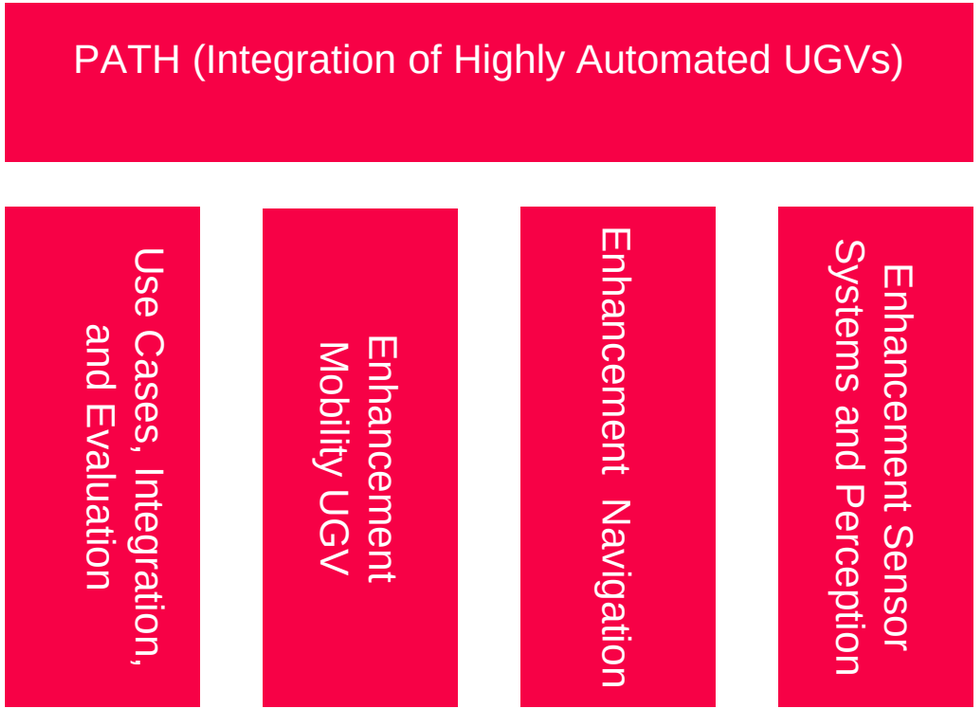
SCIENCE
PASSION
TECHNOLOGY

Wege für moderne UGVs in die militärische Praxis (PATH)

