Control of teams of unmanned aerial/ground vehicles

ATG applied research overview

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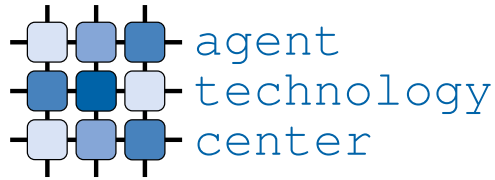


Overview

The domain of intelligence gathering (IRS) missions offers a range of interesting challenges for multi-agent systems research.

1 AgentFly

2 Tactical AgentFly

3 Tactical AgentScout

4 On-going and future work

5 Conclusion

AgentFly

A set of aircrafts in a joint airspace.

control

- path planning
- no-flight zones
- simple missions
- time

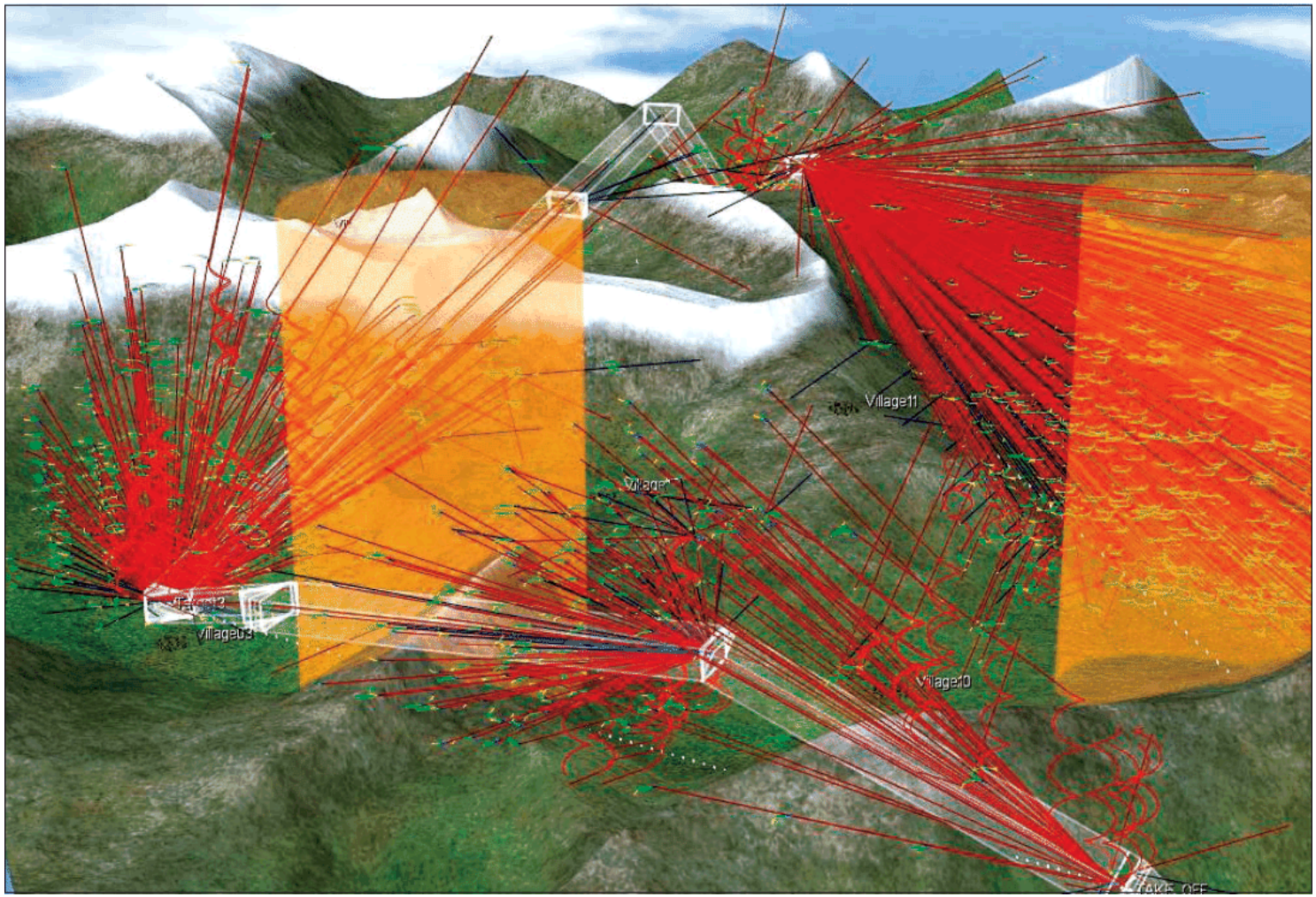
conflict avoidance $\rightsquigarrow$ crashes

current solutions

- $\rightsquigarrow$ dispatchers + teleoperation
- $\rightsquigarrow$ fixed rules

