Multi-Agency Radiological Survey and Site Investigation Manual (MARSSIM) Approaches, Issues, and Potential Use of Advanced Technologies

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* *We acknowledge contribution of MARSSIM Revision #2 Working Group Representing EPA, DOE, DOD, and US NRC*

Presentation Topics

- **Part I: MARSSIM Revision 2 Status and Update.**
- **Part II: Survey and Characterization for Subsurface.**
- **Part III: Outline of New Technologies for Potential Use in Survey and Characterization.**
- **Summary and Conclusions**

PART I: MARSSIM Revision 2

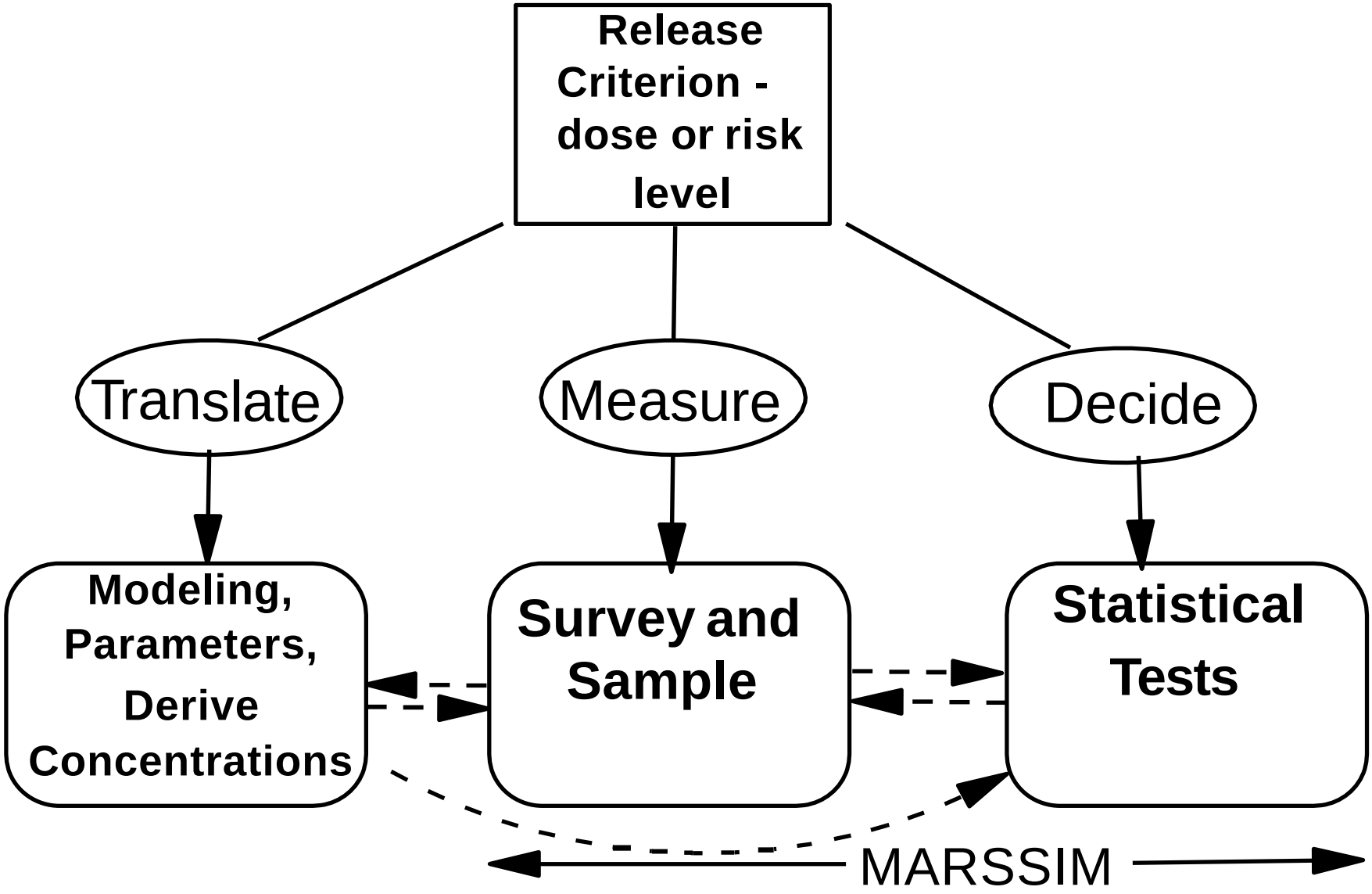
Status and Update

MARSSIM Revision 2 Background

- Four Federal Agency Members
  - Department of Defense (Air Force, Army, and Navy representatives)
  - Department of Energy
  - Environmental Protection Agency
  - Nuclear Regulatory Commission
- Family of Three Multi-Agency documents
  - MARSSIM—Originally published 1997, Revision 1 published in 2001

  (MARSSIM has not been updated since 2001)
  - MARLAP—Published 2004
  - MARSAME—Published 2009
