TECHNOLOGY IN SIMULATION
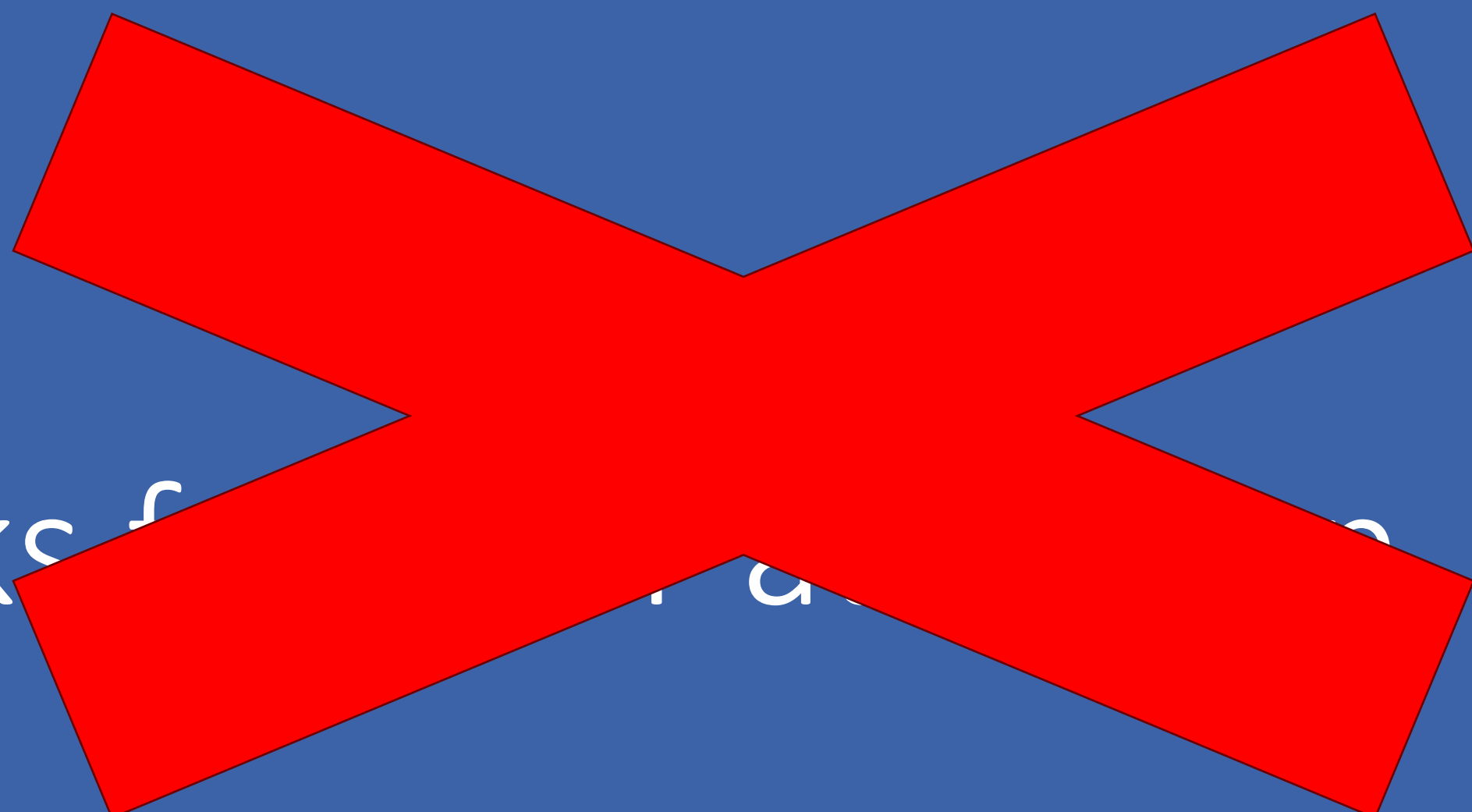
Sandro Savino

Simulation is a technique and not a technology!

Thanks for your attention

Thanks f...

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Actually…

Our aim

Technology plays
an important role
in simulation and
we need to know
how to control it!

- In the next hours to talk about the technology used in simulation

- It's a lot

- It doesn't seem easy

...but I am confident we can make it, so please bear with me !!

Technology plays an important role:

BEFORE THE SIMULATION

- To plan the simulation
  - To understand what we need to prepare ahead and what we will use during the simulation (internet, batteries, ac, …)
- To buy things
  - To understand what are the features and what are the limitation

DURING THE SIMULATION

- To make the manikins / simulators work
- To let us control the manikins / simulators
- To communicate with the federates and those in the simulation
- To record / stream the simulation

Technology comes into play:

IN THE SIMULATION ROOM
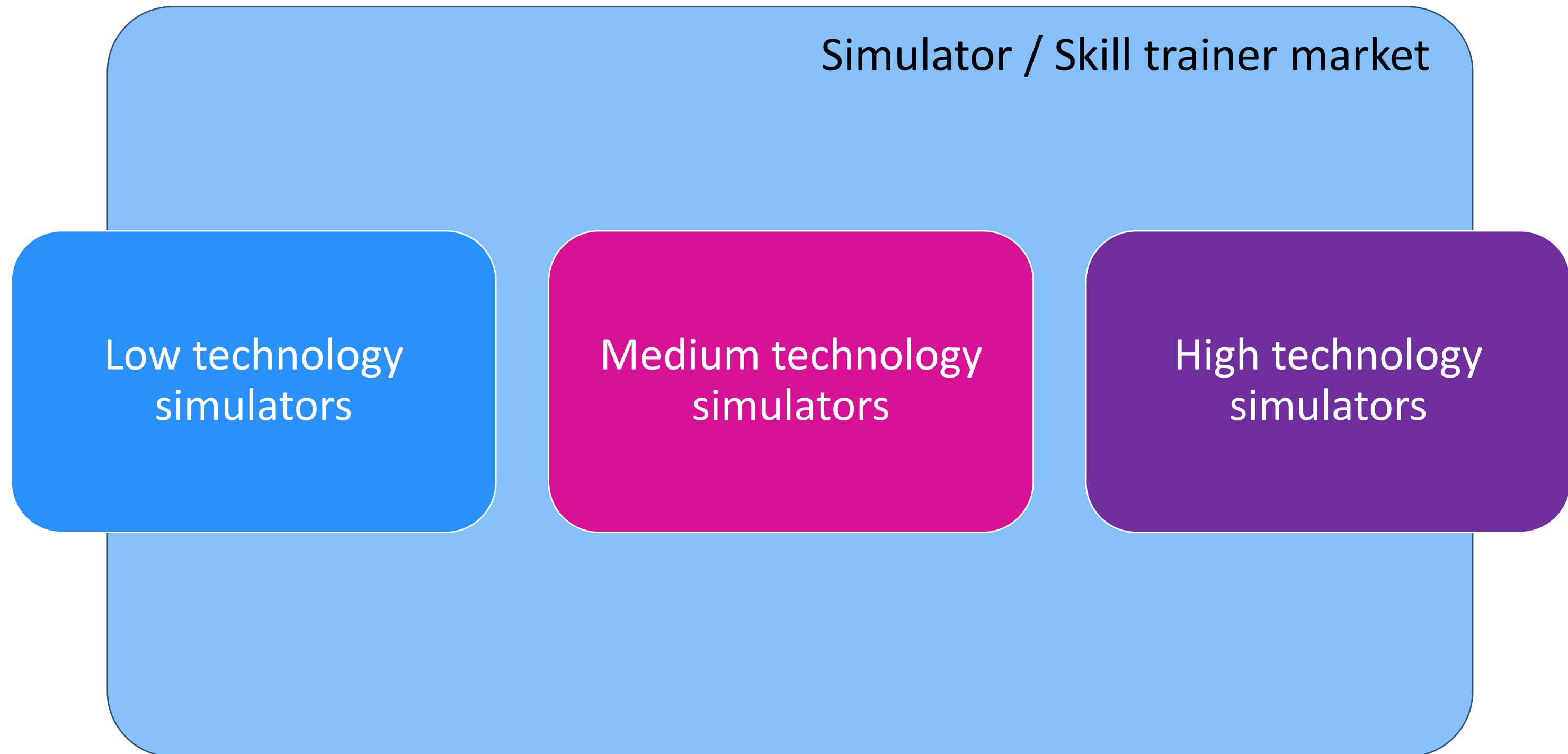
IN THE CONTROL ROOM

Technology in simulation

Technology is everywhere

Technology is expensive

do we need all this technology?

An engineer's perspective

Simulator / Skill trainer market

Low technology simulators

Medium technology simulators

High technology simulators

LOW TECH SIMULATORS

LOW TECH SIMULATORS

Have no or little technology

They make me happy 😊

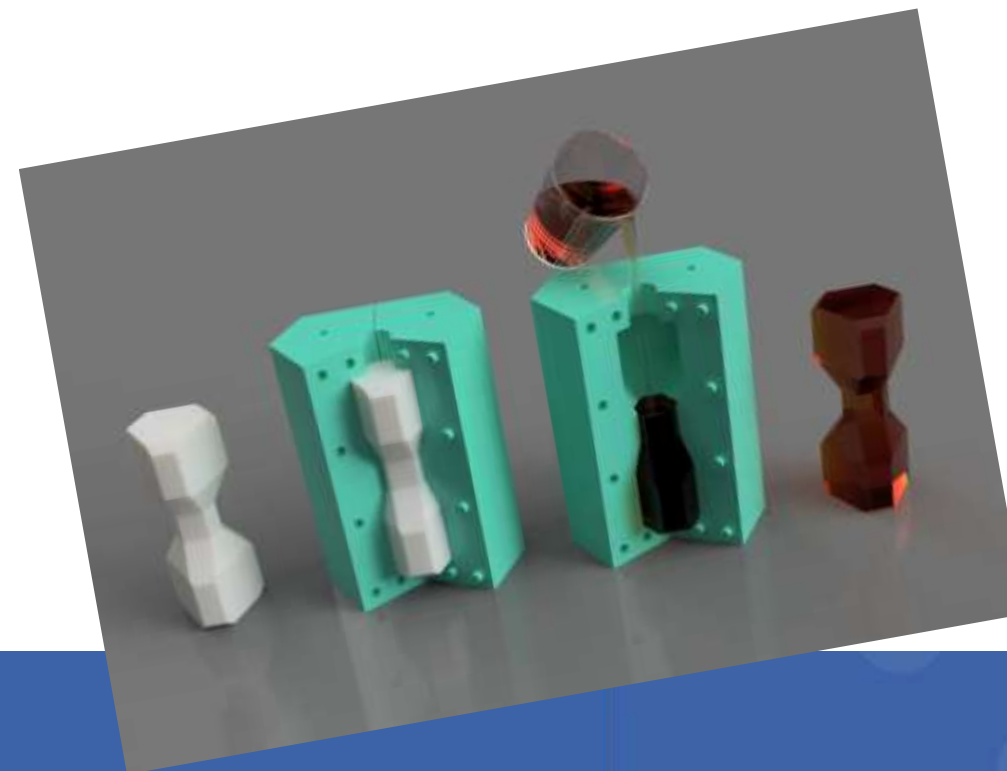| PROS	CONS
• Simple	• Static
• Cheap / Affordable	• Limited
• Can be purchased in numbers for big classes	• Can do only one / a few things
• Durable	
• They deliver!	

