occur
  - Resulting level of rigor for peer review
    - Red = high
    - Yellow = medium
    - Green = low



Insert link to tool here and demo tool

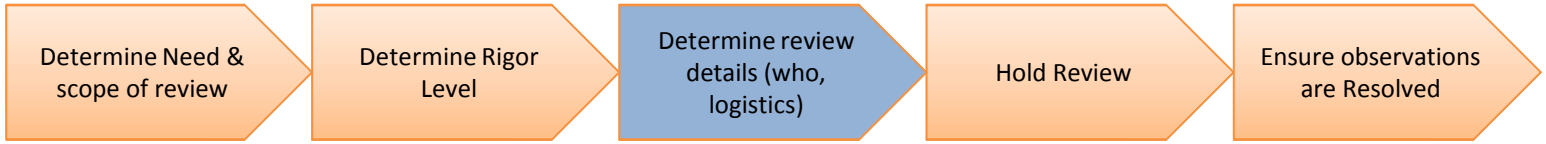
Peer review roles



Function	Roles	Tasks
Requests review	Requestor	Requestor
Ensures accountability	Product Team Mgmt	Management
Presents at review	Product Team	Product Design
Performs review	Peer Review Panel	Panel Chair
		SMEs
		Facilitator (optional)
		Tech. Writer (optional)
		Note Taker (optional)
Administers review	Steward	Steward
		Coordinator (optional)

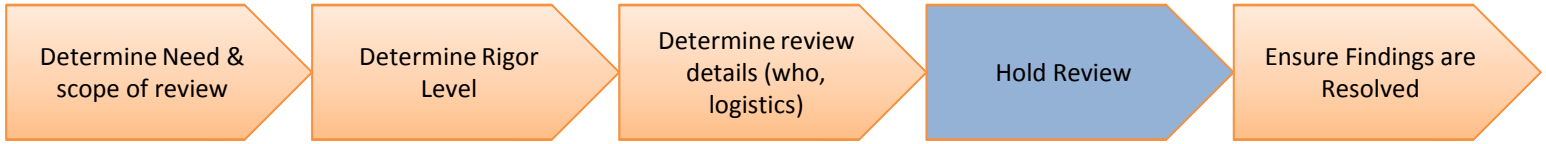
A person may have multiple roles. Important for high rigor peer review is that the steward is independent.

Panel Membership Based on Rigor Level



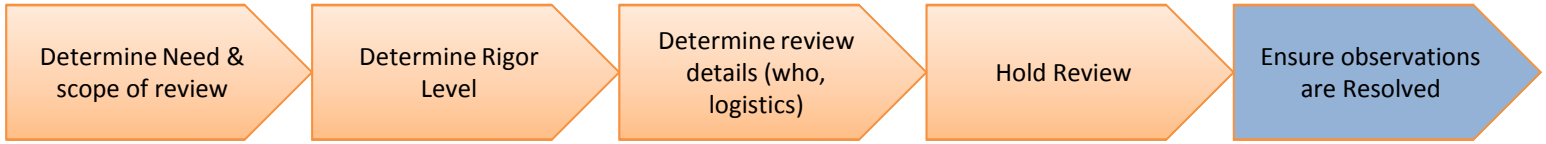
Rigor Level	Panel Size	Depth	Reviewers
High	6-8	• Review process may take time (Weeks to Months) • Homework for review team before on-site focused review • Primary Interaction is an on-site focused review • Review panel may perform their own analysis/investigation or ask for additional analysis to be performed	External Required
Medium	4-6	• Interaction is likely a >1 day meeting • Tutorial in advance of meeting • Homework for review team before meeting • Opportunity for review team to ask for additional analysis • Review panel takes time to form their opinion (weeks)	External Recommended
Low	2-4	• Interaction is likely a <1 day meeting • Project team provides information to review team • Review team is not expected to perform homework or assign design team homework • Review panel takes time to form their opinion (hours to days)	External Optional
All			• Lead from similar product • Science subject matter expert • Mod/Sim subject matter expert

Hold Review



- Conduct Review with Management Team, Panel of Subject Matter Experts, Panel Chair, Presenters, Facilitator, and Coordinator present as appropriate to the review needs
  - Conduct formal Opening Briefing
  - Presentations explaining the issue
  - Conduct interviews
  - Review work documents
  - Review computer models
  - Review parts designs
  - Perform independent tests & analyses
  - Conduct Formal Closeout Briefing

