A Flexible Toolkit Supporting Knowledge-Based Tactical Planning for Ground Forces

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Motivation

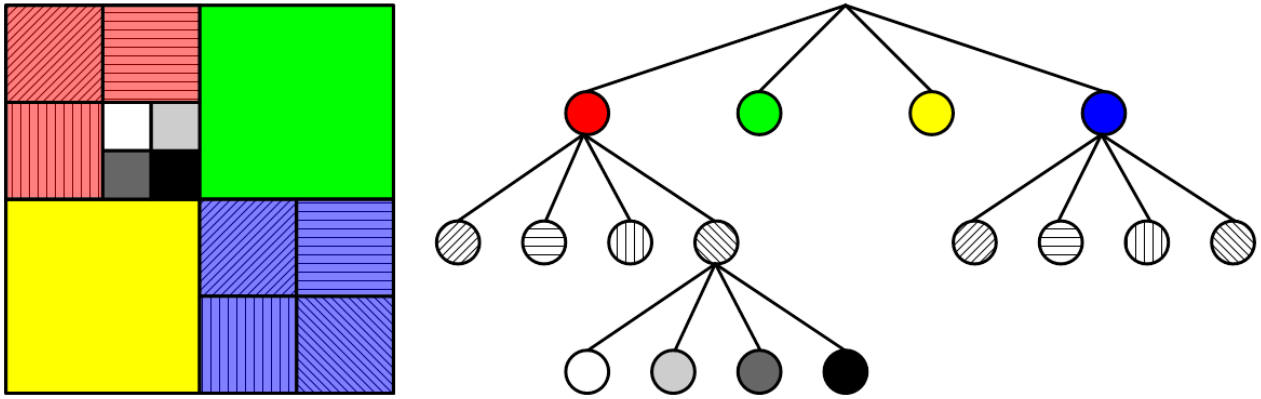
- Improved C2 decision making and planning support through the integration of
  - Battlespace terrain information
  - Operational/situational picture
  - Business rules and constraints
- Following tasks should be supported by a corresponding toolkit / framework:
  - Determination of optimal paths for friendly troops based on different optimization functions
  - Calculation of troop movement projection
  - Determination of visibility and zones of fire
  - Modeling of enemy movement and engagement opportunities
  - Identification of danger zones
- Research Project: C2DSAS (Command and Control Decision Support and Advisory Services)

Main Scope of C2DSAS

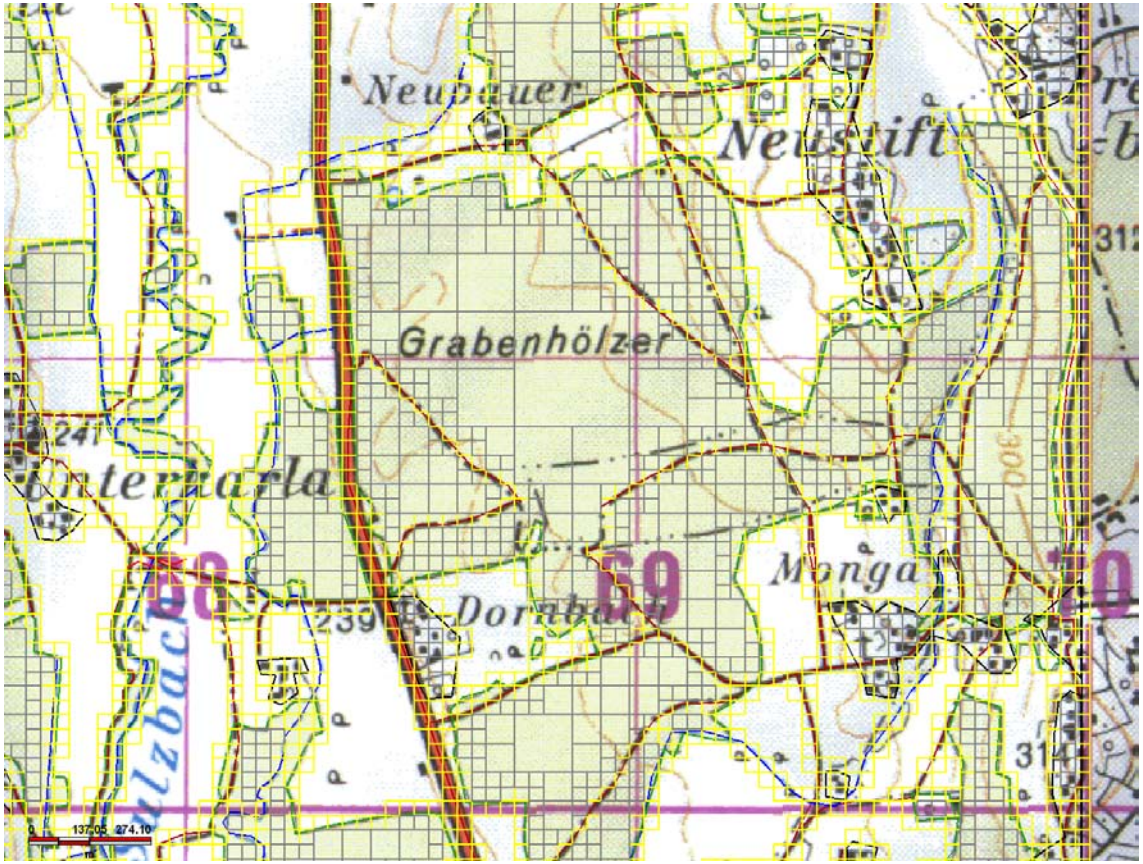
- Development and test of data structures and algorithms for
  - C2 decision support
  - Ressource optimization
  - Quick replanning in complex situations
- Supporting planning handcrafts by maintaining well defined planning procedures
- Algorithms for
  - Movement planning
  - Enagement planning
  - Visibility and zones of fire
- Efficient data structures for configuration space
- No focus on visualisation
- Development of a prototype framework / toolkit

