

## → Video for Space Teleoperation

Combining Haptic Data Over Multiple Networks Using the Data Distribution Service

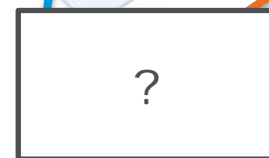
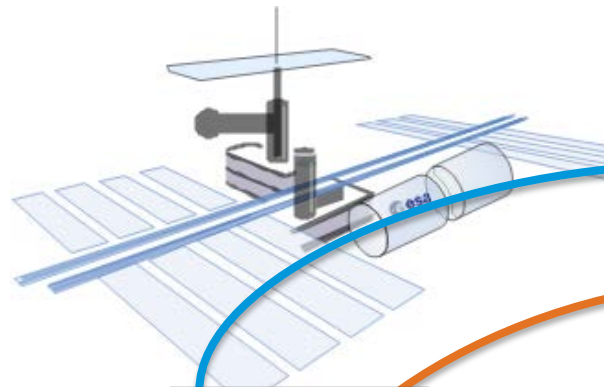
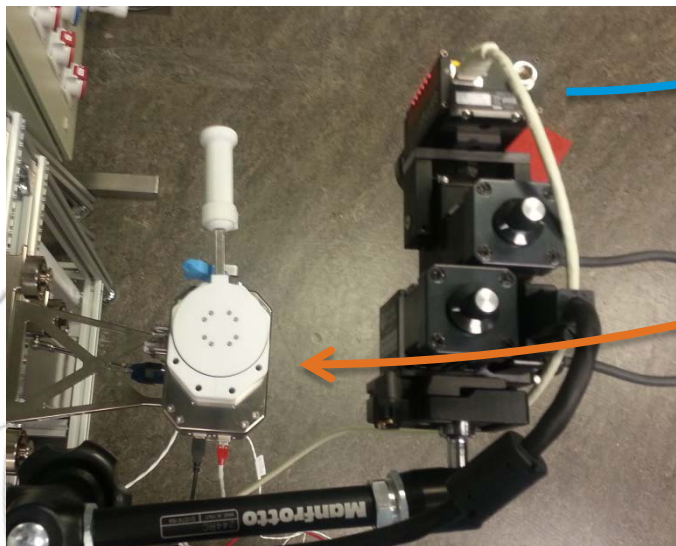
Stefan Kimmer



