EPRI ELECTRIC POWER RESEARCH INSTITUTE

Demonstration of Advanced 3D ALARA Planning Prototypes EPRI Report: 1025310

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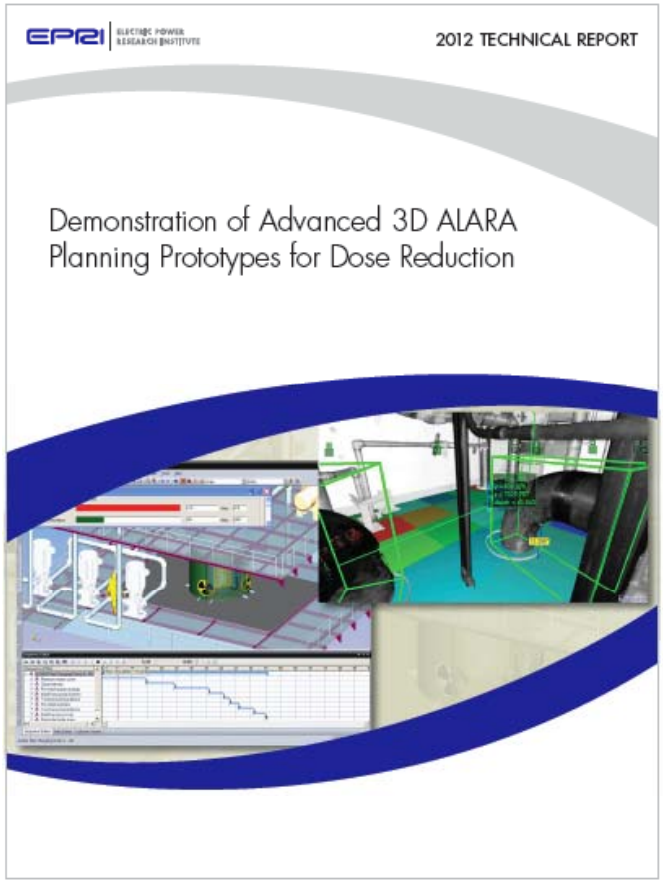

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3D ALARA Work Planning Prototype

Objective:

- Work with FIATECH and 3D Technology Providers to develop the **next generation** ALARA and work planning tool.

Description:

- Leverage and adapt advanced 3D technologies from other industries to **enhance work planning** and provide more **accurate dose estimation**.

Results to Date:

- Beta version of EPRI dose rate algorithm (final in 1Q 2013), 2 vendor prototypes: CSA and Siemens, validation testing completed

Benefits:

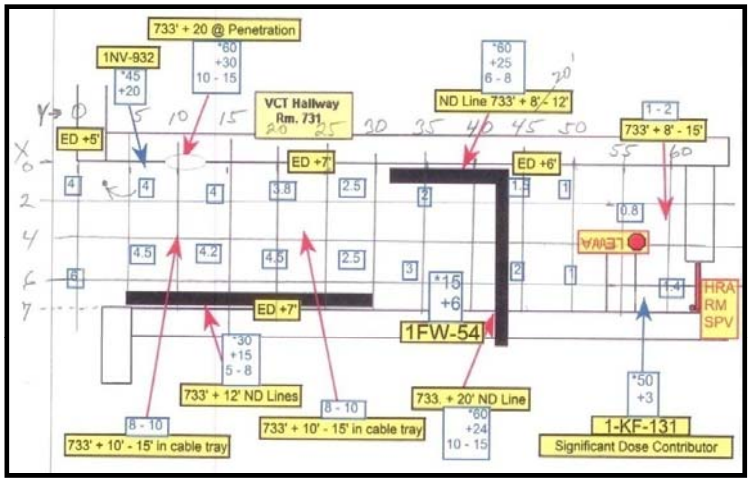
- **Partially automate dose estimation process** and allows for quick updates to dose estimates based on changing conditions
- **Develop "What-if" scenarios** to identify radiation field reduction opportunities (e.g. shielding) and optimize work activities to reduce dose

Typical Dose Estimating Methodology

Local Dose Rate $\left[\frac{mrem}{hr}\right]$ × Time in rad. field $[hr]$ = Individual Worker Dose $[mrem]$

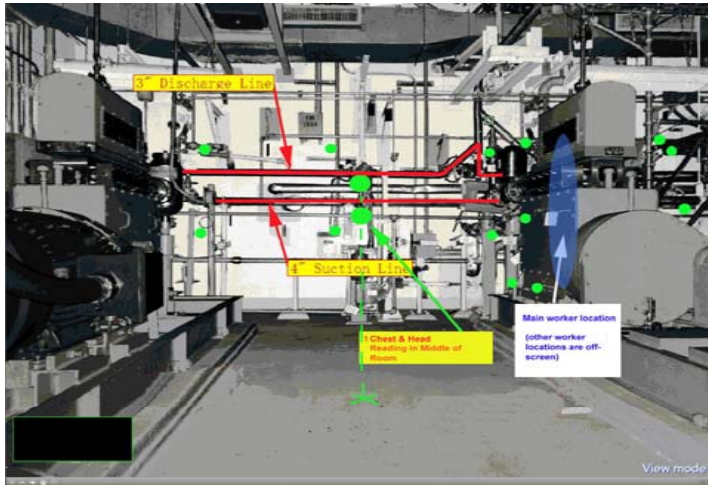
- Industry is required to minimize radiation exposure to workers As Low As Reasonably Achievable (ALARA)
- Radiation Protection organization works with maintenance and work planners to identify opportunities for dose reduction
- However, current process may not provide us with sufficient details to identify specific steps or assess opportunities to reduce dose
  - Examples:
    1. Historical performance: Last time, we did it for 25 mrem so this time we must do it for 23 mrem OR
    2. Use “effective dose rate” and an “adjusted time estimate”
       - 80 man-hrs X ¼ = 20 hours on job location
       - Effective dose rate = total dose from last time/ total time

