

Improving Training to Achieve High Fidelity for Safe Laboratory Operations

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Disclosures

- MRIGlobal (Distinguished Research Fellow)
- Co-founder Oyanalyika Inc., Chief Scientific Innovation Officer

No other relevant disclosures

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Agenda

- UTMB Galveston National Laboratory 1
- H5N1 Update 2
- High & Maximum Containment Training 3
- Rethinking Workforce Development Solutions 4
- Emerging Trends & Discussion 5

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The Galveston National Laboratory (GNL): *A National Resource*



- Completed in 2008
- 98,000 sf complex
 - 34,000sf BSL3
 - 14,000sf BSL4
- One of only two BSL4 labs on a college campus in the US



BSL3 Infrastructure at UTMB



53 Principal Investigators

230 Registered **31,435** sf BSL3
Users

GNL

BSL3 4,479 sf (GNL)

ABSL3 9,842 sf (GNL)

BSL3-E 3,501 sf (GNL)

ACL-3 854 sf (GNL)

UTMB BSL3 Outside GNL

MMNP BSL3 1,754 sf

Keiller BSL3 W 3,189 sf

Keiller BSL3 E 1,982 sf

Keiller ACL3 749 sf

Keiller ABSL3 3,115 sf

Aerobiology (BSL2,3 and 4)

Insectaries 1970 sf

- 50 colonies of mosquitos
- 13 colonies of ticks

Select Agent Work: GNL Only

BSL3 Research at UTMB

Zika

Chikungunya

Dengue

West Nile

Yellow Fever

Rift Valley Fever

Eastern Equine Encephalitis

Venezuelan Equine

Encephalitis

Hantaviruses

SARS

SARS-CoV-2

MERS

Influenza, including H5N1

Rocky Mountain Spotted

Fever

Rickettsia Parkeri

Typhus

Anthrax

TB



Research, Education, Training



Blue Ridge Institute
for Medical Research

BRIMR RANKINGS OF NIH FUNDING IN 2023

\$55M in NIH Research Funding (2018 – 2023)

West African CREID

South American CREID

Fogarty International Center – West African Trainees
Fogarty Fellowship – Colombian Trainees

Dozens of student laboratorians and Post-Docs
7-10 Graduates with BSL3 experience each year.

Formal training for all BSL3 students and personnel.
as well as visiting scientists and international fellows.

International Biocontainment Training Center
operates as a cost center and provides training
both at UTMB and at trainee sites in US and abroad.

BSL3 Publications: <100 in 2023/2024



Science Translational Medicine, April 3, 2024

An orally bioavailable SARS-CoV-2 main protease inhibitor exhibits improved affinity and reduced sensitivity to mutations

October 18, 2023

Zoonotic mosquito-borne arboviruses: Spillover, spill-back, and realistic mitigation strategies

Nature, March 2023

Blocking NS3-NS4B interaction inhibits dengue virus in non-human primates

Cells, Sept. 23, 2023

Single-Cell Transcriptomics of *Mtb*/HIV Co-Infection

Vaccines, Sept. 28, 2023

A Vaccine for Canine Rocky Mountain Spotted Fever: An Unmet One Health Need





West African Center
for Emerging Infectious Diseases

Senegal Sierra Leone Nigeria

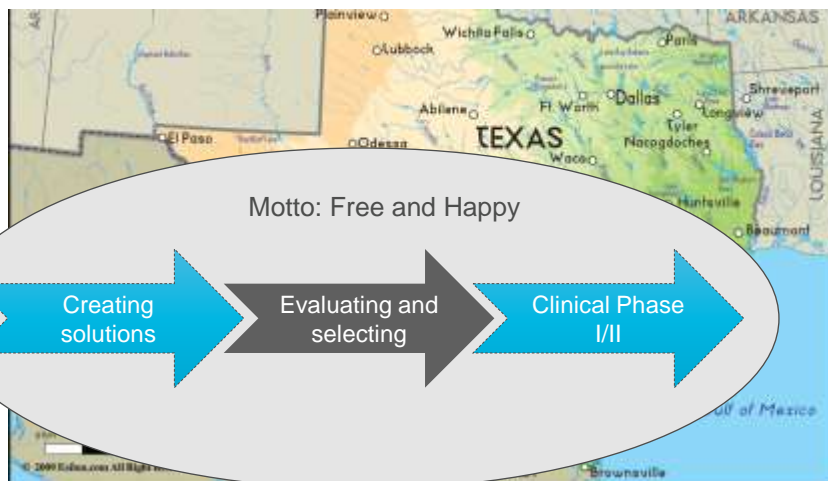
Scott Weaver, PI

- Surveillance of humans, mosquitoes, ticks, wild animals, bats
- Field studies of animal to human disease transmission.
- Clinical studies of human exposure with resulting disease.
- Identify emerging viruses.
- Produce risk maps for human exposure.
- Strengthen collaborations to assist in rapid response to outbreaks.



Vision: Maintain and expand GNL world class contribution


Mission: Grow GNL's Local, National and International' activities, together.



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THE NEXT PANDEMIC?

Although the H5N1 virus, known as the avian flu virus, does not usually infect humans, new mutated forms of this virus could represent a realistic risk of a flu pandemic, experts say.



ASPR
ADVISORY BOARD

Shorebirds
Are natural carriers of the avian flu virus in the wild.

Domestic birds
Intermediate hosts and easily infected by the virus through contact with nasal or fecal material. Contact with other domestic animals favors the spread of the disease.

Mammals
Intermediate hosts. Hogs can also be infected by human flu virus, which increases the risk of mutated human compatible viruses.

Natural viral cycle

Pandemic cycle

Waterfowl
Infected by shared water sources.

Humans
Rarely infected by unaltered strains of the avian flu virus. Experts think that mutated viruses could spread from human to human.

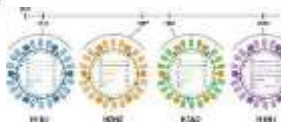
KEY

- Common virus
- Mutated virus

MAJOR FLU PANDEMICS
Number of deaths in the USA:

Spanish Flu (1918)	500,000
Asian Flu (1957)	70,000
Hong Kong Flu (1968)	34,000


Global killer: The [A(H1N1)] strain of the flu virus, commonly known as the "Spanish influenza" killed more than 50 million people worldwide.



Features and properties of A(H1N1) pre-pandemic influenza vaccine (whole virus, Vero cell-derived, inactivated) [Vepacel®]	
Indication	Pre-pandemic influenza vaccine for active immunisation against H5N1 subtype of influenza A virus
Vaccine composition	Non-adjuvanted, non-adsorbed whole virus containing Vero cell-derived, inactivated whole virions of influenza type A, subtype H5N1, clade 1 strain A/Vietnam/1133/2004
Each dose (0.5 mL) contains	7.5 µg of haemagglutinin antigen (of H5N1 strain A/Vietnam/1133/2004)
Dosage and administration	
Dose	0.5 mL
Route of administration	Intramuscular injection into the deltoid muscle
Regimen	First dose at an elected date; second dose after an interval of 10 weeks
Most common adverse events (reported data after first dose in adults (aged ≥18 y) and elderly (aged ≥65 y))	
Local	Injection site pain: 11.4% in adults and 9.9% in elderly
Systemic	Headache: 10.6% in adults and 8.8% in elderly

<https://www.vivisole.com/what-are-the-next-pandemic-prepandemic-avian-flu/>


Low Path & High Path Avian Influenza

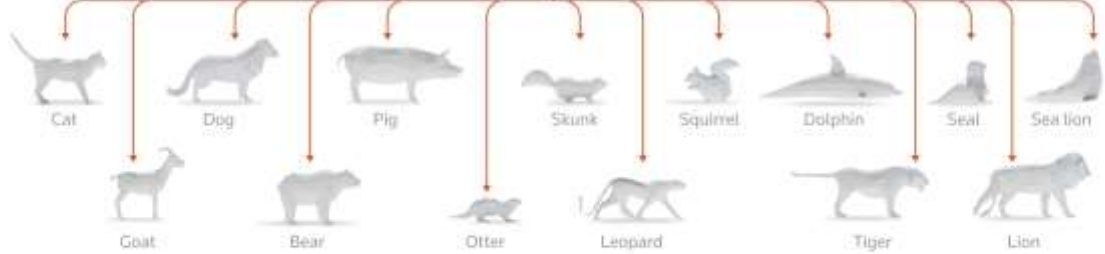


Wild birds

Bird flu in mammals

Bird flu, or avian influenza, has increasingly spread to **other mammals**, raising concern it may mutate and transmit more easily to humans.





Note: Other infected mammals include: badger, beech and pine marten, caracal, coati, coyote, ferret, fisher, fox, lynx, mink, mountain lion, opossum, polar bear, polecat, porpoise, raccoon, sable and wild dog.

Surge in Egg Prices

2022 rise of avg. price for grade A dozen eggs in the U.S.

Month	Average Price (USD)
Jan	1.80
Feb	1.90
Mar	2.00
Apr	2.40
May	2.70
Jun	2.70
Jul	2.90
Aug	3.10
Sep	2.90
Oct	3.40
Nov	3.60
Dec	4.20

SOURCE: U.S. Bureau of Labor Statistics

2022 - 2023 HPAI (Avian Flu) and the Egg Market

2022 HPAI Outbreak Among Commercial Flocks

	Total Incidents in 2022	Total Birds Impacted in 2022	Average Flock Size
TURKEYS	192	6,887,560	44,312
LAYERS	28	40,847,800	1,462,411
BROILERS	27	2,135,300	97,089
DUCKS	13	289,100	20,700
TOTAL	260	52,019,960	---

The Food Institute

Infections generally happen through direct contact with a person's tears, nose or mouth, or when the virus is inhaled through droplets, small aerosol particles or possibly dust.

