SAND2017-12104C

Summary of Analysis Methodology Results of the Nuclear Security Assessment Methodologies (NUSAM) Coordinated Research Project

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SAND2017-XXXXC

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Outline

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- NUSAM Methodological Framework and Process
- 3 Steps for Conducting an Assessment
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  - Path Analysis
  - Scenario Analysis
- Comparison of Analysis Tools and Methods
- Other Technical Results
- Conclusions

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Background On NUSAM

- Coordinated Research Project Objectives
  - Establish a risk-informed, performance-based methodological framework
  - Provide an environment to share knowledge, provide guidance on and examples of good practices in assessing security

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Background on NUSAM: Organizational Structure

- Essential Information Working Group
  - Identified key components and information needed to conduct a nuclear security assessment
- ***Analysis Working Group***
  - Developed risk-informed, performance-based approaches and tools to conduct a nuclear security assessment
- Security Case Study Working Groups
  - Irradiator Facility
  - Transport
  - Nuclear Power Plant

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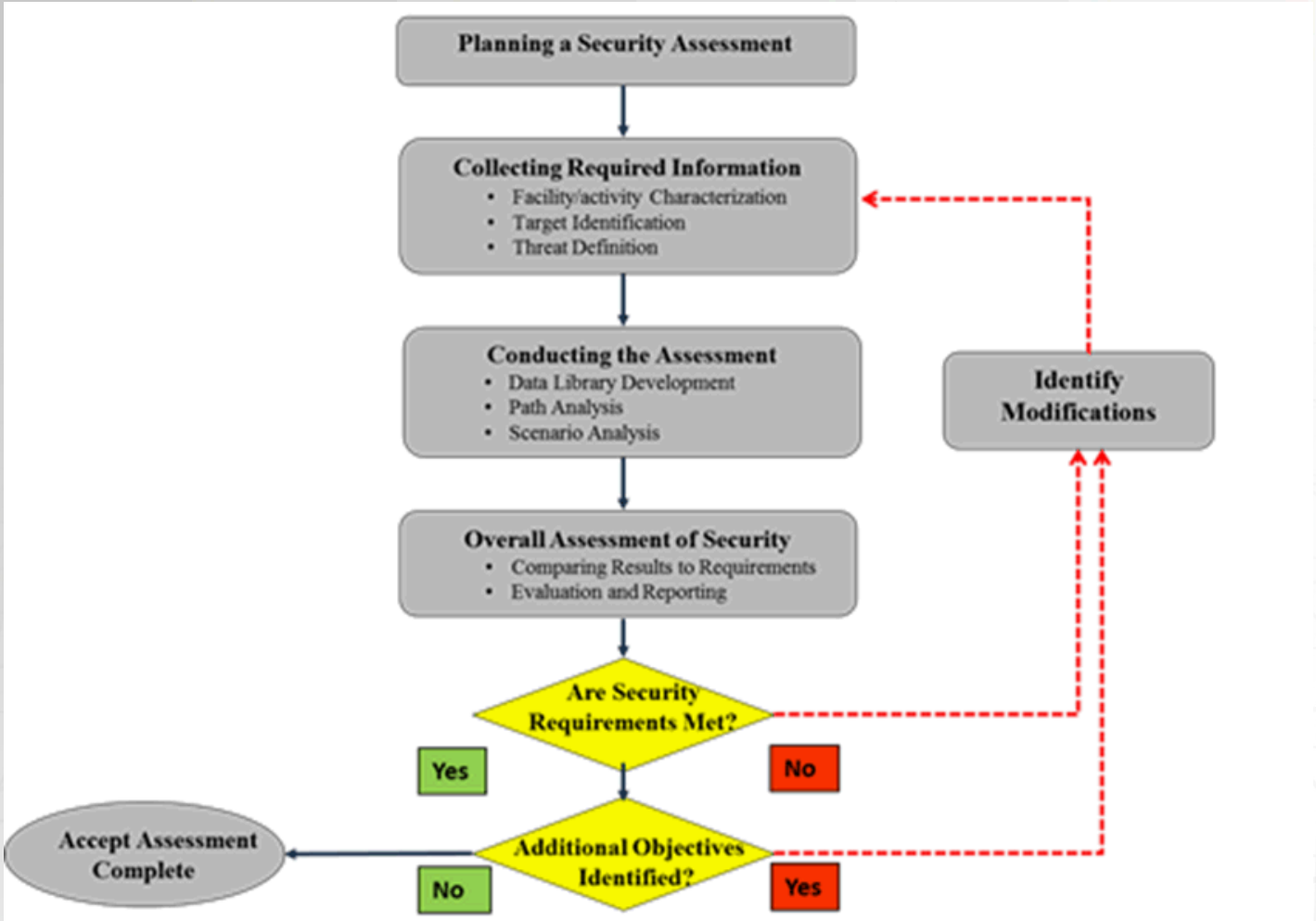
NUSAM Methodological Framework and Process



