

# Integration of Triad into Site Management Planning

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June 11, 2008

Triad Investigations: New Approaches and  
Innovative Strategies  
2008 International Conference and Training  
University of Massachusetts Amherst



# Objectives

- **Problem Statement:**
  - How to integrate copious amounts data into site management decision making
- **Solution:**
  - Apply a set of proven data management and decision support tools
- **Demonstration:**
  - Show that these tools can be used to integrate Triad data into bigger picture site management decision making processes



# Take Home Messages

- The 3 tenets of Triad are easily assimilated into the full-breadth site management (SM) routine
  - For example, “adaptive site management” by the US Navy
- Real-time data evaluation is important to make informed decisions and to maintain steady remedial progress
  - Consistent with the fast pace of a Triad project
- Decision support tools are useful to evaluate the data and reduce them to critical decision focal points



# Problem Statement

- Typical Triad projects collect a ton of data
  - Inevitably, some get “lost” without data management
  - Or are wasted without evaluation tools that can be used in a real-time manner
- If data get “lost”, then uninformed decisions are made
  - Most of the data is useful and important to decision making



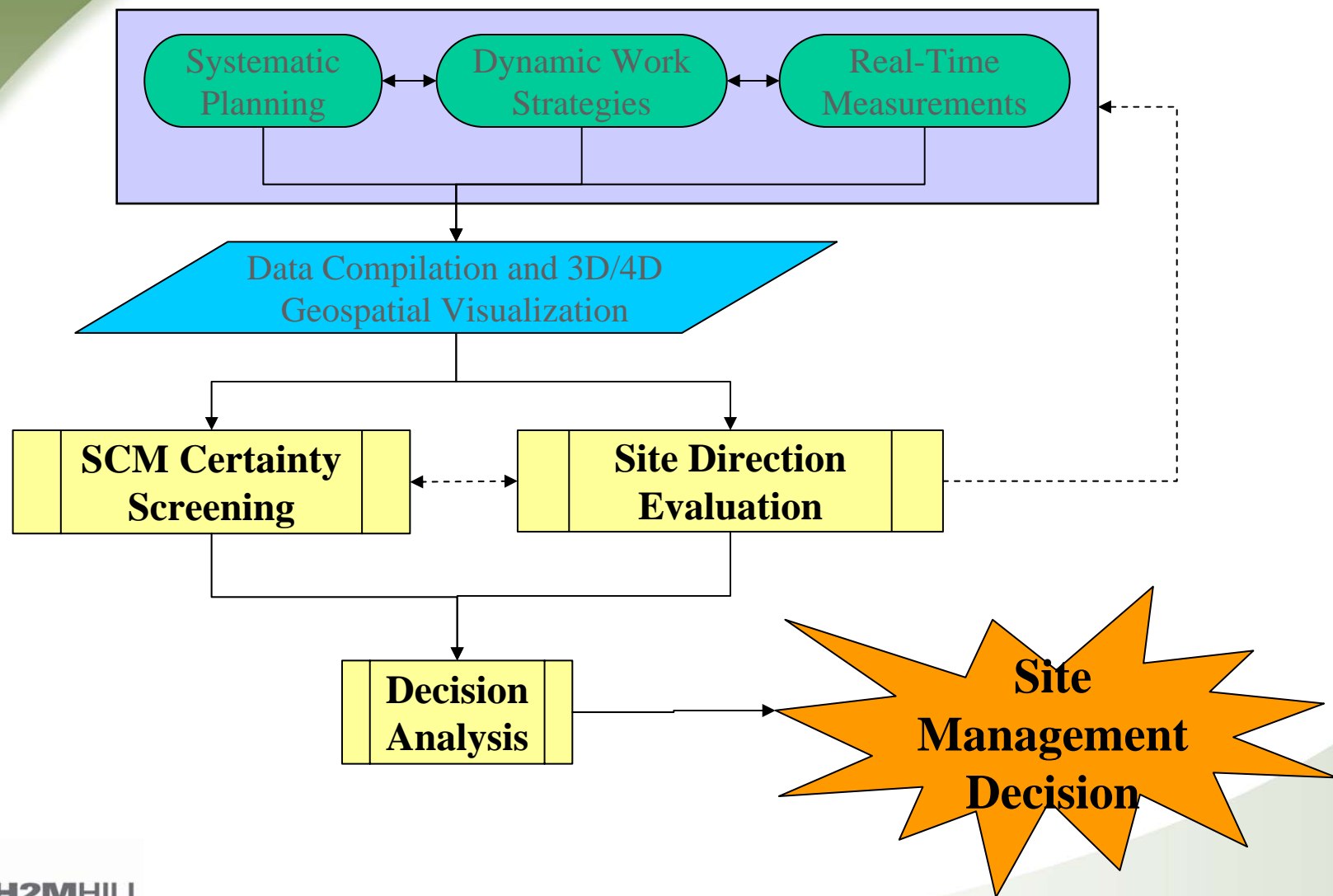


## Problem Statement (continued)

- Practical and accessible tools are needed to facilitate data evaluation and make informed decisions
  - Anyone can collect a ton of information
  - Real challenge is to optimize data use and collect minimum amount of data to serve as many remedial decisions as possible



