NRR

T/64

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

RIC 2009: State-of-the-Art Reactor Consequence Analysis (SOARCA)

Charles Tinkler – Session Chairman
Office of Nuclear Regulatory Research

March 11, 2009

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

Status Of SOARCA Study

- All scenarios have been analyzed
  - Newly completed scenarios:
    - Surry:
      - Interfacing System Loss of Coolant Accident
      - Thermally Induced Steam Generator Tube Rupture
    - Peach Bottom:
      - Short Term Station Blackout
  - Completion of offsite consequence predictions
- Public information booklet has been developed to complement technical NUREG

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

Upcoming Activities

- May
  - Complete technical NUREG (4 vol.)
- June
  - Start Peer Review
  - Start Uncertainty Study
- July
  - Brief ACRS

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

Presentations

- **Updated Accident Progression Analyses** – Jason Schaperow
- **Reporting Offsite Health Consequences** – Terry Brock
- **Risk Communications** – Dorothy Collins
- **Phenomenological Advances of Severe Accident Progression** – Randall Gauntt

U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Updated Accident Progression Analyses

Jason Schaperow

Office of Nuclear Regulatory Research

March 11, 2009

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

Updated Accident Progression Analyses – Progress since RIC 2008

- Added Peach Bottom short-term station blackout
  - Frequency of 3×10^{-7}/year is below SOARCA screening criterion of 1×10^{-6}/year
  - Analyzed to assess risk significance relative to long-term station blackout
- Completed Surry containment bypass events
  - Interfacing systems LOCA
  - Short-term station blackout with consequential thermally induced steam generator tube rupture

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

Updated Accident Progression Analyses – Preliminary Conclusions

- All events can reasonably be mitigated
- For unmitigated sensitivity cases – no LERF
- Releases are dramatically smaller and delayed from 1982 Siting Study (SST1)

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

Thermally Induced Steam Generator Tube Rupture

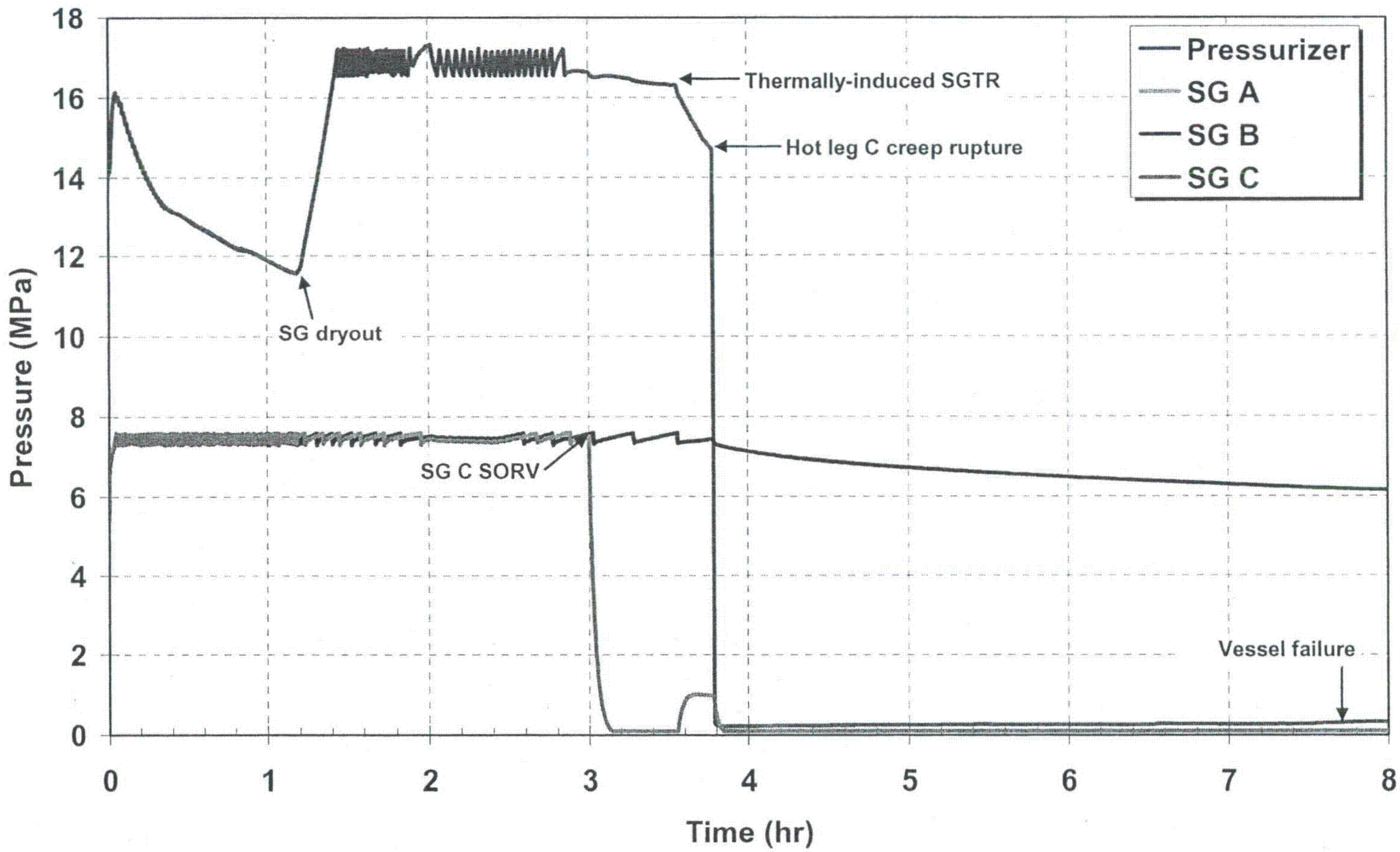
- Timing of event is controlled by assumption that the turbine-driven auxiliary feedwater pump (TD-AFW) failure occurs immediately due to failure of Emergency Condensate Storage Tank
  - Release starts at 3.5 hours
- But, release magnitude (<1%) is reduced from earlier assessments due to
  - Subsequent hot leg rupture
  - Decontamination factor of 7 in the steam generator (ARTIST tests)
- Basic thermal hydraulic behavior (hot leg failure after tube rupture) was confirmed by SCDAP/RELAP5 analysis

