Training for Human Autonomy Teaming

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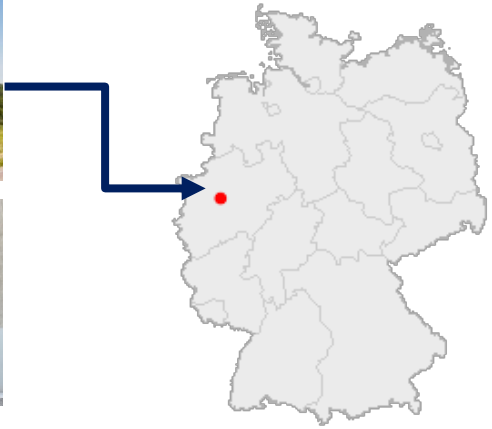
The Ruhr-University Bochum (since 1965)



- ~5,600 employees
- 480 professors
- 42,718 students
- 3,387 international students
- 2,251 students with immigration background
- about 830 foreign doctoral students and international guest researchers

Faculties

Humanities

- Faculty of Protestant Theology
- Faculty of Catholic Theology
- Faculty of Philosophy and Educational Research
- Faculty of History
- Faculty of Philology
- Faculty of Law
- Faculty of Economics
- Faculty of Social Science
- Faculty of East Asian Studies
- Faculty of Sports Science
- Faculty of Psychology

Engineering Sciences

- Faculty of Civil and Environmental Engineering
- Faculty of Mechanical Engineering
- Faculty of Electrical Engineering and Information Technology

Natural Sciences

- Faculty of Mathematics
- Faculty of Physics and Astronomy
- Faculty of Geosciences
- Faculty of Chemistry and Biochemistry
- Faculty of Biology and Biotechnology

Medicine

- Faculty of Medicine
  - RUB Clinics

Our research focus

Taskwork

Skill acquisition and retention
→ The threat of skill decay
→ Effects of refresher trainings

Cognitive readiness for **non-routine/abnormal** situations
→ Information overload
→ Task overload cognitive readiness & skill retention under stress

Training for **decision making** under stress
→ Stress exposure training
→ Training for surprise
→ Task technology fit and technical support (App for fault diagnosis)

Teamwork

Team training for high responsibility teams and performance under stress („Team Performance Breakdowns“)
→ Training for adaptability
→ Task reprioritization
→ Task allocation
→ Mutual support
→ Back up behavior

The role of Collective Orientation (CO)