Configuration Space

- Efficient data structures needed
- In C2DSAS framework: *quadtree* data structure
- Recursively divide map until resulting cells can be classified (or a minimum cell size is reached)
- Quadtree decreases memory consumption and accelerates all further computations



Example Quadtree Computation

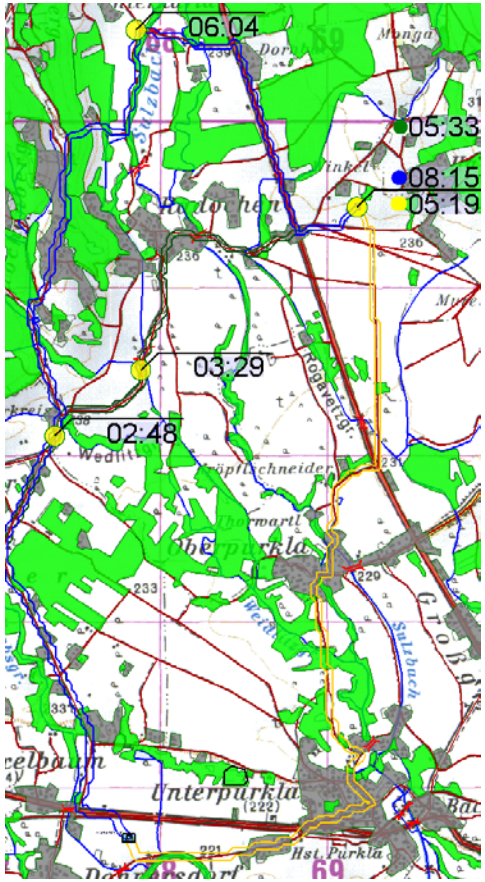


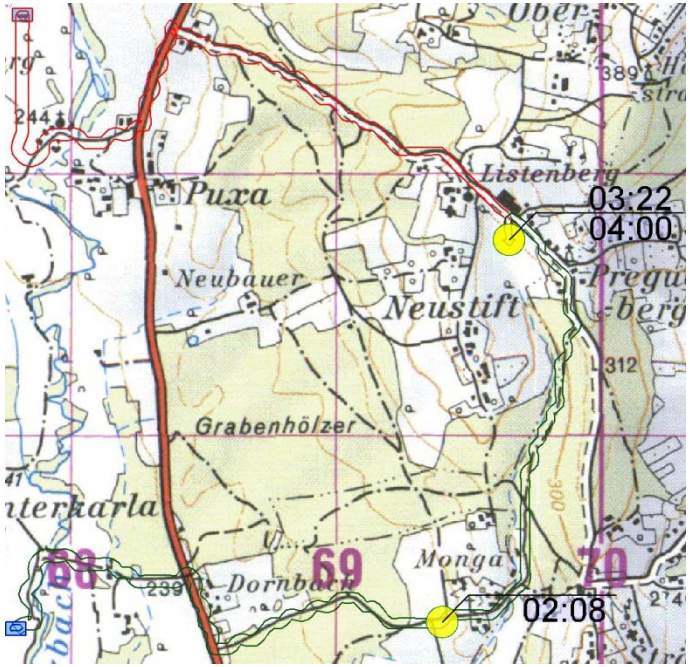
- Different cell sizes
- Basis for search tree construction

