SAND2014-3576P

Chemical and Biological Risk Management

SAND XXXX-XXXX
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Session Objectives

- Define hazardous materials, safety versus security, and laboratory risk management
- Describe the spectrum of biological and chemical risks
- Provide an overview of the need for laboratory risk management, and difference between hazard and risk
- Highlight basic aspects of the laboratory risk management process

Why Worry about Laboratory Safety and Security?

- Materials used in laboratories are often hazardous
- We live and work in a world where hazardous materials are frequently encountered and handled
- Dangerous nuclear, biological, and chemical materials are used legitimately all over the world for basic, essential needs
  - Pathogens → public, animal, environmental health
  - Chemicals → agriculture, water
  - Nuclear materials → energy, medicine




Realities of our World

- Risks of accidental and intentional misuse of these materials will increase over time
- Intentional abusers have more tools
  - ubiquity of some hazardous materials,
  - globalization of communications,
  - complex transportation and distribution networks,
  - expanding/available knowledge and technology
- Resources to mitigate those risks are shrinking

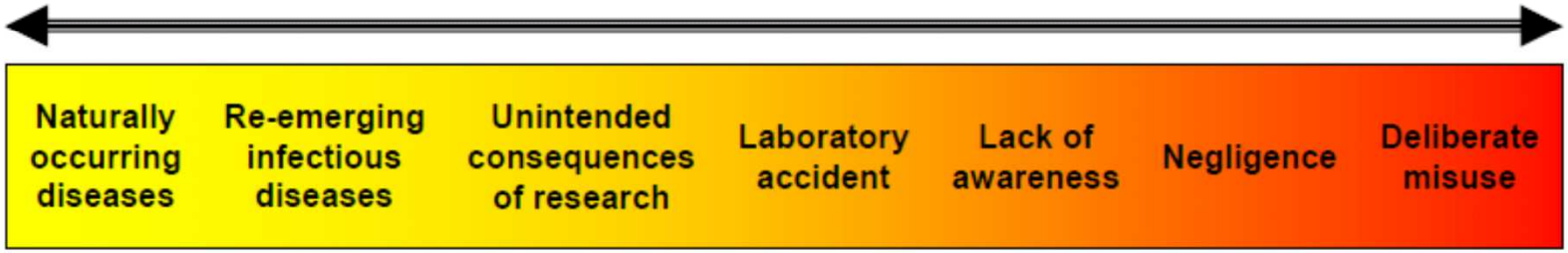
- There is a fundamental need to achieve safety and security in today's world

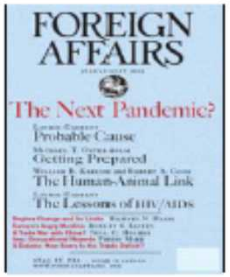
Incidents are Costly

- Costs:
  - Loss of life
  - Injury
  - Loss/damage of property
  - Loss of work
  - Loss of goods & services
  - Environmental damage
  - Loss of public confidence/respect

Bhopal 25-yr vigil

Spectrum of Biological Risks





Source: Chatham House

Evolution of the biological threat

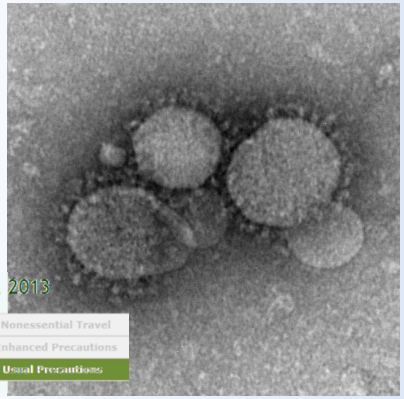
- "Globalization" of biological risks raises the specter of naturally occurring or maliciously introduced outbreaks of highly infectious disease
  - Increasing emergence and re-emergence of highly infectious disease
  - Advance in biotechnology
  - Rise of transnational, asymmetric terrorism
  - Travel and trade

Infectious Disease Affects International Security

FMD outbreak UK, 2001

Avian Influenza

SARS in Asia, 2003



MERS-CoV, 2013

Amerithrax, 2001

Bioterrorism - Examples

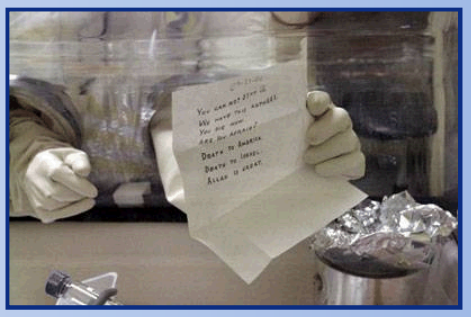
- Rajneeshees – 1984
  - Contaminated restaurant salad bars in The Dalles, Oregon with salmonella spp. bacteria

Bhagwan Shree Rajneesh

Aerosolization of Bacillus anthracis and botulinum toxin by Aum Shinrikyo

- Aum Shinrikyo – 1990s
  - Aerosolized and disseminated biological agents in Tokyo
  - Vaccine strain of *Bacillus anthracis*
  - Inactive strain of *Clostridium botulinum*

- Anthrax – 2001
  - Organism: *Bacillus anthracis*
  - Dissemination: 7 letters sent through postal system
  - 22 confirmed cases (11 inhalational, 5 deaths)



Laboratory accidents: Infections of workers

- SARS
  - Doctoral student infected in Singapore
  - Student worked in virology laboratory
  - Did not work on SARS, samples were cross contaminated
- Cowpox virus
  - Student laboratory worker
  - University of Illinois, Urbana-Champaign
  - In advertently handled contaminated materials
- *Yersinia pestis* KIM D27
  - Researcher in university laboratory
  - Unknown route of exposure

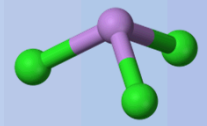
Spectrum of Chemical Risks

Toxic Industrial Chemicals | **Chem Process Sabotage** | **Theft and Diversion** | **Criminal Black Markets** | **Explosives** | **Chemical Weapon (CW) Precursors** | **Chemical Weapons**

Therence Koh/AFP /Getty Images

[1]


[3]

[2]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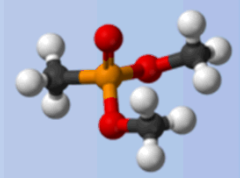
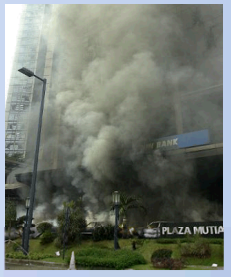
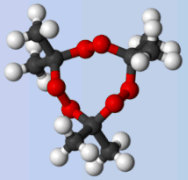
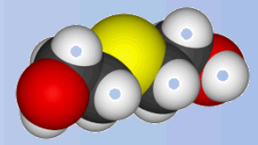
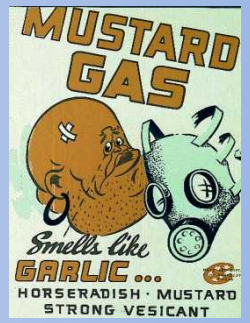





(AP Photo, Ric Feld, 2004)







[1] Source: http://www.millercountyliberal.com/news/2011-04-20/Community/PGC_Farms_Chemical_Warehouse_victim_of_theft.html