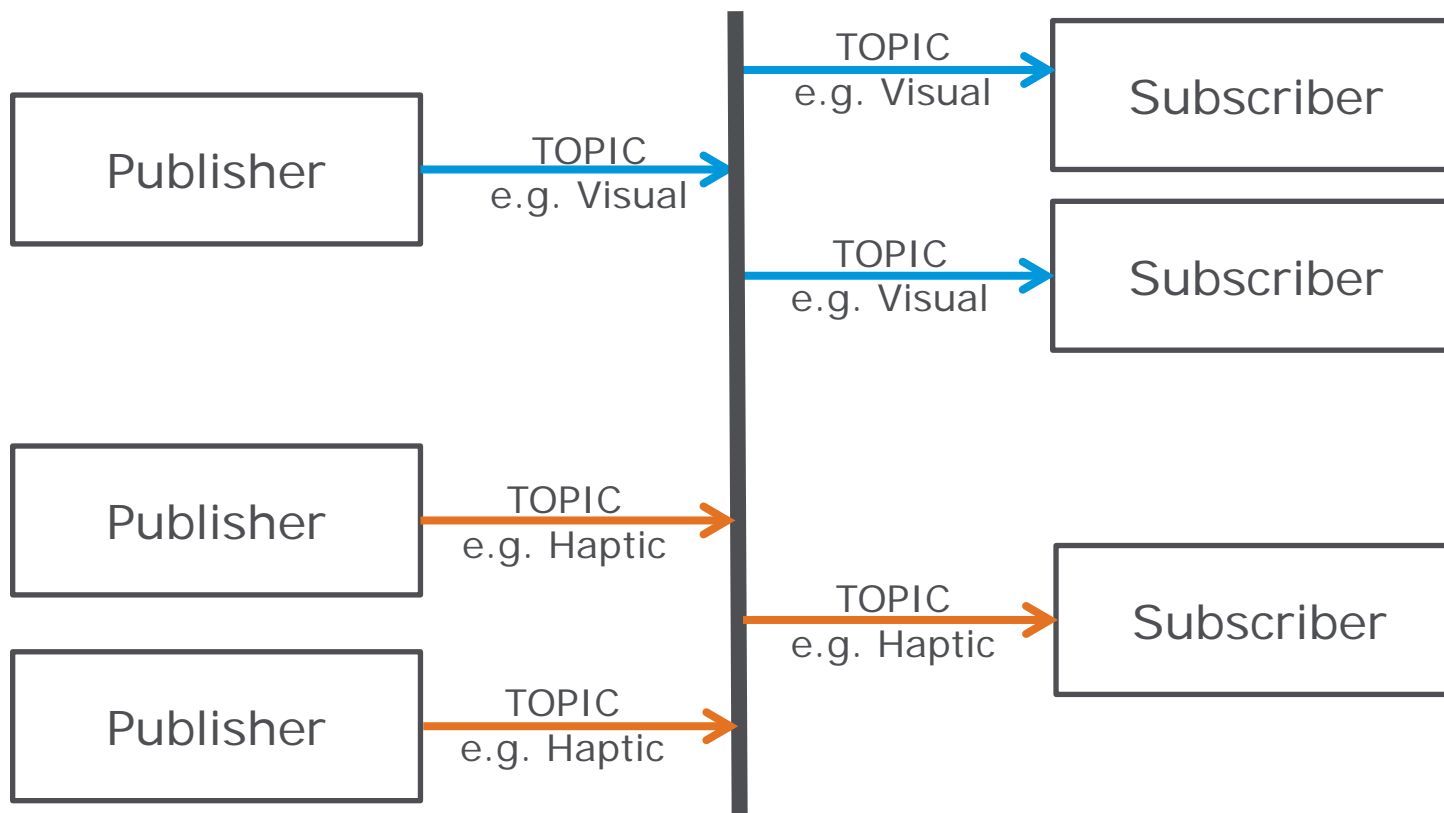


Data needs to be combined

-> **Data Distribution Service**

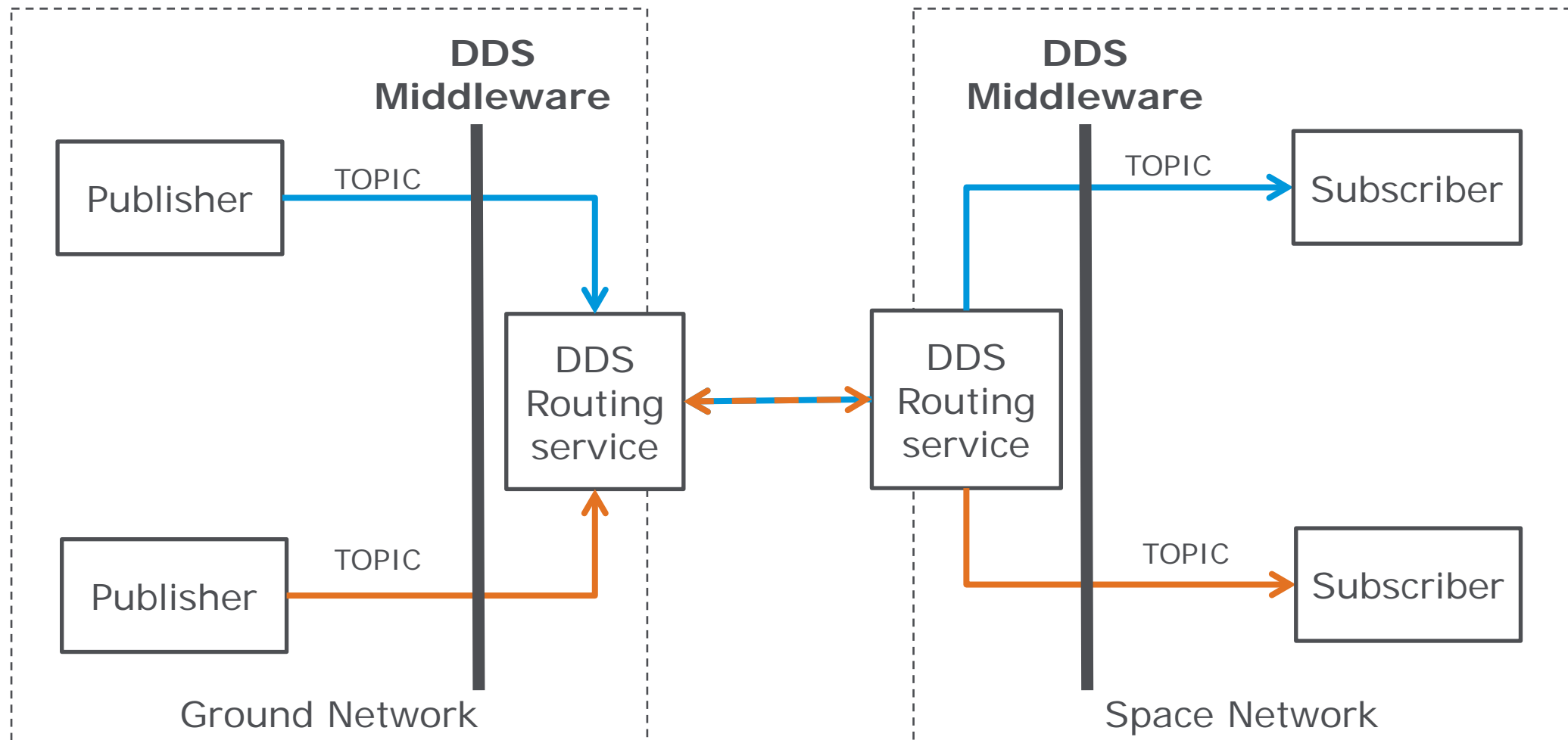


Synchronization issues,  
Security, Port limitations, ...  
-> Prevent usage of multiple  
channels