# Integration of Triad into SM





# A Toolbox Solution

- Practical real-time data management tools for SM:
  - SCM checklist and certainty screening tool
  - Real-time model for assessing remediation direction
  - Multi-criteria decision analysis (DA) to integrate the data and systematically rationalize a decision
- Applicable to a broad range of SM decisions:
  - Stop investigation and proceed with remediation
  - Implement partial mass removal
  - Define a soil excavation volume
  - Identify a site exit strategy or remedial direction



## Decision Making Requires Project Team Consensus!

- These tools are useful only if the project team is committed to consensus
- An engaged project team is a critical success factor for efficient execution of Triad and SM
- Each core project team member must do their homework
- Consensus building is challenging
  - Unfortunately, environmental data are often debatable

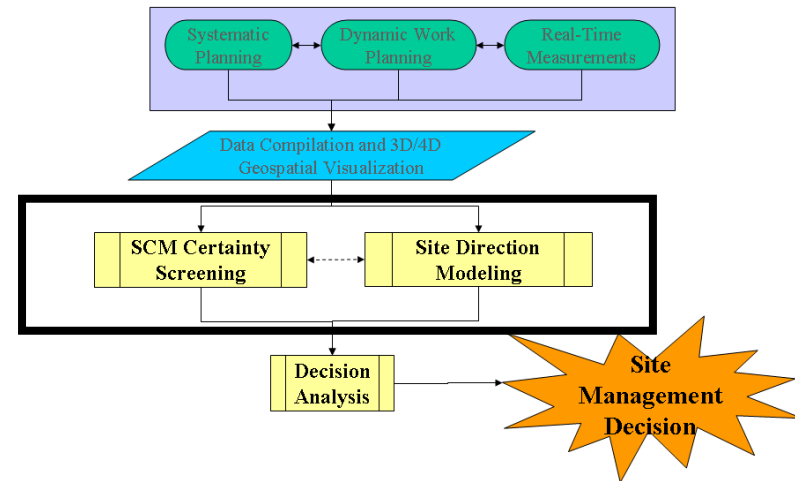


# We Have the Data, Now What?



# SCM and Site Direction Certainty Screening

- Concurrent process of looking at where you're headed and what data you need to get there



- Two synergistic certainty screening tools which assist the project team with the questions:
  - How much data is enough?
  - What is the general site direction?



# SCM Checklist Certainty Screening Tool

- Simple spreadsheet developed to pull a lot of data into useful format for assessing when enough is enough
- Itemizes components of the SCM and asks specific questions about the level of user's understanding
- Project team consensus process
- Compiled into one resource for efficient review
- This tool aids group decision-making by laying it all out on the table (requires people's commitment to detailed data review and scrutiny)
- Explicitly addresses uncertainties