Advanced Tools for ALARA Job Planning and Dose Estimating Dose



That was Then…,

This is Now…,



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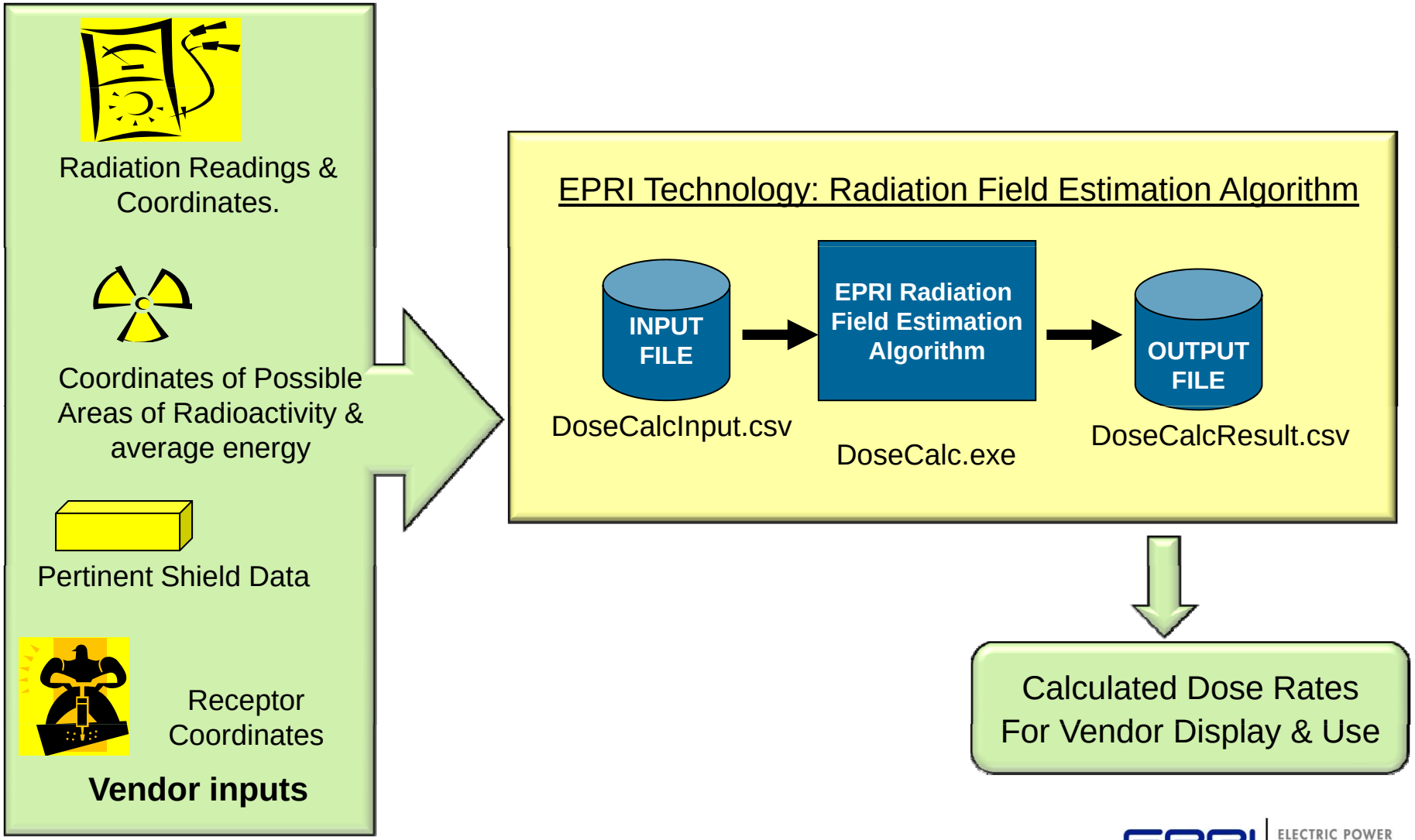
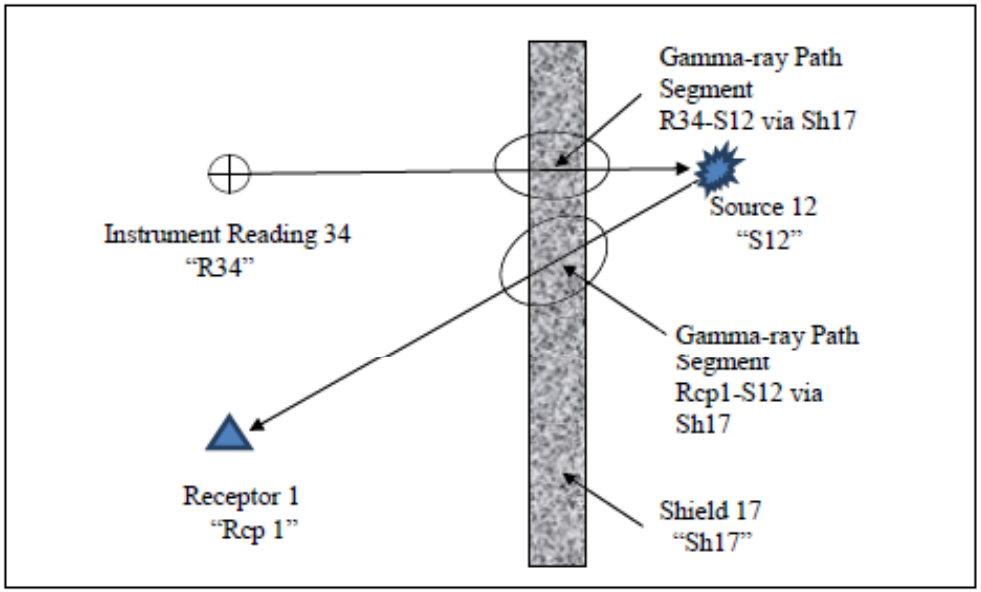
Integration of Vendor Solutions with EPRI Technology