UAV control

A*-based maneouver planner



UAV control (cont.)

conflict avoidance/deconfliction

- iterated negotiation:
  1. broadcasting plans/plan fragments
  2. idenfication of conflicts
  3. utility-based plan adaptation

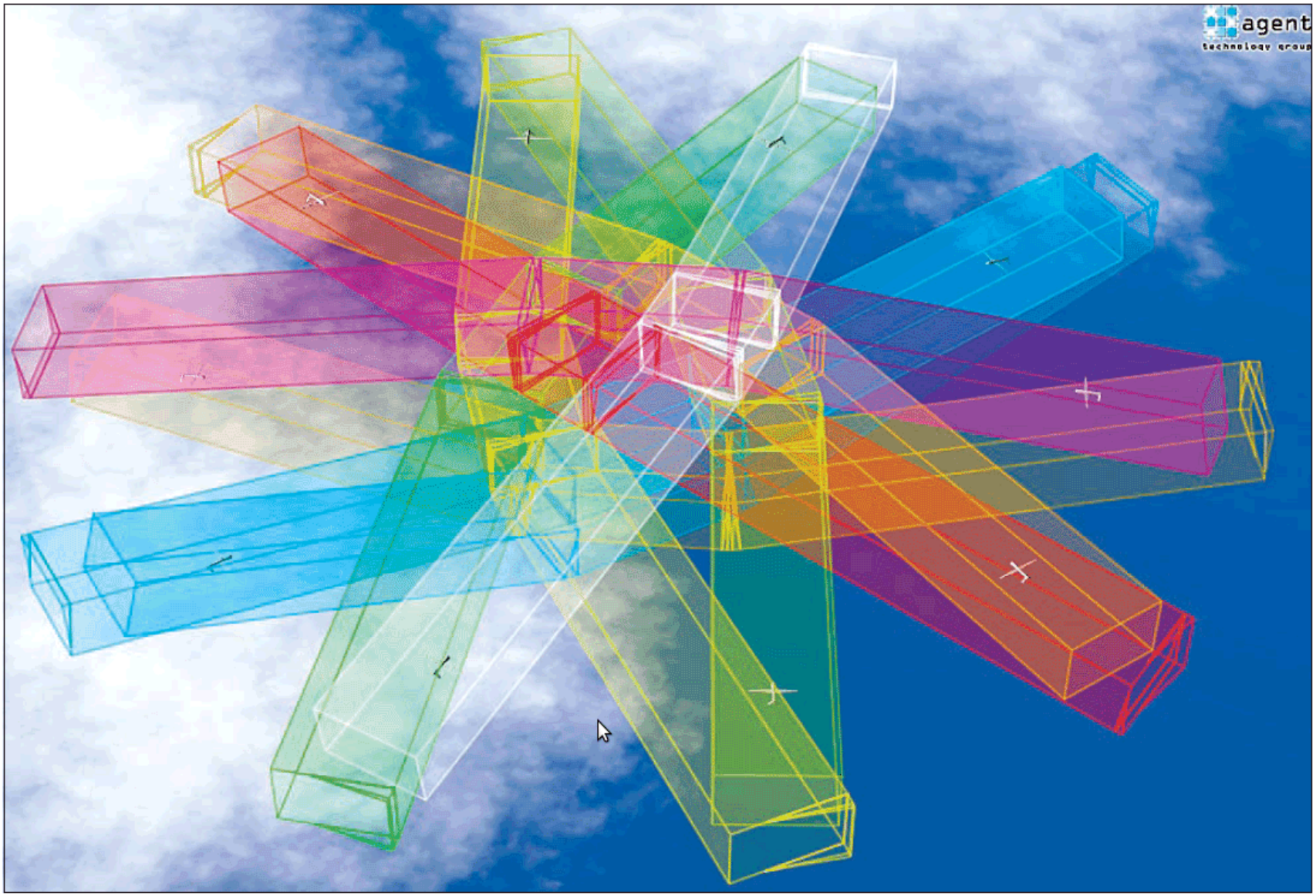
extensions

- mountaneous terrain
- time constraints
- cooperative vs. non-cooperative deconfliction
- weather

Simulation framework

- A-Globe MAS platform
  - asynchronous distributed message passing
  - agent containers
- simulator
  - environment
  - embodiment of agents
  - models of physical dynamics of entities
- visualization
  - 3D, textures, etc.

