



## THIRD WORKSHOP ON TRAINING AND ASSESSMENT

University College of Southeast Norway, Research Park, Campus Vestfold, Norway  
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 POLITECNICO DI MILANO



# Training Simulators for Extreme Environments

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- 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:

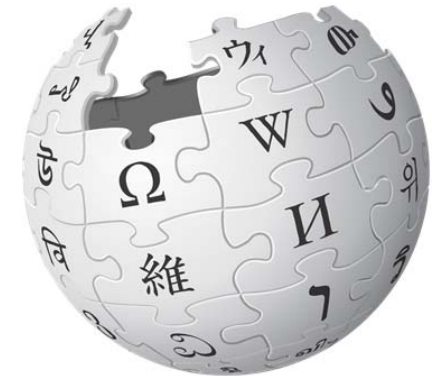
- *Startups, shut downs (programmed and emergency), grade changes*
- *Malfunctions and alarms*
- Abnormal situations
- **Accident events**
  - Effects on the equipment
  - Effects on the FOPs
  - Effects on the surrounding environment
- **Interaction with field operated devices**
- **Remote interaction 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.



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.





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





**CROPs**



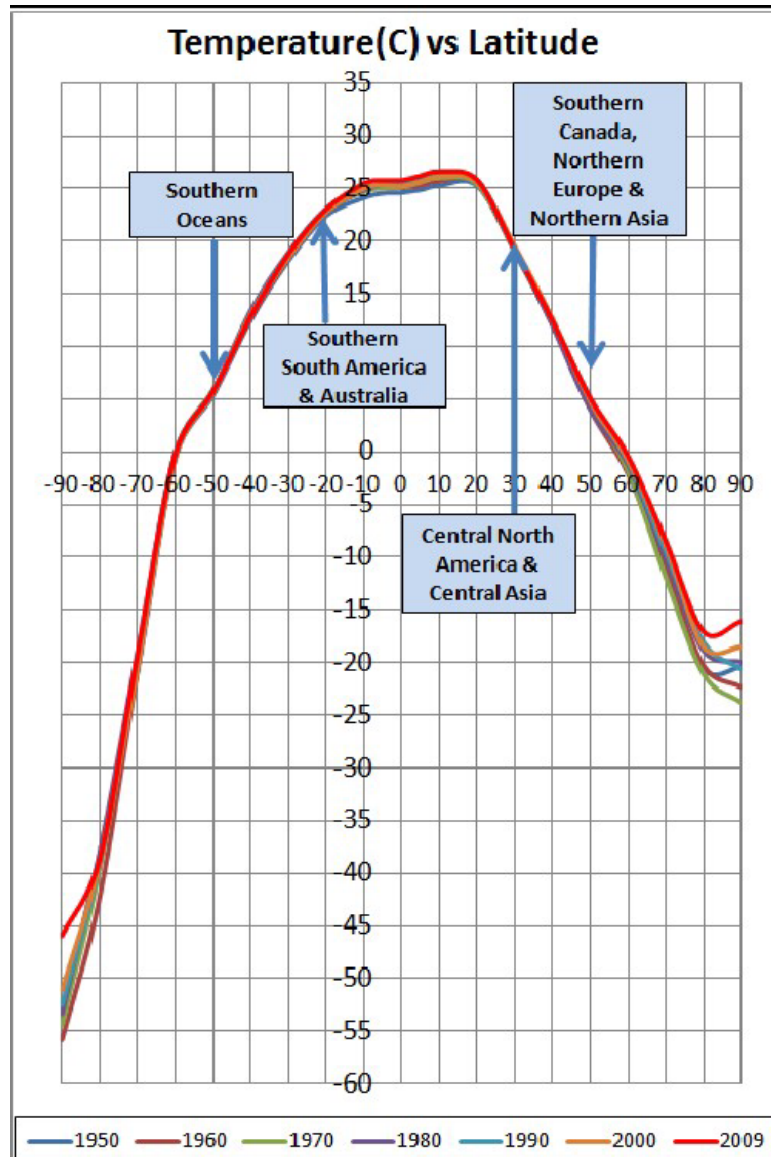