Organization

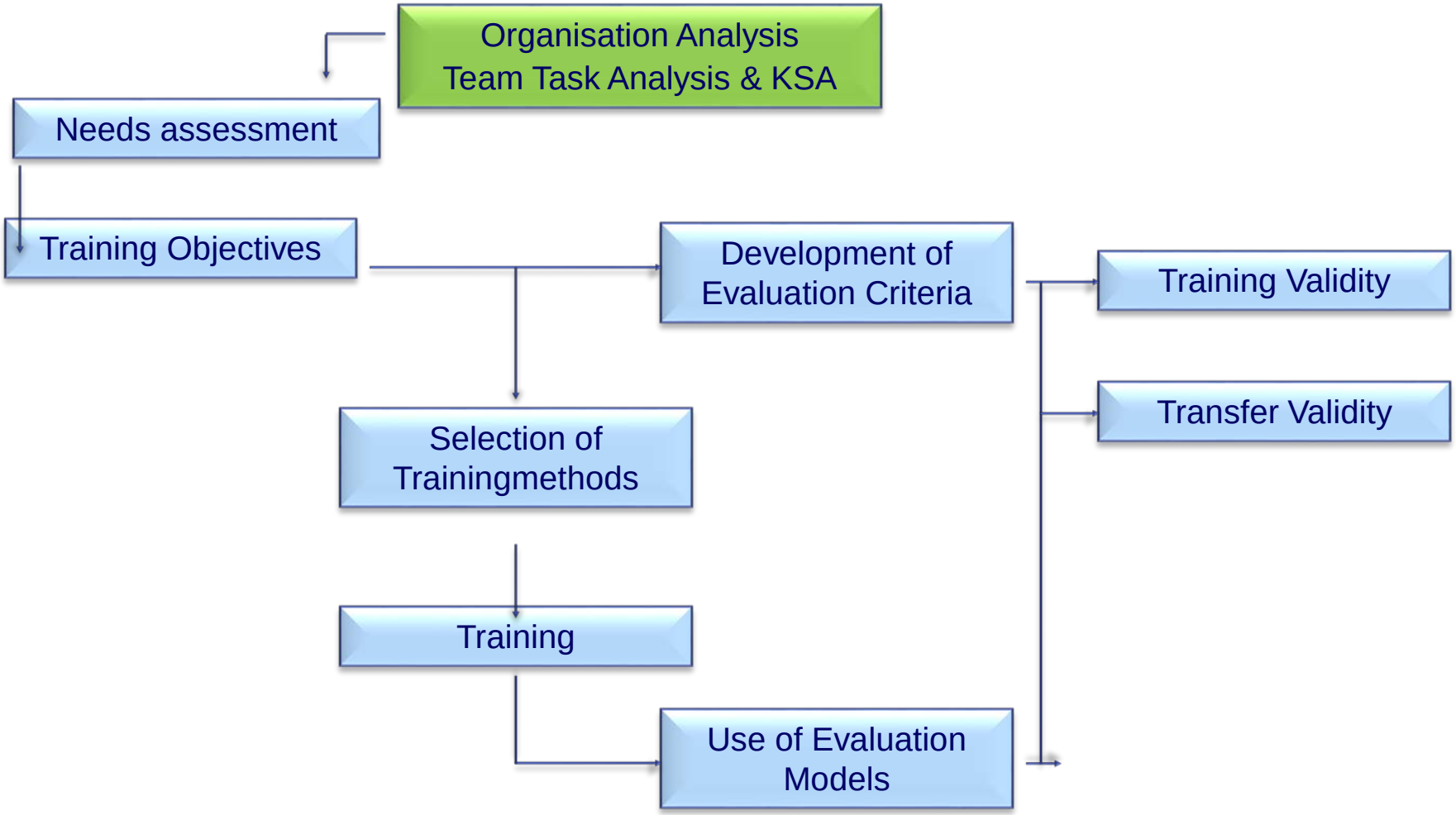
Safety management in high reliability organizations

Organizational learning from errors

Organisational forgetting (adaptation to information overload)

Stressors as antecedence for safety related **rule violations** („work safety tension“)

Training- Which steps need to be considered?



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NEEDS ASSESSMENT

Needs Assessment: Human Autonomy-Teaming (H-A-T)

The difference between „supervisory control“ und H-A-T?

- Human-agent Teams build a relationship that goes beyond what we know if a human agent controls or supervises a technical agent (Chen & Barnes, 2014)
- Is based in mutual understanding (smart collaboration, Iganaki, 2008)
- Requires conflict resolution (resolving opposing interpretations) (Kluge 2014)
- Is characterised by mutual trust, cohesion, transactive memory, shared SA, shared mental models, back-up behavior…

https://www.youtube.com/watch?v=JLmOteqmDYc

Chen, J. Y., & Barnes, M. J. (2014). Human–Agent Teaming for Multirobot Control: A Review of Human Factors Issues. *Human-Machine Systems, IEEE Transactions on*, *44*(1), 13-29.

Inagaki, T. (2008). Smart collaboration between humans and machines based on mutual understanding. *Annual reviews in control*, *32*(2), 253-261.

Kluge, A. (2014). *The acquisition of knowledge and skills for taskwork and teamwork to control complex technical systems: A cognitive and macroergonomics perspective*. Springer.