Movement Planning

- Different optimization functions such as
  - Time
  - Distance
  - Engagement opportunities
- Directing path calculations
  - Intermediate path points
  - Special areas

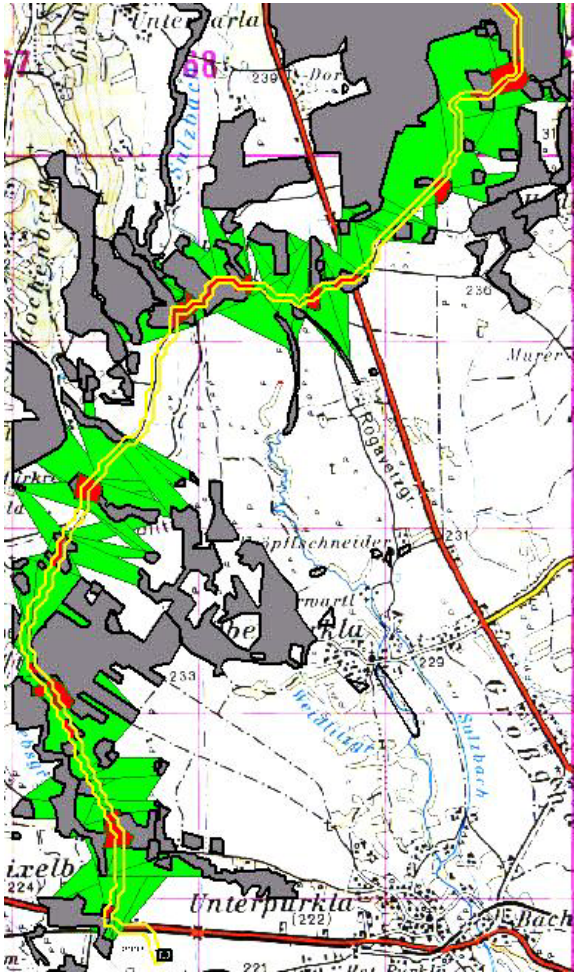
Optimal Paths Based on Heuristic Search





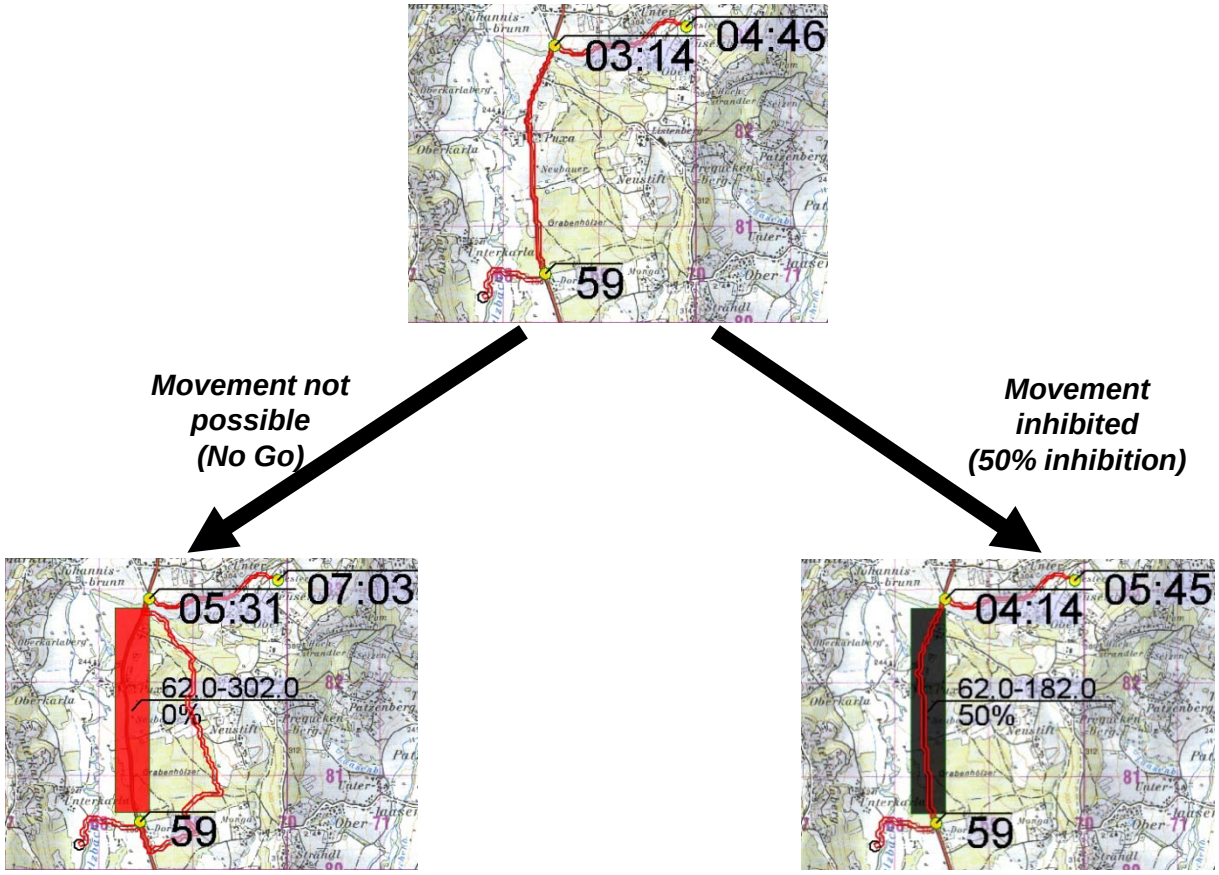
- A*-Algorithm
