

Developing a Maximum Containment Laboratory: Biosafety and Biosecurity Considerations

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Strategic Rationale and Purpose

New DSO lab to fight deadliest diseases

B2 | SINGAPORE

THE STRAITS TIMES | WEDNESDAY, JULY 21, 2021

Maximum security lab to tackle biothreats

Singapore will establish its first biosafety level 4 (BSL-4) lab by 2025 to handle unknown or highly dangerous pathogens. Biosafety labs are categorised based on the risk levels of viruses and bacteria which they are equipped to handle safely. Here are what the different risk levels mean and key features of the upcoming lab by DSO National Laboratories.

BSL-1 Biological agents in this group are not known to consistently make healthy adults sick. One example is *E. coli*. The level of protection at this level is minimal, and a BSL-1 lab is not required to be isolated from surrounding facilities.

BSL-2 Biological agents at this level pose moderate hazards to lab personnel and the environment, and are associated with diseases of varying severity. They include salmonella, measles, human immunodeficiency virus, and dengue. All procedures that can cause infection from aerosols or splashes must be performed within a biosafety cabinet.

BSL-3 Biological agents here can cause serious or potentially lethal diseases through respiratory transmission. Examples include the bacteria or viruses that cause tuberculosis, severe acute respiratory syndrome and Covid-19. Access to a BSL-3 laboratory is restricted and controlled at all times.

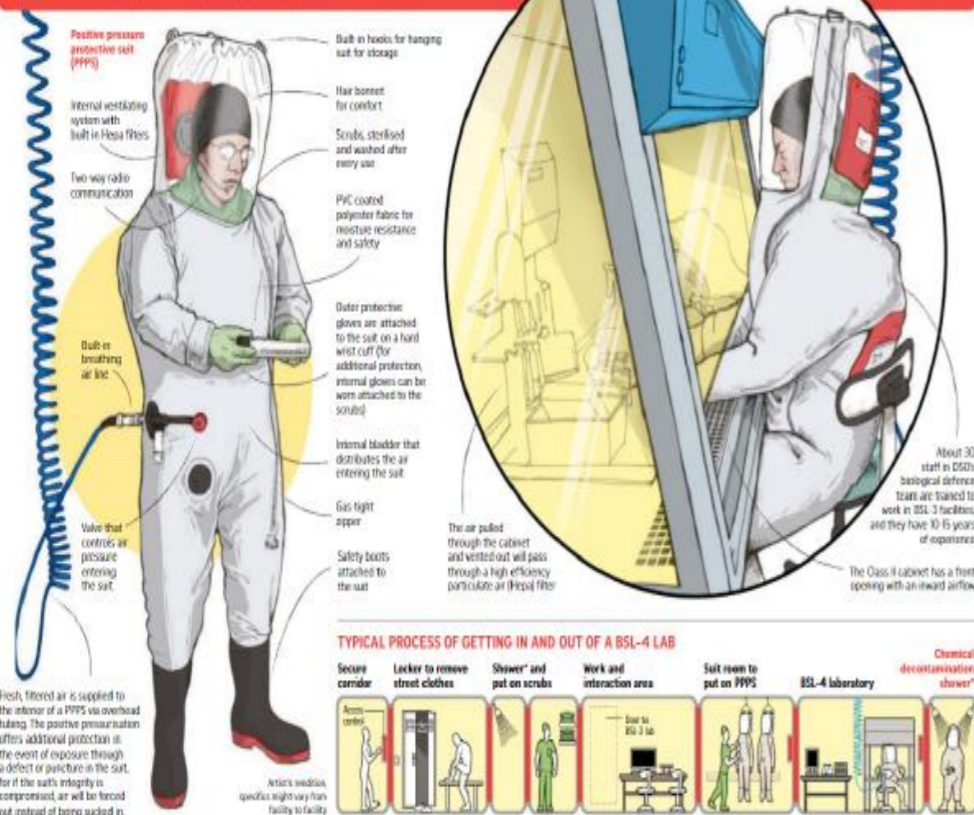
BSL-4 Biological agents in this group can cause severe disease and death, usually with no available treatments and vaccines, and pose a high risk of being transmitted by aerosols. Extreme isolation precautions must be taken when handling agents such as Ebola, Marburg virus, Lassa fever, and Bolivian haemorrhagic fever.

BSL-4 lab users wear a positive pressure protective suit (PPPS), which is like a spacesuit with its own air supply.

The suit creates a protective bubble around the user, on top of the protection provided by a biosafety cabinet.

The lab will be like a box within a box, with an air corridor built around it.

Biosafety cabinet Class II
A completely sealed Class III cabinet will not be required if personnel are wearing a BSL-4 suit.



TYPICAL PROCESS OF GETTING IN AND OUT OF A BSL-4 LAB



Handling Dangerous Pathogens

Safely manage highly transmissible and lethal infectious diseases under strict containment protocols.

Outbreak Preparedness and Response

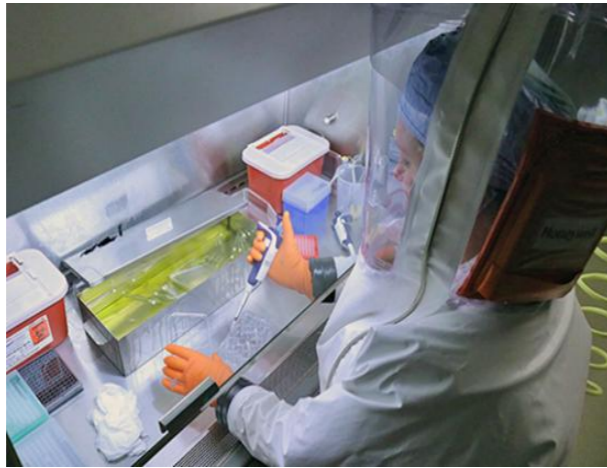
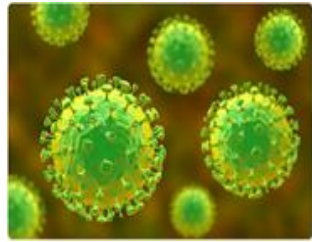
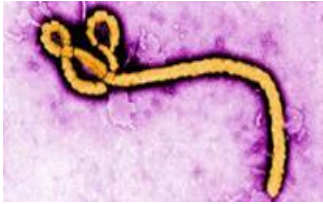
Support development of diagnostics, vaccines, and treatments to prepare for and respond to outbreaks effectively.