Human Agent (HA) Teaming for Multirobot Control

Chen & Barnes (2014)

Human Agent roles:

H-A teams particularly effective for open-ended missions

The agent is always the subordinate, who can be given permission to act autonomously under specific conditions

Human Agent Communication

Effective H-A communication should be as natural als H-H- communication

Teaming agents should support team behavior, e.g.

- support opt. task allocation,
- planning,
- flexibel execution of the plans,
- allow graceful degradations of the plans and
- Recognition primed decision making

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A Model for Types and Levels of Human Interaction with Automation- and the issue of Autonomy

HIGH	**10. The computer decides „everything“, acts autonomously, ~~ignoring~~ collaborating with the human**
	9. Informs the human only if it, the computer, decides to
	8. Informs the human only if asked, or
	7. Executes automatically, then necessessarily informs the human, and
	6. Allows the human a restricted time to veto before automatic execution, or
	5. Executes that suggestion if the human approves, or
	4. Suggest one alternative
	3. Narrows the selection down to a few, or
	2. The Computer offers a complete set of decision/action alternatives, or
LOW	1. The computer offers no assisstance: human must take all decisions and actions

(Sheridan, 1992)

Tsang, P. S., & Vidulich, M. A. (2003). *Principles and practice of aviation psychology*. Lawrence Erlbaum Associates Publishers

What is needed? SA-based Agent Transparency (SAT) Model

What's going on and what is the agent trying to achieve?

Why is the agent doing it?

What should the operator expect to happen?

Level 1

- Purpose
- Desire (Goal selection)
- Process
- Intentions
- Planning/execution
- Progress
- Performance

Level 2

- Reasoning process (Belief/Purpose)
- Environmental and other constraints

Level 3

- Projection to the future/End state
- Potential Limitations
- Likelihood of error
- History of performance

Stowers, K., Kasdaglis, N., Rupp, M., Chen, J., Barber, D., & Barnes, M. (2017). Insights into Human-Agent Teaming: Intelligent Agent Transparency and Uncertainty. In Advances in Human Factors in Robots and Unmanned Systems (pp. 149-160). Springer International Publishing.

