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AUTONOMOUS SYSTEMS INCIDENTALLY CONTROLLED BY A REMOTE OPERATOR

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- Autonomy + VT
- Detection of a too difficult situation/problem
- Examples of application
- Conclusion



Introduction



Genesis 😊



[John Deere, 2022]



Genesis ☹️



Virtual teleportation

(how we understand and apply it)



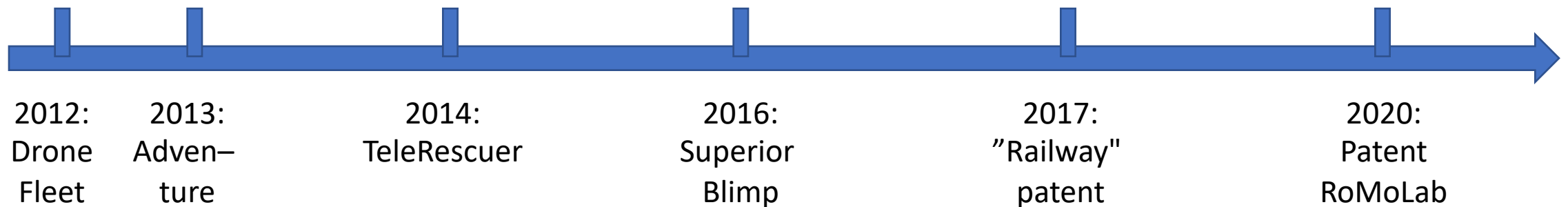
What is virtual teleportation (how we understand it)?

VT = Virtual Teleportation is a functionality of innovative user interfaces that allows for full immersion of the user in an environment distant from her/his current location, and thus to create an impression received by the senses of this user, as if she/he was physically present in this environment and could be there personally in a way passive or active to carry out various activities.

In the applications we develop, we use VT on a real time scale!



A bit of a history...