**FOPs**



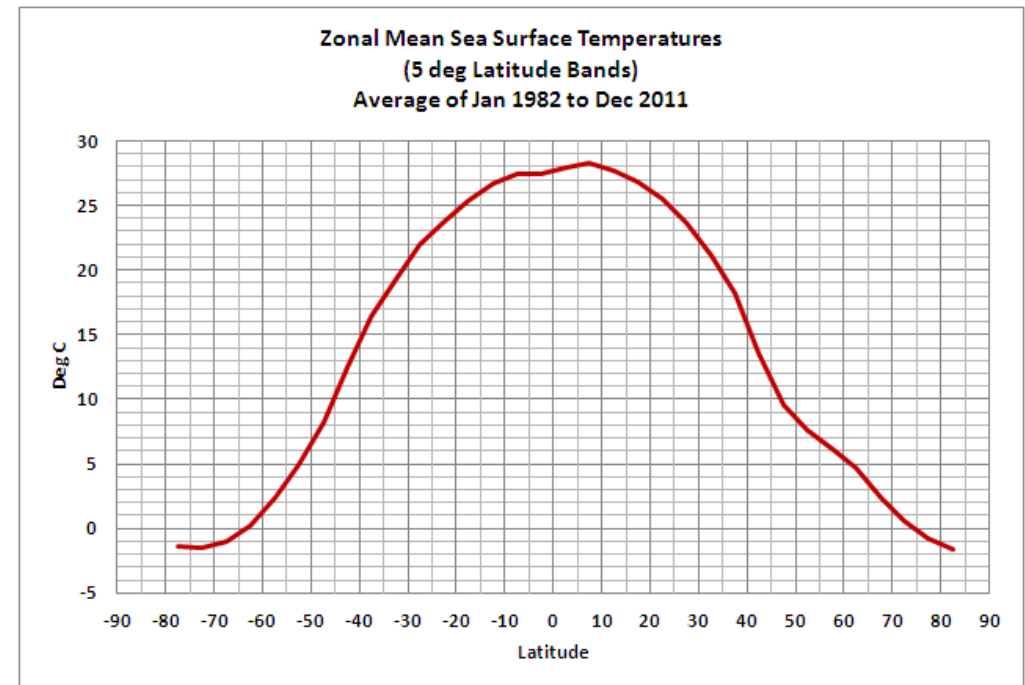




## Air temperature

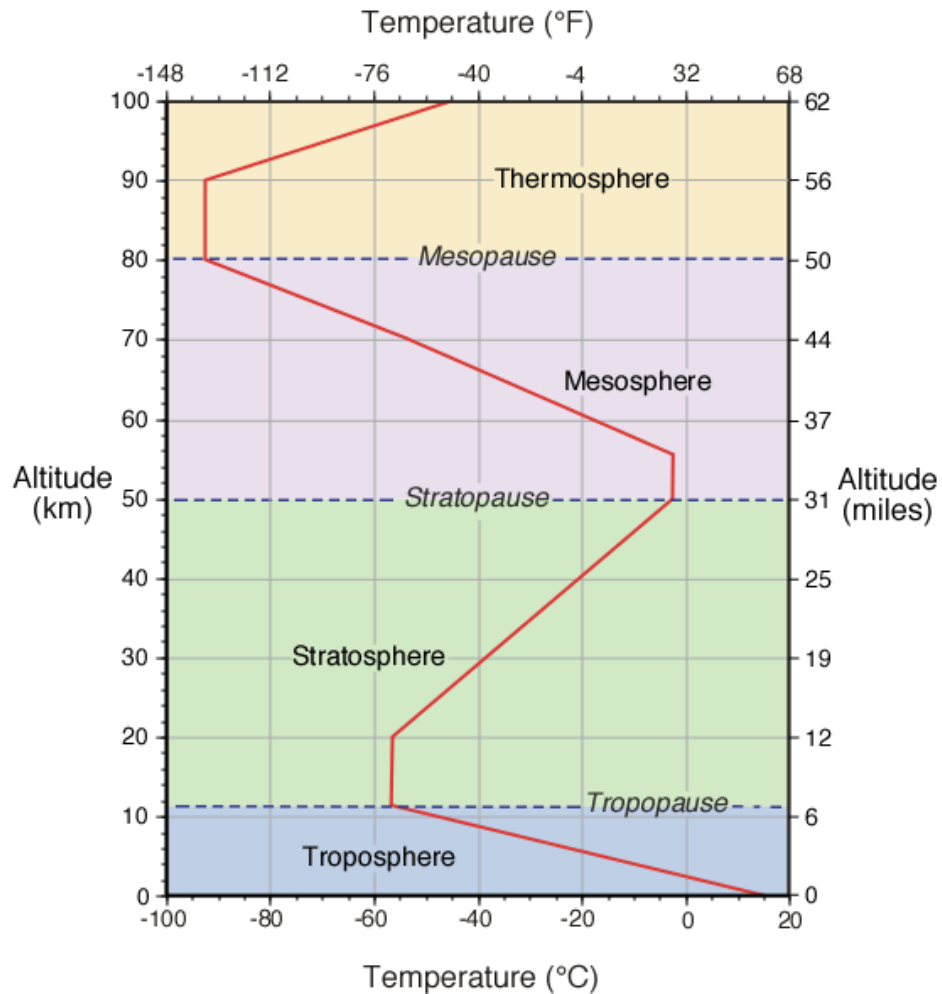


## Sea temperature

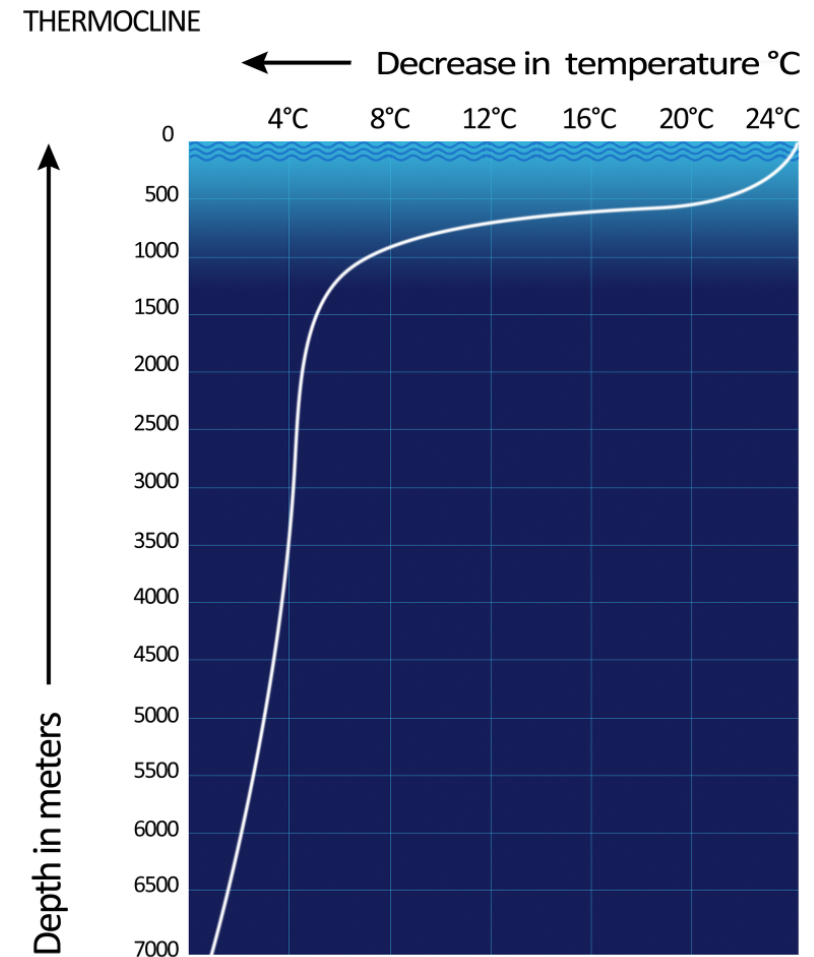




## Air temperature



## Sea temperature

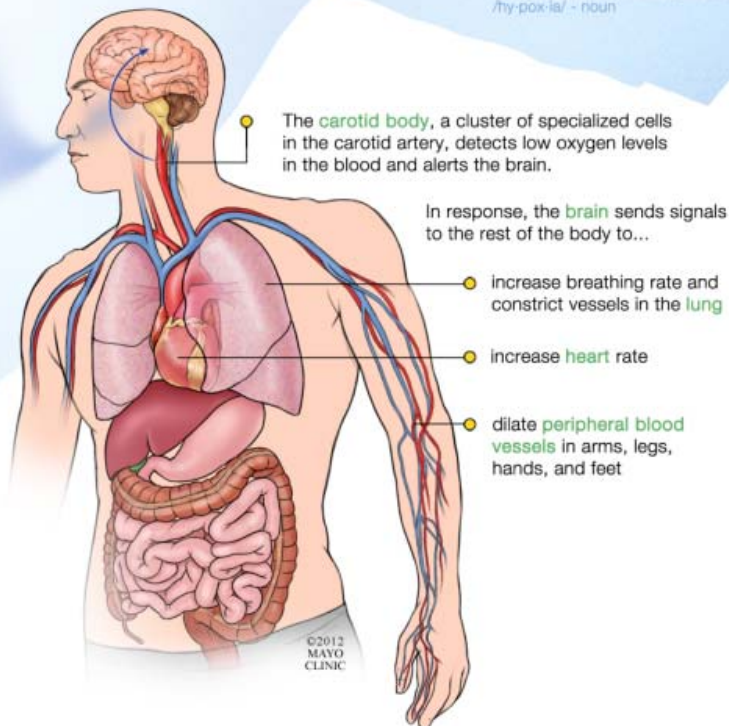




## Effects of Hypoxia (hi-pok'se-ah)

: a condition in which the body as a whole or a region of the body is deprived of adequate oxygen supply.  
/ty-pox-ia/ - noun