LOW TECH SIMULATORS

Another great thing?

They are so simple that we can try to build them on our own!

- 3D Printing
- Life casting
- Printing + Moulding

MEDIUM TECH SIMULATORS

They employ one main technology
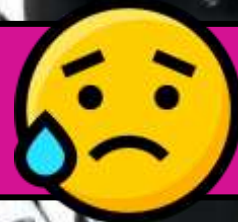
NFC
Near
Field
Communication

MEDIUM TECH SIMULATORS

They employ one main technology
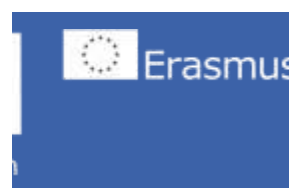
They run through a software

They make me worried 😥
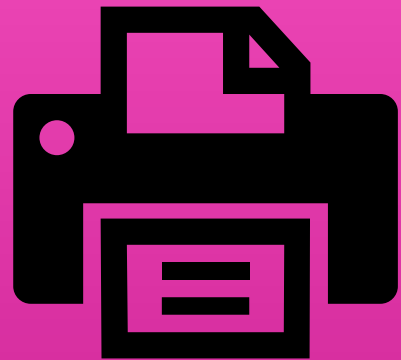
NFC
Near
Field
Communicatior

PROS	CONS
• Can do more than static manikins	• From pricey to expensive • Lock in

Technology LOCK IN

Once you purchase a technology, you are somehow obliged to keep using that technology

When you buy a printer and then you need to buy its cartridges

Technology LOCK IN

This is common to ALL the simulators with some technology and especially if they have a software!

Once you purchase a simulator:

- You need to accept its limitations
- You need to adapt to the idea the designer / programmer had of the product

Technology LOCK IN

The bad part is that usually you find these "imperfections" only while using the product (ie. after paying it!)

- The product performs well, but not exactly what you want / need
- it can not be changed (no customization)
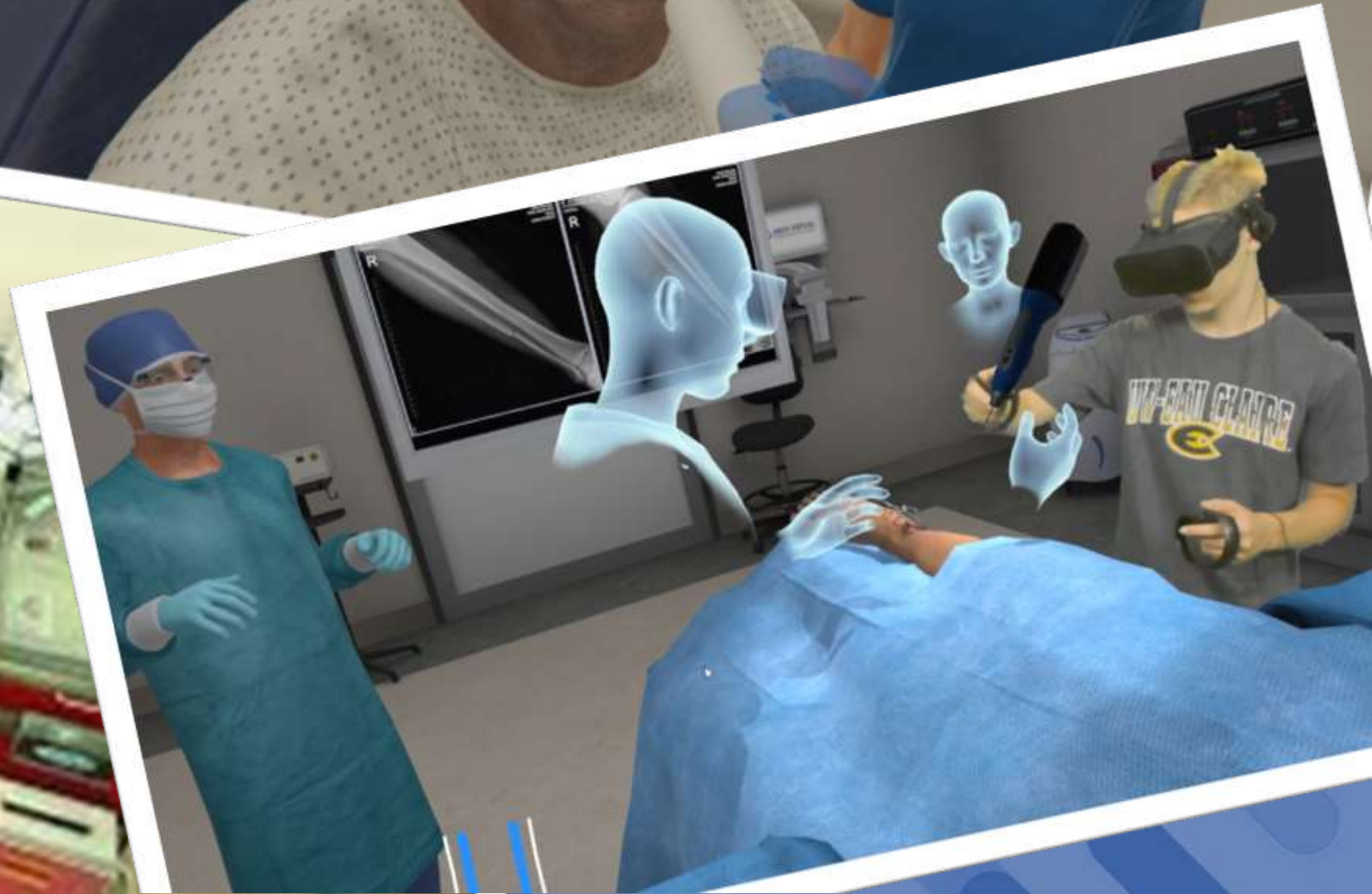- You need to purchase extra features

MEDIUM TECH SIMULATORS

- Check that the way the simulator operates follows what you intend to do with it

- Ask the vendor about customization, and its cost

- Accept the limitations of the software

SCREEN BASED SIMULATORS

SCREEN BASED SIMULATORS

They suffer from lock in

...unless you build your own!

PROS

- Somehow cheap
- Require less staff
- Adaptable to many scenarios

CONS

- Need to find the correct software
- Lock in

HIGH TECH SIMULATORS

HIGH TECH SIMULATORS

They employ many technologies

They are run by a software

They make me wonder 😲

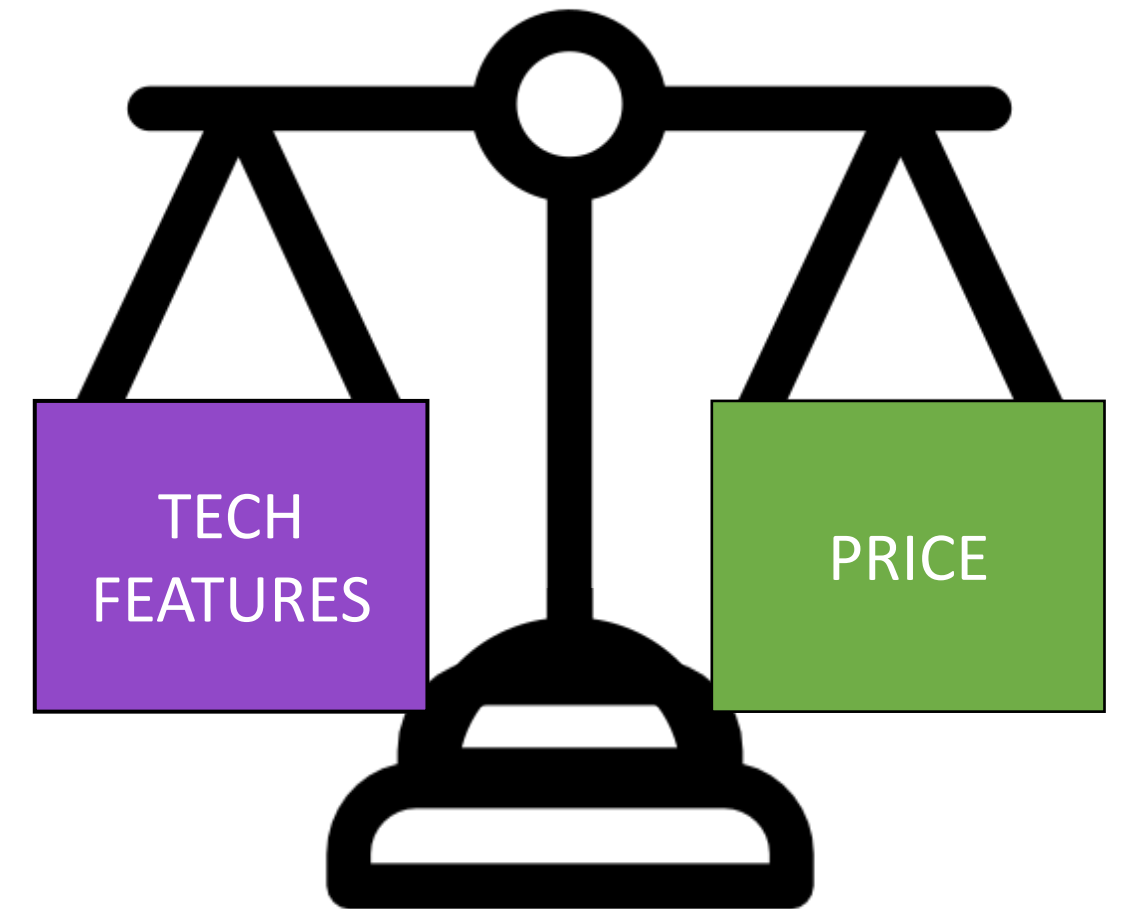? 😟 …is all this technology necessary?