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

Thermally Induced Steam Generator Tube Rupture

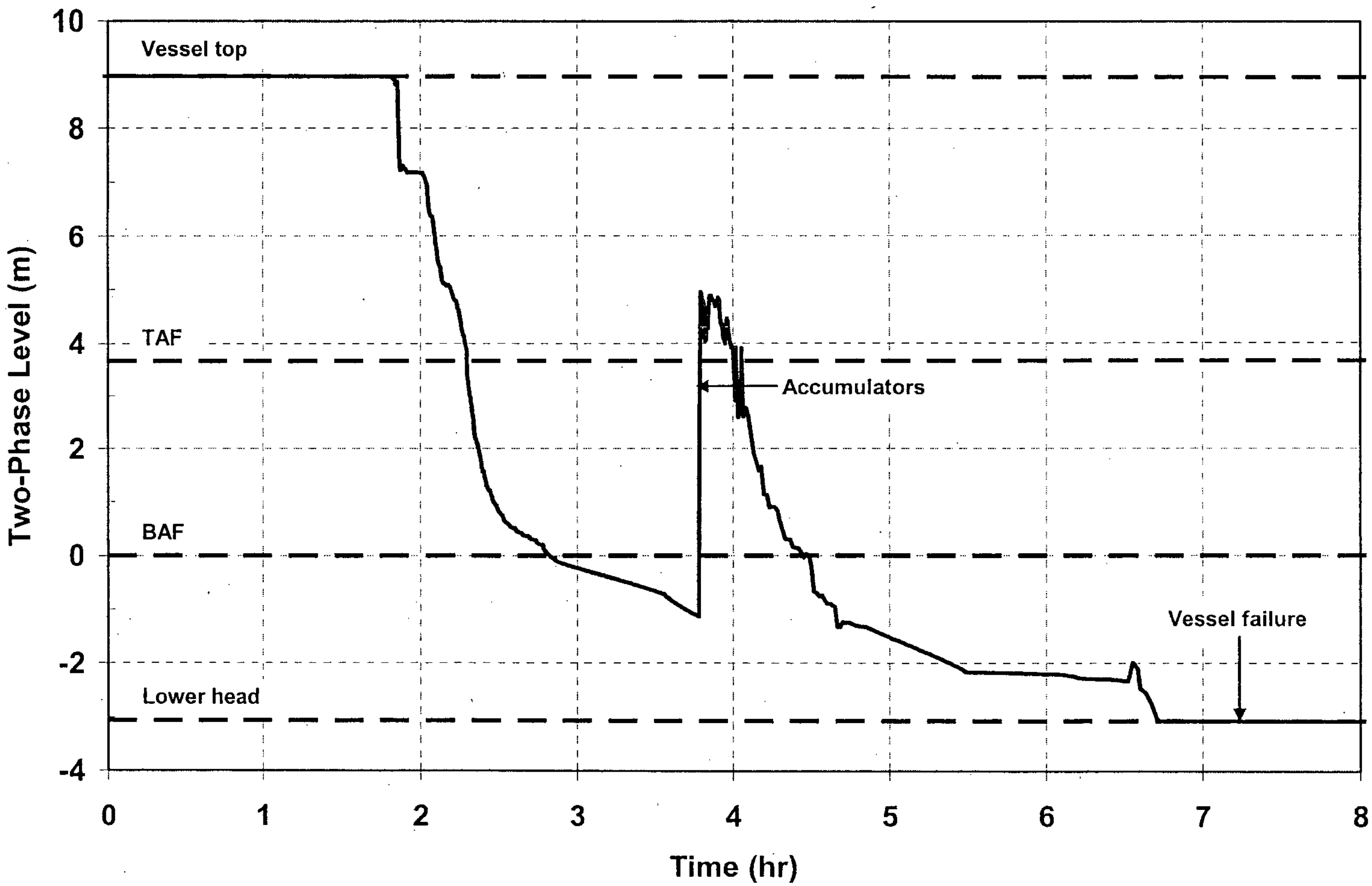
- Mitigation
  - Other severe accident analyses showed core damage could be delayed for 9 hours if TD-AFW available to fill steam generators one time following event initiation
  - Security-related diesel-driven pump available for containment flooding