# Overview – SCM Certainty Evaluation Tool

Item	Criteria	Certainty (0-100%)	Importance (0 or 100%)	Score (0-1)
<b>Technical Factors</b>				
T-1	With what certainty can all above-grade and/or sub-grade contaminant release mechanism(s) be identified at the site?	95%	100%	0.95
	If the source of the original contaminant release is no longer in use, has it been properly decommissioned, abandoned, demolished, or removed?			-
	If the facility is active, are routine leak tests performed with adequate detection limits to prove that leakage is absent?			-
	If the facility is active, do routine accidental spills have a pathway to the subsurface?			-
T-2	With what certainty has adequate exposure/risk assessment been performed to understand existing and potential future human and/or ecological impacts?	60%	100%	0.60
	Is the source within a residential area of high potential exposure (ingestion, dermal, inhalation)?			-
	Has the indoor air pathway been considered and determined to be complete?			-
	Does the source appear to be leaching contaminants to groundwater at a rate faster than NA can attenuate it (expanding plume)?			-
	Is there an effective connection between contaminated groundwater and surface water that may pose a risk to			-
	the contamination within the shallow subsurface (0-15 ft bgs) and accessible by workers?			-
T-3	With what certainty is the presence of mobile- and/or residual-phase LNAPL understood in the vadose and saturated zones?	100%	100%	1.00
	NAPL accumulated in a monitoring well?			-
	NAPL physically observed in a soil or water sample?			-
	Have NAPL indication tools (laser-induced fluorescence, ribbon sampler, Sudan IV dye, etc.) been used?			-
	Have contaminant partitioning equations been used to back-calculate the potential presence of free-phase NAPL using			-
T-4	With what certainty is the source material (e.g., mobile-, residual-, or sorbed-phase contamination that emits mass to the soil gas or groundwater) geometry characterized?	60%	100%	0.60
	Has the lateral extent of source material been defined to within an appropriate tolerance?			-
	Has the vertical extent of source material been defined within an appropriate tolerance?			-
	Are interconnections of multiple sources, if present, well characterized?			-
	Is the NAPL trapped within low permeability lithology?			-
	Is NAPL present as residual with relatively small mass?			-
T-5	With what certainty is the groundwater contaminant plume geometry characterized?	70%	100%	0.70
	Has the lateral extent of the plume been defined in all principle directions?			-
	Has the vertical extent of the plume been defined?			-
	Is plume co-mingling, if any, well characterized?			-
T-6	With what certainty has the LNAPL fate and transport mechanisms been characterized?	75%	100%	0.75
	Have the contaminant migration pathways been defined from the source to the toe of the plume?			-
	Have the mechanisms of natural attenuation (NA) been defined and assessed with respect to its ability to control LNAPL			-
	Has site-specific fate and transport modeling been performed to predict long-term LNAPL and plume configuration?			-
	Has the variability of subsurface conditions been assessed with respect to its temporal impact to the LNAPL and			-
T-7	With what certainty is the lithology of the site characterized?	60%	100%	0.60
	Does the site consist of a relatively homogeneous geologic unit?			-
	If the site consists of multiple geologic zones, is bedding planar?			-
	Are lithologic lenses continuous?			-
T-8	With what certainty are the groundwater-surface water hydraulic interactions characterized?		0%	*
	Are the interactions temporally and spatially variable?			-
	Are there no significant temporal variations in groundwater flow patterns?			-
	Are there no significant vertical gradients?			-
<b>Subtotal Technical Factors</b>				<b>5.20</b>
<b>Maximum Possible Technical Factor Score</b>				<b>7.00</b>
<b>Total Technical Certainty</b>				<b>74.3%</b>



# User Entry – SCM Certainty Evaluation Tool

Item	Criteria	Certainty (0-100%)	Importance (0 or 100%)	Score (0-1)
<b>Technical Factors</b>				
T-1	With what certainty can all above-grade and/or sub-grade contaminant release mechanism(s) be identified at the site?	95%	100%	0.95
	If the source of the original contaminant release is no longer in use, has it been properly decommissioned, abandoned, demolished, or removed?			-
	If the facility is active, are routine leak tests performed with adequate detection limits to prove that leakage is absent?			-
	If the facility is active, do routine accidental spills have a pathway to the subsurface?			-
T-2	With what certainty has adequate exposure/risk assessment been performed to understand existing and potential future human and/or ecological impacts?	60%	100%	0.60
	Is the source within a residential area of high potential exposure (ingestion, dermal, inhalation)?			-
	Has the indoor air pathway been considered and determined to be complete?			-
	Does the source appear to be leaching contaminants to groundwater at a rate faster than NA can attenuate it (expanding plume)?			-
	Is there an effective connection between contaminated groundwater and surface water that may pose a risk to			-
	Is the contamination within the shallow subsurface (0-15 ft bgs) and accessible by workers?			-
T-3	With what certainty is the presence of mobile- and/or residual-phase LNAPL understood in the vadose and saturated zones?	100%	100%	1.00
	NAPL accumulated in a monitoring well?			-
	NAPL physically observed in a soil or water sample?			-
	Have NAPL indication tools (laser-induced fluorescence, ribbon sampler, Sudan IV dye, etc.) been used?			-
	Have contaminant partitioning equations been used to back-calculate the potential presence of free-phase NAPL using			-