  - Technical Guidance Documents—not policy

MARSSIM & Compliance with Release/Remediation Criteria



MARSSIM Revision 2 Overview

MARSSIM

- Covers real property (surface soils and building surfaces)
- Provides guidance for defensible and rigorous surveys for cleanup, especially final status surveys
- Uses a graded approach starting with a historical site assessment
- MARSSIM not updated since 2001

ISO Guide to the Expression of Uncertainty in Measurement
First edition 1995

NIST Technical Note 1297
1994 Edition
Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results
September 1994

Planned Revisions

Include measurement quality objectives (MQOs) and measurement uncertainty

- **MARSAME and MARLAP in line with the state of the science regarding MQOs and measurement uncertainty**
- **Complies with current guidance from ISO and NIST**

Planned Revisions

Expand measurement methods to include scan-only surveys

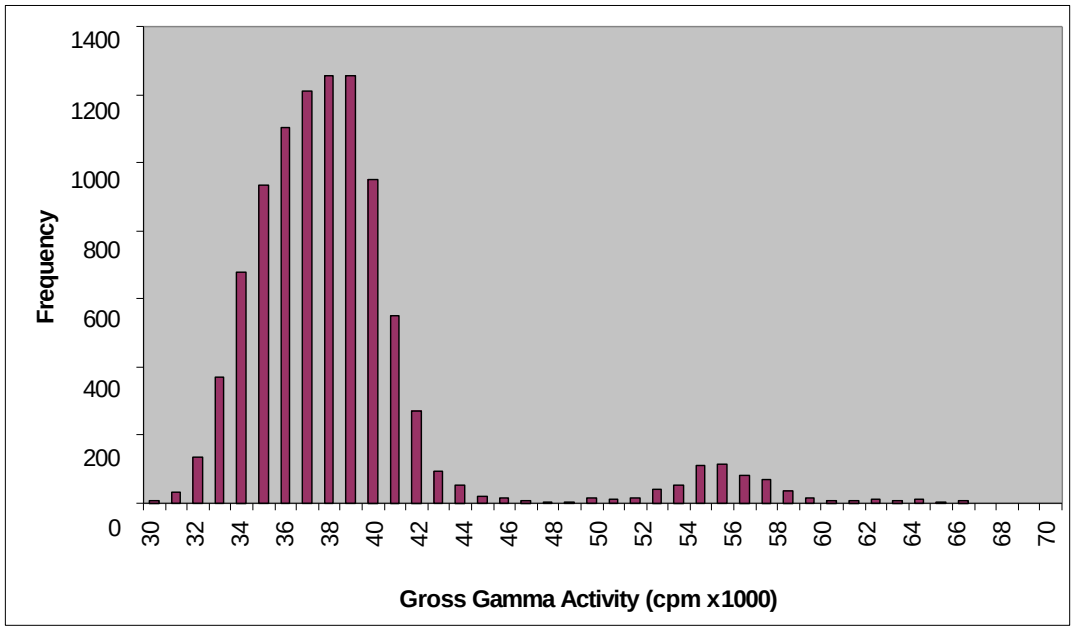
- **MARSSIM written with the current (~1995) measurement techniques in mind**
- **Updates the state of radiation instrumentation**