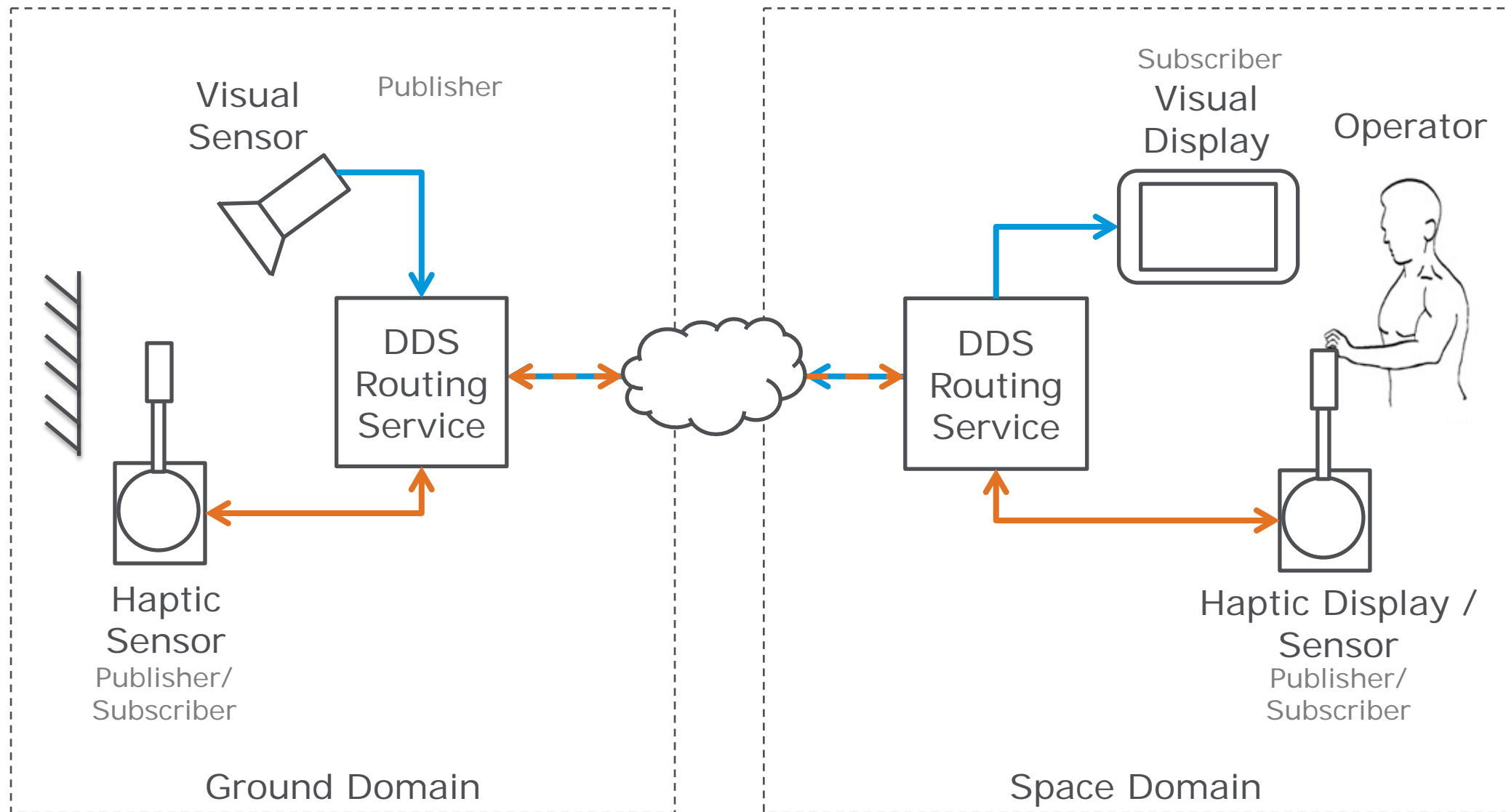


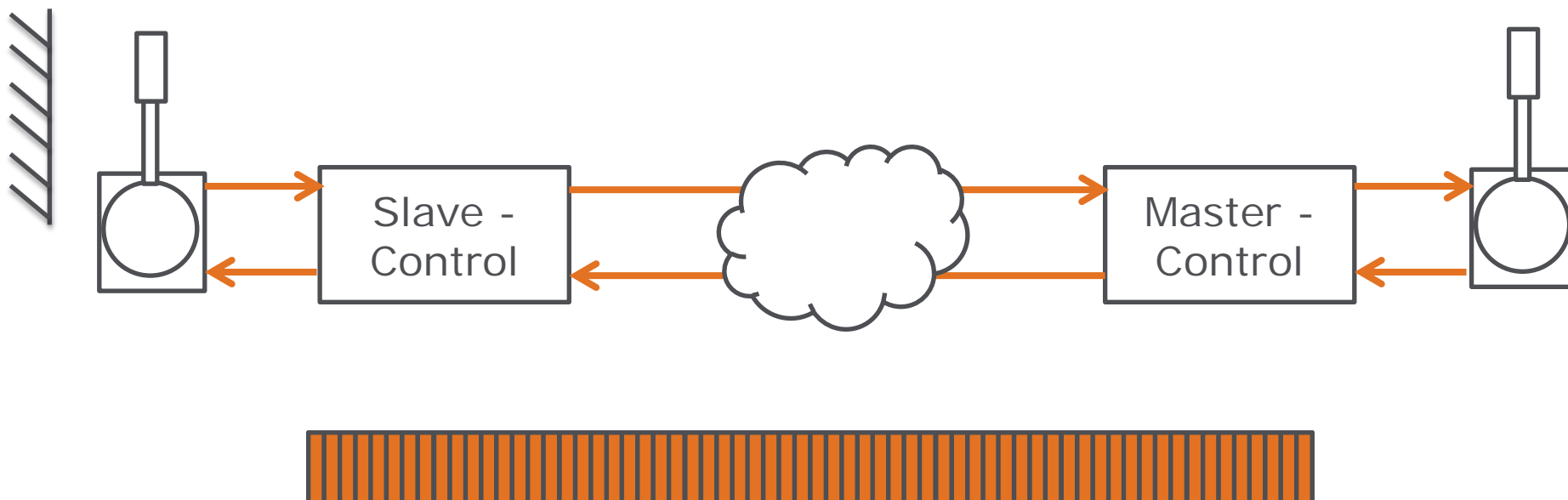
TOPIC:  
- TYPE  
- NAME

### Data Distribution Service (DDS) Middleware

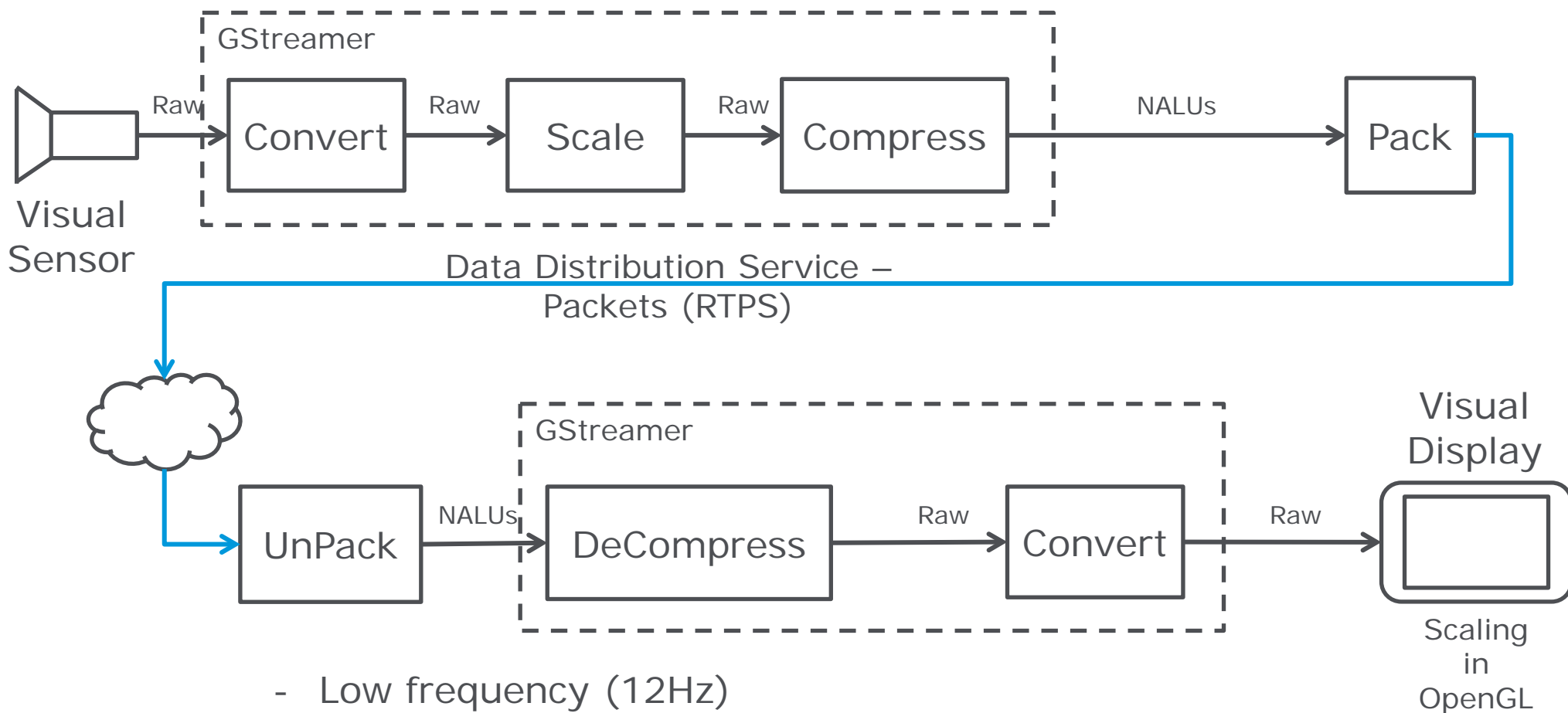


- Transmission Control Protocol (TCP) **OR**
- User Datagram Protocol (UDP)