# Multi-Site Composite – SCM Certainty Evaluation Tool

Item	Criteria	Site A Score	Site B Score	Site C Score	Site D Score	Site E Score	Site F Score	Site G Score	Site H Score	Basewide Average
<b>Technical Factors</b>										
T-1	Contaminant Release Mechanism	0.50	0.80	0.70	0.80	0.80	0.90	0.70	0.80	0.75
T-2	Risk Assessment	0.50	0.75	0.80	0.70	0.75	0.85	0.70	0.85	0.74
T-3	NAPL Assessment	0.65	0.90	0.90	0.75	1.00	0.85	0.85	0.60	0.81
T-4	Source Material Characterization	0.50	0.80	0.80	0.70	0.70	0.70	0.65	0.60	0.68
T-5	Groundwater Plume Characterization	0.50	0.75	0.90	0.75	0.70	0.90	0.85	0.60	0.74
T-6	Fate and Transport Evaluation	0.50	0.50	0.85	0.60	0.90	0.90	0.65	0.65	0.69
T-7	Lithology Characterization	0.80	0.75	0.90	0.80	0.95	0.90	0.75	0.75	0.83
T-8	Groundwater-Surface Water Connection	0.80	*	0.90	0.90	*	*	0.65	0.65	0.78
T-9	Support for Remediation Timeframe Estimates	0.95	0.50	0.95	0.25	0.60	0.50	*	*	0.63
<b>Subtotal Technical Factors</b>		<b>8.10</b>	<b>8.65</b>	<b>10.35</b>	<b>8.25</b>	<b>9.85</b>	<b>9.75</b>	<b>7.85</b>	<b>6.75</b>	<b>8.69</b>
<b>Maximum Possible Technical Factor Score</b>		<b>12.00</b>	<b>12.00</b>	<b>12.00</b>	<b>13.00</b>	<b>12.00</b>	<b>12.00</b>	<b>11.00</b>	<b>10.00</b>	
<b>Total Technical Certainty (SCM only)</b>		<b>63.3%</b>	<b>71.9%</b>	<b>85.6%</b>	<b>69.4%</b>	<b>80.0%</b>	<b>81.3%</b>	<b>72.5%</b>	<b>68.8%</b>	<b>74.1%</b>

If the current level of certainty is unacceptable to the project team, then additional analysis must be performed in order to increase it.  
 Criteria that are scored a "Certainty" of 50% or lower are highlighted in **RED**.  
 Criteria that are scored a "Certainty" between 50% and 70% are highlighted in **ORANGE**.  
 This scoring sheet can be revisited at the end of each analytical phase to re-assess the level of certainty and satisfaction of the project team.



# Real-time Model for Assessing Remediation Direction

- Tackles the question of what direction should remedial efforts be headed
- Site direction is useful to optimize Triad data collection efforts
  - For example, if DNAPL is present, then finer investigation spacing and pore fluid soil samples may be needed for remedial design
- Results are used to re-assess and re-prioritize Triad data objectives and to focus collection on data to define an Exit Strategy (or come as close as possible)
- Similar format as the SCM Certainty Screening Tool



