HELMHOLTZ ZENTRUM
DRESDEN ROSSENDORF

Virtual and Augmented Reality Methods in Firefighter and Rescue Personal Training

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112 FEUERWEHR DRESDEN

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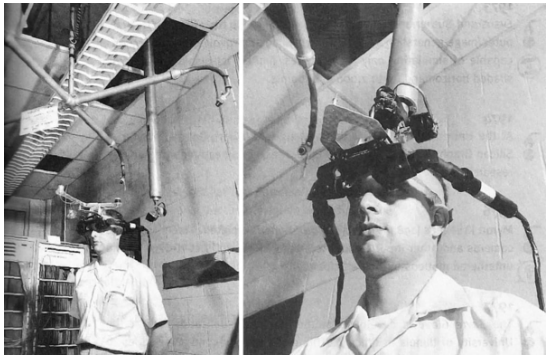
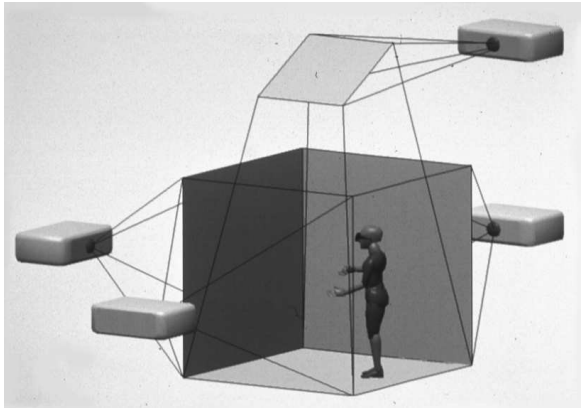
Topics

- VR everyone speaks about, but what is it?
- Some aspects of firefighting and rescue service
- Training - do it the classical or in a "modern" way?
- How to do it in VR, AR, XR
  - requirements
  - incident command training
  - mass casualty incident / triage training
  - CBRN
  - real fire fighting
  - ...
- Conclusion

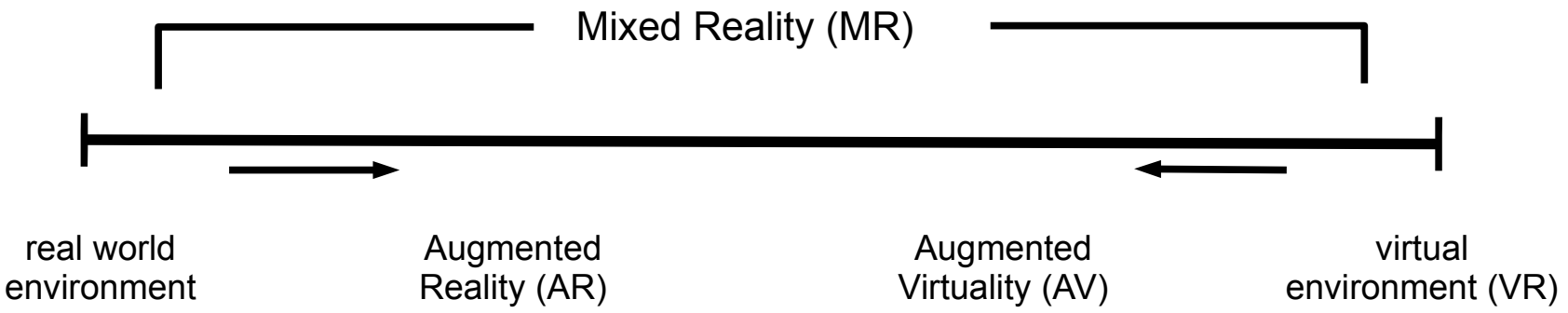
VR? What is it?

- It's not new!
- first example: Ivan Sutherland, 1966
  - see-through-display
  - data glove
- first mentioned, "Neuromancer", W. Gibson, 1984
- "Cyberspace: First Steps", Benedikt, 1991
- The CAVE: "Cave Automatic Virtual Environment", C. Cruz-Neira, 1992





VR? What is it?

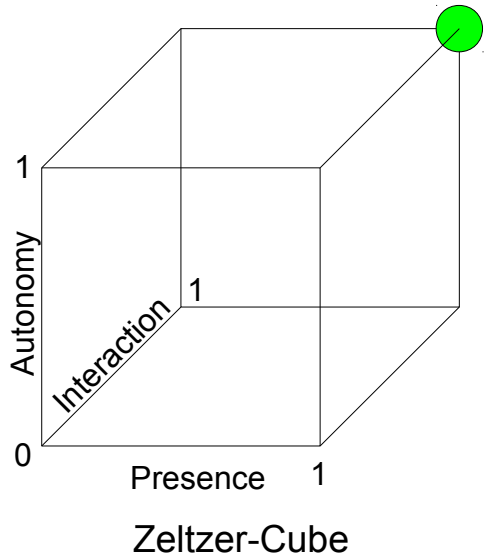


Reality-Virtuality-Continuum (RV)

- real environment ("the obvious"):
  the "*real*" world as perceived by human senses
- Augmented Reality (AR):
  computer generated *Extension* of real world perception
- Augmented Virtuality (AV):
  Integration of real objects into a virtual world
- Virtual Reality (VR):
  presentation and perception of *computer generated „reality“*

VR? What is it?

- VR does not only mean "VR-googles"!
- *Presence*: the user shall perceive the virtual world as if it would be the real one
- *Interaction*: the user shall be able to interact with objects living in the virtual world
- *Autonomy*: objects shall behave independent of the users state but according to rules
- best known implementation:
  The "Holodeck" as kown from NCC-1701
  → This is no longer fiction!
  → Cave Automatic Virtual Environment; CAVE (1992!)



