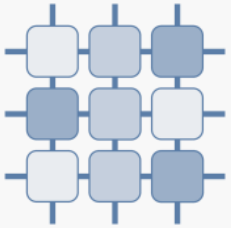
NAS-WIDE SIMULATION OF AIR TRAFFIC WITH ATC BEHAVIOR MODEL



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agent technology center

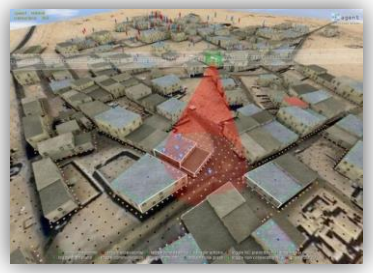
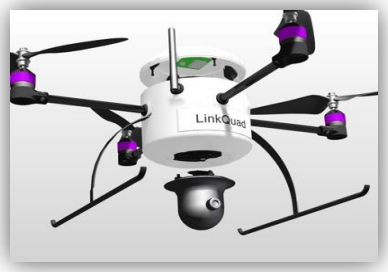
AGENTFLY

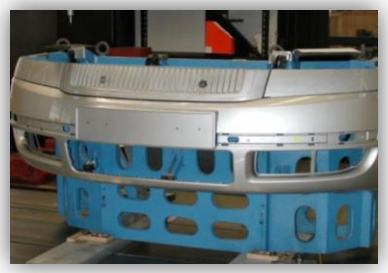
Agent Technology Center

- Size: 35 researchers, PhD/MSc students & CTU faculty members
- Objective: fundamental/applied research, empirical evaluation & tech transfer

- Core competences:
  - » multiagent modeling and simulation
  - » multiagent planning and coordination
  - » multiagent data analysis
  - » adversarial reasoning & game theory

- Application domains:
  - » air traffic, ground transportation
  - » cyber security, privacy, steganalysis
  - » UAV robotics, ground robotics
  - » physical security (maritime)

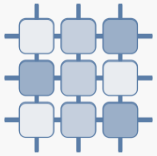





AgentFly Introduction

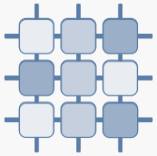
- AgentFly is a complex multi-agent system developed as a result of multiple research activities since 2006
- Funded by the US Air Force, FAA (NextGen), US Army, ONR, Czech Government
- Cooperation with other universities
  - » Drexel (US, Philadelphia), Bradley (US, Peoria), Linkoping (Sweden), TU Dresden (Germany)
- Industrial cooperation
  - » NASA (US), BAE Systems (UK), SAAB (Sweden), CS SOFT (Czech), DSTO (DoD Australia)

AgentFly Overview



- Distributed fast-time large-scale air-traffic simulation platform
  - » Civil piloted air-traffic
  - » Various UAS (RPAS) models
- Simulation of air-space environment, airplane physics and human operators
- Enable to study global effects using micro actors / actions
  - » Modeling individual airplanes up to thrust, drag and lift forces
  - » Modeling air traffic controllers using atomic actions (radio communication, keyboard typing)
  - » Simulation of individual airplane including flight envelope and basic pilot actions
  - » Simulation of ATC's behavior to model cognitive load, reaction delays, air traffic control
  - » Study of global flow management, interaction between sectors, spreading of changes in non-planned situations