National Security

Enhance resilience by reducing dependency on external facilities during global health emergencies.

Role of National Maximum Containment Facility

Virus isolation, propagation, inactivation



Public Health and Diagnostics

Rapidly confirm and characterize high-risk pathogens to support outbreak containment and clinical decisions.

Research and Development

Enable development of diagnostics, therapeutics, and vaccines under controlled high-risk conditions.

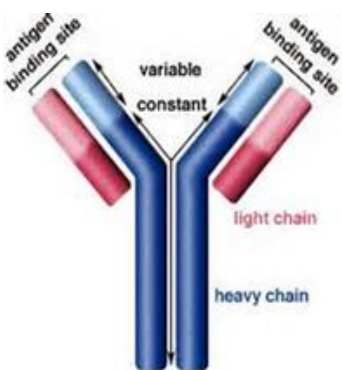
Operational Support and Surge Capacity

Provide surge capacity during health crises with environmental surveillance and countermeasure validation.

Development & validation of diagnostics assays



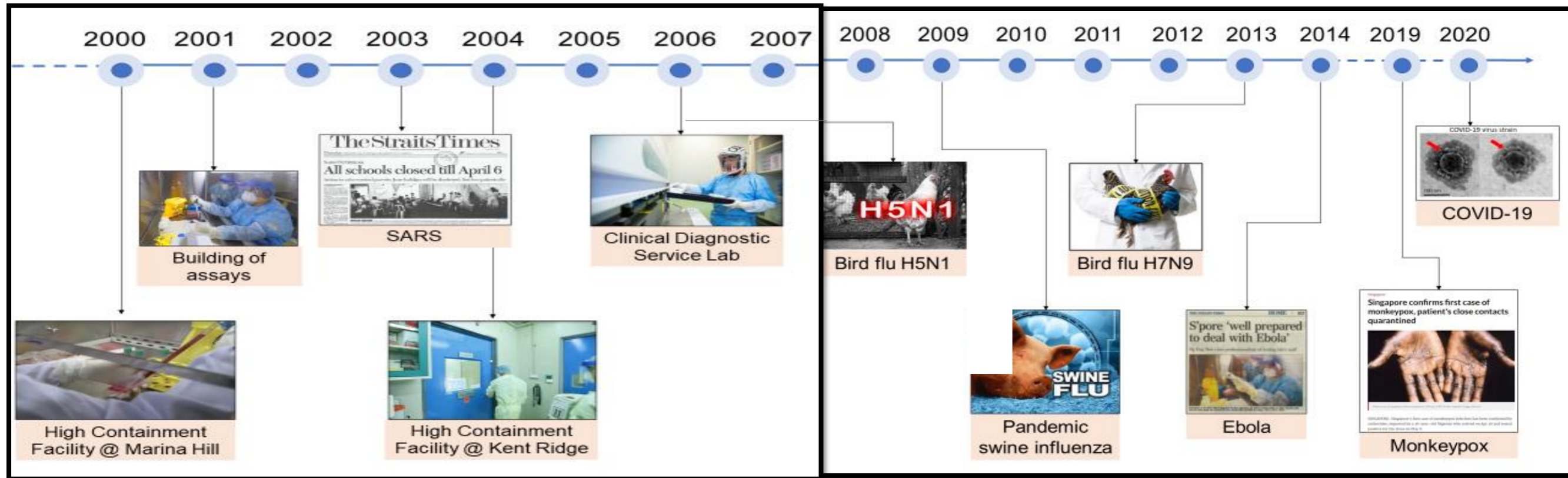
Therapeutics Development & Assessment



WHEN

Are we ready to take on the next level?

Timeline of Biological Crises & Events



↑
1st BSL3 lab
in Singapore
in 2000

↑
2nd BSL3 lab
in **2004**

↑
2016-2017

← Building up technical competency through R&D projects, Operational support →

Numerous BSL3 laboratories set up and decommissioned

WHERE

Do we start?

Conducted study trips to overseas BSL4 laboratories and Established Advisory Forums