Thermally Induced Steam Generator Tube Rupture – System Pressure



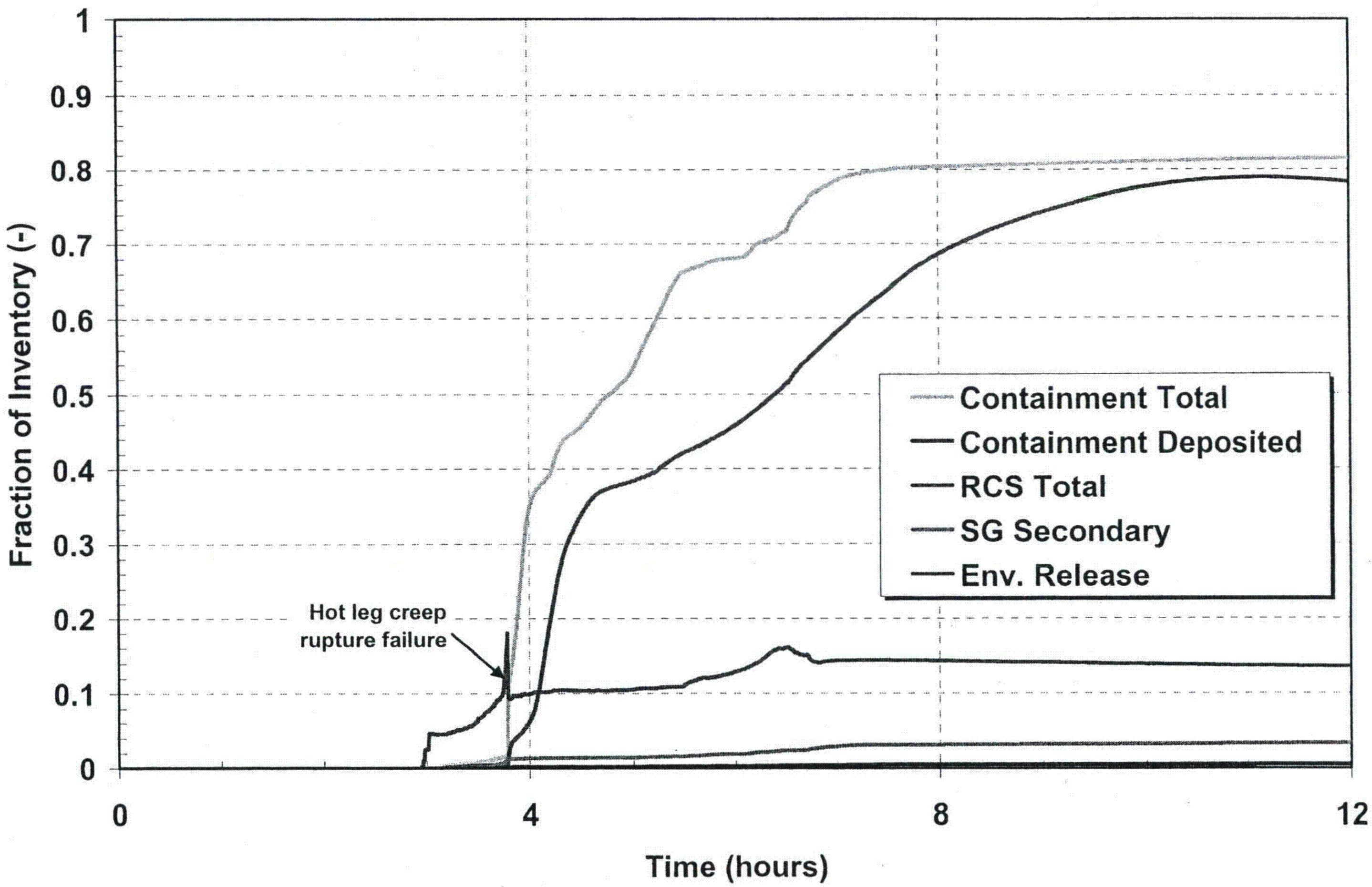
U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Thermally Induced Steam Generator Tube Rupture – Reactor Water Level



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

Thermally Induced Steam Generator Tube Rupture – Iodine Distribution



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

Scenarios – Peach Bottom

Scenario	Initiating event	Core damage frequency (per year)	Description of scenario
Long-term SBO	Seismic, fire, flooding	$3x10^{-6}$	Immediate loss of AC power and eventual loss of control of turbine driven systems due to battery exhaustion
Short-term SBO	Seismic, fire flooding	$3x10^{-7}$	Immediate loss of ac power and turbine driven systems

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

Key Accident Progression Timing for Unmitigated Sensitivity Cases – Peach Bottom

Scenario	Time to start of core damage (hours)	Time to lower head failure (hours)	Time to start of release to environment (hours)
Long-term SBO	10	20	20
Short-term SBO	1	8	8

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

Scenarios – Surry

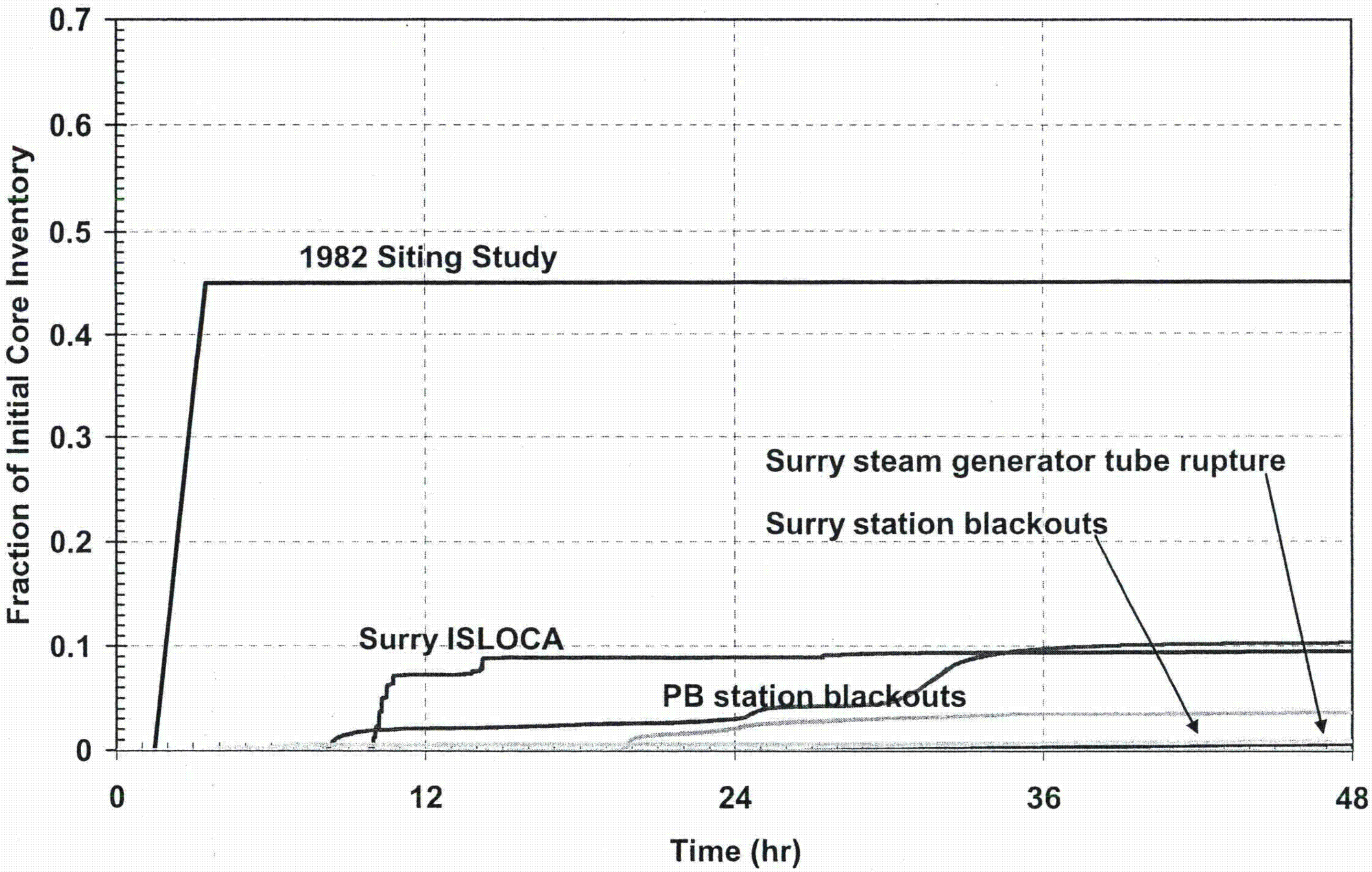
Scenario	Initiating event	Core damage frequency (per year)	Description of scenario
Long-term SBO	Seismic, fire, flooding	$2x10^{-5}$	Immediate loss of ac power, eventual loss of control of turbine-driven systems due to battery exhaustion
Short-term SBO	Seismic, fire, flooding	$2x10^{-6}$	Immediate loss of ac power and turbine-driven systems
Thermally induced steam generator tube rupture	Seismic, fire, flooding	$5x10^{-7}$	Immediate loss of ac power and turbine-driven systems, consequential tube rupture
Interfacing systems LOCA	Random failure of check valves	$3x10^{-8}$	Check valves in high-pressure system fail open causing low pressure piping outside containment to rupture, followed by operator error