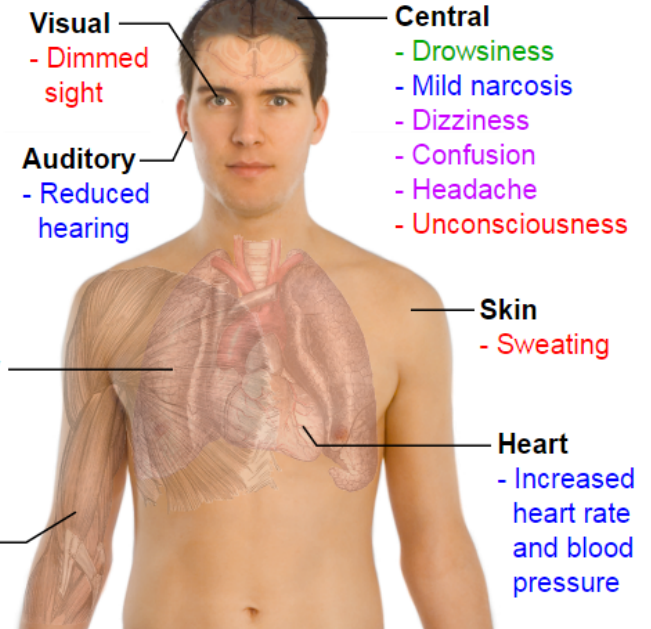
Low oxygen pressure at high altitude



## Main symptoms of Carbon dioxide toxicity

Volume %  
in air

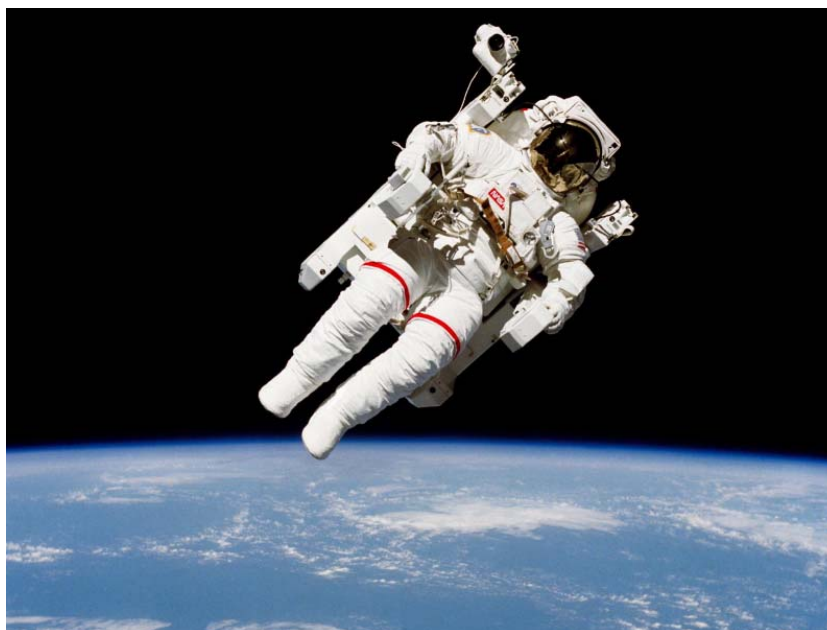
- - 1%
- - 3%
- - 5%
- - 8%





# Noise and silence

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- 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**.