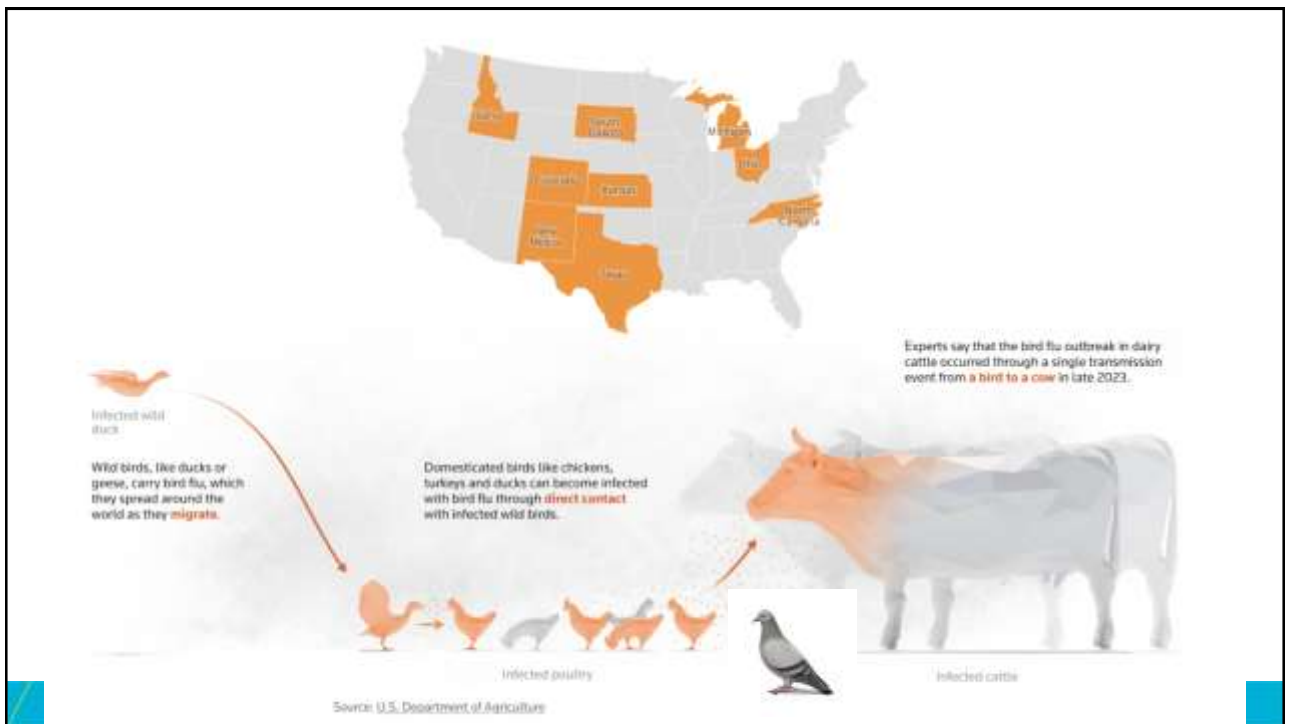
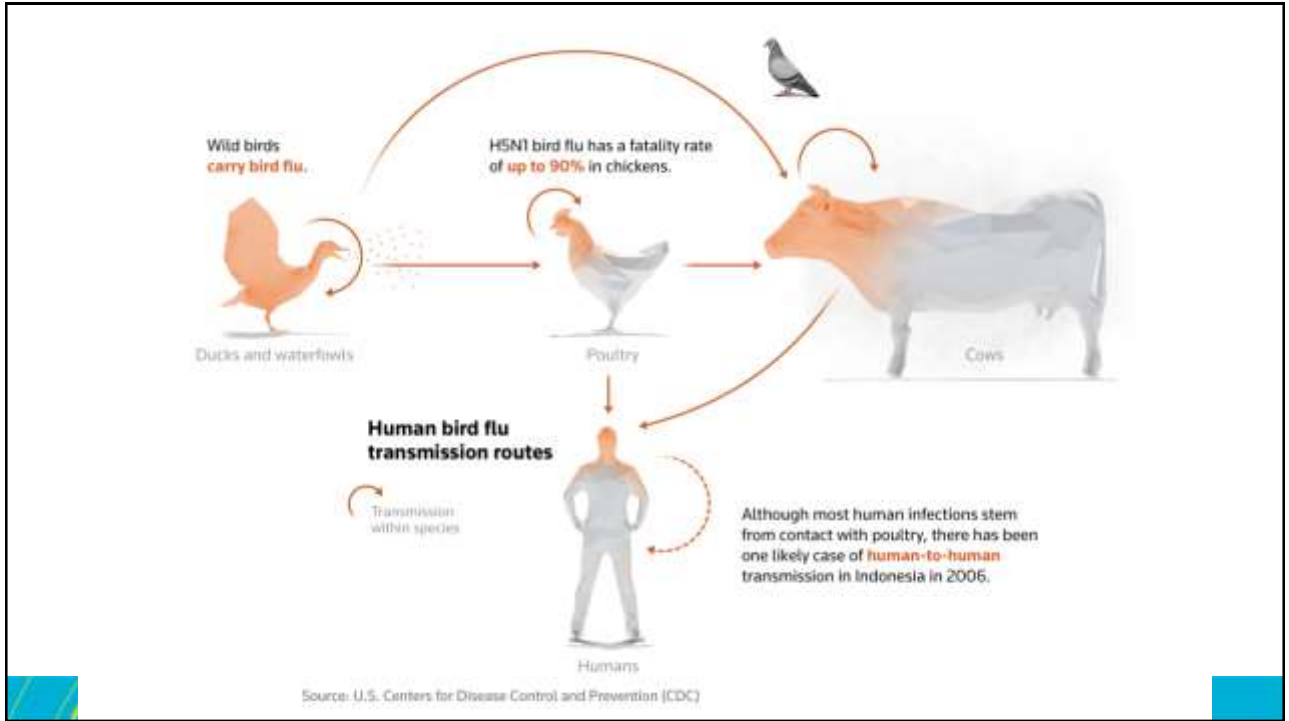
Symptoms of the disease can result in respiratory issues including conjunctivitis and acute respiratory distress syndrome.

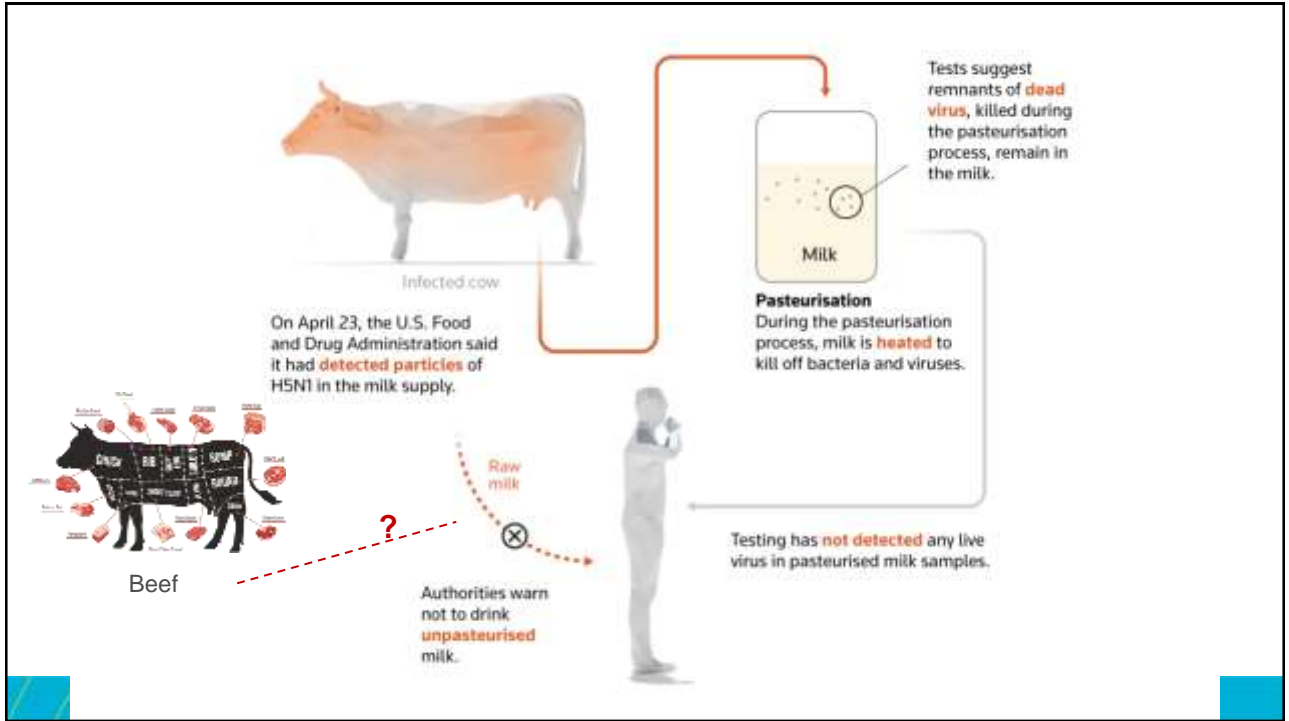
Through contact, most cases for infections in people occur after close, prolonged and unshielded contact with infected birds or surfaces contaminated by them.

Not human infections from these types of outbreaks are common, but they can be deadly when they happen. Symptoms often include coughing and difficulty breathing, which can lead to hospitalization.