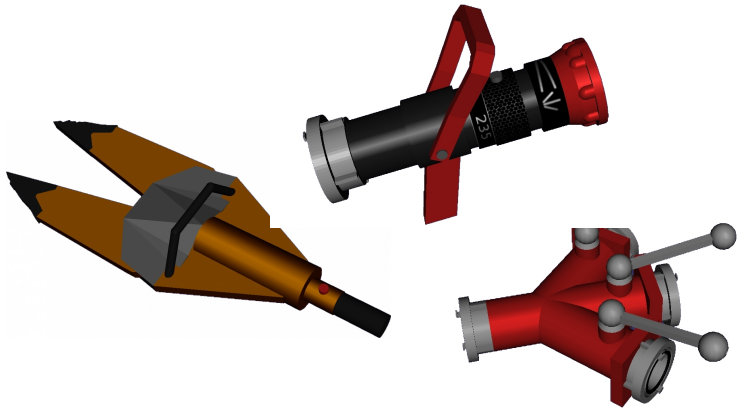
Zeltzer-Cube

Some aspects of firefighting and rescue service

- rescue: eliminate direct/current threats for life and health
- extinguish: more general eliminate threats, includes classic "extinction" of fire as well as fighting hazards imposed by CBRN
- recover: eliminate direct/current threats to non-living objects
- protect: protect non affect person/objects from beeing affected by threats

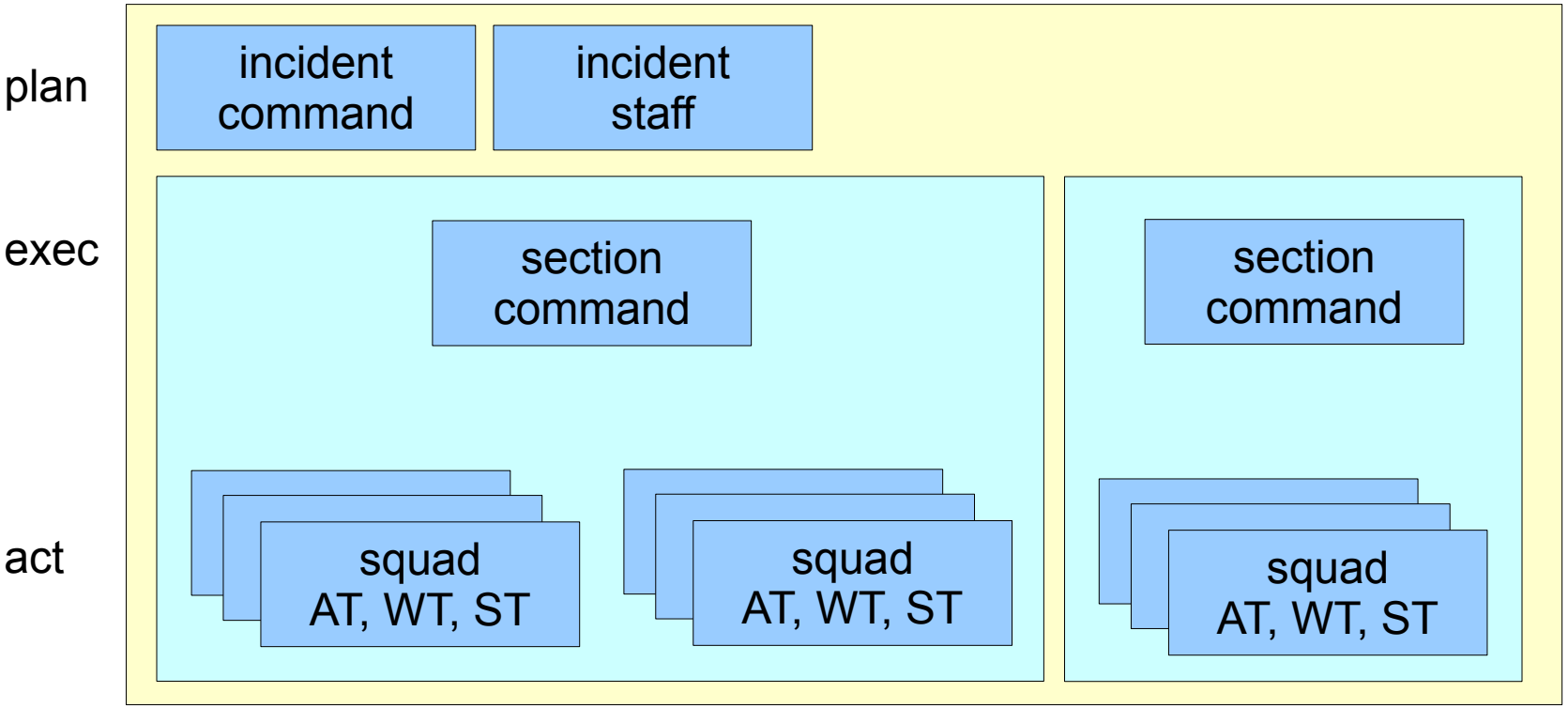
Some aspects of firefighting and rescue service

- hardware
  - pumps, tubes, divider, nozzles, ...
  - spreader/cutter, Halligan-Tool, ...
  - ELW, LF, TLF, HLF, DLK, AB *, ...
  - ...
- personal, hierarchical organisation
  - squad (min. 2, TF, TM)
  - squadron (6, 1 * command)
  - group (9, 1 * command)
  - subunit (german: "Löschzug",
    typ. ELW, 2 * TLF, 1 * DLK, 4 * command)
  - ...



Some aspects of firefighting and rescue service

- different levels of planning/executing/acting
  - the more up the more abstract
  - the more down the more practical

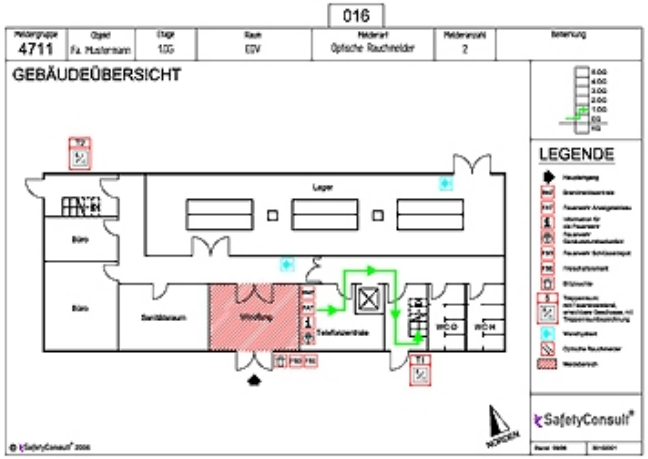


The classical way or the "modern" approach?