PROS	CONS
- Robust - Adaptable to many scenarios	- From pricey to expensive - Delicate - Lock in (mitigated) - Technology upgrade is pricey!

HIGH TECH SIMULATORS

- Manikins usually come in versions, with different prices for different feature sets

TECH FEATURES

PRICE

HIGH TECH SIMULATORS

- Manikins usually come in versions, with different prices for different feature sets

 The focus should be on what we need / we can do with the features we buy!

- Are we sure that the latest model is worth the money? Do we need all those features?
- Can we obtain the same in other way?
- Is it better to buy one last-gen manikin, or two lower specs ones?

NEEDS NEW POSSIBILITIES

PRICE

ADVANCED SIMULATORS

Standardized patients

- Need proper training
- With wearables add-on can simulate invasive procedure and measurable pathological signs
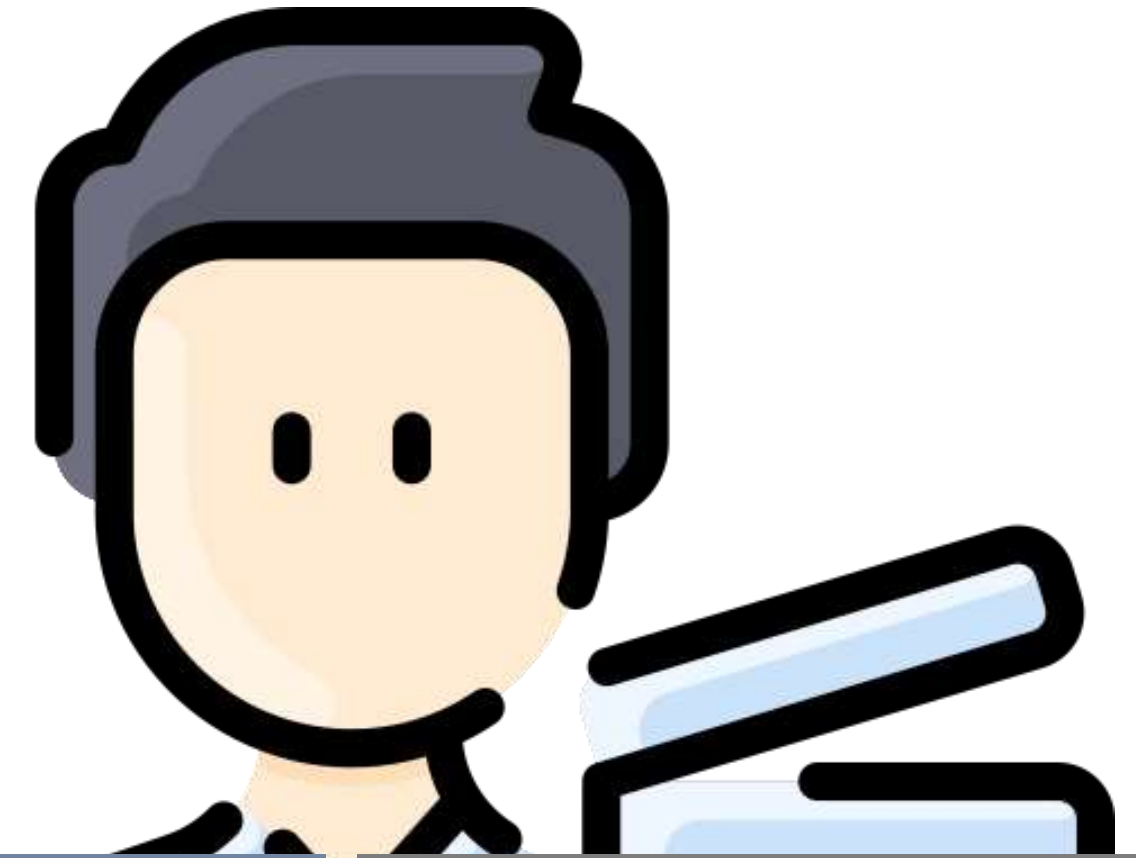
PROS

- Usually healthy
- Interactive
- Autonomous
- Can move

CONS

- Allergic to needles and physical procedures
- Usually healthy
- Increases team size +1
- Requires training

SIM TECH GAME!

SIM TECH GAME

- In groups, pick one of the following simulators
  - HAL S315.400
  - Decent Simulator Airway Management
  - Limbs and Things Abdominal 60000
  - Kyoto Kagaku M99
  - Limbs and Things Venipuncture 70300
  - Susie Simon® S104
  - Extreme Simulation Josh
  - Invidia Medical Urology

- Find information about it to understand:
  - In which category it falls
  - What do you need to operate it
  - If you were to plan a simulation using it, what would you need in your room?

TECHNOLOGY

HOW IT WORKS

In the simulation room

How simulators work?

- Static simulators
  - No moving parts

- Mechanic simulators
  - Moving parts manually / motor operated

- Electronic simulators
  - Various degrees of complexity

- Software simulators
  - Screen based simulators, AR/VR simulators

Static simulators

- No moving parts
- No extra equipment required
- Simple
- Cheap

How does it work…

Suture pad

- You put them on the table and you can do stuff on them!

- What's the tech behind them?

No tech!

- It can be easy to produce these simulators by yourself

- Using

  - Existing materials
  - Creating 3D prints
  - Doing casts (or a mix of 3D print + casting)

SimGhosts
https://simghosts.org/page/resource_links

Suture
https://www.youtube.com/watch?v=PVdFvjJAS5Q
https://www.youtube.com/watch?v=94HnZZPx-ME

Laparoscope
https://www.youtube.com/watch?v=3EfPRIsuG2s

Kelly JJ, Han JJ, Patrick WL, Mays JC, Iyengar A, Helmers MR, Smood BF, Cevasco M. Do-it-yourself simulators and building a culture of practice in the virtual era. JTCVS Tech. 2021 May 19;8:100-111. doi: 10.1016/j.xjtc.2021.05.012. PMID: 34401826; PMCID: PMC8350878.

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Mechanic simulators

- Enhanced version of the static simulators

- Can have cranks / handles

- Can use physics to operate (compressed air, liquid in pressure)

- Can have a motor (pump)

- We need an operator and/or tanks

- (and prepare for eventual floodings!)

How does it work…

IV access simulator

- You put them on the table, prepare the fluids, operate them, and then you can do stuff
- (then dry all the water spilled on the floor)
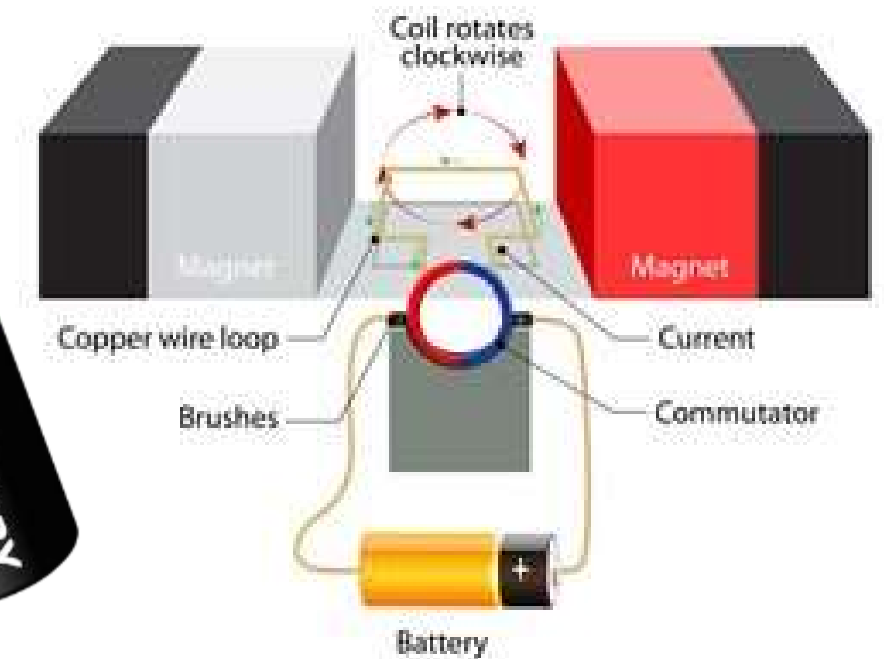
- What's the tech behind them?
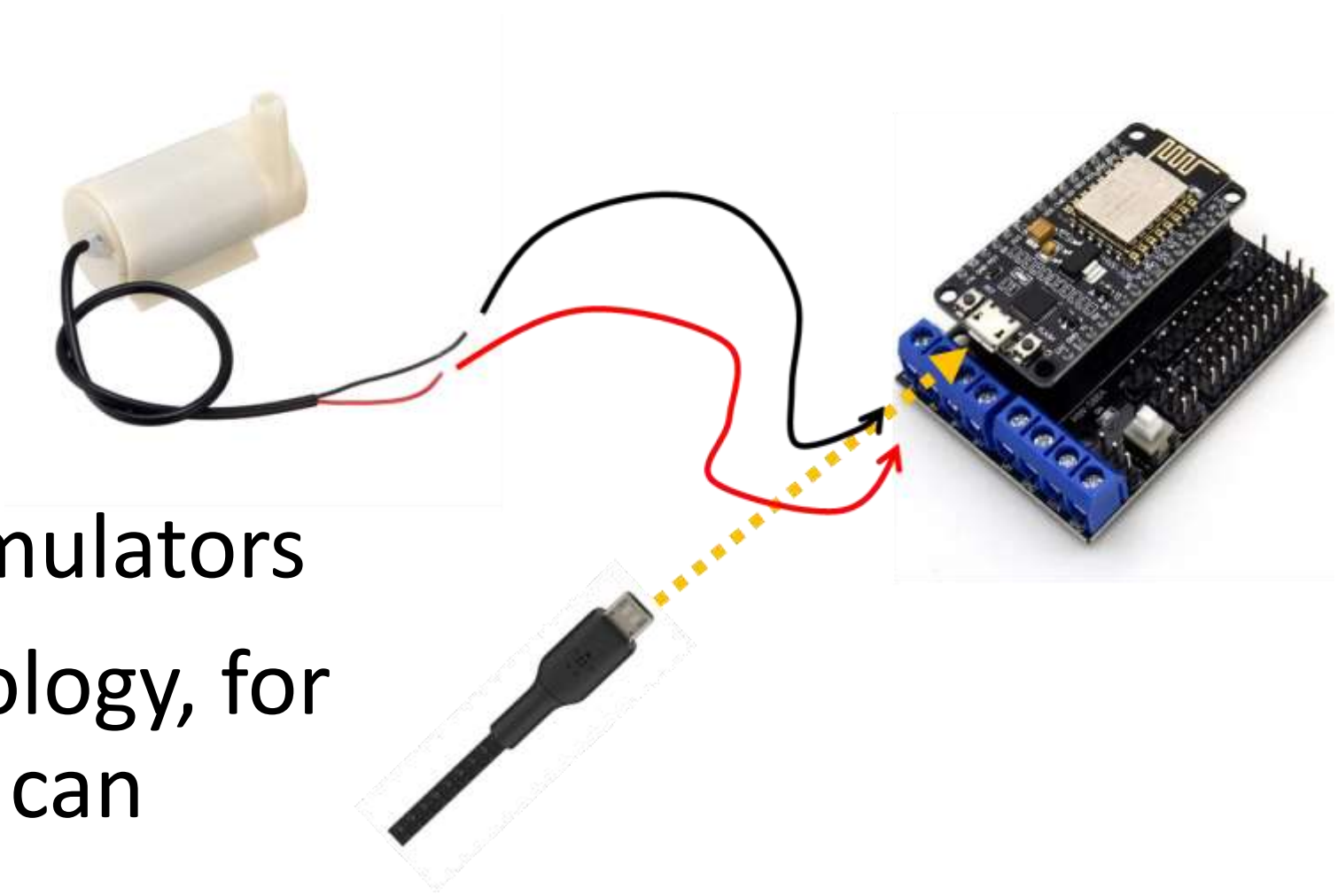
Almost no tech!