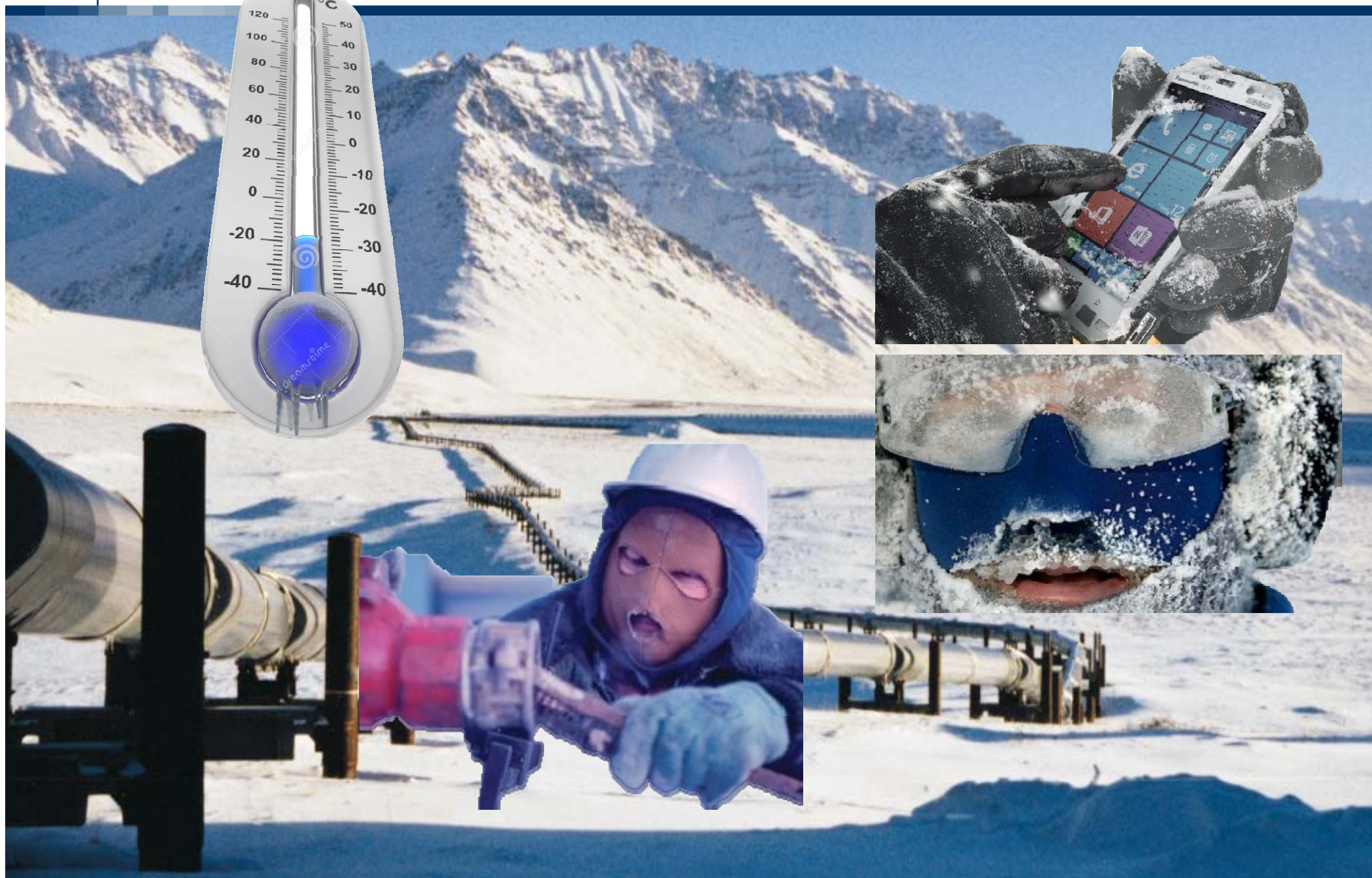






# Extreme operations

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## 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







## Basic features:

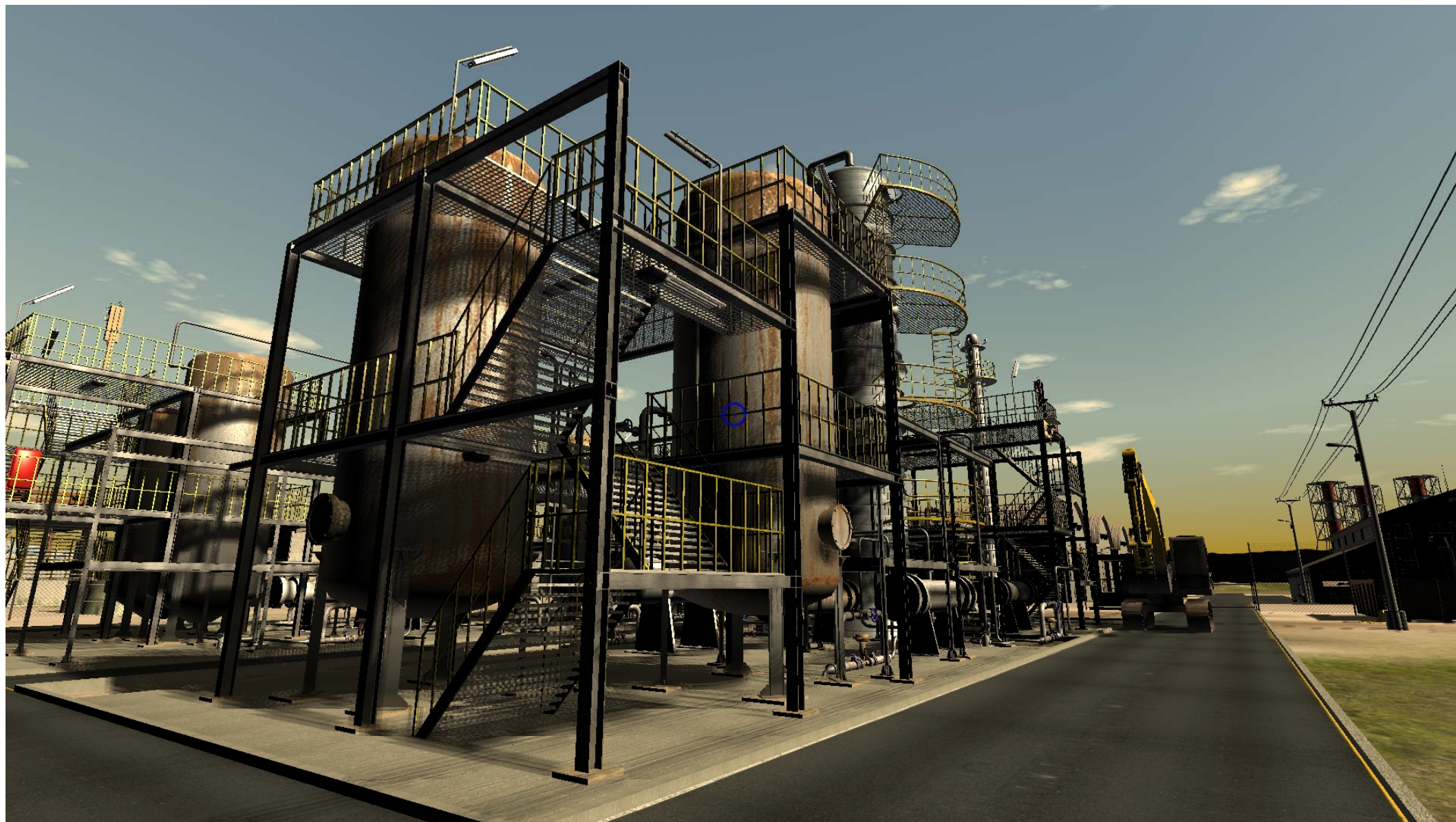
- 3D immersive and stereoscopic Virtual Reality
- 3D sounds effects
- Augmented virtual reality