	classical (map exercise)	classical exercise	VR/AR/XR
	map exercise plane	real hardware	Computer, Projektor, Monitor, Head Mounted Display, ...
advantages	simple to realize	real handling real feed-back	ego-perspective flexible dynamic evolution no limitation no presence required
disadvantages	no ego-perspective not very flexible no dynamic evolution limited number of part. presence required	limited flexibility limited dynamic evolution limited number of part. presence required	higher technical effort

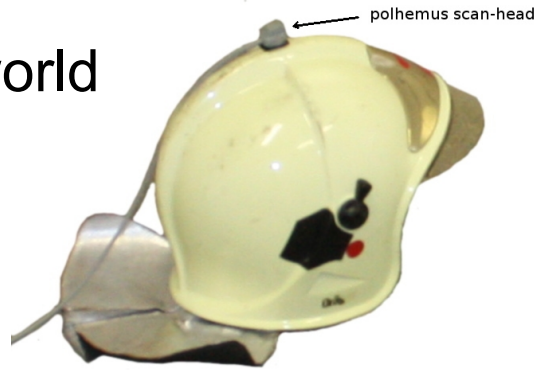
Requirements: a virtual world / presence

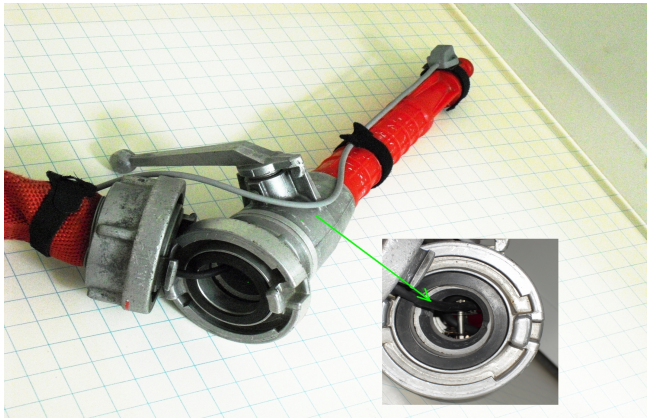
- statics objects
  - buildings, rooms, interior
  - obtain from CAD, 3D scan, ...
- dynamic objects
  - state changes over time
  - typical: person, fires, cars, ..
  - programming required



Requirements: interaction

- position and orientation in the virtual world
  - virtual walking model
  - with modern devices mapping of physical and virtual coordinates
- hand base interaction
  - data glove or virtual hands (LEAP)
- other input devices, e.g. nozzle, radio with PTT button





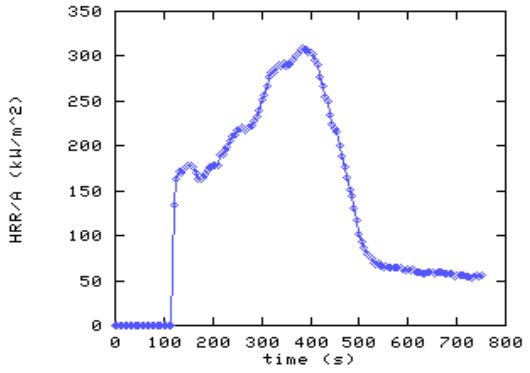
Requirements: autonomy

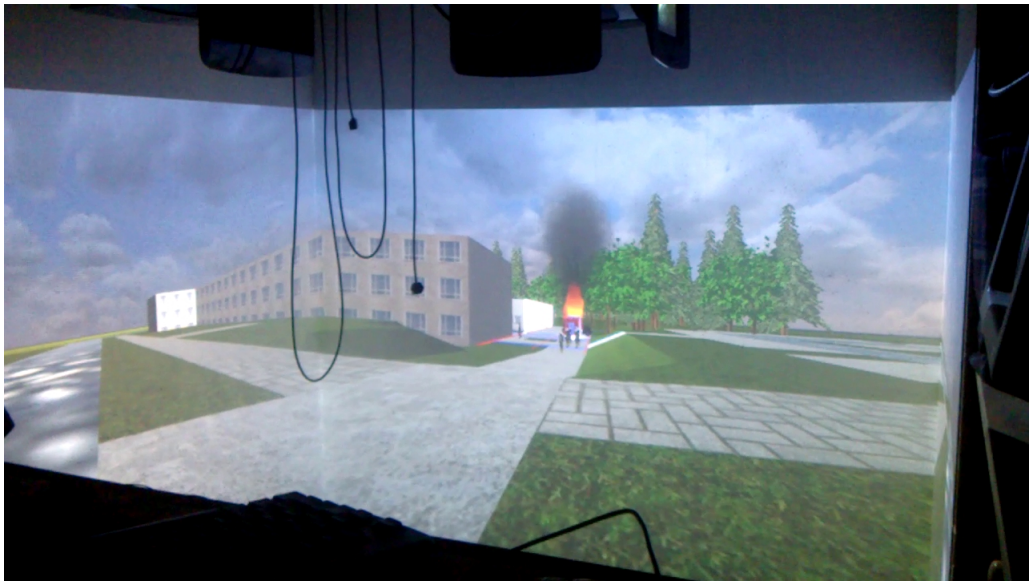
- Behaviour of a fire is described by physics:

$$\dot{q}_F = \dot{m} \cdot \Delta H_c$$

- visual feedback (Heskestad, 1995)

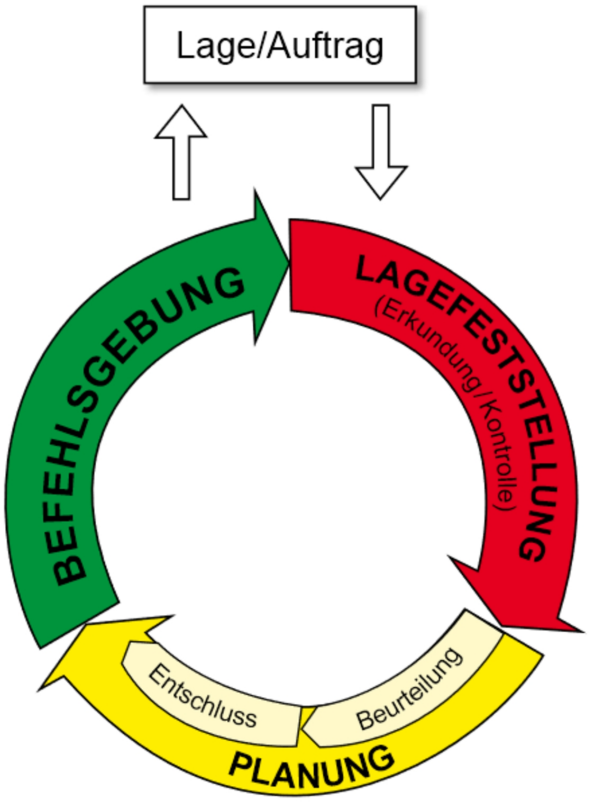
$$h_F = 0.235 \cdot HRR^{2/5} - 2.04 \cdot r_F$$