Source: U.S. Centers for Disease Control and Prevention (CDC)

While bird flu infections in humans are rare, they can be deadly when they happen. According to the World Health Organization (WHO), there have been 889 H5N1 infections in humans from 2003 to 2024. Of those, **463 or 52% resulted in death.**



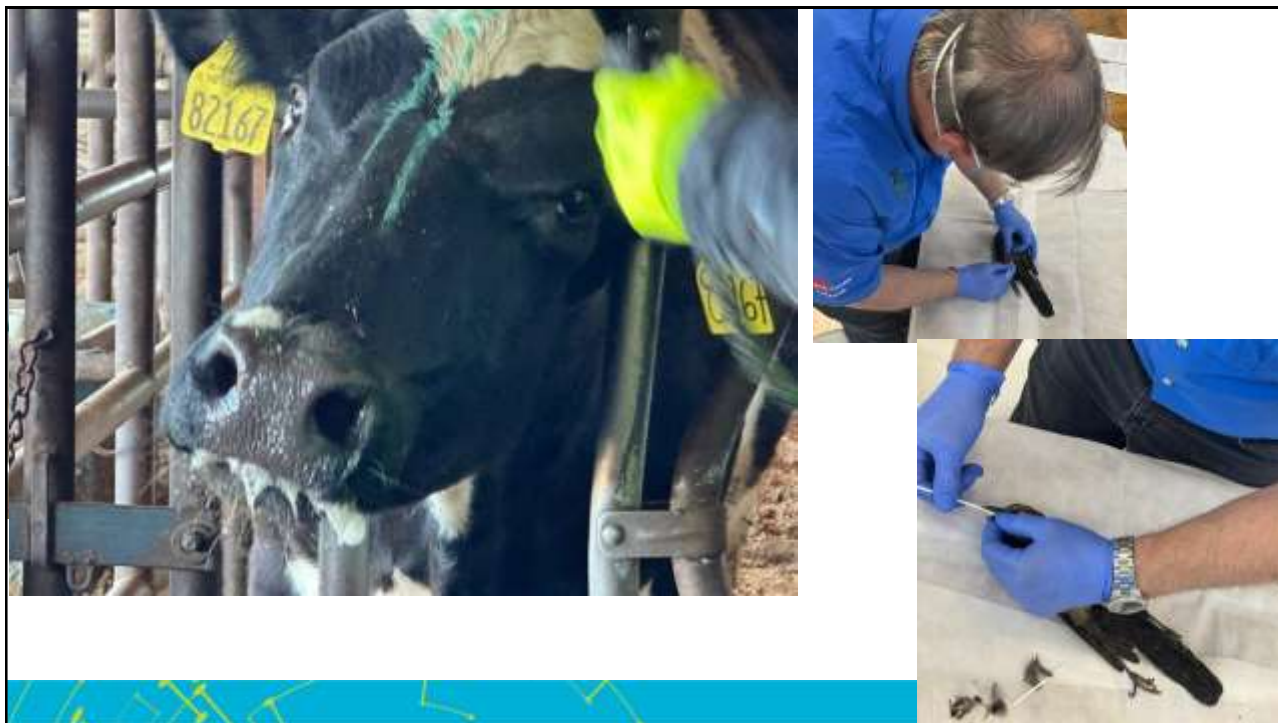


Rapid Detection of Incursions of SARS-CoV-2 and Novel Coronaviruses on Texas' Meat and Dairy Farms

UTMB Health | One Health

Gregory C. Gray, MD, MPH, FIDSA
 University of Texas Medical Branch (UTMB)
 Robert E. Shope, MD, Professor in Infectious Disease Epidemiology, Departments of Internal Medicine (Infectious Diseases), Microbiology and Immunology, and Global Health & Emerging Disease

Photo from Hoard's Dairyman





Future UTMB One Health Efforts

- We have recently run 3 raw milk and 12 cattle swab specimens from another dairy farm in Kentucky and all were negative for FluA
- This week we received an array of 100 new specimens (colostrum, raw milk, semen, milking machine swabs) from dairy farms in New Mexico and Texas to examine multiple transmission hypotheses.
- We are helping a team from California study farm hesitancy to collaborate with the government
- We are planning an international serological survey for H5N1 among animal workers
- We are enrolling four farms in Kentucky in our USDA study in early May

Future OH Work

- Raw cattle milk H5N1 inactivation study in our One Health laboratory using a recombinant H5N1 that is safe to work with in BSL2
- Etiology of Unexplained encephalitis in Malaysia
- We will soon be working with John Tomecek of TAMU in studying feral hogs and beef cattle for H5N1 infections in Texas




UTMB One Health Web Site

UTMB One Health | Advancing Health Care in Humans, Animals and the Environment

utmb Health

UTMB One Health | About Us | Partners | Training | Seminars | Research | Media



UTMB One Health

What is One Health?

One Health is a worldwide strategy for advancing health care in humans, animals and the environment through communication and collaboration between multiple disciplines with the realization that human, animal, and environmental health are all connected.

<https://www.utmb.edu/one-health/home>

utmb Health | One Health

Issue 27 | May 2024

Updates on UTMB One Health Projects





Image: Dairy cows and wild birds
(Photo credit: Hoards Dairyman)

Avian Influenza and One Health

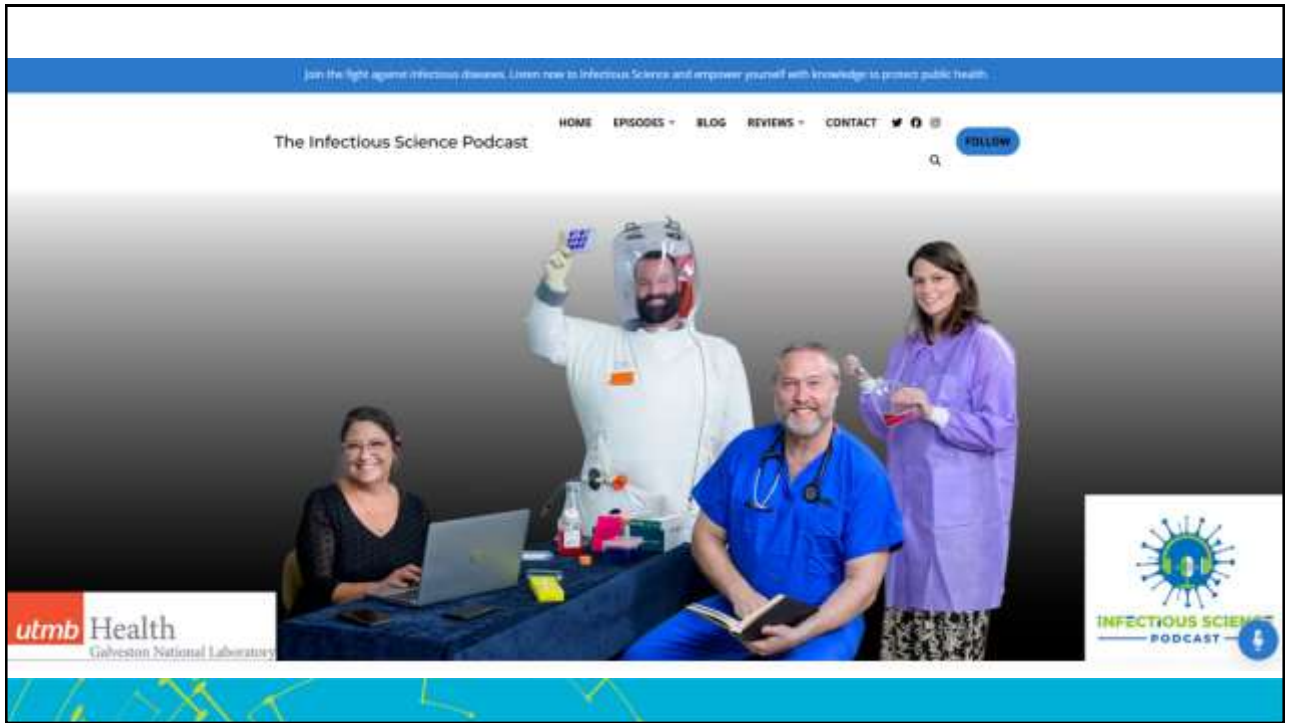
UTMB One Health Monthly Newsletter

Meet the Newsletter Editors:



From left to right, Mohamad Abayyssa, Camille Ledoux, Madeline Steck, MPH, Timothy Warringer, and Austin Weyrland, MHS serve as the editors of the UTMB One Health Team News. Mohamad is a T32 fellow and a clinical sciences PhD/MPH student; Camille is an HTPM PhD student; Madeline is an experimental pathology PhD student; Austin is a third-year medical student; and Timothy Warringer is an MD/PhD student, all at UTMB.

Newsletter is led by young researchers



High & Maximum Containment Training

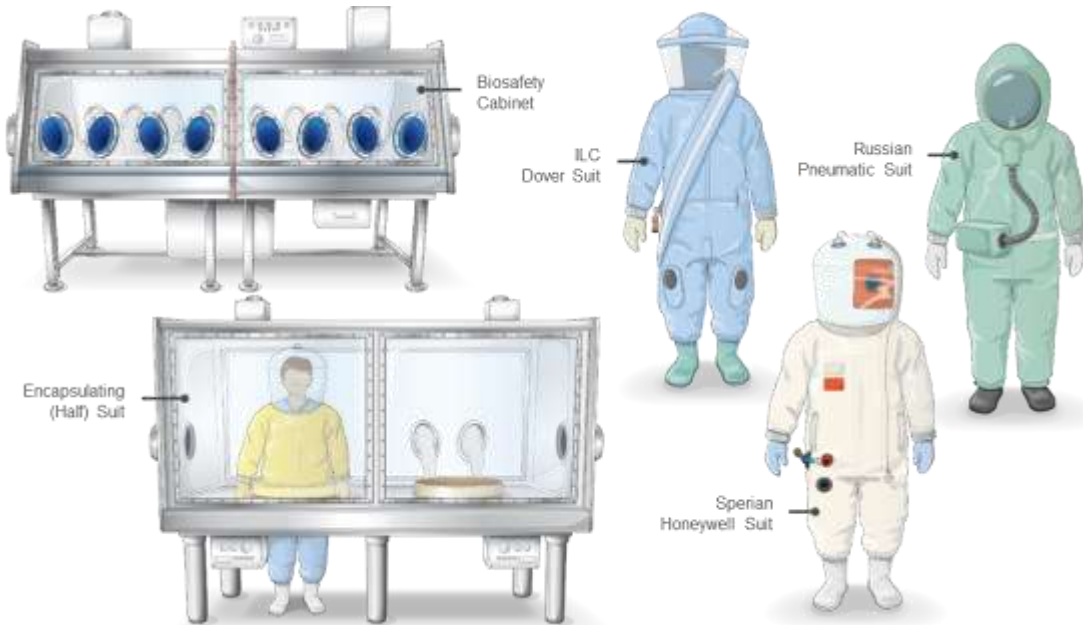
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National Emerging Infectious Diseases Laboratories Institute