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Three Steps for Conducting an Assessment

- Three Steps:
  - Develop Data Libraries
  - Perform Path Analysis
  - Perform Scenario Analysis
- Purpose is to estimate performance measures:
  - Probability of Interruption, P_I,
  - Probability of Neutralization, P_N,
  - Probability of System Effectiveness, $P_E = P_I \times P_N$

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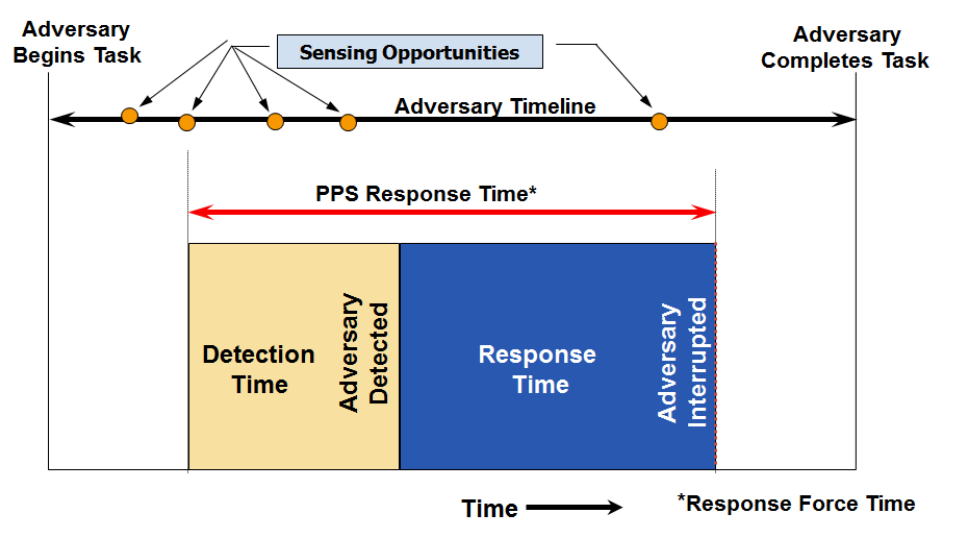
Path Analysis

- *Definition of Path: A time-ordered sequence of adversary tasks/actions, associated with locations*
- Path analysis determines if the physical protection system (PPS) is effective against many paths



Generally used to Calculate P_I for a Most-Vulnerable Path

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Scenario Analysis

- *Definition of Scenario: Specially constructed stories, each modeling a distinct, plausible set of conditions that might occur as part of an attack*
- Determines if P_E is adequate for several detailed, credible adversary attack scenarios
- Leads to a more realistic evaluation of PPS effectiveness than path analysis
  - Also easier for analysis stakeholders to understand what a scenario means than a path

