Red Risk School
TRISH Disruptions on Display

Level Ex Virtual Human Simulator and Digital Twin Projects
December 9th, 2020
Overview
  ○ Introductions and Level Ex background

Virtual Human Simulator Project
  ○ Medical research and content identification
  ○ Visual content development
  ○ Ultrasound simulation R&D
  ○ VHS Platform Demonstration
    ■ Anatomy Viewer
    ■ Clinical training scenario concept
  ○ TRISH COVID-19 content
    ■ Airway Management
    ■ Cardiology Diagnosis

Digital Twin Framework Project
  ○ Digital Twin Framework Prototype Plans
    ■ Medical Research, Analysis, and Reporting
    ■ Personalized Anatomical Imaging R&D
    ■ Collaborative Spaceflight Medical Procedures and Techniques
  ○ Virtual Technique Guides and Collaborative Remote Play Demos
Virtual Human Simulator

Presenter: Erik Funkhouser
VHS Project: NASA Risk and Gaps

NASA Risks and Gaps (https://humanresearchroadmap.nasa.gov/intro/)

Risks:
• **Primary:** Risk of Adverse Health Outcomes & Decrements in Performance due to Inflight Medical Conditions
• **Secondary:** Risk of Performance Errors Due to Training Deficiencies

Gaps:
• **Med05:** We do not know how to train crew for medical decision making and medical skills to enable extended mission or autonomous operations
• **Med10:** We do not have the capability to provide computed medical decision support during exploration missions
• **TRAIN-02:** We need to identify effective methods and tools that can be used to train for long-duration, long-distance space missions.
• **TRAIN-03:** We need to develop guidelines for effective onboard training systems that provide training traditionally assumed for pre-flight.
Project Description

Need: Long duration deep space missions will require tools and solutions to support autonomous medical care.

The goals of the VHS project are to:

- Research and aggregate data on spaceflight adaptations, medical conditions, medical checklists, diagnostic and treatment information from terrestrial and space medicine to support research insights and training opportunities for flight crews.

- Develop a data driven virtual human simulator that provides a foundation for future development of medical training and real-time guidance solutions
Research and Needs Identification
- SME interviews, research, and analysis on adaptations & countermeasures
- Collection of research data and reference material needed to develop platform content, decision support systems, and just-in-time training solutions
- Author research reports summarizing methods, activities, findings, gaps, and next steps.

Software Feature Development
- Spacecraft environment
- Female and male astronaut bodies
- High fidelity anatomy: Heart, IJV, common carotid, lungs, ocular
- Virtual ultrasound simulation
  - Real time US simulation capability
  - Scannable volumetric content pipeline
  - Application to IJV thrombosis

Training Demonstration Scenario Development
- IJV thrombosis clinical scenario demonstration
Virtual Human Simulator Project: Medical Research Analysis and Design

Presenter: Victoria Perizes
**Data Capture**

Identification and collection of:
- HRP evidence reports
- Peer-reviewed publications
- NTRS publications (limited access)
- LSDA + LSAH experiment data

**Filter**

- Published on 1/1/99 or later
- Language: English
- Subject: Human
- Study/experiment type: Spaceflight studies and spaceflight analogues*

**Gap ID**

- Knowledge/information gaps that impacted development
- “We need x to do y”

**Synthesis**

- Story of condition and/or SA
- Stakeholder specific documentation

**Analysis**

- Changes to relevant condition parameters
- Level of evidence/ NASA categories of evidence
- Consensus or conflict

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*Qualifying analogues will vary by target - specifics available upon request.
## Exploration Medical Conditions

### SKIN
- Burns secondary to Fire
- Skin Abrasion
- Skin Laceration

### EYES
- Acute Glaucoma
- Eye Corneal Ulcer
- Eye Infection
- Retinal Detachment
- Eye Abrasion
- Eye Chemical Burn
- Eye Penetration

### EARS, NOSE, THROAT
- Barotrauma (sinus block)
- Nasal Congestion (SA)
- Nosebleed (SA)
- Acute Sinusitis
- Hearing Loss
- Otitis Exerna
- Otitis Media
- Pharyngitis

### DENTAL
- Abscess
- Caries
- Exposed Pulp
- Tooth Loss
- Crown Loss
- Filling Loss

### CARDIOVASCULAR
- Angina/Myocardial Infarction
- Atrial Fibrillation / Atrial Flutter
- Cardiogenic Shock secondary to Myocardial Infarction
- Hypertension
- Sudden Cardiac Arrest
- Traumatic Hypovolemic Shock
- Venous Thromboembolism

### GASTROINTESTINAL
- Constipation (SA)
- Abdominal Injury
- Acute Cholecystitis
- Acute Diverticulitis
- Acute Pancreatitis
- Appendicitis
- Diarrhea
- Gastroenteritis
- Hemorrhoids
- Indigestion
- Small Bowel Obstruction

### PULMONARY
- Choking/Obstructed Airway
- Respiratory Infection
- Toxic Exposure: Ammonia
- Smoke Inhalation
- Chest Injury

### NEUROLOGIC
- Space Motion Sickness (SA)
- Head Injury
- Seizures
- Headache
- Stroke
- Paresthesia
- Headache (SA)
- Neurogenic Shock

### MUSKULOSKELETAL
- Back Pain (SA)
- Abdominal Wall Hernia
- Acute Arthritis
- Back Injury
- Ankle Sprain/Strain
- Elbow Dislocation
- Elbow Sprain/Strain
- Finger Dislocation
- Fingernail Delamination (EVA)
- Hip Sprain/Strain
- Hip/Proximal Femur Fracture
- Knee Sprain/Strain
- Lower Extremity Stress fracture
- Lumbar Spine Fracture
- Shoulder Dislocation
- Shoulder Sprain/Strain
- Acute Compartment Syndrome
- Neck Injury
- Wrist Sprain/Strain
- Wrist Fracture