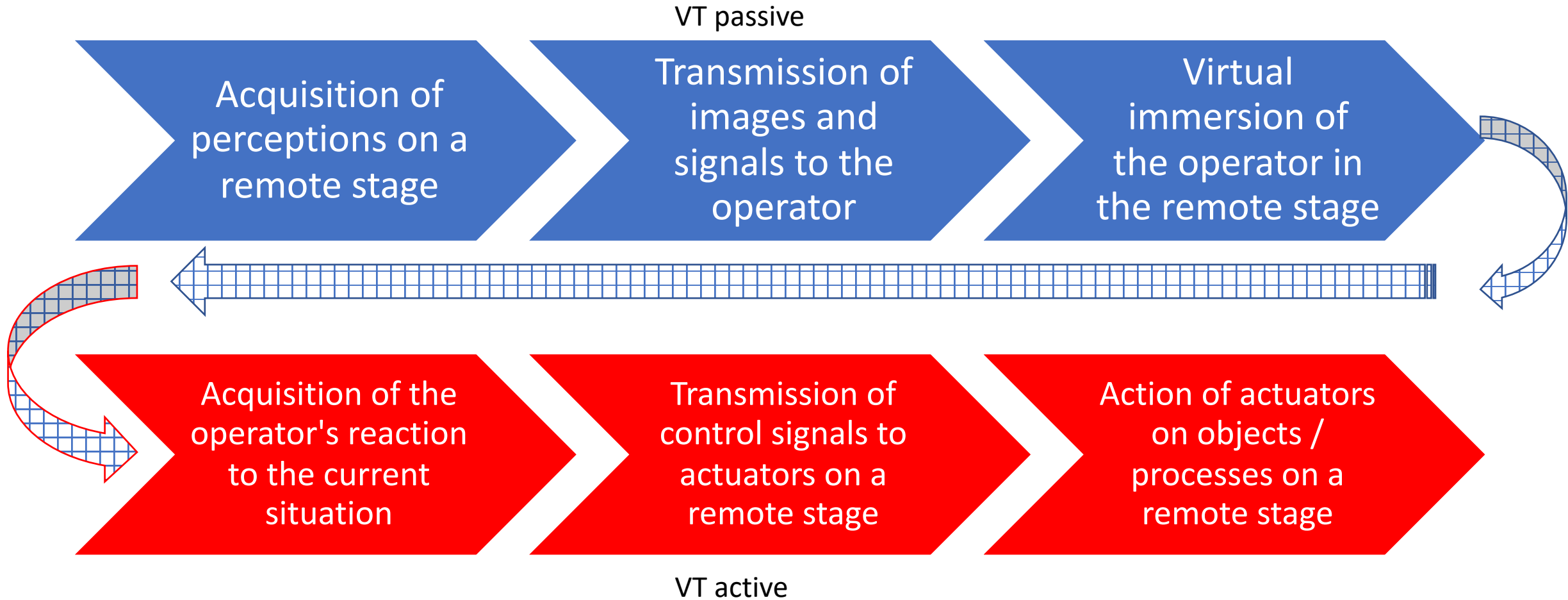


The author of the early conception: dr hab. inż. Krzysztof CYRAN, prof. PŚ

Further development: K. Cyran, W. Moczulski, M. Adamczyk, D. Myszor, M. Paszkuta, T. Rohn, P. Gramała, Ł. Osdarty, ...



VT: How to get it?



Acquisition of perceptions on a remote stage

Kind of perception

Image of the scene and objects

Sound

Fragrances

Touch, mechanical resistance

...

The form of the data

Stereo image

Stereo sound

Components of the vector of fragrances

Pressures, forces, ...

...

Acquisition method

Stereo camera / omnicaamera

Array of microphones (static / moving)

Fragrances acquisition system

Artificial leather, strain gauges

...



Data transmission (signals / images)

- Wired / wireless transmission
- Wireless transmission range
- Transmission costs
- Delays



Inducing a feeling of immersion in the operator

- Realistic reproduction of signals and images
 - Specialized interface
 - Acceptable delays
 - Teleporting a human to a remote scene requires the use of VR / AR techniques



Acquisition of the operator's reaction to the current situation

- Use of devices for control
- Use of voice commands and natural language messages
- Use of gestures
- User eye tracking
- Tracking body movements
- Use of facial expressions and other symptoms of the mental state
- ...



