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Safe
Human Robot Collaboration

Agenda

- Introduction
- Innovative robotics application
- Safe human robot collaboration
  - Your challenges and our offer
  - Human safety on the highest level
  - System architecture
  - Maintenance in an easy way
  - Social acceptance

Back to future

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Human-Robot-Collaboration

Škoda 110R coupe 1972, Kvasiny

1972

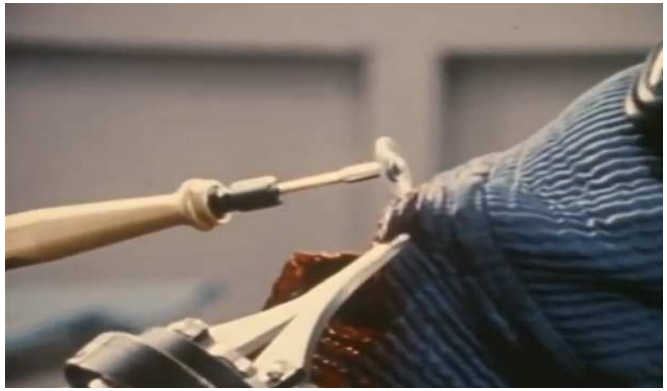
Silent Running is a 1972 environmentally-themed American science fiction film directed by Douglas Trumbull.

Science-Fiction – Today

Human-Robot-Collaboration

Human and robot playing cards

Human and robot playing basketball

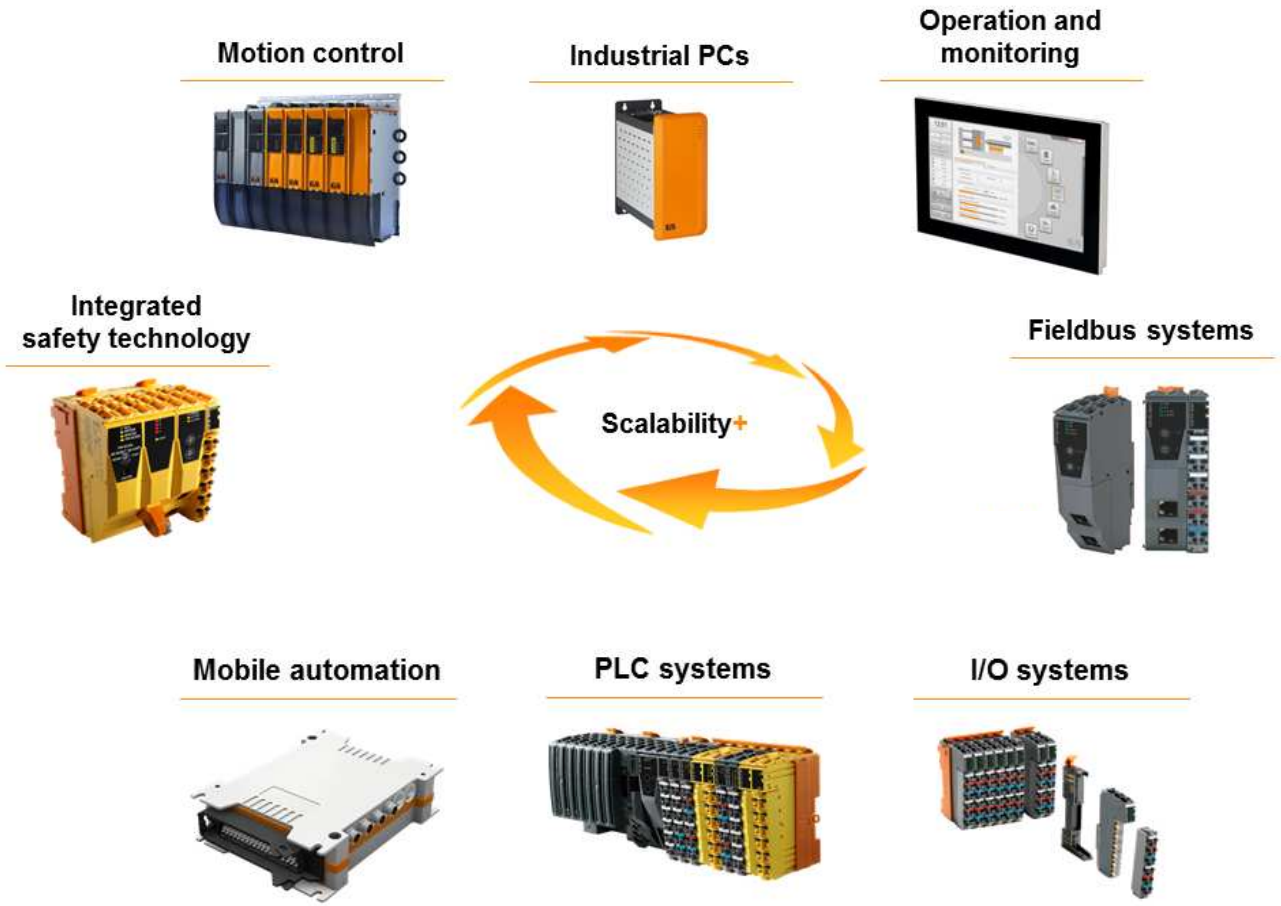


The robot operates on an astronaut

LEONI ORION
Precision patient positioning system
Synchronicity with six degrees of freedom

Huge product portfolio

Next generation automation



We offer the complete portfolio for machine and line automation.

Market leaders put their trust in B&R

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Sealing/Welding

CHERY
COMAU ROBOTICS
BM3

Bending

AMADA
TRUMPF

Finishing / Coating

b+m surface systems

Packaging

KRONES
DIVIDELLA KÖRBER SOLUTIONS
Thimonnier
GORBEL A CLASS ABOVE

Assembling

CODIAN ROBOTICS
WIESER Automation - Maschinenbau

Milling/Grinding/Drilling

Fill
ePROJECT4 ENGINEERING PROJECTS

Handling

WEMO
YUDO
ATM
ENGEL
GEIGER HANDLING®
REMAK

Palletizing

EKTAM
Columbia
KOSME
Sidel
ocme MOVING IDEAS

Flexible production in small series

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Robotics Embedded

TRUMF bending: TruBend Cell 7000 the innovative high speed bending cell

For automated bending is the TruBend Cell 7000 the fastest system worldwide.

Video:
https://www.youtube.com/watch?v=yS0F60XiZ-Q

More productivity
Synchronized processes on one CPU enable the double productivity

More flexibility
Any product variant due to the automated tool changer

Safe realization of the process

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Optimal paint quality due to path truth

B+M painting:
New T1 robot

The new „T1“ painting robot series „X5“ based fully on B&R solution of integrated robotics

Continuity
Backwards compatibility for user programs

Matching the coming norms
SLS @ TCP fulfilled already today

www.bm-systems.com

Energy consumption dramatically reduced

Flexibility up to batch size 1

Ultra sound spot welding with 6 cooperating tripods

Car door interior manufacturing - Skoda Octavia

Increase of productivity

Dynamic cooperating robots

Reduction of energy consumption

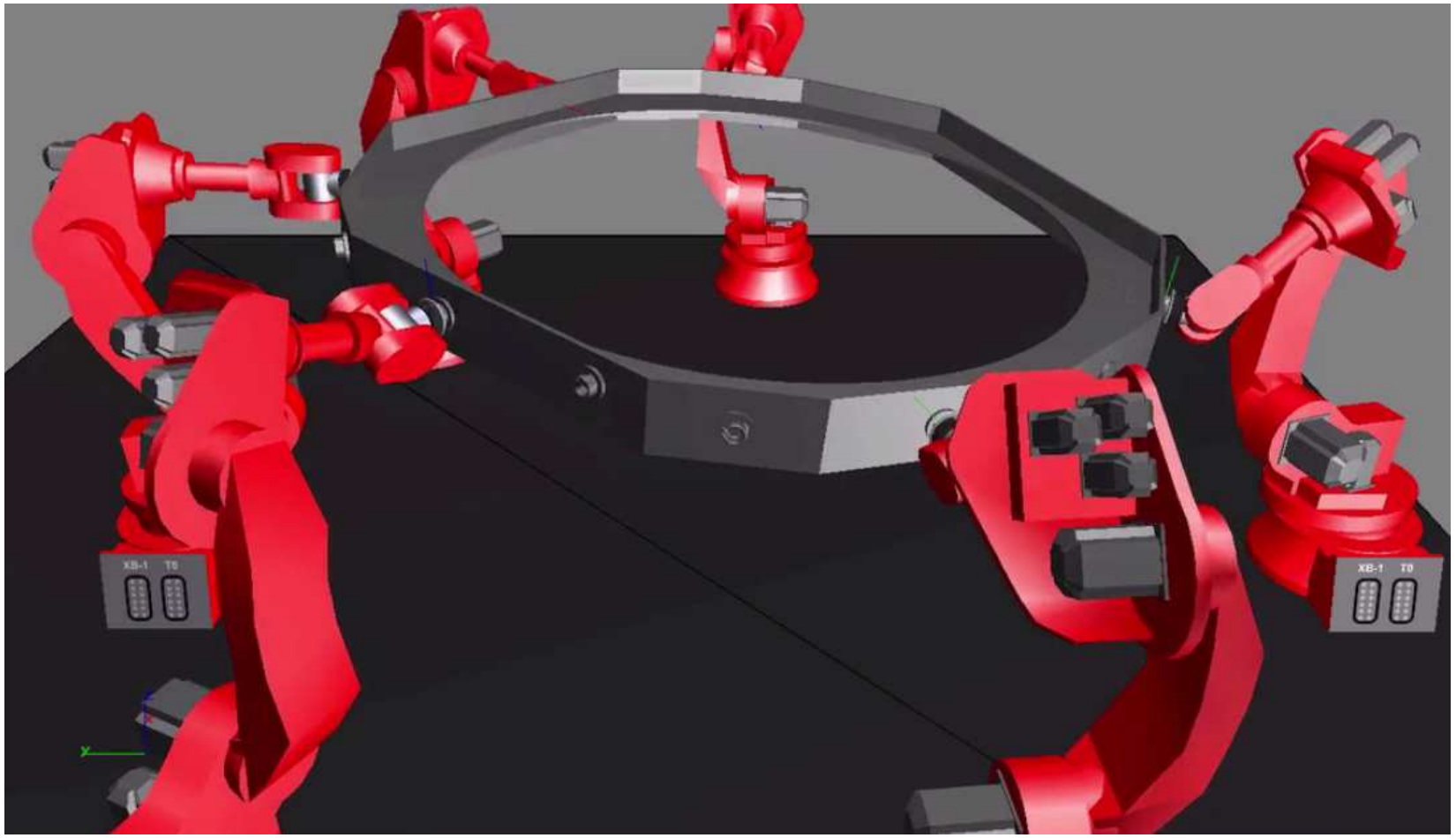
Reduction of moving mass due to light construction kinematics