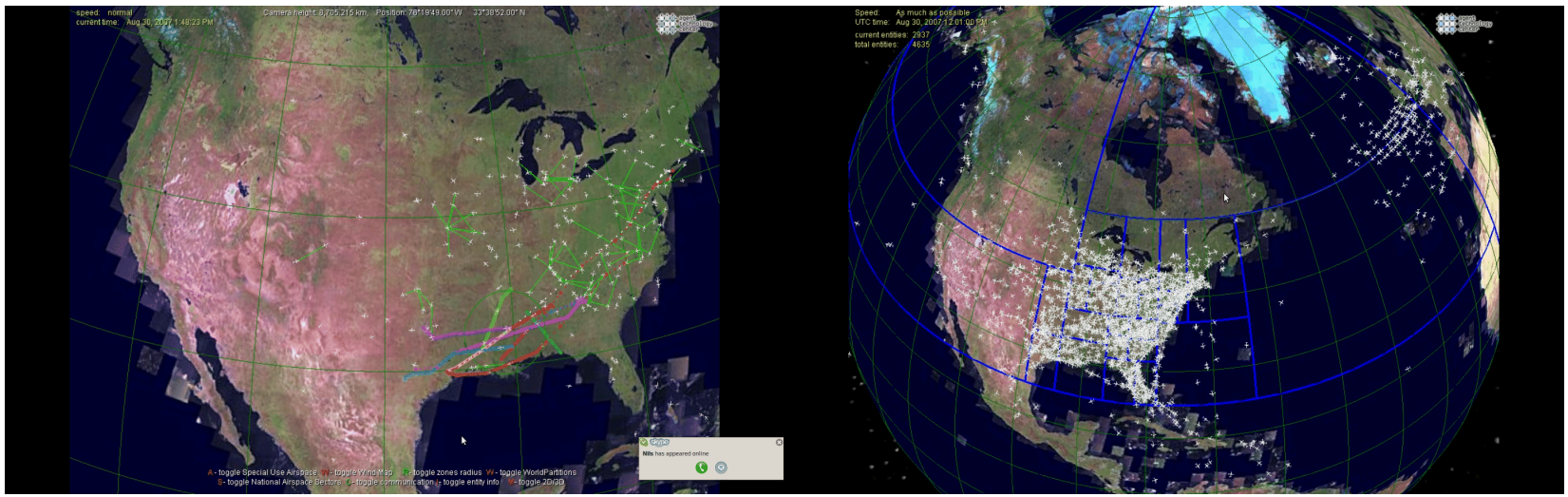
Demo



Next-gen air traffic control

Airspace becomes too congested $\rightsquigarrow$ free-flight concept

- massive distributed simulations $\rightsquigarrow$ US/Europe airspace
- US FAA funded efforts



Tactical AgentFly

ISTAR missions in urban environment

=

semi/fully-autonomous control of a team of UAVs

current:

- single UAV $\rightsquigarrow$ operator (teleoperation)

near future:

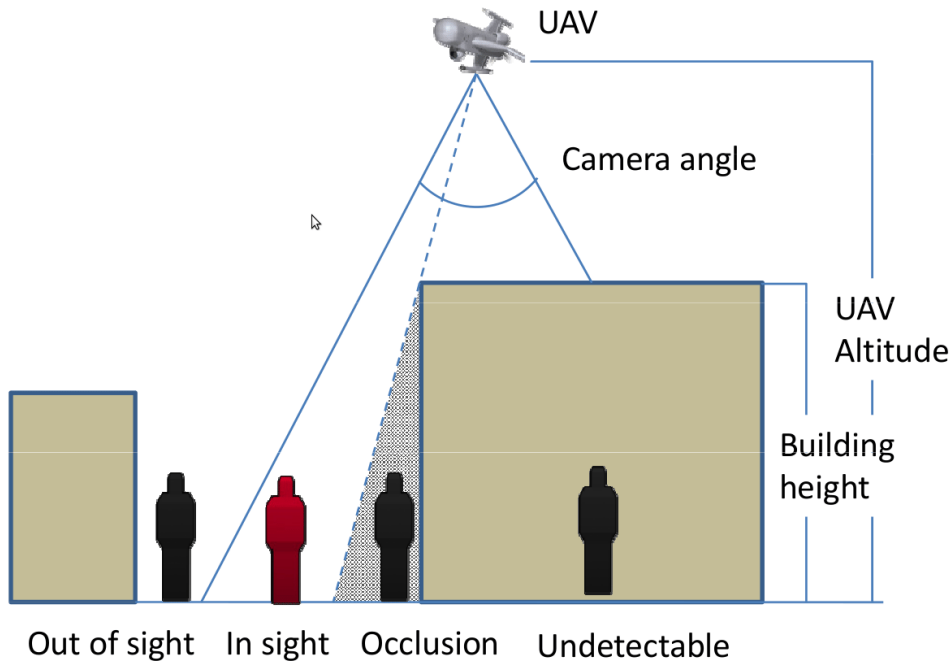
- team of UAVs $\rightsquigarrow$ single operator (team tasking)

far future:

- team of UAVs $\rightsquigarrow$ autonomous control (overwatch)

Subproblems (semi-automatic)

- algorithms for
  - terrain exploration (reconnaisance)
  - surveillance
  - target tracking
- sensors: gimballed/fixed camera, etc.
- occlusions in urban terrain



Subproblems (autonomous)

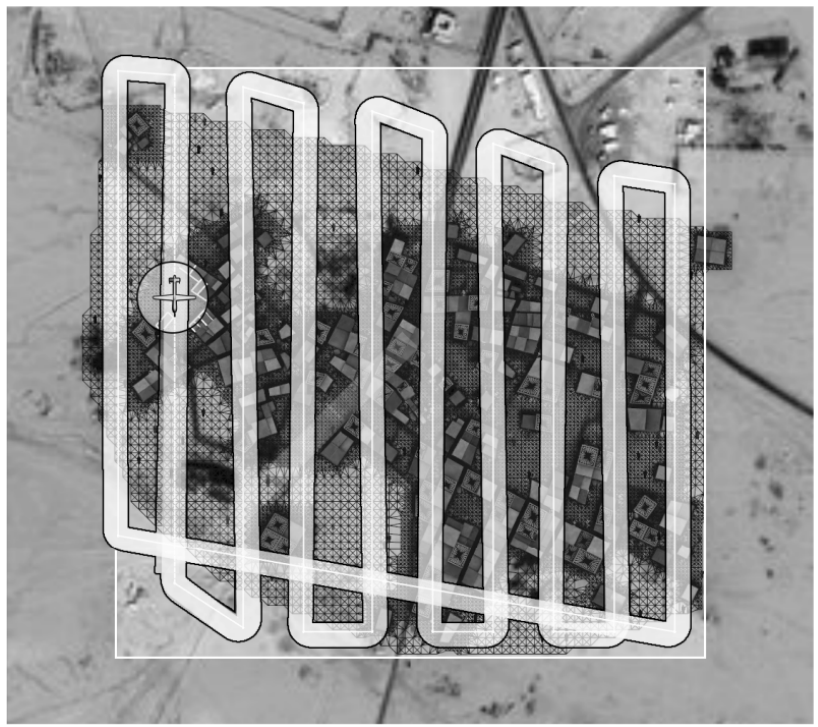
- dynamic reconfiguration/re-allocation of tasks
- MxN tracking- multiple targets vs. limited resources
- ground mission support

Heterogeneous teams:

- fixed-wing aircrafts (CTOL)
- helicopters (VTOL)
- planning $\rightsquigarrow$ 4D planner
  - time
  - physical dynamics model

