Design of a Decision Support Architecture for Human Operators in UAV Fleet C2 Applications

Oktay Arslan and Professor Gokhan Inalhan

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Istanbul Technical University

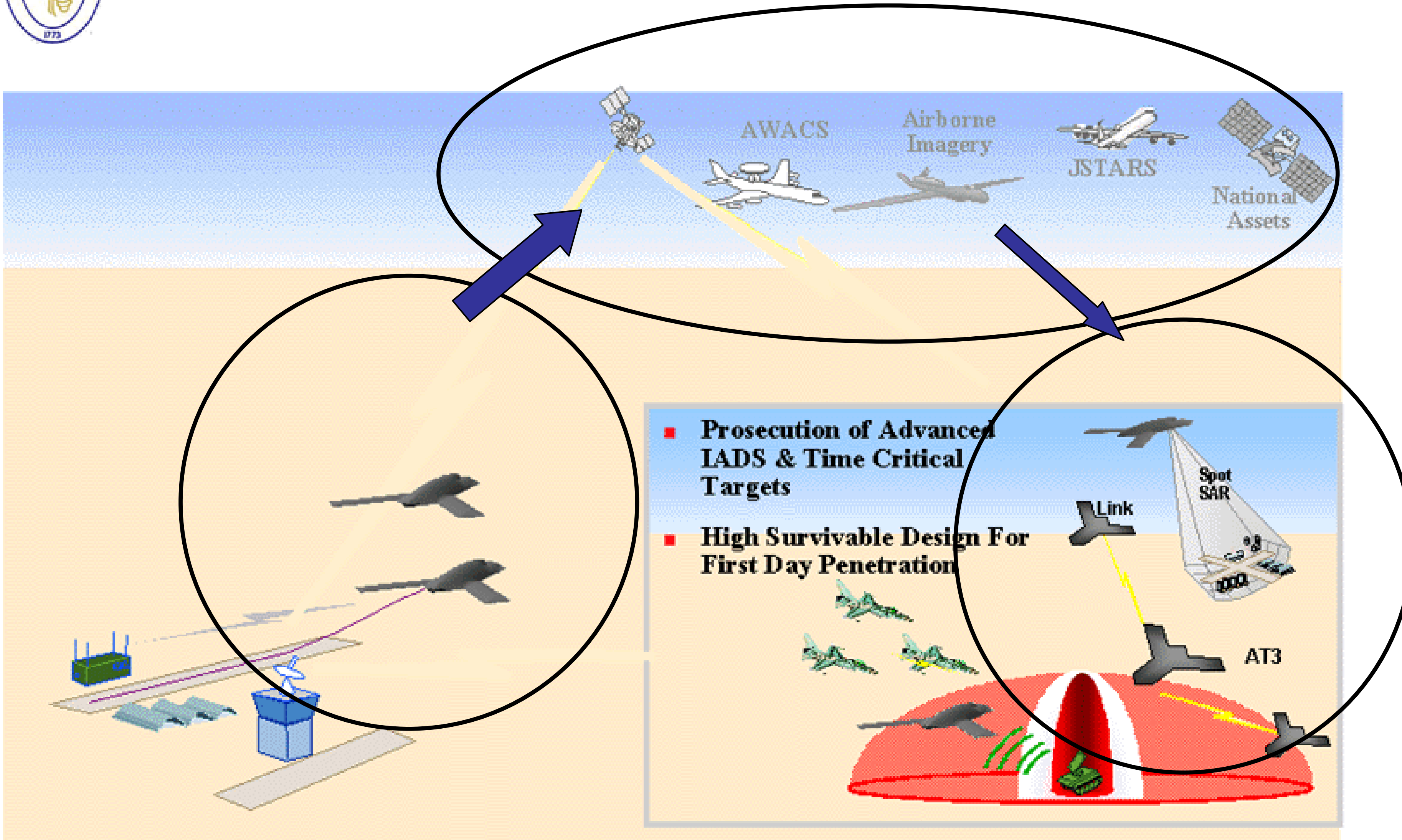
Controls and Avionics Laboratory

http://cal.uubf.itu.edu.tr

Outline of Presentation

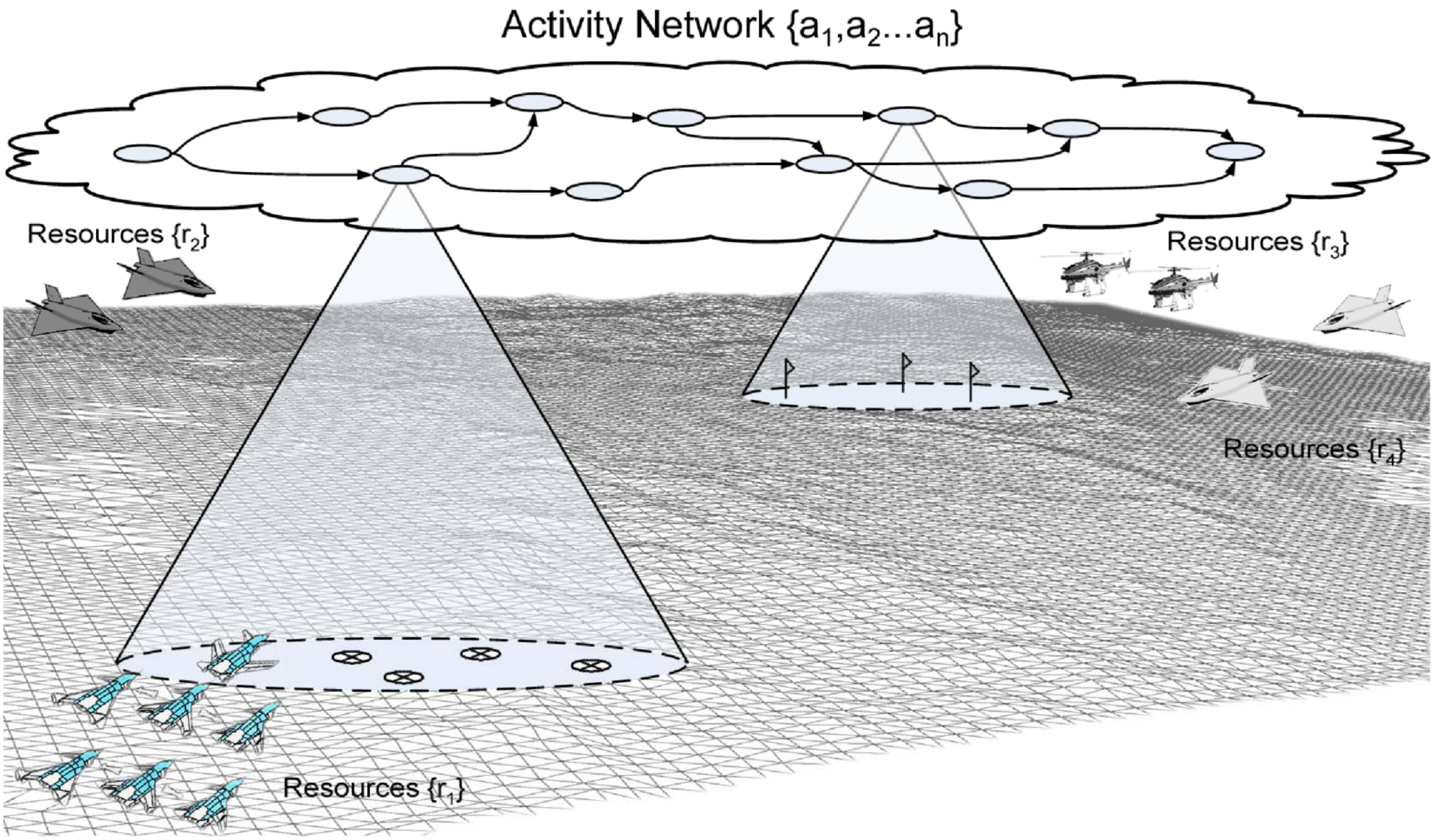
1) Introduction
2) Design of a Decision Support Architecture
3) General Architecture of the Mission Simulator
4) Integration of the Decision Support System to the Mission Simulator
5) Conclusion

