

Decision Support for Workload Mitigation in Supervisory Control of Multiple UAVs

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CERI Human Factors of UAVs
Workshop

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Outline

- Supervising Multiple UAVs
- Experiment Motivation
- MAUVE Interface
- StarVis Decision Support Design
- Experiment Design
- Experiment Results
- Future Work



Supervising Multiple UAVs

**Team of people flying
one UAV**



**One person supervising
mission of multiple UAVS**





Experiment Motivation

- Multiple UAVs → More Tasks → Higher Workload
- How do we manage the schedule?
Prioritize activities?

**Need workload mitigation
decision support!**



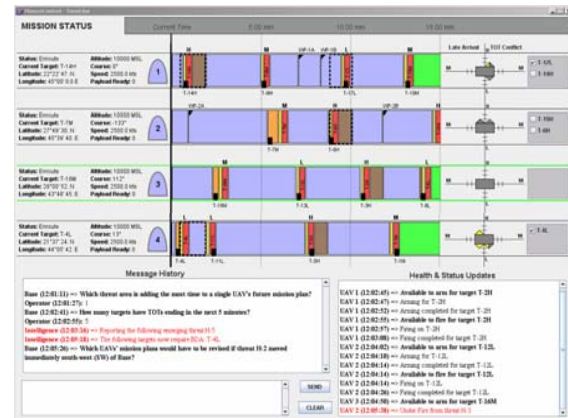
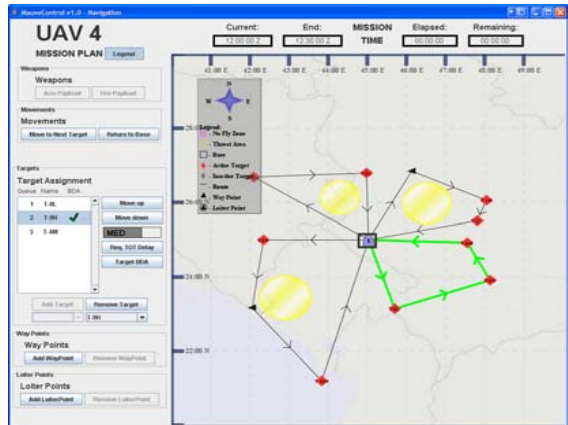
Experiment Focus

- Does a workload mitigation decision support visualization increase a multi-UAV operator's performance by helping them manage their schedule?
- Using a simulated environment, test human subjects conducting a multi-UAV mission under two conditions
 - With schedule management decision support
 - Without schedule management decision support



MAUVE Interface

- Multi-Aerial Unmanned Vehicle Experiment
- One user, four homogenous & independent UAVs
- Mission: Destroy/Image multiple targets
- Supervisory control of schedule, path replanning, emergent events





Map Display

MauveControl v1.0 - Navigation

UAV 4

MISSION PLAN Legend

Weapons

Weapons

Arm Payload Fire Payload

Movements

Movements

Move to Next Target Return to Base

Targets

Target Assignment

Queue Name BDA

1	T-8L	
2	T-9H	✓
3	T-4M	

Move up Move down

MED

Req. TOT Delay

Target BDA

Add Target Remove Target

T-9H

Way Points

Way Points

Add WayPoint Remove WayPoint

Loiter Points

Loiter Points

Add LoiterPoint Remove LoiterPoint

Current: 12:00:00 Z End: 12:30:00 Z MISSION TIME Elapsed: 00:00:00 Remaining: 00:00:00