To Jumpstart and accelerate our learning curve

- Learn what to do
- Learn what NOT to do



Biosafety, Biosecurity, and Risk

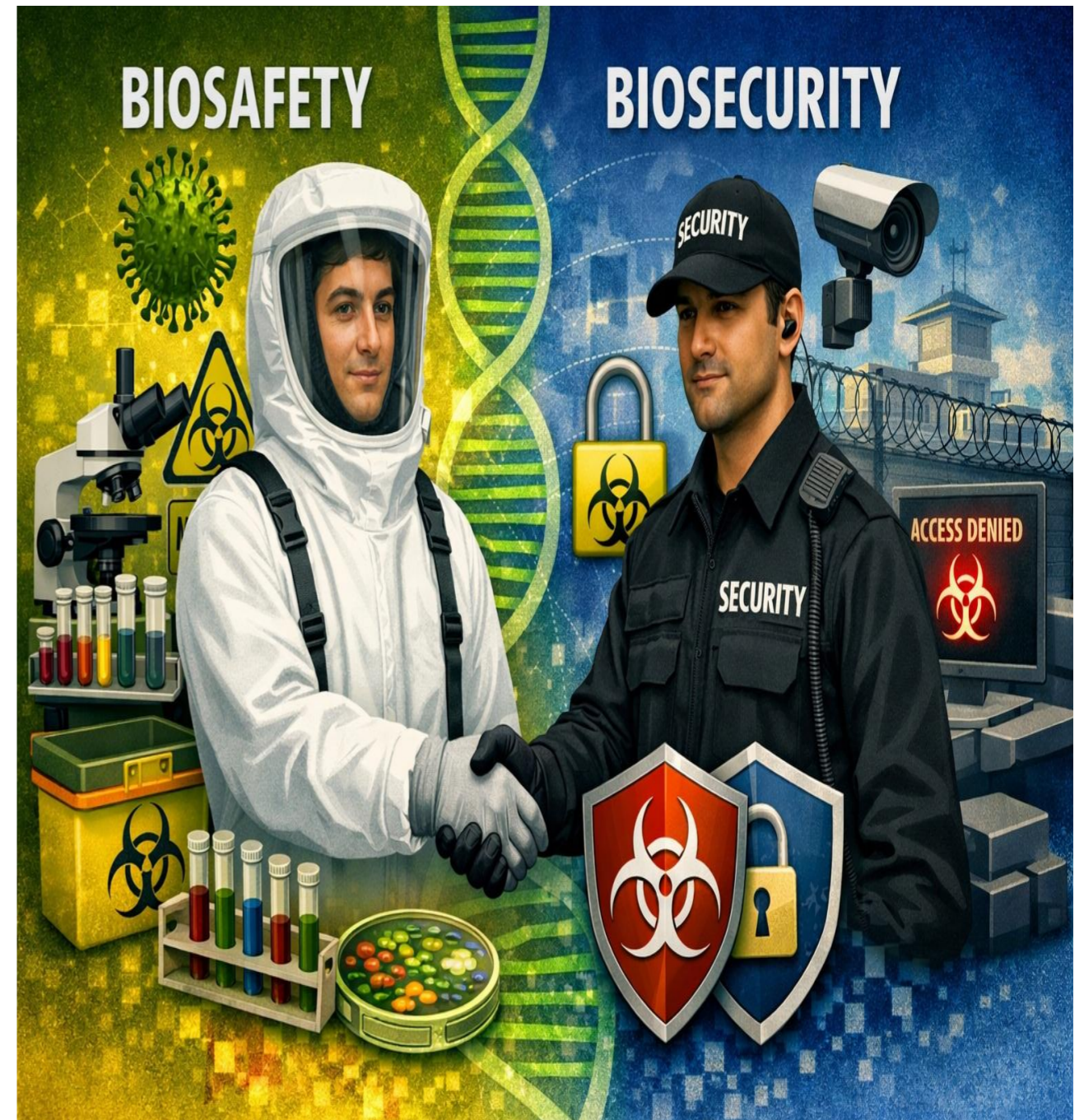
Biosafety Focus

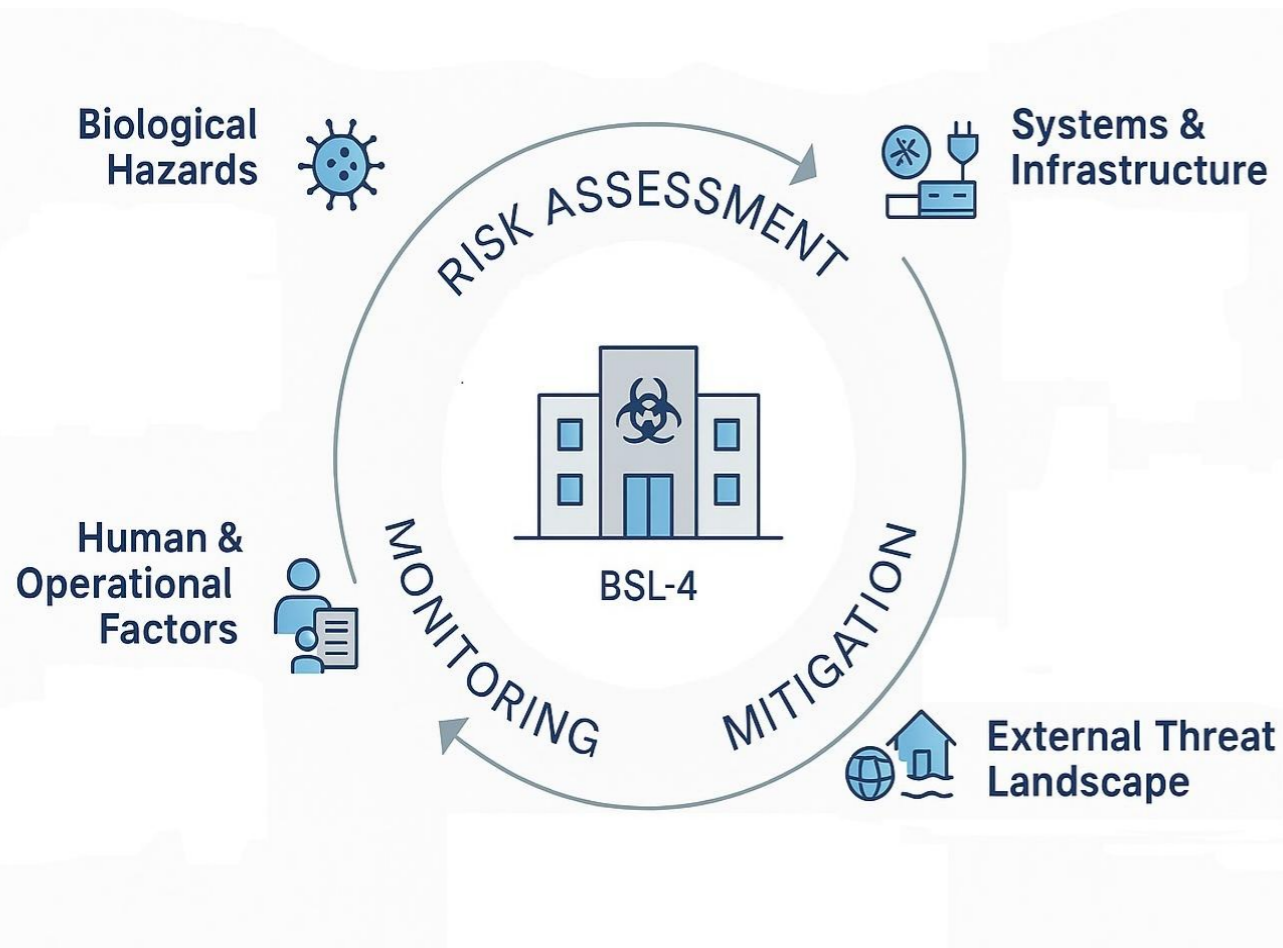
Prevent accidental exposure through engineering controls, safe practices, and training in high-risk labs.

Biosecurity Measures

Stop intentional misuse and unauthorized access to biological agents and critical systems.

Ethical Pathogen Stewardship





Risk Assessment Fundamentals

Identifies hazards and evaluates exposure likelihood to select appropriate mitigation measures.

BSL-4 Facility Risks

Includes infections, aerosol hazards, equipment failures, natural disasters, and human error impacts.

Threat Landscape Overview

Encompasses insider threats, emerging pathogens, global connectivity, and climate-driven disease changes.

Continuous Risk Management

Ongoing process adapting with scientific knowledge and informs facility design and safety procedures.