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

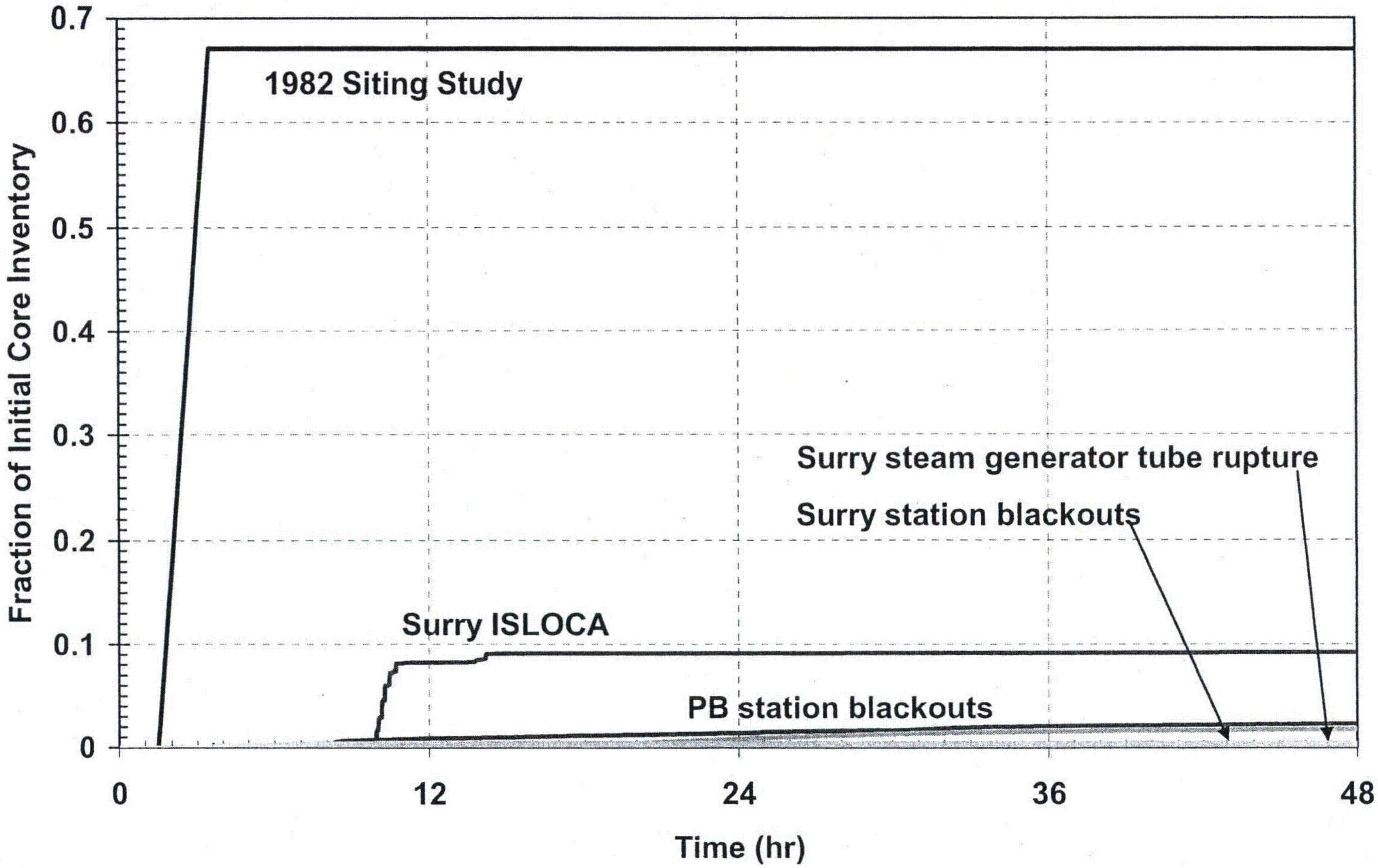
Key Accident Progression Timing for Unmitigated Sensitivity Cases – Surry