Autonomy + VT

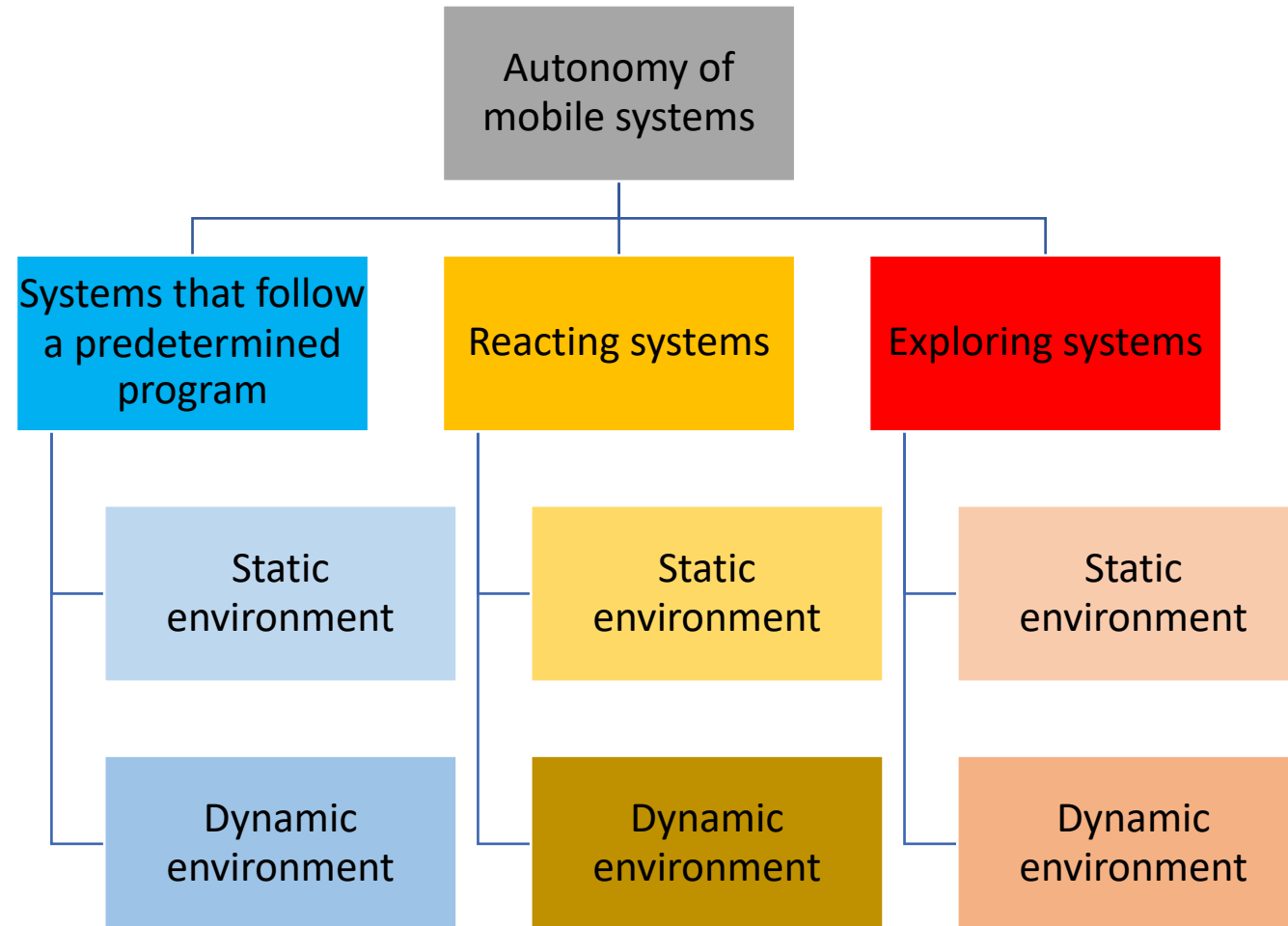


Autonomy – general remarks

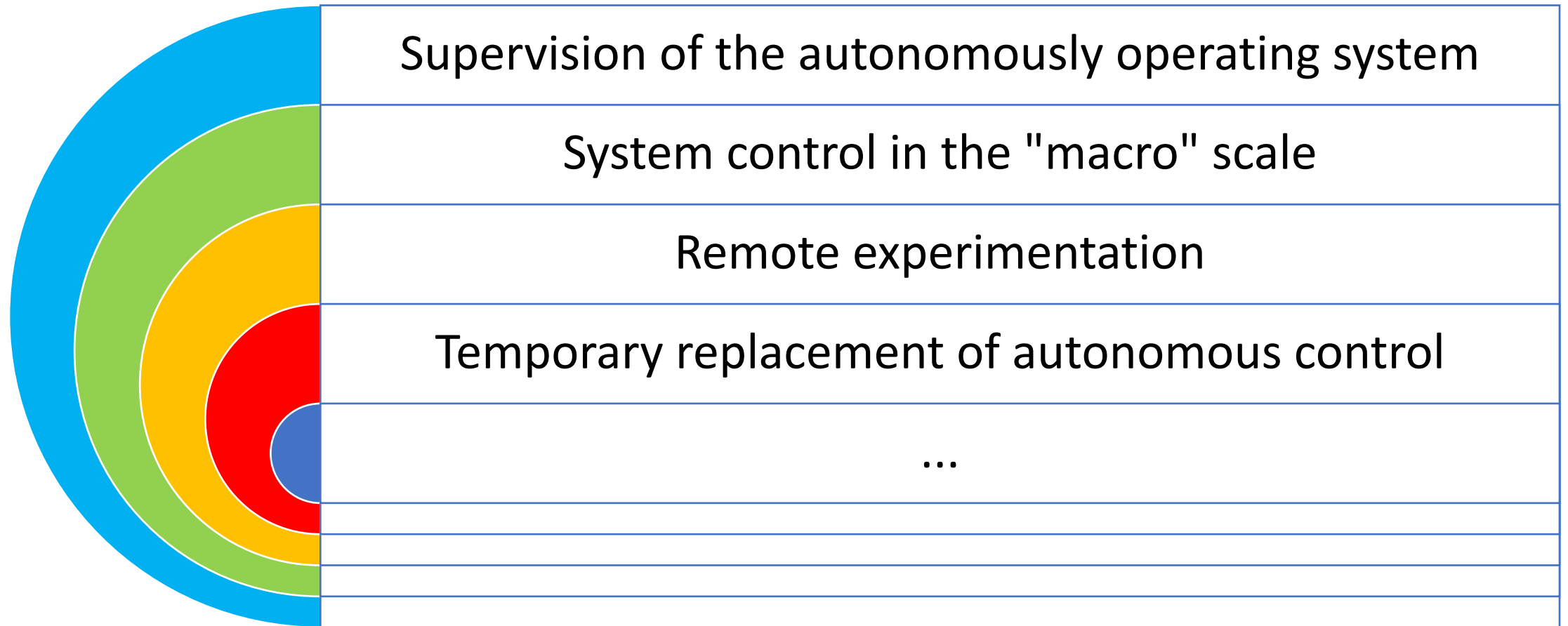
- Autonomy applies to each class of automation and robotics systems:
 - Autonomous laboratory system
 - Autonomous agricultural tractor
 - Autonomous UAV
 - Autonomous Mars rover
- In general, autonomy relates to control (extended to decision making)
- In the case of mobile systems, the autonomy takes into account the power supply, the collection of consumption products, etc.