Methodology



- 3 step process:
  1. Source Activity Calculation
  2. Dose Rate Calculation
  3. Estimate Uncertainty

1. Estimate activity of virtual source using iterative calculation
   - Reading
   - Shield configuration
   - Source location
2. Sum each source's gamma dose contribution to each Receptor point
3. Uncertainty: Reconstruct dose rate readings and compare to actual input

Laboratory Test Results

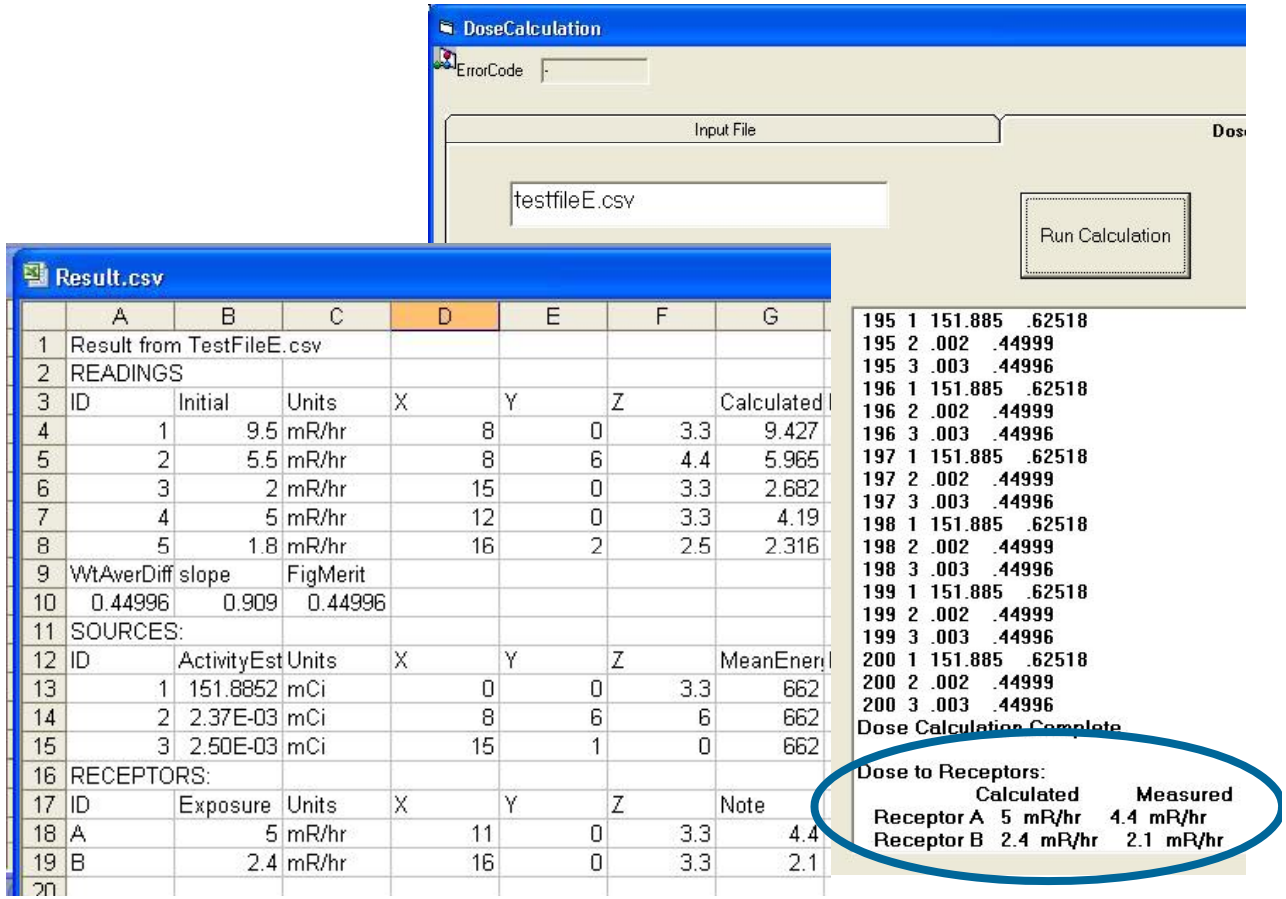
Input:

- Dose rate survey measurements (x, y, z)
- User identified potential sources, mean energy
- Worker location (x, y, z)

EPRI Dose Rate Algorithm

Output:

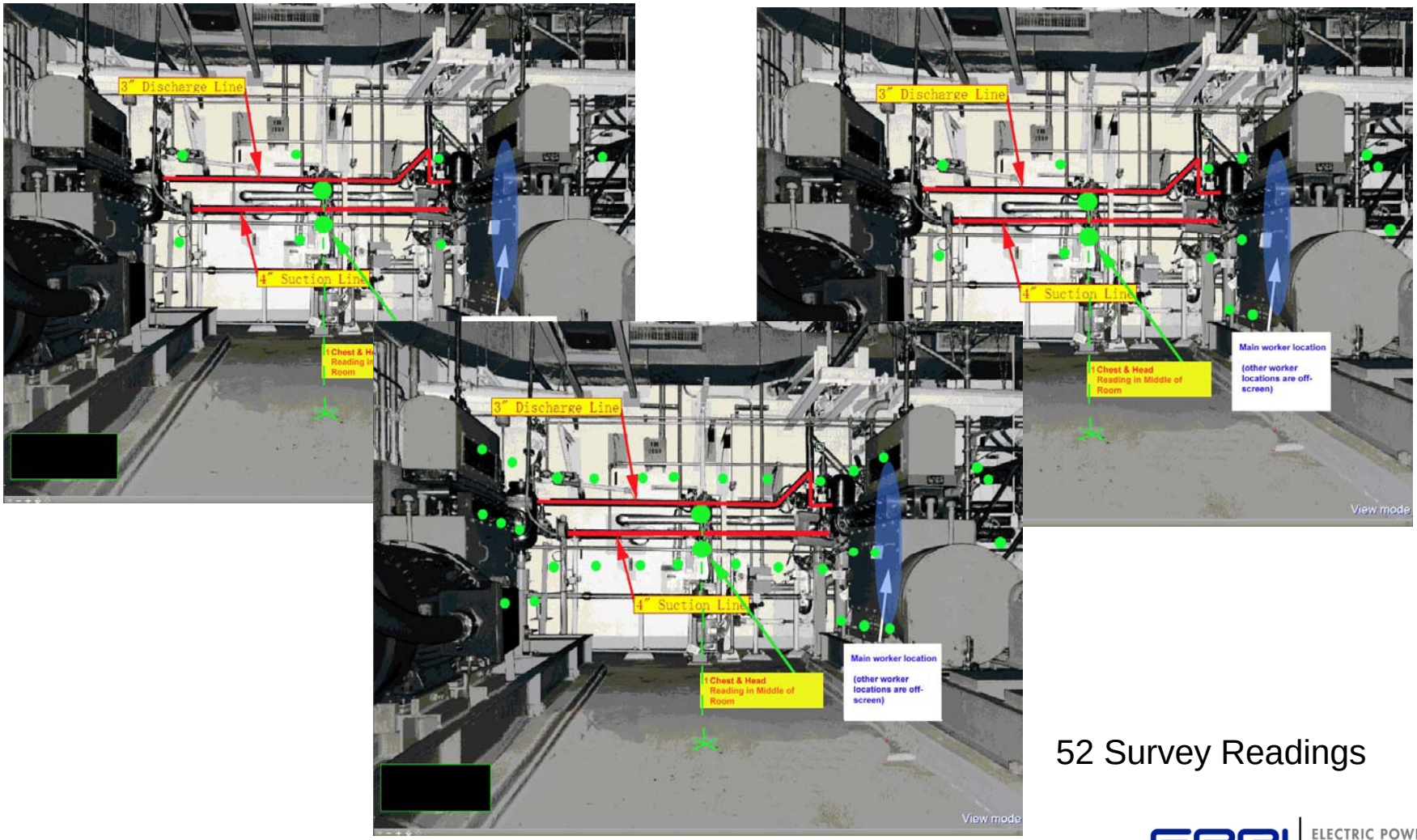
- Estimated source activity
- Estimated Dose Rate at a non-measured location