### PSYCHIATRIC
- Insomnia (Space Adaptation)
- Late Insomnia
- Anxiety
- Behavioral Emergency
- Depression

### GENITOURINARY
- Abnormal Uterine Bleeding
- Acute Prostatitis
- Nephrolithiasis
- Urinary Incontinence (SA)
- Urinary Retention (SA)
- Vaginal Yeast Infection

### INFECTION
- Herpes Zoster (shingles)
- Influenza
- Mouth Ulcer
- Sepsis
- Skin Infection
- Urinary Tract Infection

### IMMUNE
- Allergic Reaction
- Anaphylaxis
- Skin Rash
- Medication Reaction

### ENVIRONMENT
- Acute Radiation Syndrome
- Altitude Sickness
- Decompression Sickness (EVA)
- Headache (CO2)

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**Medical conditions researched in year 1 with findings included in the medical reports and the VHS platform prototype deliverable:**

- Burns secondary to Fire
- Skin Abrasion
- Skin Laceration
- Acute Glaucoma
- Eye Corneal Ulcer
- Eye Infection
- Retinal Detachment
- Eye Abrasion
- Eye Chemical Burn
- Eye Penetration

**Medical conditions researched in year 1 with findings included in the medical reports, but not included in the VHS platform prototype deliverable:**

- Barotrauma (sinus block)
- Nasal Congestion
- Nosebleed
- Acute Sinusitis
- Hearing Loss
- Otitis Exerna
- Otitis Media
- Pharyngitis

**Medical conditions for which research was not performed in year 1 of the VHS Platform project:**

- Abscess
- Caries
- Exposed Pulp
- Tooth Loss
- Crown Loss
- Filling Loss
- Constipation
- Abdominal Injury
- Acute Cholecystitis
- Acute Diverticulitis
- Acute Pancreatitis
- Appendicitis
- Diarrhea
- Gastroenteritis
- Hemorrhoids
- Indigestion
- Small Bowel Obstruction
- Choking/Obstructed Airway
- Respiratory Infection
- Toxic Exposure: Ammonia
- Smoke Inhalation
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- Urinary Retention
- Vaginal Yeast Infection
- Herpes Zoster (shingles)
- Influenza
- Mouth Ulcer
- Sepsis
- Skin Infection
- Urinary Tract Infection
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- Altitude Sickness
- Decompression Sickness (EVA)
- Headache (CO2)
VHS Software Design

Stakeholder centered design based on input captured in SME interviews
Virtual Human Simulator Project: Artistic Asset Development

Presenter: Clifton Garner
Artistic Astronaut Model Development
Artistic Anatomy Model Development
Artistic Spacecraft Model Development
Virtual Human Simulator Project: Ultrasound Development

Presenter: Clifton Garner
Ultrasound Development
Ultrasound Simulation Process

**Simulation R&D**
- Determine application + use cases
- Math model: wave propagation theory
- Enhanced backscatter and speckle calculations

**MRI Data R&D**
- Resolution
- Sequence(s) needed
- Image weight
- Volumetric data acquisition and segmentation

**Ultrasound Simulation**

**Integration and Operation**
Real-time ultrasound scans of volumetric patient anatomy based on MRI data (NIH Database)

**Verification Testing**
- Butterfly IQ™ + phantom analogue output
- Virtual US + phantom analogue
- Output comparison
Ultrasound Simulation Comparison

Real Ultrasound

Dynamic ultrasound simulation integrated into VHS Platform
Ultrasound Simulation Application - Spaceflight Associated IJV Thrombosis
COVID-19 Airway Management Training

Level Ex’s *Difficult Airway* unit is being repurposed to train frontline medical professionals to:

- Secure and manage compromised airways
- Minimize spread of the virus
Level Ex has developed challenging COVID-19 patient cases that harness the power of our existing Diagnosis game mechanics, requiring HCPs to flex their deductive reasoning skills.
Digital Twin Framework Project

Presenter: Erik Funkhouser
VISION FOR LONG DURATION EXPLORATION MISSIONS

In the future, each astronaut will have a personalized “digital twin” that captures an accurate model of their anatomy and physiology. The “digital twin” is seen as a key component among a host of solutions to support personalized medical training, precision medicine, and real-time clinical support for flight surgeons and astronauts on crewed exploration class mission to Mars.

KEY COMPONENTS

- Personalized baseline volumetric anatomical data
- High fidelity visualization of key anatomy
- Integration of ultrasound capabilities
- Integration with physiological models
- Dynamic representation of medical conditions and space flight adaptations
Digital Twin Framework
Project: Research Analysis and Dev Process
Example composition of patient MRI and CT imagery and volumetric data segmentation to identify anatomical components of the brain for surgical planning and intraoperative anatomy tracking.
Digital Twin Framework Project: Collaborative Clinical Procedures

Presenter: Victoria Perizes
Digital Twin Framework: Collaborative Virtual Clinical Techniques
Powered by Remote Play

LEVEL EX VIRTUAL TRAINING PLATFORM

Users interact with the content simultaneously, making observation and immediate feedback possible

Real-time interactivity and high-fidelity visuals

Shared platform access via standard video conferencing tools, including WebEx, Zoom, Veeva Engage, Microsoft Teams, etc.

Platform content is web-based and accessible via mobile and desktop browsers
Feedback and Discussion