HACAS
Human-Automation Collaboration in Incident and Accident Situations

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Marja Liinasuo
VTT Technical Research Centre of Finland Ltd

Introduction

- Effective and efficient performance of the operating personnel plays a key role in the safe production of nuclear power

- Currently the importance in safety management is considered to be **resilient functioning of the whole socio-technical system** especially during events difficult to anticipate

- Resilience at the operational level
  - mainly based on continuous and active monitoring
  - supported by regular training

HACAS's main objectives

- Main objectives of HACAS have been to study
  - Operating procedures in incident and accident management
    - effect of routines of procedure usage during severe accidents
    - parallel use of EOPs and safety HSIs in accident management
    - procedure design process from the HF perspective.
  - Development of an integrated approach to HFE and CR V&V
    - effect of digital I&C systems on operator practices during accidents
    - review approaches for more integrated and unified HFE processes
    - identify challenges in the design of interactive wall-mounted displays for the simulator environment
    - develop an integrated validation concept for multi-stage modernization projects.
  - Automation awareness and its development
    - operators' automation awareness and the effect of automation complexity on automation awareness and skills
    - designed an Apros-based simulation demonstrator for testing automation awareness in experimental settings
    - outlined a method for measuring automation awareness and competence
    - automation competence among automation maintenance personnel.

HACAS focus

How digital automation and CR upgrades affect resilient performance

How HFE activities should be organised to support plant safety and productivity

How humans and automation systems collaborate to accomplish safety and NPP production goals