# Overview – Remedial Direction Screening Matrix

Item	Criteria	Certainty (%)	Importance (%)	Score
<b>Technical Factors</b>				
1	Is the source on-going and continuing to add mass to the subsurface?	10%	100%	0.1
2	Is there a potential or real risk to human or ecological exposure from the contaminants of the source?	100%	100%	0.0
3	Is residual or mobile DNAPL suspected to be <b>ABSENT</b> in vadose or saturated zone soil samples?	50%	100%	0.5
4	If residual or mobile DNAPL is present, is its architecture amenable to cost-effective remediation?	100%	100%	1.0
5	Is the source geometry well characterized?	0%	100%	0.0
6	Is the extent of the source material of reasonable size/depth for cost-effective remediation?	50%	100%	0.5
7	Is delivery of in-situ amendments into the target treatment zone feasible?	50%	100%	0.5
8	Is a cost-effective technology available and proven to remediate the source to the remedial action objectives?	20%	100%	0.2
9	Are the numeric remedial action objectives realistic (i.e., not MCLs)?	50%	100%	0.5
10	Is the lithology of the source area simple?	20%	75%	0.2
11	Are the aquifer hydraulic conditions within the source area amenable to remediation?	50%	75%	0.4
12	Are quantitative tools available and implementable to provide cost/benefit analysis and remediation progress monitoring?	30%	75%	0.2
13	Is NA activity present which may support, with or without amendment, an MNA polishing step after source treatment?	0%	50%	0.0
14	Have realistic remediation timeframe estimates been set based on site-specific conditions (using SourceDK model or similar)?	100%	50%	0.5
<b>Subtotal Technical Factors</b>				<b>4.6</b>
<i>Maximum Possible Technical Factor Score</i>				<i>12.25</i>
<b>Management Factors</b>				
15	Are near-term site use goals (i.e., less than 30 years) strict enough to require source area remediation to NFA?	100%	100%	0.0
16	Does current site infrastructure and use allow for relatively unimpeded site remediation activities?	10%	100%	0.1
17	Is there a strong desire to reduce contaminant mass and thereby reduce the environmental burden of future generations?	100%	100%	1.0
18	Are the project stakeholders willing to accept a relatively high level of risk in seeking, and possibly failing, to remediate to NFA?	20%	75%	0.2
19	Is there a strong commitment to test new technologies and advance the science of DNAPL remediation?	100%	25%	0.3
<b>Subtotal Non-Technical Factors</b>				<b>1.5</b>
<i>Maximum Possible Management Factor Score</i>				<i>4.00</i>
<b>TOTAL</b>				<b>6.1</b>
<i>Maximum Possible Total Score</i>				<i>16.25</i>
<b>TOTAL SCORE INTERPRETATION:</b>				
	If one or more GREEN cells appear, then the certainty score is irrelevant. MORE aggressive remediation techniques should be strongly considered.			
>14	- The site is extraordinarily well suited for aggressive source remediation.			
9-14	- Indicators favor some degree of aggressive source remediation, less inherent risk of success with scores at the higher end of the range.			
7-9	- Around the 50/50 mark, stakeholders will have to closely weigh the pros and cons of aggressive source remediation.			
4-7	- Less aggressive source remediation approaches are recommended. Stakeholders should consider alternative less aggressive or partial mass removal technologies			
<4	- The project conditions are not amenable to source remediation and stakeholders should consider containment or long-term monitoring/land use control options.			
<b>If additional certainty is required by the project team, then additional data collection must be performed in order to close data gaps.</b>				
<b>This scoring sheet can be revisited at the end of each data collection phase to assess the level of certainty and the need for additional data.</b>				



# User Entry – Remedial Direction Screening Matrix

Item	Criteria	Certainty (%)	Importance (%)	Score
<b>Technical Factors</b>				
2	Is there a potential or real risk to human or ecological exposure from the contaminants of the source?	100%	100%	0.0
	Is the source within a residential area of high potential exposure (ingestion, dermal, inhalation)?			-
	Has the indoor air pathway been considered and determined to be complete?			-
	Does the source appear to be leaching contaminants to groundwater at a rate faster than NA can attenuate it (expanding plume)?			-
	Is the contamination within the shallow subsurface (0-15 ft bgs) and accessible by workers?			-
7	Is delivery of in-situ amendments into the target treatment zone feasible?	50%	100%	0.5
	Does source contain small thicknesses of soil containing less than 20% silt/clay?			-
	Is soil uncemented/less dense to allow access with standard DPT?			-
	Does the source exist at depths less than 100 feet below grade?			-
8	Is a cost-effective technology available and proven to remediate the source to the remedial action objectives?	20%	100%	0.2
	Are there case studies of remediation at similar sites that have shown success?			-
	Are chemical scavengers present at only low concentrations (i.e., low TOC for ISCO, low sulfate for ERD)?			-
	Is the projected cost of the technology reasonable from a cost/benefit perspective and consistent with long-term site use goals?			-
9	Are the numeric remedial action objectives realistic (i.e., not MCLs)?	50%	100%	0.5

**TOTAL SCORE INTERPRETATION:**

**100%** If one or more GREEN cells appear, then the certainty score is irrelevant. MORE aggressive remediation techniques should be strongly considered.