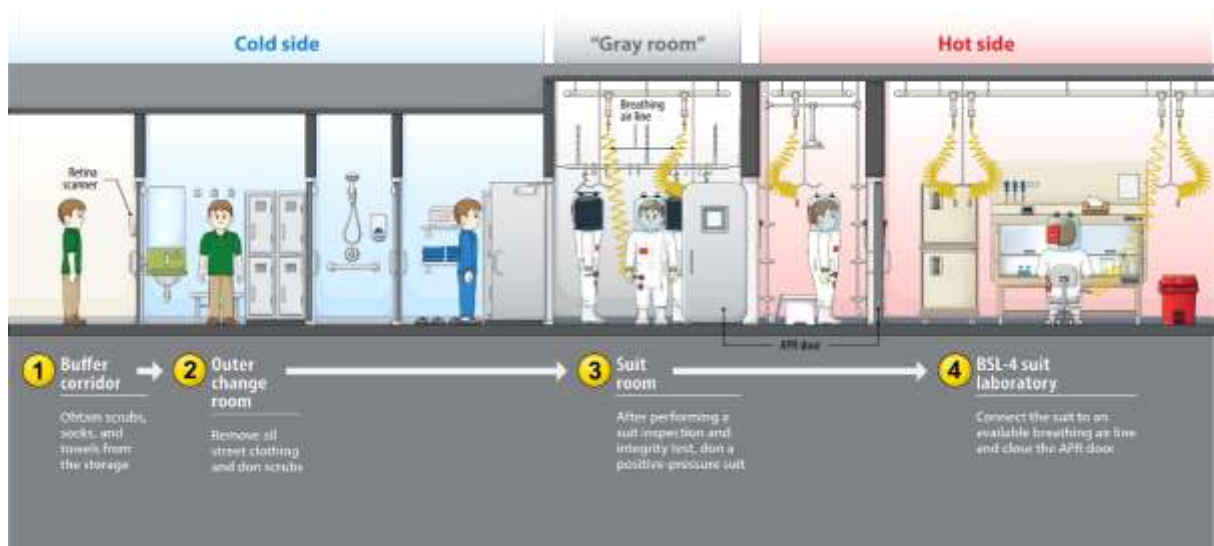
bu.edu/NEIDL
neidl@bu.edu



**BOSTON
UNIVERSITY**

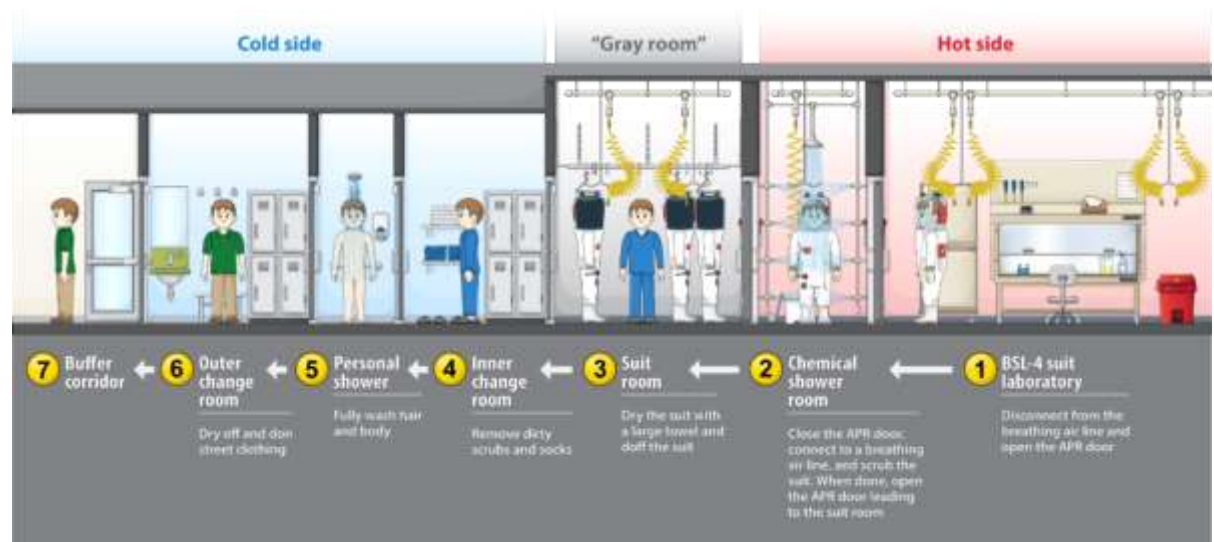


BSL-4 Lab Entrance Procedure



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BSL-4 Lab Exit Procedure



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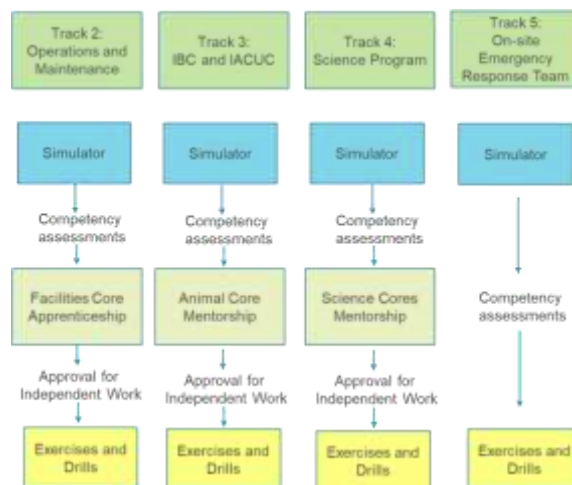
NEIDL Training Advisory Committee NTAC

- Oversight and peer review.
- Entry, and advancement of the trainee
- All approvals are voted on within the committee
- Advises Training Program and NEIDL Director

Training Stages

- **Application Process- Individual Training Plan (ITP)**
- **Baseline Training:**
 - **Stage I:** Beginning encapsulating suit, entry and exit procedures and basic maneuvering in containment.
 - **Stage II** – Advanced training
 - Bisoafety in Microbiological & Biomedical Laboratories (BMBL)
 - Scenario based training (at least three additional entries and exits in the simulator)
 - Incident procedures and non-standard procedure
- **Stage III – Core Specific Training**
 - Mentored training on specific duties within Cores
 - 10 entries with a mentor (minimum)
 - 1 with Nadya or I, then 4 with the same mentor, then 5 with any mentor.
- **Independent Access**
- **Mentor Training**

Workflow for each track (continued)



Operations and Science Staff training for BSL4

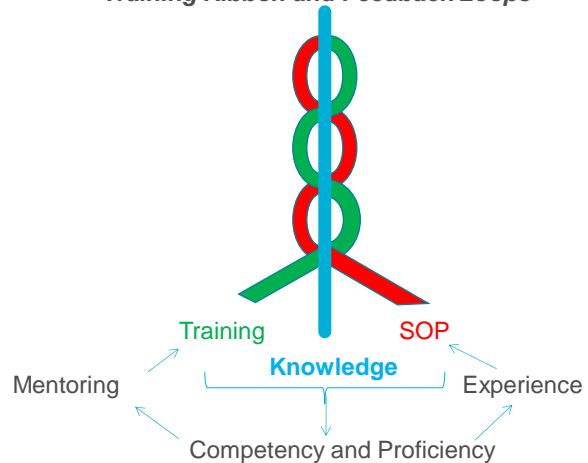
Safety and Surety are the priority

All trainees will come with their unique set of training and experience. BSL4 is a high hazard and consequence laboratory environment where training is paramount.

Training is built on prior laboratory experience. When prior experience is documented, training will focus on the BSL4 environment.

Otherwise, training will be obtained in "tracks" to gain experience prior to full completion of the BSL4 training program.

Training Ribbon and Feedback Loops



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Stage I

Stage I –
Positive
Pressure
Suit
Training
1 week

- Two classroom sessions (“Biosafety Principles” and “Introduction to the Positive Pressure Suit”).
- Three training simulator entries (donning/doffing suit, connecting and disconnecting to air, basic movements – standing, sitting, bending, stretching, operation of APR doors, actions in a chemical shower).

Assessments

- Classroom sessions: Quiz before and after the lecture.
- Simulator entry: Observation by trainer and use of checklist.
- Based on the above, the trainee is signed off by the EHS trainer.