Features

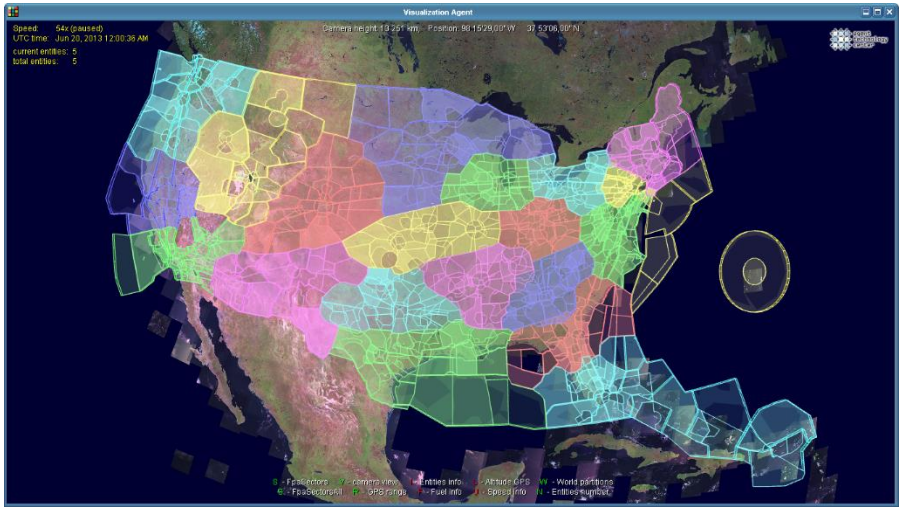


- Runway-to-Runway simulation of airplanes
  - » BADA performance model and specific models for UAS / RPAS
- Trajectory planning
  - » Constructed using fixes, routes, and vertical profiles with respect to special use airspaces
- Simulation of en-route (TMA) sectors using cognitive model of ATC's behavior
- Integration with other systems
  - » Traffic flow management, real data feed
- Distributed fast-time large-scale simulation to minimize running time
  - » tens of thousands of airplanes, hundreds of sectors / ATCs

- Detailed configuration
  - » Fast setup of scenarios, airspace reconfiguration, ATC's behavior, or airplanes trajectories
- Modularity of the system to easily replace specific components
- Detailed logging
  - » raw and processed data for further analysis
- Visualization tools for global overview as well as local state information

Data

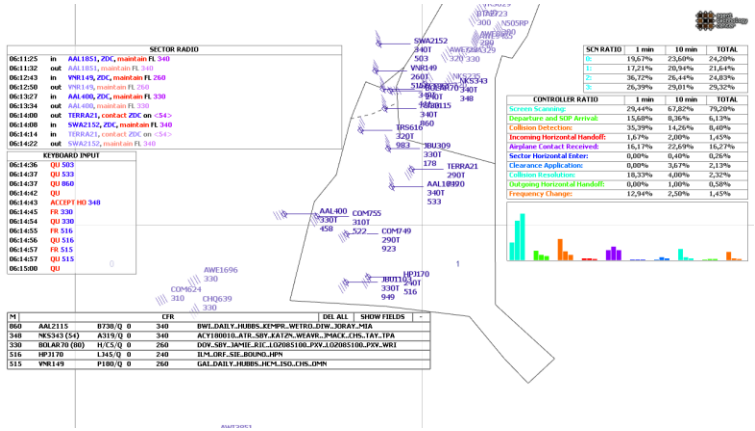
- Flights – definition by flight plan, filed altitude and speed
  - » PDARS, ASDE-X, CMS, FPX
  - » BADA family 3
- Sector definitions
  - » ERAM, FPA, FAV
- Fixes, Routes, SID, STAR
  - » ERAM, FPA and similar
- Special Use Airspaces
  - » ASP
- Weather
  - » PGB (wind), GRIB (complex data)
- Airports
  - » Initial internal format



Air Traffic Controller Model

- VCAP model (visual, cognitive, auditory, psychomotor)
  - » Based on Multiple Resource Theory (MRT)
  - » Controller duties are modeled as activities (e.g. hand off) composed from actions (e.g. radio)
  - » Each action defines which components from VCAP it requires, its duration and priority
  - » Action can be performed if its VCAP resources are available

- Supported En-route ATC procedures
  - » Handoff (both lateral and vertical)
  - » Conflict detection and resolution (vertical, lateral and speed changes)
  - » Application of Standard Operating Procedure (SOP)
  - » Point-outs
  - » Miles-in-trail
  - » Tactical conflict probe