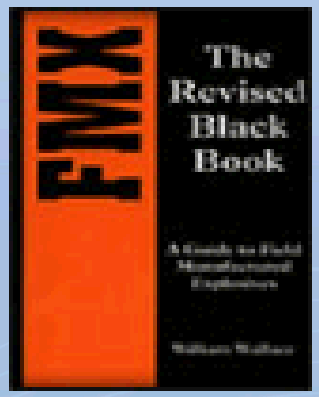
[2] Source: http://www.longwarjournal.org/archives/2007/03/al_qaedas_chlorine_w.php

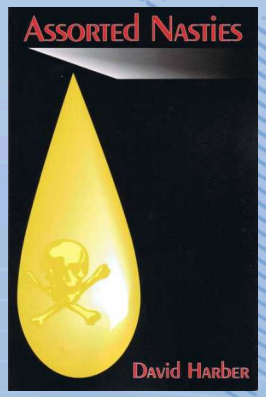
[3] Source: http://cached.newslookup.com/cached.php?ref_id=32&siteid=1199&id=1708039&t=1364910596

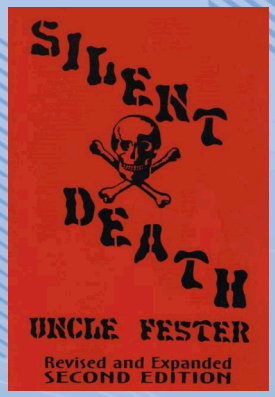
[4] Source: http://www.vosizneias.com/132460/2013/06/04/paris-france-says-now-certain-sarin-gas-used-in-syria/

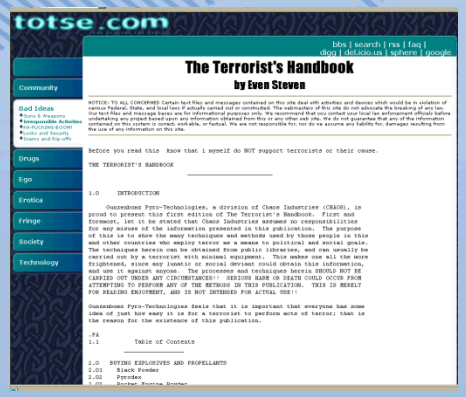
Evolution of the Chemical threat

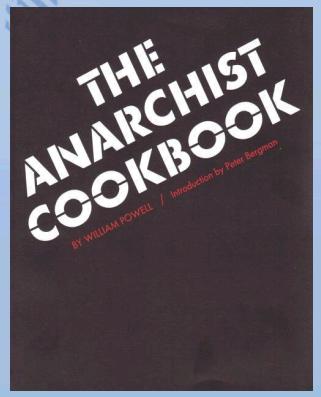
- "Globalization" of chemical risks raises the specter of accidental or maliciously introduced releases of highly hazardous materials
  - Increasing use of hazardous chemicals
  - Advances in chemical technology
  - Rise of transnational, asymmetric terrorism
  - Travel and trade
- History of people deliberately using chemicals to harm others
- Information on how to acquire and deliver them is easy to get







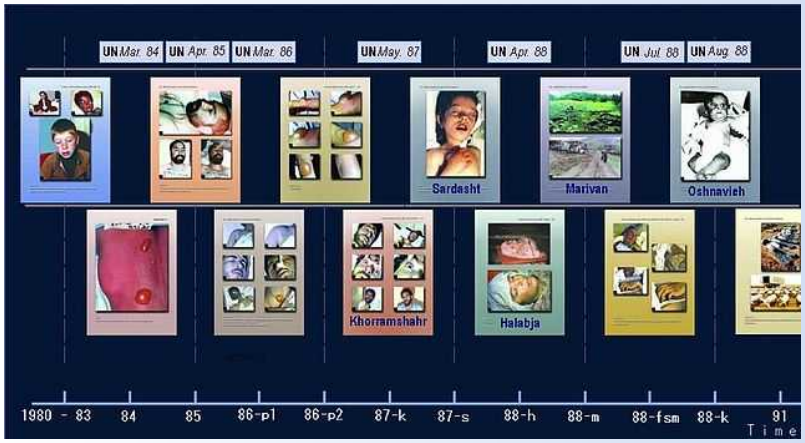




Chemical Abuse Affects International Security

Syria CWA neutralization[1], 2014

Export Controls[4]; Australia Group, since 1985



Iraq CWA use[3], 1980-91

Legacy CWA waste[2], since 1915

[1] Source: http://www.bbc.co.uk/news/world-middle-east-26979101, and http://www.bbc.co.uk/news/world-middle-east-22307705

[2] Source: http://www.dw.de/wartime-ammunition-still-rotting-in-german-waters/a-17359132

[3] Source: http://en.wikipedia.org/wiki/Iraqi_chemical_weapons_program

[4] Source: China Ministry of Commerce: http://lb2.mofcom.gov.cn/article/annualstatisticsdata/201105/20110507552156.shtml

bb3

Chemical terrorism – Examples

- 1982, Chicago, USA; unknown/criminal
  - Poisoning of Tylenol medicine; Cyanide (7 deaths)
- 1994-95, Japan, terrorists
  - 1994: night attack on Judges; Sarin spray (7 deaths, 144 injured)
  - 1995: attack on 3 Tokyo subway lines; Sarin (12 deaths, >4000 injured)
  - 1995: attack on Tokyo subway; Cyanide (0 deaths, 4 injured)
- 2001, San Adolfo, Columbia; terrorists
  - Gas bomb attack on police; cyanogen chloride (4 deaths, 5 injured)
- 2002, Chicago, USA; anarchist
  - Theft of chemicals for attack (prevented); multiple toxics/explosives (0 deaths/injured)
  - Large quantities stolen from labs and warehouses, stored in subway room
- 2002-2005, Indonesia, terrorists;
  - 2002: 2 bombs, Bali (202 deaths, 240 injured)
  - 2003: car bomb, Jakarta (12 deaths, 150 injuries)
  - 2005: 3 bombs detonated, 3 ***not*** detonated; Bali (20 deaths, 129 injured)
- 2007, Iraq, terrorists
  - 15 truck bombs; chlorine (115 deaths, 854 injured/85 children)
- 2010-2013, Afghanistan, terrorists
  - 43 attacks on girls' schools; pesticides (2,624 injured/2,560 children)
  - 9 attacks on police stations; food poisoning; (53 deaths, 40 injured)

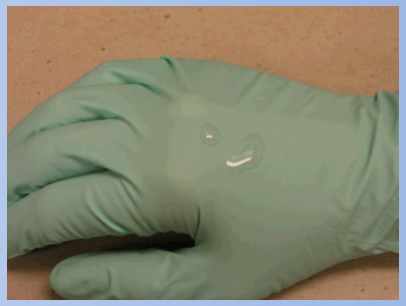
http://www.longwarjournal.org/archives/2007/03/al_qaedas_chlorine_w.php

bb3 Indonesia examples - chemical terrorism?

bb, 4/23/2014

Laboratory accidents: Injury & damage

- Injury/death:
  - 1996 Lab exposure: Dartmouth University; dimethlmercury
    - Professor, expert in metal toxicity spilled dimethylmercury on her gloved hand
    - Six months later, became ill and died.
  - 2008 Lab reaction: Univ. California – LA; tert-butyllithium
    - Young researcher using a pyrophoric chemical (ignites spontaneously in air).
    - Died from injuries sustained in the chemical fire.
- Damage:
  - 2002 Lab fire: Univ. California – Santa Cruz; unknown cause
    - Fire detectors and inventory of chemicals allowed firefighters to enter building and contain fire
    - no automatic sprinkler system
    - Two years to restore lab, loss of work
    - Other labs in building damaged (water, smoke)
  - 1994 Earthquake/lab fire: California State Univ. – Northridge
    - Poor inventory of chemicals, no sprinkler system
    - Science buildings allowed to burn because firemen worried about chemical hazards
    - Complete loss of labs, equipment, work.