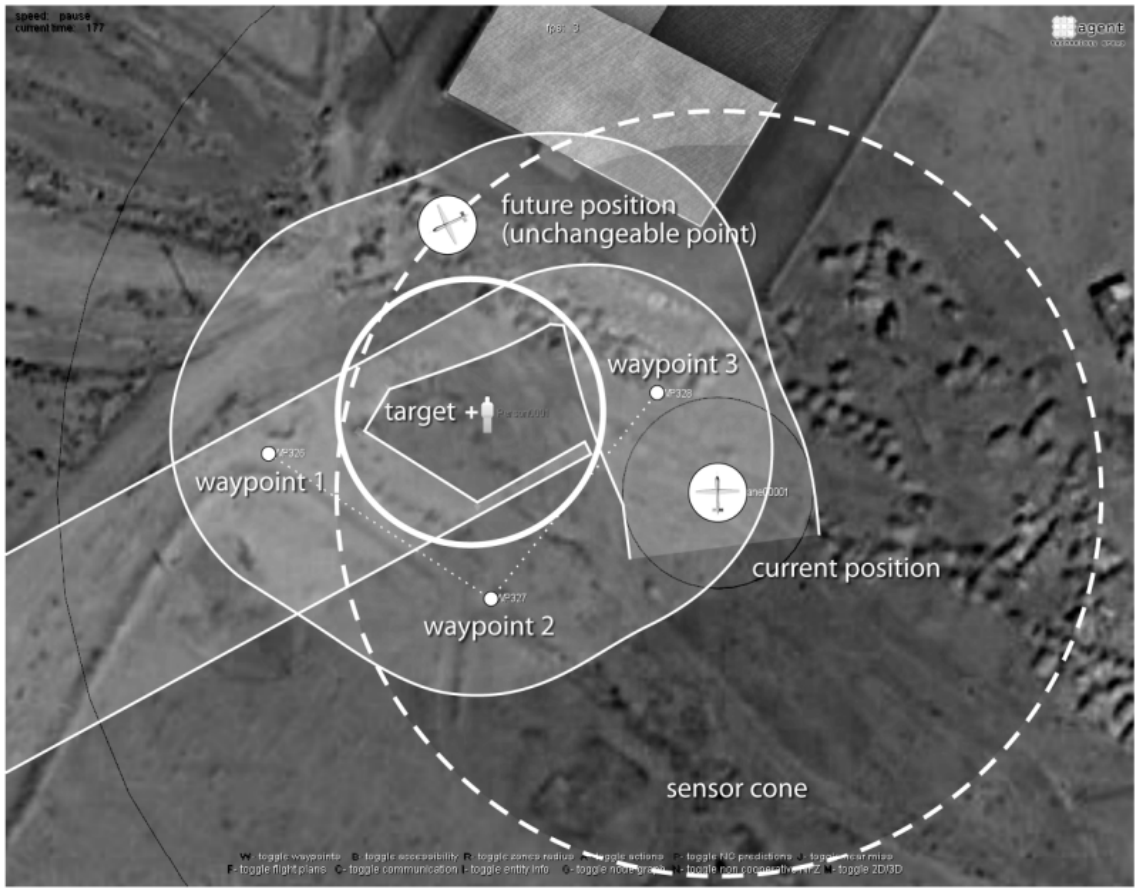
Surveillance

- surveillance (measure = information-age)
  - spiral
  - zig-zag
  - greedy
  - dynamic reconfiguration: DVRP-based task allocation with various heuristics