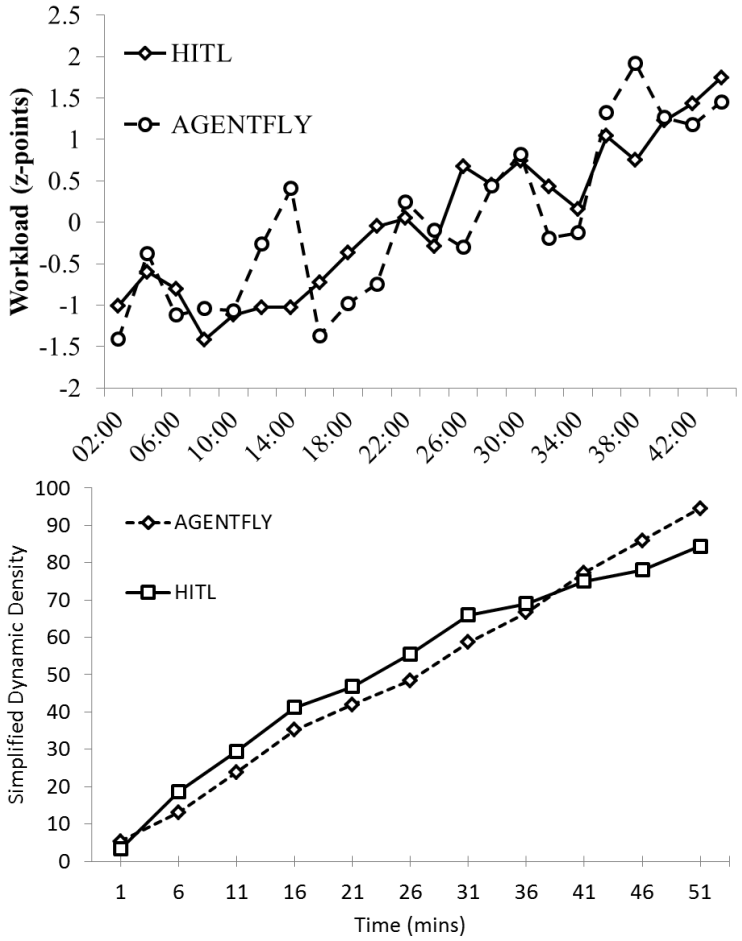
- Ghost ATC (unlimited capacity)
  - » Covers air space around simulated sectors
  - » Limited ATM functionality: handoffs, provides initial clearances

Validation of ATC Behavior Model

- Cooperation with FAA, TASC, Drexel University
- Comparison of Human-in-the-loop (HITL) experiment and AgentFly simulation using same input data

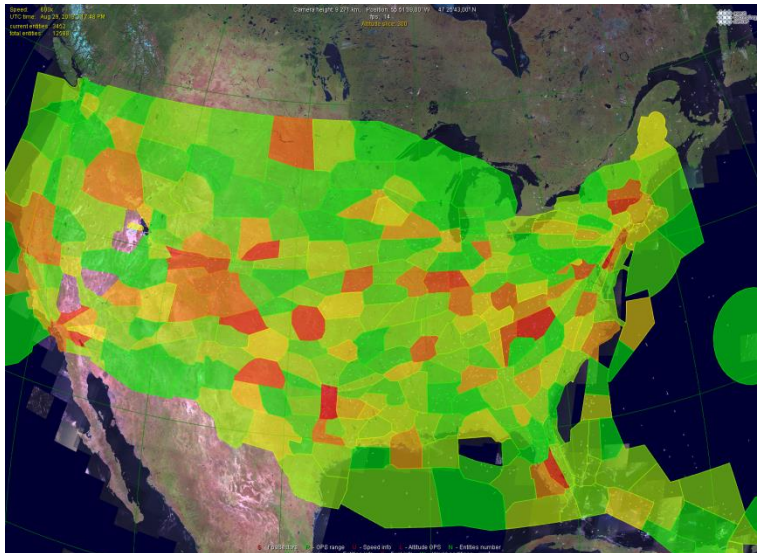
- Human performance metrics:
  - » Workload
  - » Simplified Dynamic Density (SDD)
  - » Aircrafts under control, handoffs
  - » Flight Level (FL) occupancy
  - » Aircraft mix, climbing, descending

- System performance metrics:
  - » Average sector flight time
  - » Minimum separation distance