- Intermediate path points for directing search and producing alternatives
- Estimate the probability of enemy contact

Secure Paths

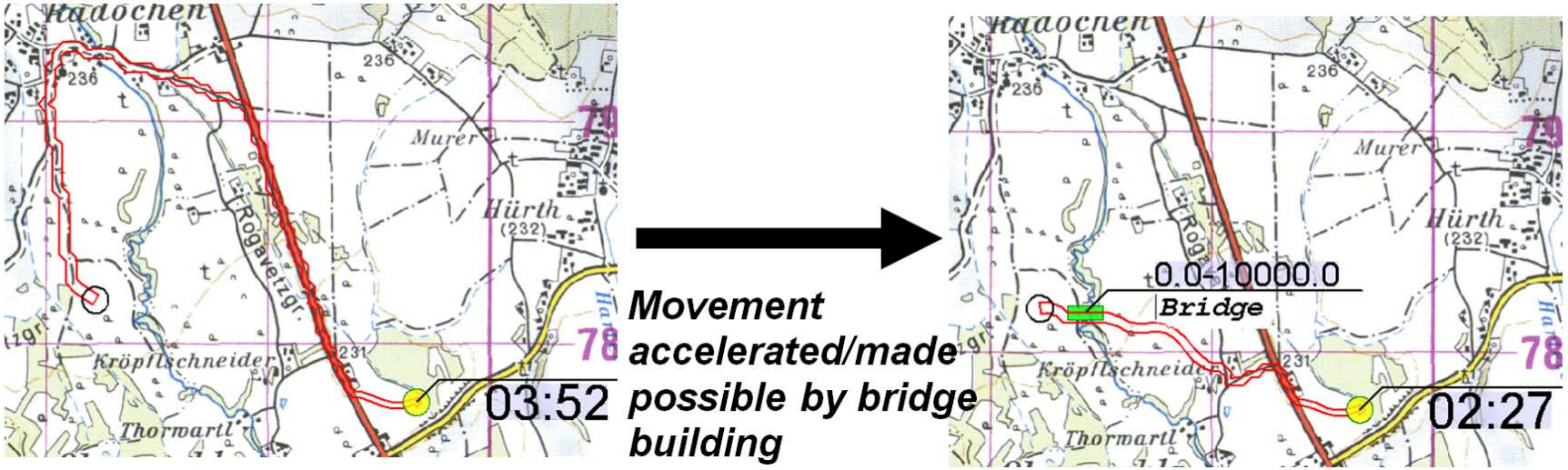


- Identification of danger zones by calculating areas with limited troop formation opportunities along a path
- Green: slightly limited
- Red: extremely limited
- Other areas: unlimited