# Results Interpretation – Remedial Direction Screening Matrix

Item	Criteria	Score		
<b>Technical Factors</b>				
<b>Subtotal Technical Factors</b>		<b>4.6</b>		
<i>Maximum Possible Technical Factor Score</i>		<i>12.25</i>		
<b>Management Factors</b>				
<b>Subtotal Non-Technical Factors</b>		<b>1.5</b>		
<i>Maximum Possible Management Factor Score</i>		<i>4.00</i>		
<b>TOTAL</b>		<b>6.1</b>		
<i>Maximum Possible Total Score</i>		<i>16.25</i>		
<b>TOTAL SCORE INTERPRETATION:</b>				
>14	- The site is extraordinarily well suited for aggressive source remediation.			
9-14	- Indicators favor some degree of aggressive source remediation, less inherent risk of success with scores at the higher end of the range.			
7-9	- Around the 50/50 mark, stakeholders will have to closely weigh the pros and cons of aggressive source remediation.			
4-7	- Less aggressive source remediation approaches are recommended. Stakeholders should consider alternative less aggressive or partial mass removal technologies			
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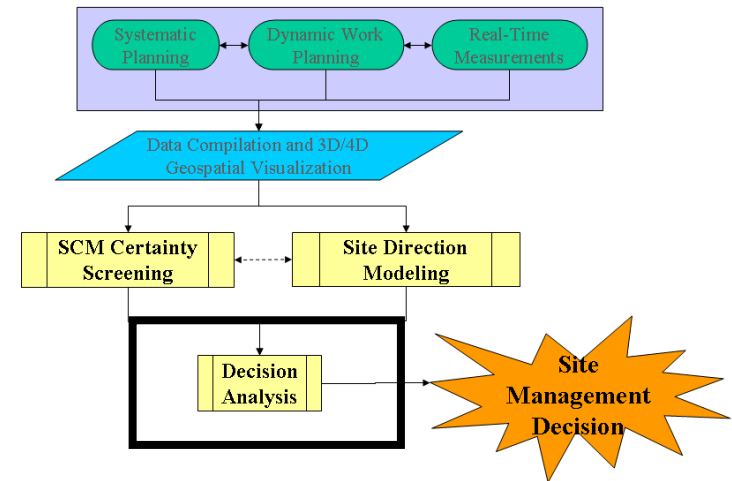