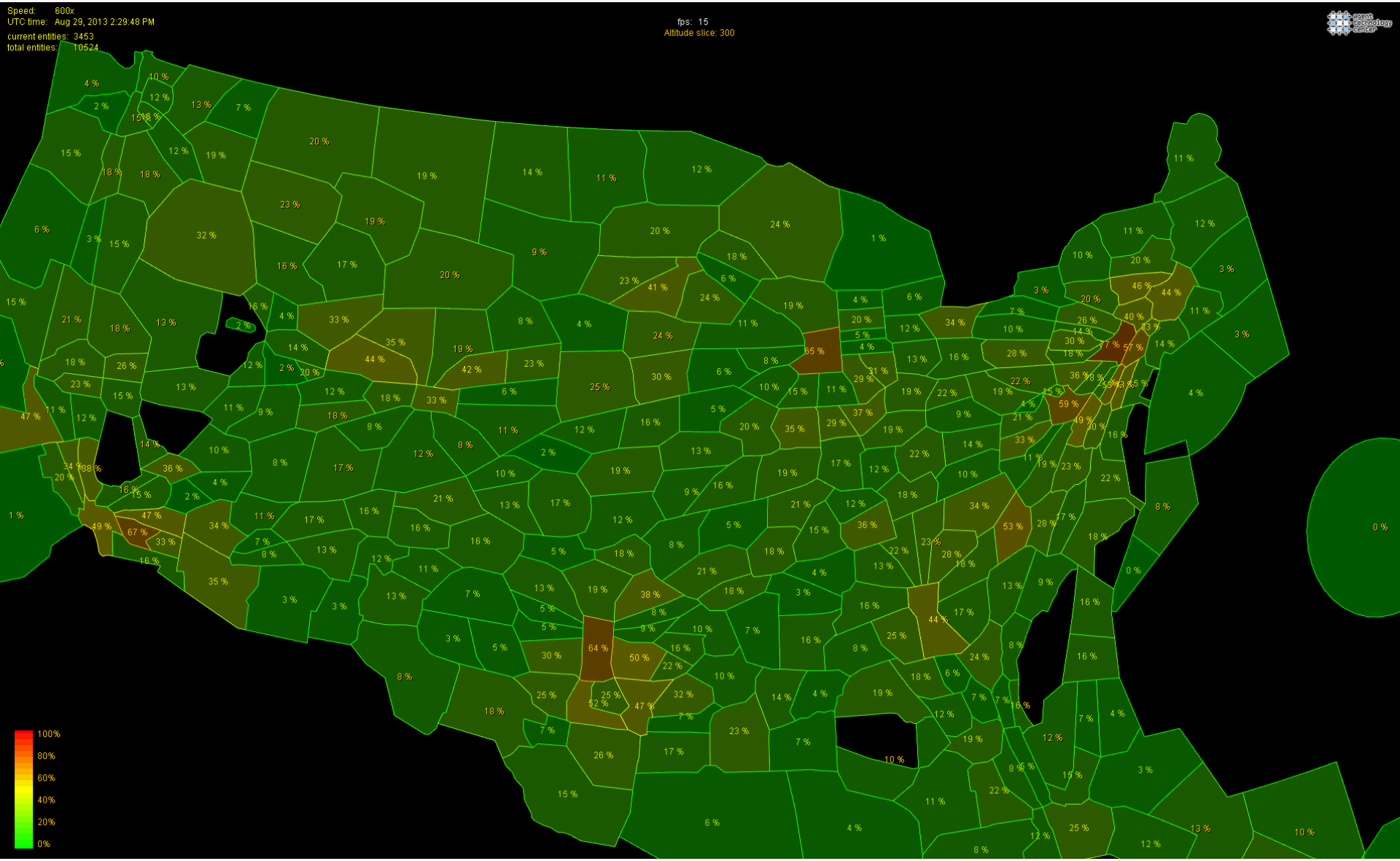


Use Cases

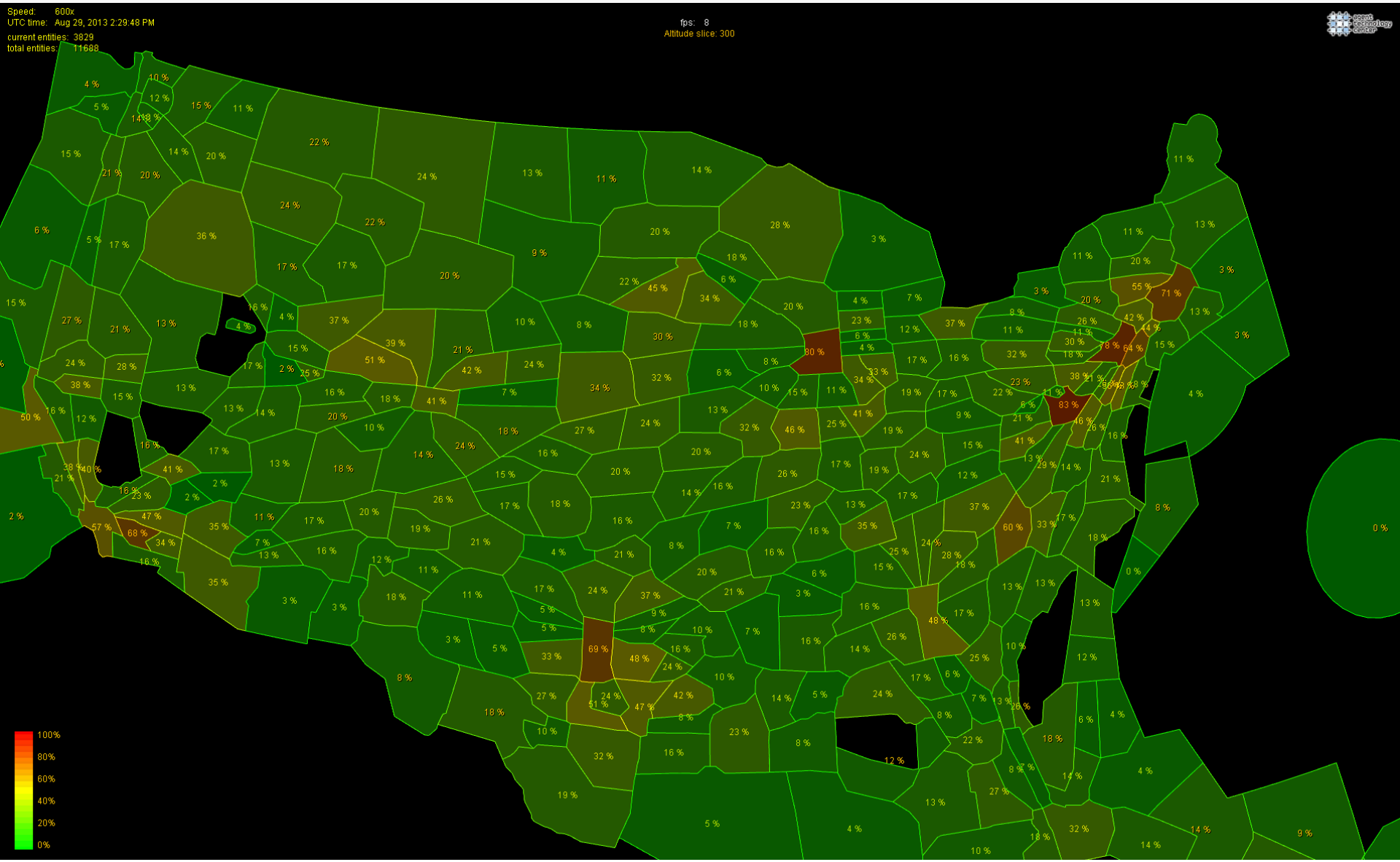
- Large-case studies focused on behavior changes according to input data
  - » What-if analysis when changing e.g. flights amount, wind, ATC behavior, adding/changing ATC duties, etc.
- Increasing safety and efficiency when developing new tools / features for current / future systems
  - » Possibility to test new tools using thousands of configurations and settings
- Providing better interaction for HITL experiments
  - » Improving interaction between human controlled and surrounding environment
- Integration of UAS / RPAS into shared airspace
- Allows to study future concepts