Planned Revisions

Update survey instrumentation information

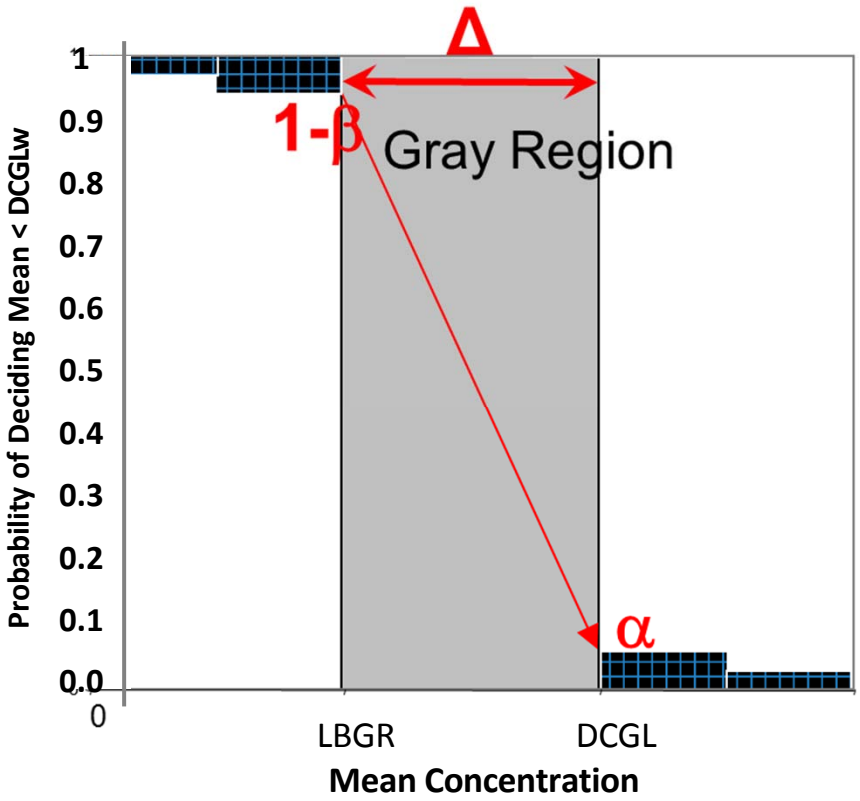
- **Chapter 6 on Field Surveys**
- **Appendix H on Survey Instrumentation**

Planned Revisions



Include Scenario B ("assumed to meet the release criteria until proven otherwise")

- **MARSAME allows the use of Scenario B**
- **Already used in some states that use MARSSIM**



Planned Revisions

Improve description of the *lower bound of the gray region* (LBGR)

- **Re-phrased from statistical language**
- **"Represents a conservative estimate of the remaining residual radioactive material in the survey unit"**

Planned Revisions

Expand information on survey requirements for areas of elevated activity

- **Alter language to address concerns about the current hotspot procedure**

$$\frac{C_1}{DCGL_1} + \frac{C_2}{DCGL_2} + \cdots + \frac{C_i}{DCGL_i} + \cdots + \frac{C_n}{DCGL_n} \leq 1$$

Planned Revisions

Include information on survey requirements for discrete radioactive particles

- **MARSSIM addresses areas of elevated activity**
- **Methodology becomes unwieldy at certain small sizes**
- **Modeling pathways are different for discreteradioactive particles**