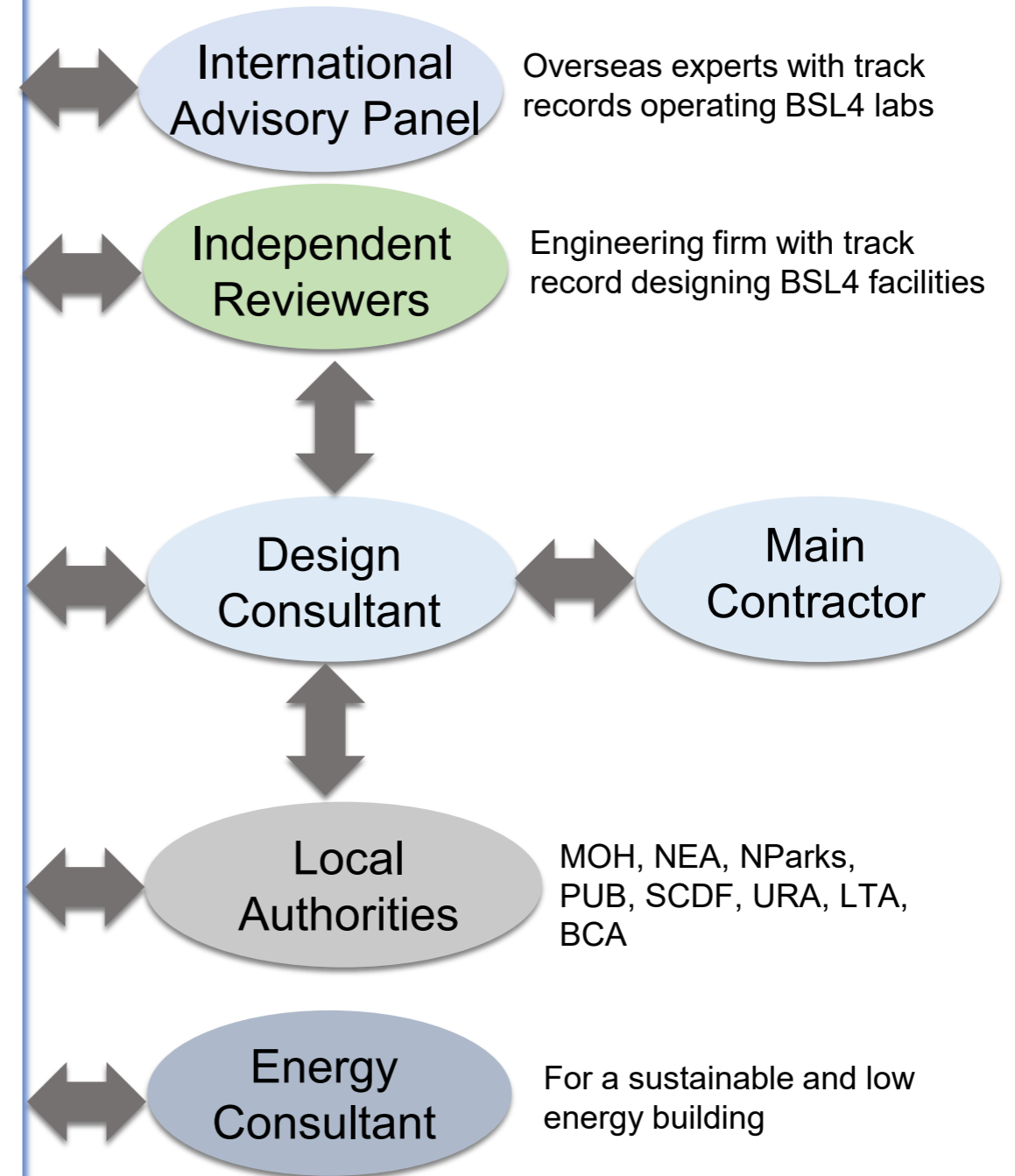
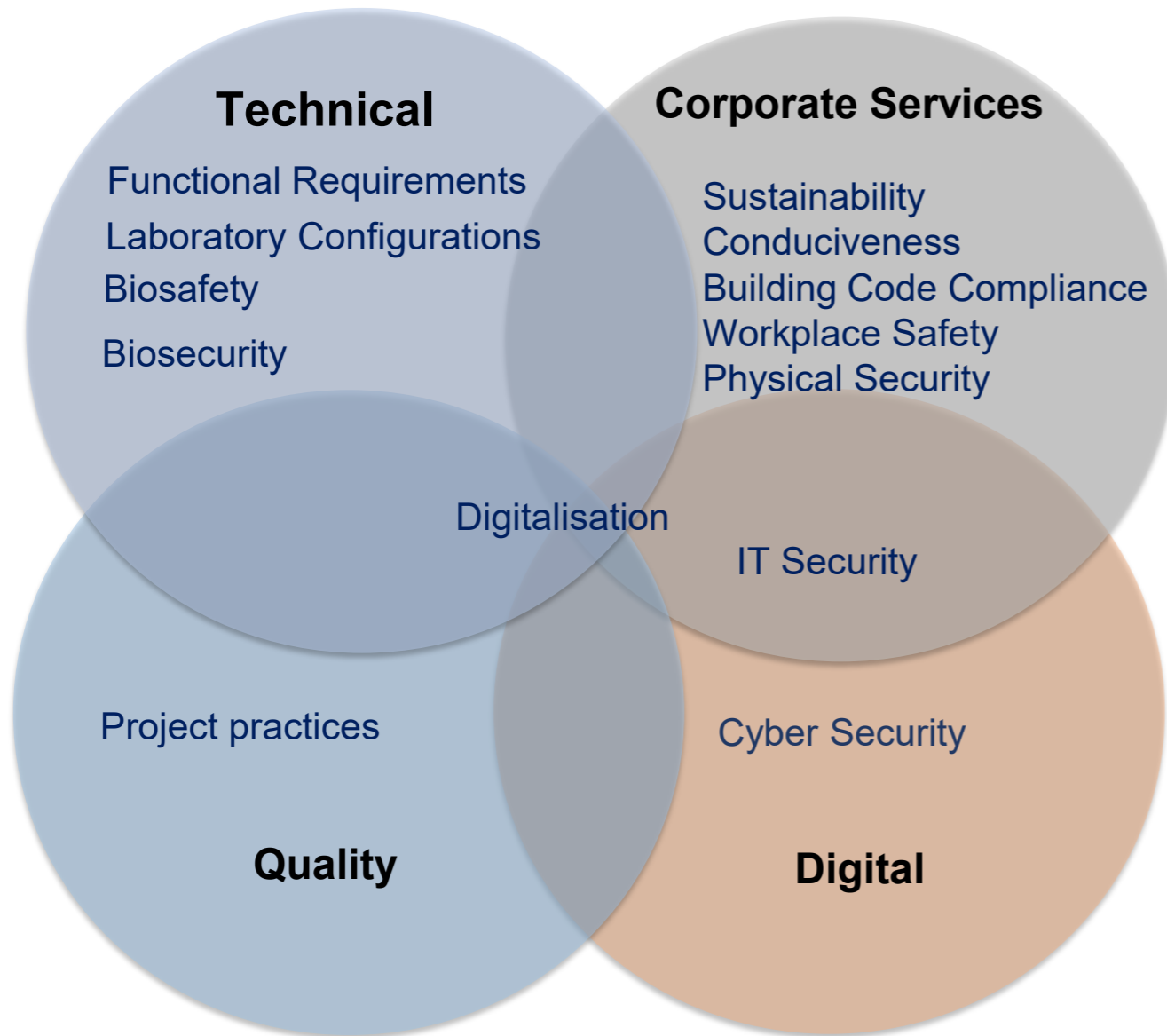
Facility Design and Engineering Controls