Footprint reduction

Overlapping working areas

Multi robot cooperation

Coordinated path planning



Automation is enabler for I4.0

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Modern Shop Floor

Focus on Automation and Engineering

Technology-Know-how, fast project development

Smart Factory

Transparent communication on all levels

Energy management

Disclose leakage, Increase of effectivity

Intelligent maintenance

Productivity and availability

Safe technic

Complete integration of all components

Robot and human

Working in one team

Safety technic and robotics hand-in-hand

Our philosophy

- Smart programmable safety technic offers enormous innovation potential
  - THE Key for personal safety AND productivity
- Highly precise and highly dynamic robot control
- Motion coordination in multi robot cooperation
- Human-Robot-Collaboration
- Melting borders of robot and application technic
  - Welding, gluing, painting, milling, cutting …

Your challenge …

autogramm
Die Zeitung für die Mitarbeiterinnen und Mitarbeiter der Marke Volkswagen
Ausgabe 11/2014

Industrie 4.0 – Große Chance für die Arbeit

Ein Gastbeitrag von Horst Neumann, Vorstand für Personal, Organisation und IT der Volkswagen AG
Digitalisierung und Vernetzung sind dabei, unsere Arbeitswelt fundamental zu verändern. Gleichzeitig gehen die stark besetzten Jahrgänge der „Babyboomer" in Rente. Mit Blick auf die Fabrik der Zukunft ergibt sich daraus für den Industriestandort Deutschland eine einzigartige Chance.


Horst Neumann.

Die Digitalisierung zieht durch die Arbeitswelt: Unter dem Stichwort Industrie 4.0 diskutieren Maschinenbauer und Wirtschaftswissenschaftler, Informatiker und Produktionsfachleute, Gewerkschafter und Politiker das künftige Zusammenspiel von Maschinen, Produkten und Menschen. Sie entwerfen Szenarien, in denen Mensch und Maschine „Schulter an Schulter" arbeiten oder in denen die Fabriken von morgen gar „menschenleer" sind. Doch wie realistisch sind diese Szenarien? Und sind sie Segen – oder Fluch? Die menschenleere Fabrik ist weder realistisch noch wünschenswert.

Wer Industriemessen, Forschungslabore, Universitäten oder Pilotanwendungen in Industrieunternehmen besucht, stellt jedoch fest, dass ein neuer Automatisierungsschub bevorsteht. Denn Roboter werden kleiner, leichter, leistungsfähiger und kostengünstiger. Sie verlassen die Käfige, in die sie heute aus Sicherheitsgründen „eingesperrt" sind. Die damit verbundenen Sicherheitsanforderungen scheinen lösbar.

Source: http://autogramm.volkswagen.de/11_14/aktuell/aktuell_04.html

Your challenge …

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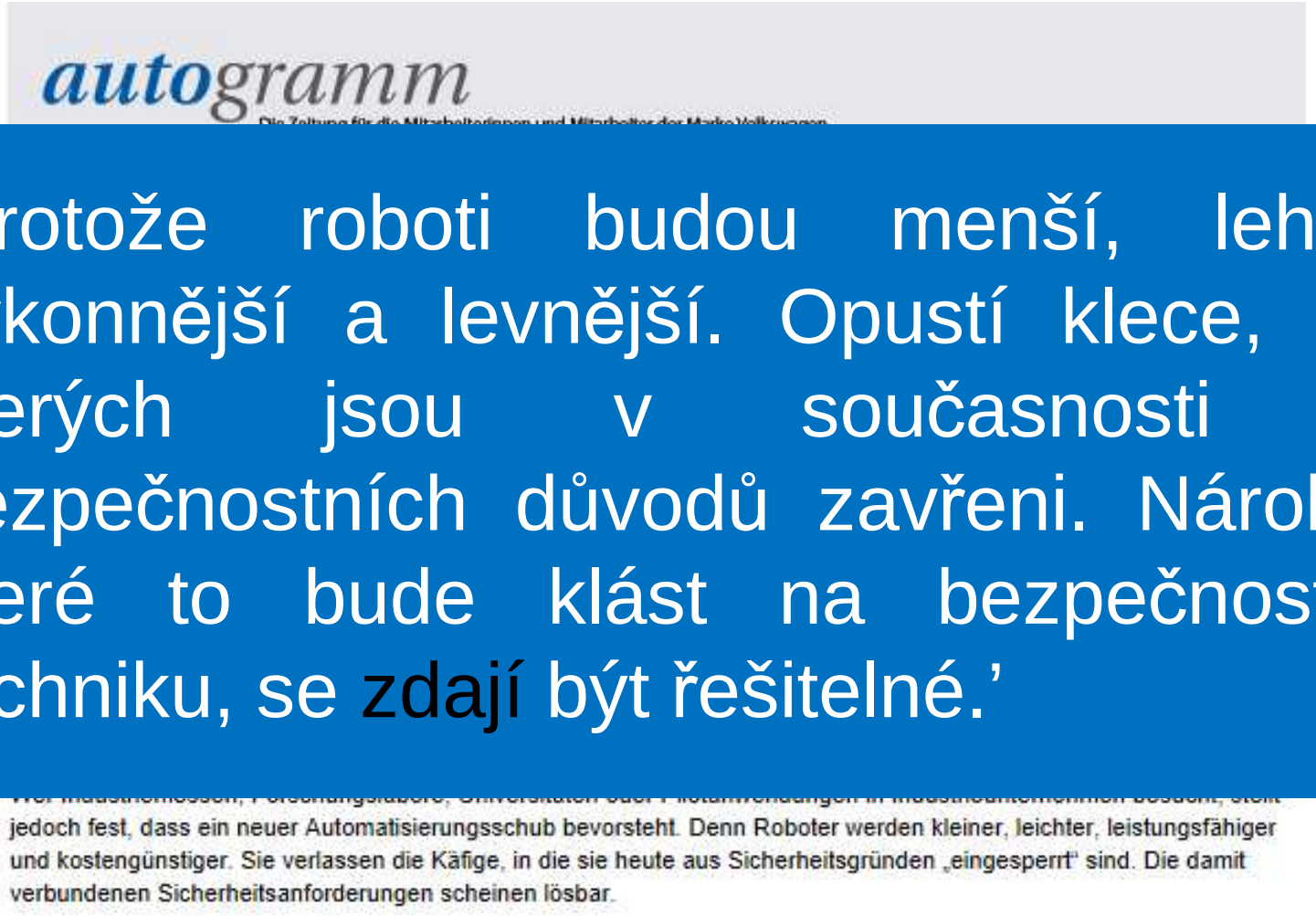

‚Protože roboti budou menší, lehčí, výkonnější a levnější. Opustí klece, ve kterých jsou v současnosti z bezpečnostních důvodů zavřeni. Nároky, které to bude klást na bezpečnostní techniku, se zdají být řešitelné.'

Source: http://autogramm.volkswagen.de/11_14/aktuell/aktuell_04.html

… naše nabídka

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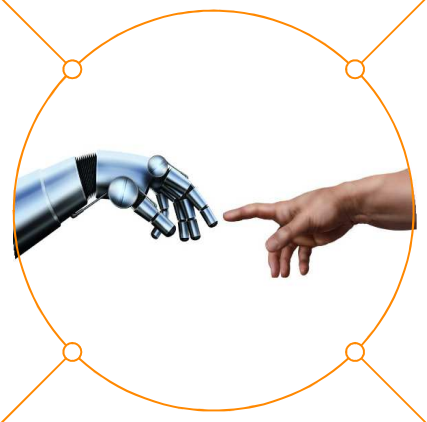
Požadavky na
Bezpečnou spolupráci
Člověka a robota
Jsou s technikou B&R
Optimálně
Řešitelné

Optimal in terms …

… the most important criteria for safe HRC

Highest level of personal safety

Social acceptance



Productivity

Maintenance without risk

The decisive factor …

… is the safe reaction time

Error case 1: Safe sensor detects an event, e.g. from a light curtain

$$\Delta s = v \cdot \Delta t$$

Δs	Remaining distance before safe reaction
v	Speed of movement
Δt	Safe reaction time

Significant reduction of remaining distance

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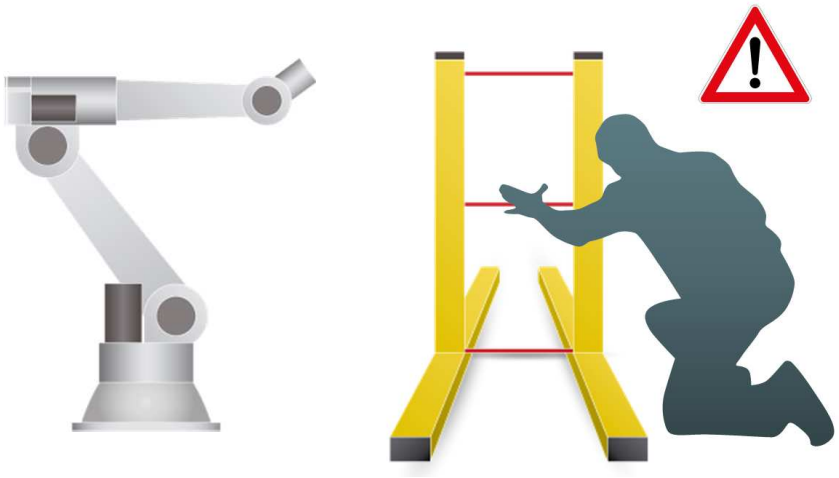
Direct consequence of shortened error reaction time