Use of MARSSIM with UMTRCA Requirements

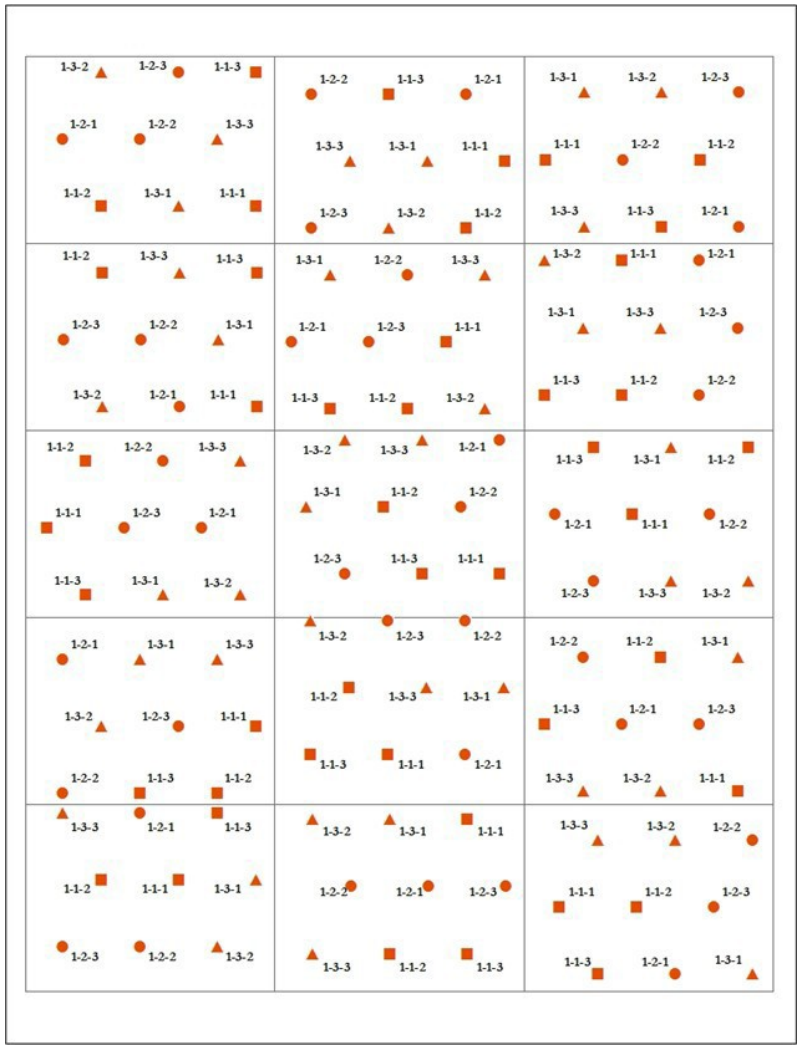
- **UMTRCA includes specific averaging areas and concentrations**

Planned Revisions

Evaluation of measurement uncertainty in the selection of measurement methods

- Selecting a measurement method will ultimately impact survey costs and statistical power of the sampling design
- Measurements or samples used in the compliance decision are typically analyzed with a very high precision

  - High precision data may be cost or schedule prohibitive even when fewer samples may be required to demonstrate compliance
  - Less precise methods may initially be less expensive upfront but can result in the need for a larger sample population due to inherent additional measurement uncertainty