Scenario	Time to start of core damage (hours)	Time to lower head failure (hours)	Time to start of release to environment (hours)
Long-term SBO	16	21	45
Short-term SBO	3	7	25
Thermally induced steam generator tube rupture	3	7.5	3.5
Interfacing systems LOCA	9	15	10

Iodine Release for Unmitigated Sensitivity Cases



Cesium Release for Unmitigated Sensitivity Cases



U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Reporting Offsite Health Consequences

Terry Brock

Office of Nuclear Regulatory Research

March 11, 2009

SOARCA Background

- SOARCA to realistically perform offsite consequence analysis
- Consequences are calculated for early fatality and latent cancer fatality (LCF) risk

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

Previous Studies

- Used the Linear No-threshold dose response model (LNT) and aggregated doses over all individuals projected to receive any exposures to calculate latent health effects

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

International Commission on Radiological Protection (ICRP)

- Risk projections of cancer deaths using the LNT model and involving trivial exposures to thousands of people is not reasonable and should be avoided (ICRP 103, 2007)

Staff recommended approach in SECY-08-0029

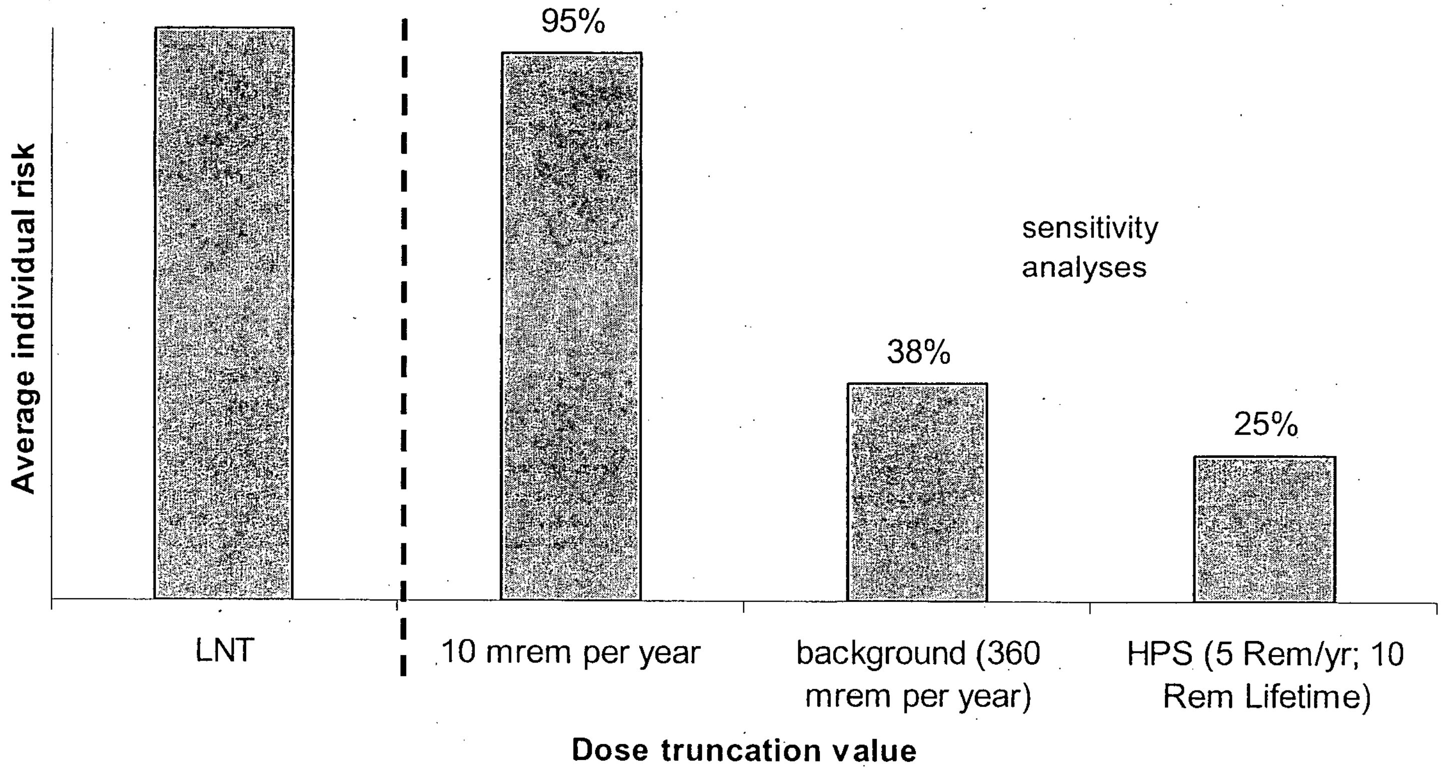
- Calculate the average individual likelihood of cancer mortality conditional to the occurrence of a severe reactor accident
  - Results portrayed as conditional risk
  - Results also portrayed as absolute risk considering scenario frequency
- The calculation includes both LNT and 10 mrem per year dose truncation response model
  - 10 mrem per year interpreted from ICRP 104

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

SOARCA provides additional sensitivity analyses

- Study includes additional consequence predictions using alternative dose truncation assumptions
  - Background dose (360 mrem/yr)
  - HPS position (5 rem/yr and 10 rem lifetime)
- Intent of multiple dose response models is to provide more perspective on potential outcomes and provide insight on the sensitivity of the range of dose values to risk

