REMOTE OPERATION OF TRAINS

100% Autonomy
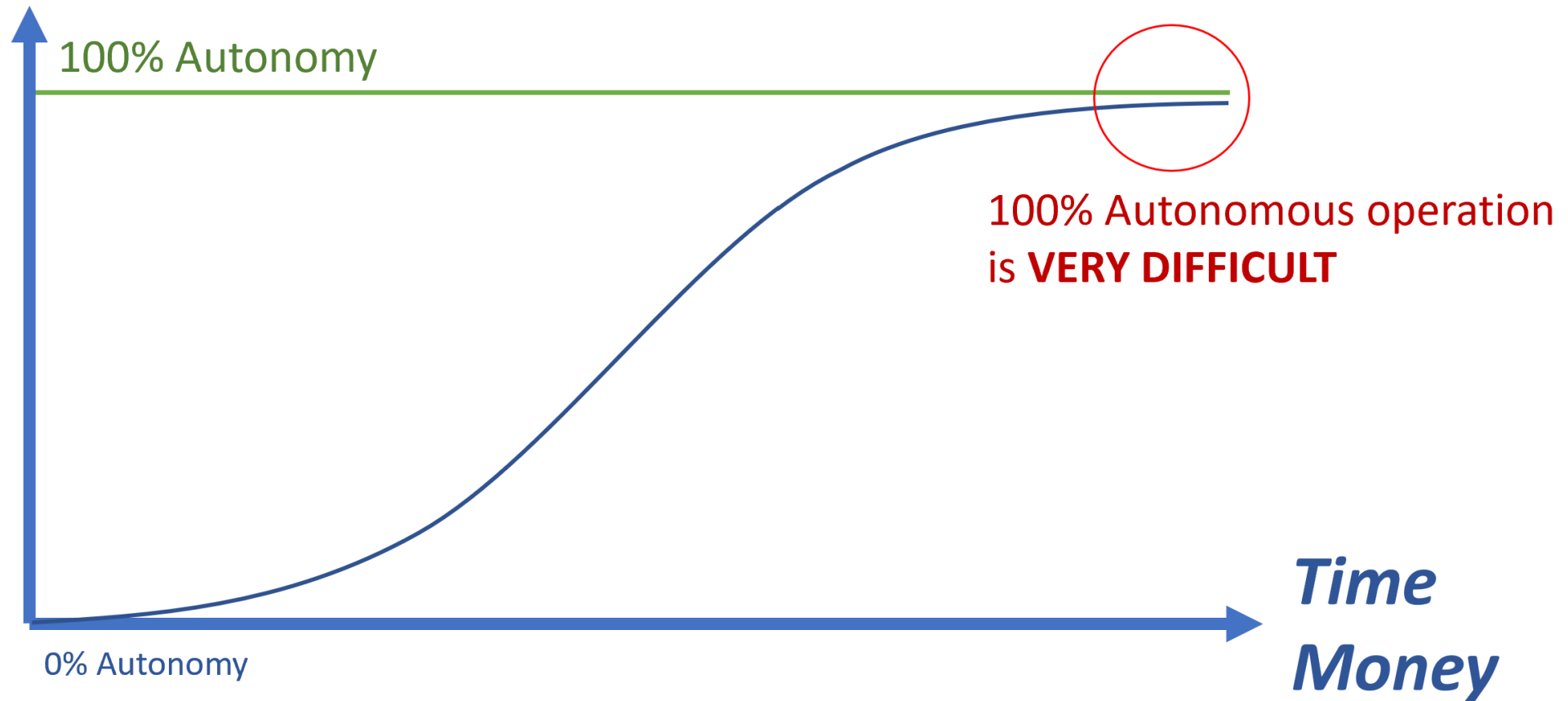
100% Autonomous operation is **VERY DIFFICULT**

Time
Money

0% Autonomy

Picture: Voysys

Tomas Rosberg, Researcher VTI

vti

REMOTE OPERATION OF TRAINS

Tomas Rosberg
Researcher, VTI

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FP6-FutuRe
Cost effective regional lines

REMOTE OPERATION OF TRAINS

- Malfunction of ATO
    – normal operation under ECTS
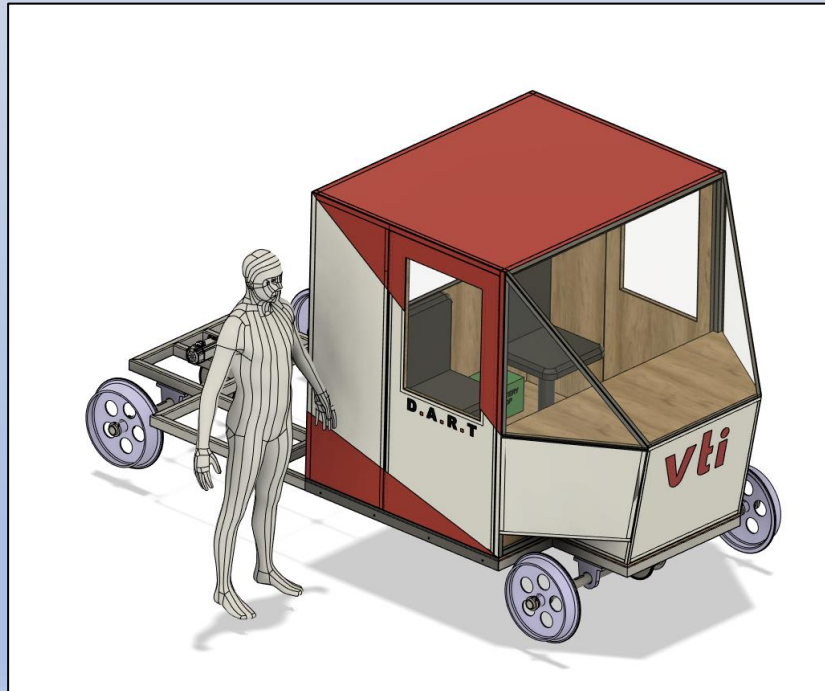- Shunting/platform movements
- Trams