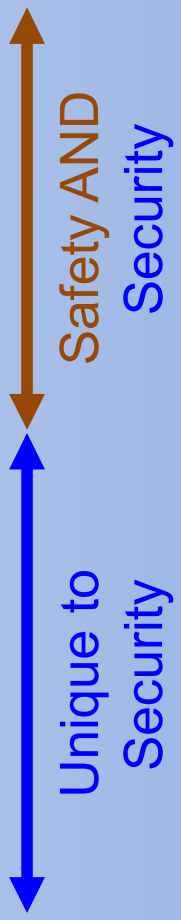


http://ehs.ucsc.edu/emergency/pubs/sinshfire2.htm

Image courtesy: P.W. Weigand, CSU Northridge Geology Department

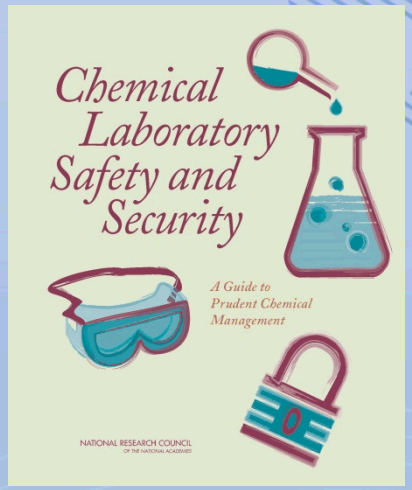
Why worry about Laboratory safety & security?

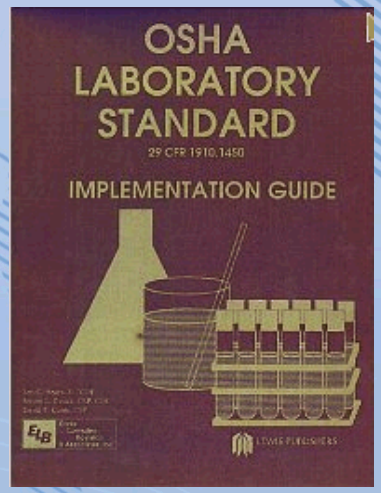
- Health and safety of workers
- Health of the environment
- Community health
- Public confidence/reputation
- Costs of damage to labs and equipment
- Prevent criminals and terrorists from getting dangerous materials & information
  - Wide variety of materials have been used
  - Wide variety of motivations for actions
- A deliberate attack on a laboratory facility could release a large amount of hazardous material

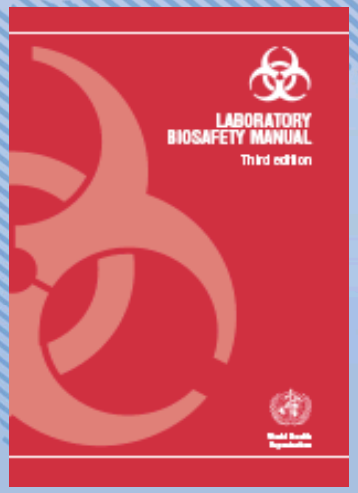


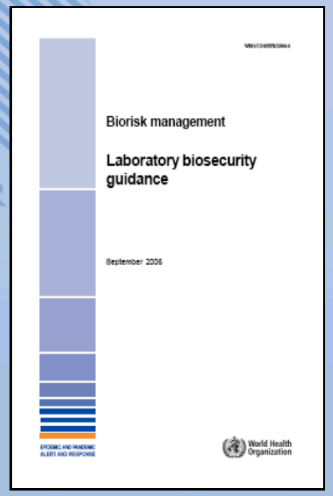
Relationships Between Laboratory Safety and Security

- **Laboratory safety**
  - **Protection against *accidents* and *authorized* activities.**
- **Laboratory security**
  - **Protection against *deliberate* harm and *unauthorized* activities.**



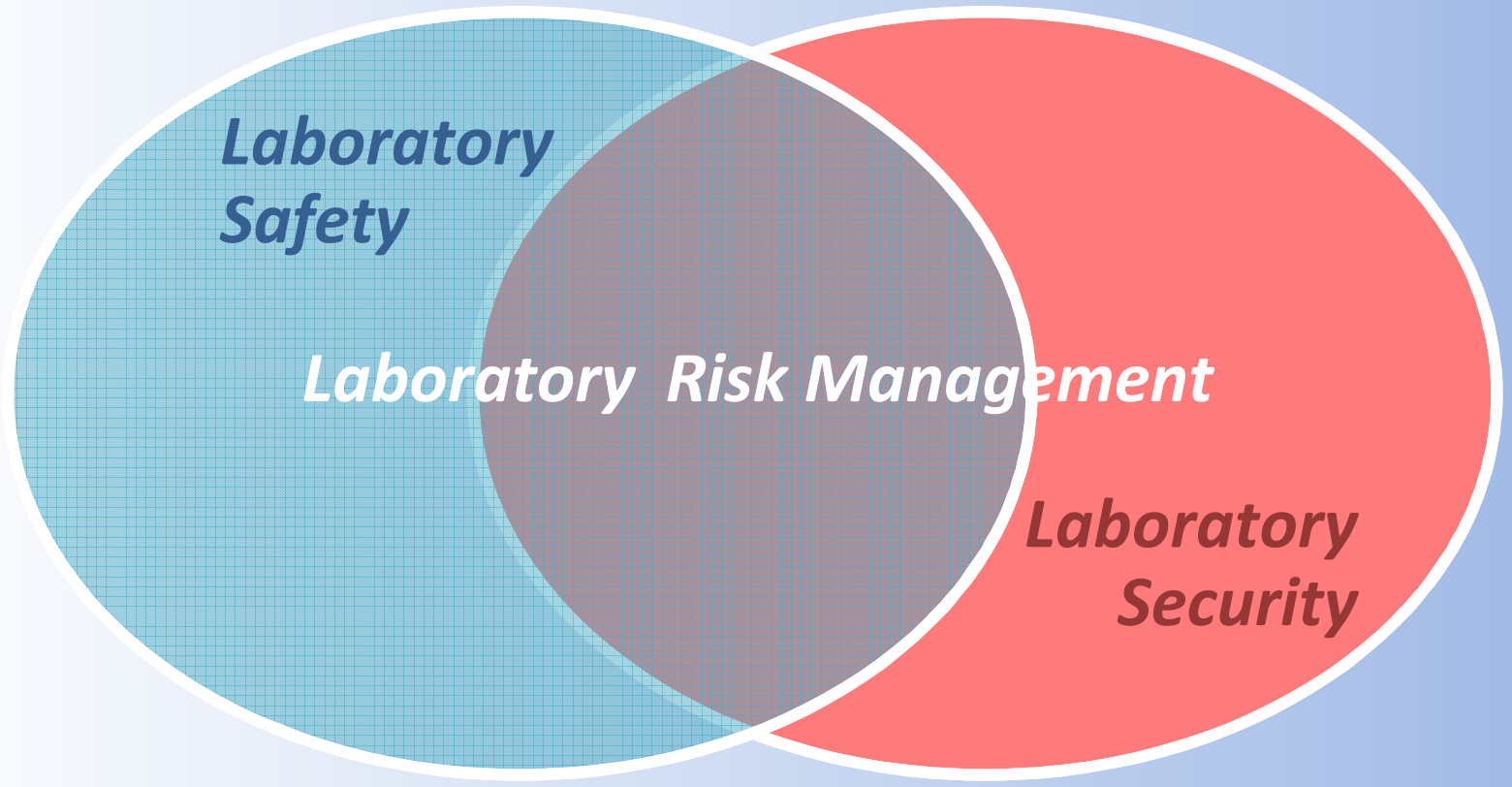






Laboratory Security and Safety

- **Chemical and biological risks may be mitigated through the application of laboratory security and safety measures:**