# We've Optimized the Data Collection, Now What?



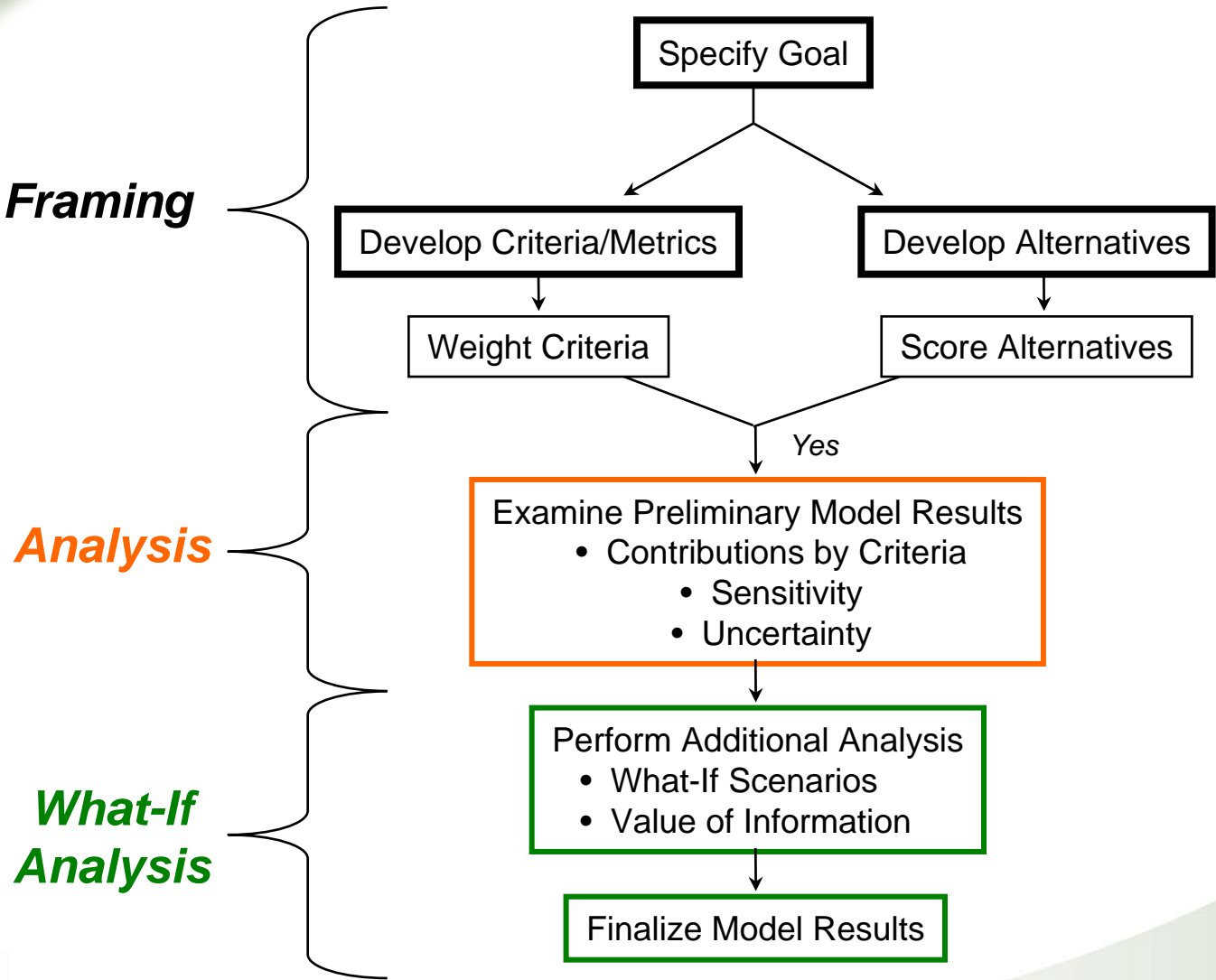
# Multi-Criteria Decision Analysis

- A systematic approach to resolving complex problems involving multiple variables and competing objectives
- Synergies with Triad process include:
  - Allows real-time decision making
  - Evaluates both qualitative and quantitative criteria
  - Quantifies uncertainty
  - Builds consensus among multiple stakeholders