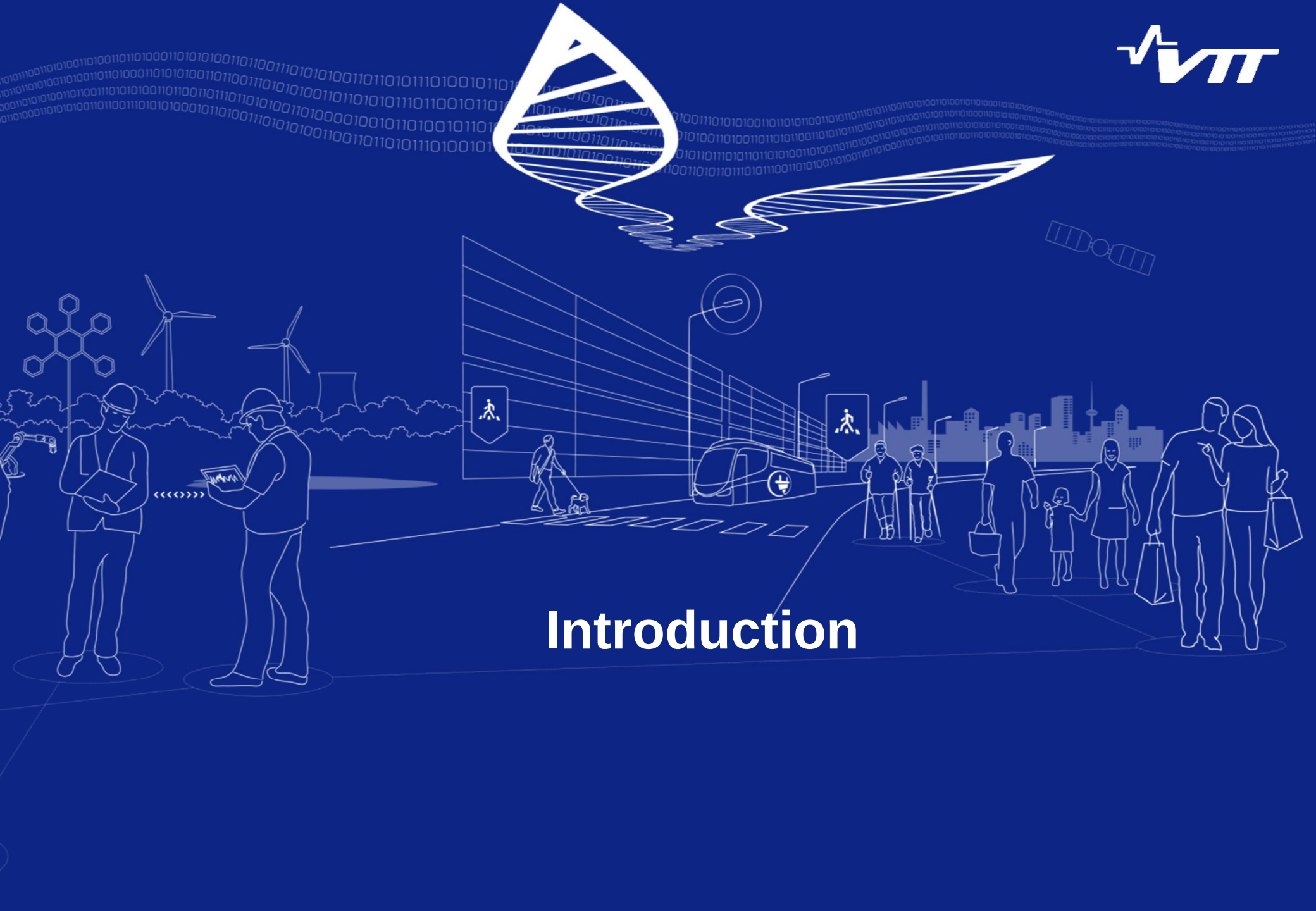
HACAS main results

Tools and guidelines for resilient-based analysis of work practices developed

Multi-stage approach to verification & validation developed

Automation awareness and competence were studied

Challenges and training needs in NPP automation maintenance



Introduction

Background

- Goal of maintenance work: to maintain operational reliability and the economic value of installation (to ensure power production)
- Automation systems in the majority of NPPs still use the original analogue systems and the next step is automation modernisation

- Maintenance work ensures operational reliability and maintains economic value
  - Predictive maintenance
    - Major part: pre-planned overhauls and periodic tests
  - Corrective maintenance
  - Modifications

- Increased digitalisation > requirements for new skills

Background

- Personnel of two Finnish NPPs were interviewed
  - One plant had turbine part digitalised in early 2000, reactor part is expected to be updated
  - The other plant I&C modernisation is ongoing but details are not defined yet
  - Automation modernisation affects the work of maintenance personnel

Fortum Loviisa NPP

TVO Olkiluoto NPPs

- Aim of the study is to acquire knowledge about
  - the competence of automation maintenance personnel
  - training needs relative to the modernisation of automation systems

Methods

Interview study

- Performed among automation maintenance personnel at two Finnish NPPs
  - Nine interviewees
  - Average working experience 25 years (7-40 years)
  - Almost all with mechanic education (two technicians, and one engineer)

- Semi-structured interview, topics
  - educational and professional background
  - work tasks and tools
  - training practices and on-the-job-learning
  - challenges of modernization

- Interviews were audio recorded and transcribed

Results

Maintenance work

- Tasks (according to interviews)
  - Preventive maintenance
  - Performing periodic tests
  - Repairing failures
  - Implementing new systems
  - Supporting control-room operators in troubleshooting activities and in providing operators measurement information

- Focus on preventive maintenance and periodic tests - failures are rarely the cause of action, but failure work orders with high-priority labels overrun other tasks

- Skills and competencies needed as conceived by interviewees
  - Professional (ability to do the tasks, understanding process and failures; interest in work and plant in general as well as in skill development)
  - Personal (careful, thorough, deliberate, composed)
  - Communicative (courage to ask if uncertain, knowledge transfer)

Tools and technology used in automation maintenance

Traditional	Modern	Special purpose
maintenance-PC/service unit	maintenance-PC/service unit	temperature transmitter
multimeter oscilloscope function generator	multicalibrator	tensions measurement (programmable)
procedures	procedures with digital images	IO converters
log sheets	electronic logs (datalogger)	radiation sources for calibration
circuit and electric diagrams	online circuit diagrams (NPP1), FUP diagram (NPP2)	radiation measurement equipment (programmable)
analog panel meters and panel indicator lamps	computer interface for programmable logic	pulse measurement in plant protection system
recorder	card tester	
pressure pump		
screwdriver, wrench...		