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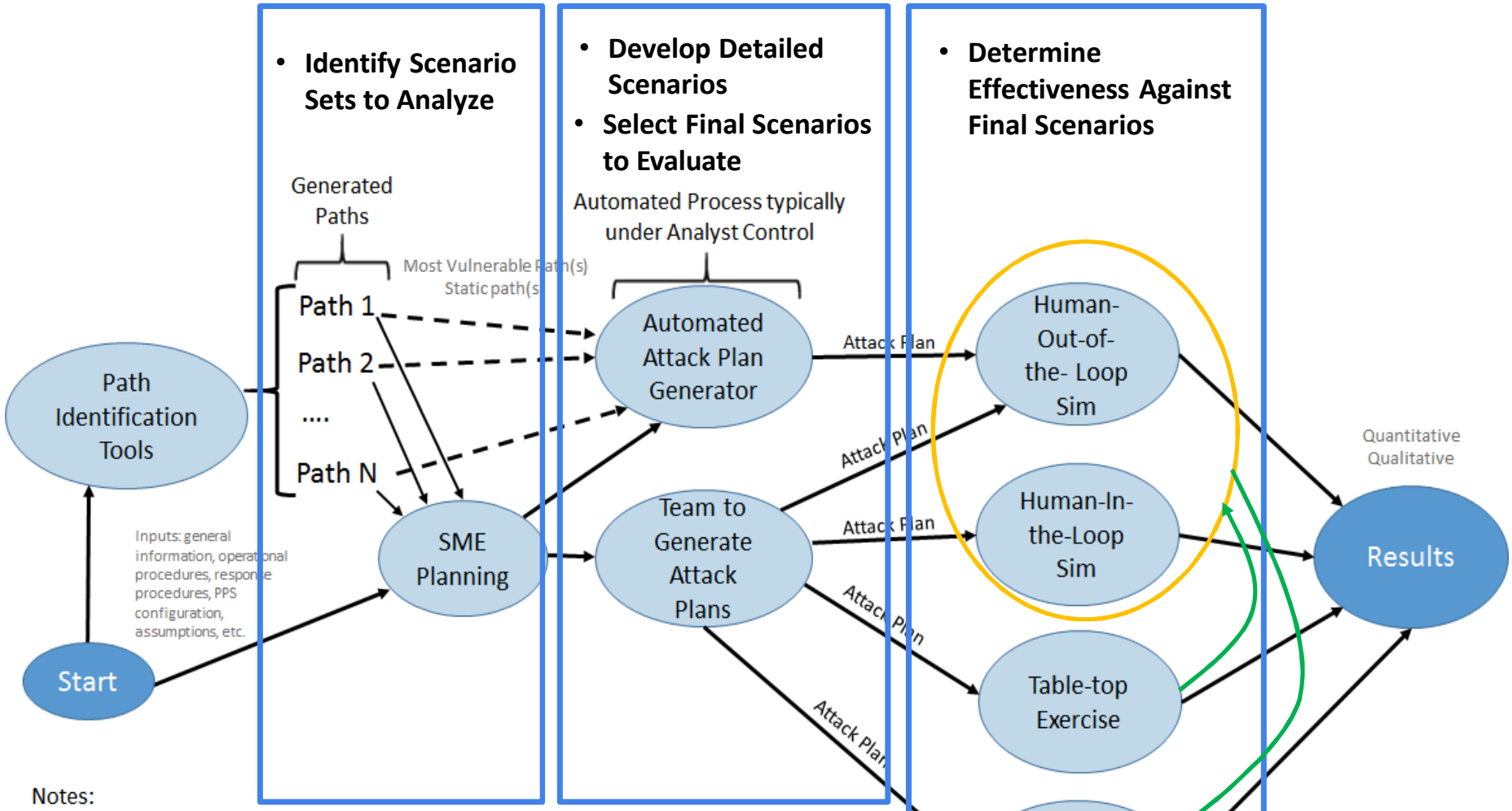
Process for Using Evaluation Tools and Methods Combined with Scenario Analysis Sub-Steps

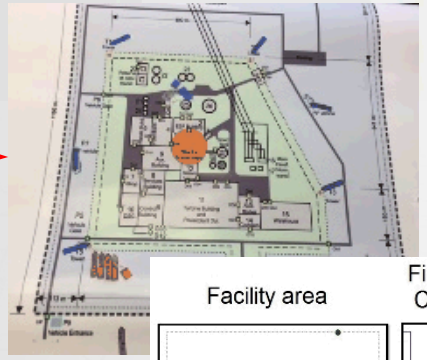


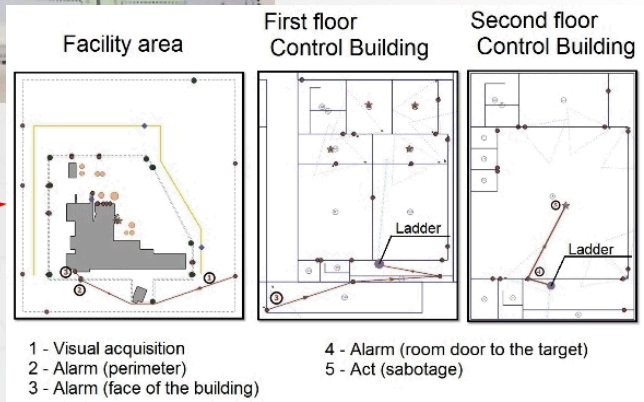
Notes:

1. Scenario development generates attack plans that will be followed up to some point where they will deviate, based on the under conditions that occur during a simulation (sim), Tabletop Exercise (TTX), LSPT, or FoF.
2. Human-Out-of-the-Loop Simulations can produce vast quantities of data based on simulating multiple attacks based on the same attack plan.