Challenges:
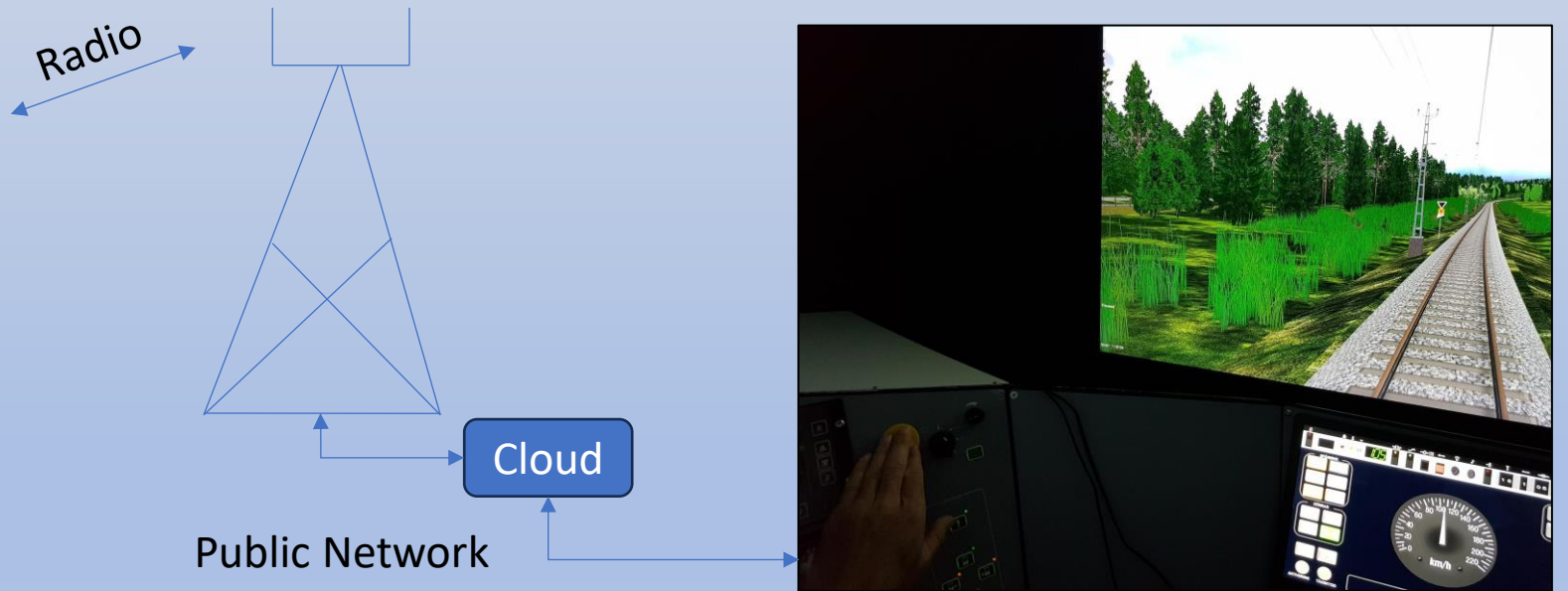- Build competence
- Build test platform

SYSTEM PERSPECTIVE

Test train:
- Electric (battery)
- Regenerating brakes
- Mechanical emergency brake
- High performing radio (4G, 5G)
- Variable gauge (891, 1000, 1435mm)

Remote Control Center:
- VTI train simulator
- New control interface

Radio

Cloud

Public Network

Video link

Control channel

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TRAIN DEVELOPMENT TOGETHER WITH LIU

6 month

12 month

18 month

21 month

TEST ENVIRONMENT AT VTI

First full-scale test in Linköping together with NTNU

-> Train controlled from remote center cross public 5G

THE security challenge - latency

Experience with drone pilots shows that:

- latency of 100 ms between pilot command and confirmation of execution is unnoticed

- With a latency of 200 ms, the pilot is aware that he/she needs to invest some additional energy to pilot. This awareness is a light discomfort.

- With a latency in reaction time between reality and video > 500 ms, pilots need to dedicate such an amount of their cognitive energy that their performance tasks other than controlling vehicle attitude have drastically dropped

In addition - if latencies grow, reaction distance become excessively long!