- Physics operated trainer
- No needs

- Manually operated trainer
- Need energy drink!

- Motor operated trainer
- Need electric energy!
- Need battery OR ac plug + transformer
- Need long enough cable!

A simple electric motor

Coil rotates clockwise
Magnet
Magnet
Copper wire loop
Current
Brushes
Commutator
Battery

DIY

- We can build by ourself some of these simulators
- We can enhance them with a little technology, for example adding a pump to our circuit we can
  - get rid of the pole
  - Add a pulsing pattern to the fluid, to simulate an arterial access
- We can enhance them even further adding a controller (e.g. Arduino)

(note: a bit of hardware and skills are required)(but not that much!)

Electronic simulators

- Enhanced version of the mechanic simulators

- One or more functions: complexity can vary (and also the price!)

- Can have a **_remote control_**

- We need battery or electric outlet and/or connectivity
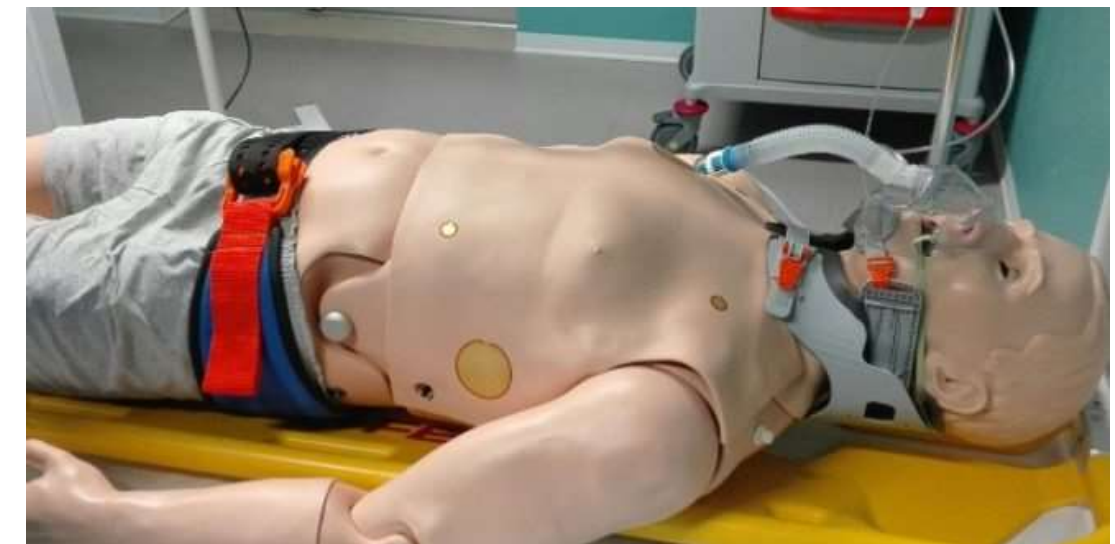
How does it work…

Auscultation Manikins

- Placing a custom stethoscope (or a device attached to a normal stethoscope) on some landmarks of the manikin, you can hear specific sounds

- What's the tech behind it?

NFC: Near Field Communication

- It is the technology behind contact-less payment
- In the NFC tag there is a coil and a memory chip with a code
- The reader emits radio waves and when it is close enough (near field), these create a current in the coil
- The current makes the tag transmit its code to the receiver
  - this is how the POS terminal knows your ATM card data to process the payment
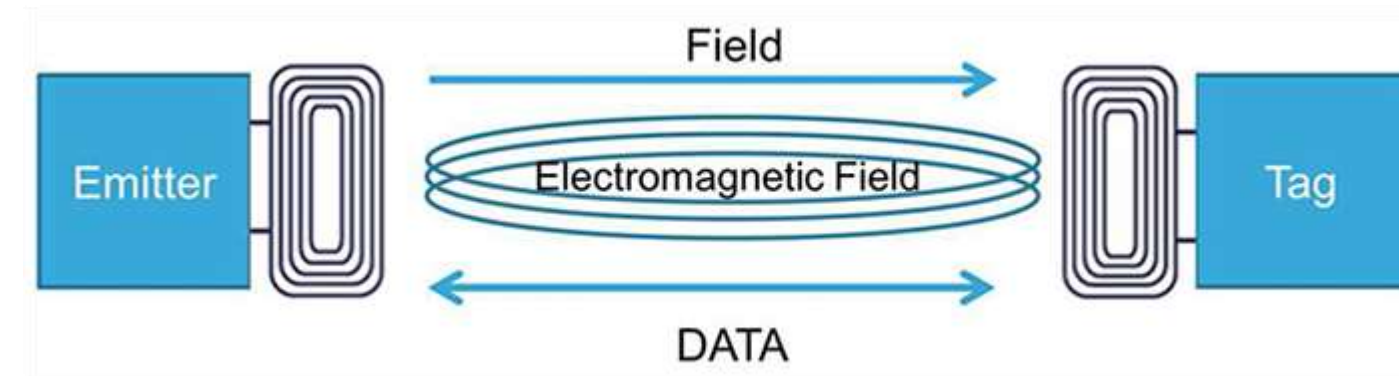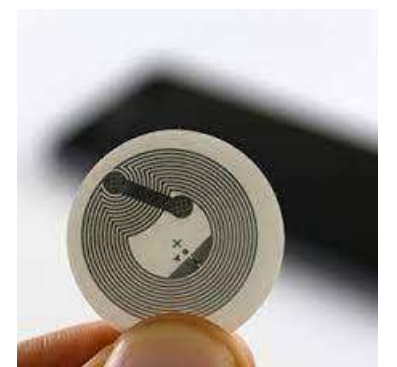
Used in…

- Simulated stethoscopes
  - The tag code tells the device/stethoscope which sound to play

- Simulated ultrasound
  - The tag code is linked to the Ultrasound video to be played on the monitor

- To detect drugs delivered to the simulator
  - The syringe has a NFC tag, the IV access on the simulator has a NFC reader

Pro / Cons

Pro:
- The tag do not need batteries!
- Tags can be small, flexible, durable

Limitations:
- Each tag has only one code, you can't change it
- The video / sound is played only if the "probe" is on the exact landmark

- Note:
  It's a cheap technology: tags, Programmer and Reader can be bought for 10-20 euros and you can prepare your own simulator (some programming needed!)

- Similar to: the QR Code (or the old barcode)