Tests Using Kewaunee Data from Charging Pump Room

9 Survey Readings

19 Survey Readings



52 Survey Readings

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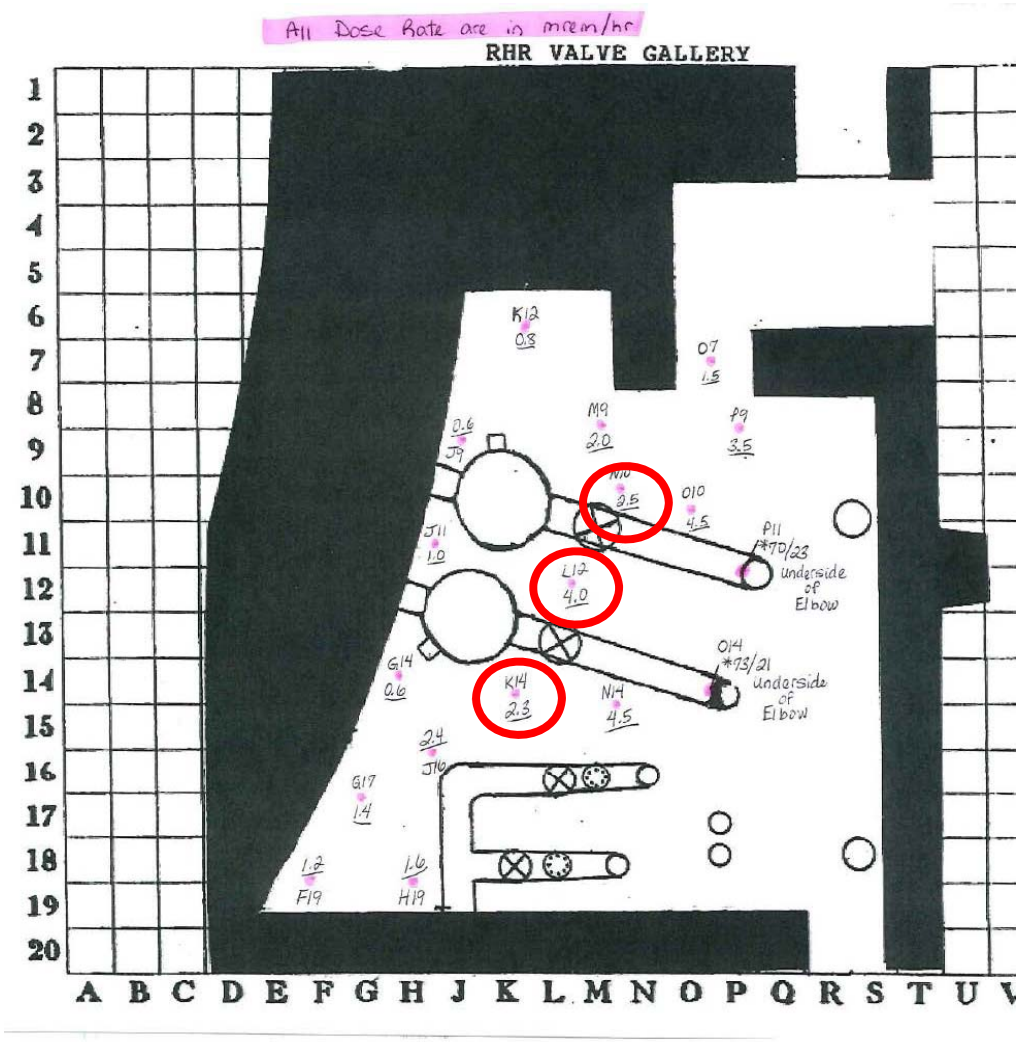
Example Results from Validation Testing Using Data from Charging Pump Room

- Uncertainty decreases as more survey information around the worker location is used
- Calculated dose rates correlate reasonably well with measured

Job Dose Estimates	Total Dose (mRem)
Plant estimate for job	21
Job estimate using algorithm	17
Actual job dose	~15

Testing Using Data from RHR Valve Maintenance Work



	PanoMap Coordinates (feet)		Dose Rate (mrem/hr)
F19	X=	30.33333	1.2
	Y=	53.25	
	Z=	588.75	
G14	X=	22.33333	0.6
	Y=	56.66666	
	Z=	588.5	
G17	X=	27.41667	1.4
	Y=	56	
	Z=	588.25	
H19	X=	30.16666	1.6
	Y=	58.16667	
	Z=	589	
J11	X=	16.33333	1
	Y=	59.16667	
	Z=	587.5	
J16	X=	25.25	2.4
	Y=	59.41667	
	Z=	587.8333	
J9	X=	15.00333	0.6
	Y=	59.75	
	Z=	588.5	
K14	X=	23.25	2.3
	Y=	63.25	
	Z=	587.75	
K7	X=	9.833335	0.8
	Y=	61.58333	
	Z=	588.4167	

	PanoMap Coordinates (feet)		Dose Rate (mrem/hr)
L12	X=	18.91667	4
	Y=	65.25	
	Z=	587.9167	
M9	X=	14.16667	2
	Y=	64.83334	
	Z=	588.25	
N10	X=	15.5	2.5
	Y=	65.83333	
	Z=	588	
N14	X=	22.08333	4.5
	Y=	65.83333	
	Z=	587.5833	
O10	X=	16.16667	4.5
	Y=	67.25	
	Z=	587.3333	
O14	X=	21.66667	21
	Y=	67.5	
	Z=	585.0833	
O7	X=	10.50334	1.5
	Y=	68.33334	
	Z=	590.0833	
P11	X=	17.75	23
	Y=	68.58334	
	Z=	585.1667	
P9	X=	15	3.5
	Y=	68.58334	
	Z=	588.0833	