Laboratory Security and Safety: Hazard vs. Risk

Hazard – ***the potential to harm***

Risk – ***the probability that harm will result***

Risk Basics: Hazard vs. Risk

- Hazard:
  - anything with the *capacity* to cause harm:
    - driving in Algiers can be hazardous

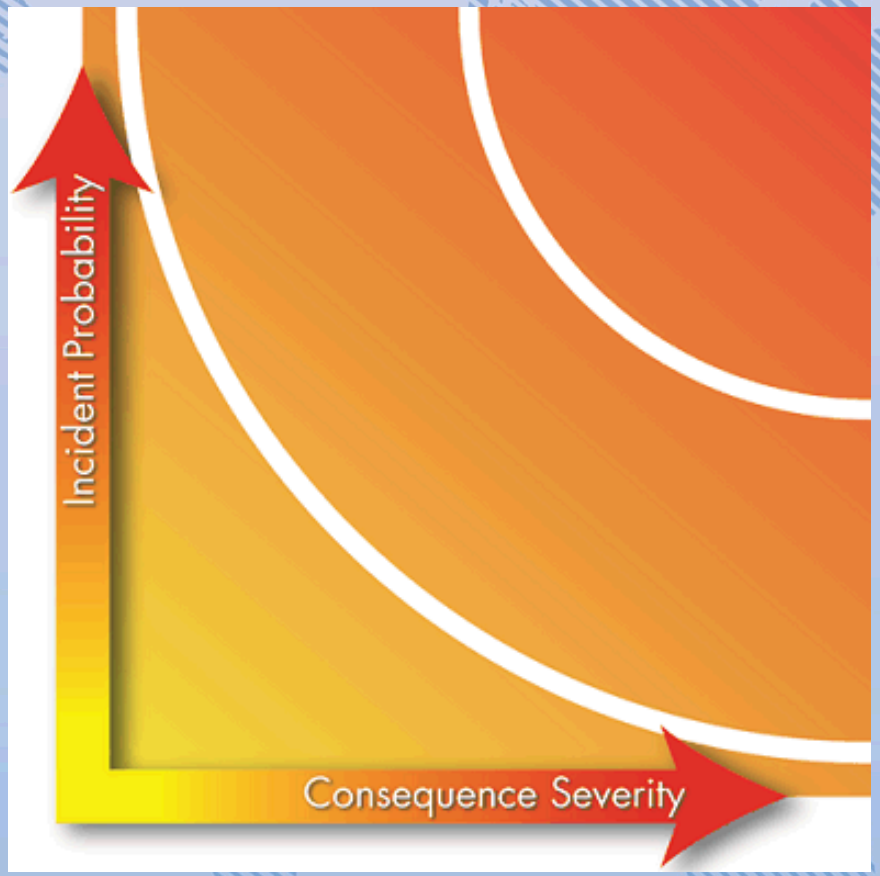
- Risk: bb4
  - the *probability* that a *condition* will result in harm.
  - risk *varies* with conditions:
    - *me* driving in Algiers = higher risk!
    - *you* driving in Algiers = lower risk
- Mitigations:
  - Reduce risk
    - seatbelts
    - anti-lock brakes
    - driving lessons

Slide 20

bb4 Joe - we also incorporate "hazard" or "source of harm" into our standard risk definition...
bb, 4/23/2014

Risk Basics: Definition

- Risk is a function of:
  - Probability that an incident will occur (**likelihood**)
  - Severity if the event occurs (**consequence**)



$$\text{Risk} = f(\text{Likelihood, Consequence})$$

BREAK

Laboratory Risk Management: the AMP Model

Laboratory Risk Management =
Assessment, Mitigation, Performance

Key Components of Laboratory Risk Management

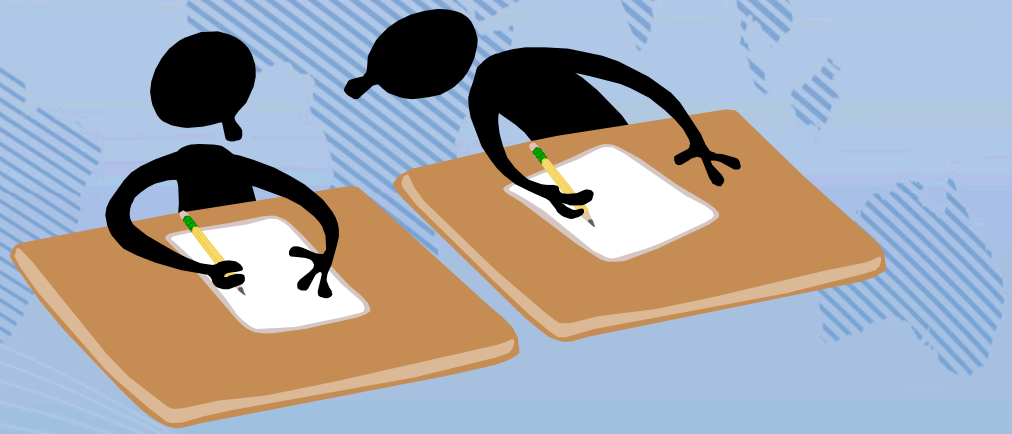
- Laboratory Risk **Assessment**
  - Process of identifying the hazards and evaluating the risks associated with hazardous materials (e.g. biological, chemical, radiological) in the laboratory, taking into account the adequacy of any existing controls, and deciding whether or not the risks are acceptable

Key Components of Laboratory Risk Management

- Laboratory Risk **Mitigation**
  - Actions and control measures that are put into place to reduce or eliminate the risks associated with hazardous materials in the laboratory

Key Components of Laboratory Risk Management

- **Performance**
  - The implementation of the entire **laboratory risk management (LRM)** system, including evaluating and ensuring that the system is working the way it was designed. Another aspect of performance is the process of continually improving the system.