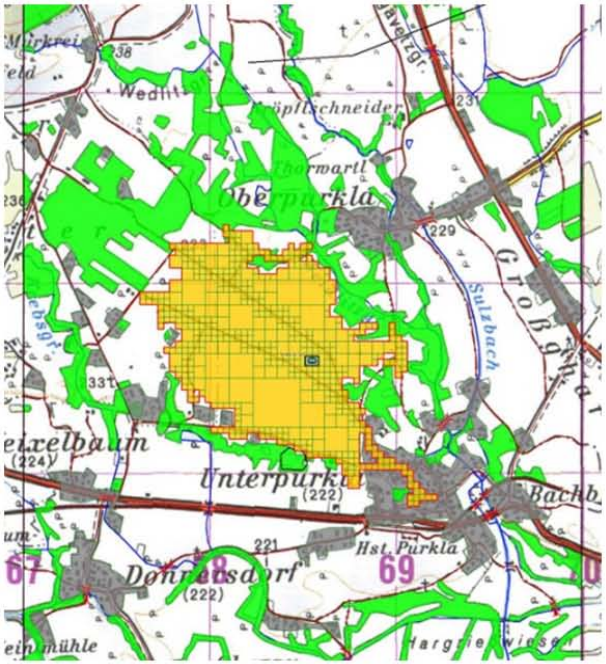
Special Areas: Inhibition



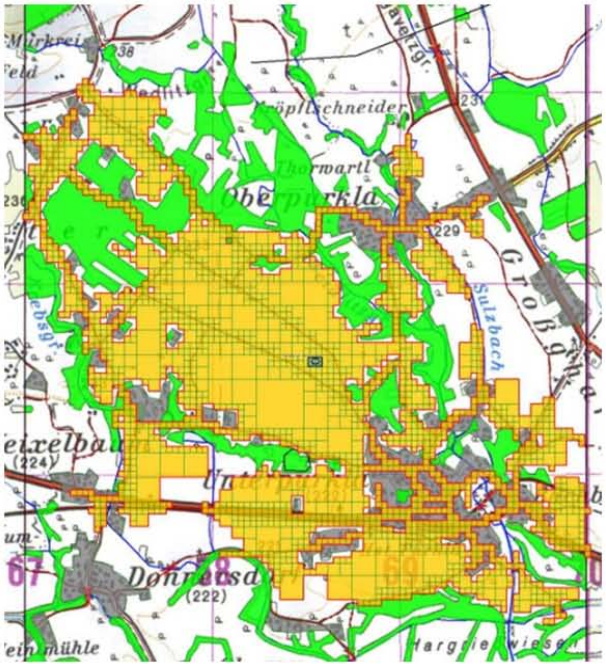
Special Areas: Acceleration



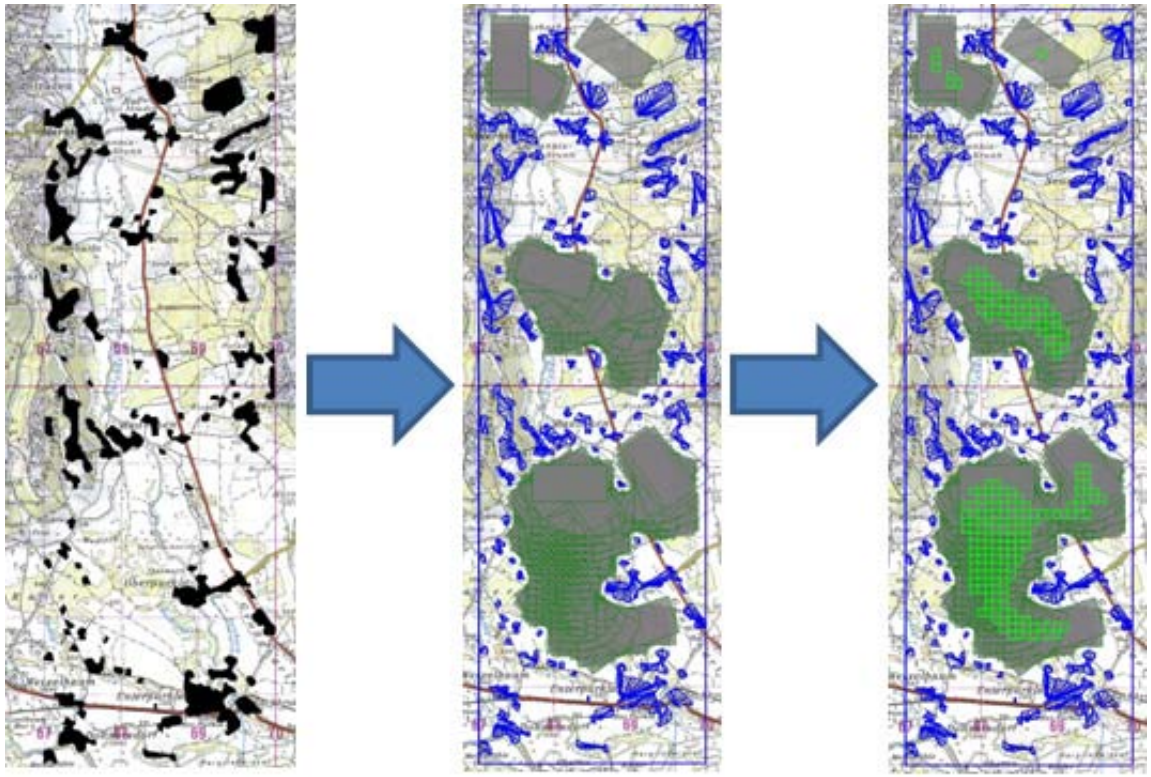
Troop Movement Projection



Reachable areas for two different time periods