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Examples of Stage 1 exercises to practice dexterity



Agenda example for Stage 1 classwork

Technical Skills Development in Biosafety Level 4 Laboratory Training: Encapsulating Suit Suitability & Assessment (LIC-Dover) Baseline Training Stage 1

Day 1: Introduction Lecture	
1:00-1:15	Welcome and Introduction to Overview
1:15-1:30	The Knowledge Assessment - Principles & Role in Positive Pressure Suit
1:30-1:45	Principles of BSL-4 Training Program
1:45-2:00	Overview of the Principles of Suitability (Lecture)
2:00-2:15	Break
2:15-2:30	Introduction to the Positive Pressure Suit (Lecture)
2:30-2:45	Pre-Training Assessment - Principles & Role in Positive Pressure Suit
2:45-3:00	Break, Training and Operation in the Operation Room
3:00-3:15	LEAK TEST (on your suit)
3:15-3:30	Introduction to the Positive Pressure Suit (Lecture)
3:30-3:45	Positive and Negative Pressure Suits - (Hands-on) Suit for Suit
3:45-4:00	Positive and Negative Pressure Suits - (Hands-on) Suit for Suit
4:00-4:15	Introduction: Suit and Shell Suiting
4:15-4:30	Introduction: Suit Shell Assembly, Contamination, Cleaning, Suiting
4:30-4:45	Introduction: Shell and Suit, Exercise 1: Mobility & Dexterity, Chemical Shower, Suit and Shell Suiting
4:45-5:00	Overview and Feedback from

Day 2: Entry 3: Exercise 3	
Time Requirement	1 hour
1 hour	Preparation of encapsulating suit: Positive Pressure Suit Maintenance Table
1 hour	Donning Suit and Simulated Entry: Exercise 3: Mobility & Dexterity, Chemical Shower, Suit and Shell Suiting
30 minute	Debrief, questions, log entry

Day 3: Entry 4: Exercise 4	
Time Requirement	1 hour
1 hour	Preparation of encapsulating suit: Positive Pressure Suit Maintenance Table
1 hour	Donning Suit and Simulated Entry: Exercise 4: Mobility & Dexterity, Chemical Shower, Suit and Shell Suiting
30 minute	Debrief, questions, log entry

Day 4: Entry 5: Exercise 5 (Optional Support as needed)	
Time Requirement	1 hour
1 hour	Preparation of encapsulating suit: Positive Pressure Suit Maintenance Table
1 hour	Donning Suit and Simulated Entry: Exercise 5: Mobility & Dexterity, Chemical Shower, Suit and Shell Suiting
30 minute	Debrief, questions, log entry

Day 5: Entry 6: Suit Suitability Assessment	
Time Requirement	1 hour
1 hour	Practical Assessment: Guidelines Procedure/Scoring
1 hour	Preparation of encapsulating suit: Positive Pressure Suit Maintenance Table
1 hour	Donning Suit and Simulated Entry: Assessment 6: Mobility & Dexterity, Chemical Shower, Suit and Shell Suiting
30 minute	Debrief, questions, log entry, DASH/BAF Preparation

Stage II

Stage II –
Scenario
based
Simulations
1 week

Scenario-based simulations: Three entries into the simulator covering non-standard exits and basic incident response (alarms/alerts, glove/suit breach with and without injury, chemical shower malfunction, emergency egress, etc).

Assessment

- Simulator entry: Observation by trainer and use of checklist.
- Based on the above, the trainee is signed off by the EHS trainer.



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Mentored Laboratory Work

Track/Lab-
specific
Training:
Mentored
Work in
BSL4
(Typically
>25 entries
and 100h)**

Training to Core-Specific SOPs (Note: The trainee is already considered trained to function safely in the BSL4 but the mentorship is designed to provide guided instruction on tasks that they will be required to perform as part of their job-assignments. Initially, this will be via observation, but – at the discretion of the mentor – will be allowed to gain experience and eventually proficiency in all requisite procedures). The trainee cannot enter without being escorted during mentorship.

- The first 5 entries with the assigned mentor are carefully logged into the training record.

Assessment

Documented direct mentor observations and proficiency assessments (these assessments are mostly subjective based upon how the trainee performs assigned tasks).



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Example of Checklist for Training Documentation

BSL-4 Laboratory							
Employee Information							
Name:		Date:					
Training Topic	Completed	Date	Mentor/Trainer	Training Topic	Completed	Date	Mentor/Trainer
Stage I Baseline Training	Yes	No	/	Proper Use of Biological Safety Cabinets			/
Stage II Baseline Training	Yes	No	/	Maintenance/Certification of BSC	Yes	No	/
Personal Protective Equipment			/	Change of Filter	Yes	No	/
Suit Check	Yes	No	/	Discontinuation of BSC	Yes	No	/
Suit Mobility	Yes	No	/	Spill Procedures			/
Entry Exit Procedures			/	Spill on Containment	Yes	No	/
Entry Safety Walkthrough	Yes	No	/	Spill on BSC	Yes	No	/
MSDS	Yes	No	/	Small Spill Outside BSC	Yes	No	/
Use of Chemical Showers	Yes	No	/	Large Spill Outside BSC	Yes	No	/
Emergency Response Procedures			/	Proper Use of Equipment			/
Exit/Close-Room Response	Yes	No	/	Biohazard Cabinets	Yes	No	/
Man Down/Showers Egress	Yes	No	/	MHC Clearance/Training	Yes	No	/
Miss Door/Unlock Egress	Yes	No	/	Proper Use of Autoclaves			/
Needle Stick	Yes	No	/	Loading/Unloading Substrate	Yes	No	/
Yellow/Red Alert Lights	Yes	No	/	Autoclave Validation/Records	Yes	No	/
LAB ALERT	Yes	No	/	Proper Use of Autoclaves			/
Handling of Biohazardous Waste			/	Understanding Lockout	Yes	No	/
Proper Disposal of Waste	Yes	No	/	Shops/Precautions	Yes	No	/
Transportation/Autoclave	Yes	No	/	Monthly Safety Checks			/
Proper Use of Duck Park	Yes	No	/	Filling Rooms	Yes	No	/
Communication			/	Checking Next Steps	Yes	No	/
Use of Vacuums	Yes	No	/	Conductivity of Filtered Chem	Yes	No	/

Trainer Name	Signature	Date
Mentor Name	Signature	Date
Responsible Official Name	Signature	Date
Biological Safety Officer Name	Signature	Date

Independent (Unsupervised) Access

BSL4 Access
Granted

After a requisite number of hours and entries (typically 40 entries/100h) the mentor presents the case to NTAC for the trainee to be granted unescorted access. This assessment is based upon the mentor's direct observation and proficiency. The NTAC committee members then vote to approve or deny the application for unescorted access.

After reviewing the application, the NTAC reserves the right to call for an additional independent assessment of the proficiency of the trainee by an experienced BSL4 user before granting or denying unescorted access. This is most commonly applied in the case of personnel who already come with experience and require less hours in the BSL4 before consideration for unescorted access.



Refresher Training and Ongoing Activities

Annual Refresher Training*

Annual select agent refresher training is required for all workers.

Any BSL4 worker, whether they have escorted or unescorted access to the BSL4 must undergo hands-on suit and laboratory refresher training any time they have not been in the BSL4 for a period of 90 days or greater.

Training or Biosafety department ongoing activities:

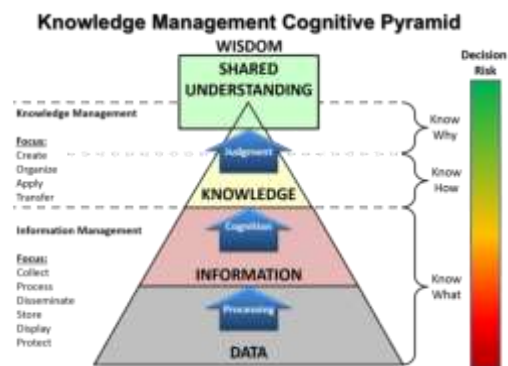
- Topic of the week emails
- Annual drills to include staff
- Buddy program
- Share Daily Critical System Checklist duties
- EHS and Biosurety requirements



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Mentoring Is....

- A strategic approach to developing an employee (mentoree).
 - Pairs him/her with a more experienced employee (mentor) who will teach, coach, counsel and encourage.



Advanced Training



Mentor training is focused on providing skills necessary to be functional and effective

- Effective Feedback – role play/case studies
- Planning
- Roles and responsibilities
- Mentor relationship (coaching vs consulting)
- Common mentor: trainee issues
- Supervisory conflicts
- Servant leadership models
- Mentor meetings/review