Motivating CONOPS : DARPA-NAVY Example



Transition from a strictly centralized mission command and control into a distributed/ decentralized mission command and control for robustness and sustained QoM

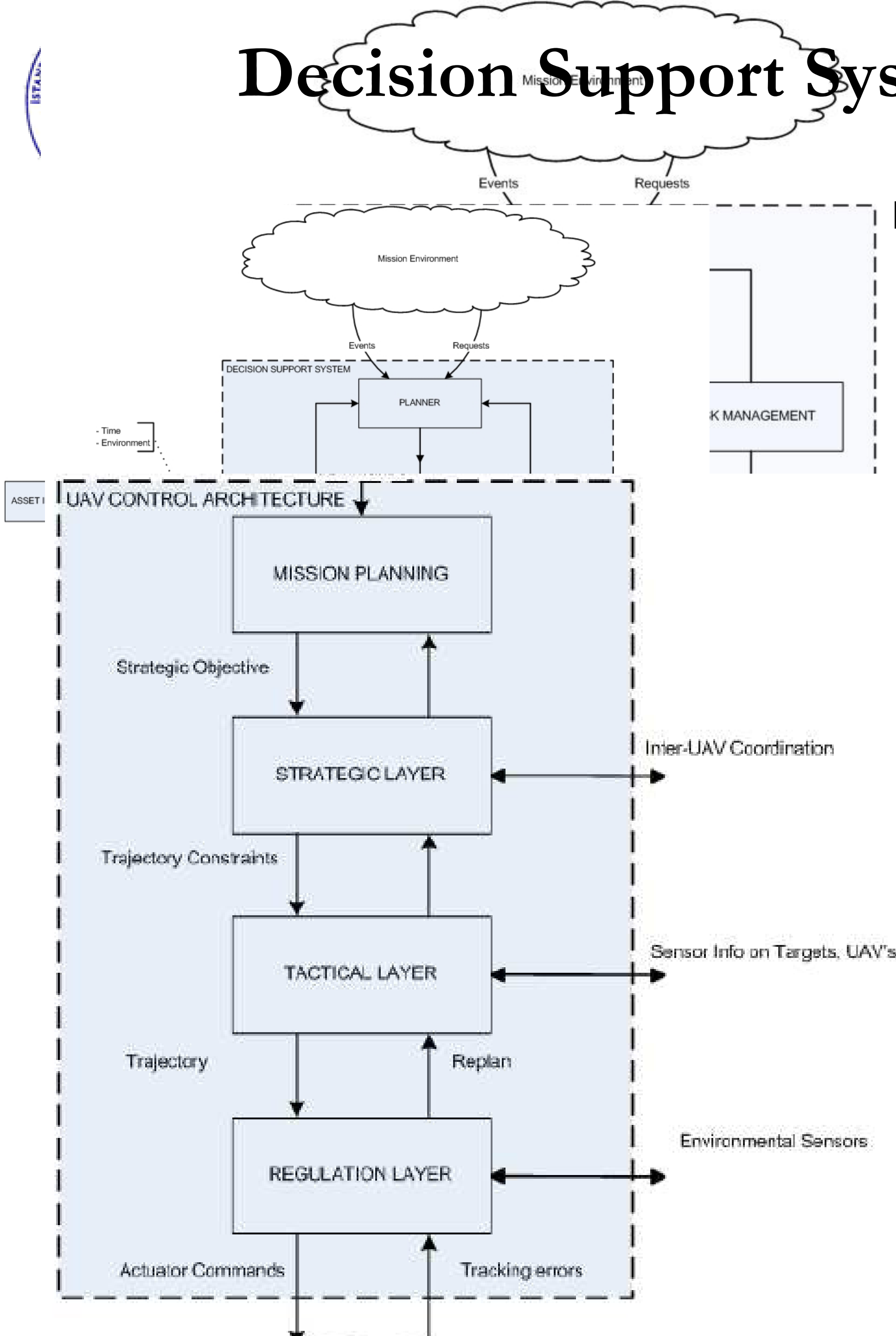
The Basic Problem That We Studied



Mission Environment

Decision Support Systems for C2 Operations