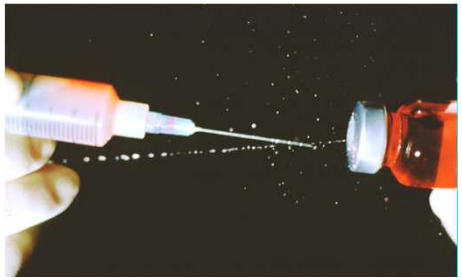
Risk Assessment

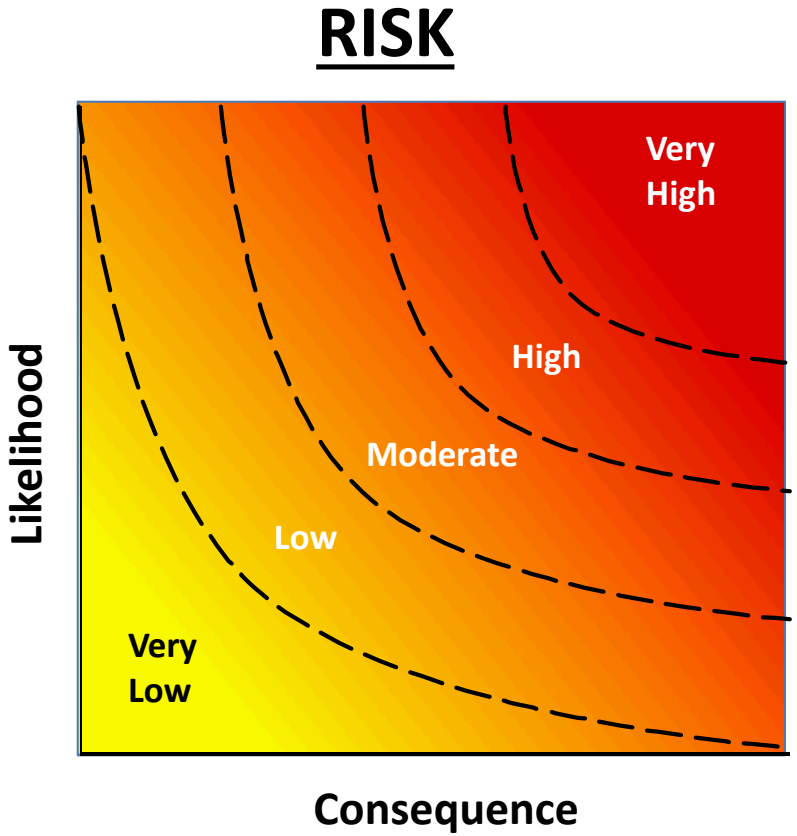
A **risk assessment** could be defined as a procedure that analyses a particular process or situation in order to determine the **likelihood** and **consequences** of a certain adverse event.

R = f(L, C)

Risk Assessment

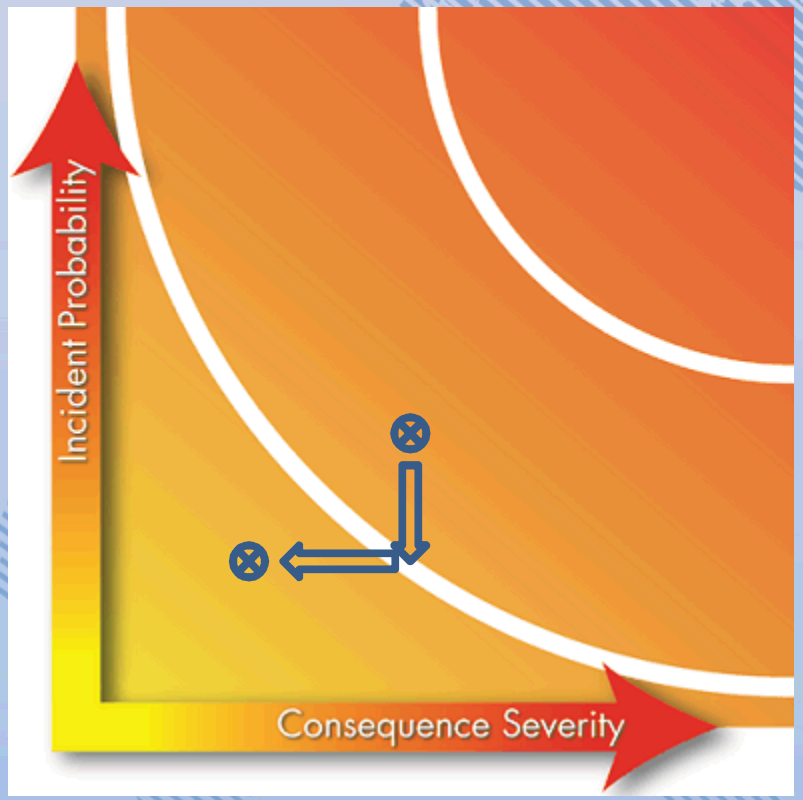
A **risk assessment** assigns values for **likelihood** and **consequences**, which allows us to represent the risk of a particular adverse event on a graph.





Risk Reduction

- **Types of Lab Risk Controls**
  - Elimination
  - Engineering
  - Administrative
  - Operational
  - Personal protective equipment (PPE)



- Decrease likelihood +
- Decrease consequence

→ **reduce risk**

$$\text{Risk} = f(\text{Likelihood, Consequence})$$

Laboratory Safety
Risk Assessment: A Process

Laboratory Security
Risk Assessment: A Process

Risk Characterization

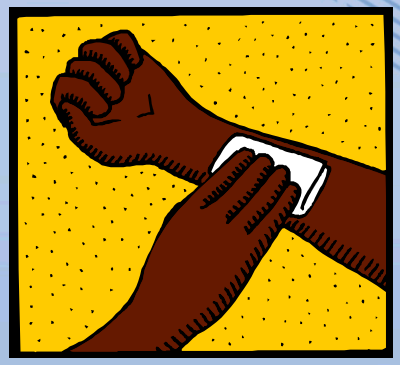
Part of this process is the identification of the appropriate **hazard** or **threat**.

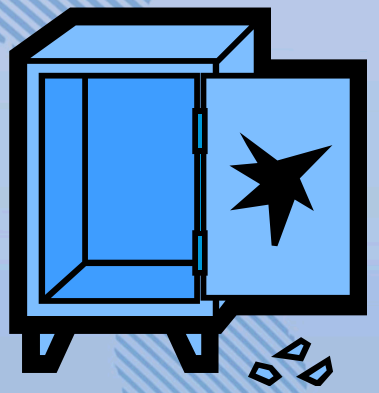
The **hazard** or **threat** is the **source** or **causative agent** of a particular **risk**.

The term **hazard** is used in the **safety** context, and **threat** is used in the **security** context.

What is the Objective?

Risk assessment informs the selection of appropriate **laboratory safety** and **security** risk mitigation measures to reduce likelihood and consequences of:

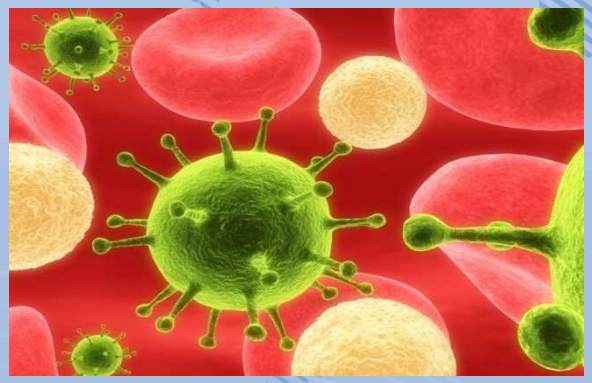


Risk Characterization

For **laboratory safety Risk**, the **hazard** is the dangerous material or process worked with in the lab.

Characterizing the material/process allows one to determine important parameters for **likelihood** and **consequences**; such as **route of exposure**, **dose vs. response**, **incubation time**, **morbidity**, **mortality**, **communicability**, **reactivity**, **injury**, **damage**, and others.