THE MENTORING SKILLS MODEL

SHARED CORE SKILLS

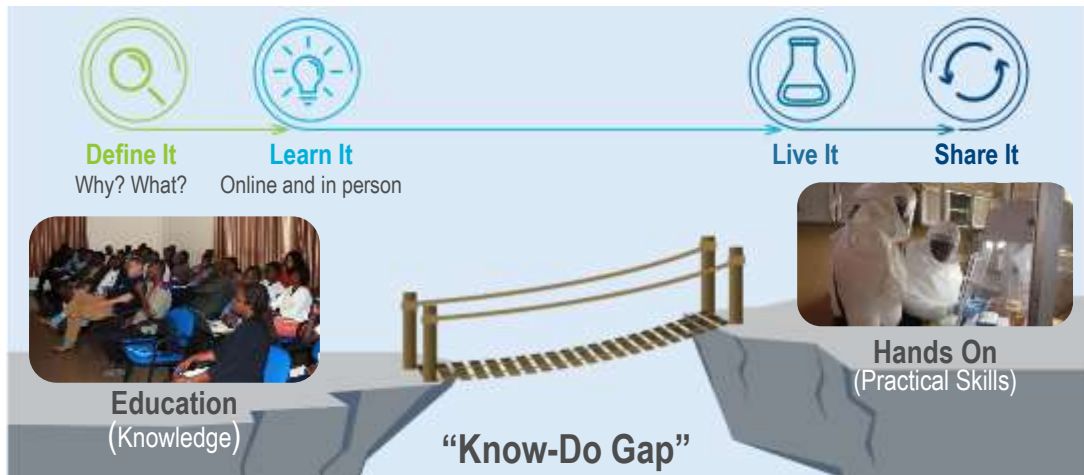


Rethinking Workforce Development Solutions

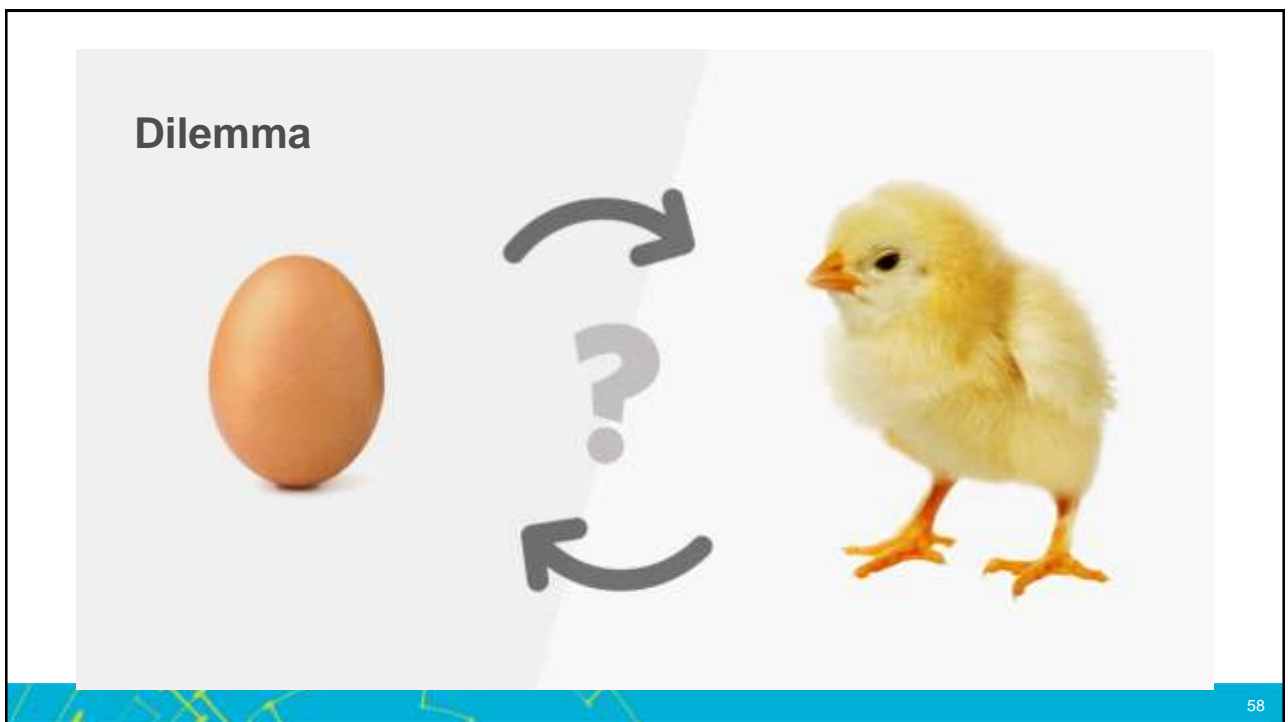
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Blended Training - To enhance capability building

what did you **learn?** what do you really **know?**

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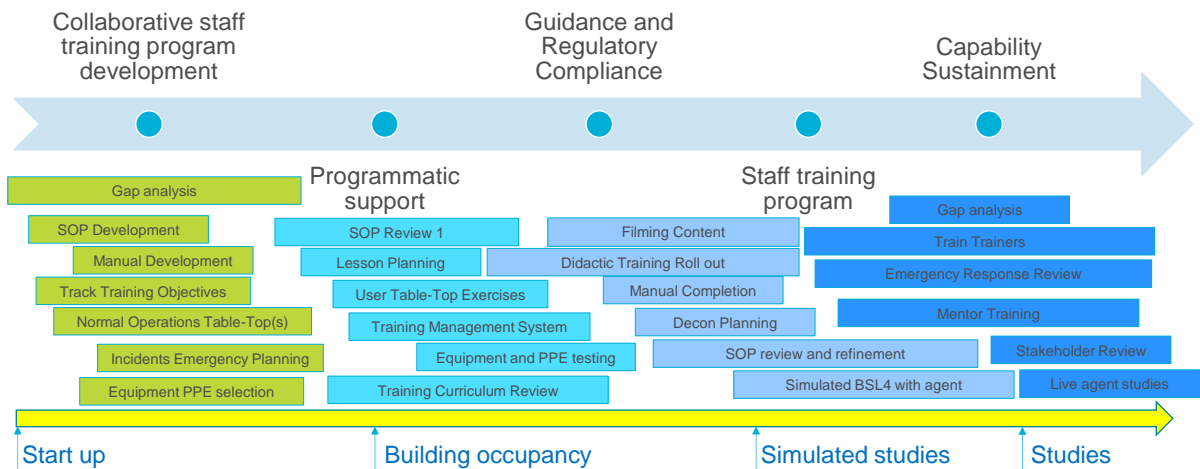
Comprehensive Training program elements



- Continual improvement process to the training materials
- Add additional training as determined by the stakeholders and NBAF senior staff
- Quarterly classes for newly hired NBAF staff
- Risk assessments on new infectious agents
- Regularly address gaps in the training or operations support
- Train in-house trainers as needed

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Challenges of developing training programs



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Collaborative Knowledge Acquisition

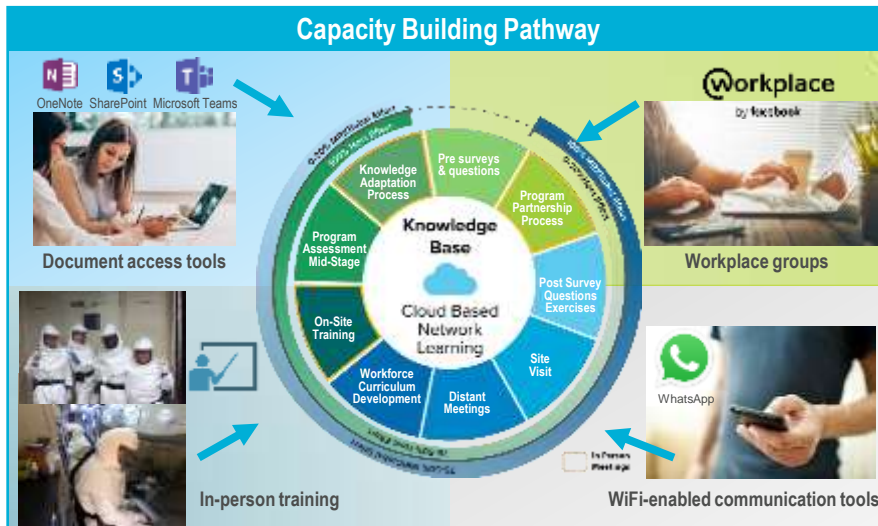


P3: Program Performance Process (P3) includes the factors of practice, results, program goals, strategy, and resources, objectives, outcomes, and metrics. Through collaborative activities, quality metrics and P3 data, the P3 team aims to establish a peer-based network that supports networks and learners.

WCD: Once defined, the **Workforce Curriculum Development (WCD)** is considered as a defined process to meet the needs of employers, apprentices and other learning partners (e.g., training when a learner has a specific learning need or a more focused long-term career path). The WCD process involves the development of the curriculum, which is then used to develop and deliver the training. The WCD process is a core element of the approach referred to as **operating workforce network (OWN)**. OWN is a (virtual) network designed to facilitate a robust system of knowledge and learning, resources and social connections and real-time learning activities, with the focus on learning to provide the business services to the workforce.

KAP: In the final phase, **Knowledge Adaptation Program (KAP)**, the learning through face-to-face and virtual training is reinforced and put to work through various levels of knowledge acquisition and certification (beginner, intermediate, and advanced). This phase also provides the opportunity to deploy the IT program training with selected participants. Ultimately with IT completed, administration of OWN is transferred to the host country to allow ownership to be transferred to the host country for taking continued learning and capacity is achieved in further workforce development. At this stage, OWN can be modified to existing needs and even combined with other disciplines/areas.

Integrate Multi-Media Tools Staff for Engagement



Elements of OWN^{iT}

Systems Engineering Design Training

Social Networking e-learning tools

- Social platform for continued virtual interactions
- Mentored Web of connected collaborative interactions.
- Knowledge transfer requires knowledge-able students and active learning
- Proposed OWN^{iT} training model includes:
 - MRIGlobal- teacher, coach, mentor
 - Stakeholders
 - Students- active participants gaining sustainable skills and developing institutional SOPs
 - Can use short videos to make personal bios and group posts.
- Uses both Consulting and Coaching
 - Coaches help you build and refine skills while consultants provide solutions
 - Both are co-creative processes
- Builds a customized, replicate-able, and expanding knowledge system



*Learn it - Live it - Share it
Operational Workforce Network*

BLENDED LEARNING

VIRTUAL CLASSROOM

- 1 Webinars
- 2 Self-Guided Learning
Media, VR Experience and PowerPoints
- 3 Case Reviews & Exercises
- 4 Pre- and Post-Assessments
- 5 One-on-One Coaching



Instructor-Led Training (ILT)

- 1 Classroom/Tabletop discussions
Walk -Through
- 2 Scenario-based,
Hands-on Simulation
- 3 Pre- and Post-
Assessments
- 4 One-on-One
Coaching
- 5 On the Job/Mentoring



All Curriculum, Lesson Plans and Assessments provided by training team

Fundamentals of Instruction

Basic Levels of Learning



Core Topic 13 - Effective Teaching
April 1 through June 30, 2012

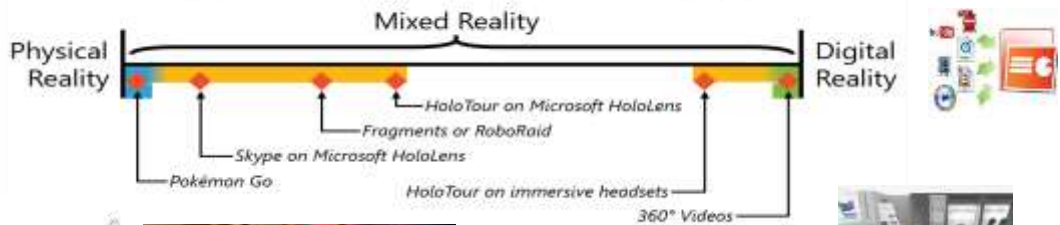


Federal Aviation
Administration

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Shared Mentored AR Technology- SMART

Where experiences exist on the mixed reality spectrum



Virtual Reality
Experience-learning tools



Augmented Reality Guiding-learning tools

SMART training tools

• Accessory VR

- Google Cardboard
- Samsung Gear VR



• Stand alone units

- Oculus Rift and Go



Simulated Learning Environment

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Virtual Reality

What is
Virtual
Reality?



360 Camera



Oculus Quest 2



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Haptic Feedback



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Facility Orientation

Orientation
to the
Facility

Application
Review
Prior
Experience

Orientation and acceptance into the BSL4 training program (nominated by sponsor, background and resume reviewed by the Training Advisory Committee), and completion of pre-requisite trainings (e.g., general laboratory safety training, Select Agent training, and Agent Specific Training).