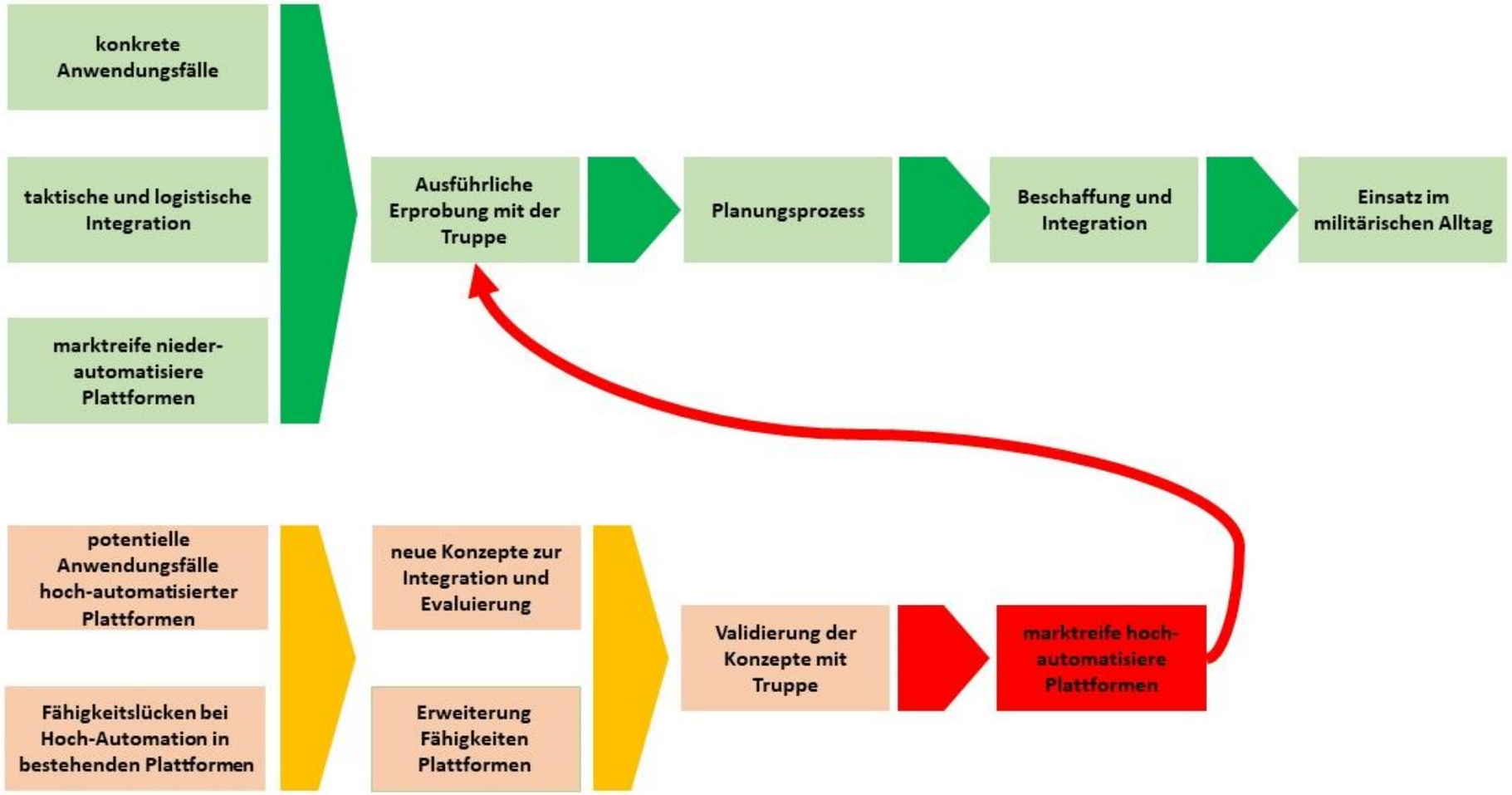
Fortissimo 29.4.2025

Central Project Goals

- **Integration of highly automated UGVs into daily military use (e.g. infantry)**
  - Showstoppers: Missing concepts for integration and operation, missing sound evaluation procedures, still missing advanced UGV capabilities



Motivation - The MOD Systems Pipeline

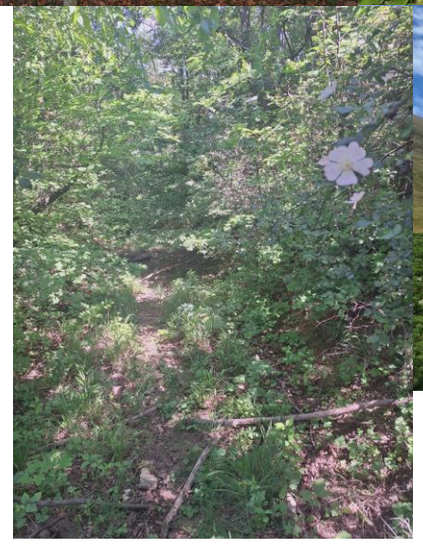
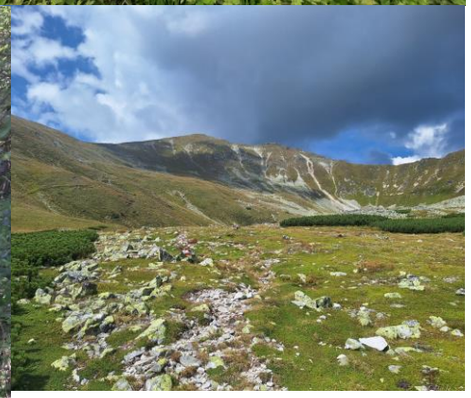