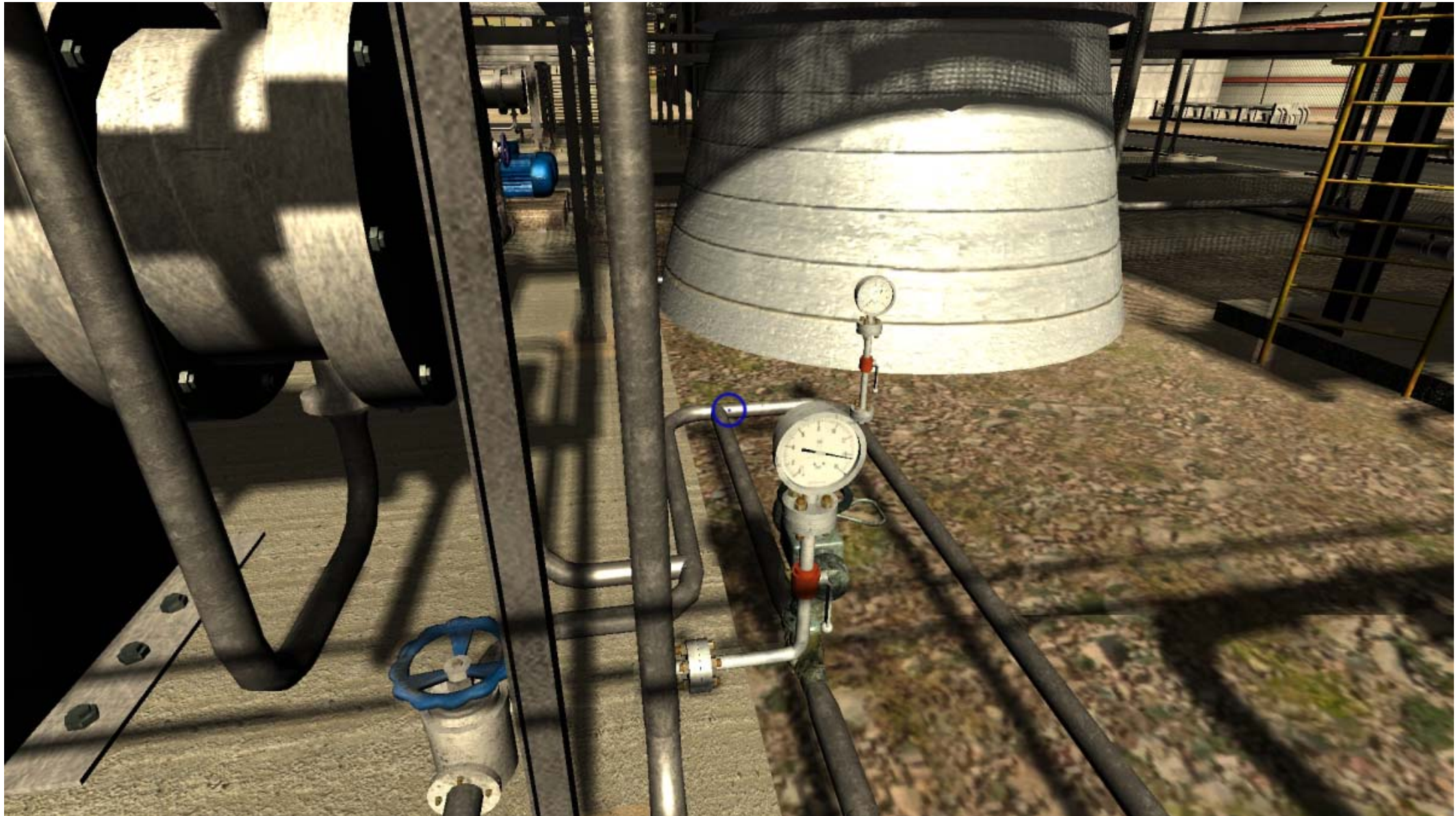


# 3D immersive and stereoscopic VR

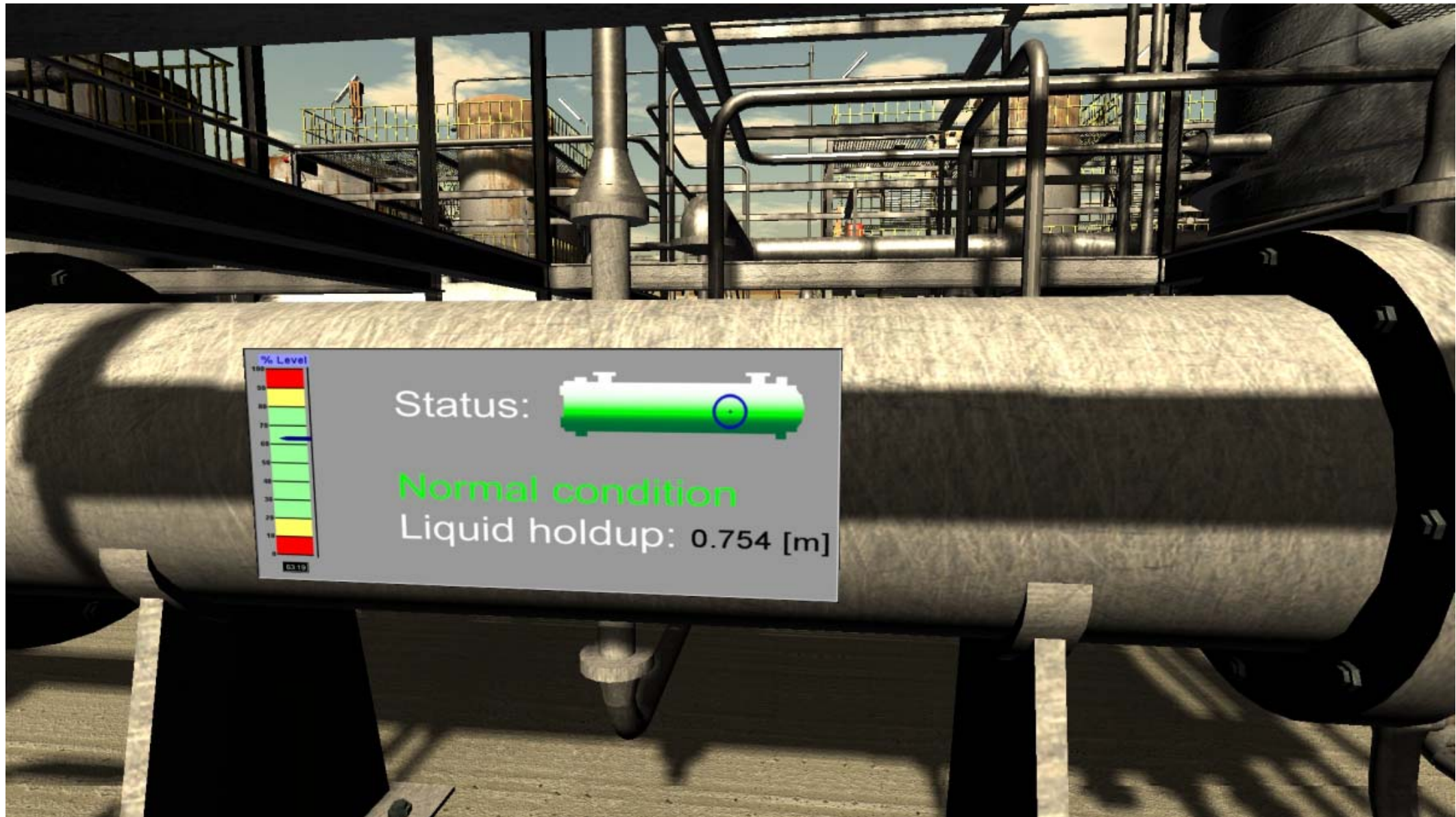
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## Advanced features:

- 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

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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.





## **TOWARDS THE AUTOMATIC MEASUREMENT OF HUMAN PERFORMANCE IN VIRTUAL ENVIRONMENTS FOR INDUSTRIAL SAFETY**

S. Colombo, D. Manca, S. Brambilla, R. Totaro, R. Galvagni

Proceedings of the ASME 2011 World Conference on Innovative Virtual Reality, WINVR 2011, June 27-29, 2011, Milano, Italy, 67-76, (2011)

<http://dx.doi.org/10.1115/WINVR2011-5564>

## **PERFORMANCE INDICATORS FOR TRAINING ASSESSMENT OF CONTROL-ROOM OPERATORS**

D. Manca, S. Nazir, S. Colombo

Chemical Engineering Transactions, **26**, 285-290, (2012)

<http://dx.doi.org/10.3303/CET1226048>

## **THE ROLE OF SITUATION AWARENESS FOR THE OPERATORS OF PROCESS INDUSTRY**

S. Nazir, S. Colombo, D. Manca

Chemical Engineering Transactions, **26**, 303-308, (2012)

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Computer Aided Chemical Engineering, **30**, 1422-1426, (2012)

<http://dx.doi.org/10.1016/B978-0-444-59520-1.50143-3>





## **VIRTUAL REALITY AND AUGMENTED-VIRTUAL REALITY AS TOOLS TO TRAIN INDUSTRIAL OPERATORS**

S. Nazir, R. Totaro, S. Brambilla, S. Colombo, D. Manca

Computer Aided Chemical Engineering, **30**, 1398-1401, (2012)

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## **USE OF VIRTUAL REALITY FOR ANTICIPATION AND REDUCTION OF RISKS IN PROCESS INDUSTRY**

S. Nazir, S. Colombo, D. Manca

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## **TOWARDS HOLISTIC DECISION SUPPORT SYSTEMS. INCLUDING HUMAN AND ORGANIZATIONAL PERFORMANCES IN THE LOOP**