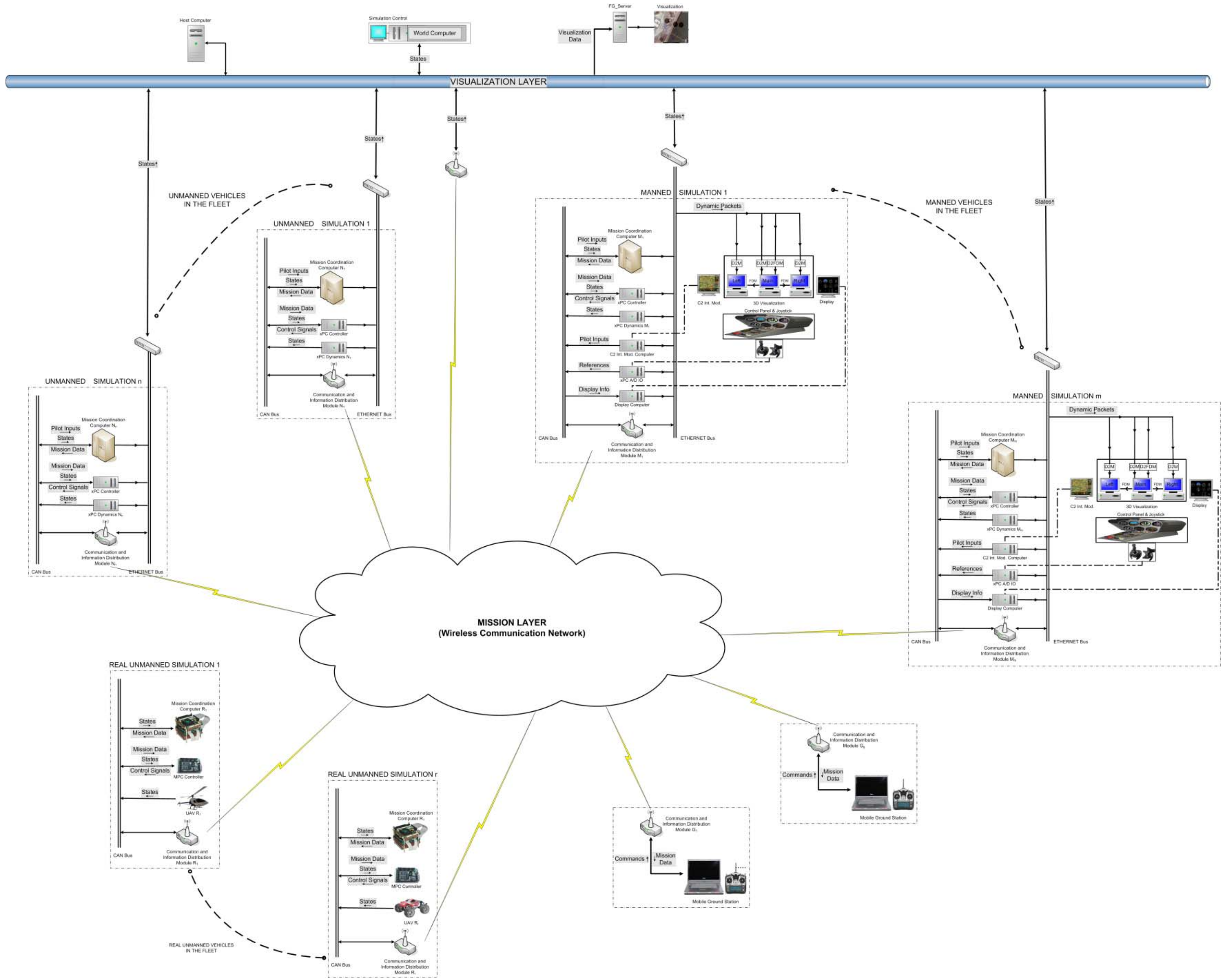
By Sastry and Godbole



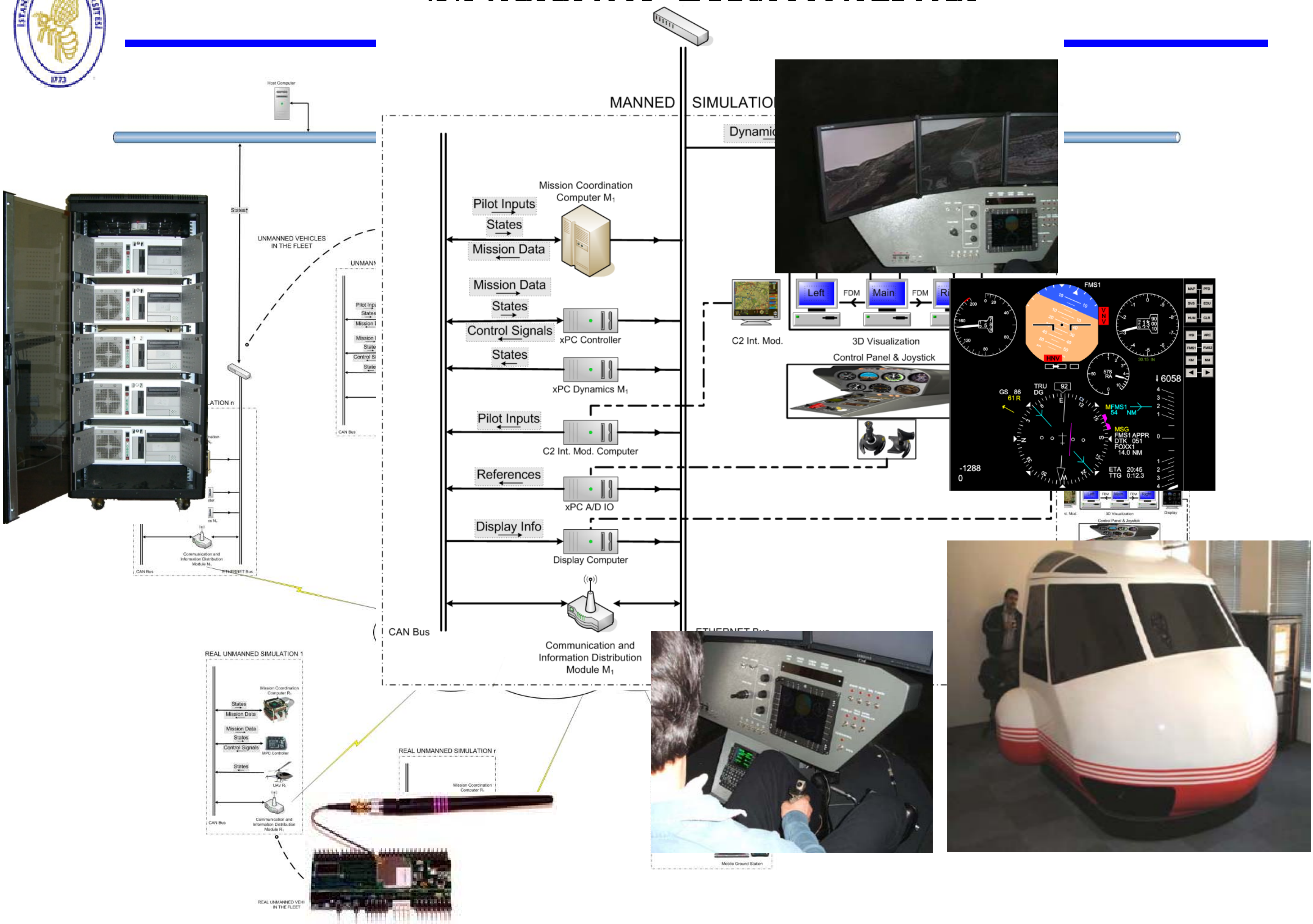
Design of a Decision Support Architecture

- Planner
  - Events/Requests
  - Action Sets
- Integration of Planner and Scheduler
  - Resource manager
  - Task manager
- Scheduler
  - Operation Constraints