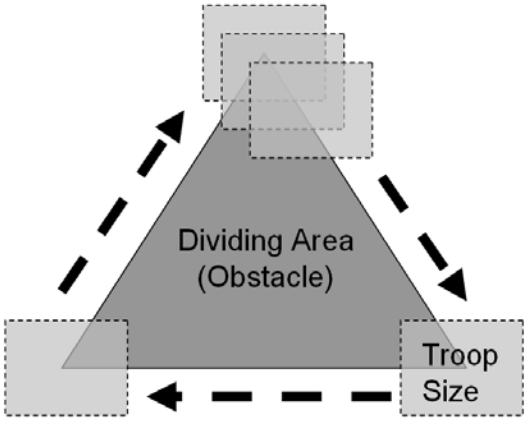
Engagement Planning

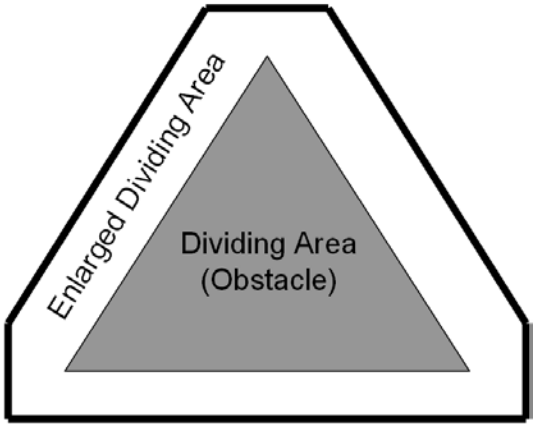


- Identification of obstacles and dividing areas
- Identification of possible and favorable engagement areas