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Example Test Results Using RHR Valve Maintenance Data– Pre-job Planning

- Used survey results for testing
- Enter 17 of the 18 readings and calculate last reading (repeat for all)
- Compared plant determined effective dose rate for Task 1 and Task 2 to actual survey and algorithm calculation dose rate (average of N10, L12, K14)

Task #	Task	Estimated Effective Dose Rate (mR/hr)	Actual Survey February 2012 Average Work Area Dose Rate (mR/hr)	Algorithm Calculated Average Work Area Dose Rate (mR/hr)
T1	Cut out and replace SI-351A/B	5.9	2.9	3.0
T2	Remove and replace valve actuators	2.7		
Average	Kewaunee Estimated Effective Dose Rate Average	4.3		

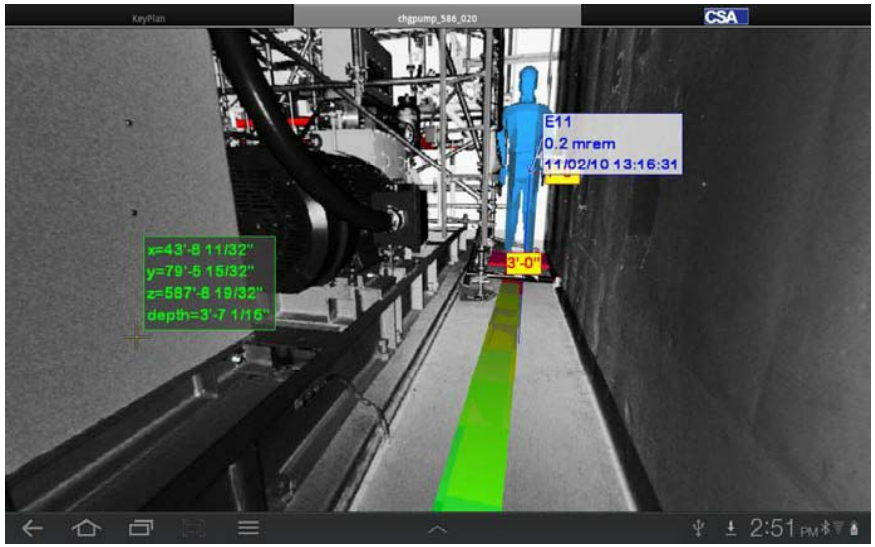
Enhancements

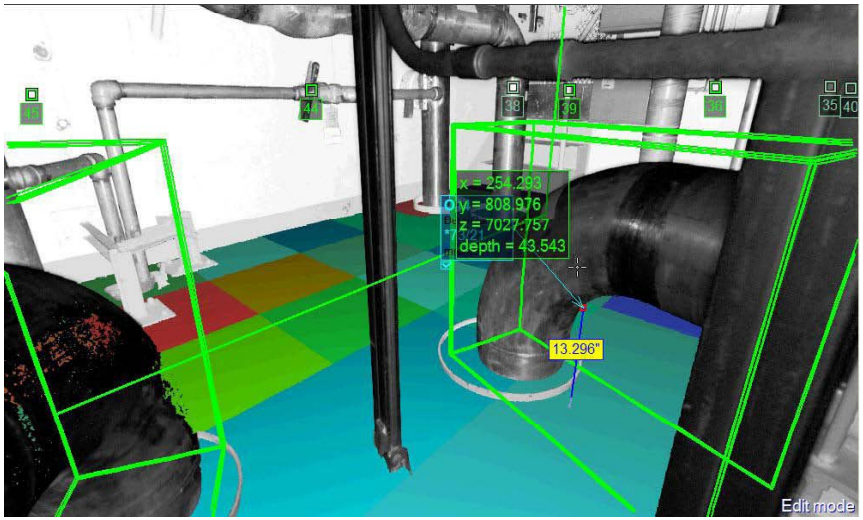
- Originally only used mean gamma energy for plant sources
- Based on utility feedback, added ability to insert isotopic breakdown for up to 4 isotopes (e.g. 50% Co-60, 50% Co-58)
- Used to estimate effect of gamma-ray shadows cast by large pipes, tanks, lead blankets, etc.
- Calculations agreed well with Microshield