- Smaller machine footprint saves costs and increases productivity
  - Safety system standard: Error reaction time 420 ms
  - Safety system B&R: Error reaction time 31 ms
  - TCP speed: 2 m/s
  - Difference in the safety distances: **778 mm**



The decisive factor …

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… is the safe reaction time

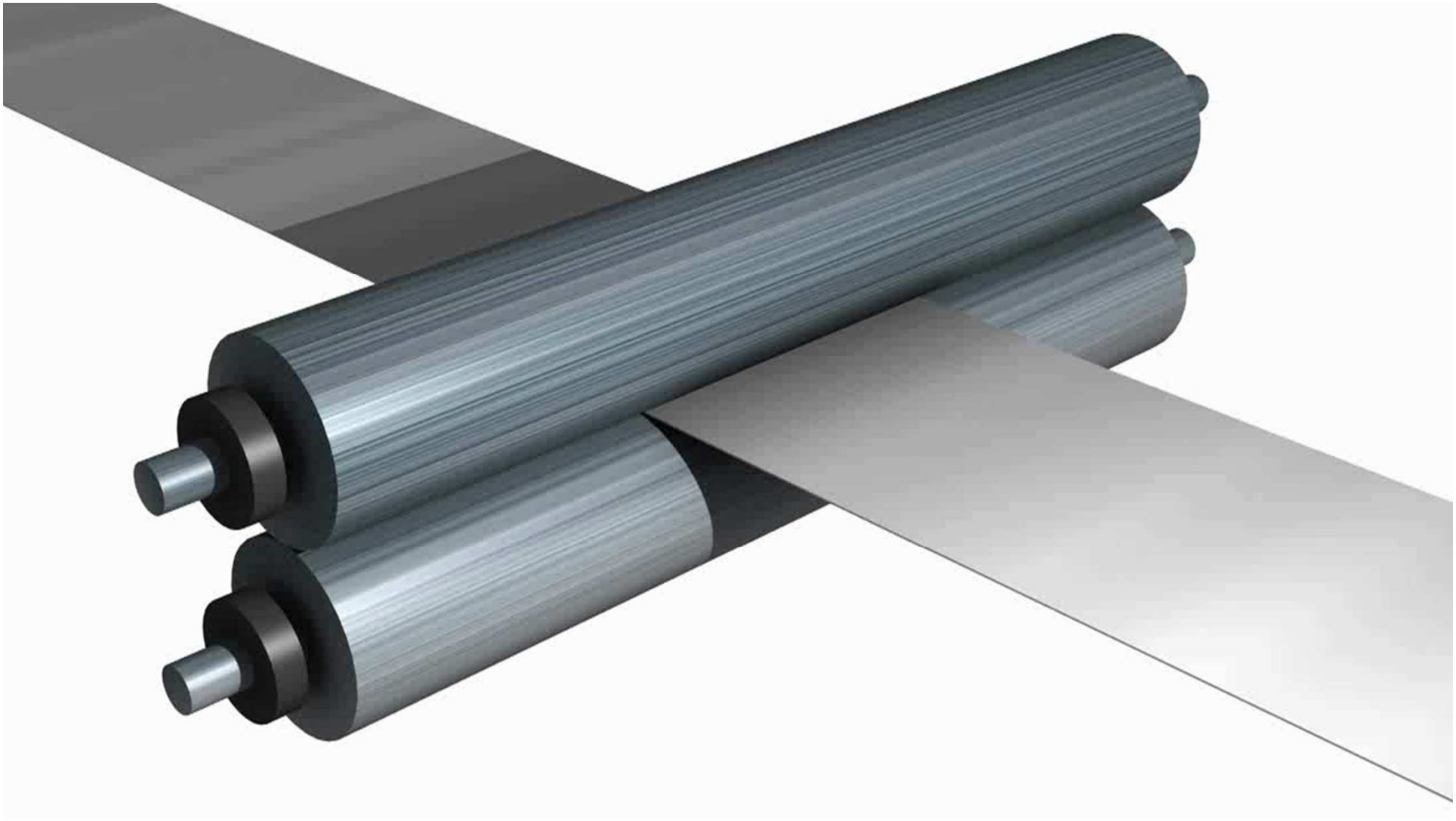
Error case 2: Acceleration phase with maximum torque

$$\Delta s = \frac{1}{2} \cdot a \cdot \Delta t^2$$

Δs	Remaining distance before safe reaction
a	Maximum acceleration in error case
Δt	Safe reaction time

Hand off? – Hand OK?

Analogy in the printing industry

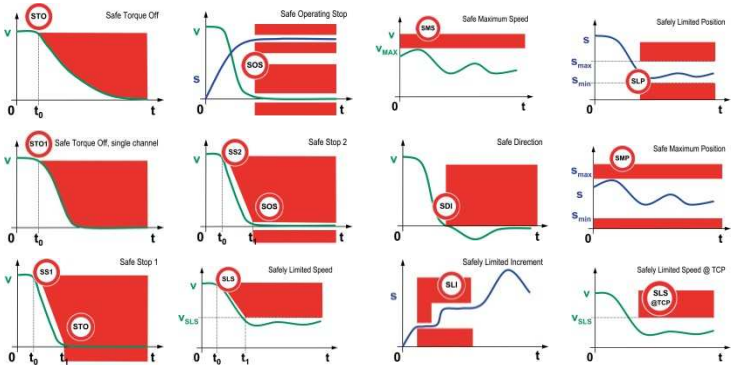


The highest level of personal protection

… on the axis level

- Safety axis functions
  - Safely Limited Speed (SLS)
  - Safely limited torque (SLT)
  - Safely limited position (SLP)
  - Remanent safe position (RSP)
  - Safe control of the motor brake (SBC)

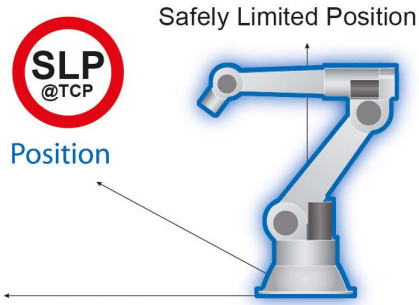
- ...shortest error reaction time
  - Safe reaction time: 7ms on the axis level



The highest level of personal protection

… on the robot level

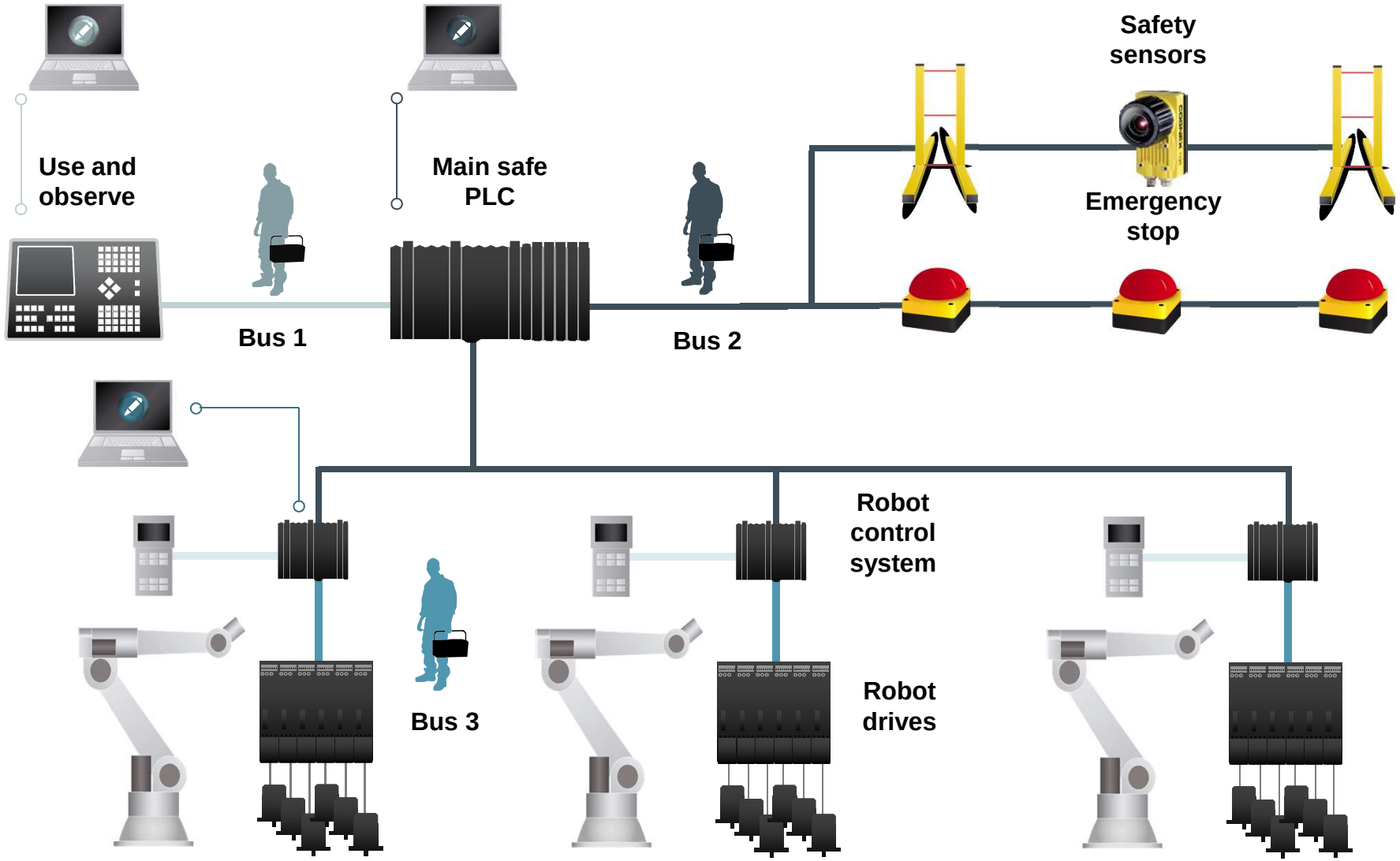
- Safety function for robots
  - SLS @ TCP
  - SLP @ TCP and SLP @ joints
    (Safely limited position)
  - SLO @ TCP (Safely limited orientation)