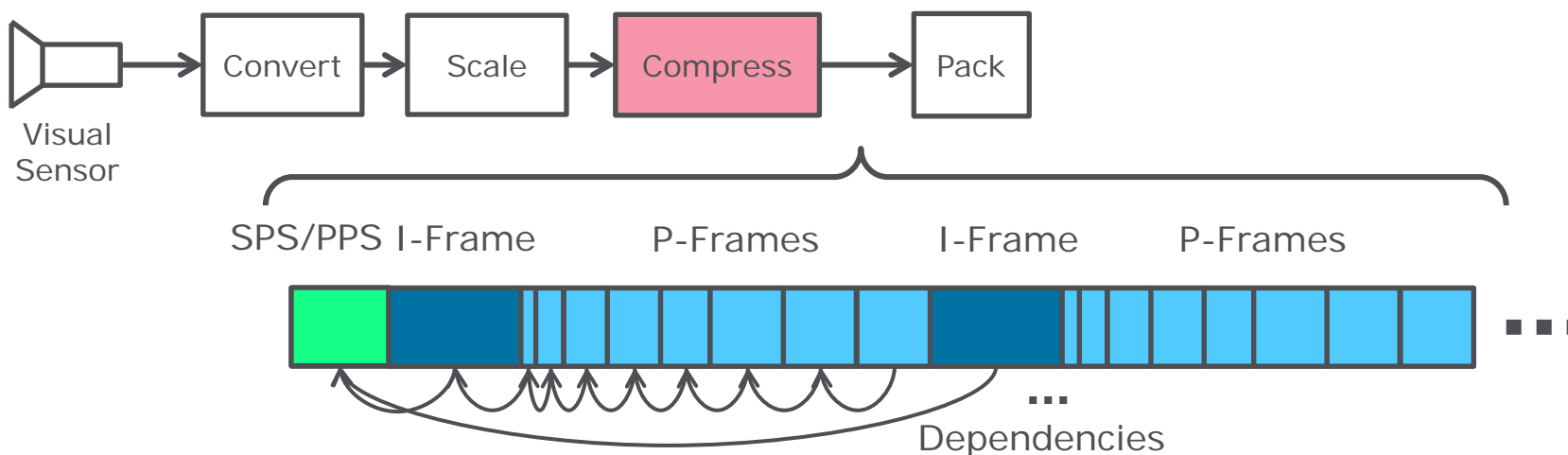




- High frequency (500Hz)
- Small packages, fixed size (8Bytes)



- Low frequency (12Hz)
- Large packets, varying size (5 Bytes till 6000 Bytes)



## Network Abstraction Layer Units (NALUs):

SPS/PPS: Parameter Set

- Global information of the entire stream (e.g. Resolution)

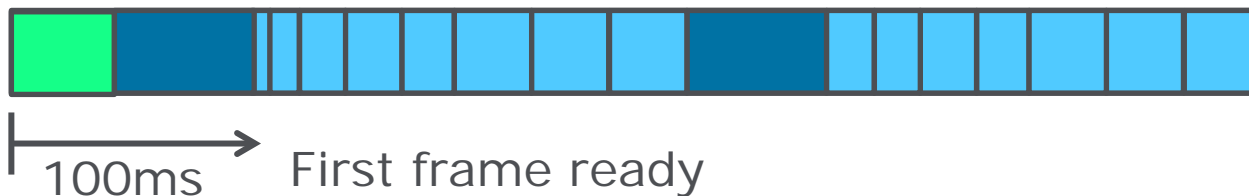
I-Frame: Intra predicted frame

- Depends only on SPS/PPS

P-Frame: Predicted frame

- Depends on previous frames (Picture Group)