NUSAM Applied a Range of Analysis Tools to the Three Case Studies

- Manual analysis tools
  - TTX
  - VISA
- Computerized tools
  - SAVI
  - VEGA
  - ProEv
  - Simajin
  - AVERT
  - STAGE





Note: The documentation within the paper or this presentation in no way should be construed as a critical evaluation nor as an endorsement for the identified tools. Rather, the information provided here is intended to show the process, results, and general capabilities of the tools.

Comparison of Scenario Analysis Tools

	Strengths	Weaknesses
TTX	• Requires modest of resources • Focuses on decision making • No need for computers • Minimal training to begin using	• Results are qualitative • Simulating a scenario may take hours • Modelling technical systems, weapons • Expertise to facilitate and manage
VEGA-2	• Addresses insider and outsider • Combines path analysis with scenario analysis tool • Searches for best P_E scenario • Used by single analyst	• Level of training to interpret output • Does not take into account sniper support outside the site territory • Would need to be adapted for use by other countries
Simajin	• Automated behaviour supports sophisticated team movement, collaboration and coordination, etc. • Highly detailed models of facility	• Maintenance and operational requirements are fairly high: probably needs permanent staff to apply • Developer support may be necessary • Effort required to build behaviours
AVERT	• Combines path analysis with scenario analysis tool • Searches for best P_E scenario • Highly detailed models of facility	• Maintenance and operational requirements are fairly high: probably needs permanent staff to apply • Developer support may be necessary • Effort to build detailed facility models

Suggested Methods and Tools To Use for Evaluating Different Types of Facilities/Activities

Performance Assurance Methods	NPP/Cat I Facilities	Irradiator Facility	Transport	LEU Fuel Fabrication	Spent-Fuel Storage
Checklists Against Prescriptive Requirements	X	X**	X	X	X
Path Analysis	X**	X**	Parked at facilities	Optional	
Tablet-Top Exercises	X**	X**	X**	X	X
Computer Simulations	Optional**	***	Optional		
LSPTs	X	X	X	X	X
RF Tests, including Force-on-Force (FoF)	X (including FoF)	Optional	X (including FoF)	Optional	X

** Indicates combinations of methods and facilities that were used for the 3 NUSAM CRP Case Studies: A nuclear power plant, an irradiator facility, and a Cat 1 source transport activity.

*** Case where a computer simulation was used at an Irradiator Facility; after its use the case study afterwards participants decided that other tools with smaller resource requirements were adequate.

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Other Technical Results

- Documented mathematical models covering line-of-sight, hearing, and weapons' effects
- An approach for evaluating effectiveness against insider sabotage attacks
- Equations to address P_D for non-independent events
- A simple risk analysis approach was proposed to harmonize security risks with safety risk models
- A game theory model for adversary deterrence was outlined, along with a hypothetical example

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Other Technical Results (Cont'd)

- Outsider path analysis based on adversary action sequences (like paths but no associated locations)
- More specific effectiveness models :
  - If P_{Dj}, P_{Ij}, P_{Nj} are probabilities of detection, interruption, neutralization given sensing at opportunity j then

$$P_E = \sum_{j=1}^{J} P_{FDj} P_{Ij} P_{Nj}$$

where P_{FDi} is the probability that the adversary is detected for the first time at sensing opportunity j:

$$P_{FDj} = P_{Dj} * \left\{ \prod_{i=1}^{j-1} (1 - P_{Di}) \right\}$$

Summary and Conclusions

- Presented analysis methodology results developed and documented during the IAEA NUSAM CRP
- Discussed/compared compares several types of modelling/simulation tools and methods used internationally to assess PPS effectiveness
- The NUSAM AWG also documented
  - A general process showing how to use these analysis tools/methods sequentially as part of an assessment
  - The technical and mathematical basis for several techniques, at a more detailed level than previously

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Comparison of Scenario Analysis Tools (cont'd)

Software/Method Name	TTX	STAGE	VEGA-2	Simajin	AVERT
Type (S = Software, M = Method)	M	S	S	S	S
Performs Path Analysis	Yes	No	Yes	Being developed	Yes
Metrics Calculated: P_I	No	Yes	Yes	Being developed	Yes
Metrics Calculated: P_N, P_E	Win/Loss Only	Yes	Yes	Yes	Yes
Computer Simulation	No	Yes	Yes	Yes	Yes
Human in the loop	-	No	No	Yes	Yes
Human out of the loop (Constructive)	-	Yes	Yes	Yes	Yes
Representation of Site and Building Floors	2D Maps	3D	2D+	3D	3D
Delay and Probability of Detection Values	Fixed	Fixed	Fixed	Sampled	Sampled
Data Analysis Tools	No	Yes	No	Yes	Yes