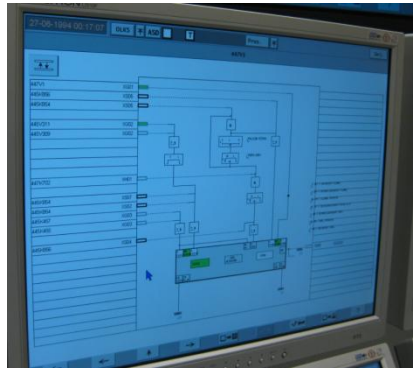
Changes and challenges in current tasks

- Changes to modern technology (although basic automation has not changed)
  - digitalization of the turbine side at one of the NPPs
  - programmable logic
  - analog equipment has been replaced by digital one, which can be calibrated using a computer or a multi-calibrator
  - use of computers has increased

- Challenges with new equipment
  - not as durable as old
  - need more maintenance
  - if broken, the component is changed entirely, because it is difficult to repair microprocessors

Digital system (turbine automation at NPP2)

- Digital is better, because…
  - more informative to both the mechanics and the control room operators (especially function block diagrams)
  - if a signal measurement is detected as faulty, a simulated overriding value can be directly put to the system
  - redundancy: If one of the three components fails, the process is not affected, and there is more time for repair
  - fewer failures than there were with the old hydraulic mechanic automation



- But…
  - failures are more difficult to identify
  - computer crashes for unknown reasons
  - more work for process-IT department

Future expectations

- Field work was expected to remain unchanged
  - predictive (or condition-based) maintenance was not discussed
- Role of computers was expected to increase
  - there was confusion on how the work (e.g. programming) was to be divided between the mechanics and the process-IT department
- Currently used multi-calibrators were considered sufficient, as long as they are available to all mechanics
  - during outage, there may be shortage of devices
- Equipment might get more complex and have more functionalities, which need programming using a smart calibrator or a computer

Training for the maintenance personnel

- At both NPPs, there is a specialized department for training
  - providing basic education for new workers or workers changing their duties
  - organizing general training related to, e.g., work safety and water hygiene
- Training databases contain courses completed by the workers (underutilized)
- Except for basic education, no formal training plans exist for the workers' professional development
- Both parties – training department and maintenance personnel - expect more initiative related to training from the other party
- Maintenance personnel prefer on-the-job learning
  - Work in pairs, suppliers' courses, vocational training outside plant
  - Anyway, training is of lower priority, not always possible to participate

Training needs of the maintenance personnel

- Training needs categorized
  - Analogue vs. digital systems
    - Analogue automation is no more taught at school
    - Digital system is more familiar but more difficult when identifying failures
  - Use of computers and new technology
    - The amount of new technology is increased also in maintenance work
  - Retirement of personnel (tacit knowledge, knowhow on analogue technology)
  - The increased amount of collaboration with other professionals > need to learn more about “neighbouring” areas (e.g., technical skills, new terminology)
  - New need for multi-skilled workers (tradition to be specialised)
  - Language skills (manuals and field training abroad; younger ones more proficient)

Conclusions

Conclusions

How to tackle the identified training needs:

1) Need for multi-skilled workers
   - task allocation and the corresponding knowledge demands should be determined
   - one option to professional development