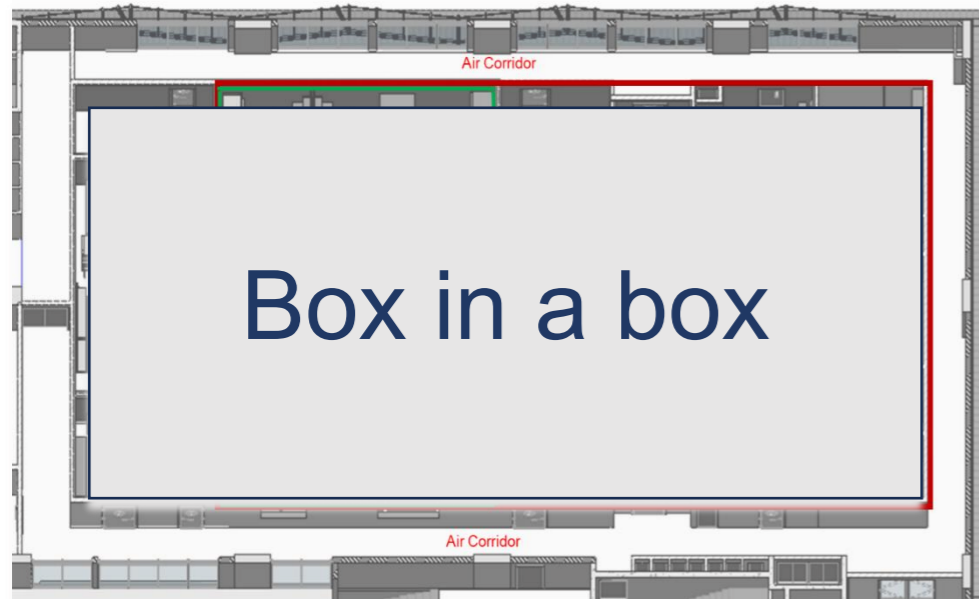
MCF Key Design Considerations



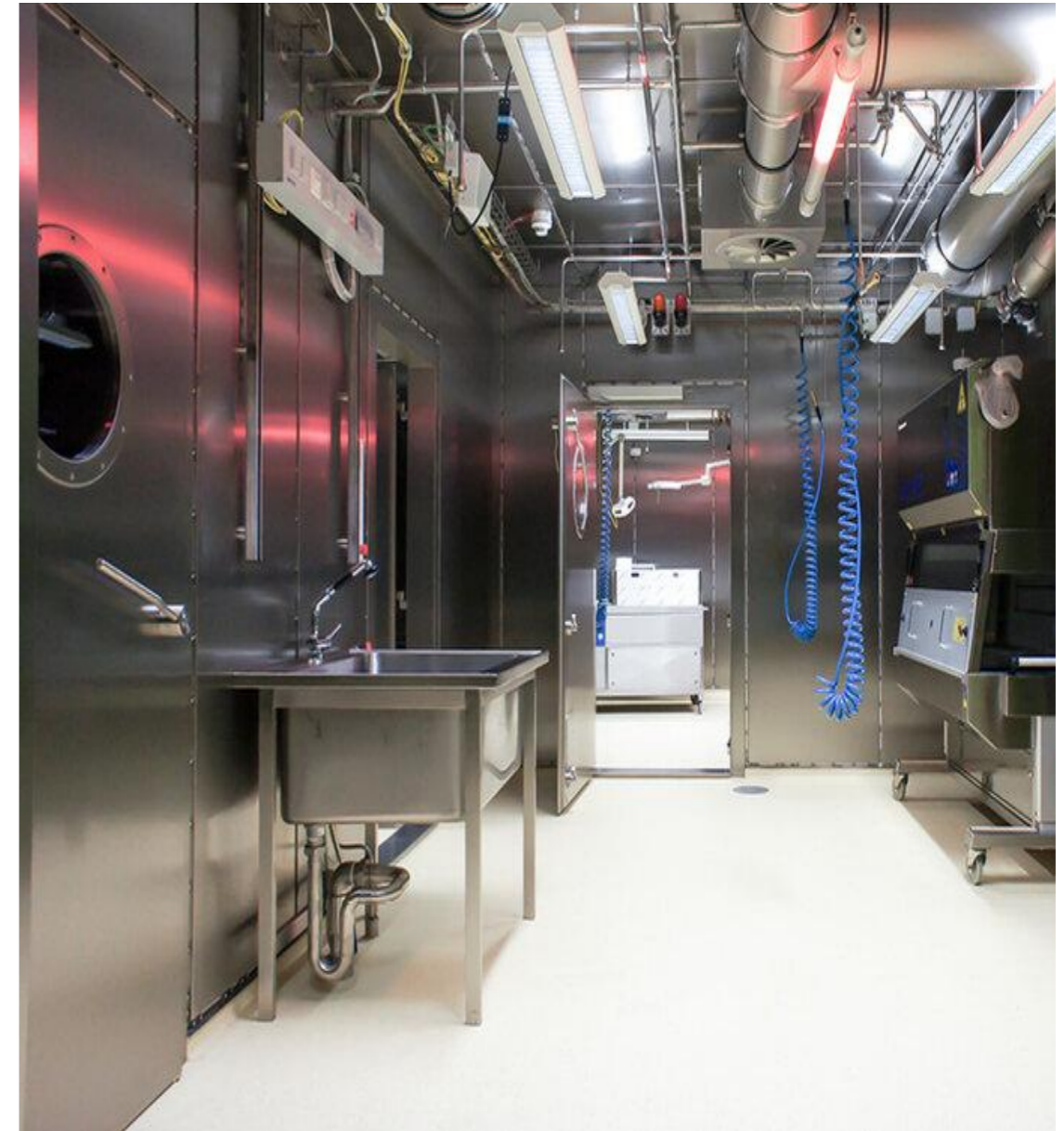
Approach

Multi-disciplinary Project Team





- 1. Layered Defence Strategy**
- 2. Facility Zoning and Access Control**
- 3. Containment Envelope Integrity**
- 4. Redundancy and Environmental Resilience**