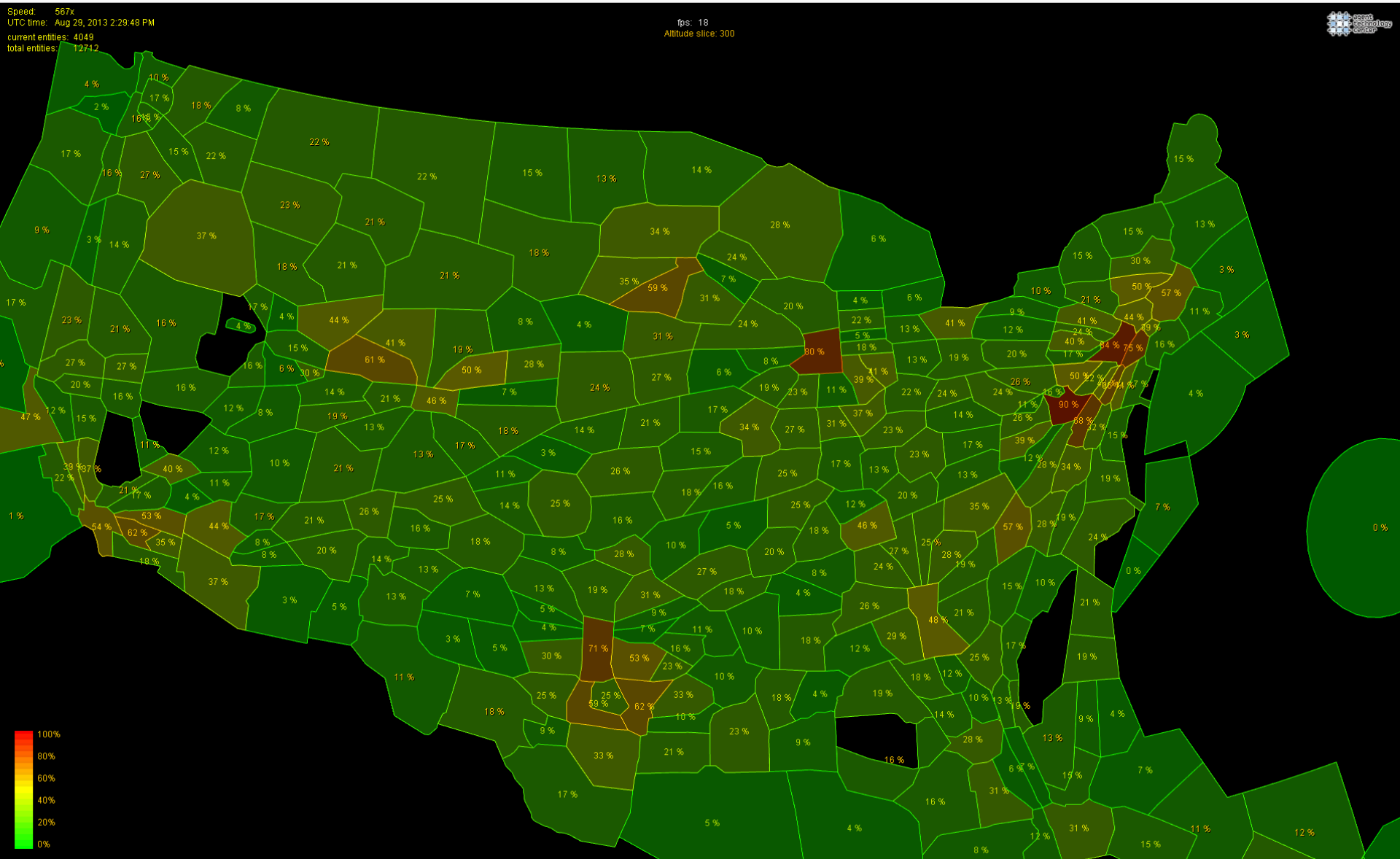
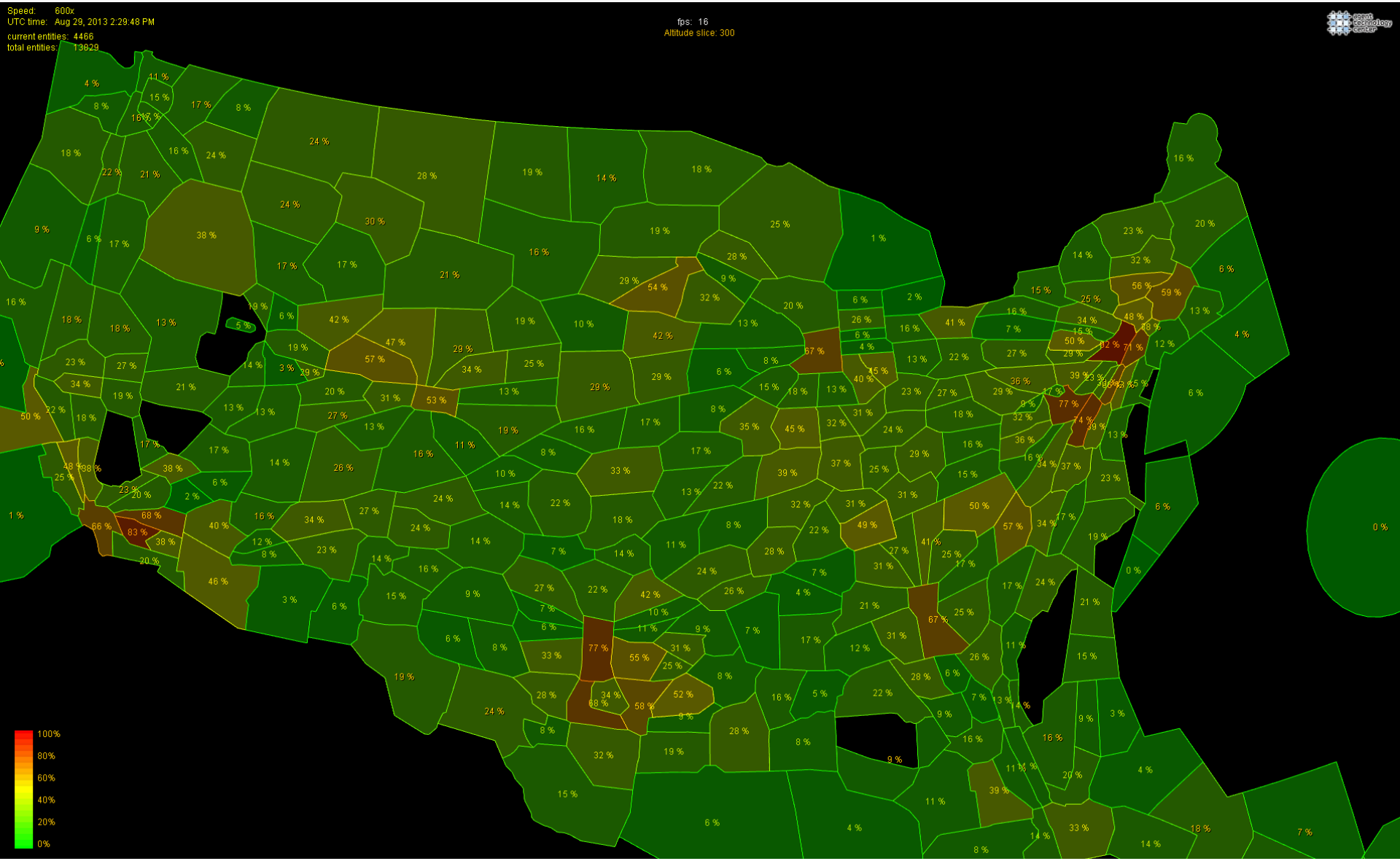
Real Air Traffic



Air Traffic Increased by 10%



Air Traffic Increased by 20%



Air Traffic Increased by 30%