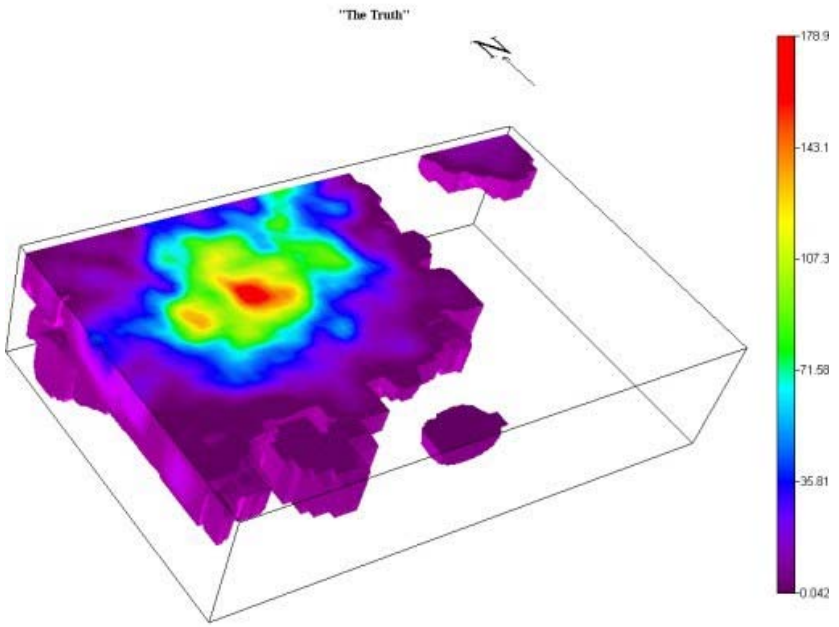
Planned Revisions

Alternative Sampling Method

- **Ranked Set Sampling technique proposed by ORAU included for hard-to-detect radionuclides in an appendix**

Next Steps

- **Complete Federal Register Notice of Availability for Comments – Route and Sign by Four Agencies**
- **Submit Draft MARSSIM Revision 2 to Science Advisory Board (SAB) for Review**
- **Make Changes based on SAB and Public Comments Received**



PART II:

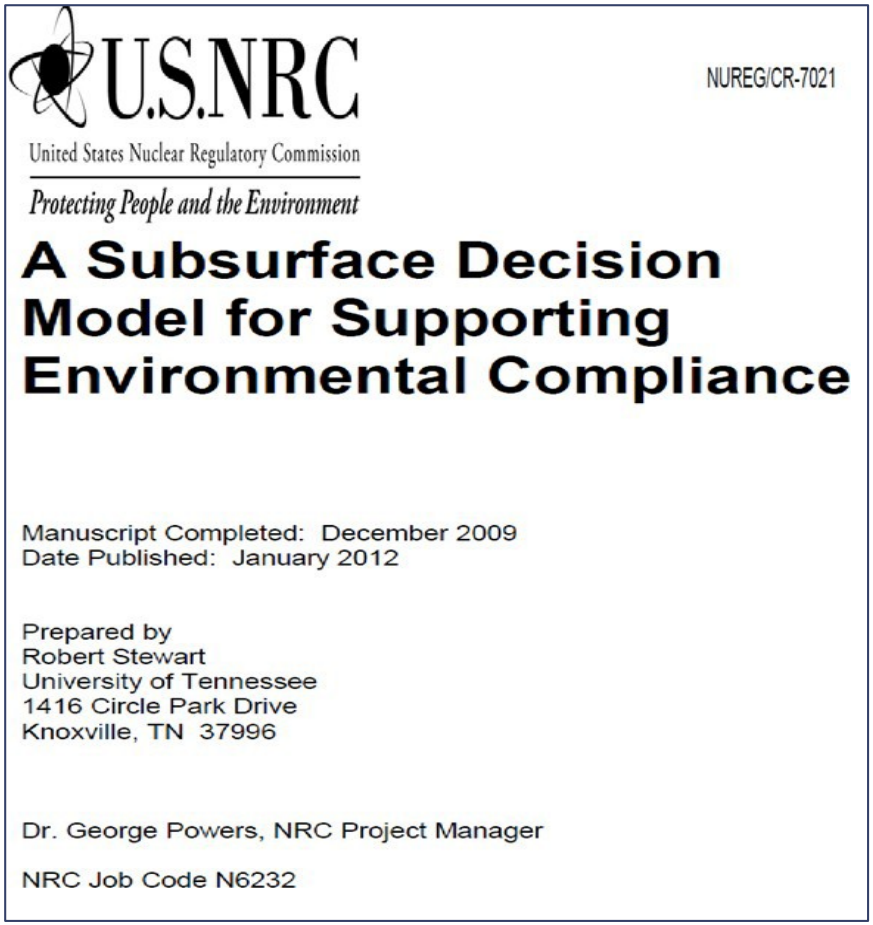
Subsurface Survey and Characterization

Status and Update

NRC SUBSURFACE INITIAL APPROACH NUREG/CR-7021

The main issues with adapting MARSSIM to the subsurface include:

- **The subsurface is difficult to access and sampling is costly;**
- **Volume (not area) is being investigated, increasing sampling requirements;**
- **No comprehensive scans are possible; and**
- **Not obvious how to apply the MARSSIM statistical approach to the subsurface (could use Bayesian approach)**