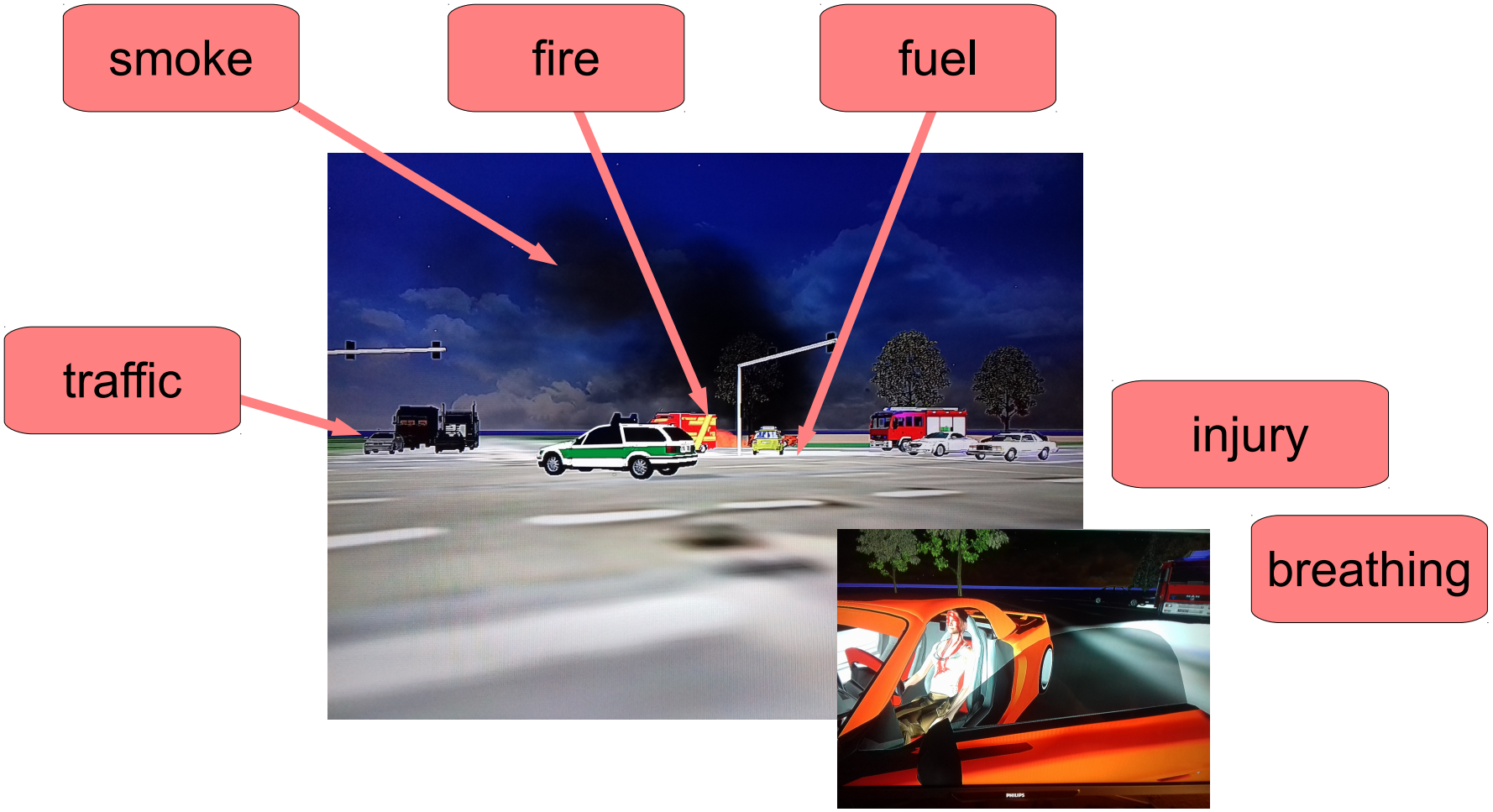


Incident Command Training

- forces are organized hierarchically
  - action forces: act
  - executive forces: plan and lead
- "Führungsvorgang"
  - guideline/algorithm for execution
- requirement for training
  - situation report (visual, audio, ...)
  - presentation of forces and instruments
  - realization of decision (interaction)
- VR is de facto standard in training and education here



Incident Command Training



MANV: mass casualty incident / triage training

- not enough ressource to treat all patients adequate,
  typ. situation: railway incident, plane crash, terror attack
- triage required, 5 categories, 3 of relevance
  - SK-I : immediate treatment, e.g. CPR required
  - SK-II : urgent treatment, no CPR required, but serious inj.
  - SK-III : deferred treatment, can walk
- strategy: "find the red ones", from center to periphery
- psychologically demanding!
- algorithmic/tactical approach
- intense training required, happens once in life time of ff/resc.