Summary of the Project Goals

- Identification of use cases and tactics of UGVs on the battlefield
- Development of sound operational procedures, and evaluation concepts and metrics (KPI)
- Integrated demonstrator implemented
  - Improved mobility with automated kinematic reconfiguration of platform
  - Extended sensor systems and environment understanding (weather, terrain, vegetation, low light)
  - Extended navigation with 2,5D trajectory planning and execution
- Test campaigns in realistic environments together with troops

Use Cases and Evaluation Methods

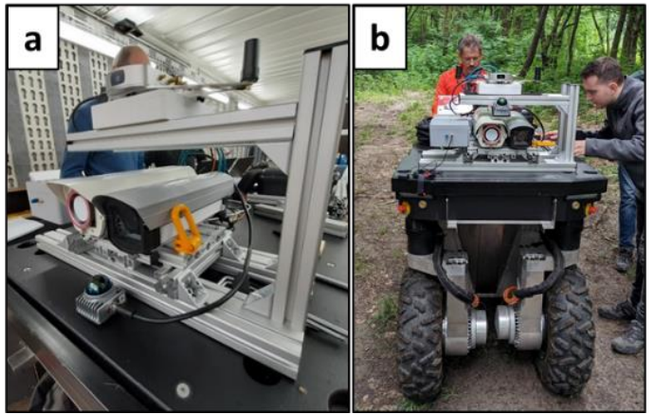
- Method
  - Requirement Workshop with Military Experts (HTS, WFE, ARWT)
  - Data Collection at Training Grounds
- Identified Tasks
  - Transport, Reconnaissance, Combat Support
- Identified Use Cases
  - Urban Terrain with Barriers
  - Negative Obstacles (e.g., Ditches)
  - Dense Vegetation/Forest
  - Mule Tracks and Hiking Trails

Enhancement Mobility and UGV Integration

- Improve Mobility in Challenging Terrain
- Target Platform ARTUS
  - 4-wheel drive and 4 wheel steering
  - dynamic lateral and longitudinal inclination
- Enhancements
  - Active configuration during driving
  - Inherent safe state using vehicle data
- System Integration
  - ROS2 Interface
  - External access to dynamic reconfiguration