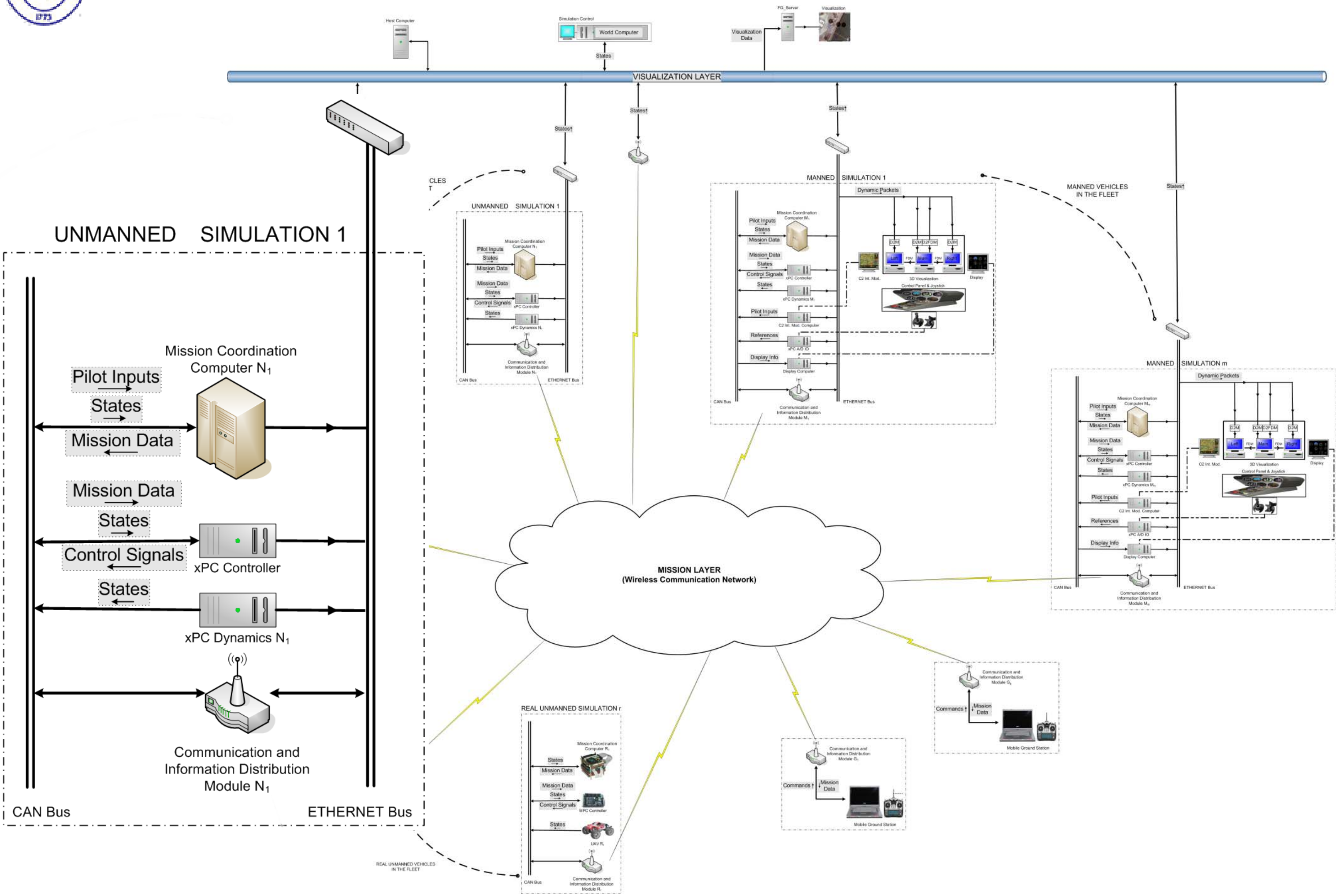
General Architecture of Mission Simulator