U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

NUREG/CR-7021

A Subsurface Decision Model for Supporting Environmental Compliance

Manuscript Completed: December 2009
Date Published: January 2012

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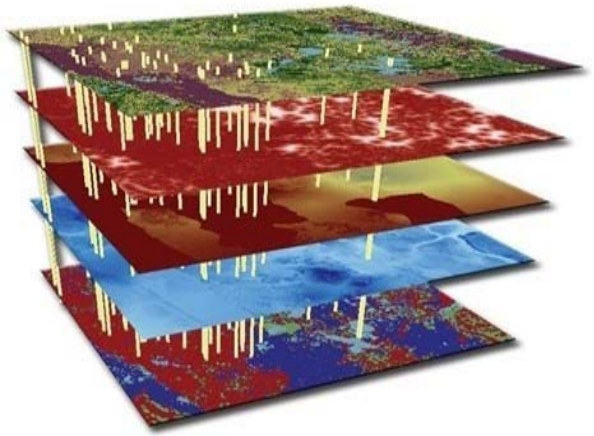
NRC Job Code N6232

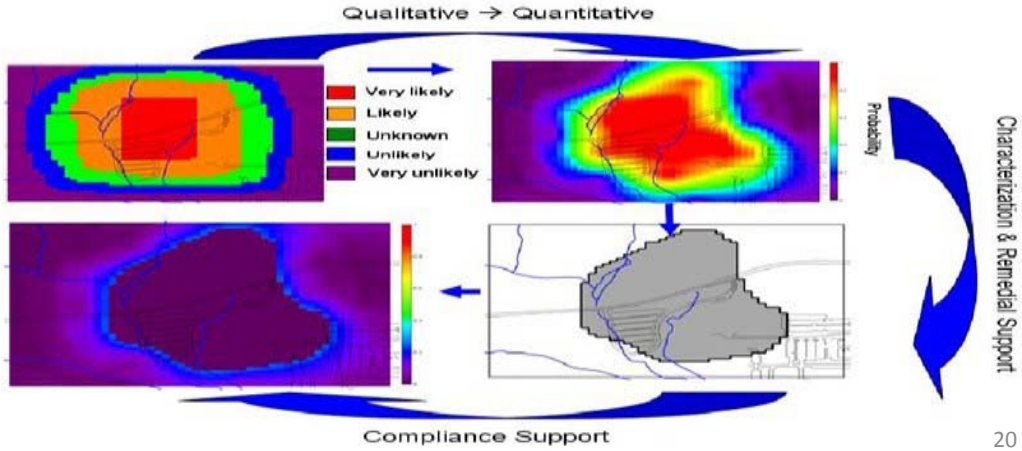
NRC NUREG/CR-7021 Approach

- **Assumes that a decision limit is available:**
  - **Based on a vadose zone to groundwater transfer (source term)**
  - **Based on a future excavation scenario**
  - **Can vary with depth**
  - **Can vary with spatial scale**
- **Makes empirical use of all available information**
  - **Information relevant to exceedance of decision limit**
  - **Provides a means to optimally locate boreholes**
  - **Spatial distribution of contaminants expressed in a Contamination Concern Map (CCM)**
- **Cradle to grave**
  - **Provides tools that facilitate empirical evolution of the CCM**
  - **Emphasizes use of EPA's Triad model.**

SPATIAL ANALYSIS AND DECISION ASSISTANCE (SADA) APPROACHES

- **SADA is free software that incorporates tools from environmental assessment fields into a n effective problem solving environment.**
- **These tools include integrated modules for visualization, geospatial analysis, statistical analysis, human health risk assessment, ecological risk assessment, cost/benefit analysis, sampling design, and decision analysis. Focus on Contamination Concern Map (CCM)**
- **The capabilities of SADA can be used independently or collectively to address site specific subsurface concerns when characterizing or surveying a contaminated site, assessing risk, determining the location of future samples, and when designing remedial action.**