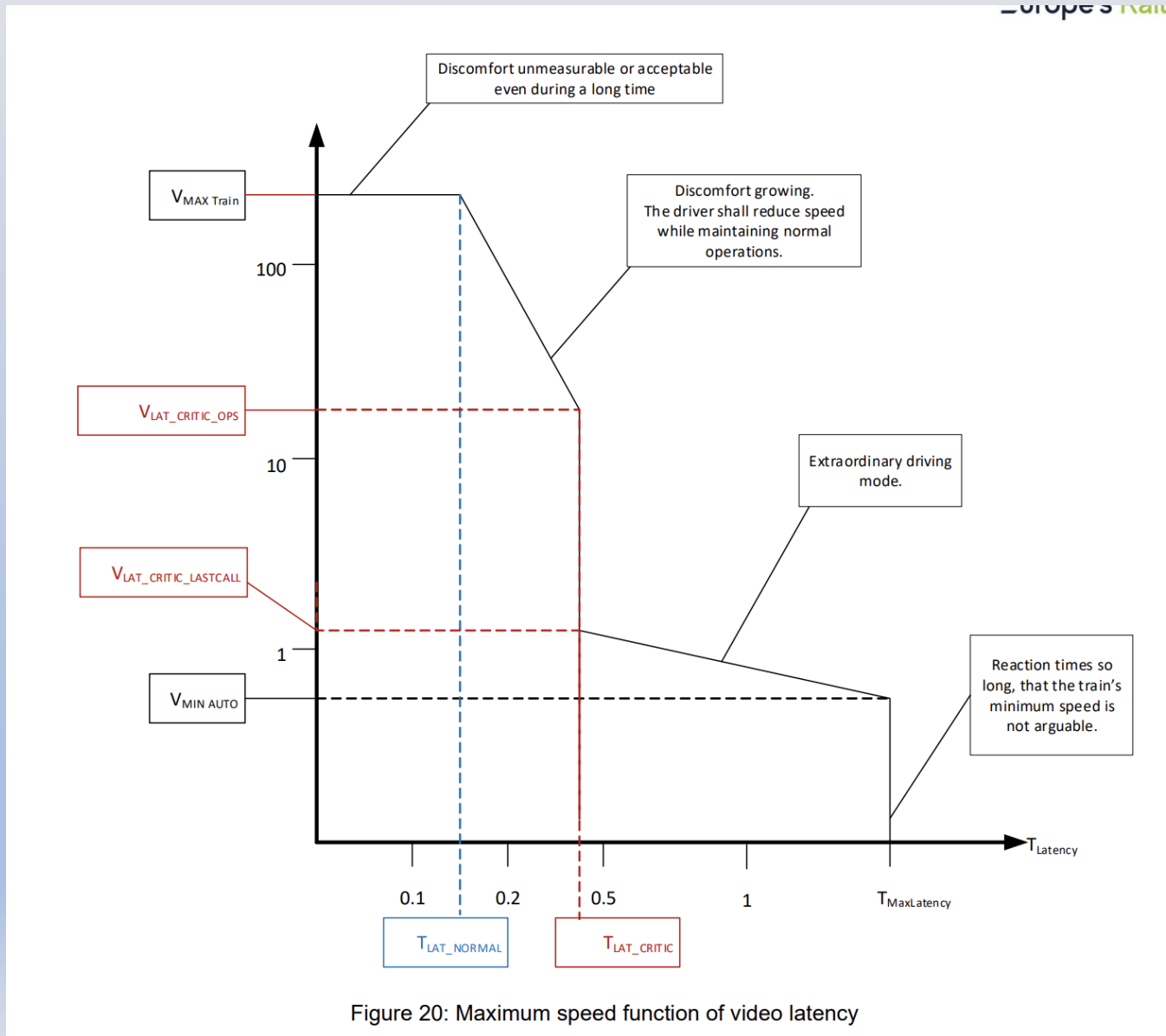vti

Latency – what speed is acceptable?

Figure 20: Maximum speed function of video latency

Results from first demo in Vadstena june 2024

Table 4.1.1: Descriptive Statistics

	Moving Train Along the Track		Moving Train Around the Station		Stationary Train at the Station	
	4G	5G	4G	5G	4G	5G
Valid	50	50	43	43	48	48
Median	400	400	400	500	400	300
Mean	384	382	376.7	483.7	445.8	325
Std. Deviation	65.02	59.56	106.54	155.73	130.40	60.14
Minimum	300	300	200	200	200	200
Maximum	600	600	600	800	800	500

Sources of delay

Shoot → Capture → Encrypt → Transfer → Decrypt → AV Sync → Display

380 ms

Shoot
Capture
Encrypt
Transfer
Decrypt
AV Sync
Display

< 100 ms

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Next steps

➔ Develop video solution. Expected latency < 100 ms. Redundant (bonded) radiocommunication.

➔ Develop remote driver warning system

➔ Test with real train drivers. Remote vs onboard.

➔ Latancy measurements of the control channel

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Thanks for listening!

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