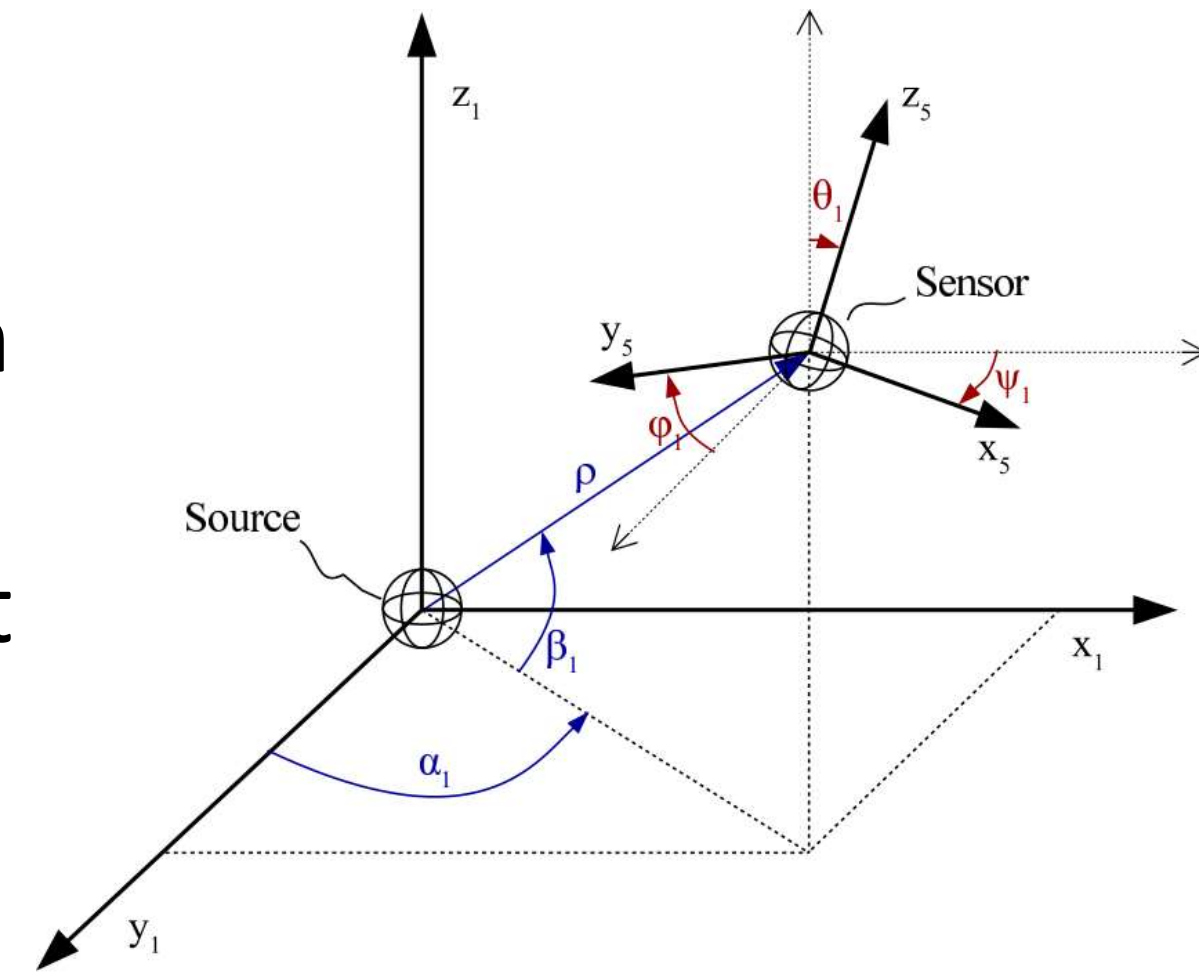# How does it work…

Ultrasound manikins

- Placing the simulated probe on the manikin will project a realistic ultrasound image on the monitor

- What's the tech behind it?

Radiowaves

- The probe is capable to track its angle of rotation (north and gravity axes)(like your mobile!)

- A device inside the manikin emits radiowave that precisely track the position of the probe

- With position + rotation, the simulator can compute where the probe is and where it is looking and displays on the monitor the ultrasound

Pro / Cons

- Pro
  - All the surface can be scanned

- Cons
  - This type of manikins are very expensive!

How does it work…

Manikins

- They can do tons of things, you can do tons of things on them, and they won't complain!

- What's the technology behind them?

A lot of tech!

- These simulators have
  - Sensors, to detect user actions (es. Needle decompression)
  - Actuators, to perform actions (es. Chest expansion)
  - Controller circuits
  - Telecommunication circuits

How does it work?

Let's figure out some of this high fidelity technology

Functions
- Programmable blinking rate, pupil dilation, and eye movement
- Programmable consensual and nonconsensual pupillary response to light stimuli
- Interactive eyes can follow a moving object
- Wireless streaming voice: be the voice of HAL and listen to participants' responses in real-time
- Bilateral palpable pulses: carotid, brachial, radial, femoral, popliteal, pedal
- Programmable circumoral skin coloration: cyanosis, redness, and pallor
- Fingerstick glucose testing on the left index finger
- Programmable capillary refill time testing located on right middle finger

- Aortic, pulmonic, tricuspid, and mitral auscultation fields and new heart sound library
- Supports 4-lead and 12-lead ECG monitoring using real monitoring devices

Pro / Cons

Pro
- Realistic
- Automation

Cons
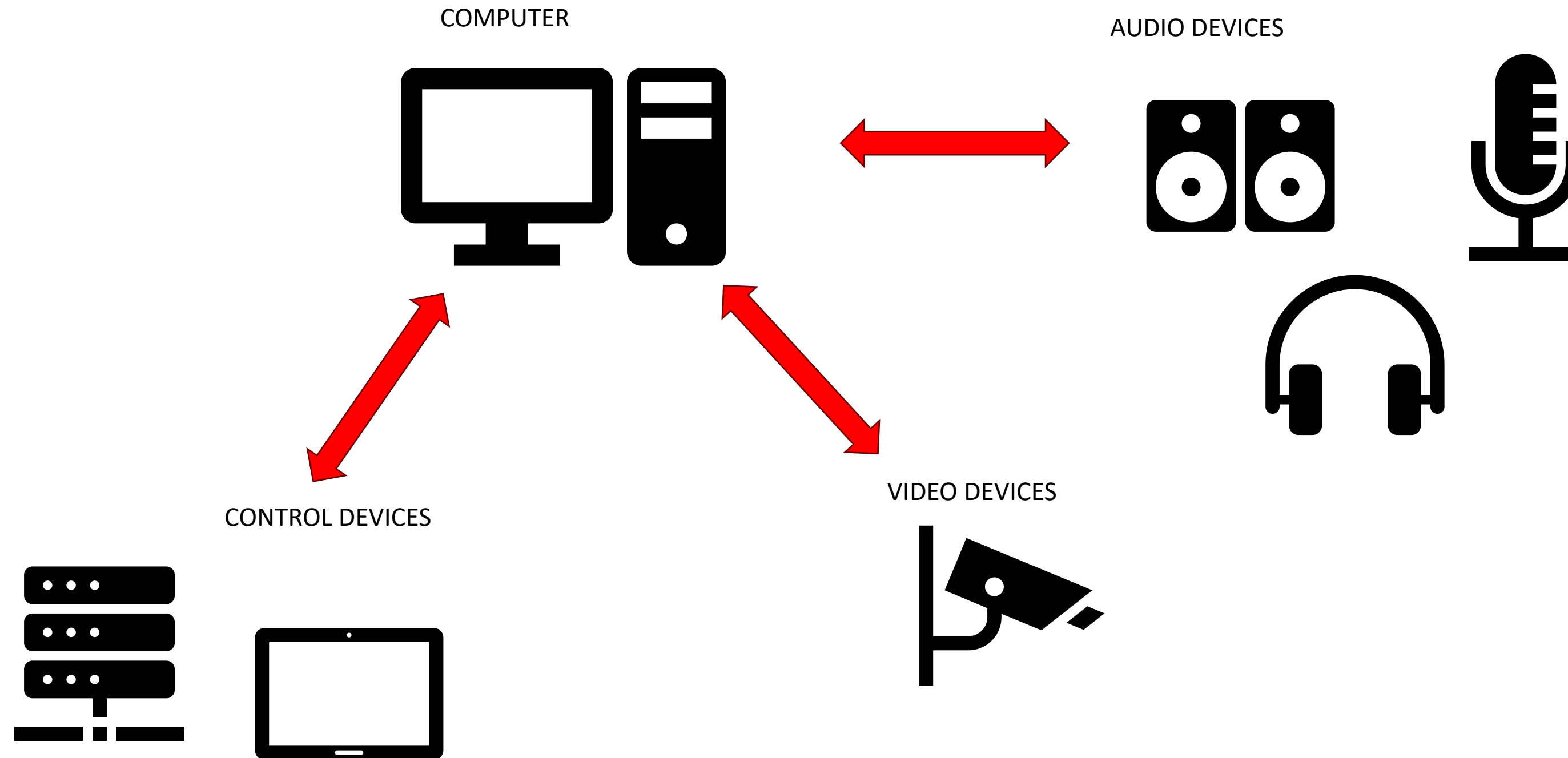- Easier to break
- Expensive to buy and repair

Remember that simulation is a technique not a technology

- Realism in the manikin is expensive: are you sure you need to pay so much?
- Maybe two lower fidelity manikins are better than one high fidelity?
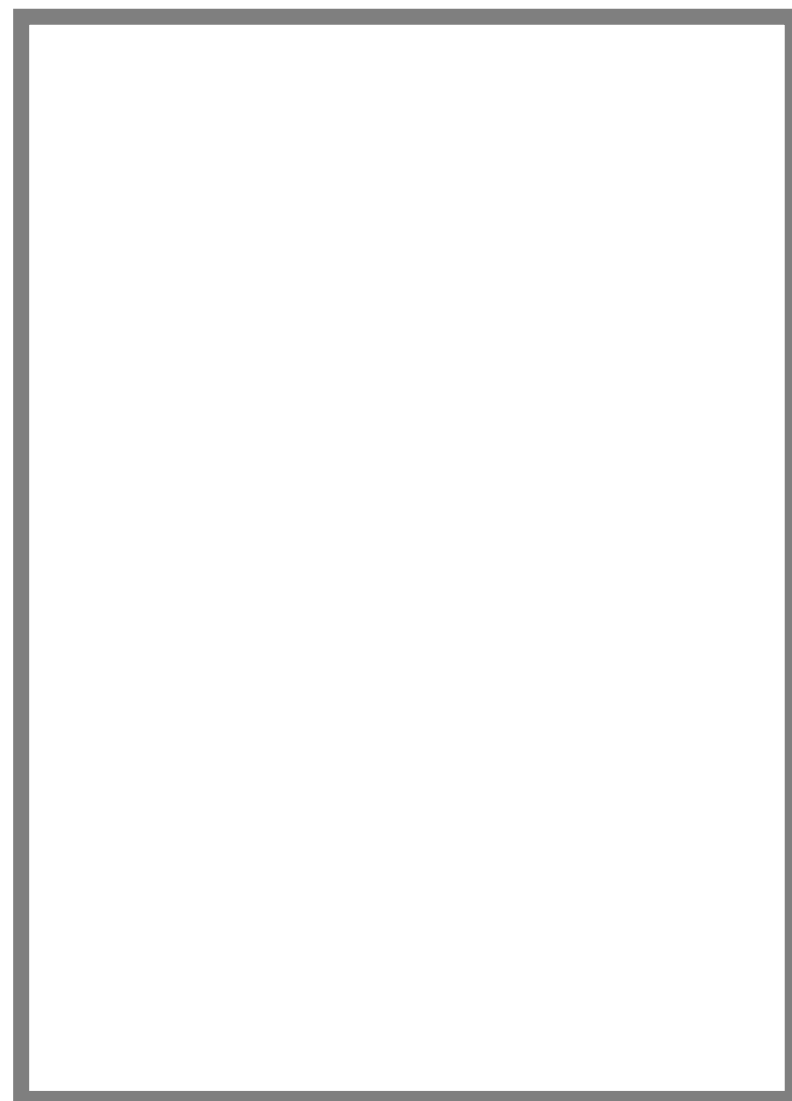
In the control room
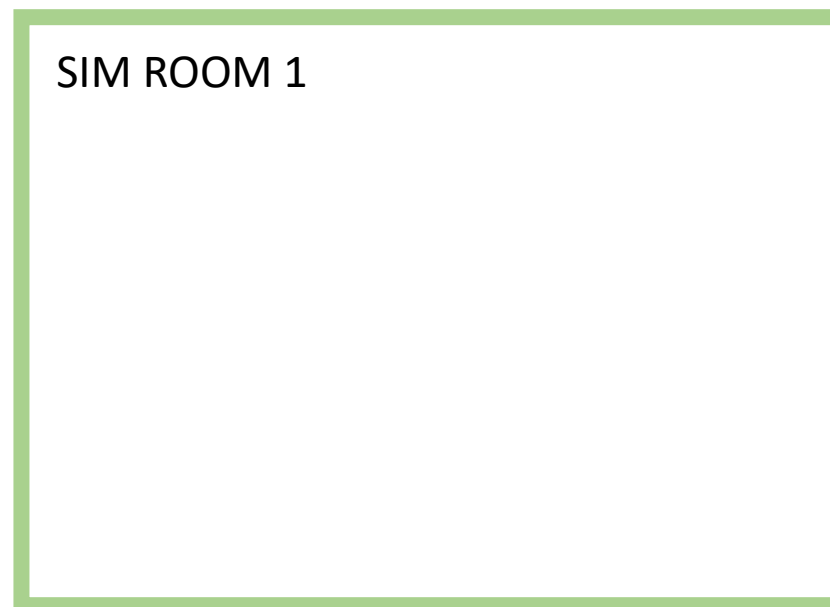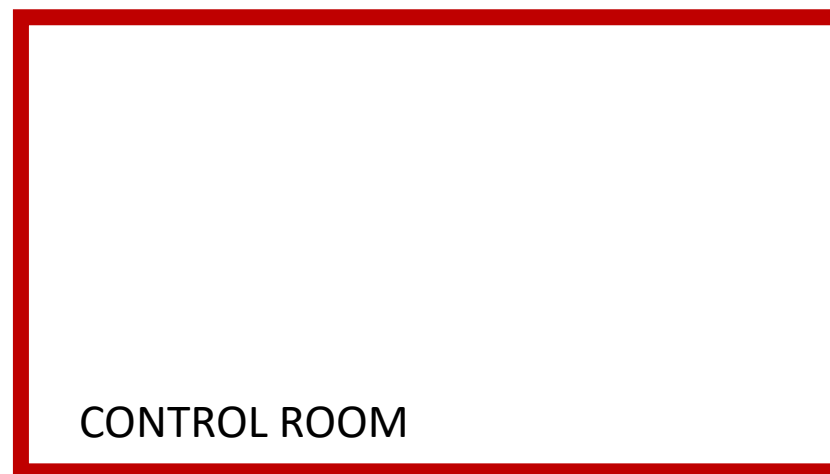
Technologies to control simulations