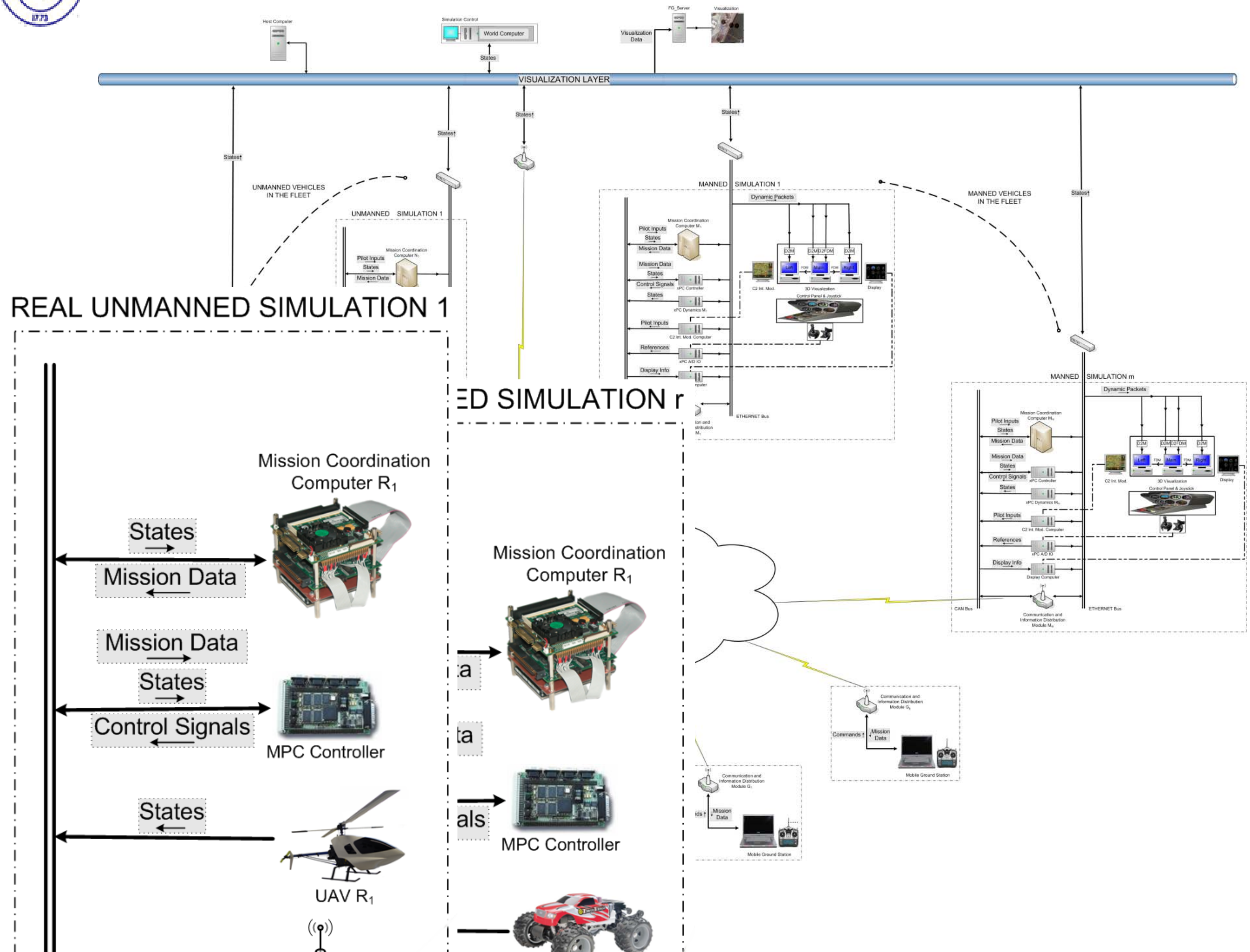
Manned Simulation



Unmanned Simulation

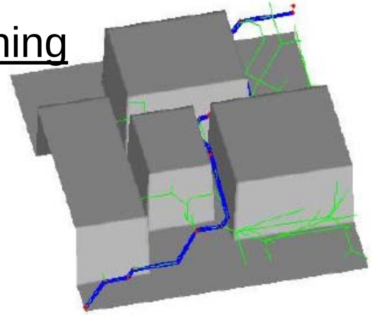


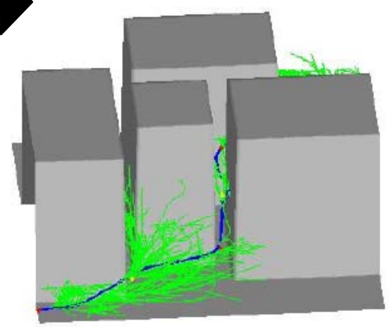
Aerial and Ground Vehicles



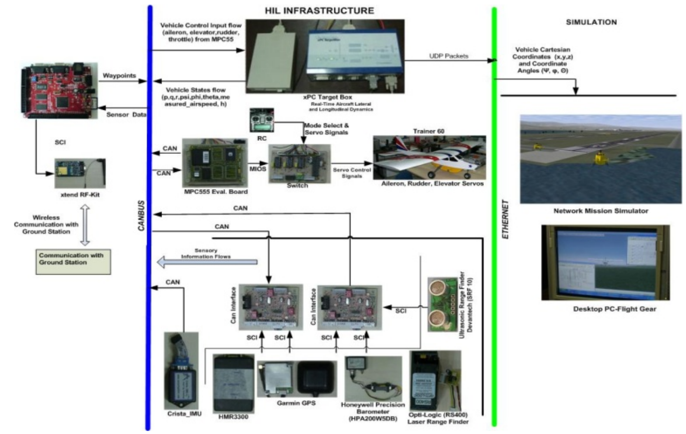
CAL Research Projects

3D Real-time Motion Planning

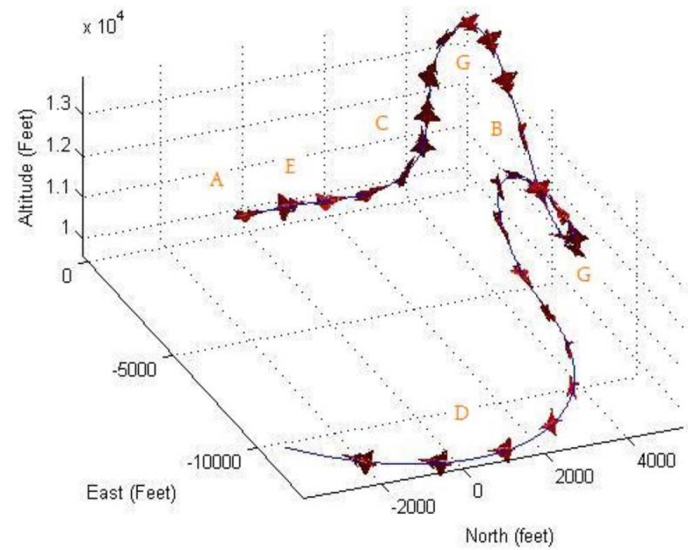




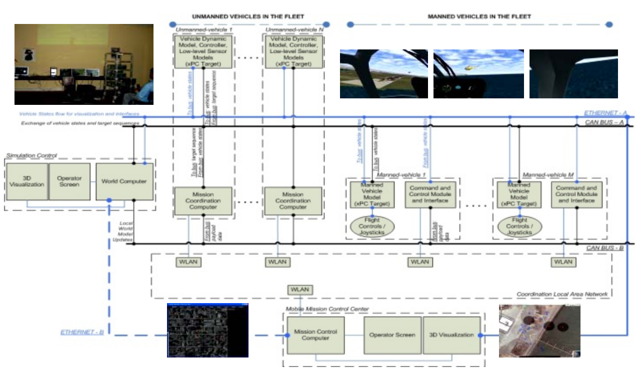
Bus backboned Microavionics

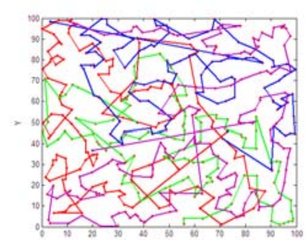


Agile Nonlinear Flight Controls



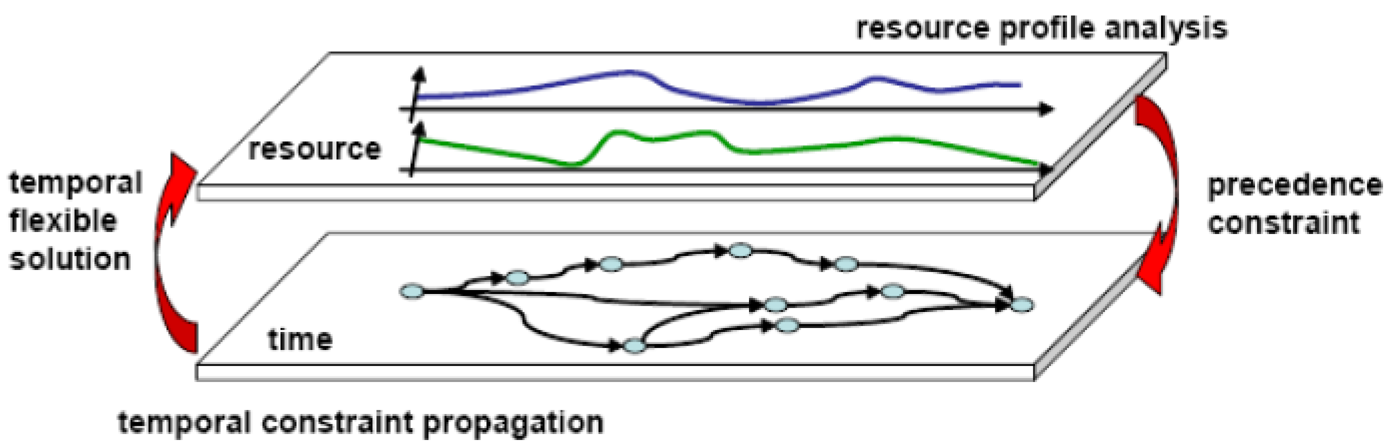
Mission Planning for Manned and Unmanned Fleets