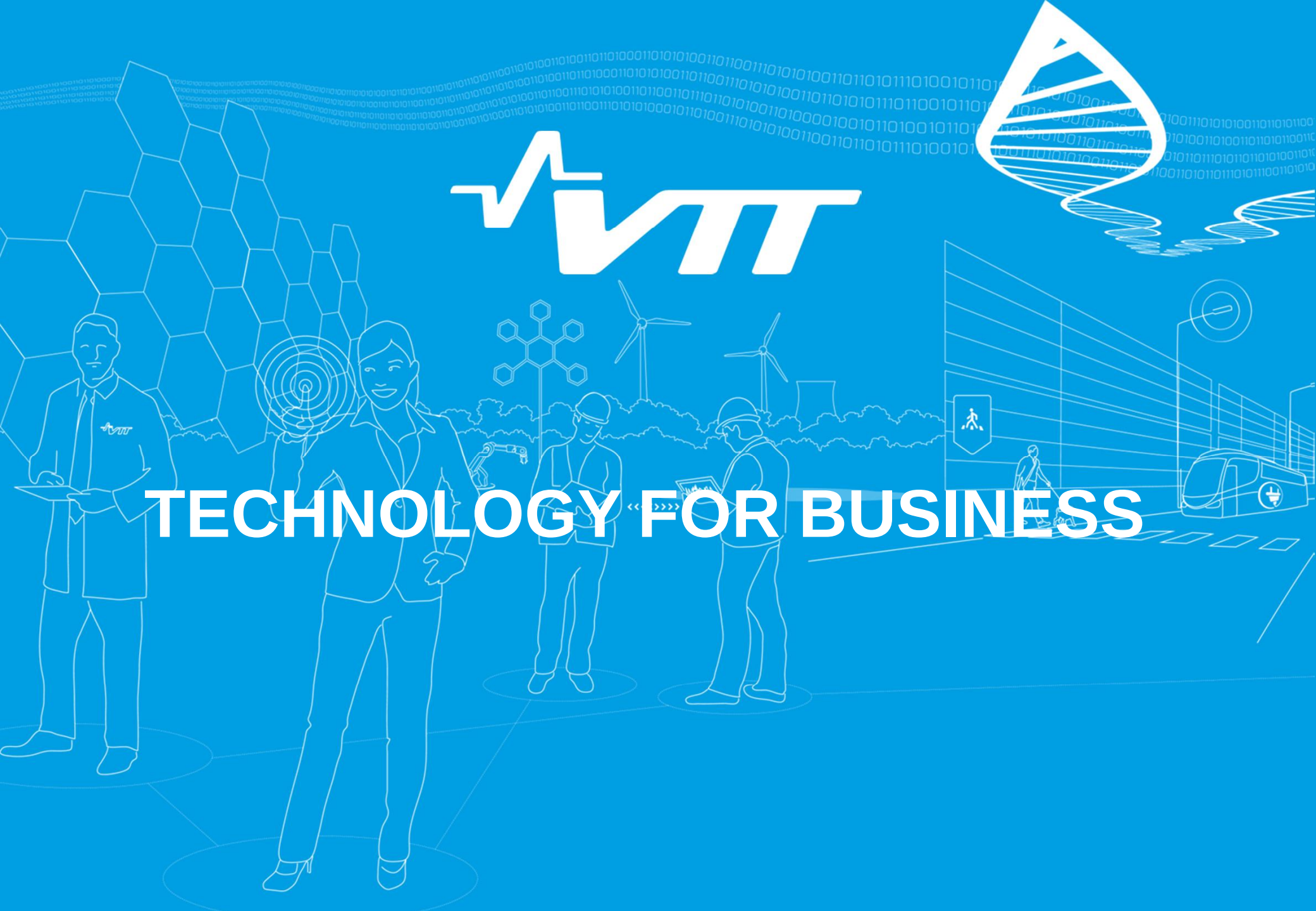
2) Currently passive training database could be utilized more actively in the planning

3) Improving the communication between the training and automation maintenance departments could be beneficial
   - Currently, both departments expect the other to take the initiative

4) Individual training plans for mechanics should be drafted
   - language and computer skills; knowledge on process and analog/digital automation
   - timing of the courses should be well planned

THANK YOU!

QUESTIONS?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