Training Simulators for Extreme Environments

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Presentation overview

- Introduction to extreme environments
- Classification and features of extreme environments
- Extreme operations
- Specifications for operator training simulators
- Recommended features of OTS in EE
- Discussion and conclusions
An advanced OTS should allow simulating:

- **Startups, shut downs (programmed and emergency), grade changes**
- **Malfunctions and alarms**
- **Abnormal situations**
- **Accident events**
  - Effects on the equipment
  - Effects on the FOPs
  - Effects on the surrounding environment
- **Interaction with field operated devices**
- **Remote interaction among CROPs and FOPs**
- **Operation at different times of the day**

- **Operation under different weather conditions**
Extreme Environments comprise conditions that are hard to survive for most known life forms.

- Extremely high or low temperature or pressure
- High or low content of oxygen or carbon dioxide in the atmosphere
- High levels of radiation, acidity, or alkalinity
- Absence of water
- Water containing a high concentration of salt
- Presence of sulphur, petroleum, and other toxic substances
Examples of natural extreme environments include:

- geographical poles
- very dry deserts
- volcanoes
- deep ocean trenches
- upper atmosphere
- mount Everest
- outer space and some other planets

The organisms living in these conditions are often very well adapted to their living circumstances, which is usually a result of long-term evolution.
Anthropic extreme environments

Examples of **anthropic** extreme environments include:

- Chemical plants
- Off-shore platforms
- Engine rooms
- Oil tankers
- Merchant ships
- Bathyspheres
- International Space Station

**N.B.**: Human beings cannot adapt to anthropic extreme environments as a long-term adaptation is not available/feasible.
Extreme features

- High
- Low
- Extremely, very, much, many...
- Absence of, lack of, missing, few, no...
Training targets

CROPs

FOPs
Temperature vs latitude

Air temperature

Sea temperature

Zonal Mean Sea Surface Temperatures
(5 deg Latitude Bands)
Average of Jan 1982 to Dec 2011
**Temperature vs elevation/depth**

**Air temperature**

![Diagram showing the temperature distribution with altitude in the atmosphere.]

**Sea temperature**

![Diagram showing the temperature distribution with depth in the ocean.]

- Thermosphere
- Mesopause
- Mesosphere
- Stratosphere
- Tropopause
- Troposphere

**Decrease in temperature °C**

- 4°C
- 8°C
- 12°C
- 16°C
- 20°C
- 24°C

**Depth in meters**

- 0
- 1000
- 2000
- 3000
- 4000
- 5000
- 6000
- 7000

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Hypoxia and hypercapnia

Effects of Hypoxia

- Low oxygen pressure at high altitude
- The carotid body, a cluster of specialized cells in the carotid artery, detects low oxygen levels in the blood and alerts the brain.
- In response, the brain sends signals to the rest of the body to:
  - Increase breathing rate and constrict vessels in the lung
  - Increase heart rate
  - Dilate peripheral blood vessels in arms, legs, hands, and feet

Main symptoms of Carbon dioxide toxicity

- Visual: - Dimmed sight
- Auditory: - Reduced hearing
- Respiratory: - Shortness of breath
- Muscular: - Tremor
- Central: - Drowsiness, - Mild narcosis, - Dizziness, - Confusion, - Headache, - Unconsciousness
- Skin: - Sweating
- Heart: - Increased heart rate and blood pressure
Noise and silence
Protective measures

- Overalls
- Low temperature clothes
- Thermally controlled overalls
- Breathing masks, air bottles
- Earplugs
- ...

N.B.: protective measures allow living in EE but hamper the operators and may have negative impacts on their efficiency and endurance.
Extreme operations
Extreme operations

- Surge
- Yaw
- Sway
- Roll
- Pitch
- Heave
Issues involved

Consequences of extreme environments:

- Operators are hindered/hampered by protective devices
- Extreme environmental conditions modify the normal operating conditions and call for different, specific, and unconventional operations

Respect to normal operating conditions:

- The time taken to carry out an operation is longer
- The operator has to stand a higher strain to carry out the same operation
- The communication with the control room and other field operators is worsened/hampered
- The time taken to recover from the strain is higher
- The operator endurance is shorter
Call for:

• Specific overalls and protective clothes/devices
  • Sealed overalls, breathing masks, air bottles, protective glasses, gloves, ...

• Specific physical training

• Specific mental training → tailored situation awareness

• Trainers and trainees have to know and experience the effective times, rhythms, and intervals to carry out the operations
Recommended features of OTS in EE

Basic features:

- 3D immersive and stereoscopic Virtual Reality
- 3D sounds effects
- Augmented virtual reality
3D immersive and stereoscopic VR
Augmented Virtual Reality

Status:  
Normal condition
Liquid holdup: 0.754 [m]
Advanced features:

• Simulation of **extreme weather conditions**:
  • Temperature, pressure, wind, humidity, frost, ...

• Reproduction of **extreme environmental conditions**:
  • Light, darkness, noise, silence, roll/pitch/yaw, lack of breathable air, toxic substances, ...

• Reproduction of **real stuff**:
  • Stairs, valves, manholes, devices, engines, ...

• **Mixed reality**
Immersive VR headset
Discussion and Conclusions

What should be implemented and is still missing:

• Dedicated training methods for trainees
• Dedicated training of trainers
• Automated performance assessment
• Frequency of training and refresh programs
Operator training simulators for both industrial and maritime extreme environments are challenging tools that call for a systemic and holistic approach to implementation.

Both maritime and industrial sectors would benefit from the availability of **Extreme Training Simulators (ETS)**.

**OTS vendors** should reflect, discuss, and ponder on the feasibility and opportunity to implement and customize **ETS** according to the client’s requirements.
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Thank you for your attention

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