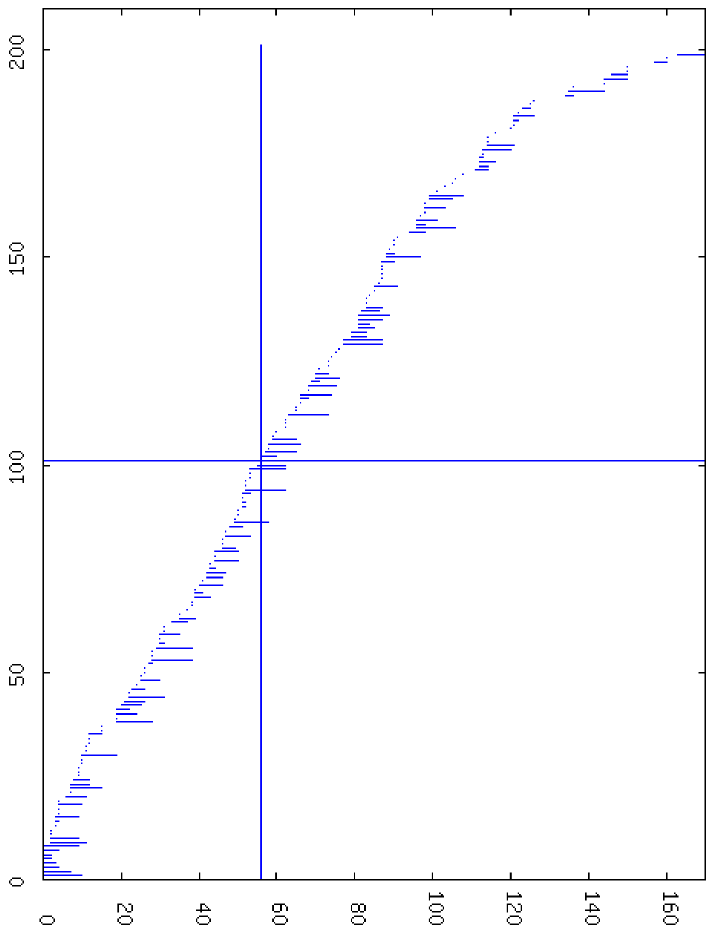


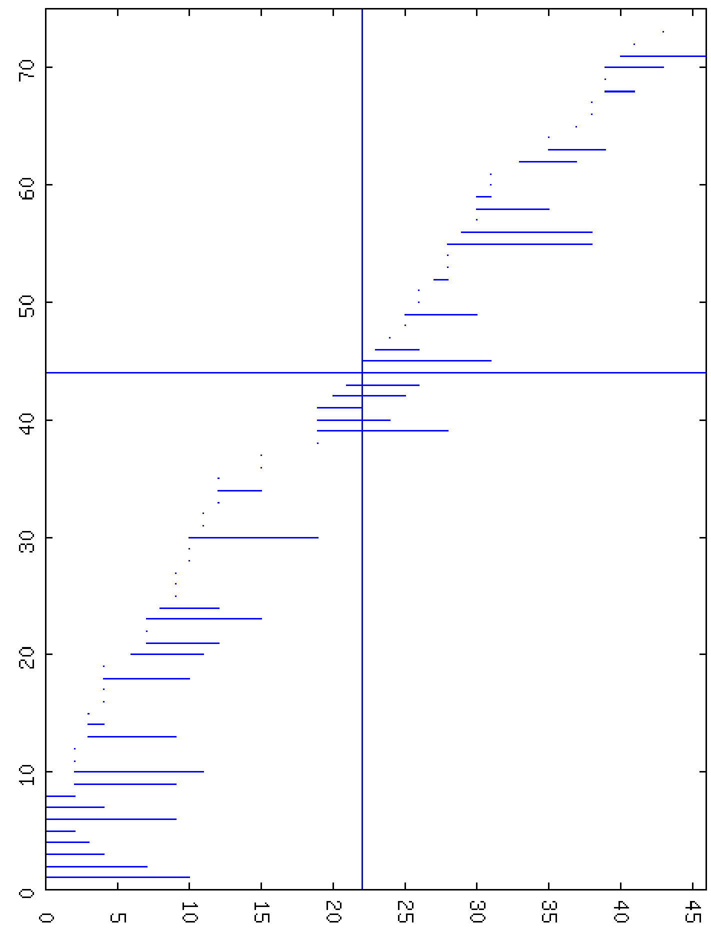
- Development of algorithms
  - Planner
  - Scheduler
    - Resource-Constrained Project Scheduling Problem with Minimum and Maximum time lags (RCPSP/max)
      - This problem is computationally NP-hard.
    - Solve & Robustify approach (by N. Policella & S. F. Smith)
      - Runs well with small-sized problems (order of tens)

- Solving step of the scheduler
  - Earliest Start Time Algorithm (by N. Policella & S. F. Smith)
    - Precedence Constraint Posting Scheme
      - Selecting a contention peak
      - Posting a precedence constraint to solve the conflict



- The temporal space partitioning approach





- Benchmark sets from RCPSP/max problem repository are used.

  (C. Schwindt. Project generator progen/max and psp/max-library. http://www.wior.unikarlsruhe.de/LSNeumann/Forschung/ProGenMax/rcpspmax.html)

- These sets are UBO50, UBO100 and UBO200 of 90 instances of problem of different size 50×5, 100×5 and 200×5 (number of activities × number resources)

- Evaluation Criteria
  - $N_{feas}\%$ the percentage of problems feasibly solved for each benchmark set
  - t_{mks} average makespan of the solutions
  - t_{cpu} average CPU-time in seconds spent to solve instances of the problem set
  - N_{pc} the number of leveling precedence constraints posted to solve a problem
  - $\Delta_{LB}\%$ the average of percentage relative deviation from known lower bound

TABLE I

PERFORMANCE OF THE ALGORITHMS (UBO50)

UBO50	t_{mks}	$\Delta_{LB}\%$	t_{cpu}	$N_{feas}\%$	N_{pc}
$ESTA_{P11}$	217.671	28.757	0.360	77.778	54.471
$ESTA_{P15}$	217.099	28.247	0.383	78.889	55.141
$ESTA_{P16}$	217.306	27.531	0.400	80.000	56.694
$ESTA_{P17}$	**218.973**	**27.459**	**0.373**	**81.111**	**56.904**
$ESTA_{P20}$	218.466	27.462	0.452	81.111	60.480
$ESTA_{P21}$	218.699	27.595	0.462	81.111	59.384
ESTA	**213.603**	**24.455**	**4.004**	**81.111**	**74.890**

TABLE II

PERFORMANCE OF THE ALGORITHMS (UBO100)