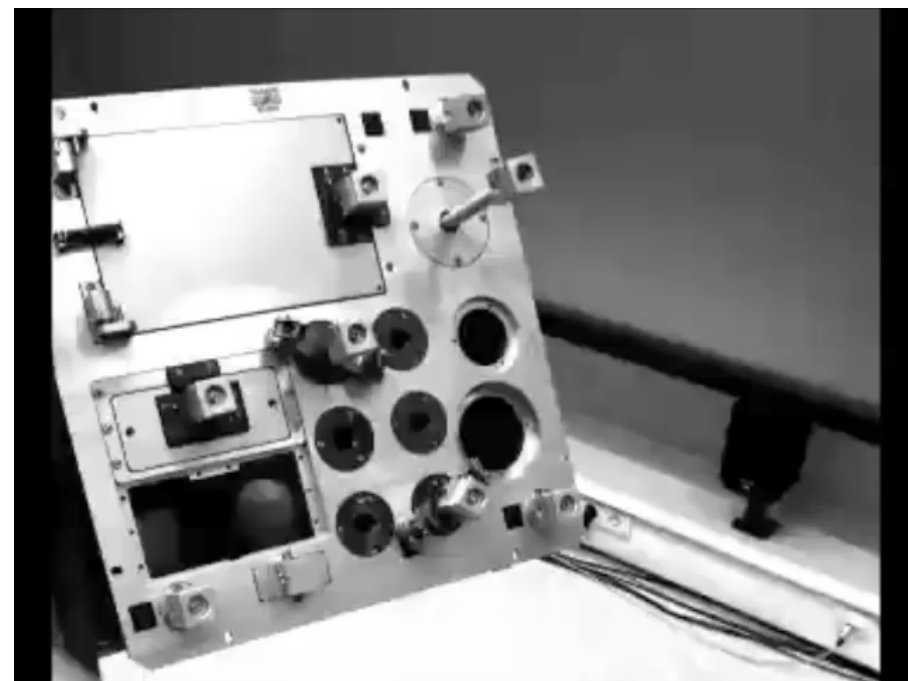


Data-rate limitation of 96kbit/s (Communication channel)

-> **Average** bitrate of Visual data < 96kbit/s

Hypothetical Reference Decoder

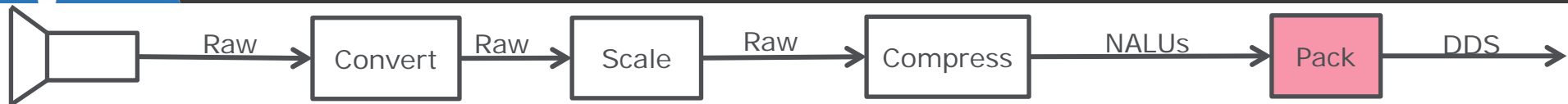
- guarantees frames (NALUs) to arrive within specified amount
- e.g. 100ms



HRD size: 50ms

500ms

- Only Hypothetical Reference Decoder (HRD) size changed!  
(NOT bitrate, resolution, ...)
- Quality drastically increases, but delay as well  
(due to data-rate limitation in communication channel)