COMPUTER

AUDIO DEVICES

CONTROL DEVICES

VIDEO DEVICES

Control Room / Simulation Center layout

SPECTATOR ROOM

SIM ROOM 1

SIM ROOM 2

CONTROL ROOM

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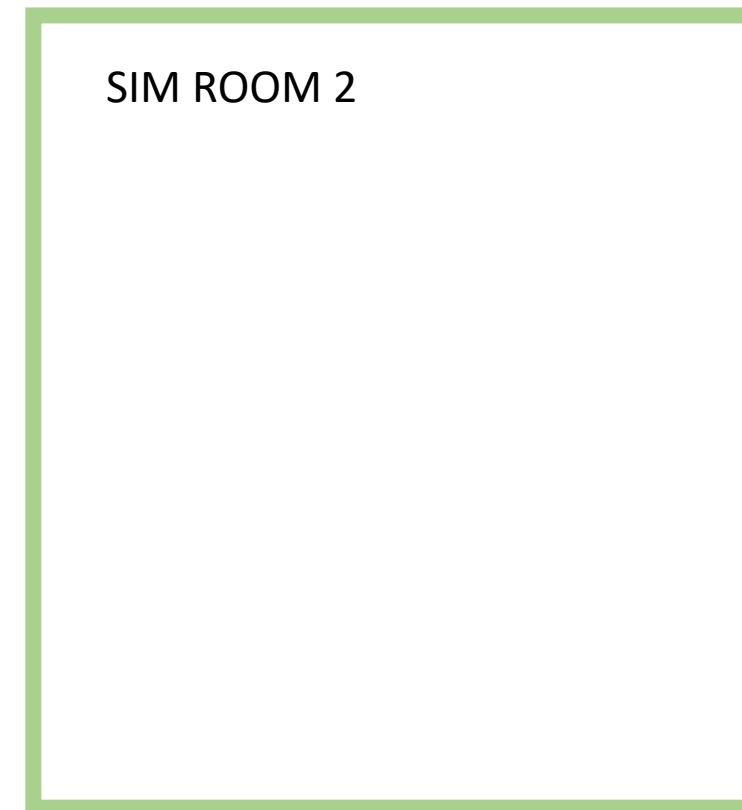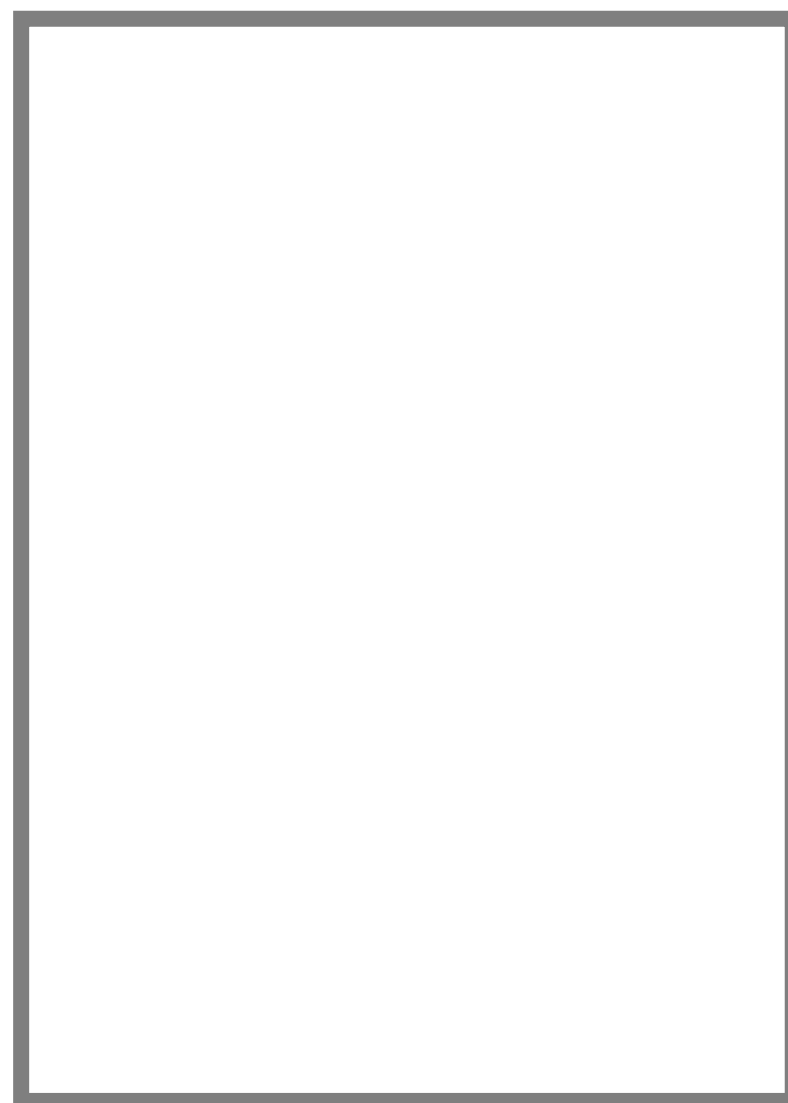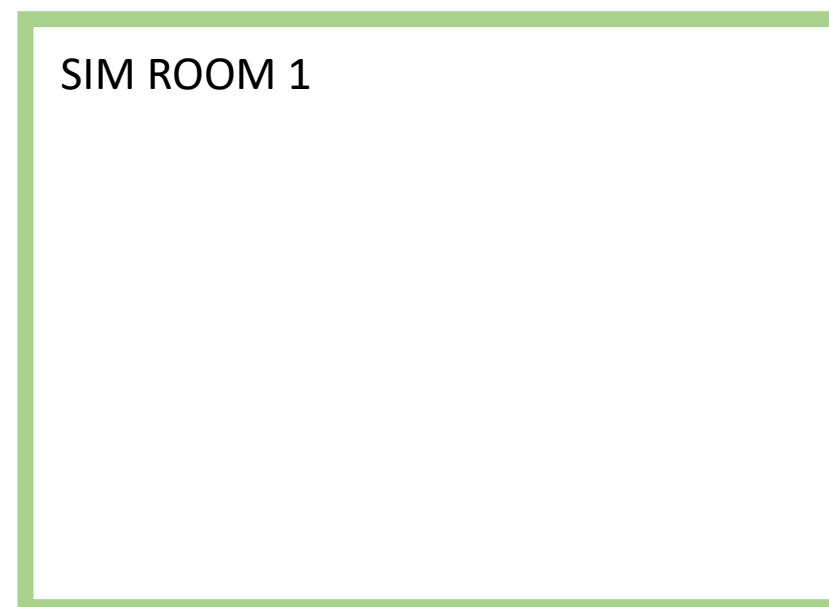
Control Room / Simulation Center layout