S. Colombo, S. Nazir, D. Manca

Computer Aided Chemical Engineering, **31**, 295-299, (2012)

<http://dx.doi.org/10.1016/B978-0-444-59507-2.50051-2>

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## **PERFORMANCE COMPARISON OF DIFFERENT TRAINING METHODS FOR INDUSTRIAL OPERATORS**

S. Nazir, A. Gallace, M. Bordegoni, S. Colombo, D. Manca

Human Factors and Ergonomics Society, Europe Chapter Annual Meeting 2012, October 10-12, 2012 Toulouse, 1.3, 1-19, (2012)

## **BRIDGING BETWEEN VIRTUAL REALITY AND ACCIDENT SIMULATION FOR TRAINING OF PROCESS-INDUSTRY OPERATORS**

D. Manca, S. Brambilla, S. Colombo

Advances in Engineering Software, **55**, 1-9, (2013)

<http://dx.doi.org/10.1016/j.advengsoft.2012.09.002>

## **A PLANT SIMULATOR TO ENHANCE THE PROCESS SAFETY OF INDUSTRIAL OPERATORS**

D. Manca, S. Colombo, S. Nazir

SPE European HSE Conference and Exhibition 2013: Health, Safety, Environment and Social Responsibility in the Oil and Gas Exploration and Production Industry; London; United Kingdom; 16 April 2013 through 18 April 2013; Code 98713, ISBN 978-162748284-4, 394-404, (2013)

<http://dx.doi.org/10.2118/164992-MS>

## **VIRTUAL REALITY AS EFFECTIVE TOOL FOR TRAINING AND DECISION-MAKING: PRELIMINARY RESULTS OF EXPERIMENTS PERFORMED WITH A PLANT SIMULATOR**

S. Colombo, S. Nazir, D. Manca

SPE European HSE Conference and Exhibition, 405-416, (2013)

<http://dx.doi.org/10.2118/164993-MS>



## **MINIMIZING THE RISK IN THE PROCESS INDUSTRY BY USING A PLANT SIMULATOR: A NOVEL APPROACH**

S. Nazir, S. Colombo, D. Manca

Chemical Engineering Transactions, **32**, 109-114, (2013)

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## **TESTING AND ANALYZING DIFFERENT TRAINING METHODS FOR INDUSTRIAL OPERATORS: AN EXPERIMENTAL APPROACH**

S. Nazir, S. Colombo, D. Manca

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<http://dx.doi.org/10.1016/B978-0-444-63234-0.50112-3>

## **CAN IMMERSIVE VIRTUAL ENVIRONMENTS MAKE THE DIFFERENCE IN TRAINING INDUSTRIAL OPERATORS?**

S. Nazir, A. Kluge, D. Manca

Human Factors: a view from an integrative perspective. Proceedings HFES Europe Chapter Conference, Turin, 251–265, (2013)

## **EXPERIMENT-BASED DECISION MAKING IN COMPLEX SYSTEMS**

S. Colombo, S. Nazir, A. Gallace, D. Manca

Chemical Engineering Transactions, **36**, 85-90, (2014)

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## **PROCEDURE FOR AUTOMATED ASSESSMENT OF INDUSTRIAL OPERATORS**

D. Manca, S. Nazir, S. Colombo, A. Kluge

Chemical Engineering Transactions, **36**, 391-396, (2014)

<http://dx.doi.org/10.3303/CET1436066>

## **HOW DISTRIBUTED SITUATION AWARENESS INFLUENCES PROCESS SAFETY**

S. Nazir, L.J.Sorensen, K.I. Overgård, D. Manca

Chemical Engineering Transactions, **36**, 409-414, (2014)

<http://dx.doi.org/10.3303/CET1436069>

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S. Nazir, A. Kluge, D. Manca

Computer Aided Chemical Engineering, **33**, 889-894, (2014)

<http://dx.doi.org/10.1016/B978-0-444-63456-6.50149-6>



## **DISTRIBUTED SITUATION AWARENESS OF INDUSTRIAL OPERATORS: MODELS AND MEASUREMENT METHODS**

S. Nazir, L. Sørensen, K. Ivar Øvergård and D. Manca

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## **IMMERSIVE VIRTUAL REALITY FOR DECISION MAKING IN PROCESS INDUSTRY: EXPERIMENT RESULTS**

S. Colombo, S. Nazir, D. Manca

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Safety Science, 73, 136–145, (2015)

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S. Nazir, P.V.R. Carvalho, K.I. Overgard, J.O. Gomes, M.C.R. Vidal, D. Manca

Chemical Engineering Transactions, 43, 1993-1998, (2015)

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## **SPACE VS. CHEMICAL DOMAINS: VIRTUAL AND REAL SIMULATION TO INCREASE SAFETY IN EXTREME CONTEXTS**

I.L. Schlacht, S. Nazir, D. Manca

Procedia Manufacturing, 3, 1817-1824, (2015)

<http://dx.doi.org/10.1016/j.promfg.2015.07.221>



# Training Simulators for Extreme Environments



## Thank you for your attention

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