- Basis
  - Certified safety-related monitoring of robot movement
  - Generic serial kinematics

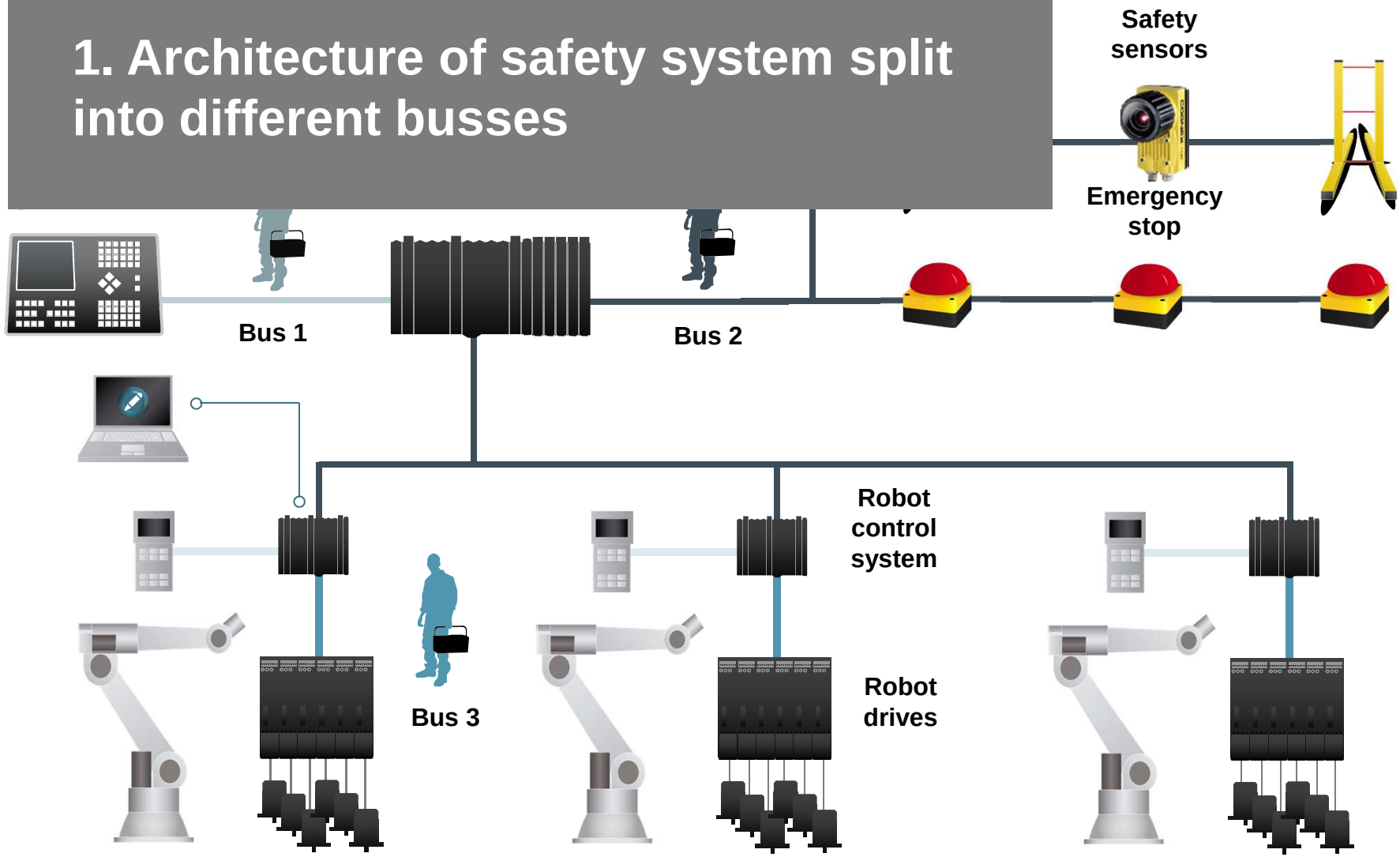
- Shortest error reaction time
  - 31 ms on robot level