Ensure Observations Are Addressed



- Following up on the recommendations and observations of a review is critical to realizing the benefit of the review
- Action items from the review shall be tracked by the product team
- Review product team management is responsible for tasking the appropriate people to perform the follow-up
- Product team management signs-off on resolution of observations with a memo to the requestor
- Resolution memo called out as a topic for required design reviews

Benefits

- Likelihood and consequence tool helped to focus the review on critical technical areas
  - Complex designs are difficult to provide the focus needed
  - Subject Matter Experts were identified for focus areas
- Focusing on high risk areas if there are cost and schedule constraints
- Flexibility in approach and execution if the review has high visibility to customers

Conclusions

- 3 successful pilots were conducted critical development programs
  - The tool was integral to scoping the review by providing a risk based approach
  - Methodology to tailor parameters to meet key design needs
- Risk-based approach that considers fundamental elements of a product life cycle and highlights key technical issues
- Instituting rigorous peer review process is essential to delivering confident design and product to maintaining the nation's nuclear deterrence

Tool for Determining Rigor Level for Design Peer Reviews

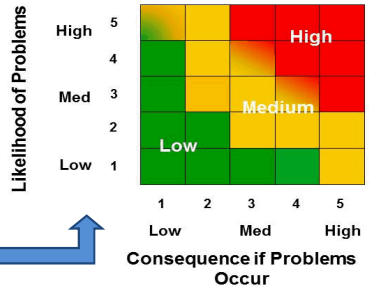
Technical Issues (Click Cell to Obtain More Information)	Please Enter Answer/Concern Level by Clicking on Cell and Using Dropdown List
Are there requirements of concern? Are there functional or performance areas of concern?	Yes/High Concern
Is there new technology that is being used? Is the design approach new? Is there a history of issues on legacy design or process?	Minor Concern
Are there any new process approaches? Are there major process changes? Have there been materials changes?	No/No Concern
Is the necessary information for the design or process difficult to obtain?	No/No Concern
Is the design or process highly complex?	Yes/High Concern
Are there qualification concerns?	No/No Concern
Are there high-risk components included in the design? Is the design or process highly dependent on other things being achieved?	No/No Concern

Programmatic Issues (Click Cell to Obtain More Information)	Please Enter Answer/Concern Level by Clicking on Cell and Using Dropdown List
Is the level of experience of design team of concern?	No/No Concern
Is anything on a critical path?	No/No Concern
Is the funding or funding profile of concern?	No/No Concern
Are there conditions of Program, program obstacles, or program constraints (i.e., use COTS, provide commonality, really long lifetime….) that are of concern?	No/No Concern
Is the program sufficiently ready?	No/No Concern

System Impact* (Click Cell to Obtain More Information)	Please Enter Answer/Concern Level by Clicking on Cell and Using Dropdown List
Are there concerns about stakeholder perceptions, political and/or social factors, if the design does fails or does not meet its performance requirements?	High/Critical
What is the time impact if design cannot be realized when needed?	Moderate/Major
What is the cost impact if design cannot be realized when needed?	Low/Minor

*Note: If design in used in multiple systems, please consult with all system owners.