Autonomy of mobile systems

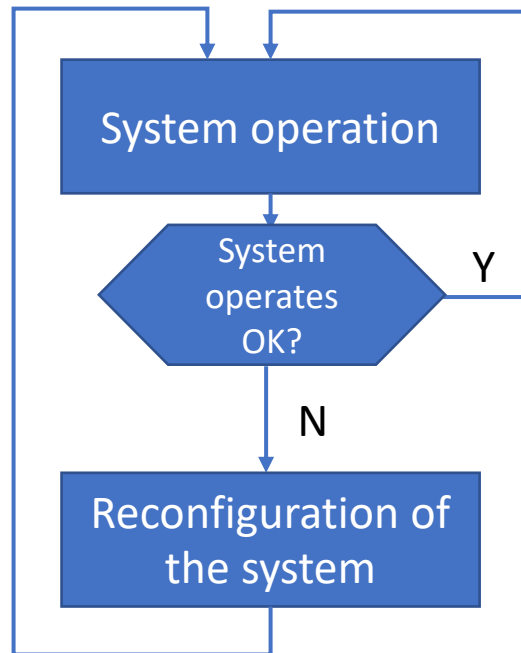


Where is the place for VT?

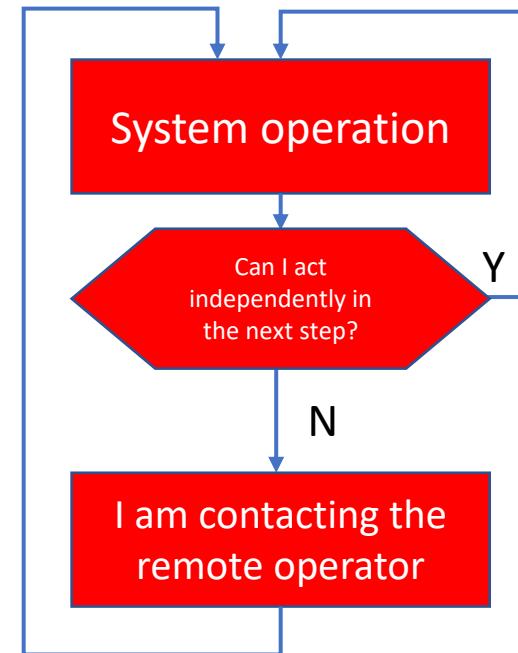


Semi-autonomous vs. Fault-tolerant system

FTS



Autonomous+ VT



Detection of a too difficult situation/problem



General remarks

- A situation / problem that is too difficult to be solved by the autonomous system can be interpreted as a **special fault case**
- Detection supported by a knowledge base
- Variants:
 - **Reactive** (the situation I am currently in exceeds the ability of my autonomous control to be solved by its own)
 - **Prognostic** (the situation I will be in in a moment will exceed the ability of my autonomous control to be solved by its own)



Exemplary solution

- Expert System with rule-based knowledge base
- Methods:
 - Induction
 - Analogy



An example of a Knowledge base

- Rules of operation:
if <premise> then <operation>
- Format of premises
 $cond_1 \wedge cond_2 \wedge \dots \wedge cond_n$
where conditions can be formulated for nominal, ordinal, interval and ratio variables of the parameters
- The **<operation>** part of the rule contains the pointer or call of a procedure to be applied if the conditions are met
- Rules can be grouped in contexts