Conventional system architecture



Conventional system architecture

1. Architecture of safety system split into different busses



Conventional system architecture

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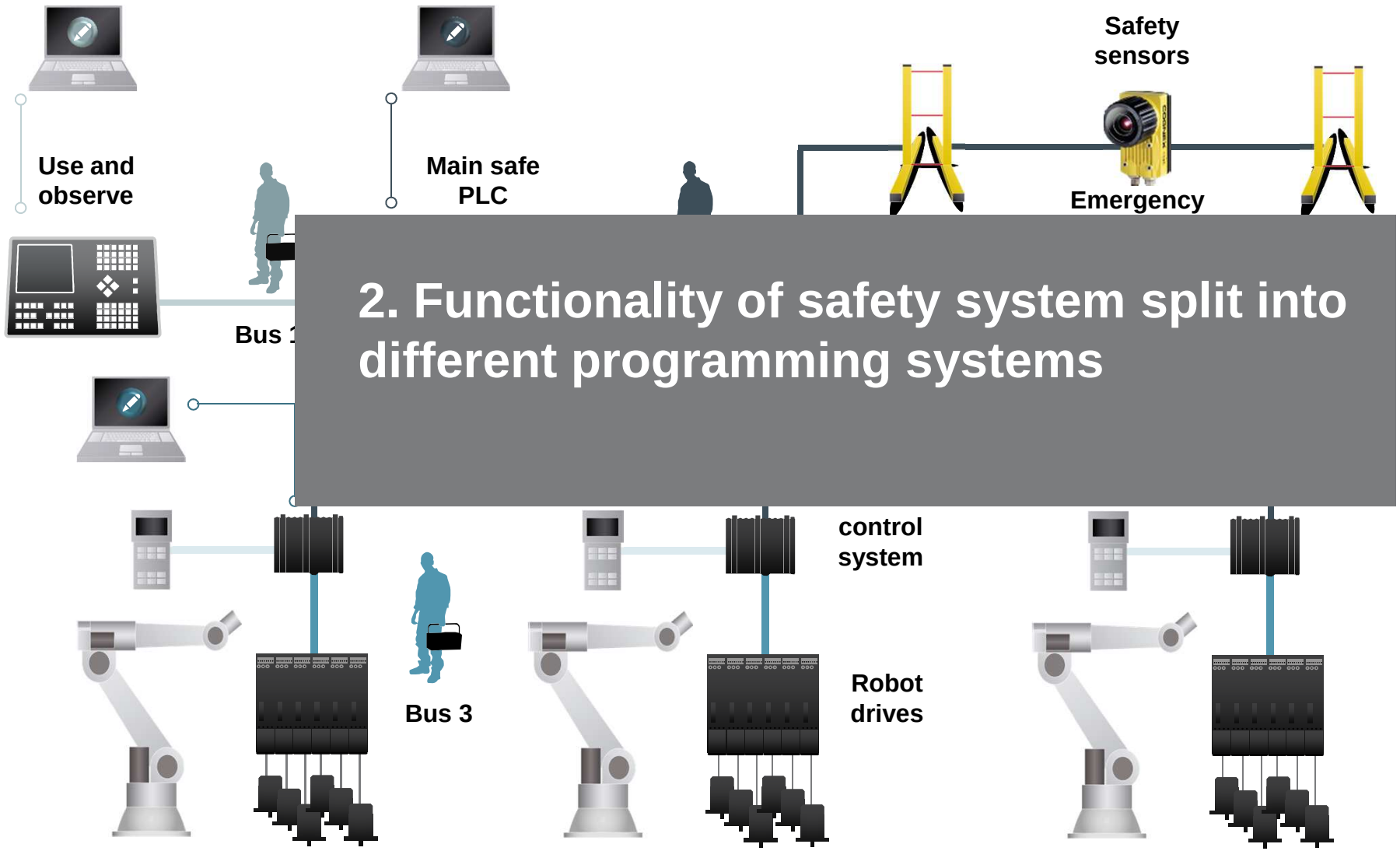
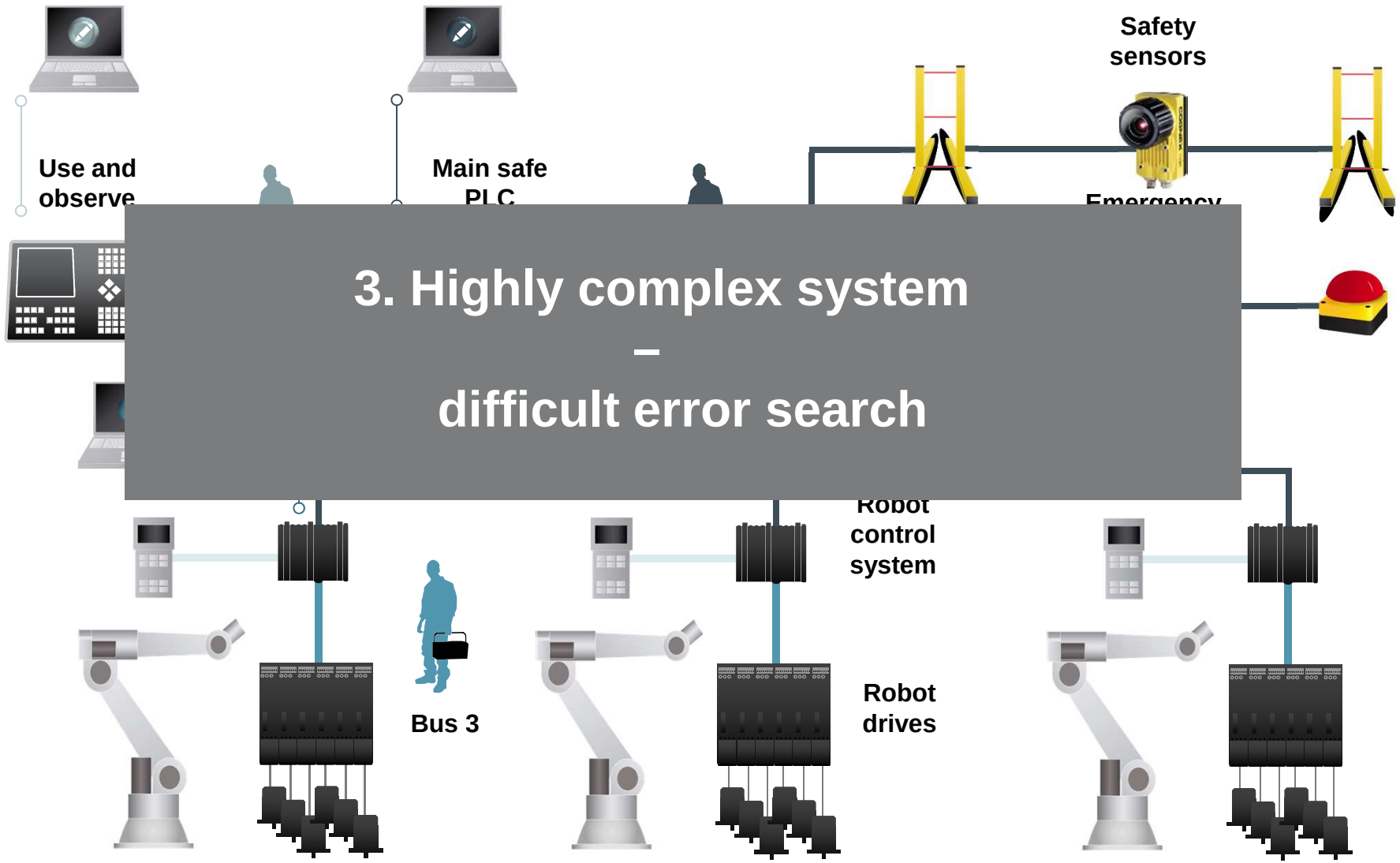
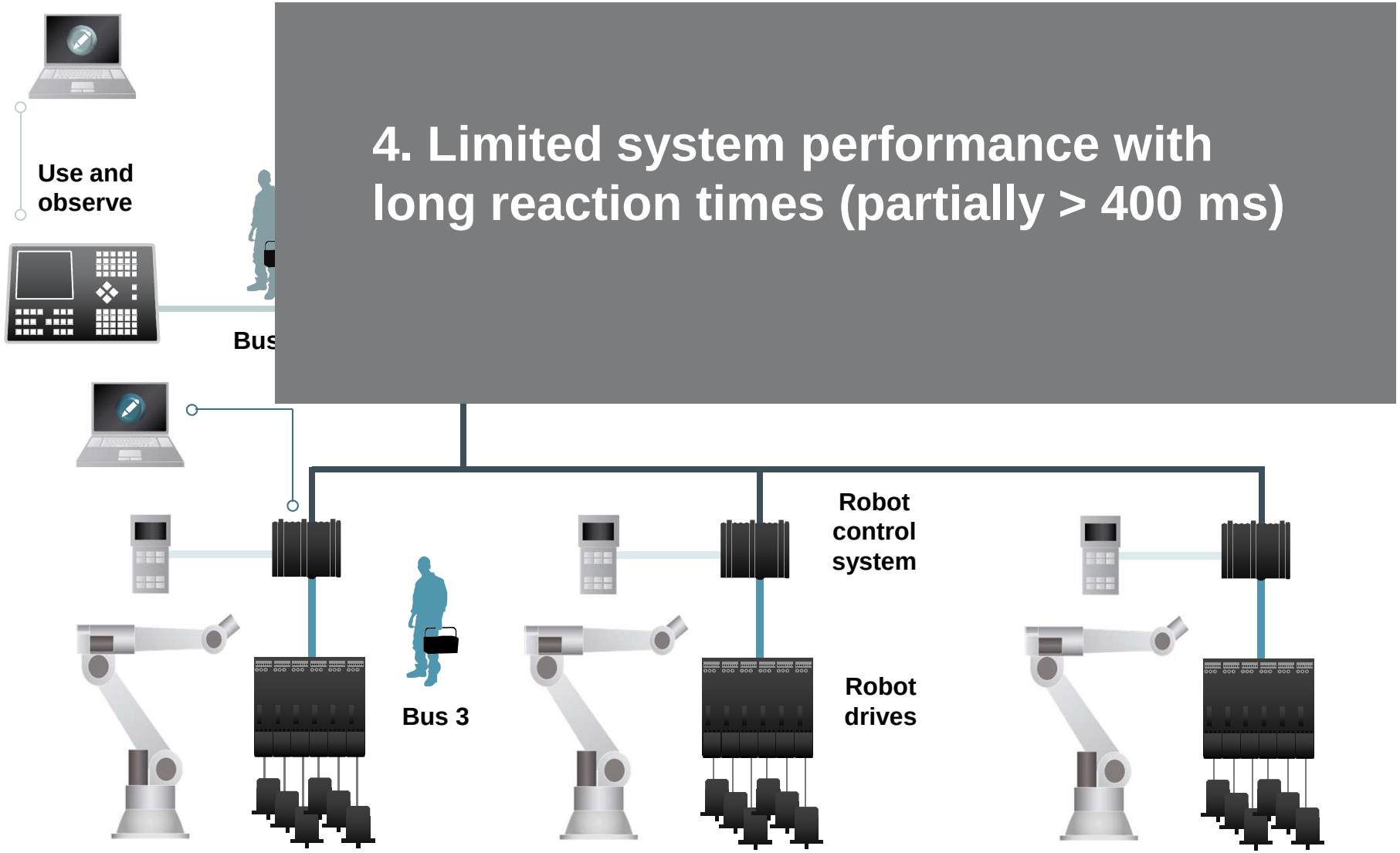