Likelihood for Problems	**4**
Consequence	**3**



	Technological Factors (Find the highest concern level at which any one or more of the listed issues apply)		Metric	No/No concern	Minor Concern	Medium Concern	Yes/High Concern
Go Back	Maturity Factor	**Are there requirements of concern?** **Are there functional or performance areas of concern?** **Are design requirements adequately stable for this point in the Phase process?** Requirements identified; interface requirements defined, TBDs or TBRs minimized, etc.	Meeting specification/ requirements	Few or no requirements listed as To Be Resolved (TBR) Can be accommodated Lots of margin Requirements deemed stable	Some less critical requirements still remain (To Be Determined) TBD or TBR Tolerances still need to be specified Some specification details missing Meeting margin specification Requirements adequately stable for this point in process	TBDs and TBRs generating concern Challenged to meet key requirements Margins must be resolved Resolution is needed within a limited timeline Requirements still changing or marginally being met	Product being scrapped Key Performance Parameter/ Critical Requirement still TBD or not being met Key requirements are unstable or unknown
Go Back		**Is there new technology that is being used?** **Is the design or manufacturing approach new?** **Is there history of issues on legacy design or process?**	TRL (vs expected for this point in the program)	TRL appropriate for this point in process Mature technology being used Readily available Legacy present no issues	TRL slightly low for this point in process New technologies are well-defined or in advanced level of technology readiness Legacy issues have been resolved or are understood	TRL stagnant or considered too low by many involved New technologies at intermediate or prototyped level of development Significant modifications to proven designs Legacy issues exists and/or historically difficult part	TRL has regressed and/or is extremely low for this point in process Many early or conceptual technologies or approaches being used New design compared to existing body of knowledge Pending problems with legacy, customer escapes, and/or upgrades have occurred
Go Back		**Are there any new process approaches?** **Are there major process changes?** **Have there been materials changes?**	MRL (vs expected for this point in the program)	MRL appropriate for this point in process Mature technology being used Materials or parts of sufficeint quality readily available Legacy present no issues	MRL slightly low for this point in process New technologies, materials, or parts are well-defined or in advanced level of technology readiness Legacy issues have been resolved or are understood	MRL stagnant or considered too low by many involved New technologies at intermediate or prototyped level of development Significant modifications to proven processes or materials Legacy issues exists and/or historically difficult part	MRL has regressed and/or is extremely low for this point in process Many early or conceptual technologies or approaches being used New process compared to existing body of knowledge Pending problems with legacy, customer escapes have occurred
Go Back		**Is the necessary information for the design or process readily available?** For example, test data, production data, process development data, mod/sim data, etc.	Information/Data availability for design or process (not requirements)	Data readily available, collected, or reproduced	Data can be collected or reproduced with minor resources or is imminent	Data can be collected or reproduced with major resources Some significant information has been delayed	Data cannot be collected or reproduced without critical resources Information is not available
Go Back	Complexity Factor	**Is the design or process highly complex?**	Part/ Process Complexity	Simple Readily understood	Specific, Routine Less than 10 parts or steps Learnable in hours to weeks and/or requires limited expertise	Complicated, changing More than 10 but less than 100 parts or steps Learnable in 1-3 years and/or requires moderate expertise	Complex, non-equilibrium More than 100 parts or steps Learnable with >5 years and/or requires highly specialized expertise
Go Back		**Are there qualification concerns?** **Are test capabilities identified and available when needed?**	Qualification Complexity	Ability to test or model	Most aspects of design or process can be tested or modeled Facilities, equipment, and/or models are ready or will be soon	Some aspects of design or process can be tested or modeled Testing is dependent on facilities, equipment, and/or models being ready	Limited or no ability to test or model Very dependent on complex models for qualification Facilities, equipment, and/or models not ready
Go Back	Dependency Factor	**Are there high-risk components included in the design?** **Is the design or process highly dependent on other things being achieved?** For example, COTS parts; piece part availability, reliability, trustworthiness; materials availability, purity; computations, simulations, code development; etc.	Realization Dependency	Not dependent, fully self-contained or sufficiently controllable	Dependent on specific procedures and processes Dependent on one to a few other parts for completion Minor concern over controllability and/or few dependency issues exist	Dependent on complicated procedures and processes Dependent on creativity, some knowledge management, and some expertise Dependent on several to many other parts for completion Medium concern over controllability and/or some dependency issues exist	Dependent on immature processes or changing processes Dependent on numerous other parts or processes for completion Dependent on computational simulation, knowledge management, and expertise Expected or existent controllability issues and/or significant dependency issues

	Programmatic Issues (Find the highest concern level at which any one or more of the listed issues apply)	No/No concern	Minor Concern	Medium Concern	Yes/High Concern
Go Back	**Level of experience of design and/or production group**	High performing team who has designed similar component before	High 10+ years program/product experience by many in design group	Medium 5-10 years experience by many in design group but not necessary on program/product applications	Low 0-5 years experience by many in design group
Go Back	**Timeline**	Schedule contingency exists Nothing on critical path	Adequate for scope of program Critical path items can be managed	Optimistic but possible with some reductions in scope/planning Actively working an item on critical path	Challenged by critical path issue(s) Many negotiated or unforeseen alterations to the scope, timeline, etc.
Go Back	**Funding/funding profile**	Contingency funds available	Some contingency funds available Dependent on funding being available when needed	No contingency funds Little margin in funding Critical funding point in program timeline exists	Funding is inadequate Program/project has been rescoped because of funding concerns
Go Back	**Obstacles/Conditions of Program/Constraints (i.e., use COTS, provide commonality, really long lifetime....)**	None	Few small constraints Staffing reasonably stable	Some constraints or one medium constraint Staff movement significant	Significant constraints or one critical constraint Turnover or loss of key staff and/or management
Go Back	**Program Readiness**	Sufficiently staffed and managed Program details sufficiently resolved	Adquately staffed and managed Program details nearly resolved	Staff and/or management issues being worked Program details still in flux	Loss/lack of critical staff and/or management Critical program details not addressed