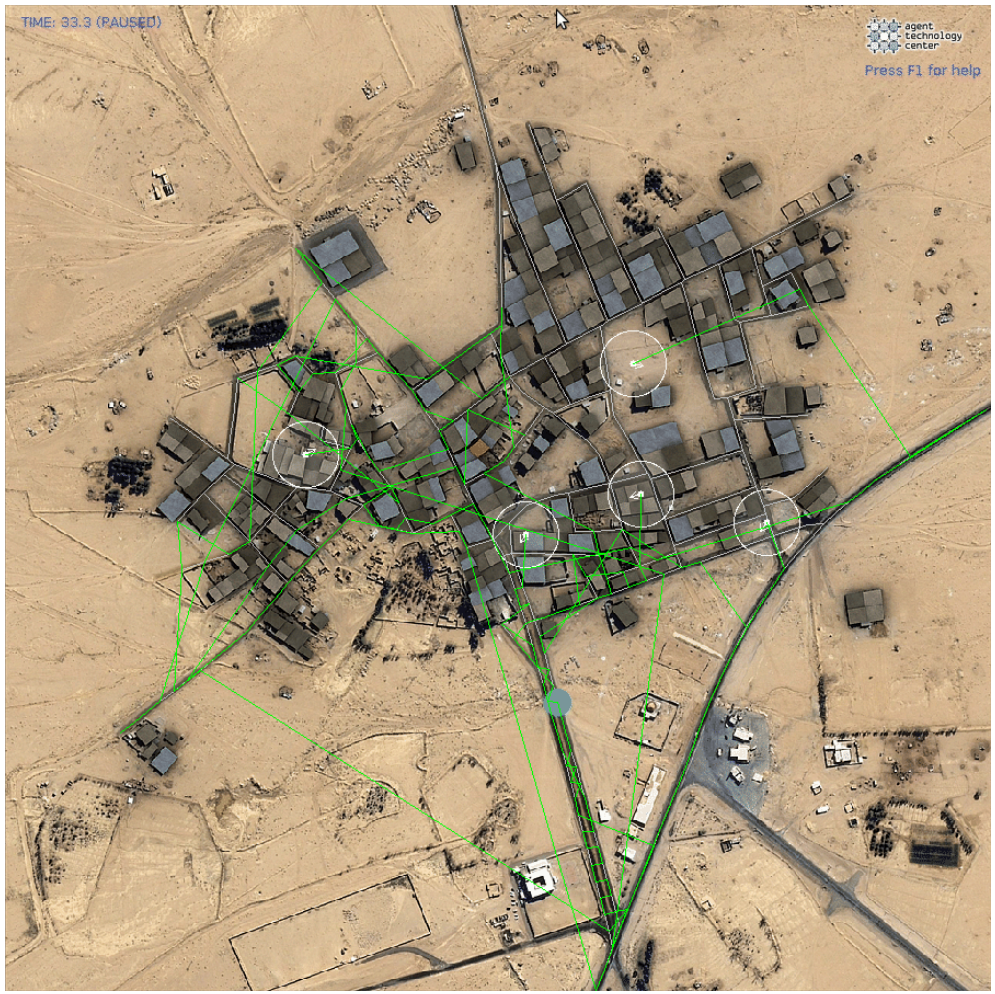
Tracking

- tracking (measure = target in view time)
  - target dynamics vs. aircraft dynamics
  - planning/deconfliction speed vs. aircraft speed



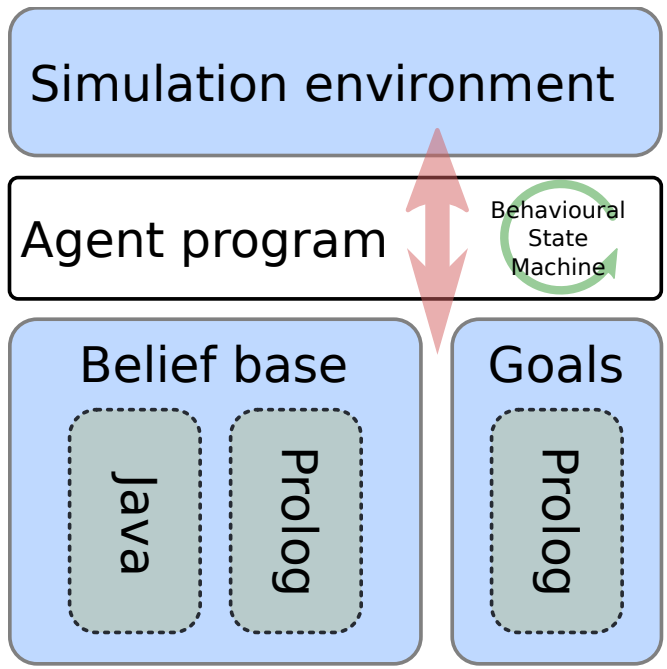
Exploration

- exploration
  - naive vs. DVRP based task allocation



Mission execution

- specification of missions and rules of engagement
- agent-oriented programming (Jazzyk/BSM)
- BDI agents



Integrated demos

Tactical AgentScout

Coordination of teams of heterogeneous agents in urban military misisons

- unmanned aerial vehicles (fixed wing aircrafts, helicopters)
- unmanned ground vehicles (cars, robots)
- unattended ground sensors
- teleoperated devices (satellites, planes, vehicles)
- humans

Subproblems

Technological objectives

- physical modelling of UGVs
- integration of UAVs, UGVs, VTOLs, etc. into a single (distributed) simulator

Research objectives

1. planning/replanning/plan-repair
   - levels of granularity
   - flexible horizon
2. continuous distributed planning
   - individual vs. collective vs. reactive planning
3. adversarial reasoning
   - patrolling of mobile targets
   - smart targets modelling

Demos


speed: normal
currentTime: 71
Pointer X: 817.867 Y: 1 028.676
fps: 13
agent technology center
W - toggle waypoints E - toggle accessibility Z - toggle zones radius X - toggle actions C - toggle node graph P - toggle NC predictions - toggle 2D/3D
F - toggle flight plans C - toggle communication I - toggle entity info A - toggle planning N - toggle node IDs - toggle near miss

Mixed simulations

Transfer the developed algorithms to mixed simulation.