There is an opportunity here to incorporate video training to train staff on the mechanics of the BSL-3 or 4 laboratories and the layout of the lab benches and equipment. At this time the staff also reviews containment-related and job-specific SOPs.



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VR CDC training



OneLab | VR
A Unified Response to Training Needs



Augmented Reality – Guide in the real world



Augmented Reality- Guide

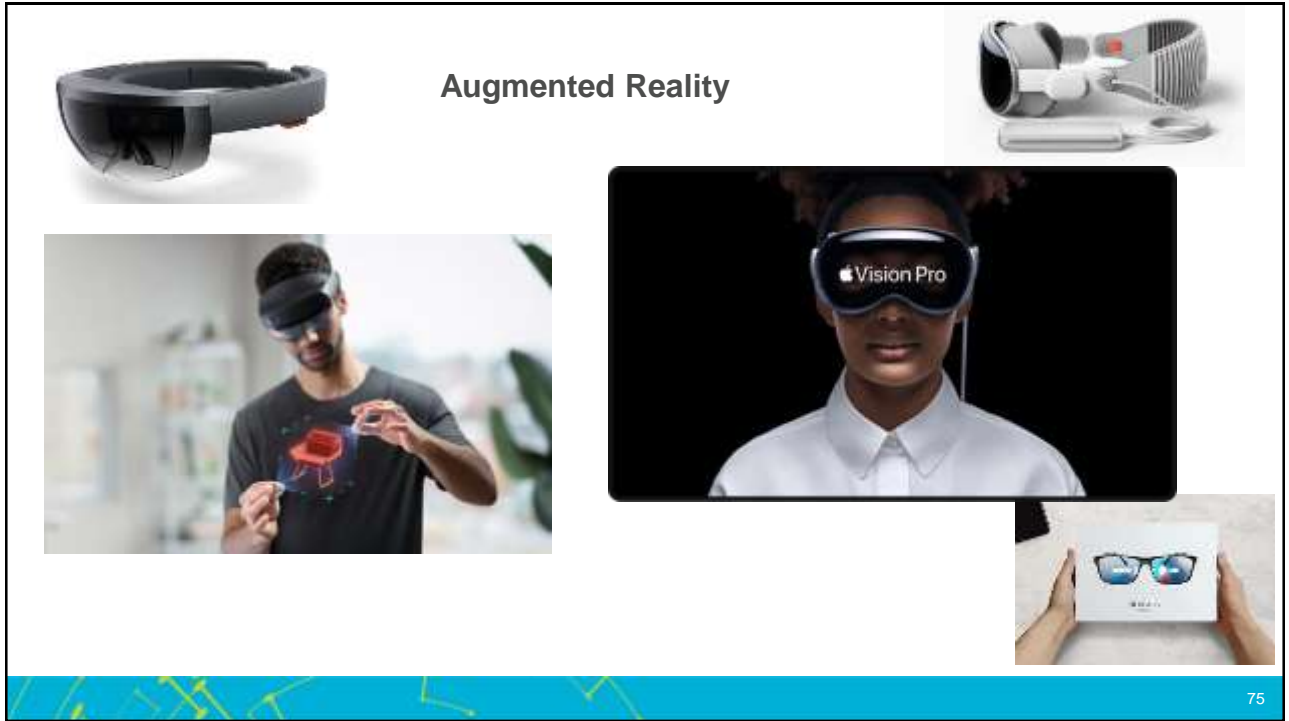
DAQRI SMART GLASSES™



<https://daqri.com/>

DAQRI Smart Helmet™
Wearable Human Machine Interface





Emerging Trends & Discussion

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Engineering Biology

A Research Roadmap for the Next-Generation Bioeconomy

Technical Themes

Engineering DNA

Biomolecular Engineering

Host Engineering

Data Science

Application Sectors

Industrial Biotechnology

Health & Medicine

Food & Agriculture

Environmental Biotechnology

Energy

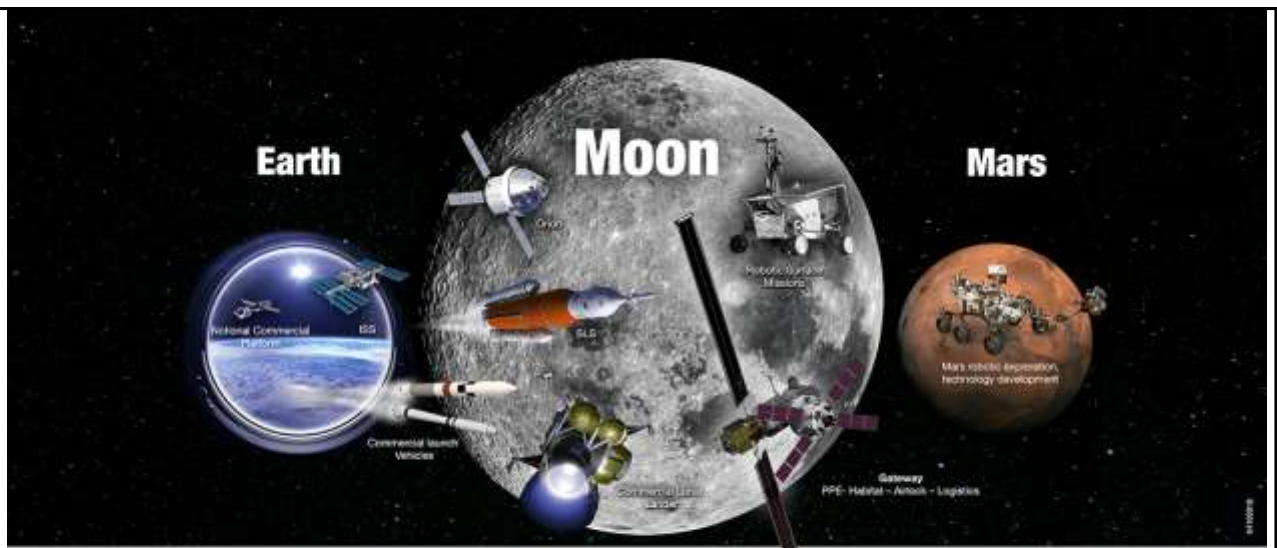
<https://roadmap.ebrc.org>

This material is based upon work supported by the National Science Foundation under Grant No. 1818248.

A Matrixed Approach

Technical Themes

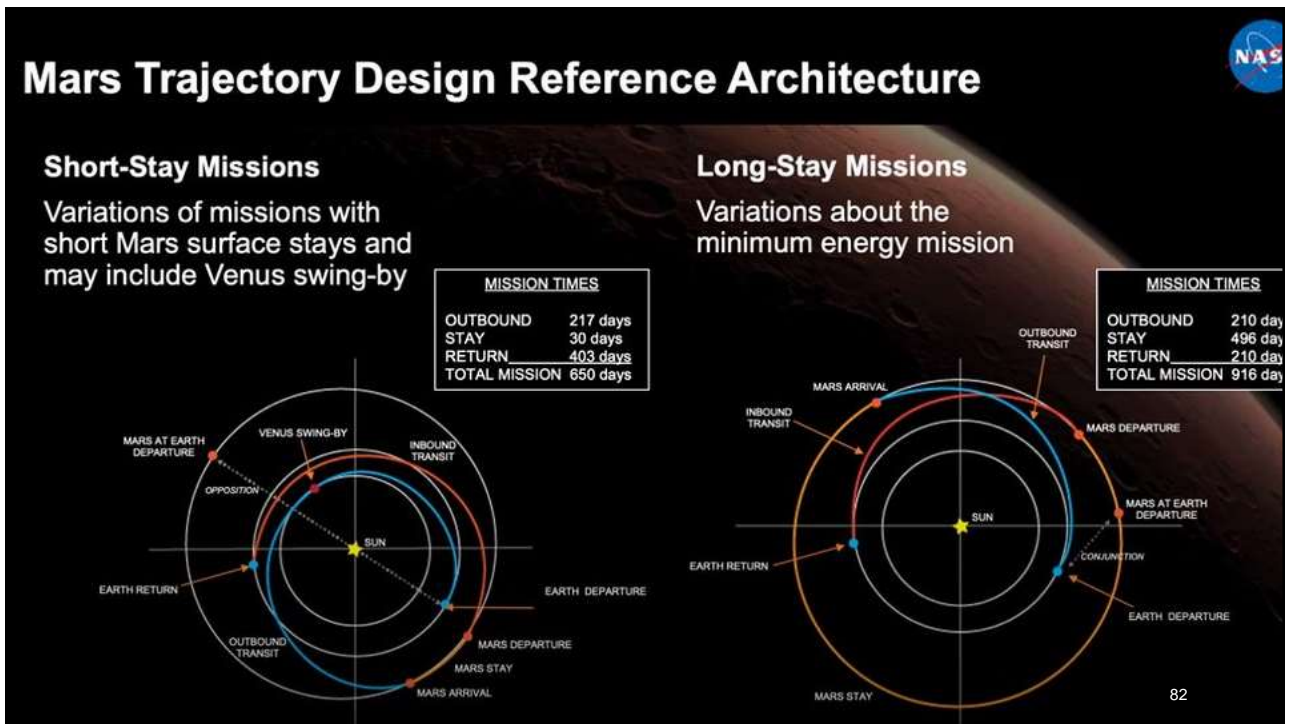
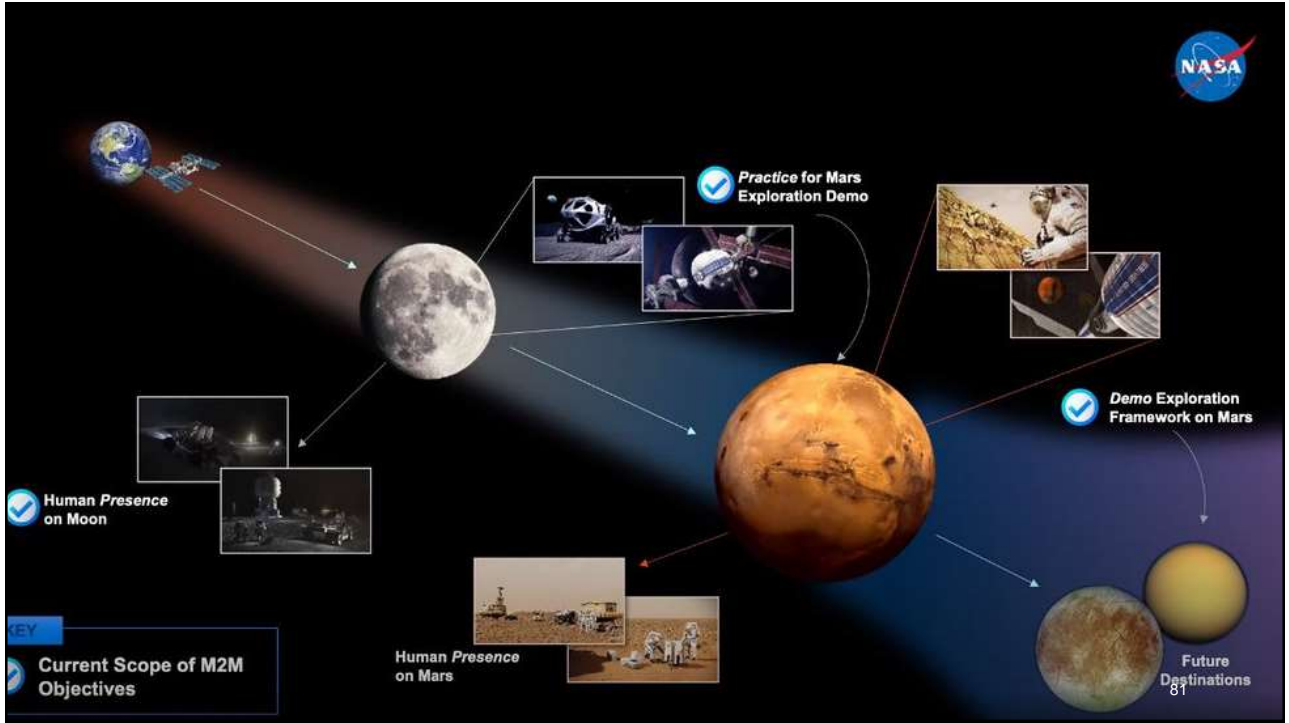
		Engineering DNA	Biomolecular Engineering	Host Engineering	Data Science
Sectors	Industrial Biotechnology				
	Health & Medicine				
	Food & Agriculture				
	Environmental Biotechnology				
	Energy				