Primary and Secondary Containment Systems

How to Choose a Suit for a BSL-4 Laboratory—The Approach Taken at SPIEZ LABORATORY

Daniel Kümin*, Christian Krebs, and Patrick Wick

SPIEZ LABORATORY, Spiez, Switzerland

Figure 1

Three suits by different manufacturers were tested. The suits will be differentiated by their colours (i.e., blue, white, and yellow) and not their manufacturers' names.

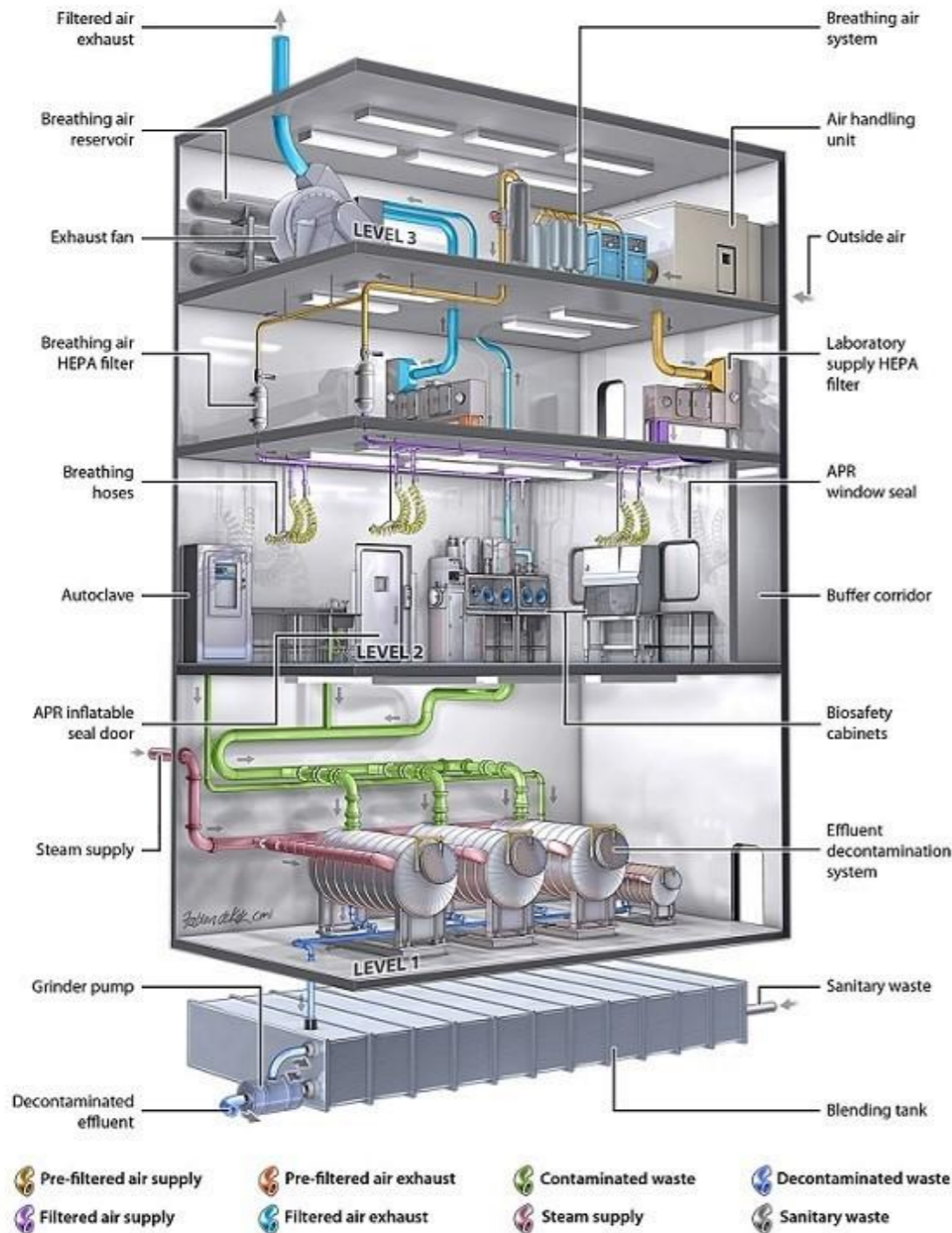


To consider:

- Supply Chain Resilience
- Dedicated Suits vs Suit Sharing

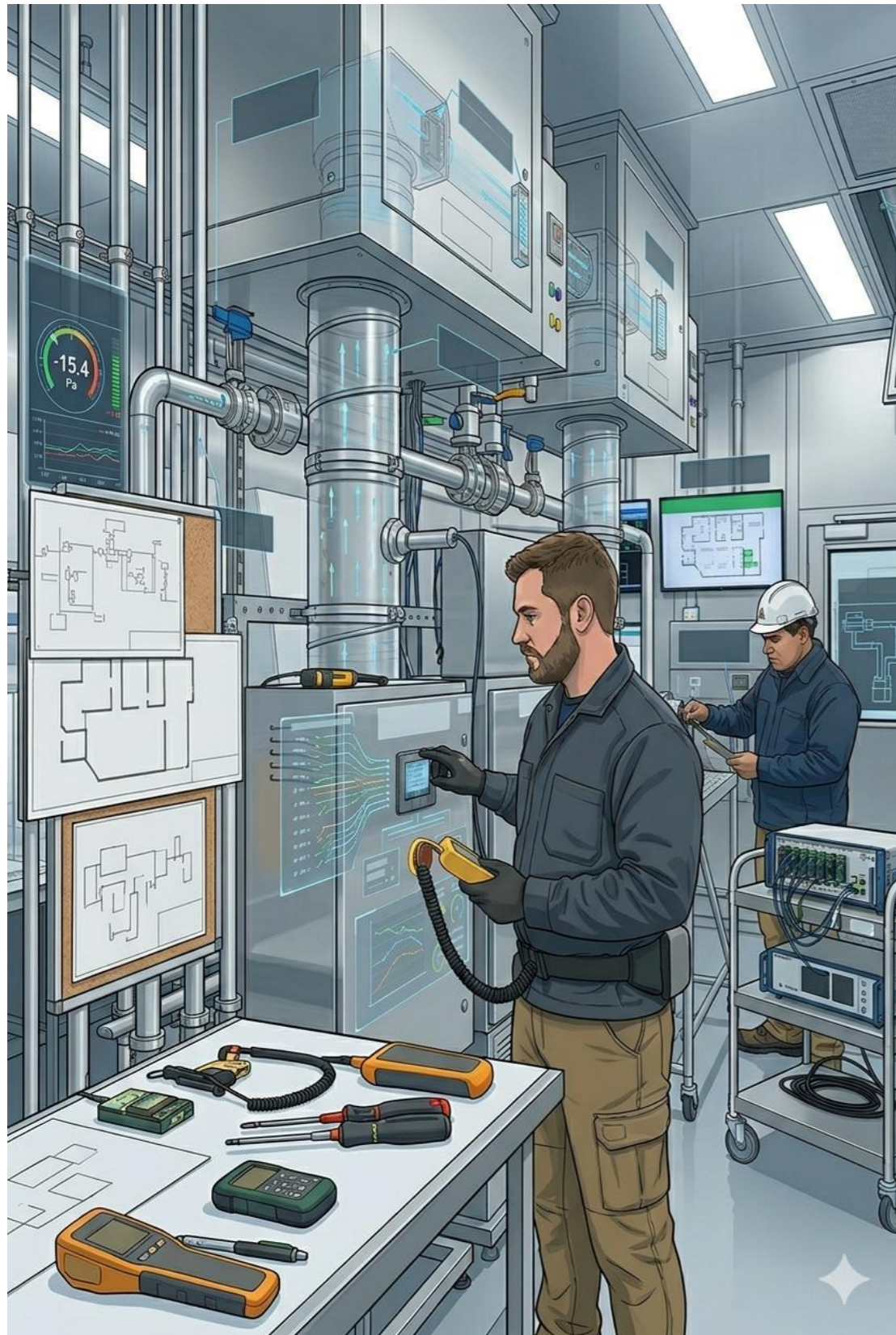
Questions
Wearer Comfort
What does the suit material feel like?
Is the suit cut comfortably?
Is the field of vision acceptable?
Can the suit be donned and doffed by one person alone?
Further comments?
Air Supply
Is the air supply to all parts of the suit guaranteed at all times, regardless of body position?
How easily does the face plate fog up? Does the air distribution inside the suit prevent the face plate from fogging up?
Does the air distribution inside the suit show any weaknesses?
Is the noise level within an acceptable range?
Further comments?
General Aspects
Can the air hose be easily connected and disconnected from the suit?
Is an additional air flow regulation necessary on the suit?

1. Airflow and Pressure Control
2. HEPA Filtration Systems
3. Decontamination Technologies
4. Monitoring and Validation



Extracted from The NIAID Integrated Research Facility at Fort Detrick, Applied Biosafety, Volume 16 (2), 2011

Testing and Commissioning



- 1. Static Commissioning**
- 2. Functional Testing**
- 3. Failure Scenario Testing**
- 4. Combined Services Test**
- 5. Reliability and Endurance Testing**

Operations, Governance, and Future Outlook

Standard Operating Procedures

Safe daily practices including protocols, waste handling, maintenance, and emergency response

Personnel Training and Competency

Classroom instruction, hands-on drills, and supervised practice

Continuous Assessment and Readiness

Refresher training, and drills

Specialized Engineering Training

To service systems without risking containment breaches.