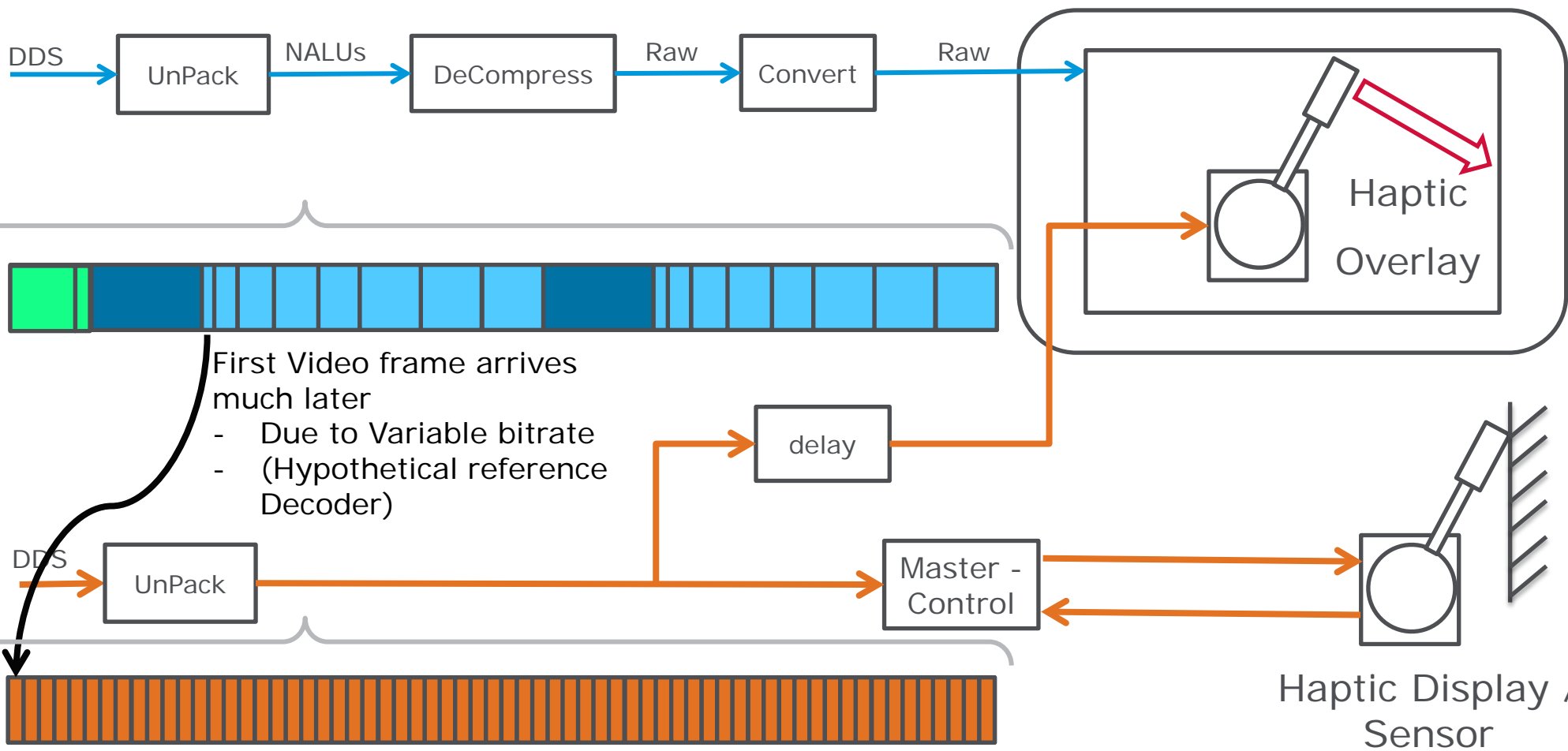


## DDS Topic Types (Interface Description Language)

```
modul e DDST
{
    // 1920 * 1080 * 3 is the maximum frame size (full HD with 3 bytes pp)
    // Data will be allocated at this size, but only the actual size of the
    // frame will be sent.
    const long MAX_NALU_SIZE = 6220800;

    struct Visual
    {
        // This contains the video nalu's
        sequence <octet, MAX_NALU_SIZE> frame;
    };
};
```

```
modul e DDST
{
    struct Haptic
    {
        doubl e torque;
        doubl e angle
    };
};
```



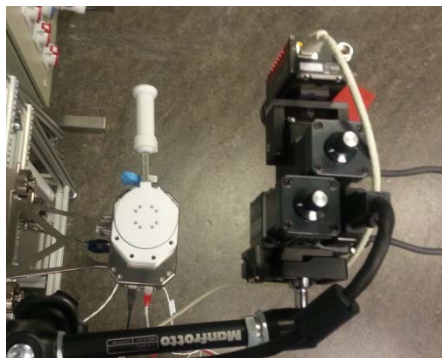
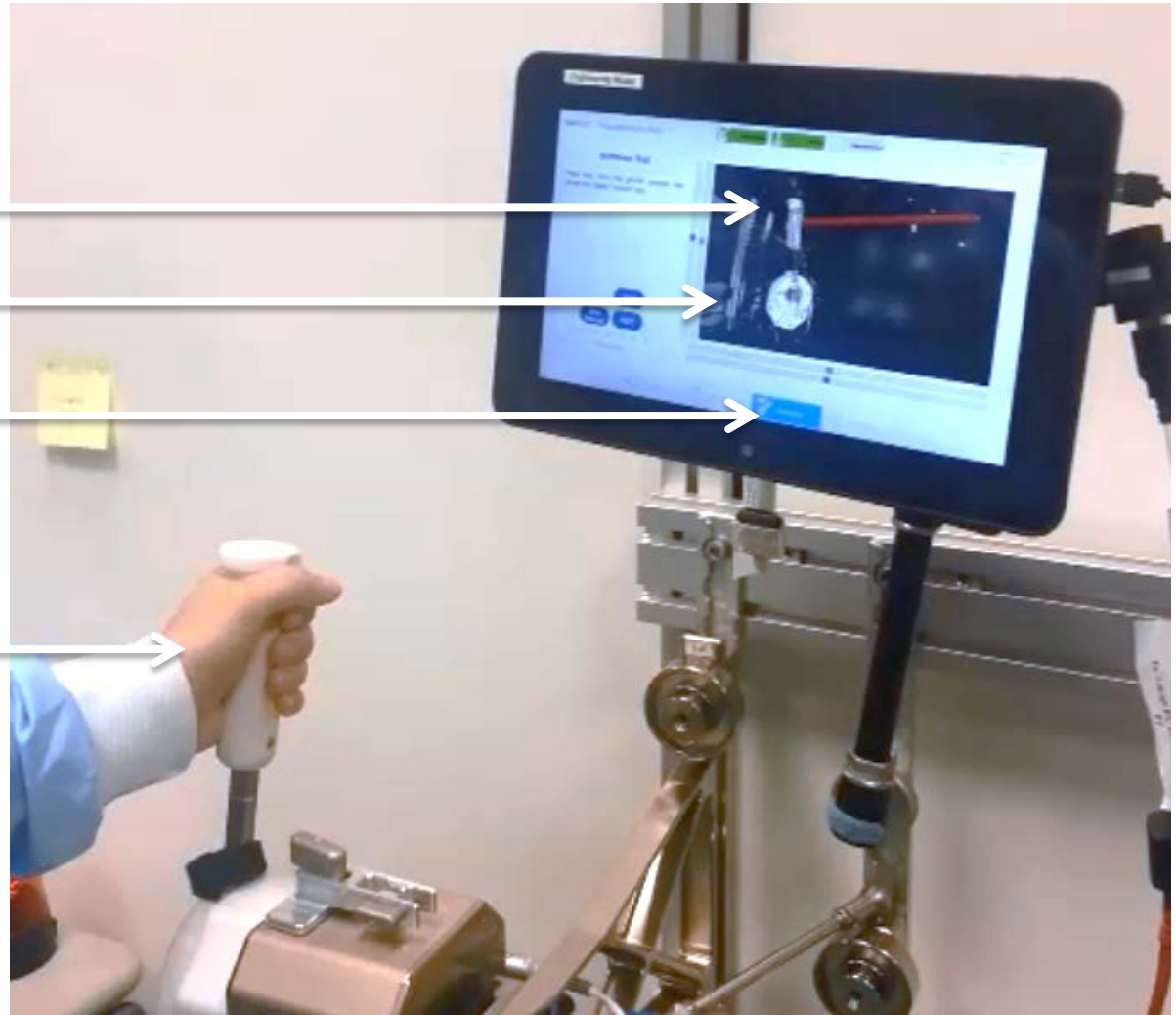