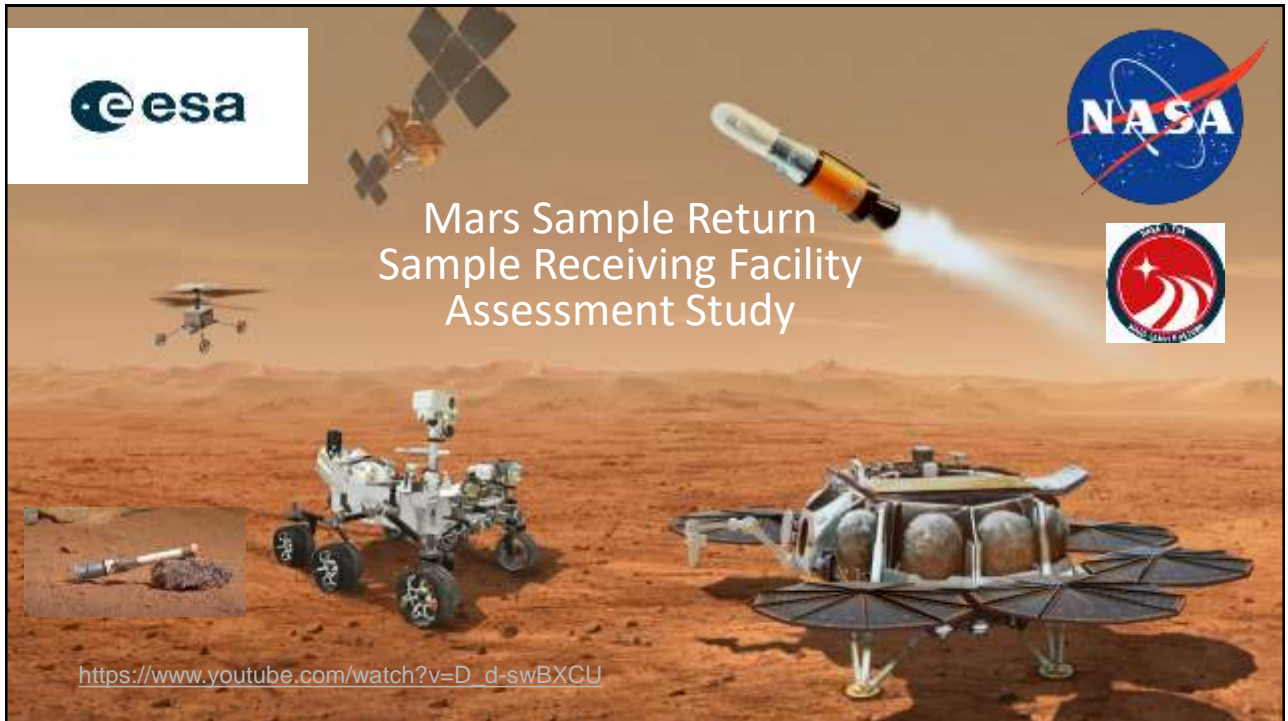


In LEO
Commercial & International partnerships

In Cislunar Space
A return to the moon for long-term exploration

On Mars
Research to inform future crewed missions





The banner features a central illustration of a Mars rover and a lander on the red planet's surface. In the background, a rocket is shown launching into space. The ESA logo is in the top left, and the NASA logo is in the top right. Below the NASA logo is the Mars Sample Return logo. The text 'Mars Sample Return Sample Receiving Facility Assessment Study' is centered over the scene. A small inset image shows a close-up of a sample being collected. At the bottom left, a URL is provided: https://www.youtube.com/watch?v=D_d-swBXCUC

esa

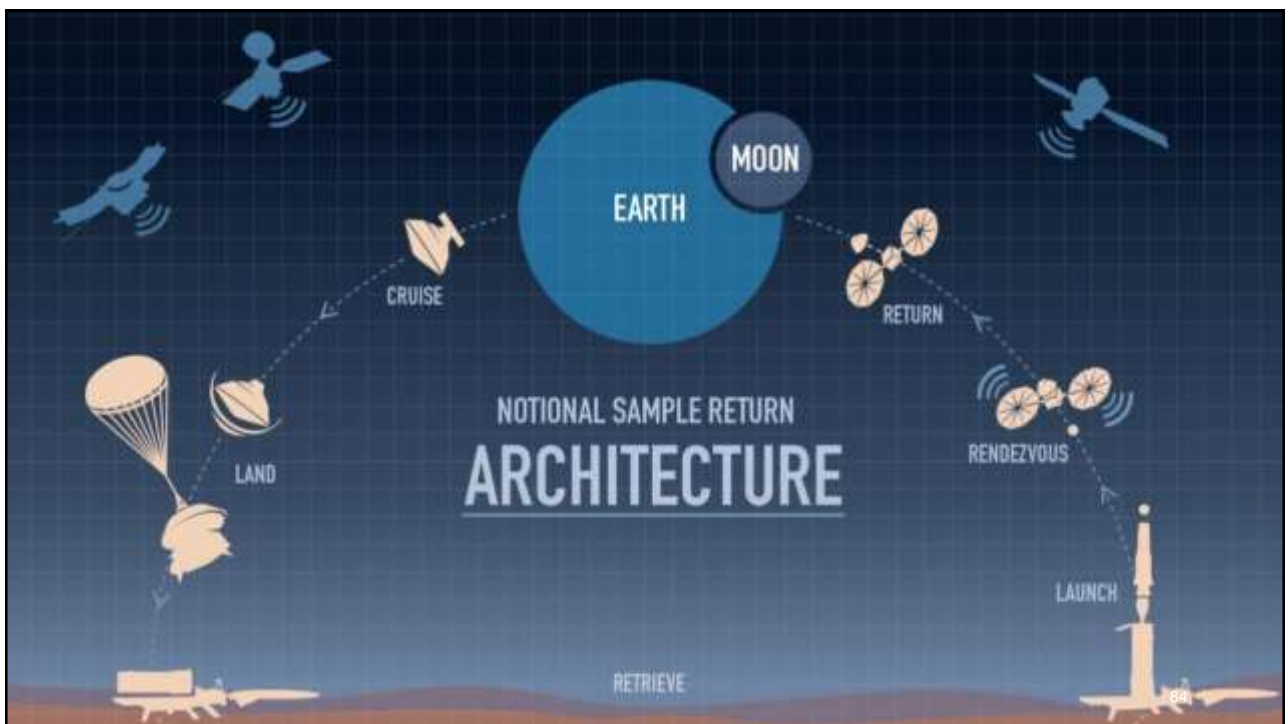
NASA

Mars Sample Return

Mars Sample Return

Mars Sample Return

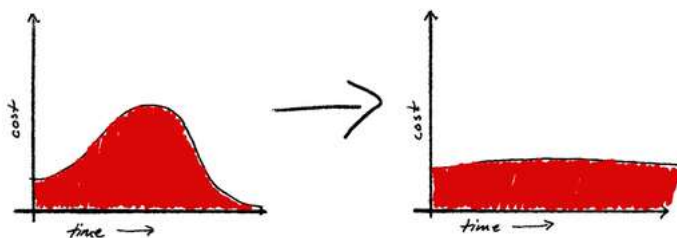
https://www.youtube.com/watch?v=D_d-swBXCUC





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Adjustments when short budget changes...schedule changes and costs increase.



<https://www.youtube.com/watch?v=5PA1qhzkSIA>



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