SPECTATOR ROOM

SIM ROOM 1
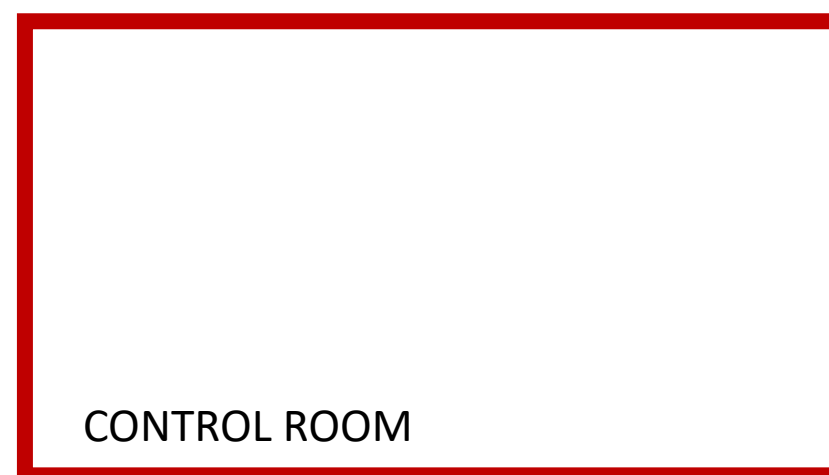
SIM ROOM 2
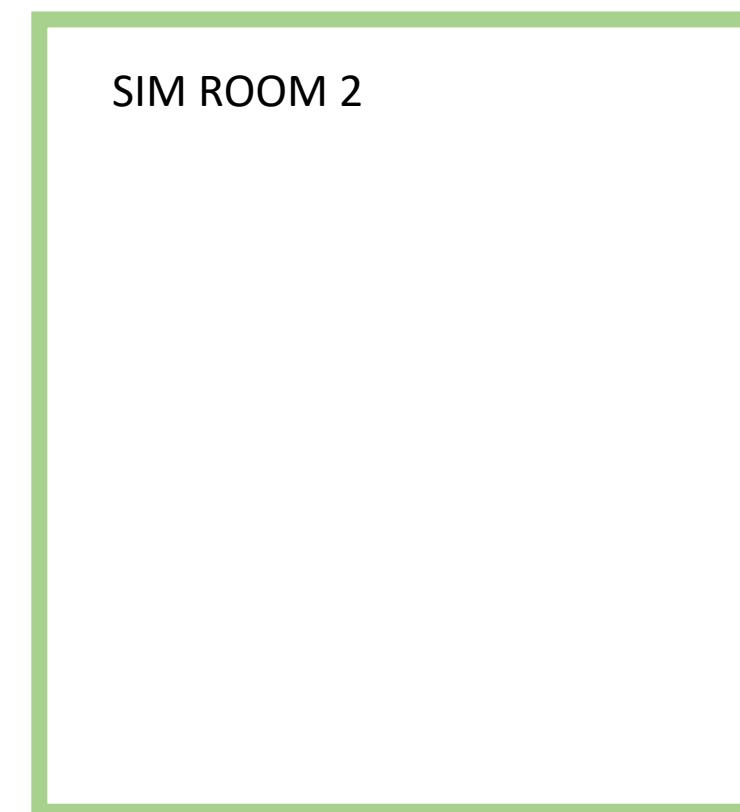
CONTROL ROOM

WHICH TECHNOLOGIES DO WE NEED TO MAKE THIS CENTER WORK ?

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Control Room / Simulation Center layout
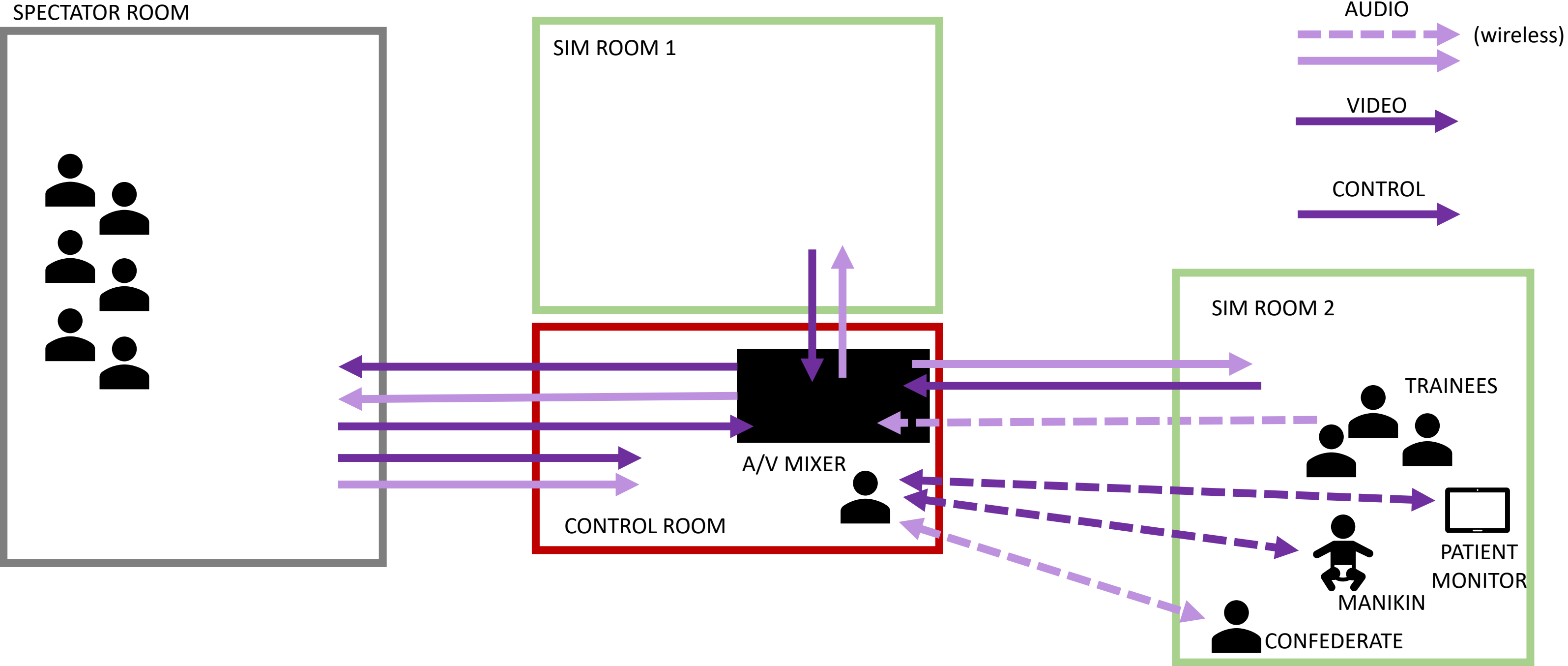
Audio and Video

Audio & Video in Simulation

Audio and Video devices are necessary to:

- Record a simulation
  - For debriefing
- Stream a simulation
  - If the control room is blind or faculty is far away
  - To have spectators

- Communicate with trainees and/or federates

- How this stuff works and how to connect it?
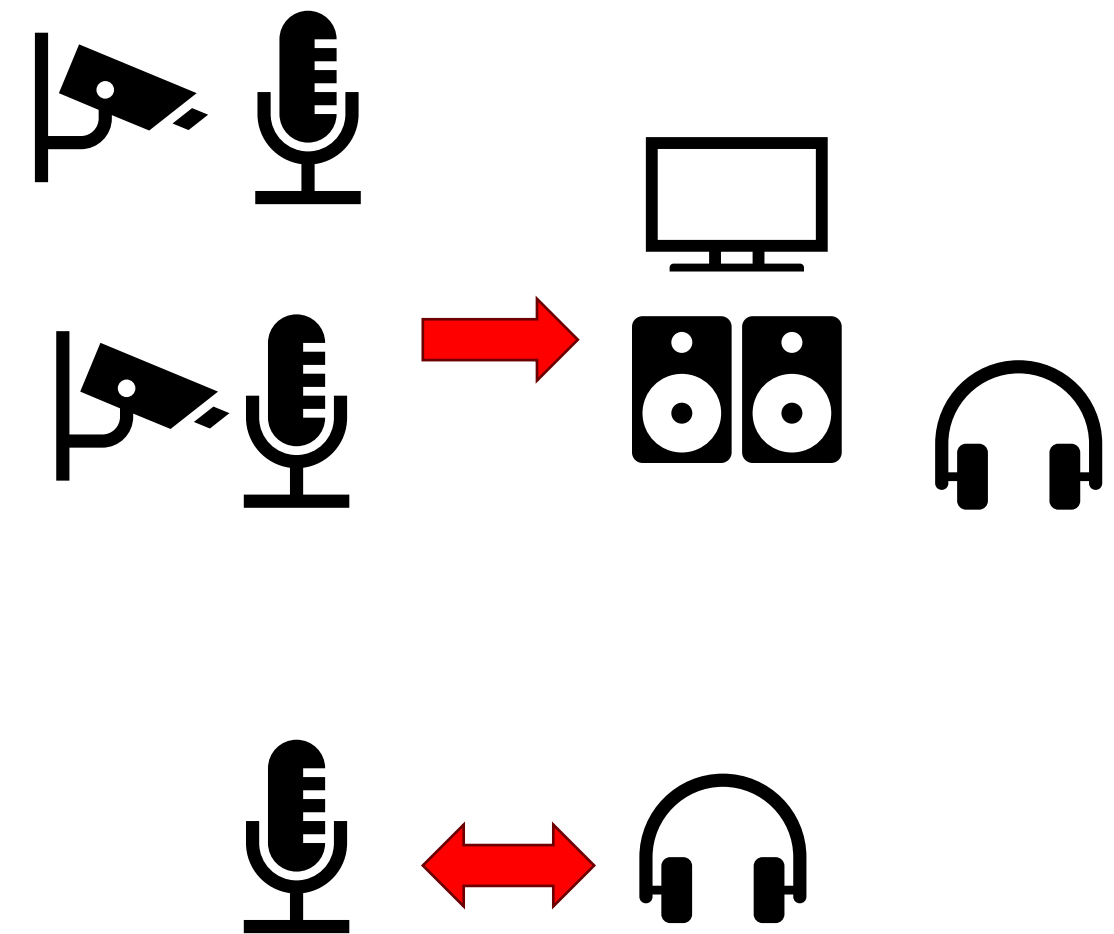
Audio and Video recording

Technically similar:

- A sensor reads a value from the reality (sound wave, colored light) and transforms it into an electrical value

- For the computer to understand the value, this needs to be translated into a number

- This is called Digitization (transformation from analog to digital)

Video device and cables in simulation

- To record a video we need a camera
- Any camera works
  - Your mobile phone!
  - A webcam
  - A more professional device: network PTZ camera

PTZ Cameras
  - PTZ: Pan Tilt Zoom
  - Camera are usually ceiling mounted
  - They transmit data on network cable
  - Once installed you can easily take them somewhere else
  - Expensive but high quality

SONY PTZ camera

Video device and cables in simulation

- To transmit a video we need a fast connection

- HDMI cables transmit digital video data at high speed (18 Gbit/s)

- Can not transmit data very far: they are usually sent on network cables (HD-BaseT) with a converter on each end

A cheaper solution

- A good webcam: Logitech C920 (90eu)

- Clamps / Camera tripod (20-50eu)

- USB extension cable 10mt (15-20eu)

- Logicam Software (2 cameras max)

- OBS

- Transmission via Zoom / Meet

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Audio device and cables in simulation

- Audio is usually recorded by an analog microphone, it requires an amplifier and the cable can not be super long

- Usually it is professional equipment

- Best solution is to have a single mic for each source to record

- Each mic requires a receiver; all the signals must be then merged in a mixer

- For a standard simulation, you will need a 8 channel mixer, and 6-8 receivers with batteries

- To talk to the federate you also need a bi-directional link

Sennheiser IEM 2000 GW Quattro Bundle

A cheaper solution

- Unfortunately a cheap / easy solutions still does not exists
- Recently there are nice wireless mic, but they come only in pairs
- There are "cheap" all-in-one solution (usually rack mounted) but a technical analysis is required to ascertain if it is junk
- Using a single "environmental" mic still requires some investment (mic + boom + cable + amplifier) and the results can be hit and miss

Hollyland Lark M1 wireless microphone and receiver

THE CABLE GAME!