Sample sensitivity analyses for individual LCF risk in the EPZ relative to LNT

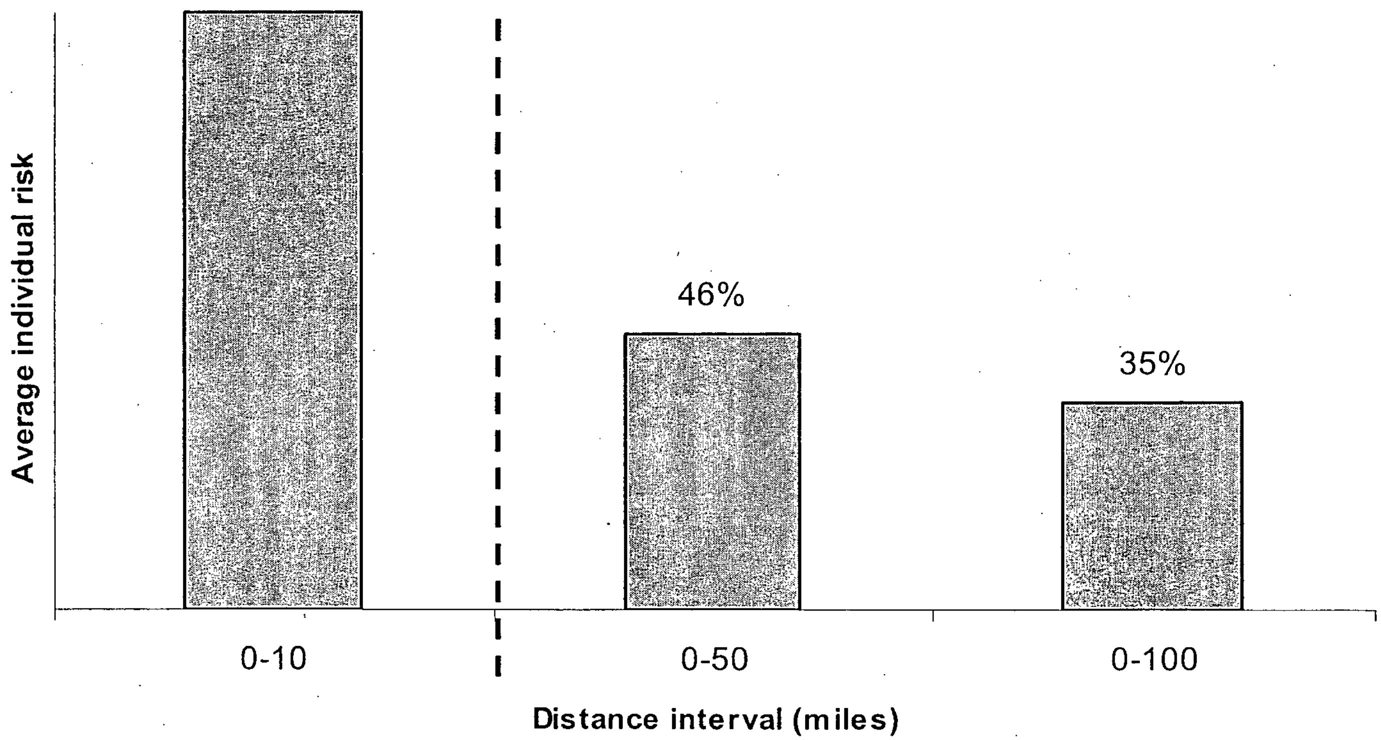


U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

Staff recommended approach cont.

- Results presented for three distances
  - 0 to 16.1 km (10 miles);
  - 0 to 80.5 km (50 miles); and
  - 0 to 161 km (100 miles)

Sample average individual risk at three distance intervals relative to the EPZ



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

Staff basis

- Facilitate public risk communication by providing a likelihood of consequences that could be compared with the occurrence of LCFs in the general population from causes other than a reactor accident
- The distances selected are consistent with emergency planning zones and the agency's strategic planning goals

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

Staff basis cont.

- This approach also would be similar to that used by the Commission in establishing its Safety Goal
- Commission approval on September 10, 2008

5

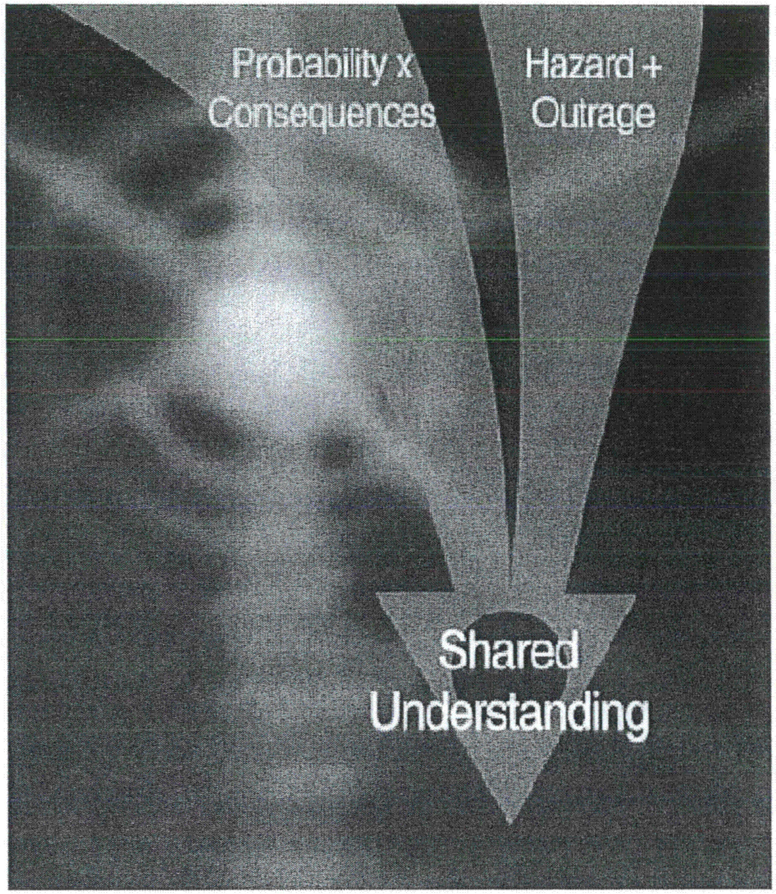
U.S.NRC
UNITED STATES NUCLEAR REGULATORY COMMISSION
Protecting People and the Environment

RIC 2009
SOARCA Risk Communication

Dorothy Collins
U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
March 11, 2009

What is risk communication?