The Team Task Analysis

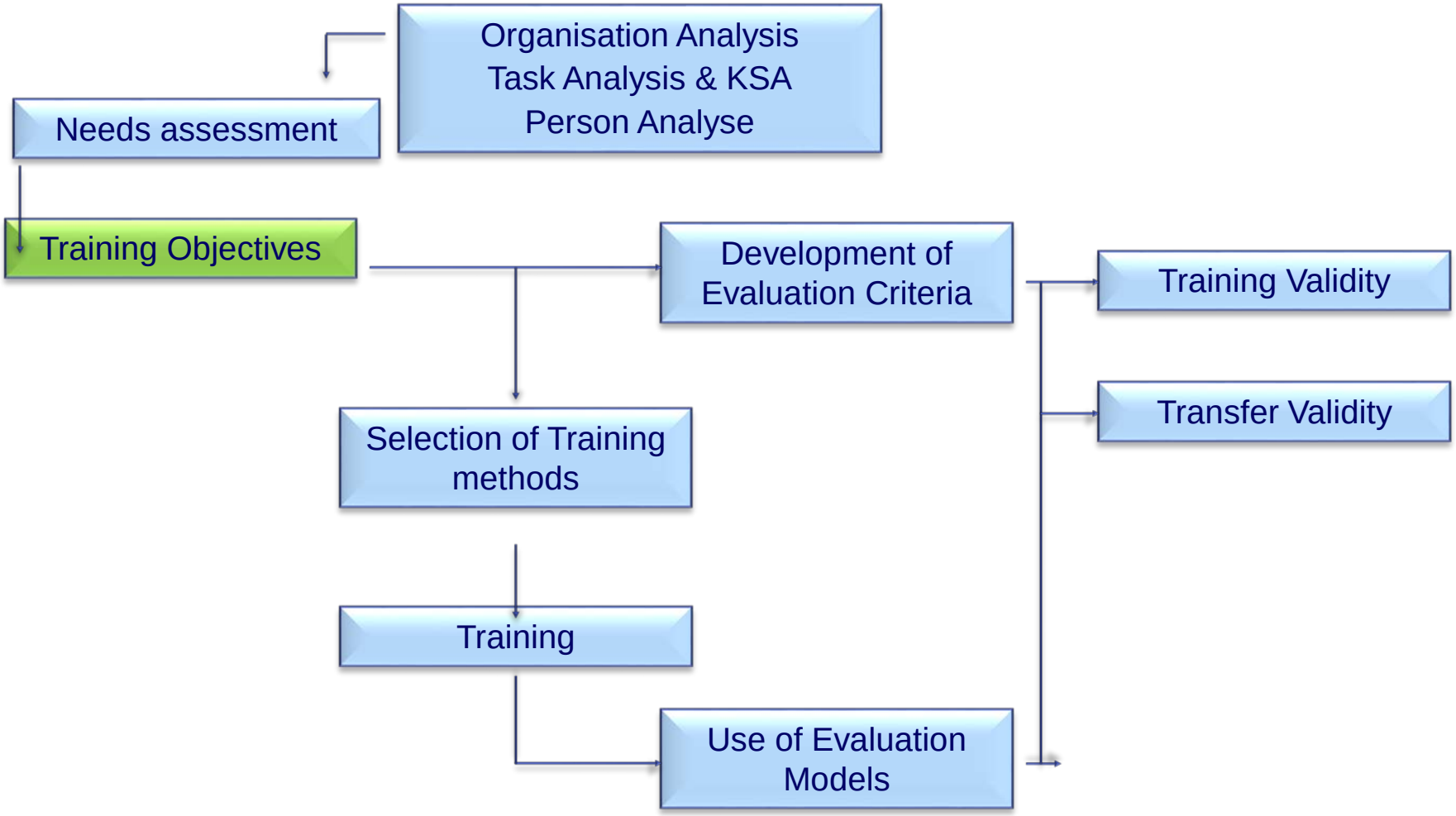
Arthur et al. (2005)
What is the **task work**? = team‘s effort to understand and perform the requirements of the job, task and equipment to be used.

What ist the **team work** ? = team‘s efforts to **facilitate interaction** among team members in the accomplishment of team task

Arthur, W., Edwards, B. D., Bell, S. T., Villado, A. J., & Bennett, W. (2005). Team task analysis: Identifying tasks and jobs that are team based. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, *47*(3), 654-669.

TRAINING OBJECTIVES

Training- Which steps need to be considered?



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Training Objectives

Acquiring technical and non technical **knowledge**, skills & attitudes (KSAs)

- *Task-related team knowledge* relatively unchanging knowledge about the task and duties for which the team in the plant is responsible.
- *Team-related team knowledge*: mental structures concerning the characteristics and qualities of one's teammate or of the team as a holistic social entity.
- *Process-related team knowledge:* the mental representation of the teamwork and interpersonal, team interaction processes involved.
- *Goal-related team knowledge*: mental representation of goals and how to achieve them, for example strategic consensus (Kluge, 2014; Wildman et al. 2012).

Wildman, J. L., Thayer, A. L., Pavlas, D., Salas, E., Stewart, J. E., & Howse, W. R. (2012). Team Knowledge Research Emerging Trends and Critical Needs. *Human Factors: The Journal of the Human Factors and Ergonomics Society*,*54*(1), 84-111.
Kluge, A. (2014). *The acquisition of knowledge and skills for taskwork and teamwork to control complex technical systems: A cognitive and macroergonomics perspective*. Springer.