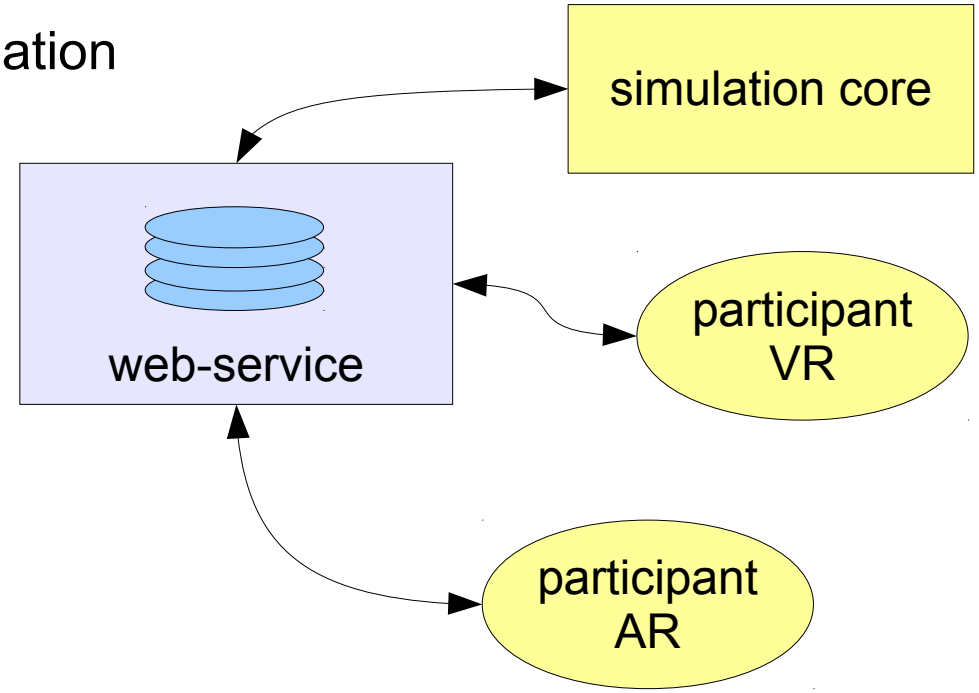
MANV

- cooperation with the Fire Department of Dresden
- setup of scenario
  - high grade of presence required; detailed presentation of injuries, "natural" behaviour e.g. crying
  - interaction is mandatory;
    - pulse and breath check
    - medical treatment e.g. application of Oropharyngeal airway (Güdel Tubus)
    - has to be "natural" - no controlers!

  - autonomy: state change on interaction; e.g. move to duty point
- collaboration of forces (trainees)
- collaboration with external ressources, e.g. hospitals

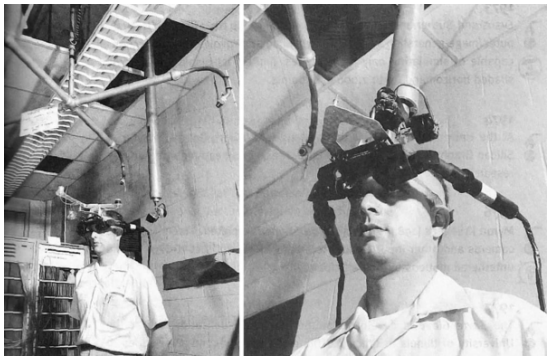
MANV

- data model for forces and instruments
- data model for patients (parameters of metabolism)
- scenario database
- web service for synchronisation
  - contains simulation core
- mixed VR/AR approach
- participants using application written with Unity3D and Openscengraph



Intermission: Augmented Reality

- extensions of the real world
  by virtual, computergenerated aspects
- as seen at start: "see-through display",
  Ivan Sutherland 1966 (sic!)



virtual object

Intermission: Augmented Reality

- real world
- natural interaction with virtual objects
- trainees do not need to leave their accustomized environment