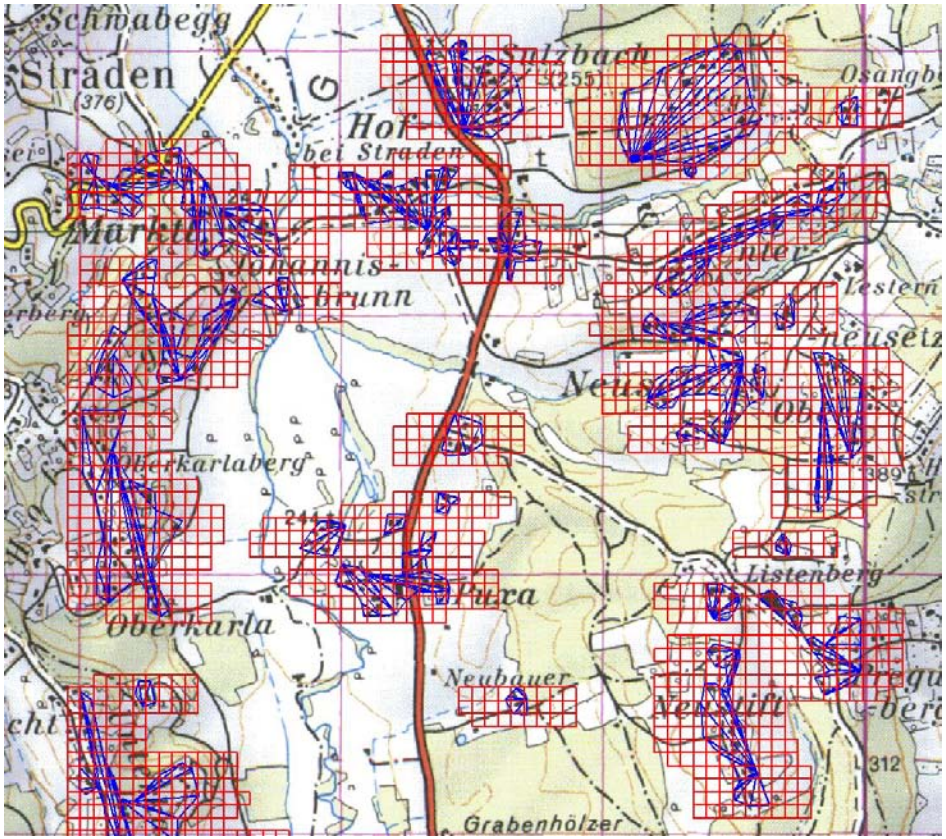
Engagement Planning: Minkowski Sum

- Sum of two sets S and T in the euclidean space:
  - $S +_M T = \{s + t \mid s \in S, t \in T\}$
- In 2D:
  - Slide one shape over the borders of another