	Impact	Negligible	Low/Minor
Go Back	**Are there concerns about stakeholder perceptions, political and/or social factors, if the design does fails or does not meet its performance requirements?**	Unaffected	Minor on over all mission and program
Go Back	**What is the time impact if design cannot be realized when needed?**	Less than 2% of program schedule Negligible amount of time to rebuild, respond, or recover	More than 2% but less than 10% of program schedule Minor amount of time to rebuild, respond, or recover
Go Back	**What is the cost impact if the design cannot be realized when needed?**	Less than 2% of item/material or program cost Neglible downstream indirect cost	More than 2% but less than 10% of item/material or program cost Minimal ($K) downstream indirect costs

Perspective	Contingency can be managed within Org.	Contingency can be managed within business unit

Moderate/Major	High/Critical
Major on overall mission and program Question competency through requirement of rigorous oversight and/or halt program	Critical on over all mission and program Public alarm Failure of assigned mission
More than 10% but less than 30% of program schedule Moderate amount of time to rebuild, respond, or recover	More than 30% of program schedule High amount of time to rebuild, respond, or recover
More than 10% but less than 30% of item/material or program cost Moderate ($M) downstream indirect costs	More than 30% of item/material or program cost High ($B) downstream indirect costs

Contingency can be managed within stakeholder	Customer gets a call

Issues
No/No Concern
Minor Concern
Medium Concern
Yes/High Concern

Consequences
Negligible
Low/Minor
Moderate/Major
High/Critical

DO NOT EDIT THIS PAGE

Implementing the Graded Approach Process at the DOE Facilities, 10/01/2002

SAND2011-0003

Table 9. Consequence dimensions and guidelines for assessing maximum levels of severity.

Consequence Dimensions	Minimal	Moderate	Significant	Severe
Public Health & Safety	• Thousands of individuals dead • Tens of thousands of individual affected • Localized geographic area	• Tens of thousands of individuals dead • Hundreds of thousands of individuals affected • Localized geographic area	• Hundreds of thousands of individuals dead • Millions of individuals + affected • Widespread geographic area	• Millions of individuals + dead or affected • Widespread geographic area
Economic Disruption	• Minimal ($M) direct cost on affected systems to handle rebuild, respond, or recover. • Minimal ($M) downstream indirect costs.	• Moderate ($100Ms) direct cost on affected systems to handle rebuild, respond, or recover. • Moderate ($100Ms) downstream indirect costs.	• Significant ($B) direct cost on affected systems to handle rebuild, respond, or recover. • Significant ($B), long-term, downstream indirect costs.	• Severe ($T) direct cost on affected systems to handle rebuild, respond, or recover. • Severe ($T), long-term, downstream indirect costs.
Psychological	• Moderate-term (months) reduction of public morale and confidence in national economic and political institutions. • Minimal changes to daily behavior (e.g. pay by cash instead of credit; Buy in person not online)	• Moderate term (months) erosion of public's sense of safety and well-being • Moderate change to daily behavior (e.g. avoid unnecessary travel; food & supply hoarding)	• Long term (year +) erosion of public's sense of safety and well-being • Significant change to daily behavior (e.g. avoid airplane travel altogether)	• Pivotal change in public perception leading to a cultural shift / sustained behavior change.
Governance & Mission Impacts	• Minimal degradation of essential capabilities is/may occurring. • Moderate degradation in secondary capabilities is/may occurring.	• Moderate degradation of essential capabilities is/may occurring. • Significant degradation in secondary capabilities is/may occurring.	• Significant degradation in essential capabilities is/may occurring. • Severe degradation in secondary capabilities is/may occurring.	• Severe degradation in essential capabilities is/may occurring.

http://www.imba.com/resources/maps/trail-difficulty-ratings

If having a review:

Extent/Size of Issue to be reviewed	Small Feature or single issue	Medium Component or topical area or several issues	Large System or complex, multi-disciplinary issue(s) and/or numerous issues
Amount of Change from Design Group Known Baseline Approach(es)/Gradient	Little Some changes but using known technology	Medium Changes to some previously unused or new technology for this design group	Great Significant divergence into new technology for this or any design group
Relative Difficulty (hard to accomplish) compared to other activities, not by same design group	Similar Predictive element(s) based on math and science	Somewhat different Quantitative analytical aspects describe function or behavior	Very different Qualitative aspects of engineered solution only
Exposure to broader community/knowledge base of peers	Lots	Medium	Little
Common sense input	Looks/seems sound by general peer groups (i.e., rumor mill) Excellent feedback from existing review(s)	Few comments of concern by general or certain population group Watchful feedback or follow-up activities required by previous reviews	High concern from many levels Concerned feedback from previous reviews