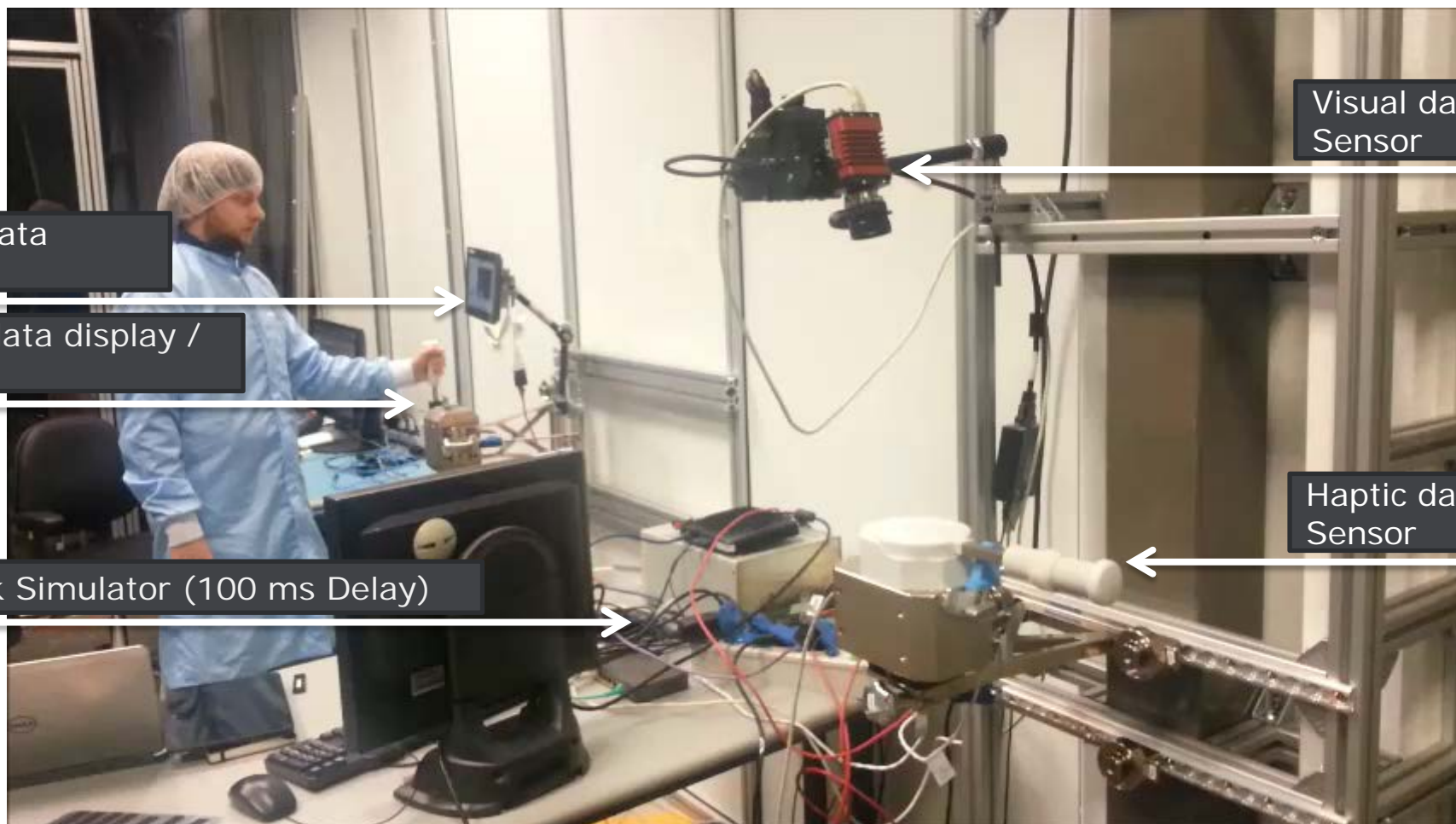
Visualization of haptic data (Overlay)

Visual data (Video display)

Graphical user interface

Haptic data display





Visual data  
Sensor

Visual data  
Display

Haptic data display /  
Sensor

Network Simulator (100 ms Delay)

Haptic data  
Sensor

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