Framework for Leadership and Training of Biosafety Level 4 Laboratory Workers

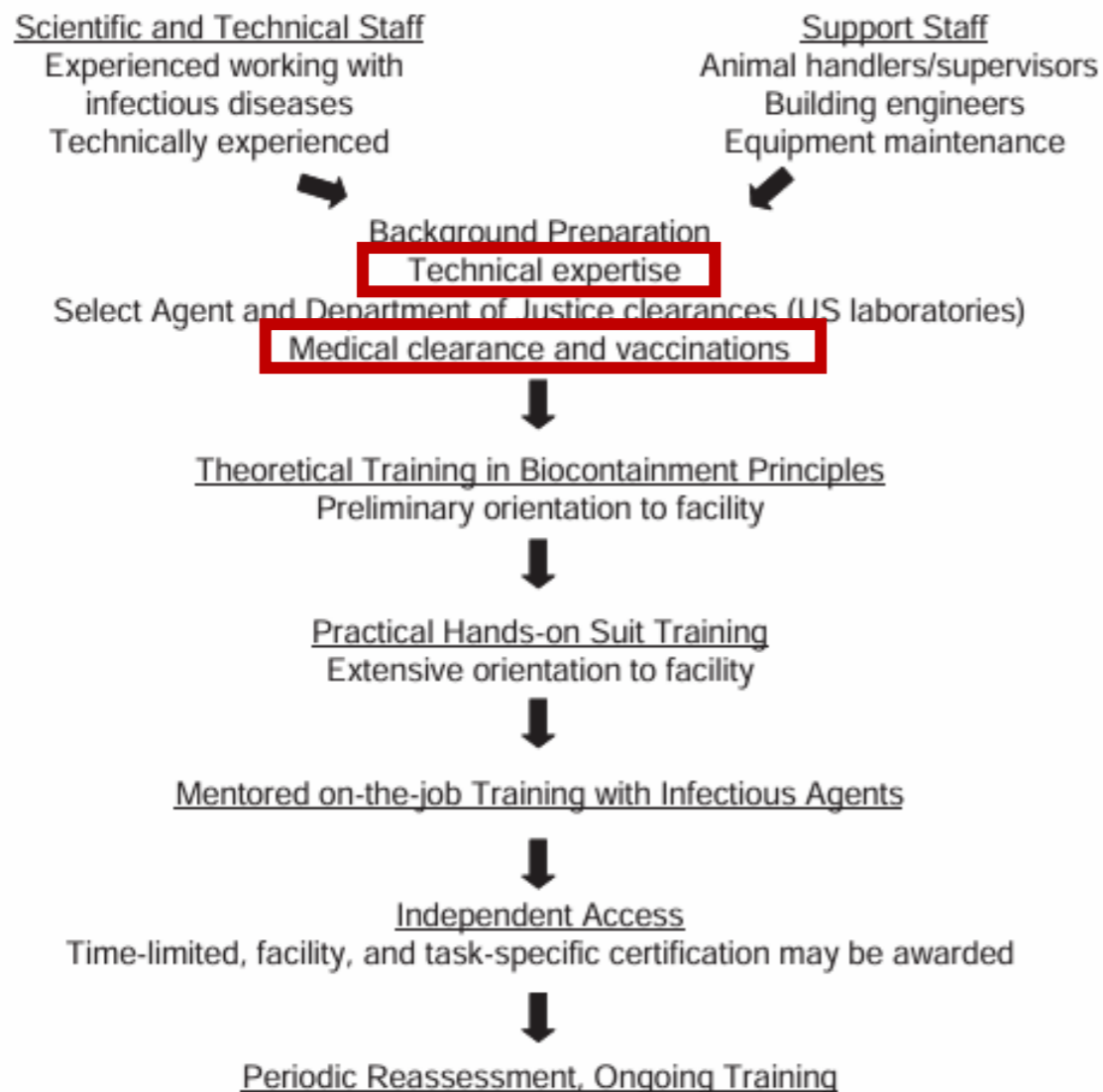


Figure. Framework for maximum containment laboratory training.

Emerging Infectious Diseases • www.cdc.gov/eid • Vol. 14, No. 11, November 2008

Gloving Strategy



Emergency Response



Regulatory Compliance Framework

Facilities follow detailed national and international regulations on design, health, waste, and emergency preparedness.

Oversight and Inspection

Governments, biosafety committees, and auditors conduct inspections and certification to ensure safety standards.

Documentation and Accountability

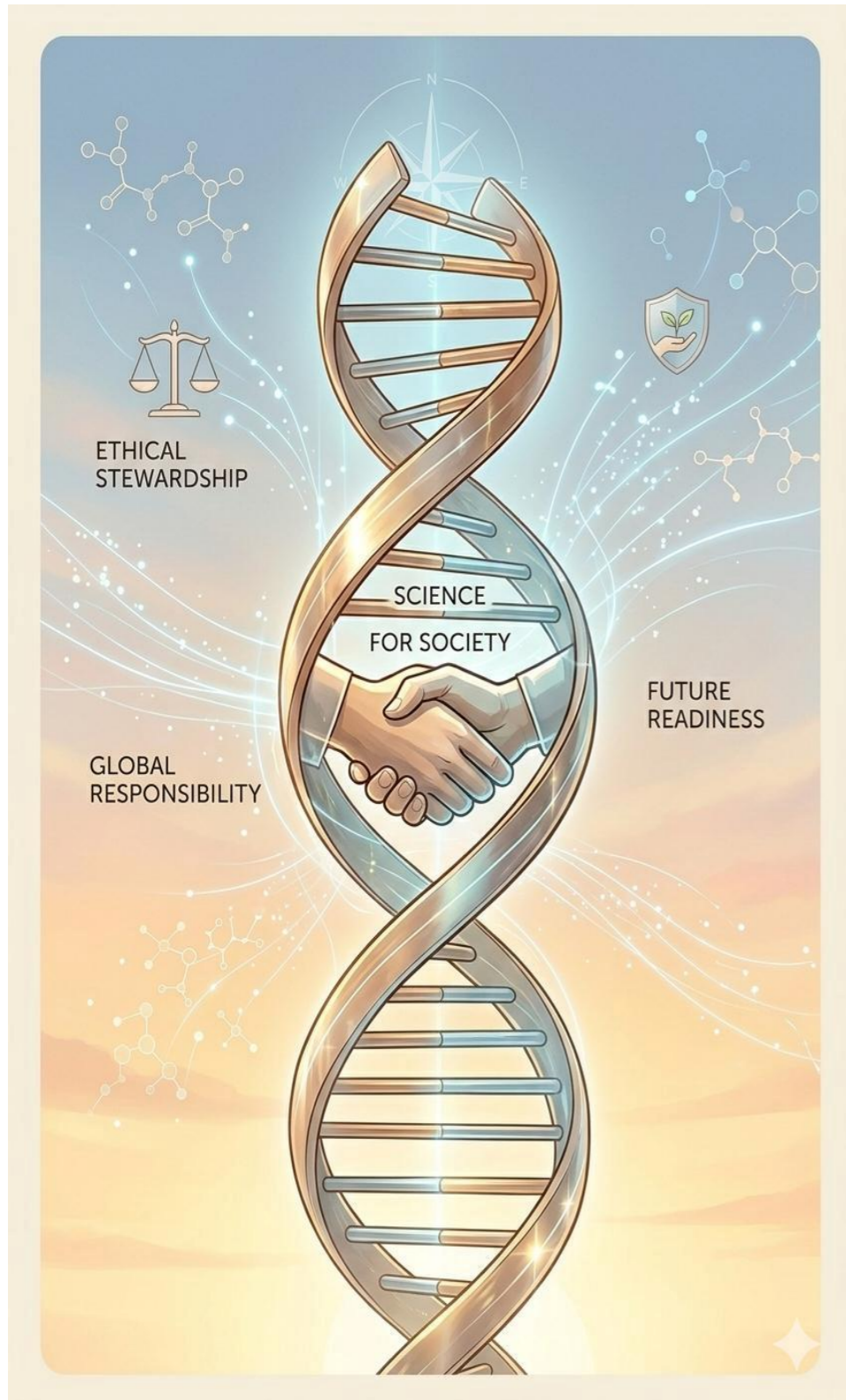
Robust record-keeping enables traceability and accountability for all compliance-related activities.

Multi-Stakeholder Coordination

Governance facilitates collaboration between health agencies, security, and emergency responders for comprehensive oversight.



1. Ethical Considerations
2. Building Public Trust
3. Future Biosecurity Challenges
4. Sustained Investment and Governance



MCF Operational



PEOPLE Competent
(Overseas & Local Training)



PROCEDURES Established



INFRASTRUCTURE Operational

24/7 Operational Readiness with Redundancy