Additional Training Objectives: „Lessons learned“ from Automation

Technical and **non technical** knowledge, **skills** & attitudes (KSAs)

6 factors have been identified as contributing to human-automation interaction:

1. Situation awareness
2. Decision Biases
3. Trust in Automation
4. Overtrust and Complacency
5. Mental Workload and
6. Workload management

Tsang, P. S., & Vidulich, M. A. (2003). *Principles and practice of aviation psychology*. Lawrence Erlbaum Associates Publishers

What can be additionally used?
„Lessons learned“ from Automation

Challenges

- Misuse →over reliance on automation
- Disuse → neglect or underutilization of automation,
- Automation abuse → or the automation of functions by designers and implementation by managers without due regard for the consequences for human performance
- Misunderstandig or Lack of Understanding of System, Mode confusion

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Human Performance in Automated Systems - Trust in Automation

Factors influencing operators‘ trust:

- Reliability of the system → monitoring performance should improve as the reliability of the system decreases

Subjective trust in automation

- If trust in automation is greater than self-confidence
- The interaction between trust and self-confidence could itself be moderated by the risk associated with the decision to use or not use automation

If automation is implemented in a „clumsy“ manner (e.g. executing an automated function requires extensive data entry or reprogramming) by human operator at times when s/he is very busy, workload is not reduced

- Studies found that automation does not always translate into a reduction of workload because it creates sometimes new demands, new coordination challenges that are difficult to manage and need to be monitored

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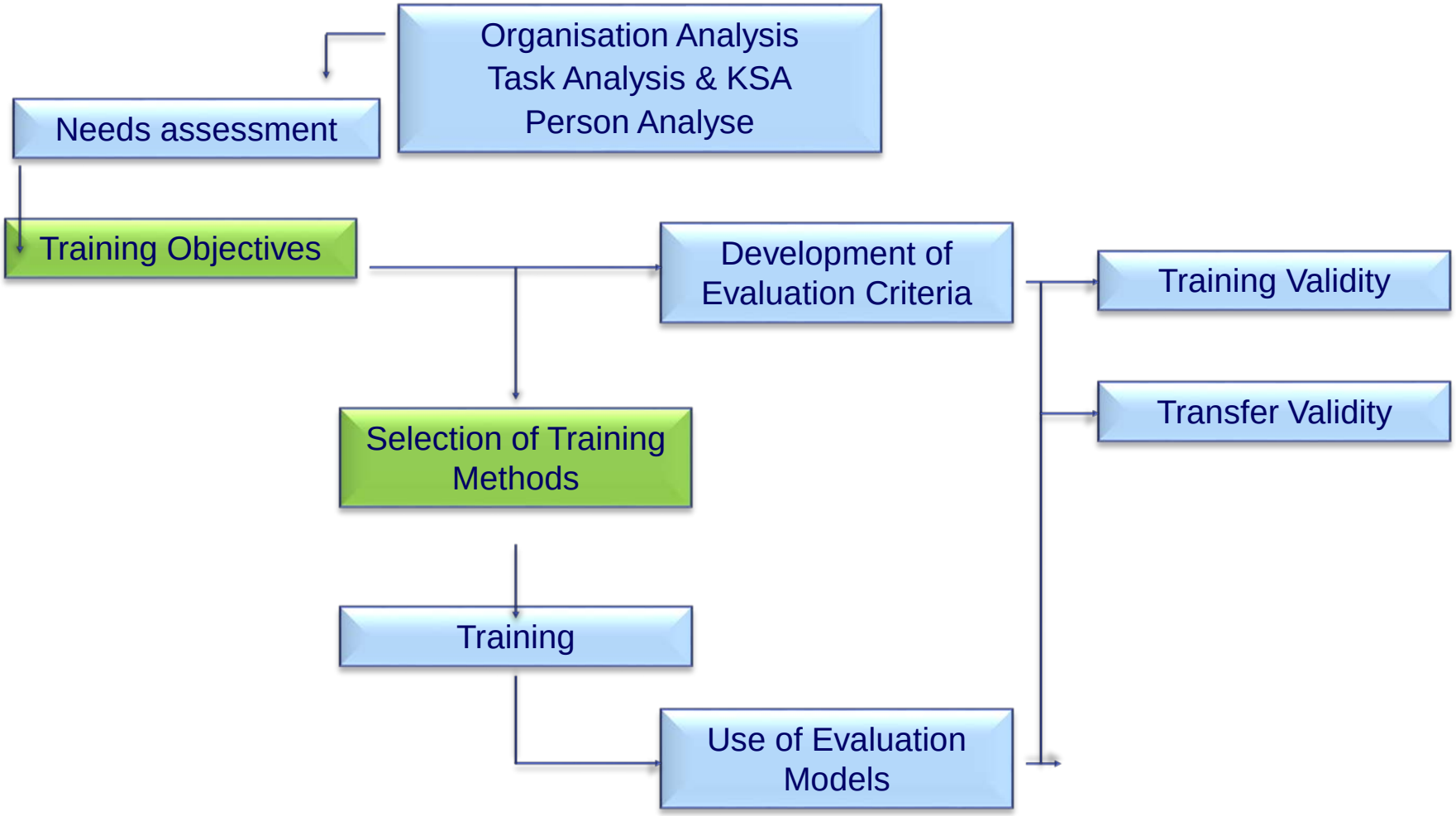
Training- Which steps need to be considered?