Current Status of Subsurface Guidance

- **NRC initiated the process of addressing licensee needs and soliciting stakeholder interest with regard to subsurface problems;**
- **SC&A was recently awarded a contract by NRC to study this problem;**
- **SC&A is developing a white paper on generic approaches to subsurface survey and characterization to enhance NRC's guidance in this area;**
- **Using NUREG/CR-7021 and SADA approaches as a starting point;**
- **Some updates related to subsurface surveys will be published in NUREG-1757, Volume 2, Revision 2;**
- **Following development of the white paper, NRC is planning a workshop with interested stakeholders to get their input on what is needed in guidance; and**
- **A multi-agency working group for radiological subsurface assessment and survey (MARSAS) could be established.**

PART III:

Outline of New Technologies for Potential Use in Survey and Characterization.

Status and Update

NEW TECHNOLOGIES OVERVIEW

- New technologies for radiological survey and characterization in support of cleanup and remediation are developing fast (e.g., nano-materials for cleanup of Uranium).
  - Need for knowledge, awareness, and exchange of information;
  - Explore potential applications and development;
  - Addressing issues when use for regulatory compliance demonstration.
- New technologies advantages:
  - Enhance remediation and cleanup;
  - Reduce exposure to workers and the public;
  - Minimize environmental damage;
  - Reduce costs;
  - Reduce implementation timeframe; and
  - Enhance risk-informed and risk-smart approaches.

A remotely operated, GPS enabled, 2x2 sodium iodide survey instrument in use.
(photo Matt Norton, DDES LLC)

Use of Unmanned Aerial Vehicles (UAV) for Gamma Surveys

- **Ground-based ϒ-surveys are typically performed using GPS-based detector systems (e.g.; mounted on backpacks of technicians, pushcarts, or vehicles). Such surveys may result in unsafe conditions and high exposures of the ground crews.**
- **Helicopters and fixed wing planes have been used but are expensive and may have accessibility issues.**

- **Aerial platforms for performing surveys in inaccessible areas have been developed.**
- **Drone-based survey capabilities were developed primarily for use in mapping of radiation levels. These include areas within and around abandoned uranium mines, culturally sensitive areas, national laboratories, and military installations.**

ROBOTIC AND REMOTE HANDLING TECHNOLOGIES

- **Robotics/remote handling technologies:**
- **Used frequently in high radiation areas monitoring, characterization or survey, (e.g.; DOE and its contractors; Sellafield/UK)**
- **Used frequently in dismantling and laser cutting (Belgium/UK)**
- **Used for radiation detection of leakage (Japan/DOE)**
- **Images below show examples of recent developments – laser cutting and robotic arm (Maestro/remote carrier):**

Variety of robotics technologies are under development to support Fukushima Daiichi decommissioning
JAEA's Naraha Center for Remote Control Technology

Development

Robots, mock-up and training exercise in the JAEA's Naraha Center

SUMMARY AND CONCLUSIONS

- **Radiological survey and characterization are important aspects of cleanup and remediation of radiological and hazardous contaminants.**
- **Federal Agencies essentially developed consensus approaches in MARSSIM; guidance for surface radiological surveys are being revised/updated in MARSSIM Revision 2.**
- **There is a need to develop further approaches, methods, and software for subsurface characterization and surveys. Development of a consensus guidance harmonized with the concerned Federal Agencies in a collaborative effort would be beneficial.**
- **There is a need for knowledge and awareness of new and advanced technologies for characterization and survey of radiological and hazardous contaminants and remediation and exploring potential application/implications for regulatory compliance.**

Questions

BACKUP SLIDES

Internal Agency Review

Major additions/revisions include (in order of difficulty):

1. Update references
2. Fix English to SI Unit Conversion Errors
3. Use the term "Action Level (AL)" instead of LBGR or DCGL for Scenario B
4. Move derivations in Chapter 5 to Appendices
5. Avoid using the term "Area Factor"
6. Include additional examples in Chapter 5
7. Explain the use of sampling for "scan-only" surveys
8. Reorganize Chapter 4