National Nuclear Security Administration

Module 10

Quantifying Late Detection in MC&A for Item Inventories

Learning Objective

1. Understand how physical inventories, sampling plans, and other checks of the inventory factor into detection of insider activity.
2. Be able to quantify the probability of detection for various scenarios in a single inventory and over several inventories.
3. Understand how physical inventory and sampling procedures relate to the assumptions, analysis, and scenarios in the vulnerability assessment.

If Insider selects the item inventory as their target, a defect will be introduced into the inventory

Ability and probability to detect a given defect depends upon several things:

1) **How the item is inspected (e.g., inspection procedure)**
   a) **Item Count**
   b) **Inventory by serial number and location**
   c) **Confirmatory measurement**
   d) **Verification measurement**
2) **Number of defects (e.g., 1 item or several items)**
3) **Number of items inspected during each inventory**
4) **Frequency of inspections (timeliness of detection)**

Types of inspections and scenarios they can detect:

- Item count
  - Missing item
- Inventory by serial number, seal, and location
  - Missing item by serial number
- Confirmatory measurement (weight and/or some other attribute
  - Tampering with item and some substitution scenarios
- Verification measurement
  - Material removal (within limits of measurement) and substitution scenarios

Relationship to the Vulnerability Assessment

- Number of defects is related to the goal quantity
- Type of inspection is directly related to insider scenario one is trying to detect
- Probability of detection from the Material Accounting is a statistical calculation based on the two preceding bullets

Sampling Formula for required sample size

$$n=(N-d/2)(1-\beta)^{1/(d+1)}$$

N = Population Size

β = specified probability of failing to find at least one critical nonconformity

d = maximum number of critical non-conforming items "allowed" in the lot or population.

n = sample size

What if the "Goal Quantity" is 3 items

Goal Quantity = 3 items and chance of finding at least one defect 90%			
N	d	β	n or sample size
100	3	0.1	43
200	3	0.1	87
1000	3	0.1	437
Goal Quantity = 3 items and chance of finding at least one defect 95%			
N	d	β	n or sample size
100	3	0.05	52
200	3	0.05	105
1000	3	0.05	526
Goal Quantity = 3 items and chance of finding at least one defect 99%			
N	d	β	n or sample size
100	3	0.01	67
200	3	0.01	136
1000	3	0.01	683

What if the "Goal Quantity" is 1 item

Goal Quantity = 1 item and chance of finding at least one defect 90%			
N	d	β	n or sample size
100	1	0.1	68
200	1	0.1	136
1000	1	0.1	683
Goal Quantity = 1 item and chance of finding at least one defect 95%			
N	d	β	n or sample size
100	1	0.05	77
200	1	0.05	155
1000	1	0.05	776
Goal Quantity = 1 item and chance of finding at least one defect 99%			
N	d	β	n or sample size
100	1	0.01	90
200	1	0.01	180
1000	1	0.01	900

What if the "Goal Quantity" is "0" Defects?

Zero defects at 90%			
N	d	β	n or sample size
100	0	0.1	90
200	0	0.1	180
1000	0	0.1	900
Zero defects at 95%			
N	d	β	n or sample size
100	0	0.05	95
200	0	0.05	190
1000	0	0.05	950
Zero defects at 99%			
N	d	β	n or sample size
100	0	0.01	99
200	0	0.01	198
1000	0	0.01	990

What happens over time (e.g., delayed detection from repeated inspections)?

Russian Roulette example:

If you play consecutive games of roulette, including spinning the cylinder between each time, you have 5/6th of a chance of surviving every time - 83.3 %.

Doesn't sound so bad?

But what happens if you keep going?

Statistics behind Russian Roulette

$$(\text{Probability of surviving})^{\text{number of games}}$$

- **Game 1 – $(\text{Probability of surviving})^{1}$**
- **Game 2 – $(\text{Probability of surviving})^{2}$**
- **Game 3 – $(\text{Probability of surviving})^{3}$**
- **Game 4 – $(\text{Probability of surviving})^{4}$**
- **Game 5 – $(\text{Probability of surviving})^{5}$**
- **Game 10 – $(\text{Probability of surviving})^{10}$**
- **Game 20 – $(\text{Probability of surviving})^{20}$**
- **Game 50 – $(\text{Probability of surviving})^{50}$**

Russian Roulette - Continued

- After 1 game, you have 83.33% chance of still being alive
- After 2 games, you have 69.44% chance of still being alive
- After 3 games, you have 57.87% chance of still being alive
- After 4 games, you have 48.22% chance of still being alive
- After 5 games, you have 40.19% chance of still being alive
- After 10 games, you have 16.15% chance of still being alive
- After 20 games, you have 2.61% chance of still being alive
- After 50 games, you have 0.011% chance of still being alive