Rules of operation - variant reactive to the internal state

Internal state
of
the robot



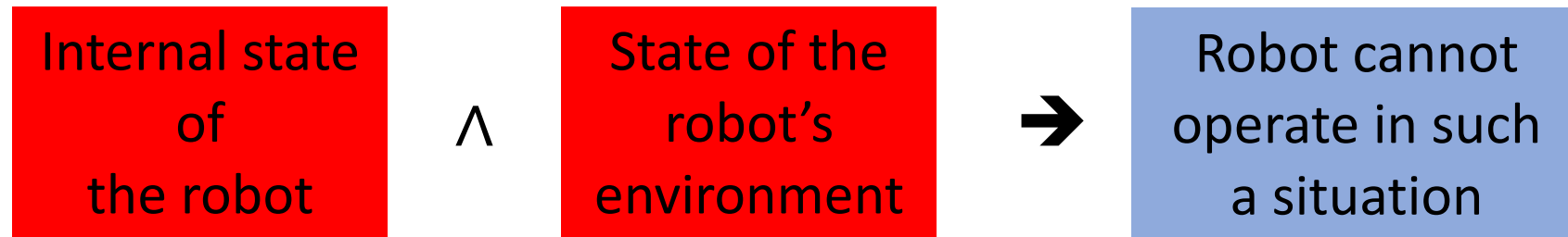
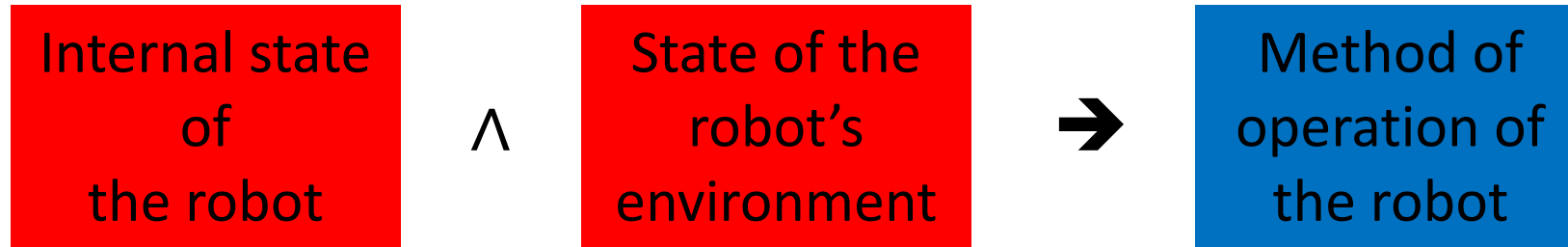
Method of
operation of
the robot