Risk Characterization

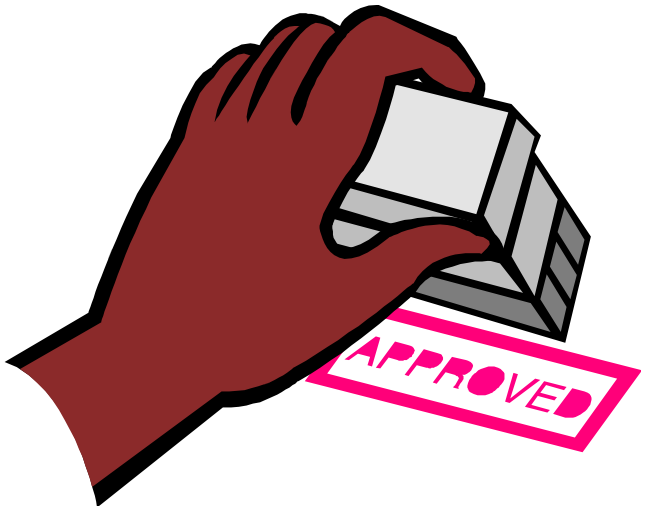
For **laboratory security Risk**, the **threat** is the potential adversary who is interested in the dangerous materials.

Characterizing potential adversaries allows one to determine important parameters for **likelihood** and **consequences**, such **means**, **motives**, **capabilities**, and **opportunity**.

Risk Evaluation

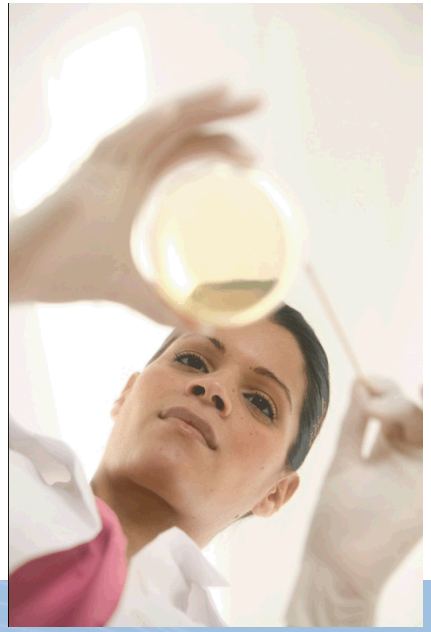
The **evaluation of risk** is highly related to the concept of **Risk Acceptance**.

Risk evaluation and **acceptance** can vary with **culture**, **experience**, **resources**, **management**, and even **current events**.



Risk Evaluation

Unfortunately, there is **no systematic way** of evaluating risk and determining risk acceptability. This will depend on the perceptions of **individuals**, **institutions**, and the **community**.

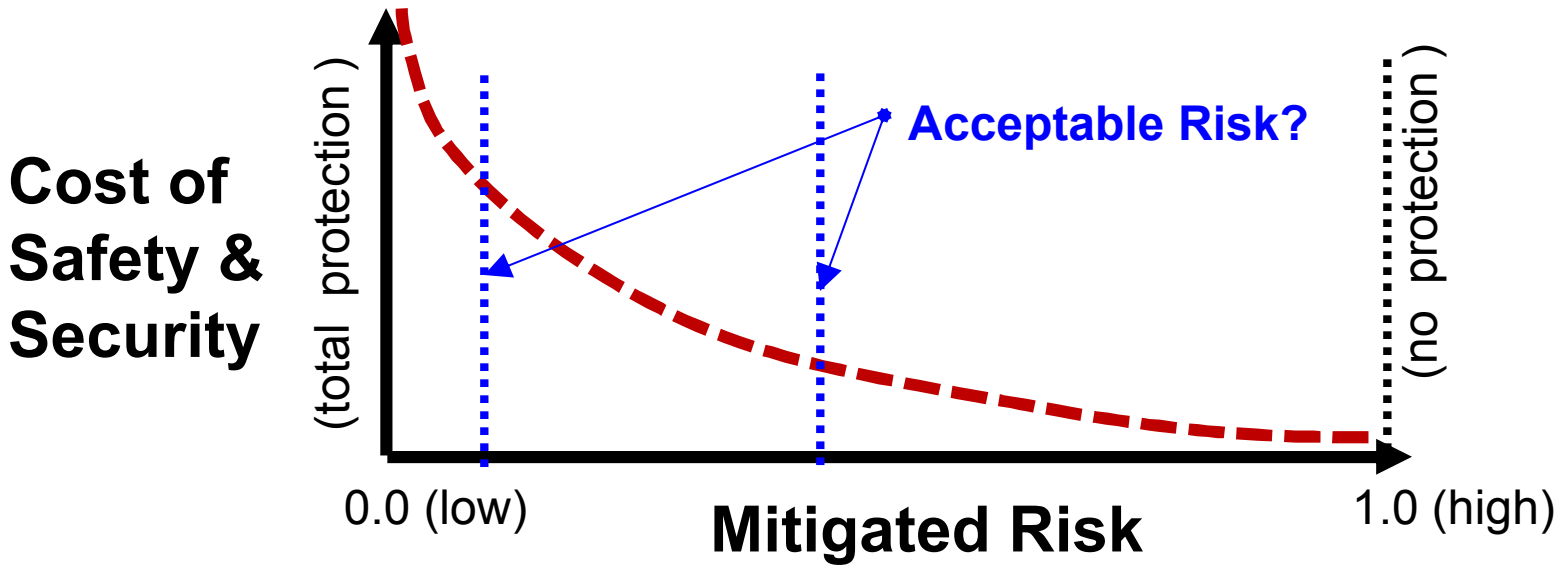


Risk Evaluation

An **institution** that considers a certain risk **high** might be motivated to spend a **large amount of resources** mitigating that risk.

Another **institution** that considers the **same** risk to be **moderate** might decide to spend a **small amount of resources** in mitigation instead.

Managed Risk



- The benefit (risk reduction) increases with increased safety & security investment (cost)
- There is a point where the increased benefit does not justify the increased cost
- What is the level of Acceptable Risk?

Target Identification

What are the *un*acceptable consequences to prevent?

- Death/severe Injury
- Contamination
  - people
  - environment
- Political Instability
- Economic Loss
- Theft of goods/equipment
- Negative public psychological effect
- Adverse media coverage
- Research/Industry capacity loss

Key Components of Laboratory Risk Management

- Laboratory Risk **Mitigation**
  - Actions and control measures that are put into place to reduce or eliminate the risks associated with hazardous materials in the laboratory

Mitigation Control Measures

There are five major categories of measures for controlling risks in the laboratory.

1. **Elimination or Substitution**
2. **Engineering Controls**
3. **Administrative Controls**
4. **Practices and Procedures**
5. **Personal Protective Equipment**

Mitigation Control Measures

- **Elimination or Substitution:**
  - *Removing* the hazard by not using the agent or process, or *replacing* the hazard with something less dangerous.

Mitigation Control Measures

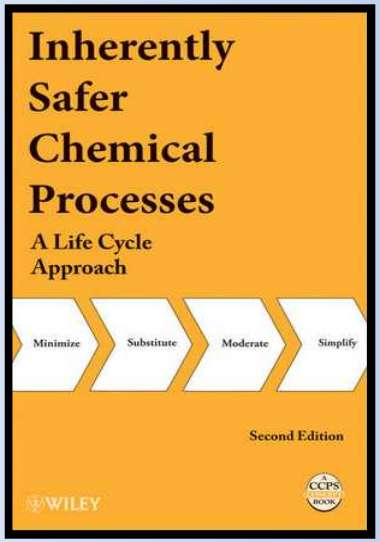
- **Engineering Controls:**
  - Physical changes to work stations, equipment, facilities, or any other relevant aspect of the work environment that reduce or prevent exposure to hazards.