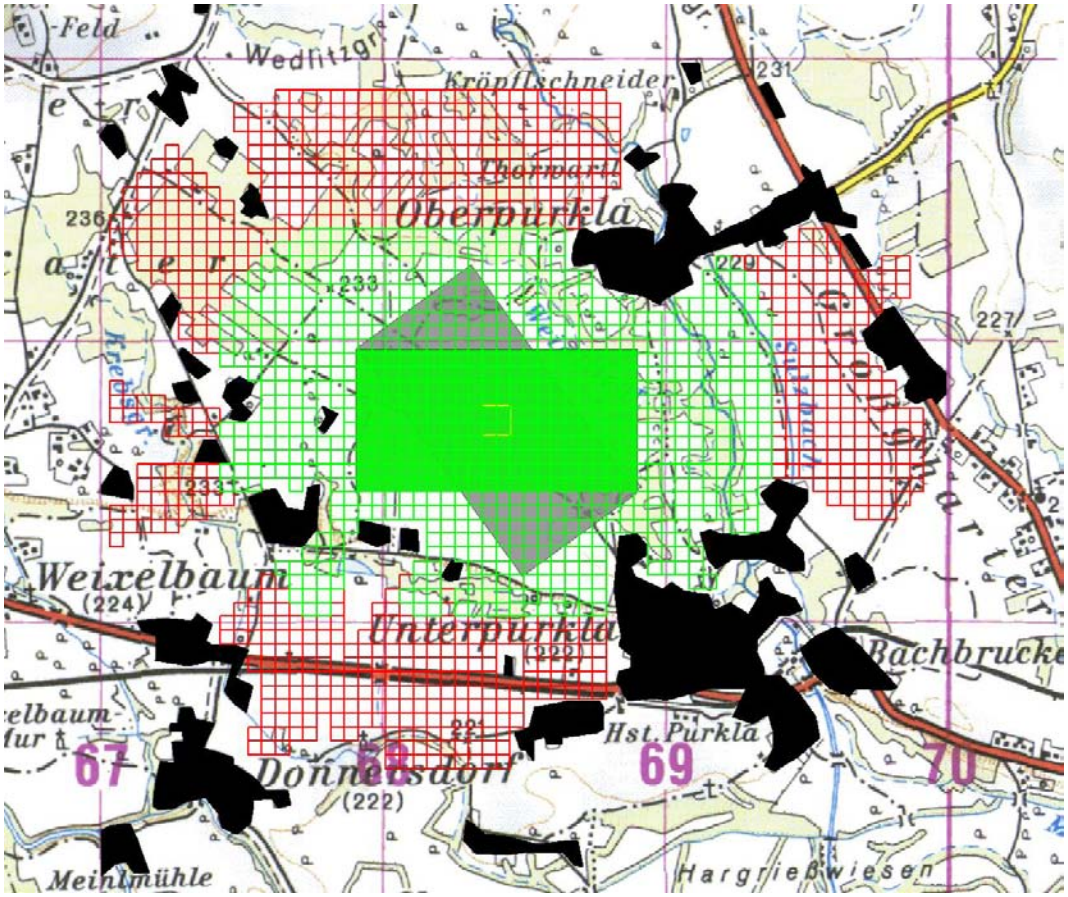


Example Minkowski Calculation



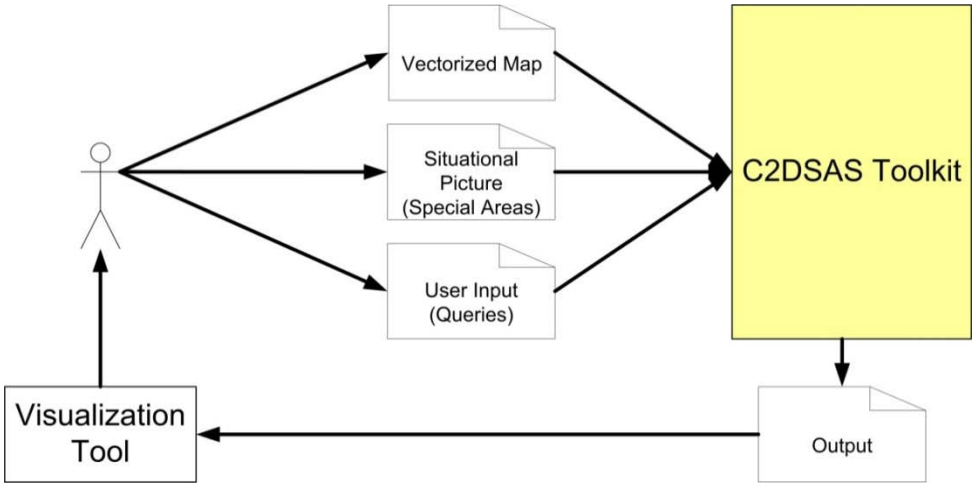
- Every cell that is not part of an enlarged area constitutes a centre point of a corresponding engagement area

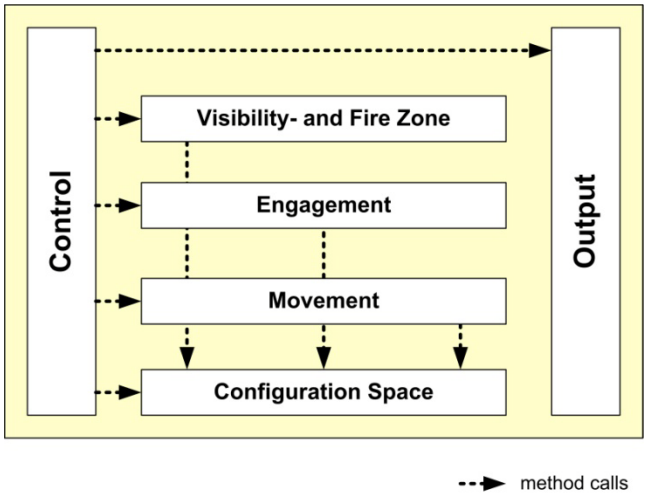
Visibility and Zones of Fire



- Based on an identified engagement area
- 2D: incorporates dividing areas like forests
- 3D: also incorporates elevation data

Toolkit Architecture





Conclusions

- C2DSAS toolkit constitutes a valuable and generic collection of AI software methods focusing on tactical planning for ground force operations
- No automatic decision making
- Effective support of basic planning handcrafts
- Future work:
  - Development of an intelligent user interface
  - Development / extension of a business rule database
  - Full integration into C2IS of the Austrian Armed Forces

Thank you for your attention!

- Questions?