overlay in the real world

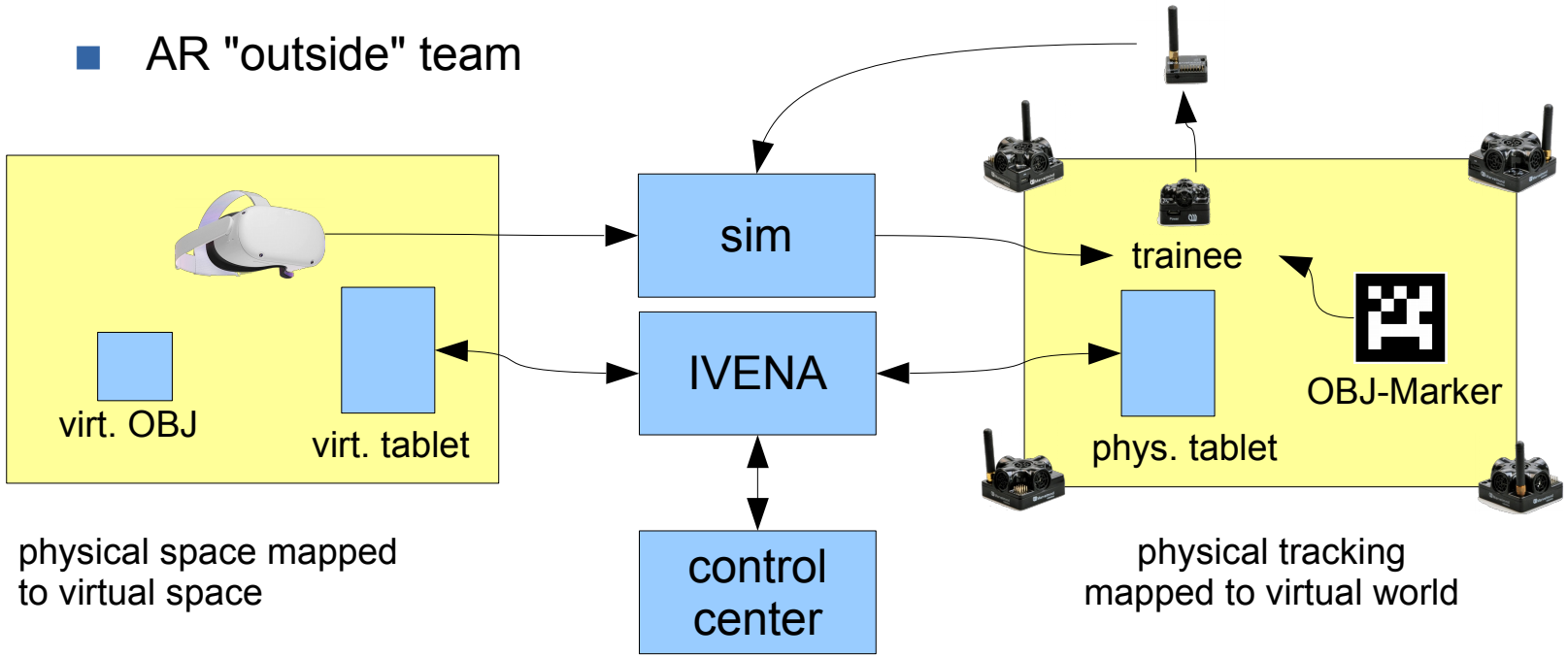
multi gas detector

dose rate measurement

- outdoor-tracking → mapping into virtual world

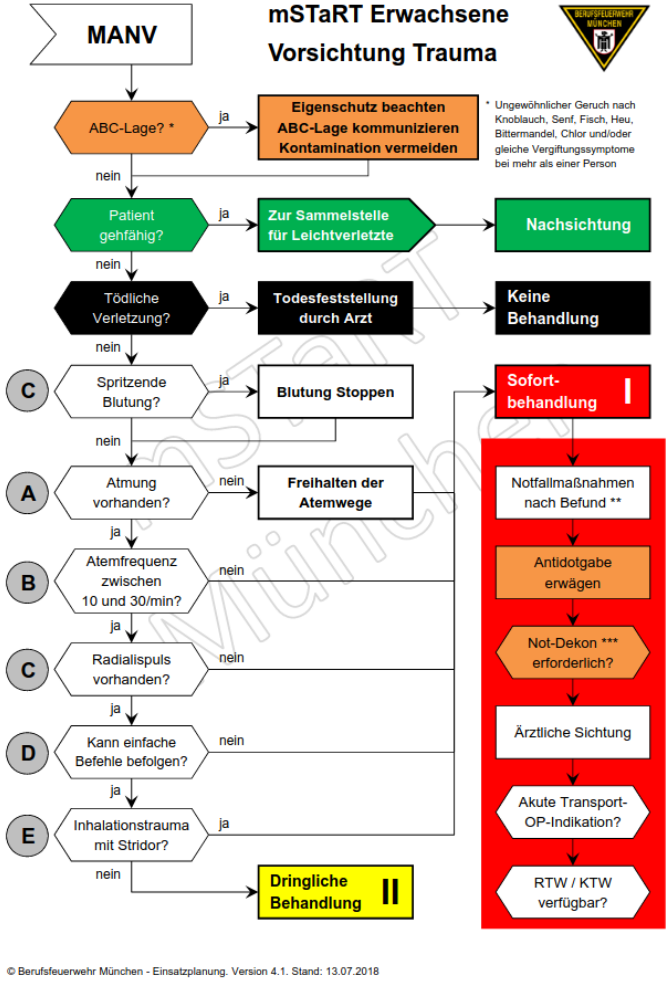
MANV

- proof of concept at the Long Night of Science 2022
- mixed reality setup
  - immersive VR lecture hall team
  - AR "outside" team



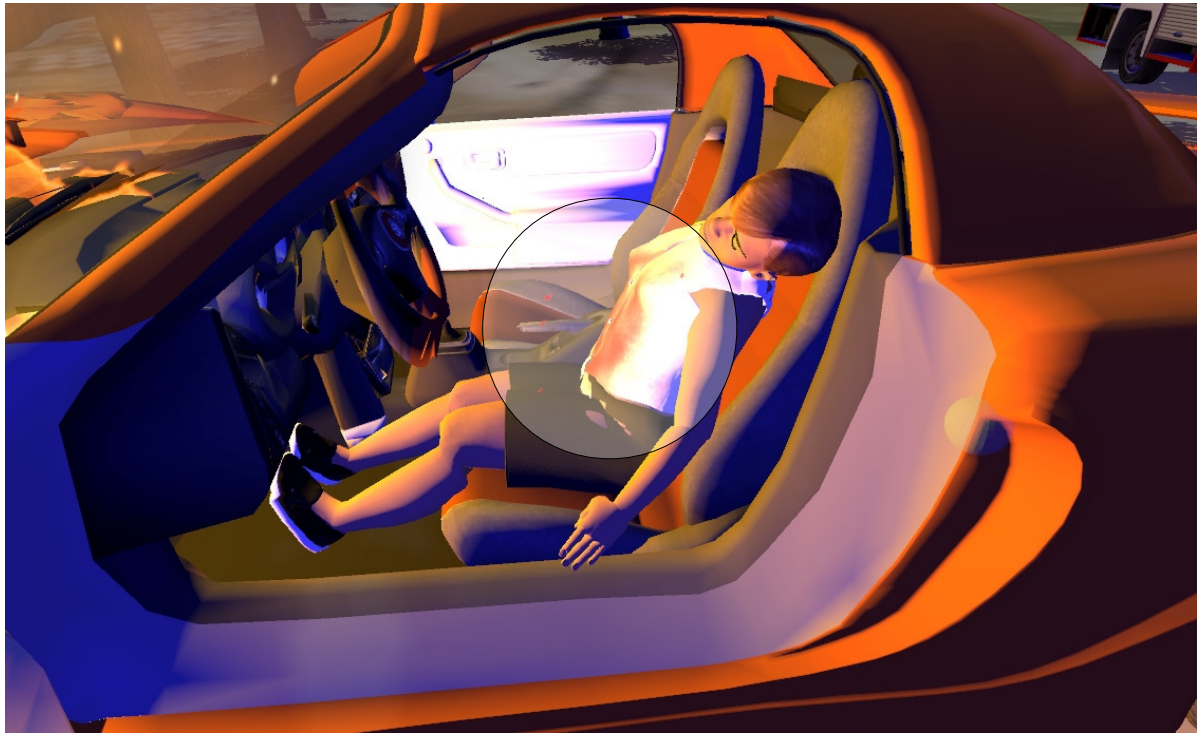
MANV - mStaRT

- algorithm for rapid categorization
- check, if patient can walk
  - defined by parameter
  - check activated on approach



MANV - mStaRT

- representation of injuries "as natural as possible"
  - e.g. blunt abdominal trauma with sputtering hemorrhage
  - sure, no real blood will come out of the screen ;-)