Mitigation Control Measures

- **Administrative Controls:**
  - Policies, standards, organization and guidelines used to control risks.

Mitigation Control Measures

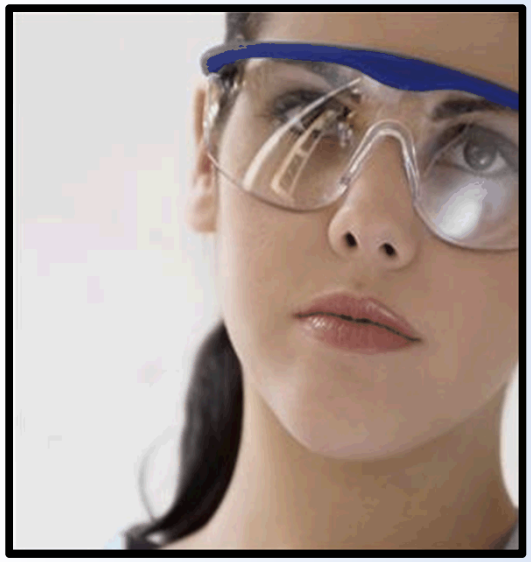
- **Practices and Procedures:**
  - Processes and activities that have been shown in practice to be effective in reducing risks.



Source:
http://www.ors.od.nih.gov/sr/dohs/Resources/lab/Pages/default.aspx

Mitigation Control Measures

- **Personal Protective Equipment:**
  - Devices worn by the worker to protect against hazards in the laboratory or workplace.

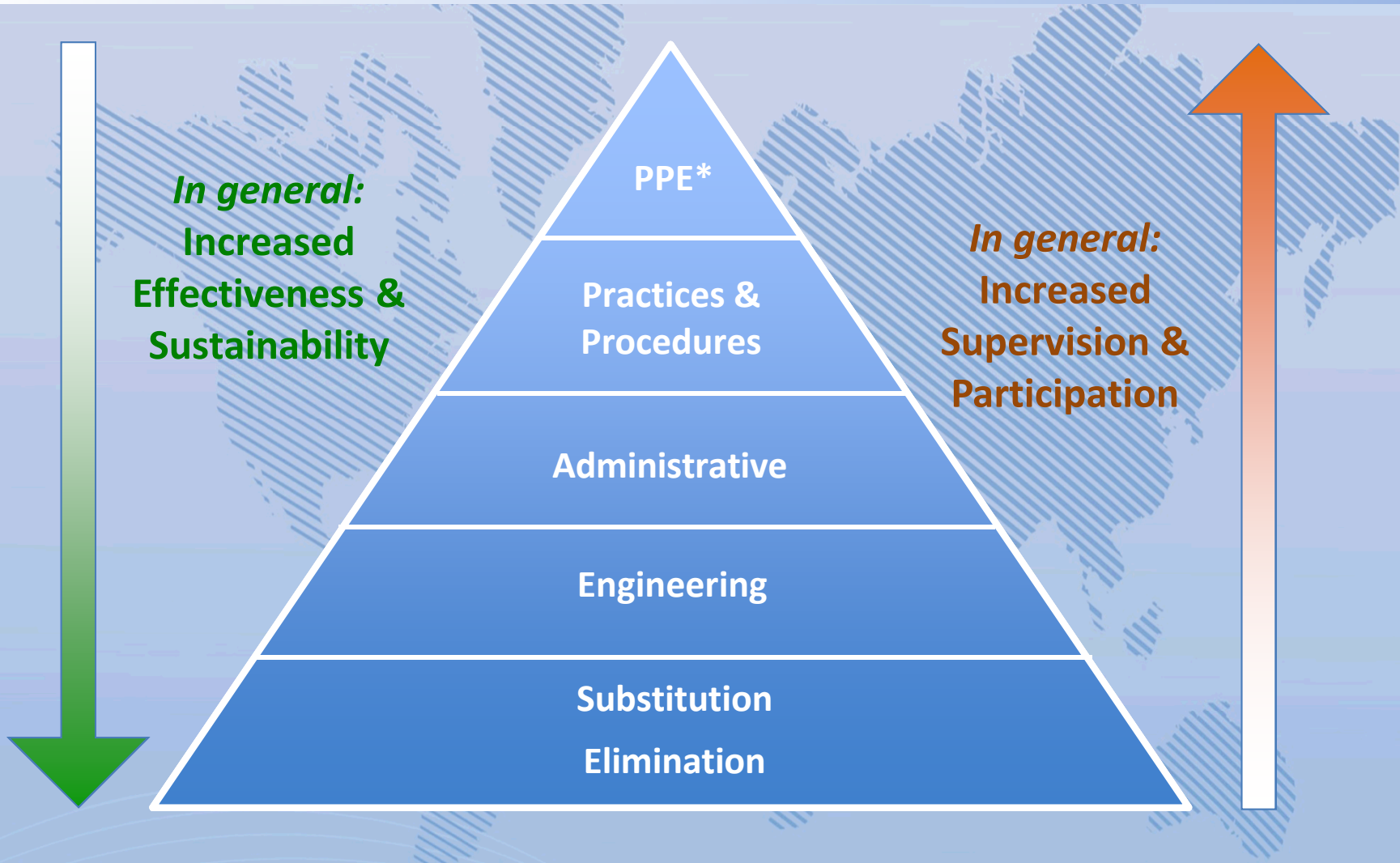


Mitigation Controls: Advantages and Disadvantages

Control Measure	Advantages	Disadvantages
Elimination or Substitution	Immediate reduction of risk	Not always available or possible
Engineering	Efficient/reliable, Provides physical separation between hazard and user	Costly, Complex, M&O
Administrative	Authority approach	Indirect approach, primarily addresses the human factor
Practices & Procedures	SOP based (standardized approach), can reduce hazard	Training and supervision requirements
Personal Protective Equipment (PPE)	Ease of use, relative cost	Does not eliminate hazard, if PPE fails exposure happens, uncomfortable, limits worker ability, protects only the user