Conventional system architecture

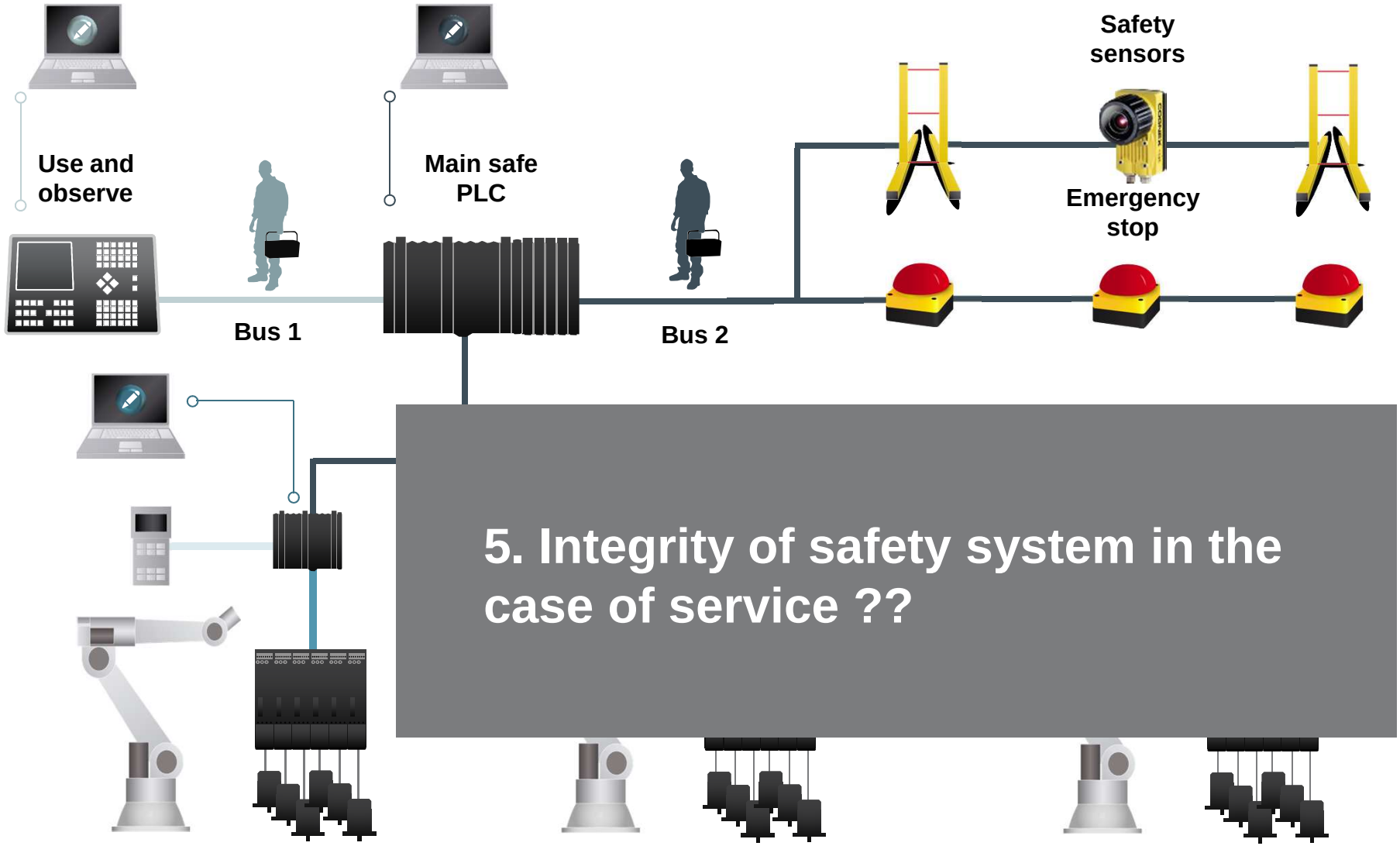


3. Highly complex system
–
difficult error search

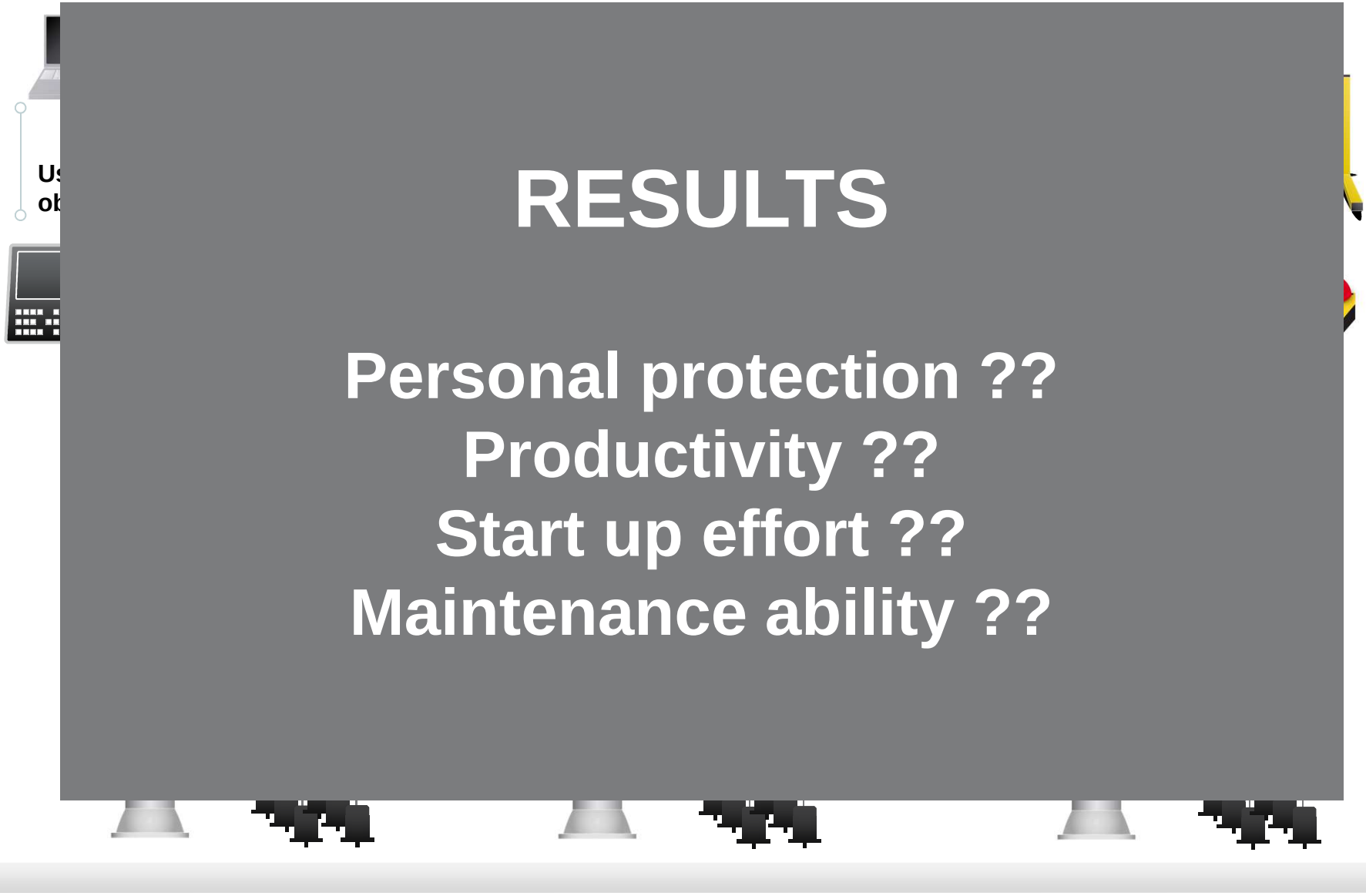
Conventional system architecture



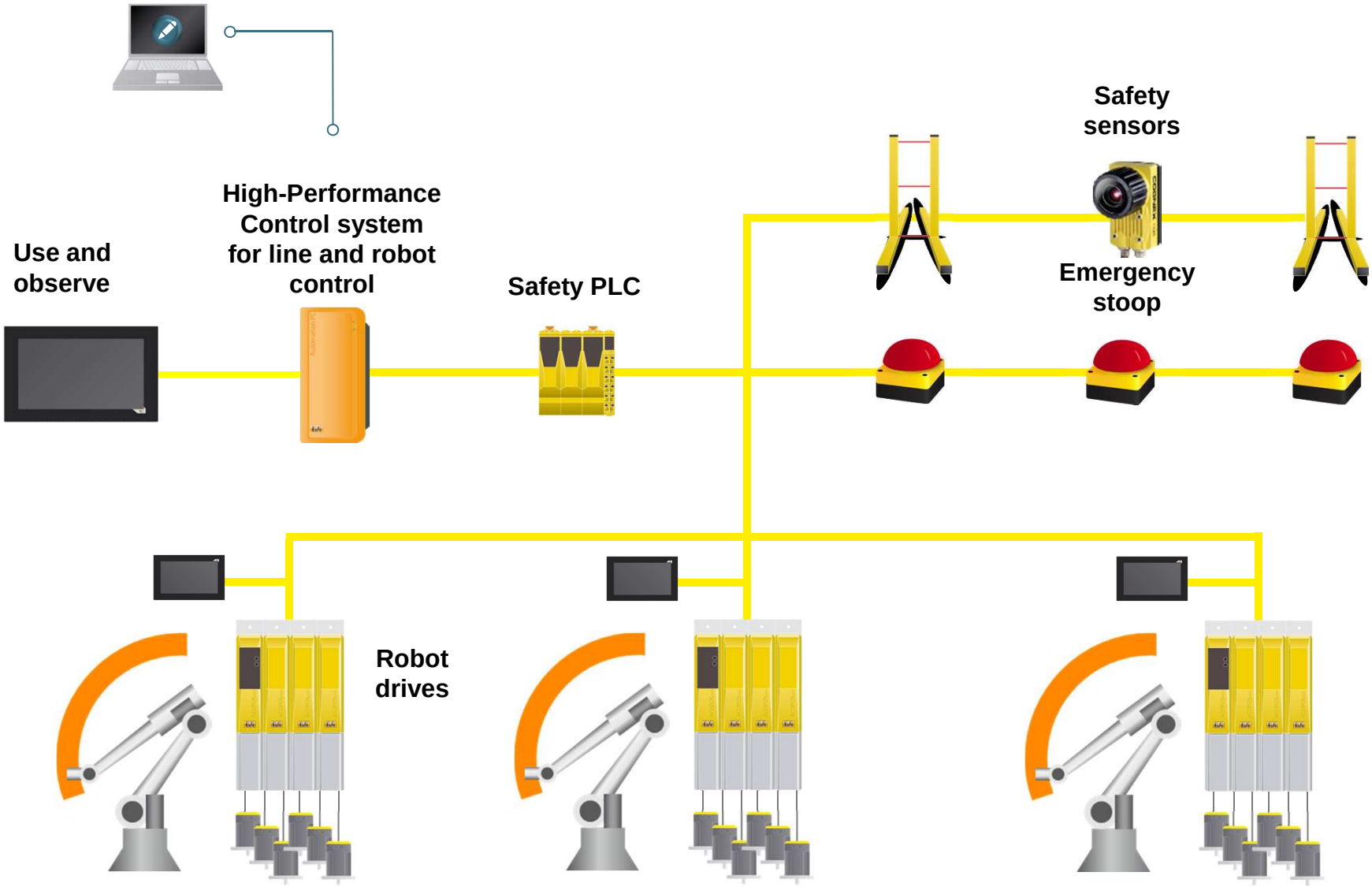
Conventional system architecture



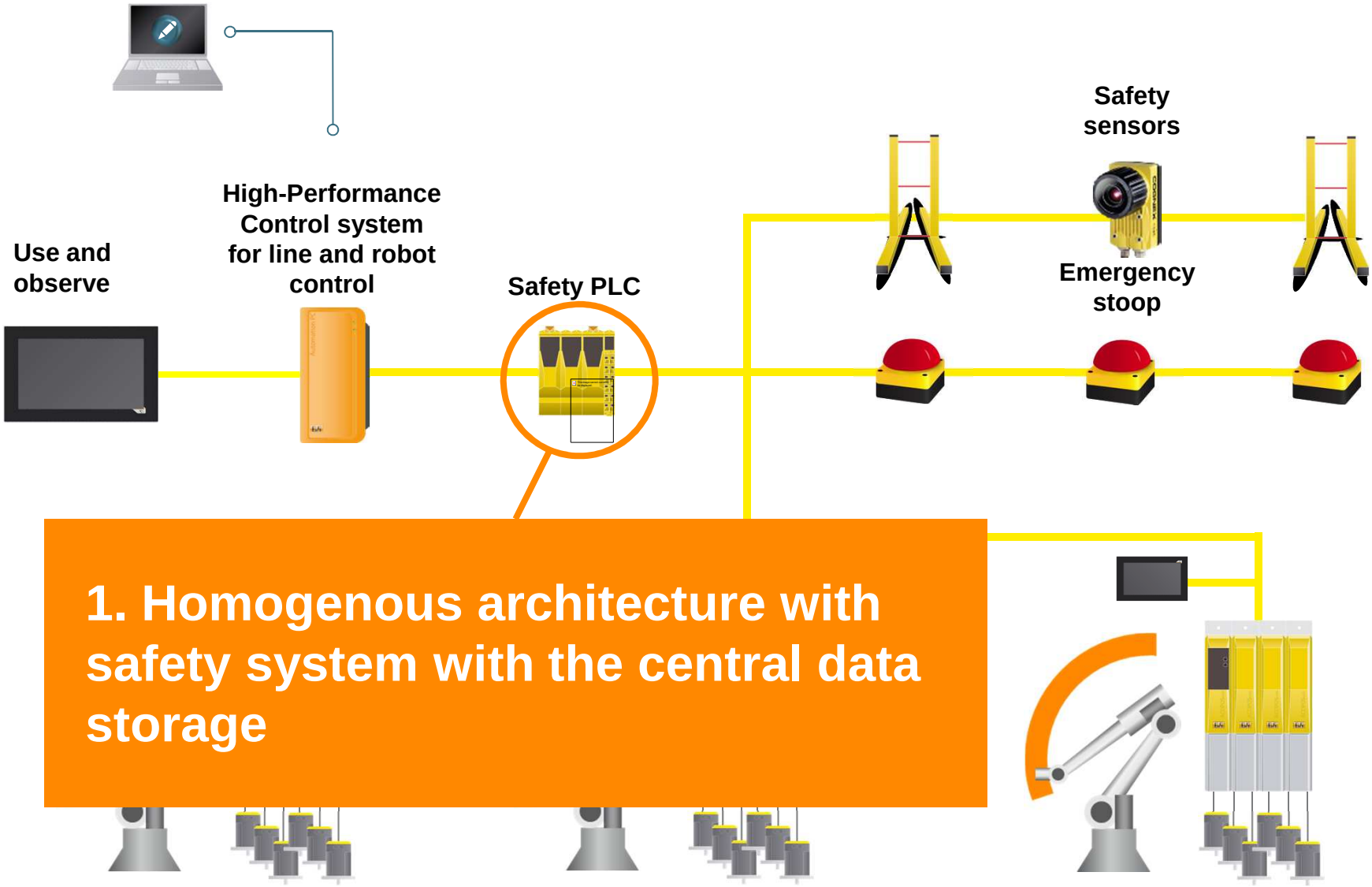
Conventional system architecture



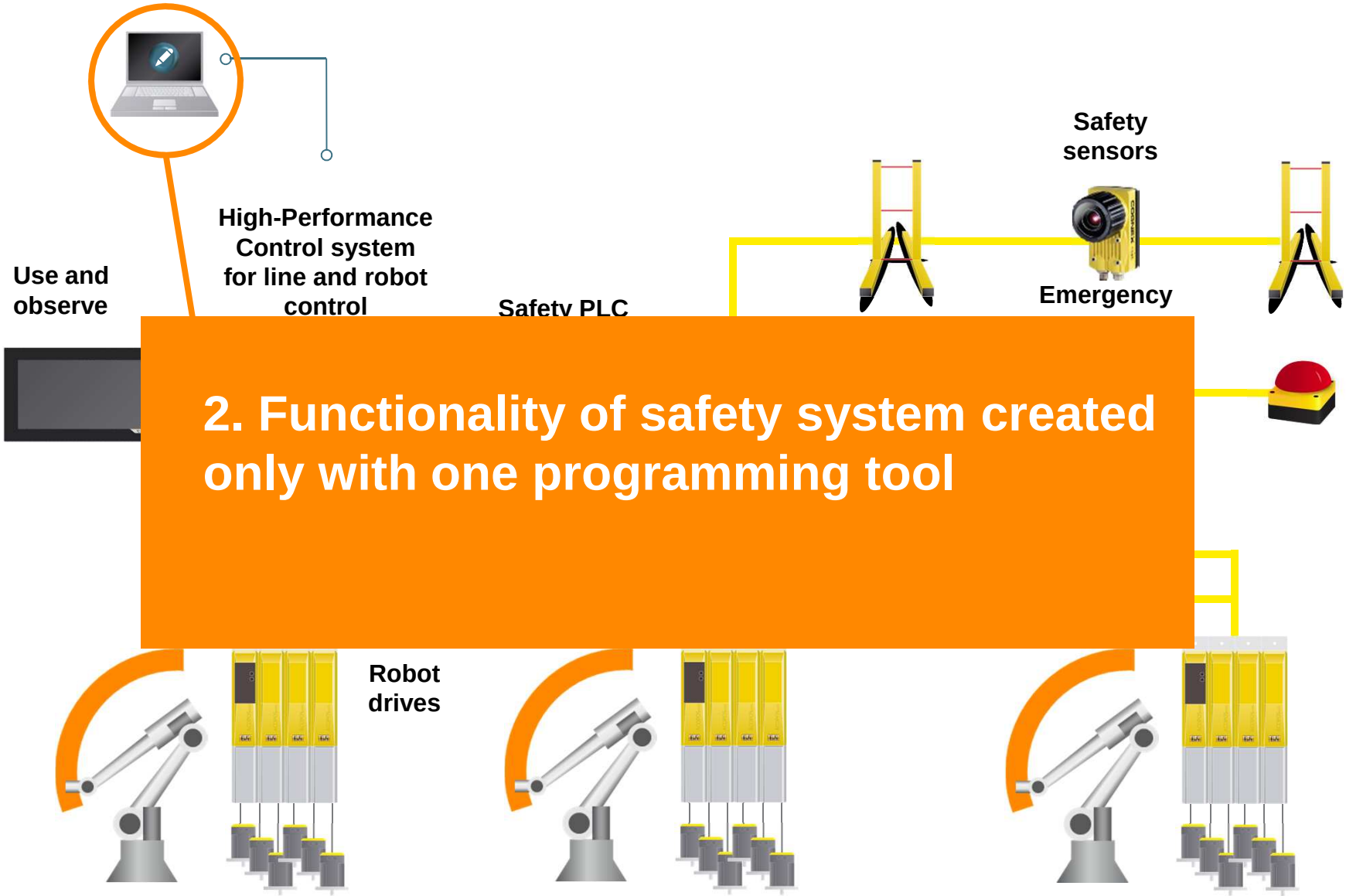
System architecture 4.0



System architecture 4.0



System architecture 4.0



2. Functionality of safety system created only with one programming tool

System architecture 4.0

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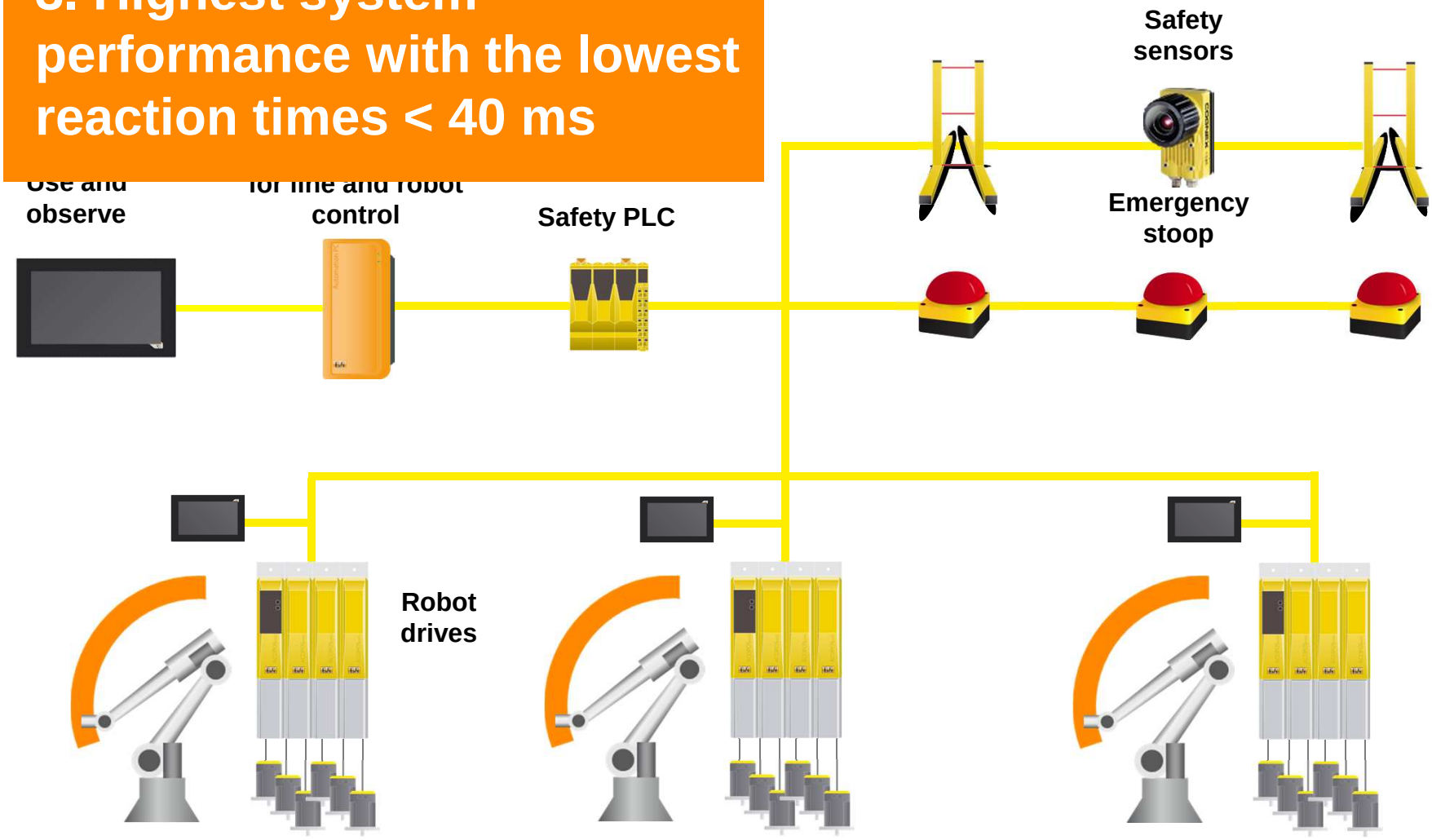
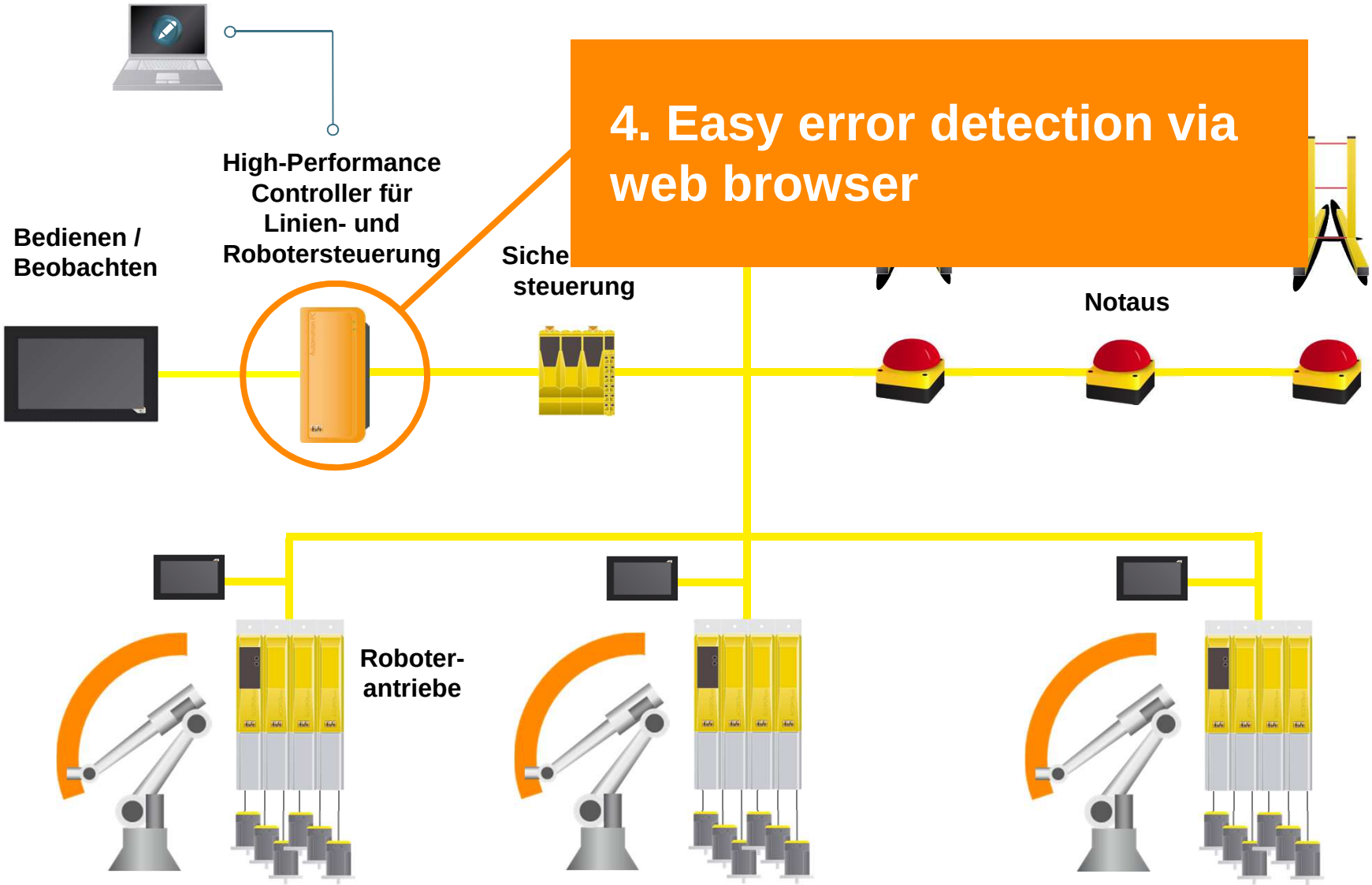
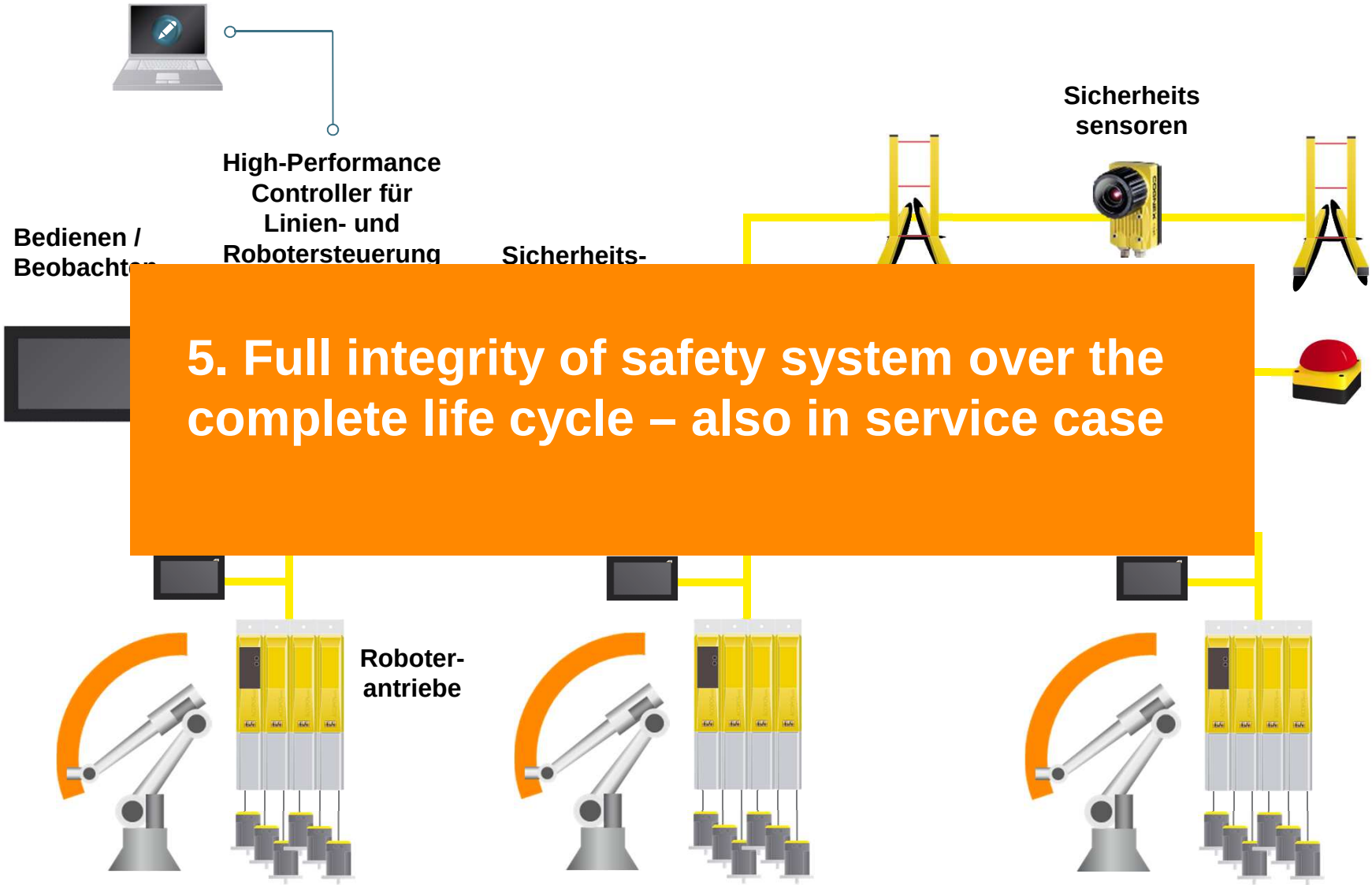
3. Highest system performance with the lowest reaction times < 40 ms



Systemarchitektur 4.0



Systemarchitektur 4.0