Internal state
of
the robot

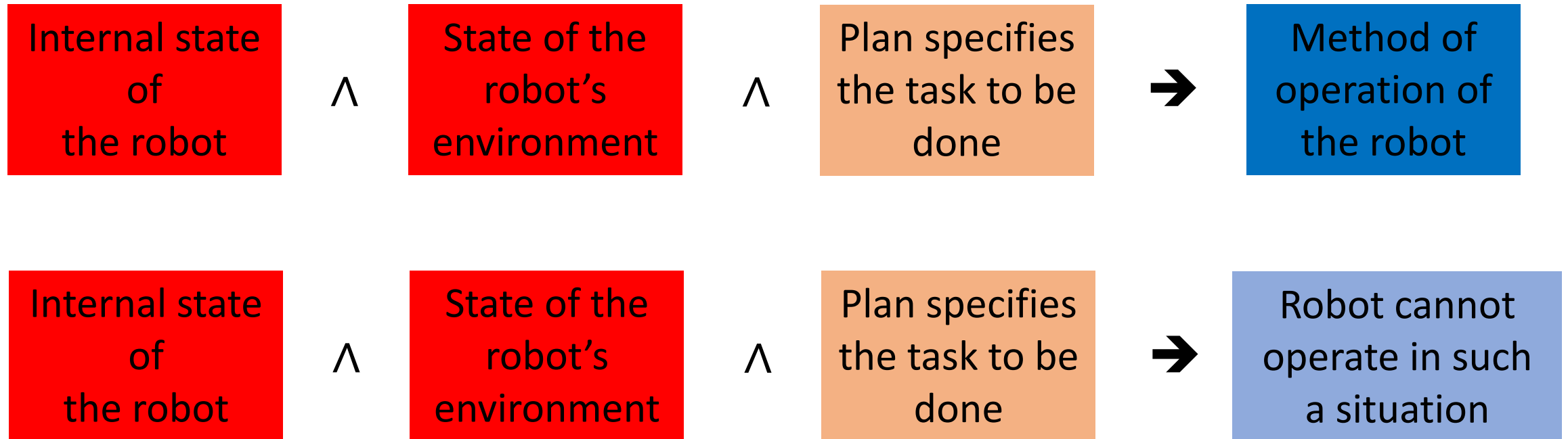


Robot cannot
operate in such
a situation

Rules of operation – reactive variant



Rules of operation - prognostic variant



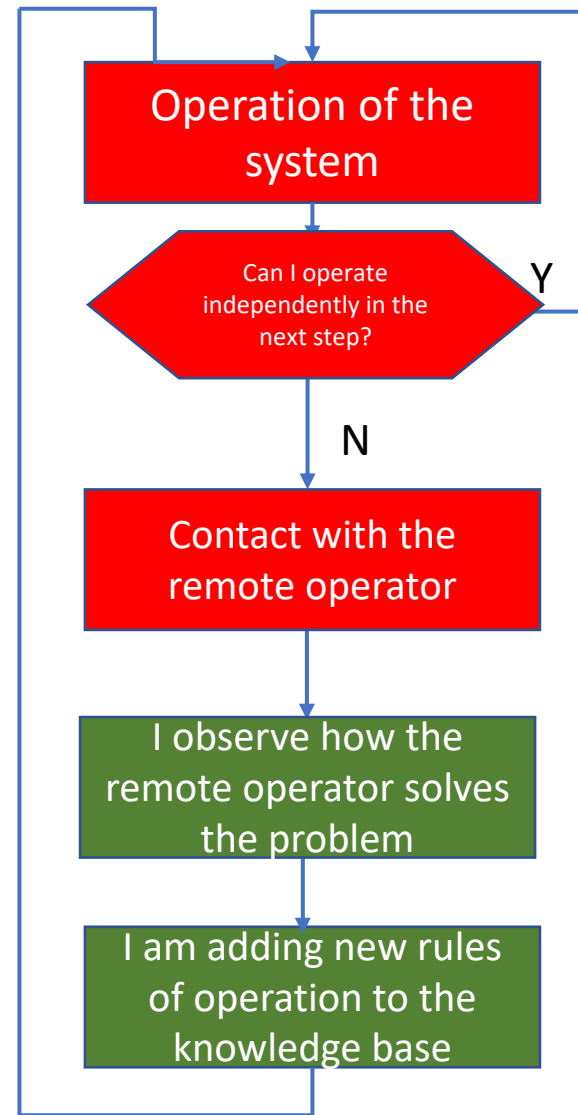
General algorithm for detection

```
Data: <CSW=feat. of int. state>, [<CO=feat. of environment>], [<P=plan>]
```

```
While (EndOfOperation) {  
  Match=false;  
  for (RuleID=1, NoOfRules)  
    if (MATCH (RulePremise [RuleID], CSW, CO, P)) {  
      DO_Action (RuleID);           // Action can be CALL_EXT_OPERATOR  
      UPDATE (CSW, CO);  
      Match=true;  
      break;  
    }  
  if ( ¬ Match) CALL_EXT_OPERATOR;  
}
```



Learning system



Examples of application



TeleRescuer – RFCS (2014-2017)



System for virtual TELEportation of RESCUER for inspecting coal mine areas affected by catastrophic events