bb2

Hierarchy of Safety Mitigation Controls



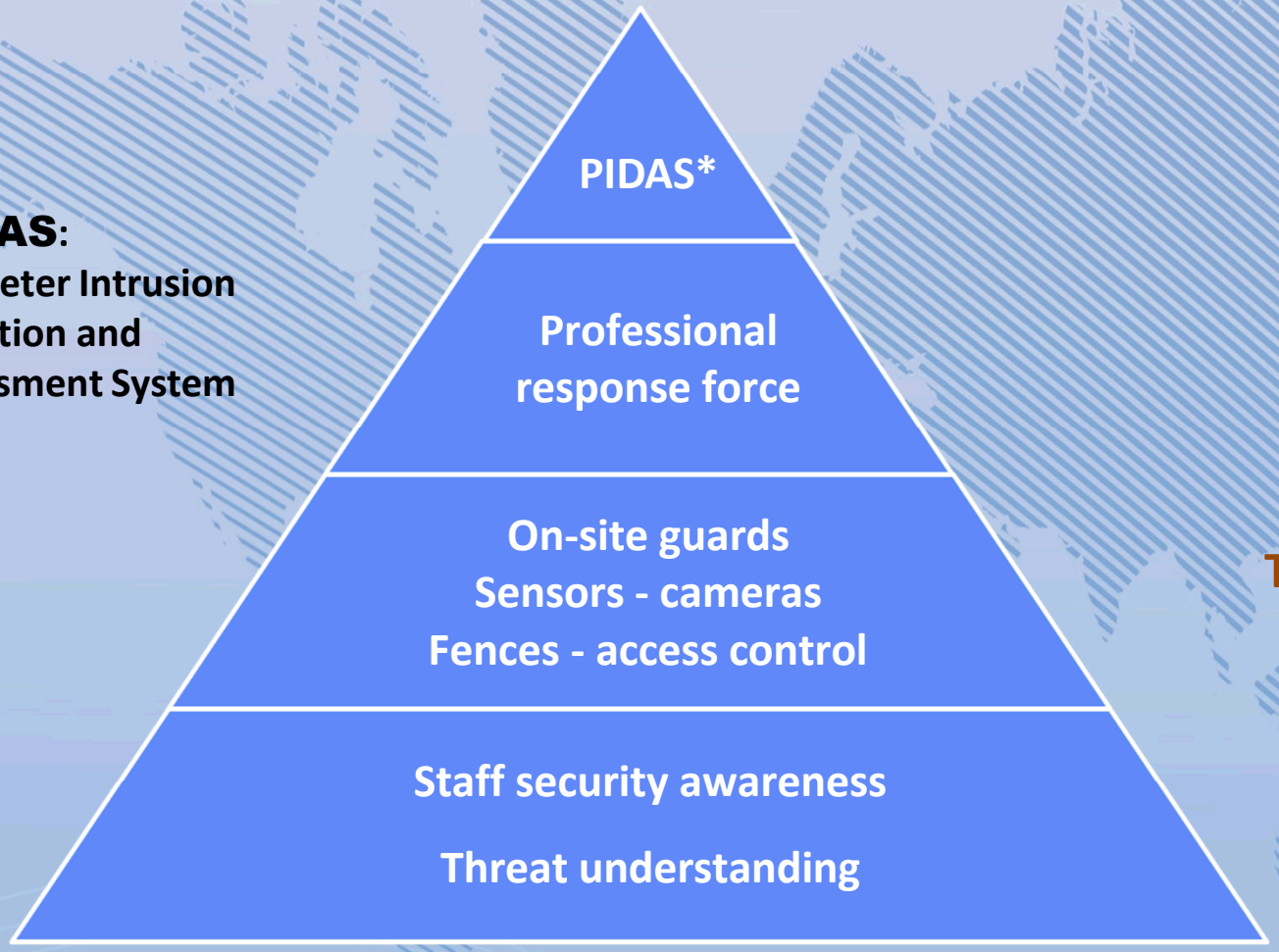
***PPE**: Personal Protective Equipment

Slide 49

bb2 This pyramid is inverse of how we typically present it
bb, 4/23/2014

bb1

Hierarchy of Security Mitigation Controls



***PIDAS**:
Perimeter Intrusion Detection and Assessment System

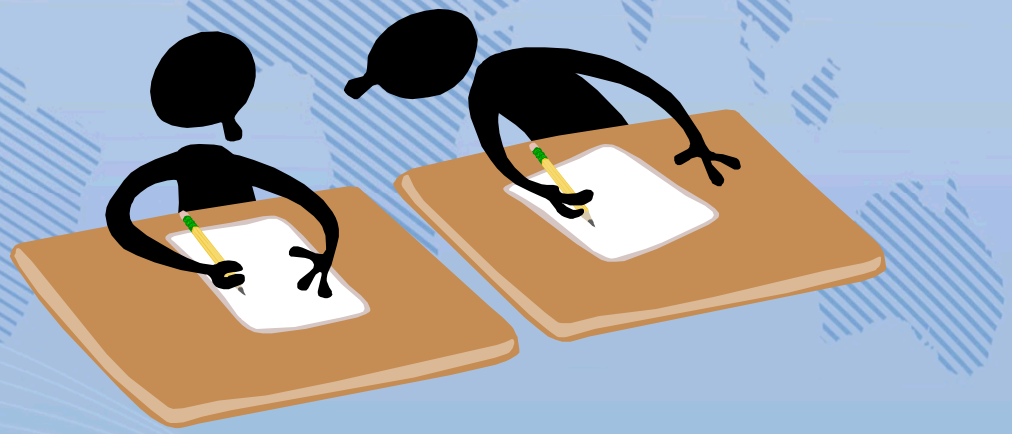
Increased Cost & Technology

Slide 50

bb1 Joe - I don't agree with the design of this hierarchy.
bb, 4/23/2014

Key Components of Laboratory Risk Management

- **Performance**
  - The implementation of the entire laboratory risk management system, including evaluating and ensuring that the system is working the way it was designed. Another aspect of performance is the process of continually improving the system.



The Concept of Performance

- **Lab Risk Management (LRM) System Performance:**
  - **The way in which a laboratory risk management system actually functions to manage or minimize laboratory risk.**

Performance

- **Questions:**
  - Do all cars perform equally well?
  - What are some signs that indicate how well a car is performing?

The Concept of Performance

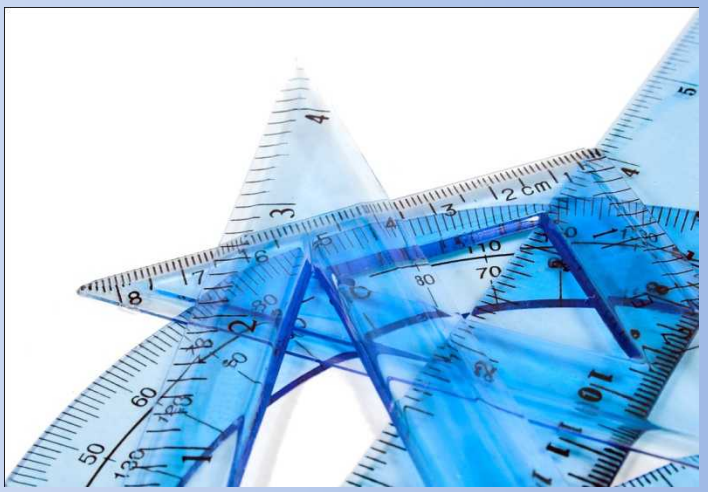
- **Characteristics of LRM System Performance:**
  - LRM **performance** is a result of all the activities and efforts of ALL people in a facility
  - Actual LRM system performance may **not** match the planned level of risk management effectiveness
    - **Measure Performance to assess the differences**
  - Performance changes *over time*: a sustained level of performance requires a *continual effort*

Measuring Performance

- Determines which parts of the LRM system are meeting stated goals or benchmarks
- Provides a demonstrable record of system performance
  - May support facility certification/accreditation process
- Helps identify areas for improvement using a consistent framework
- Provides assurance that the risk is acceptable
- Facilitates maintenance and sustainability of the system
- Can save money and time (by enabling resource prioritization)
- Helps to **prevent incidents**

Potential Measurement Methods

- Surveys and Questionnaires
- Audits and Inspections
- Performance Indicators
- Observations
- Interviews



Conclusions

- Hazardous materials are common in laboratories and represent a challenge in managing risk
- Safety addresses accidental events, while security involves intentional actions. Risk management must consider both safety and security.
- There is a broad spectrum of risks to consider when working with chemical and biological materials
- Hazards represent anything that can cause harm, while risk is a factor of the likelihood of harm and the severity of the consequences
- Laboratory risk management is a process of multiple steps to recognize hazards, assess risks, mitigate through control measures, and evaluate performance for continual improvement

LUNCH