5. Full integrity of safety system over the complete life cycle – also in service case

Systemarchitektur 4.0

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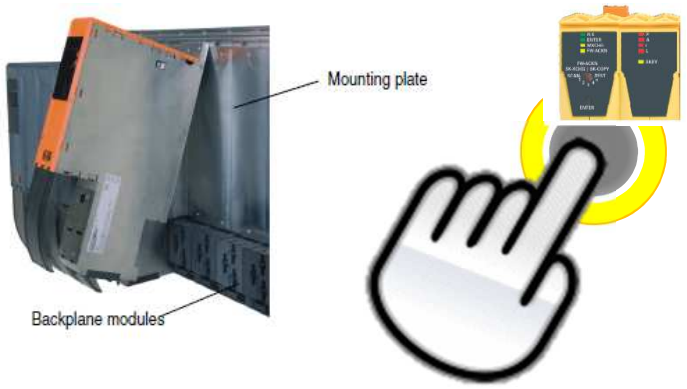
RESULTS

Highest level of **productivity**
Highest level of **human safety**
Highest level of **maintenance ability**

Let‘s make service in a safe way

Safe machine during the whole life cycle

- Automatic configuration of all safety relevant components during control system startup
  - Automatic download of firmware
  - Certified, full automatic mechanism
- Faster and easier hardware exchange in service case without any risk
  - No parametrization from service staff required
  - Service with screwdriver and web browser
- Full integrity of the machine safety level over the complete life cycle



Social acceptance

Believe in the technic

- **Simplicity and clarity**
  - Structure and function of the security system are simple and clearly understandable
  - Shortest possible response times of the robot avoids the feeling of anxiety or stress - how close the robot to the worker in case of failure ??
- **Staff**
  - Maximum operator protection for colleagues in production by using the best available technology
- **Maintenance engineer**
  - Full integrity of the machine safety levels over the entire life cycle
  - No risk in case of service - certified, fully automated mechanisms
- **Technology managers**
  - Ethical commitment to the best possible protection of persons – regardless of production location and nationality

Sociální akceptace HRC

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Technologický náskok zaručí sociální akceptaci:

„Pouze nejlepší dostupná technologie je pro ochranu Vašich pracovníků dostatečná.“

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Integrated automation
Global presence
Solid partnership