MANV - mStaRT

- checking vital parameters, pulse and breathing
  - tech: collider for hand interaction, optical feed-back
  - haptic feed-back would be possible but requires a glove to be worn

interaction volumes

feedback
- frequency
- Δ ~ strength

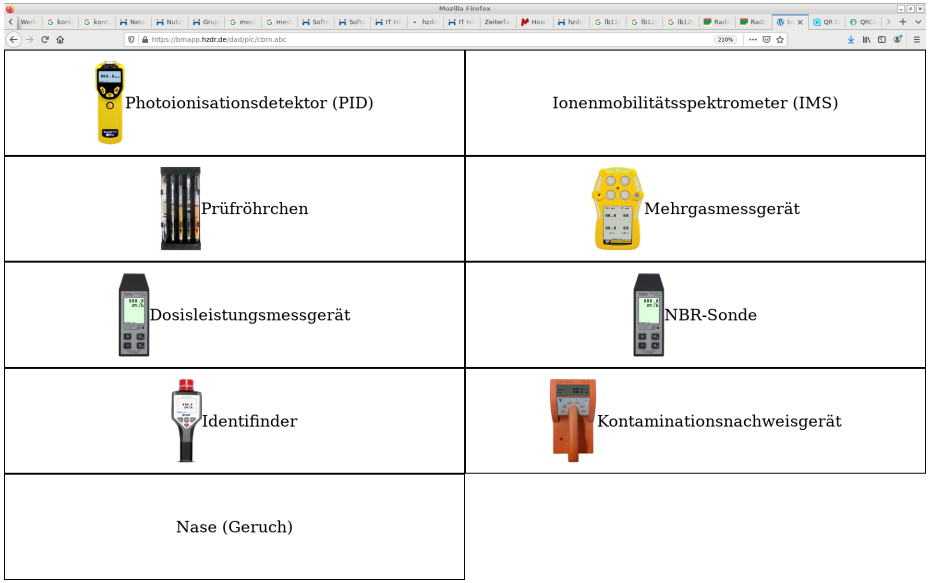
MANV - mStaRT

- IVENA MANV - mainis IT-Service GmbH
  - patient registration system, will be introduced in Dresden within the next two years
  - implements
    - triage algorithms (e.g. mStaRT)
    - assignment of rescue elements
    - registration at hospital
- API available, Unity3D module by trainee of HZDR as final theses

- virtual tablet with "virtual" IVENA implemenation
- behaves exactly like the real tablet but using virtual hands
- combined training possible (see proof of concept at LNdW)

CBRN training - AR approach

- in cooperation with the firefighters school of Nordrhein-Westfalen (IdF Münster)
- web based application implementing all standard sensors used by CBRN scouts
- device (cellphone) sends GPS position to web service
- web-service interpolates on (currently) pre-computed data and sends data back to device



CBRN training - VR approach

- implemented with "Firesim"
- to be trained
  - detection of line of safety (≤ 25 µSv/h)
  - localization of sources
- measuring a dose rate
  - source define by activity and isotop
  - computation of dose rate by DCF, depends on isotop, geralized to 2.2 • 10-8 Sv/Bq
- superposition on sources
- no shielding

$$H = \sum DCF_i \cdot \frac{A_i}{\left\| \underline{x}_S - \underline{x}_i \right\|^2}$$

The real hot stuff - firefighting

- only possible as approximation
  no option to replace real fire training
- computing a fire is very complex, usually precise with CFD methods only (NIST FDS), long computation times
- first approaches for real time computations in games (Ch. Niemand, Univ. of Kassel)
- simplified model (zone model)
  - heat release rate (~ mass loss rate)

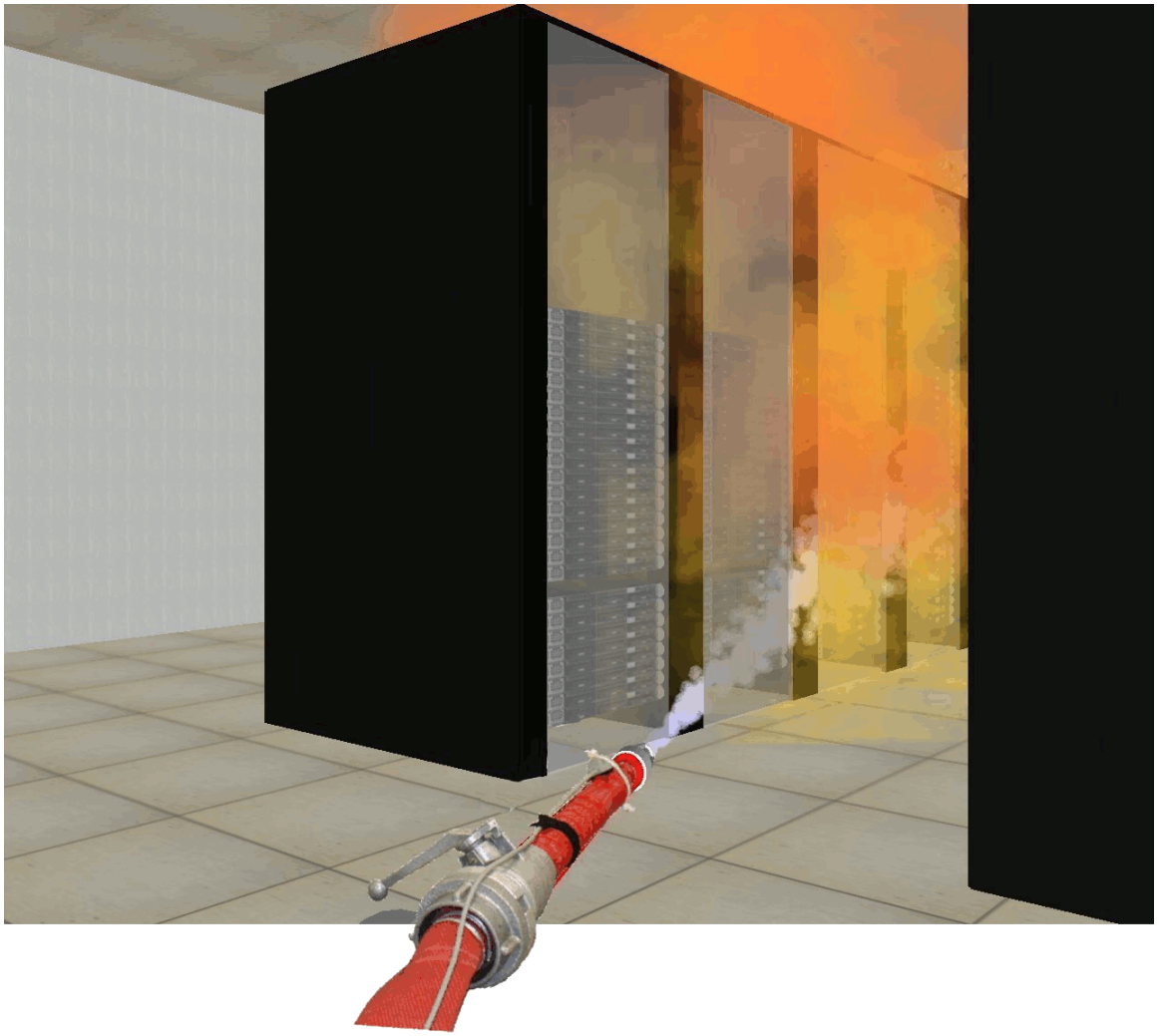
$$\dot{q}_F = \dot{m} \cdot \Delta H_c$$