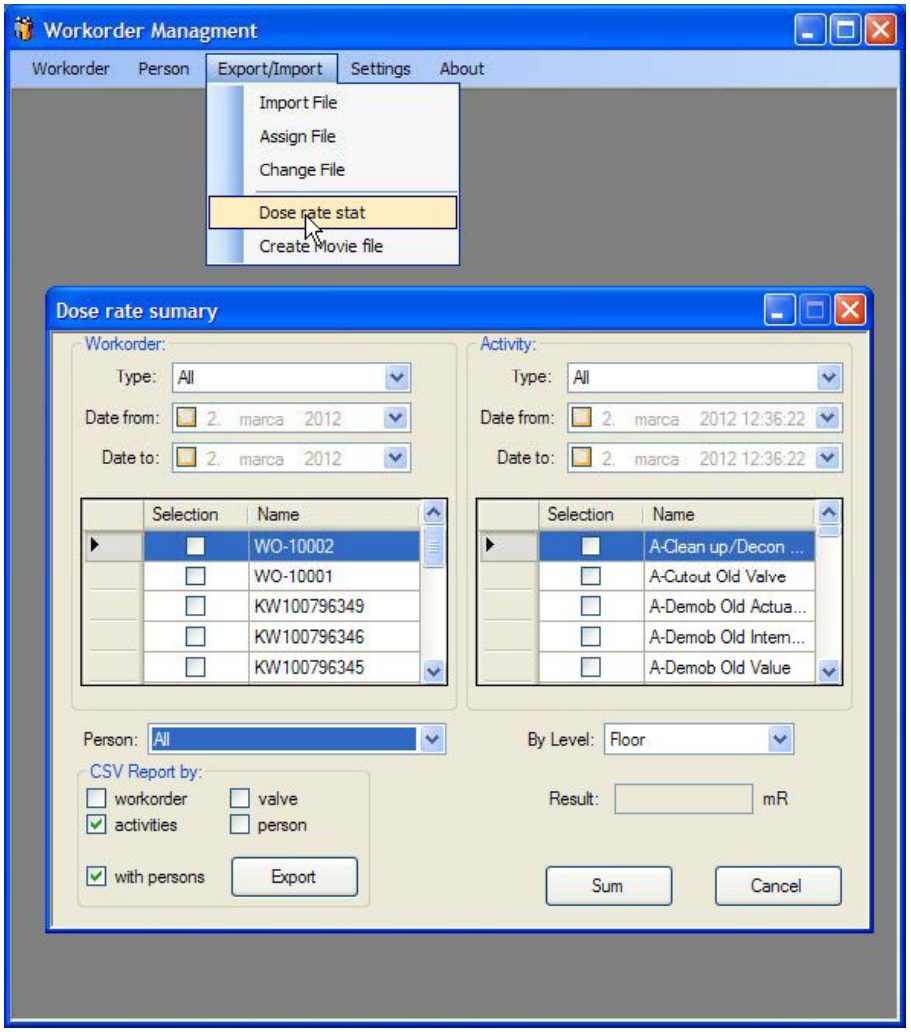
Validation Test - Algorithm Geometry and Shielding Calculation Compared to Microshield

Case No.	Description	Microshield Geometry	Dimensions	Covering	Shielding	Nuclides	Microshield Results mR/hr at 1 ft	Microshield Results mR/hr at 3 ft	Algorithm Results mR/hr at 1 ft	Algorithm Results mR/hr at 3 ft
1A	4" diameter pipe	line	6 ft long - measure at 12" away from line and midway (36" from end)	1/4" steel	none	Co-60, Co-58 500 mCi each used in Microshield 50%-50% used in Algorithm	3597*	779*	3,688	799
1B	4" diameter pipe	line		1/4" steel	2 Pb blankets		1,230	321	1,288	381
1C	4" diameter pipe	line		1/4" steel	4 Pb blankets		500	143	334	145
2A	2" valve	point	measure at 12" away from point source	1/2" steel	none	Cs-137, Cs-134 500 mCi each used in Microshield 50%-50% used in Algorithm	5194*	576*	5,193	577
2B	2" valve	point		1/2" steel	2" steel		948	105	941	105
2C	2" valve	point		1/2" steel	8" concrete		732	81	773	86

Prototype from CSA, Inc.