The Cable Game!

- You have in front of you a mess of cables
- Please identify for each cable
  - The type, from the list
  - The correct port
  - Which signal it can transport

  VGA CABLE
  SATA CABLE
  HDMI CABLE
  DVI CABLE
  SCART CABLE
  RCA CABLE
  USB CABLE
  THUNDERBOLT cABLE
  TRRS CABLE
  BNC CABLE

Control signals

Controlling stuff

- Controlling things means to send data from a controller to a controlled device
- The two devices should run a software that knows how to understand the data sent
- The cable transports a digital signal
- The most common type of cable used nowadays is the USB cable

- We found out many years ago that when we want to control something, we like to do it **remotely**

Connecting stuff

DIRECT one to one

- Your television and the remote
- Your car keys and your car

- Your phone and your wireless speaker (BLUETOOTH)
- Your controller and some manikins (e.g. Gaumard)

NETWORK

- Mostly everything nowadays, from your laptop to Alexa and your smart IOT home applications

- Some manikins
- The vitals monitor

Connecting stuff

- Communication is complex
  - Both among humans
  - And among machines!

- Among machines it is something about
  - Data transmitted on cables as currents that rapresent bits divided in packets
  - Data transmitted as radiowaves using a one or more specific frequency with symbols represented as different values of the electromagnetic field
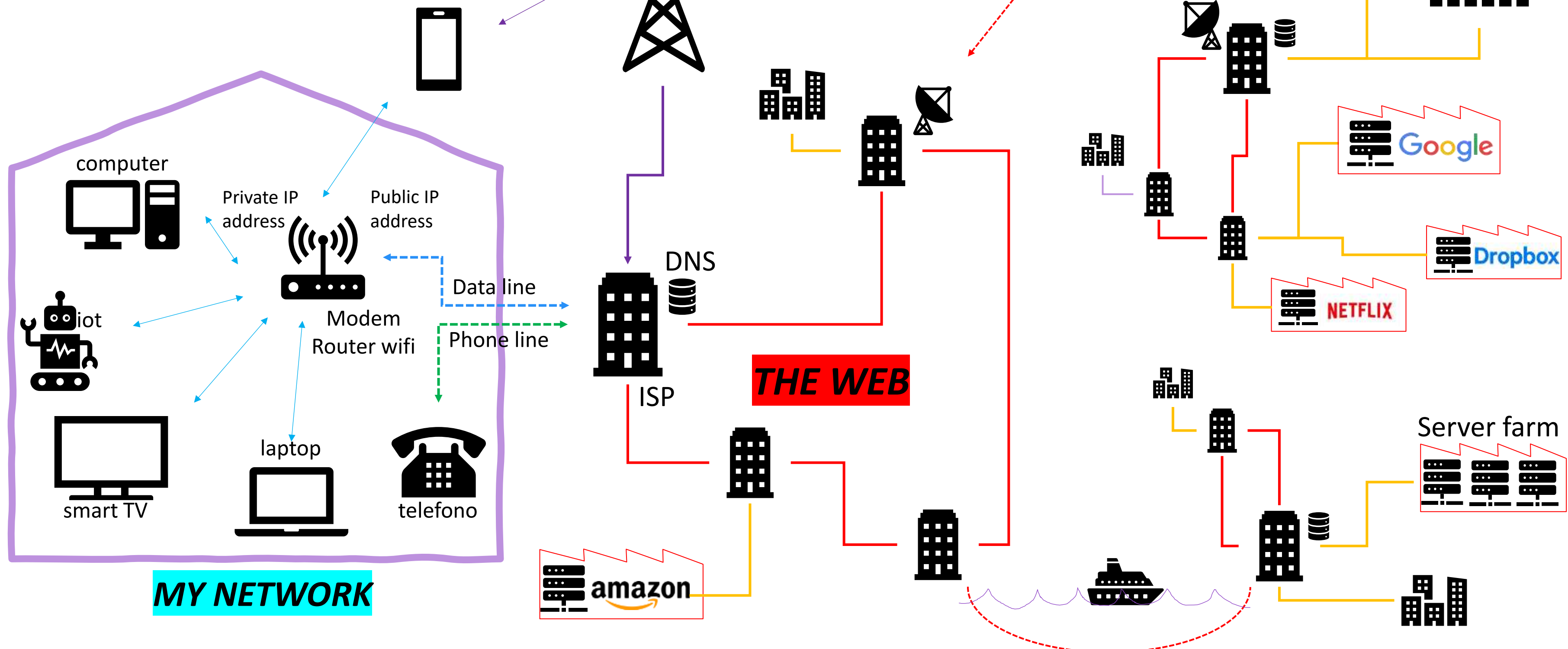
Network

- Luckily, someone else already sorted out this stuff and we can be in a network just using TWO RULES:

1. Every device connected in a network must have an unique address

2. There is MY NETWORK and *THE WEB*

(3. If the network is not working, reboot the router)

INTERNET

MY NETWORK

computer

Private IP address   Public IP address

Modem Router wifi

iot

smart TV

laptop

telefono

Data line

Phone line

DNS

ISP

THE WEB

amazon

NETFLIX

Google

Dropbox

Server farm

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Why we like Internet

- Usually you can not communicate directly with a device in *another* network

- Using Internet you can: data will "bounce" on a server on the Internet
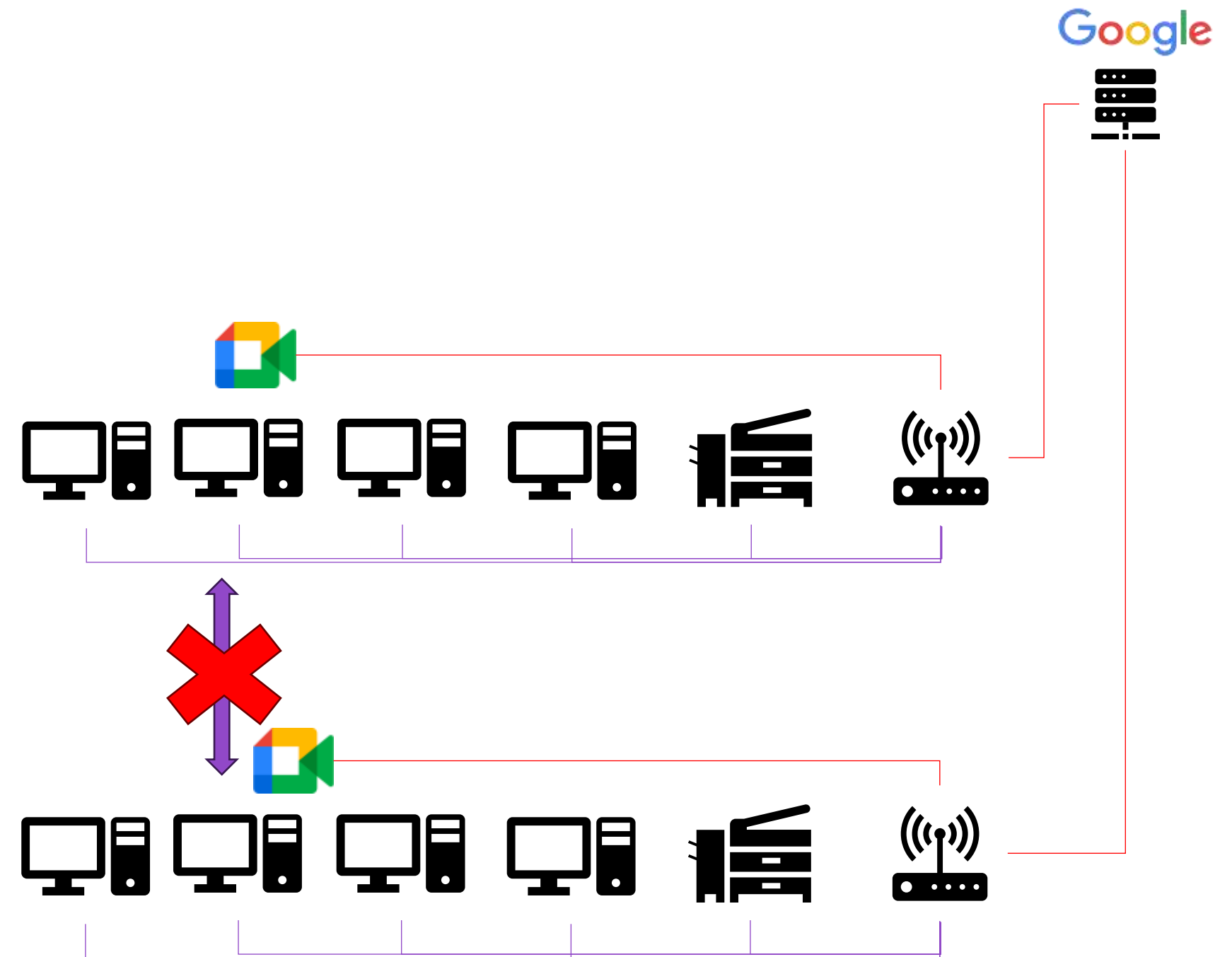
REMEMBER:
You don't need super expensive equipment to do simulation!