UBO100	t_{mks}	$\Delta_{LB}\%$	t_{cpu}	$N_{feas}\%$	N_{pc}
$ESTA_{P12}$	**423.167**	**30.970**	**3.075**	**86.667**	**120.077**
$ESTA_{P15}$	419.705	29.833	3.121	86.667	123.538
$ESTA_{P20}$	418.436	29.697	3.166	86.667	128.910
$ESTA_{P25}$	419.141	30.100	3.345	86.667	132.974
ESTA	**407.286**	**25.645**	**79.214**	**86.667**	**195.753**

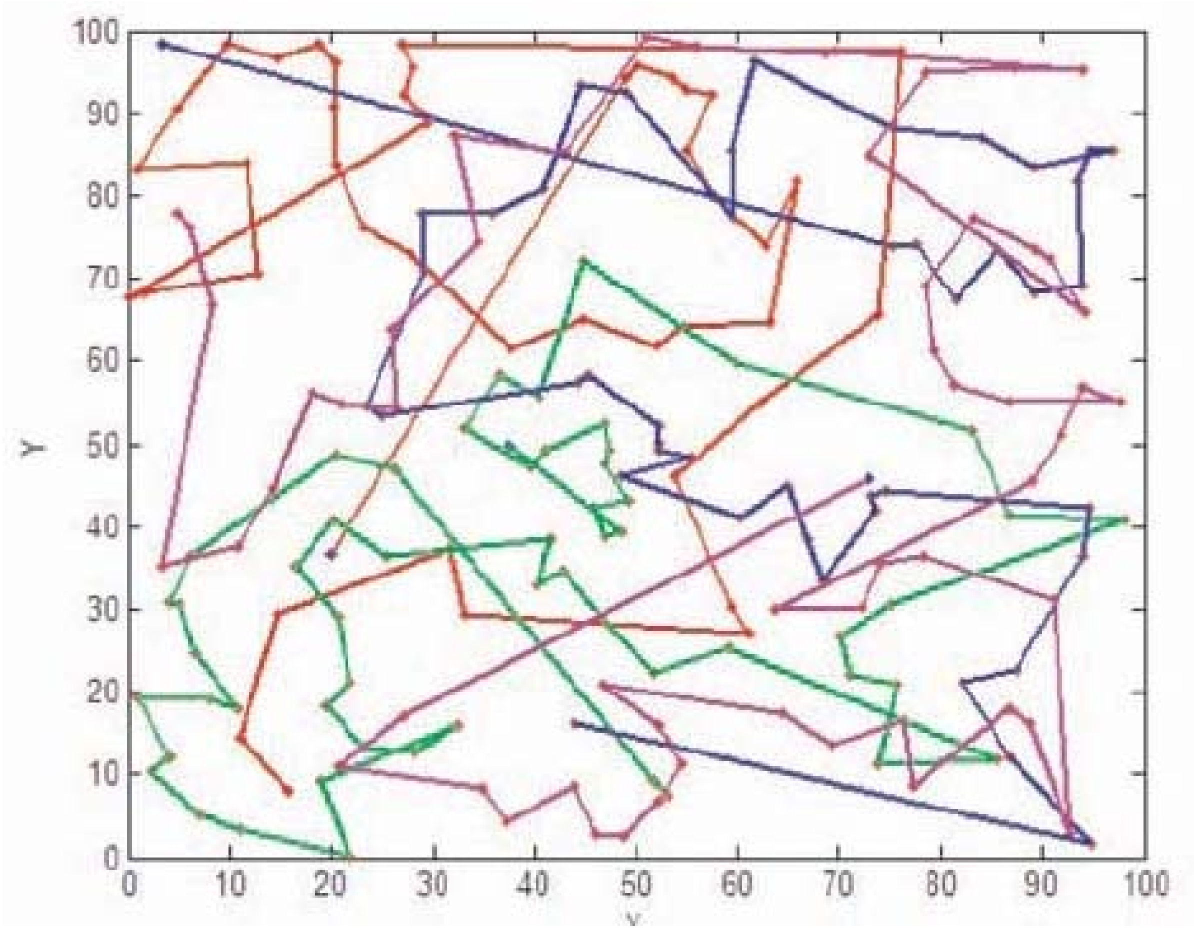
TABLE III

PERFORMANCE OF THE ALGORITHMS (UBO200)

UBO200	t_{mks}	$\Delta_{LB}\%$	t_{cpu}	$N_{feas}\%$	N_{pc}
$ESTA_{P18}$	770.974	29.970	26.761	85.556	254.961
$ESTA_{P20}$	765.481	28.987	33.866	85.556	261.091
$ESTA_{P25}$	**763.474**	**28.603**	**31.782**	**86.667**	**275.897**
$ESTA_{P30}$	759.766	27.987	33.159	85.556	281.169
ESTA	**751.962**	**26.946**	**1462.83**	**86.667**	**461.436**

C2 Implementation

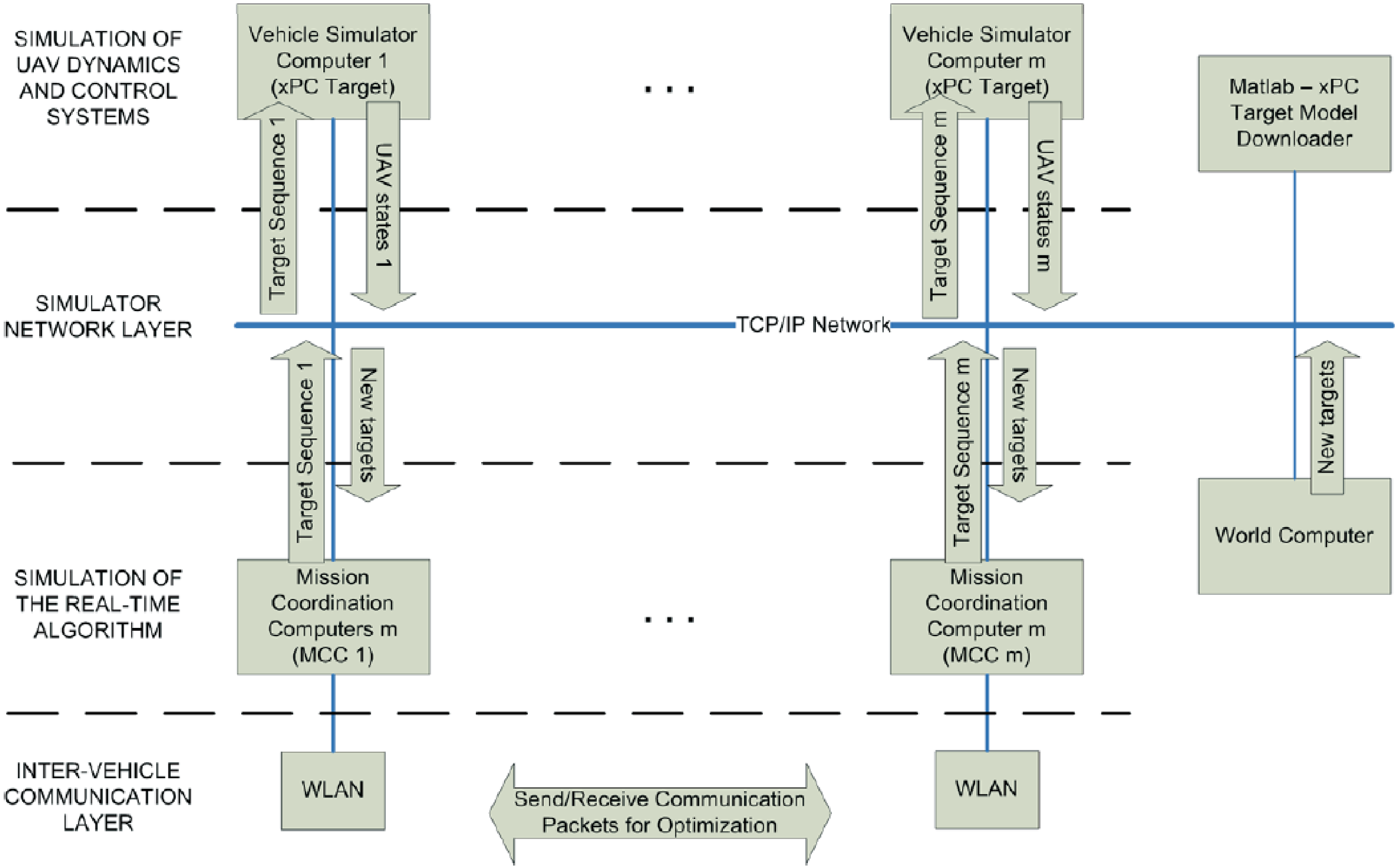
Hardware-in-the-loop Testing of a Large-scale Autonomous Target-Task Assignment Problem for a UAV Network