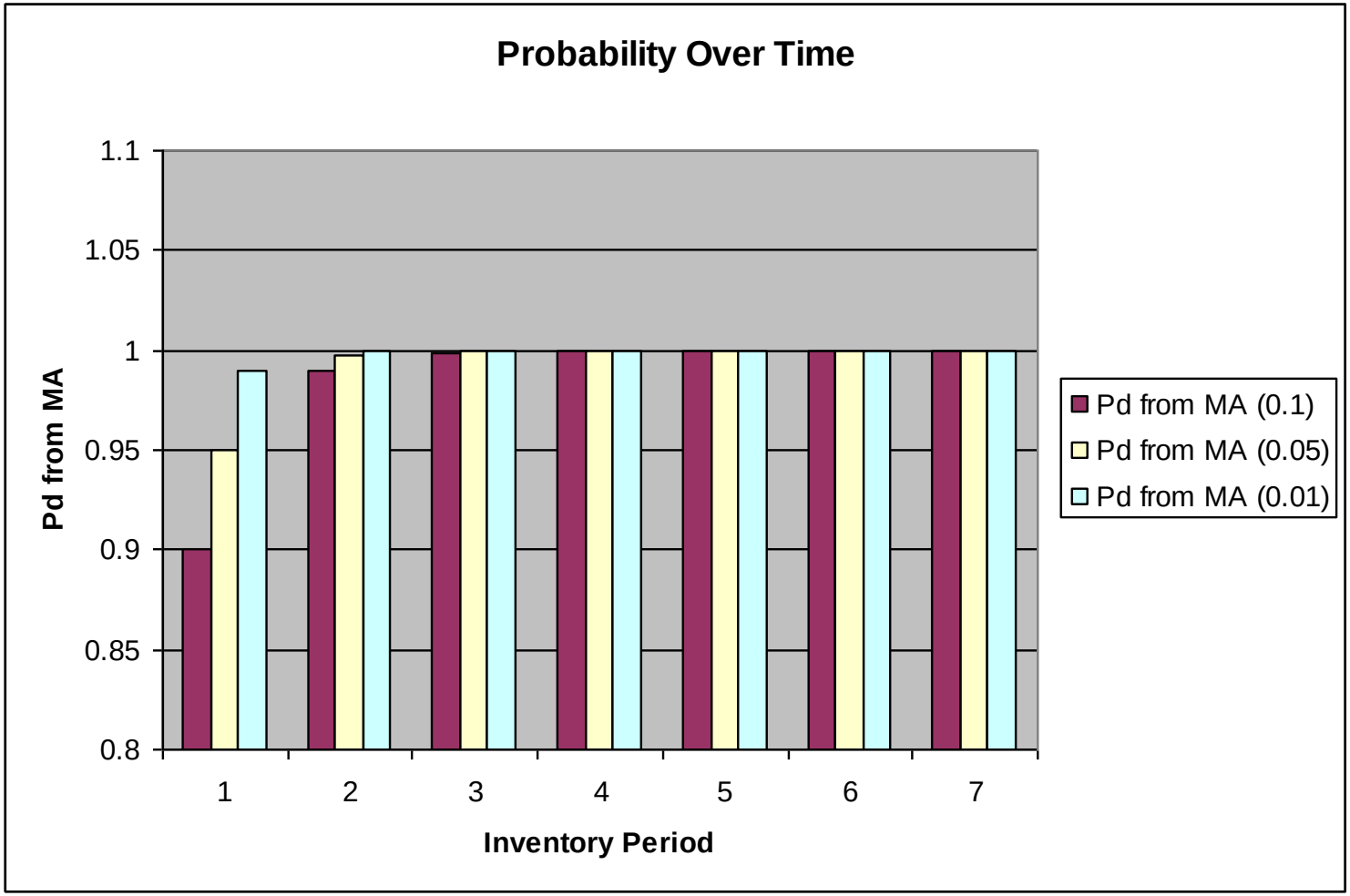
In other words: after 4 games, chances are less than 50/50 for still being alive. Perhaps it might be better to play a game of poker instead.

Multiple Inventory Periods (note: for example use β = .10)

$$P^{\text{Number of Inventories}}$$

- After one inventory insider has a 0.10 probability of escaping detection.
- After two inventories insider has a 0.01 probability of escaping detection.
- After 3 inventories insider has a 0.001 probability of escaping detection and so on…..

Probability of detection from Material Accounting over time at various inspection levels



Exercises

1. Small Group – See handout
2. Large Group – Simulated inventory with defects