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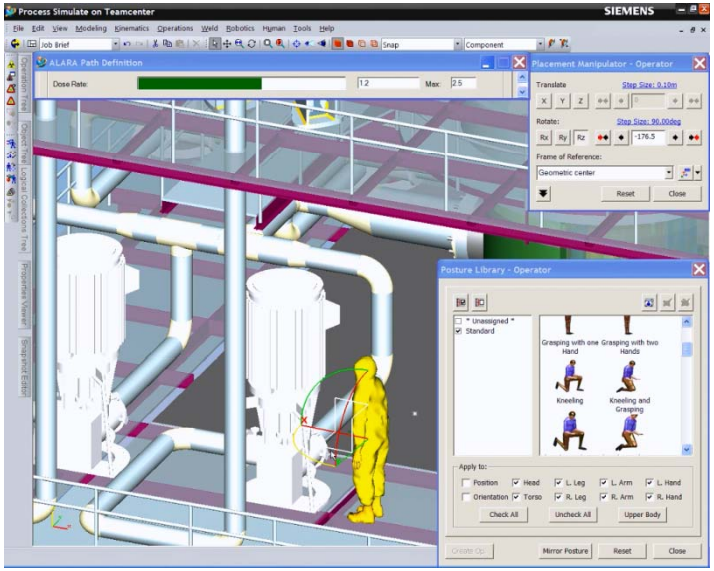
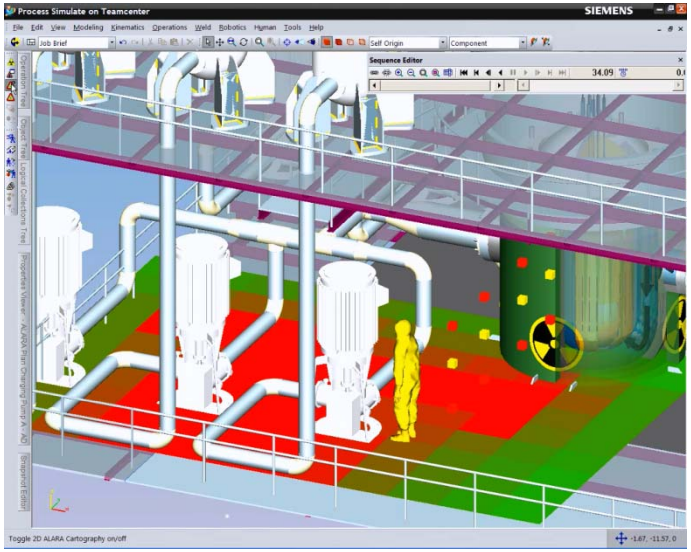
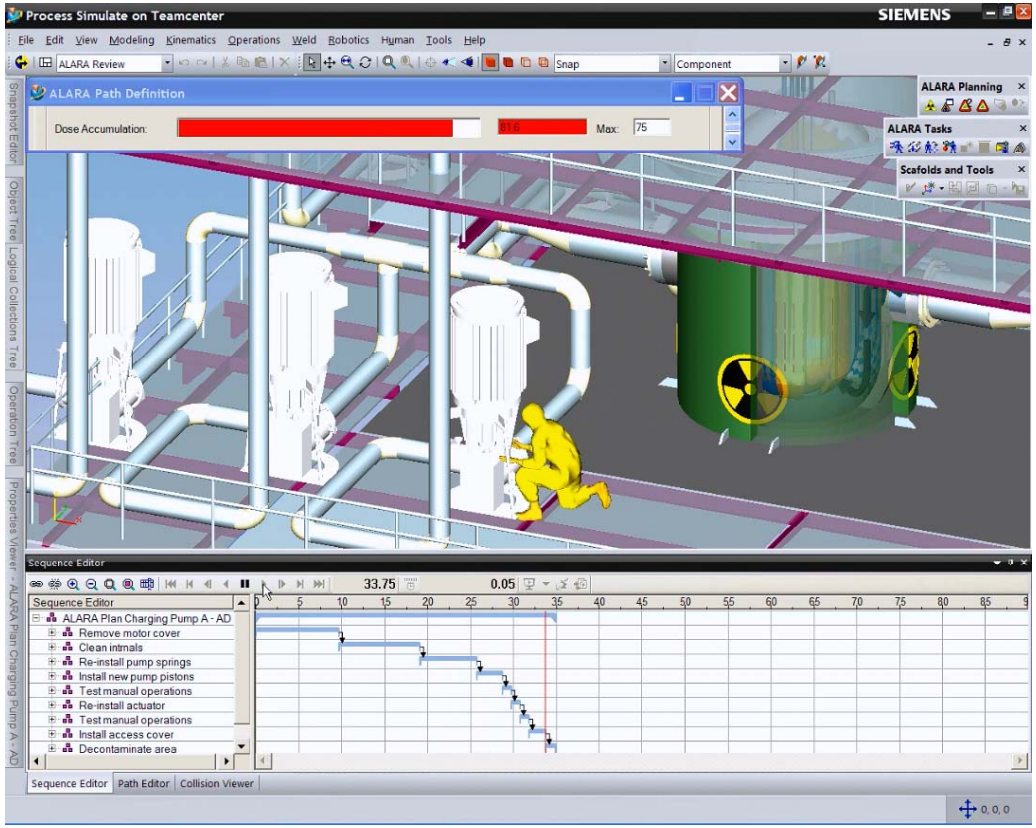
Prototype from Siemens Product Lifecycle Management Software, Inc.







Uses Identified

- ✓***Enhance communication of radiological conditions to workers***
  - Visualize dose rate gradients for pre-job briefs
  - Utilize for post-job briefs to identify improvement opportunities
- ✓***Improve accuracy and standardize dose estimating process***
  - Consistent approach to dose estimation
  - Uses data that you already have to take!
- ✓***Improve decision-making for applying dose reduction techniques***
  - Optimize work activities and work flow and develop "What-if" scenarios to further dose reduction options (e.g. impacts from shielding)
- ✓***Document ALARA Options and Decisions for Regulatory Compliance***
- ✓***Re-assess dose impacts from changing radiological conditions***
- ✓***Others (see report)***

Summary and Path Forward

- ✓Successfully designed an algorithm using typically known radiological parameters to more accurately estimate worker dose rates for planning purposes
- ✓Integrated algorithm into two distinctly different 3D vendor simulation software packages
- ✓Facilitated industry input and criteria to vendor development process
- ✓Final algorithm anticipated to be released by 1Q 2013

Acknowledgments

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- ★Robert Wible, FIATECH
- Zac Zimmerman, Burns & Roe

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- ★Amadeus Burger, CSA
- ★Noam Ribon, Siemens PLM

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