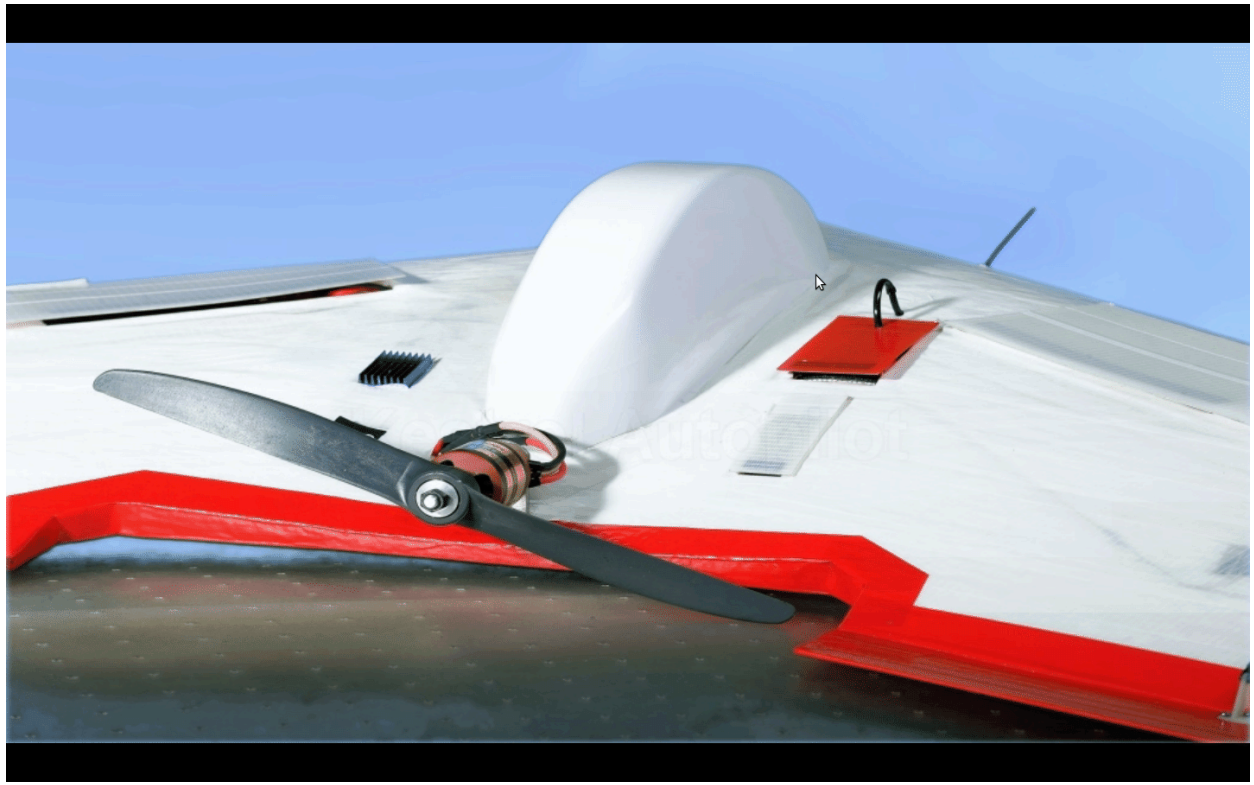
- algorithms $\rightsquigarrow$ real robots
- mixed-simulation = reality + simulation

Benefits:

- cost
- rich testbed
- preservation of requirements: deployment vs. simulation

Towards multi-robotics and explicit/implicit MAS coordination.

Demo



Conclusion

- simulations and prototype-oriented work
- high-fidelity + mixed simulations:
  - path planning vs. vehicle dynamics
  - technology transfer methodology
- military settings:
  - scripting + planning
  - human-robot interaction
  - planning on strategic vs. tactical levels $\rightsquigarrow$integration

Thank you for your attention.