"an interactive process used in talking or writing about topics that cause concern about health, safety, security, or the environment"



NUREG/BR-0308

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

Spheres of Argument

Technical Sphere

- Metaphor of "trial or experiment"
- Formality and expertise important
- Only certain kinds of evidence and reasoning permitted

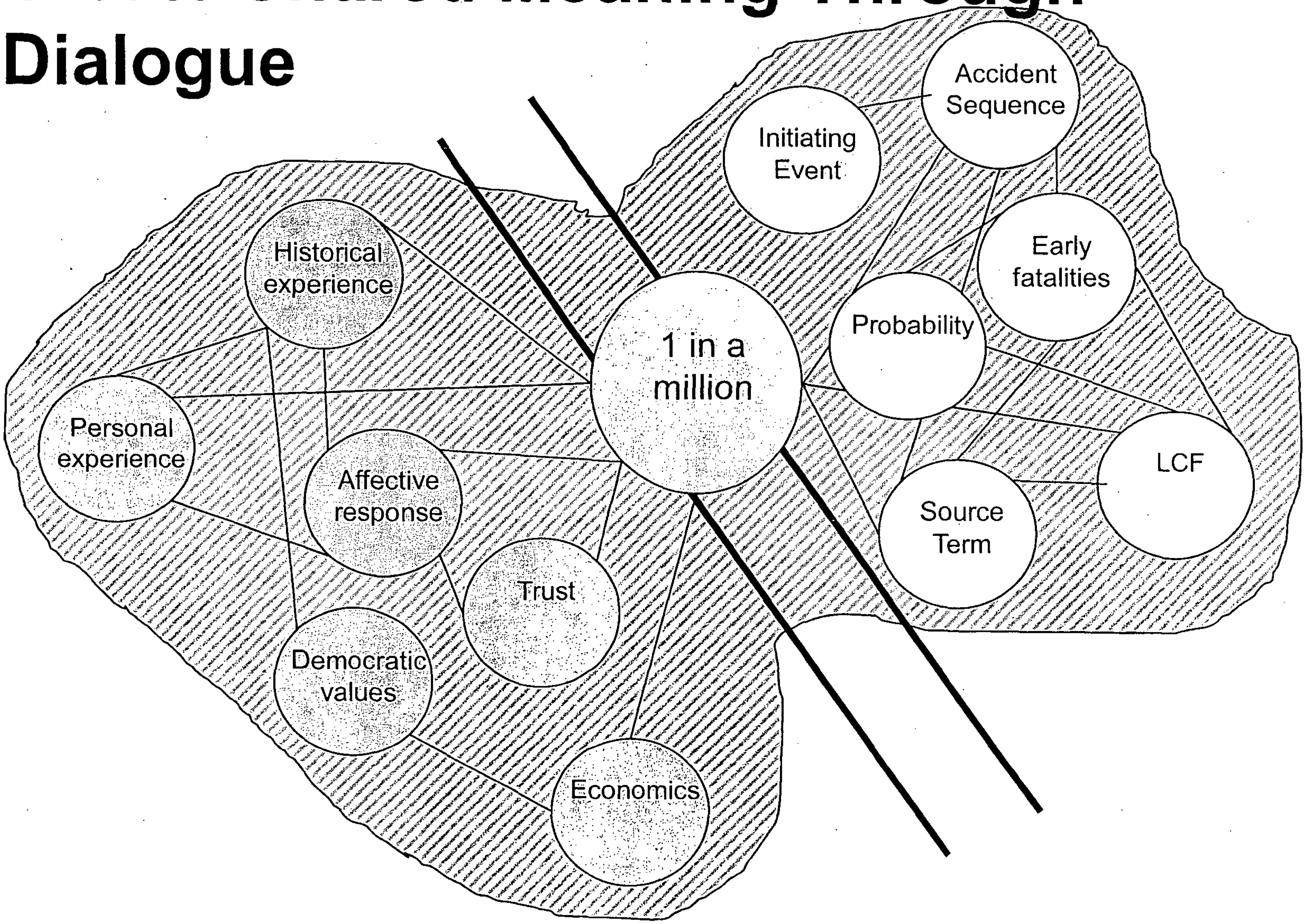
Public Sphere

- Metaphor of "public address"
- Community discussion of priorities and problems
- Both collective preference and conflict present

Goodnight, 1981

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

Create Shared Meaning Through Dialogue



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

Possibilities for Generative Dialogue

	Social Risk Symbolic Representation	Technical Risk Symbolic Representation	Opportunities for Generative Dialogue
Material Reality			• Connect process (tech) and outcome (social) • Use multiple types of expressions • Highlight shared values about safety
1. Accident at a nuclear reactor	1. Blank or violent like a mushroom cloud	1. Quantify material phenomenon of reactor behavior	
2. Health effects from radiation exposure	2. Physical descriptions of individual experiences	2. Calculate dose-response relationships	
Time/Space			• Acknowledge severity • Demystify reactor technology • Discuss historical experiences
1. Accident progression	1. Immediate progression	1. Modeled to develop over hours	
2. Historical accidents	2. Collapse time and space	2. Safety systems different/improved	

Gergen, Gergen, & Barrett (2004), Hamilton, 2003; Kinsella, 2007; Mirel, 1994

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

Opportunities to Create Shared Meaning

Technical Sphere

- Submit research to standards of evidence and reasoning
- ACRS meetings
- External peer review