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TRAINING DESIGNS FOR HUMAN AUTONOMY TEAMING-TRAININGS

The logic of team work training

Training designed to develop **task-relevant skills** should be directed at individual team members

(Dyer, 1984)

Alternatively, **training teamwork skills**, or those focused on the behaviors and attitudes necessary for effective team functioning, are believed **to be best delivered to intact teams** rather than to individual members

(Cannon-Bowers, Tannenbaum, Salas & Volpe, 1995; Moreland,Argote, & Krishman, 1998)

The logic underlying this position is **that training intact teams provides opportunities for members to integrate their teamwork skills and to jointly practice complex coordinated** actions

(Kozlowski, 1998; Kozlowski, Brown, Weisbein, Cannon-Bowers, & Salas, 2000)

Mathieu, J., Maynard, M.T. Rapp, T. & Gilson, L. (2008). Team Effectiveness 1997-2007: A Review of Recent Advancements and a Glimpse Into the Future. Journal of Management, Vol. 34 No. 3, June 2008 410-476. DOI: 10.1177/0149206308316061

Perspective of learning theory and human factors that needs to be incorporated into training

- The integration of task work and teamwork skills is a concurrent task demand. It shares elements of a dual task, which requires time-sharing and attention allocation.

→ time sharing and attention allocation needs to be trained

- The in-process integration of teamwork and task work skills can best be learned according to the learning mechanism which is also effective for dual-task performance.

→ use training methods that proofed to be effective for dual-task performance

- Pre-process and post-process coordination activities are assumed to be valuable and supportive for the creation, learning and activation of task-related, team-related, process-related, and goal-related team knowledge.

→ Use briefing and debriefing techniques before and after team training

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Perspective of learning theory and human factors

- Equivalently to learning task work skills, learning teamwork skills includes a cognitive component (knowledge), such as a schema concerning teamwork characteristics, as well as a behavioural component, in which specific concrete behaviours, e.g. scripts and skills, need to be acquired and applied.

→ train technical and non technical skill

- Teamwork is learned through the accumulation of instances of teamwork episodes.

→ train with a large variety of scenarios with increasing difficulty

- Teamwork skills, focused on the behaviours necessary for effective team functioning, are believed to be best learned in intact teams rather than individually.