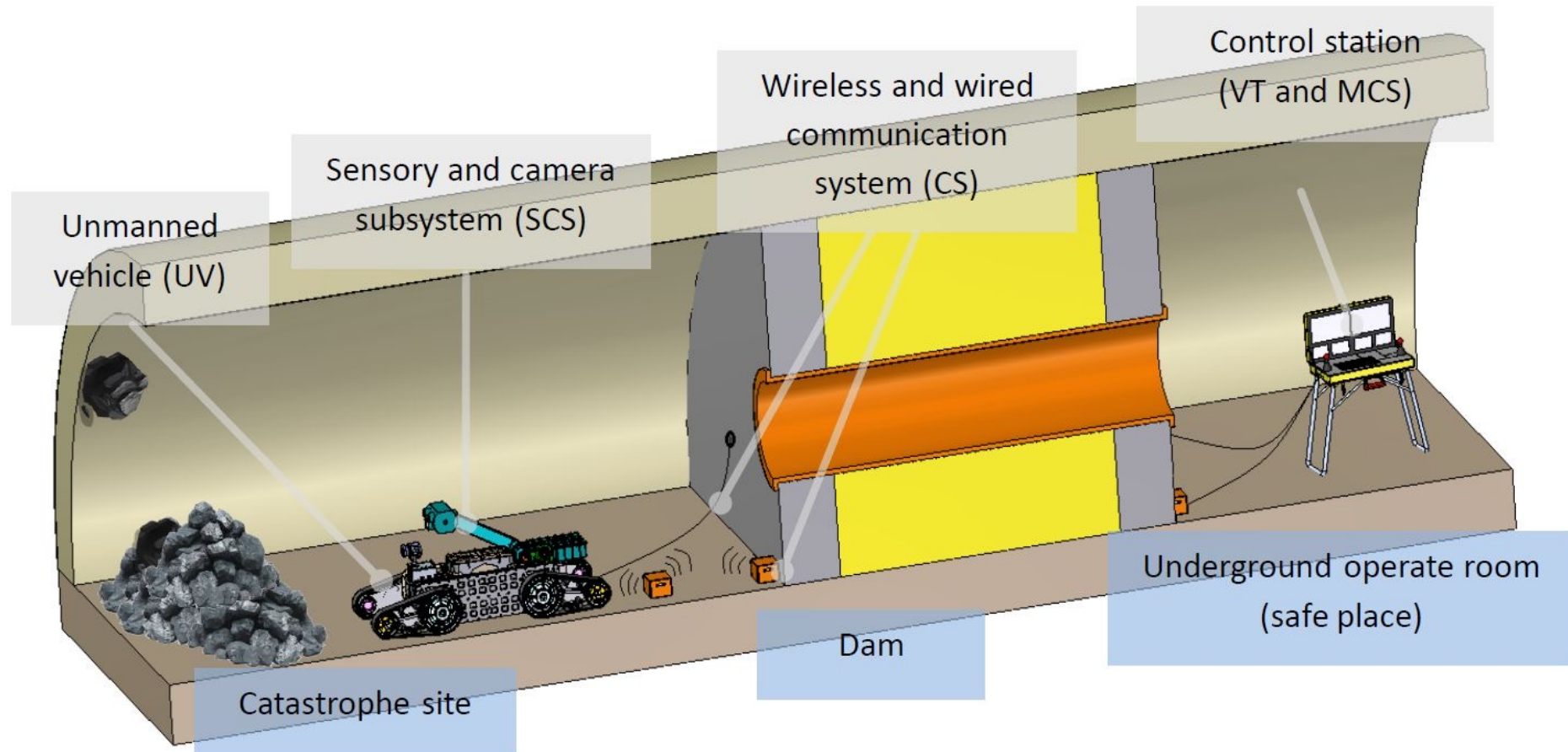
Research Programme of the Research Fund for Coal and Steel

Technical Group: TGC1

Proposal acronym: TeleRescuer

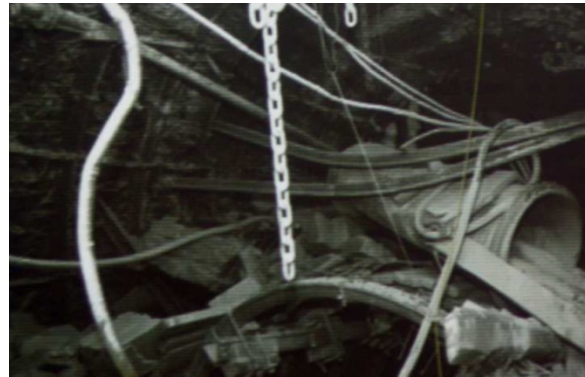


TeleRescuer – General idea



TeleRescuer – operational scene for mobile agent

- Inaccessible and dangerous to humans
 - High temperatures
 - Explosive atmosphere
 - Poisonous gases
- Obstacles difficult to traverse
- Limited range of wireless communication
- Area closed by a dam



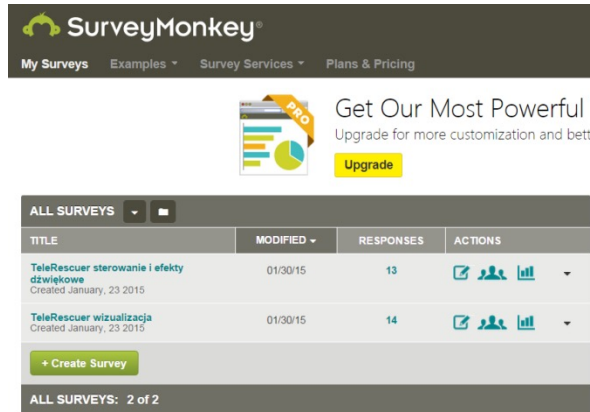
TeleRescuer – Vision system



TeleRescuer – Operator's station (VT)