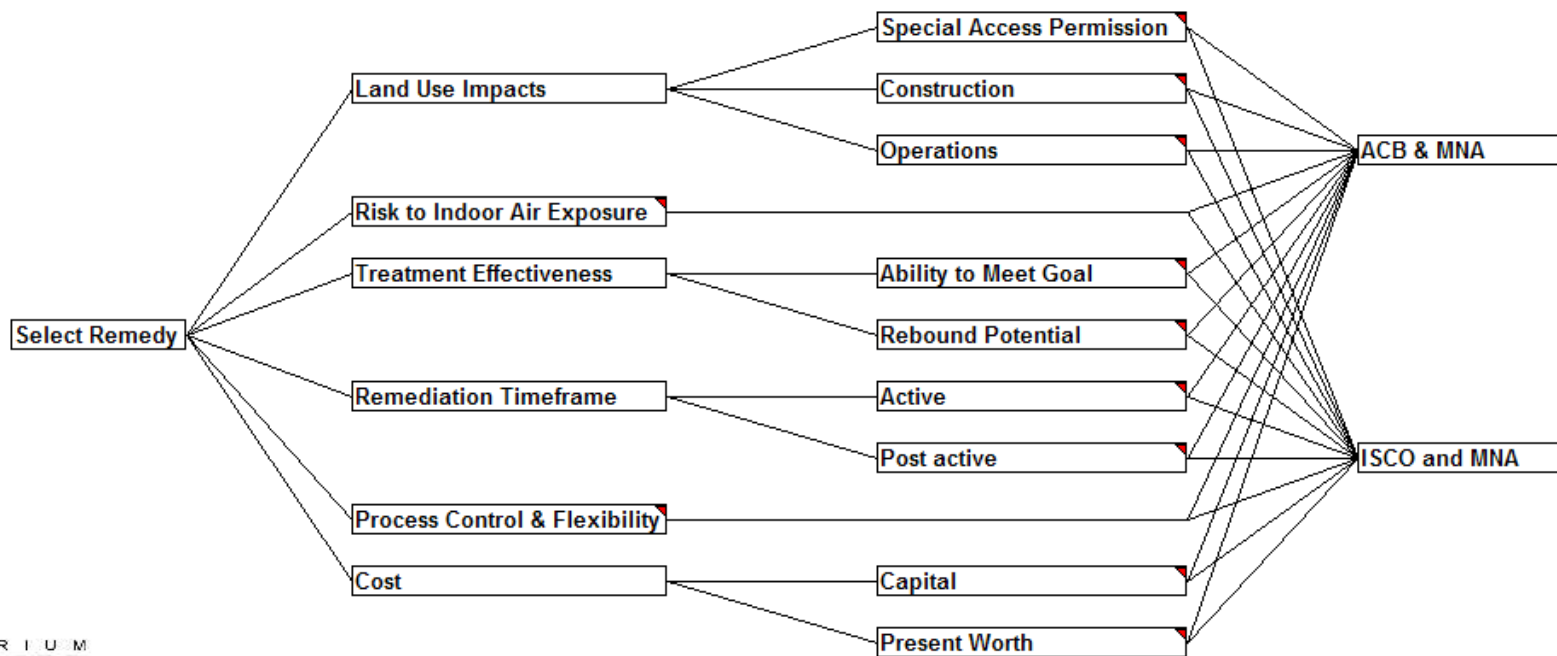
# Simplified DA Flow Chart





# Example DA Input

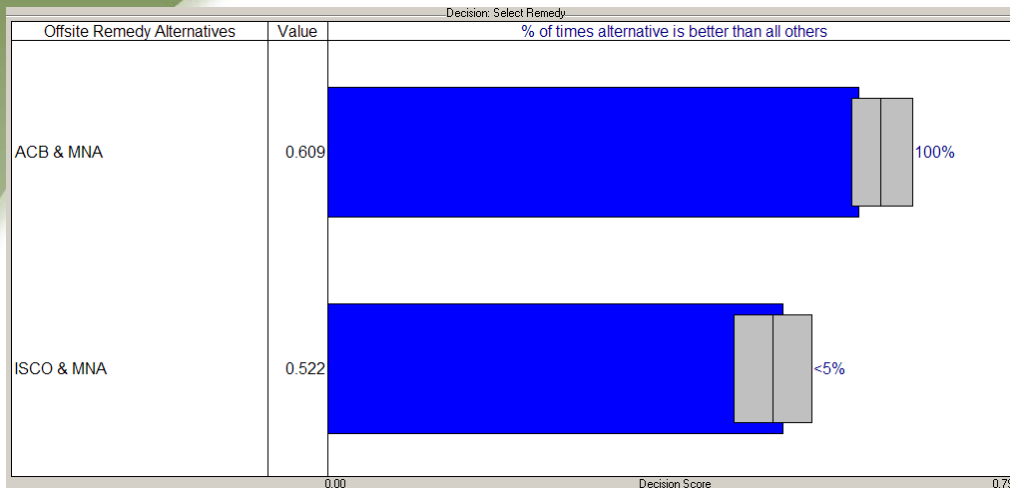
Goal	Primary Criteria	Subcriteria	Offsite Remedy Alternatives
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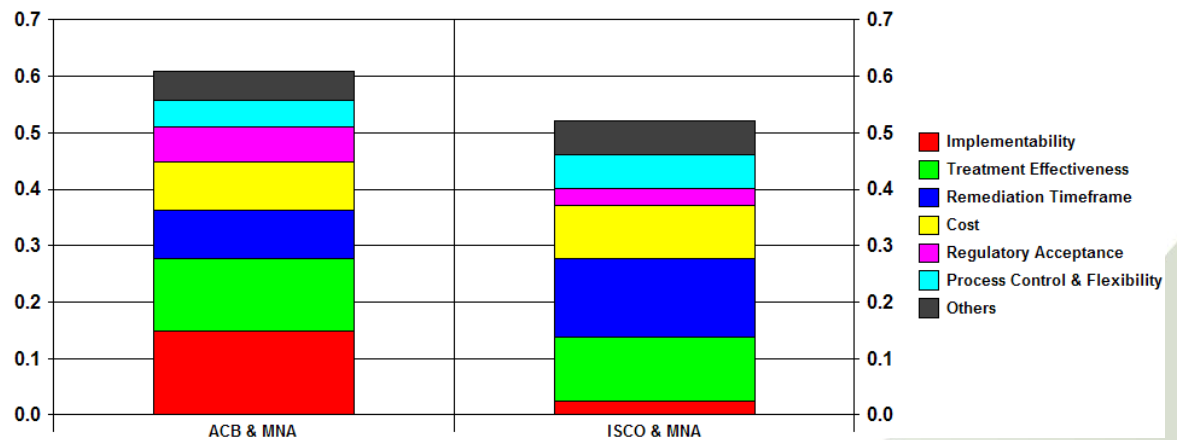
Criterion DecisionPlus® by InfoHarvest,  
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# Example DA Results



Contributions to Select Remedy from Level:Primary Criteria



Criterion DecisionPlus® by InfoHarvest,  
<http://www.infoharvest.com>



# Conclusions

- **TRIAD IS A SITE MANAGEMENT PHILOSOPHY!**
- A critical success factor for Triad projects is efficient integration of data into the SM decision making process
- Real-time, consensus-driven decision making tools are available to reduce the copious amounts of data to decision focal points
- Well informed decisions advance sites to closure



## Acknowledgments of the Hurlburt Field Triad Pioneers

- Art Kolodziejcki – Formerly with HQ AFSOC, now with HQ EUCOM
- John Steele- HQ AFSOC A7/AV
- Chris Hood and Kim-Lee Murphy – CH2M HILL
- Joann Socash – Booz Allen Hamilton
- David Miller – National Argonne Lab