→ Train with the real autonomous team mate

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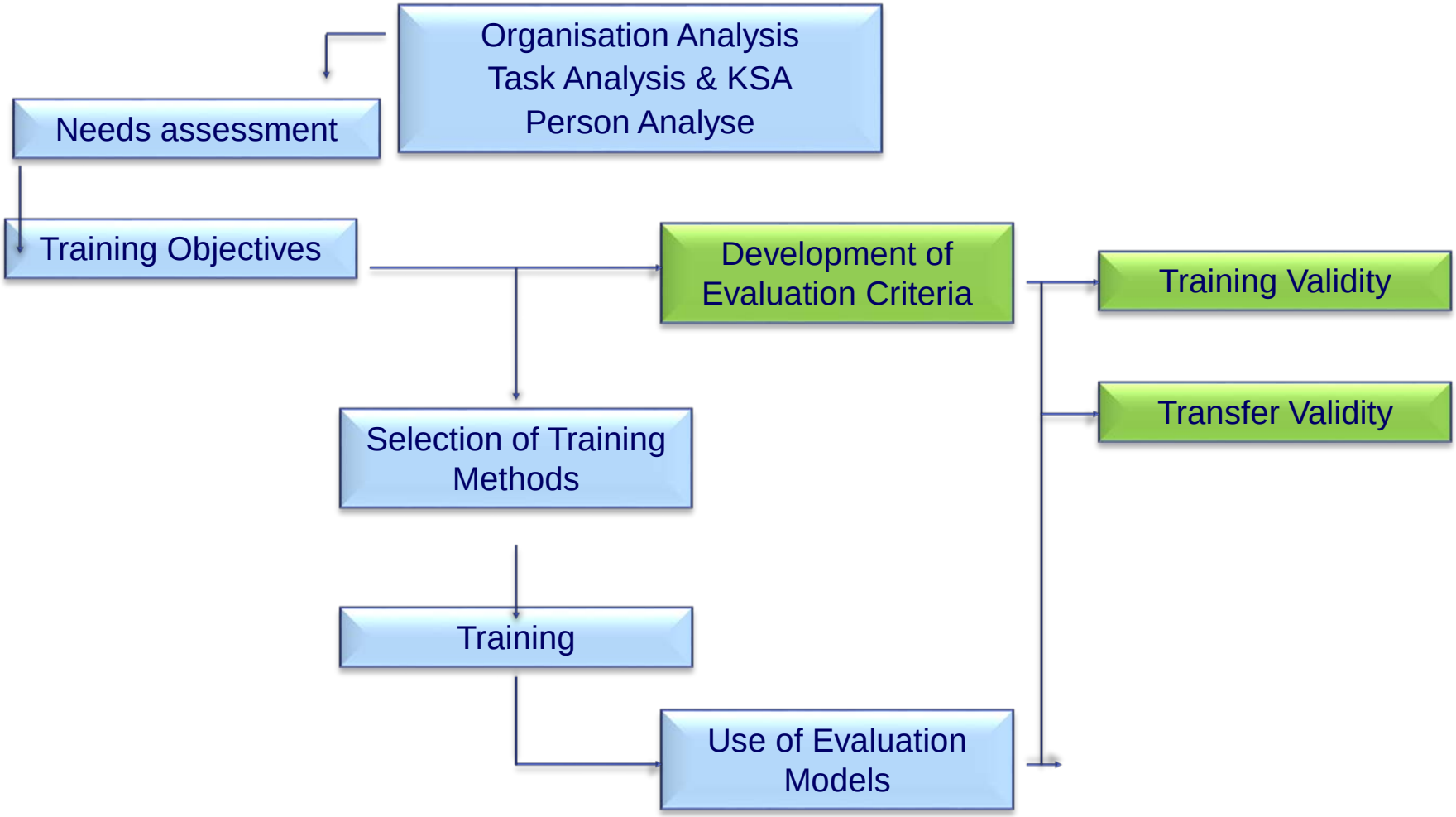
Training- Which steps need to be considered?



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Evaluation Criteria: SA-based Agent Transparency (SAT) Model

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Conclusion

- Training for Human Autonomy Teaming is similar to Human-Human Team Training
- Both parties need knowledge about capabilities and limitations of the team member
- Coodination and orchestration of task work and team work is based on mutual understanding of intentions
- HAT team training requires training as intact teams

Thank you for your attention!

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