  - simple energy equation
    for cooling by water

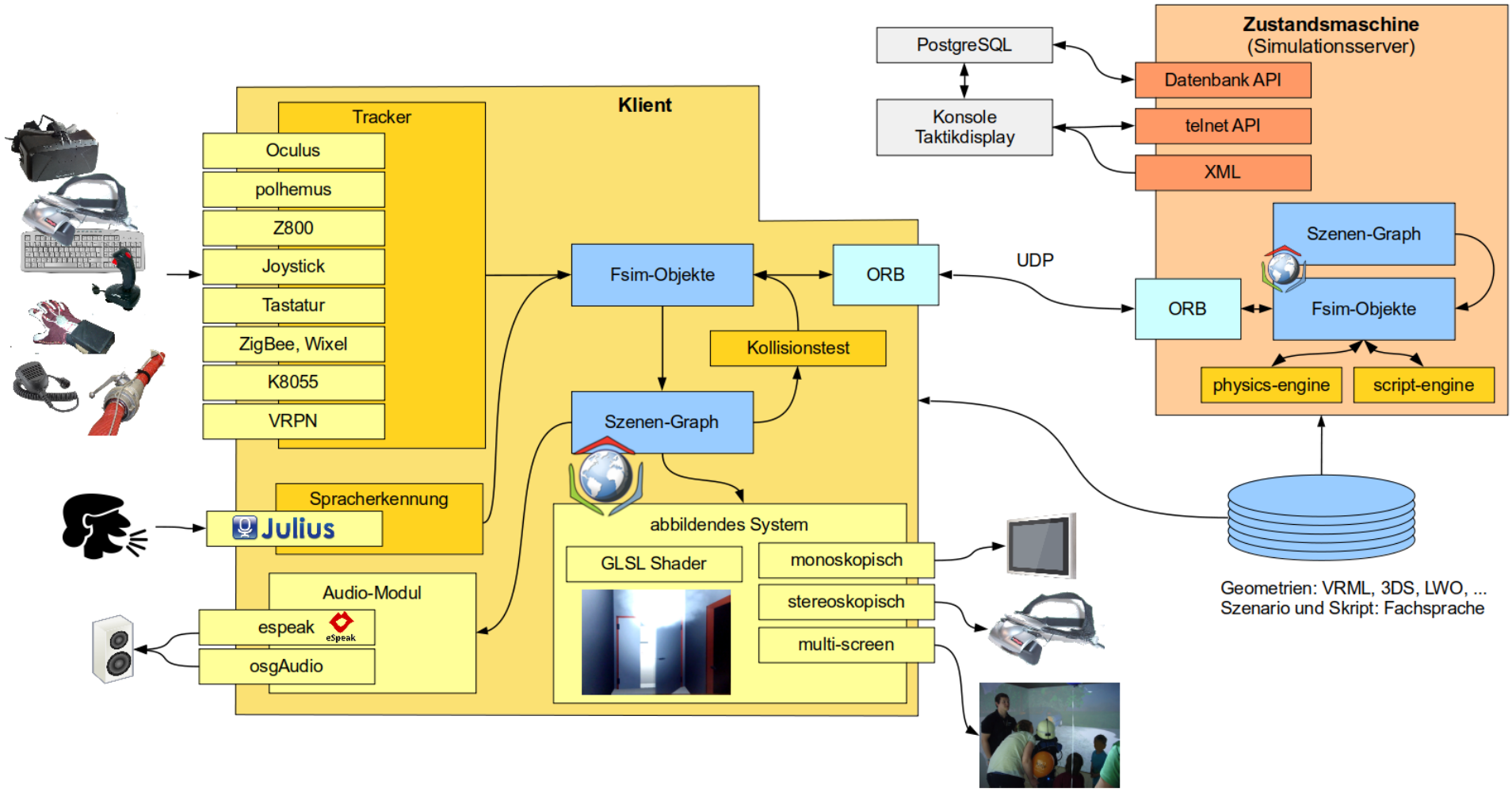
$$\dot{q}_L(t) = C_L \cdot S_L(t) \cdot S_F(t) \cdot I_L(t) \; ; S_F(t) = \frac{A_{FL}}{A_L}$$

  - full computation of system from the source(s) to the nozzle to the fire (including trajectory of water jet from the nozzle)

The real hot stuff - firefighting



and there is much more ...



Conlusion - *R, is it in use?

- as shown training of firefighter and rescue services by support of XR technologies is possible since the 60's
  - Why wasn't it introduced earlier?
    → Because of missing implementations and costs.
- Where is it used today?
  - for incident command training at the firefighter schools
  - right now, starting at the (local) fire departments for the other objectives, namely here for triage training: City of Dresden and City of Munich

More cooperations and applications

- VR experiment on radio activity, DeltaX (still available but dismounted)
  - simulation of dose rate measurement with α- und β-schielding
- BMApp - FW Tableau BMA;
  IdF NRW, HZDR, safety innovation center Paderborn, Hochschule Magdeburg-Stendahl
- CBRN-Reconnaissance
  HZDR, IdF NRW (Münster)
  - virtual detectors for different indicators
- AR-situation presentation by QR tags;
  HZDR, BF Dresden

Try it yourself ...