Five Hundred Targets in Dynamically Evolving Scenario

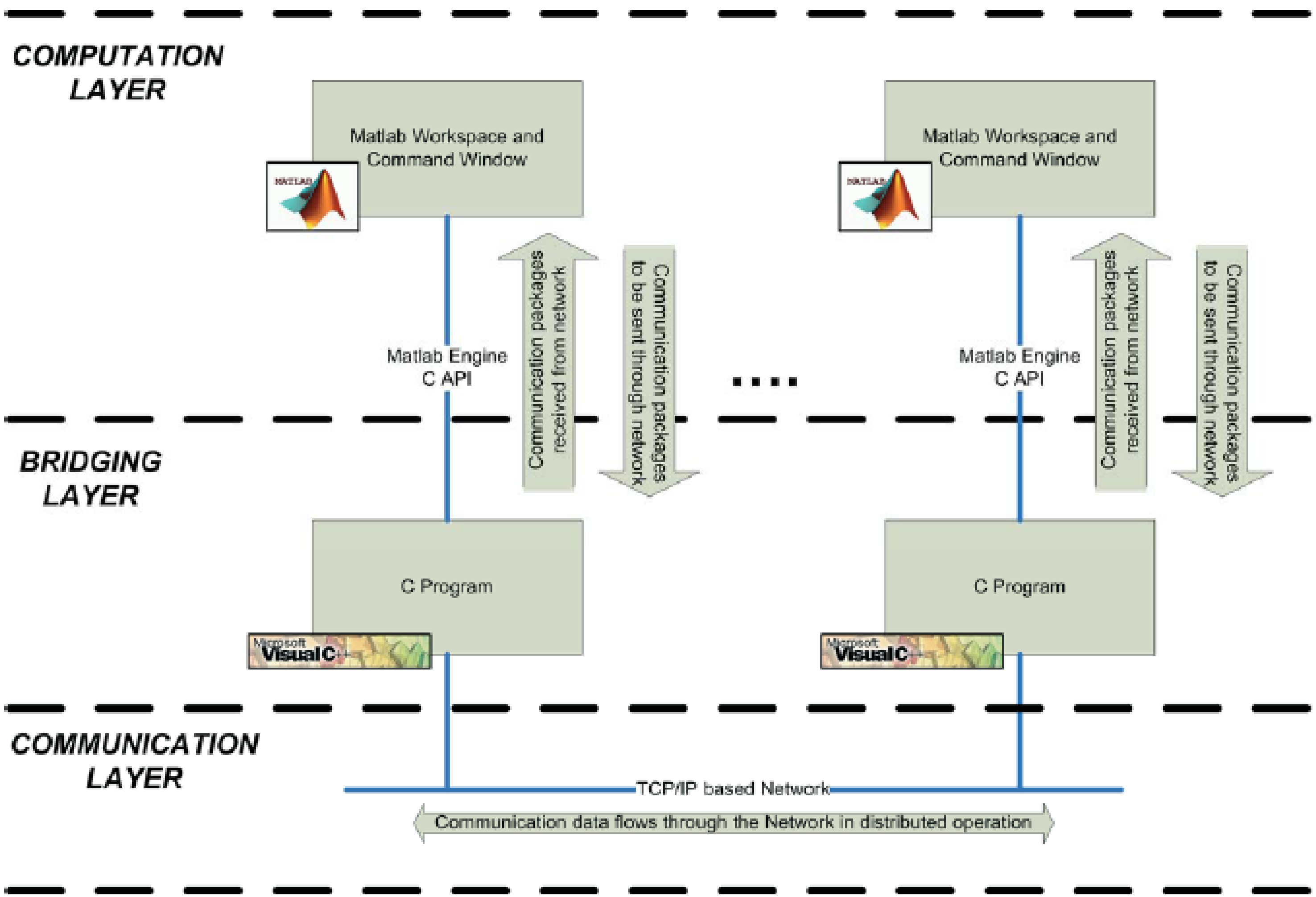
C2 Implementation

UAV Fleet Assignment Implementations



C2 Implementation

Experimental Platform –Software Structure



C2 Implementation

Expansion of the Human-Machine-Interface (HMI) to decision-support system for manned and unmanned fleets

Conclusion and Future Works

- The problem of the planning and scheduling of tasks in UAV fleet C2 applications
- Decision support architecture for human operators who are responsible for high-level decision
- C2 applications

- Development of planner part
- Testing of different type of scheduling algorithms

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  8th International Conference on Cooperative Control and Optimization, January 30 – February 1, 2008

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  A. Cetinkaya[4], S. Karaman[3], O. Arslan[2] , M. Aksugur[2], G. Inalhan[1]
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[1] Faculty of Aeronautics and Astronautics, Istanbul Technical University, Istanbul, Turkey

[2] Controls and Avionics Lab., Istanbul Technical University, Istanbul, Turkey

[3] Laboratory for Information and Decision Systems, Massachusetts Institute of Technology, Cambridge, MA

[4] Dynamical Systems Laboratory, Tokyo Institute of Technology, Tokyo, Japan

Any Questions?

Thank you