TeleRescuer – Operator's station (VT)



- Wyświetlacze boczne:
 - obraz z pozostałych źródeł obrazowania
 - wartości odczytywane z czujników
 - informacje na temat stanu robota
- Możliwość przełączenia środkowego monitora na alternatywne źródła obrazowania, w przypadku gdy obraz z kamer wizyjnych niewystarczający



1. Czy uważasz, że umieszczenie graficznych wskaźników na ekranach monitorów, w sposób przedstawiony na powyższym slajdzie, pozwoli na

	Zdecydowanie tak	Tak	Nie	Zdecydowanie nie
sprawnie odczytywanie danych o stanie robota	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
sprawnie odczytywanie danych z czujników zewnętrznych	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Inne (Proszę opisać):

Survey Monkey – tool for creation of survey (left);
Slide taken from one of surveys that were prepared (right)



Example: BSP TwinStratos[®]

- Implementation of the flight plan in accordance with the optimal mission plan
- Autonomous flight execution with dynamic path planning
- Takeover of UAV control during landing approach
- **Problem: very low bandwidth of the communication channel (Iridium - satellite communication)**



Detection of difficult cases

- Rule-based
- Rules of operation:
if <premise> **then** <operation>
- To speed up finding the right rule (or concluding, that there is no matching rule) – rules are grouped in contexts

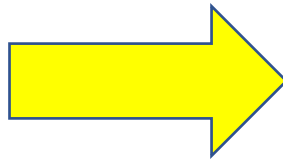
Exemplary contexts:

- *TakeOff*
- *FlightToWaypoint*
- *SideWind*
- *SuddenDescending*
- *ScheduledLanding*
- *EmergencyLanding*
- others



Example of swithing to Remote Control

- Context: *EmergencyLanding*
- Wideband duplex communication available
- Before landing the drone inspects the unknown terrain and detects that the terrain is covered by bushes and trees
- At the landing path there is strong sidewind



Conclusion:
call the Remote Operator to
take over the control

Concluding remarks



Regarding the idea of VT

- VT is a significant know-how of AuRoVT sp.z o.o (former SkyTech Research sp.z o.o.)
- The idea of VT seems to be (still) futuristic
- The pace of innovation in everyday life reinforces the belief that VT will play an increasingly important role in practical applications



Regarding the implementation of VT systems

- AuRoVT sp.z o.o (former SkyTech Research sp.z o.o.) has significant achievements in research on VT systems
- AuRoVT sp. Z o.o. effectively cooperates with the Silesian University of Technology in the field of implementing ICT systems that use VT
- The development of VT systems requires interdisciplinary research in the field of:
 - Mechatronic systems (sensors, actuators, peripherals)
 - Communication systems
 - Vision systems (stereovision, omnivision, fusion of vision and IR, ...)
 - Artificial intelligence (building knowledge bases)
 - ICT systems



Regarding the construction of autonomous systems supported by VT

- Building a knowledge base enabling autonomous operation in the vast majority of cases
- The "ability" to independently detect a situation, the solution of which "exceeds" the capabilities of the autonomous system
- Ensuring reliable communication
- Resolving the situation when communication with the remote operator is impossible

Research and implementation problems to be solved in the future!



Acknowledgements

This research was partially supported by:

- The Research Fund for Coal and Steel – in the framework of the project RFCR-CT-2014-00002 TeleRescuer „System for virtual TELEportation of RESCUER for inspecting coal mine areas affected by catastrophic events” (SkyTech Research – now AuRoVT)
- The Ministry of Science and Higher Education - Partial financing of the project TeleRescuer – grant 3120/FBWS/2014/2
- The Norwegian Financial Mechanism POLNOR „Applied Research” – in the framework of the project LEADER „Long-endurance UAV for collecting air quality data with high spatial and temporal resolutions” - grant NOR/POLNOR/LEPoIUAV/0066/2019-00
- The Silesian University of Technology – in the framework of the own research



THANK YOU FOR
YOUR ATTENTION



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