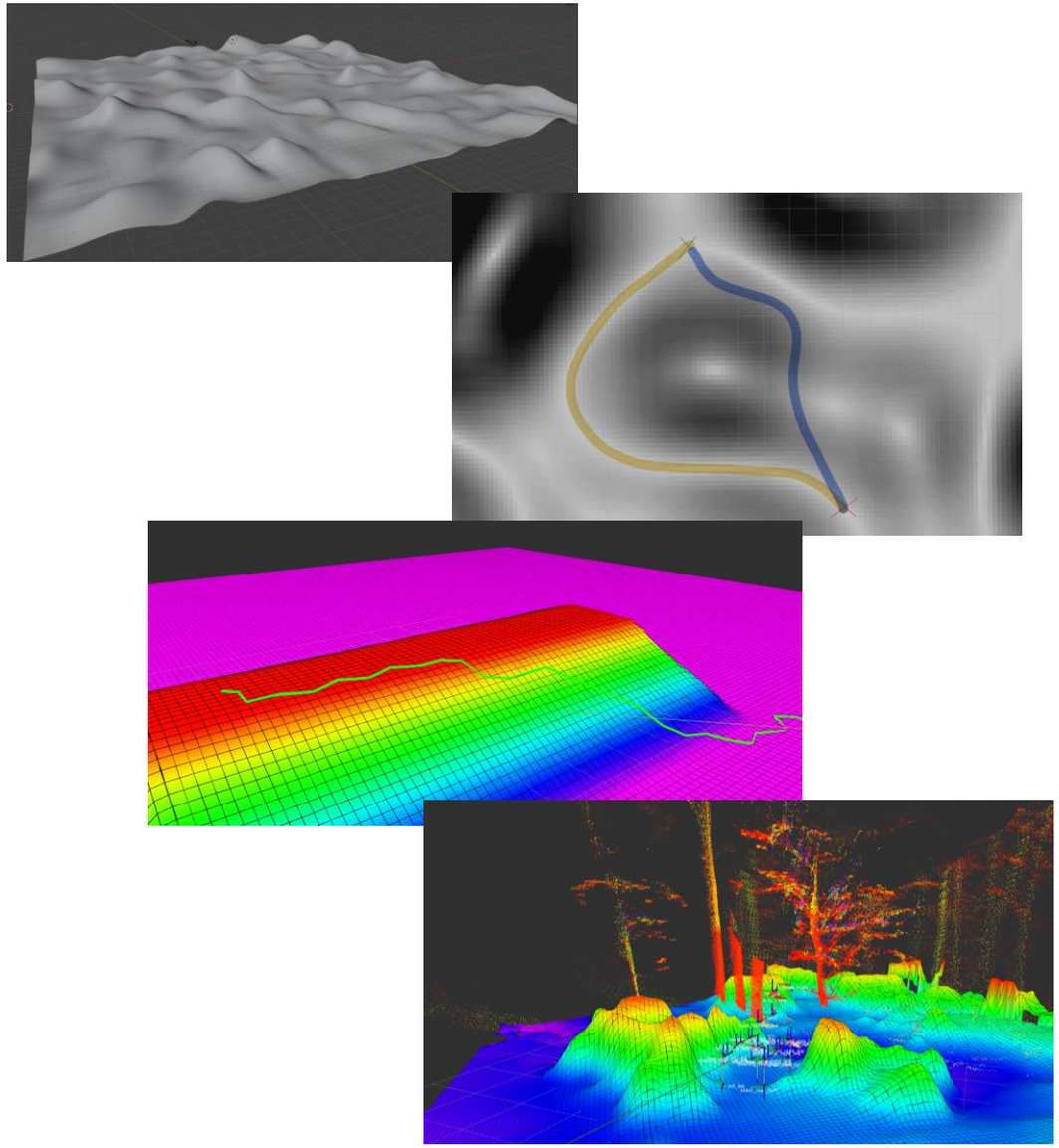
Enhancement Sensor System and Perception



- Improve Perception in Challenging Environments
  - Reduce dependency on weather
  - Improve outdoor scene understanding
- Enhanced Sensor Setup
  - Multi-modal setup (optical, thermal, RGBD, LiDAR)
  - Calibrated multi-sensor setup
- Information Fusion
  - Geometric information (primary source currently)
  - Semantic information (deep learning)

Enhancement Navigation

- Improved Navigation in Challenging Environments
  - Native use of 2,5D representations
  - Improving information utilization
- Enhanced Trajectory Planner
  - Direct use of terrain information (elevation map)
  - RRT-based planning with sampling of robot/terrain interaction
  - more intuitive and stable trajectories



Field Evaluation – AAART 2025 (TÜPL Seetaler Alpe)

- Goals
  - Systematic evaluation of automated UGV
  - To see where the automated navigation really breaks, accepting failures not avoiding them
- Evaluation Dimension
  - Route: challenging long-distance routes including dense vegetation, forest roads, open land, and alpine mule tracks up to 10km distance and 800m height difference
  - Technology: we envision tests on 3 technological difficulty levels:
    - All technology is allowed to be used
    - GNSS-denied environment
    - GNSS-denied environment plus passive sensing only

Summary and Next Steps

- Paving the way for highly automated UGVs into practice
- Establishing the foundation for integration, operation, and evaluation
- Initial improvements in locomotion, perception, and navigation

- Proper fusion of geometrical (elevation map) and semantic (segmentation) information
- Integration of fused information into trajectory planning and execution
- Integration of active reconfiguration into trajectory planning and execution

Thank you!

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