Public Sphere

Public meetings

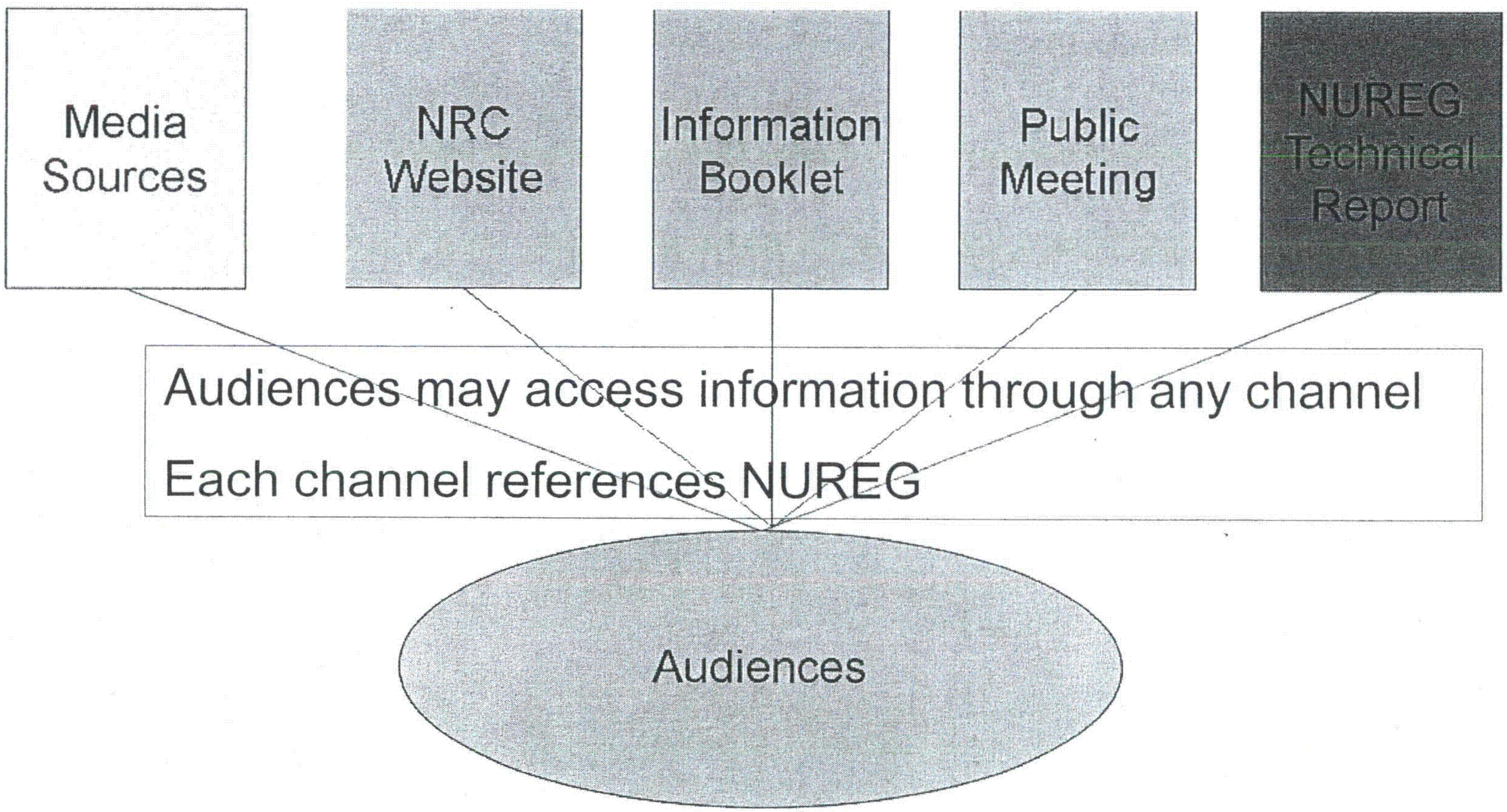
- Use facilitators to promote generative dialogue and exchange of information and perspective

Information booklet and NRC Website

- Juxtapose technical and social risk messages in shared space

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

Make SOARCA Methods and Results Transparent



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

Build Credibility

- Forthcoming external peer review
- Cross reference public communication (e.g.,information booklet) with technical report
- SOARCA is a research project that provides information to support NRC mission
  - Connect SOARCA information to NRC regulatory activity
  - Ex. Describe accident progression alongside background information about how reactors work and description of "General Design Criteria for Nuclear Power Plants" from 10 CFR 50, Appendix A

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

References

Bakhtin, M. M. (1981). *The dialogic imagination: Four essays.* M. Holquist (ed.), C. Emerson and M. Holquist (trans.). Austin, TX: University of Texas Press.

Duffield-Hamilton, J. (2003). Exploring technical and cultural appeals in strategic risk communication: The Fernald radium case. *Risk Analysis, 23,* 291-302.

Gergen, K. J., Gergen, M. M., & Barrett, F. J. (2004). Dialogue: Life and death of the organization. In D. Grant, C. Hardy, C. Oswick, N. Phillips, & L. L. Putnam (Eds.) *Handbook of organizational discourse* (pp. 39-60). Thousand Oaks, CA.

Goodnight, T. (1981). The personal, technical, and public spheres of argument: A speculative inquiry. *Journal of the American Forensic Association, 18*, 214-227.

Taylor, B. C., Kinsella, W. J., Depoe, S. P., & Metzler, M. S. (Eds.). (2007). *Nuclear legacies: Communication, controversy, and the U. S. nuclear weapons complex.* Lexington Books: Lanham, MD.

Mirel, B. (1994). Debating nuclear energy: Theories of risk and purposes of communication. *Technical Communication Quarterly, 3*, 41-55.

US NRC. (2004). Effective risk communication: Guidelines for external risk communication. NUREG/BR-0308.

U.S.NRC

UNITED STATES NUCLEAR REGULATORY COMMISSION

Protecting People and the Environment

Phenomenological Advances of Severe Accident Progression

R.O. Gauntt, Reactor Analysis and Modeling Department

Sandia National Laboratories, Albuquerque, New Mexico

Dept 6762 rogaunt@sandia.gov

March 11, 2009