41:00 E 42:00 E 43:00 E 44:00 E 45:00 E 46:00 E 47:00 E 48:00 E 49:00 E

28:00 N

26:00 N

24:00 N

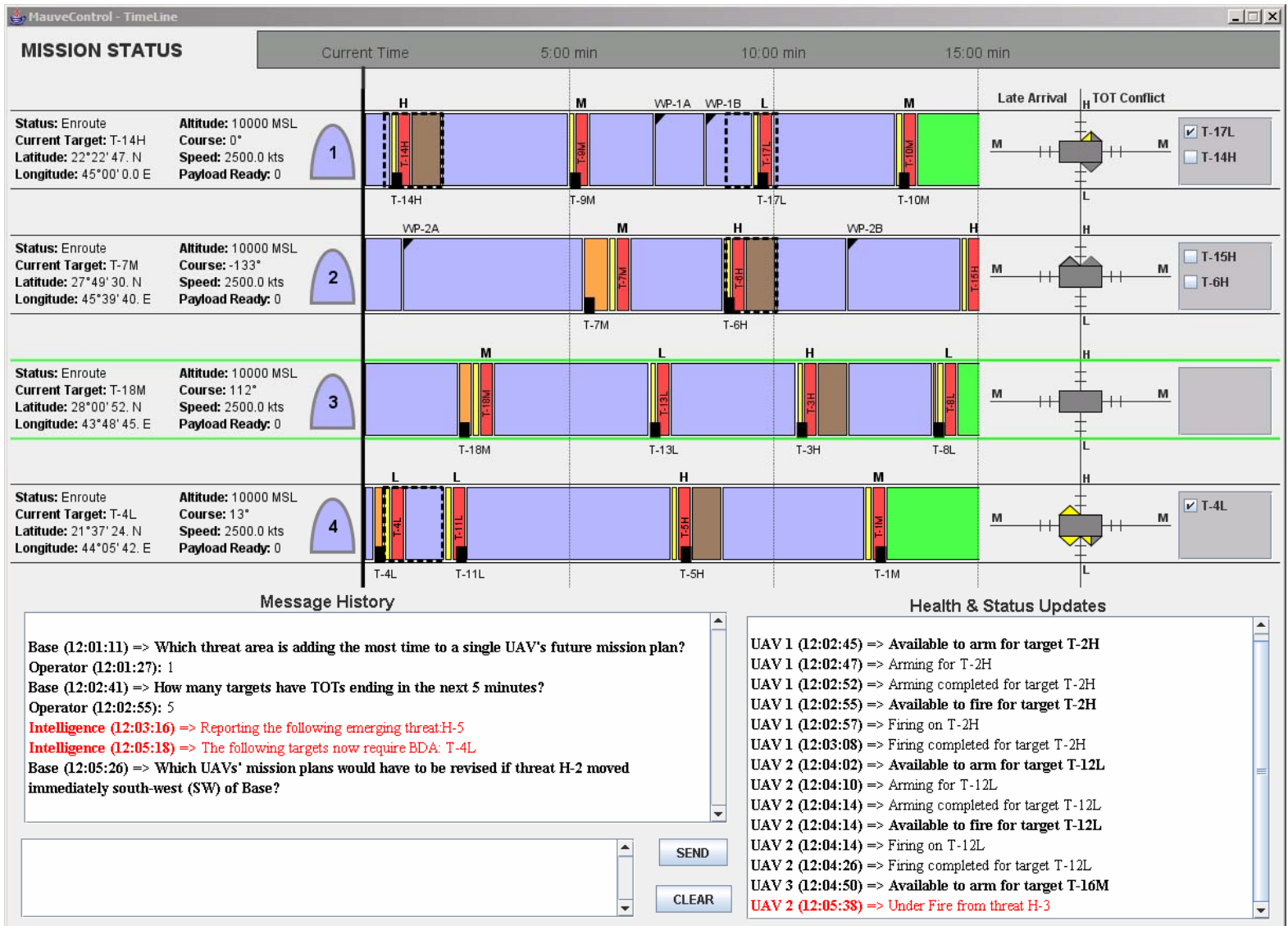
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Legend:

- No Fly Zone
- Threat Area
- Base
- Active Target
- Inactive Target
- Route
- Way Point
- Loiter Point



Timeline Display





Previous Work

- Different automation levels in multiple UAV control task
- Hypothesis - Active level as best performance
- Result – Active level was worst performance at high re-plan levels
- Reason – Subjects overly focused on schedule replanning

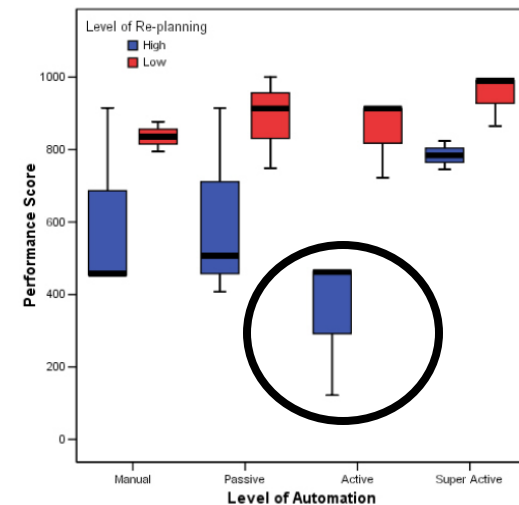
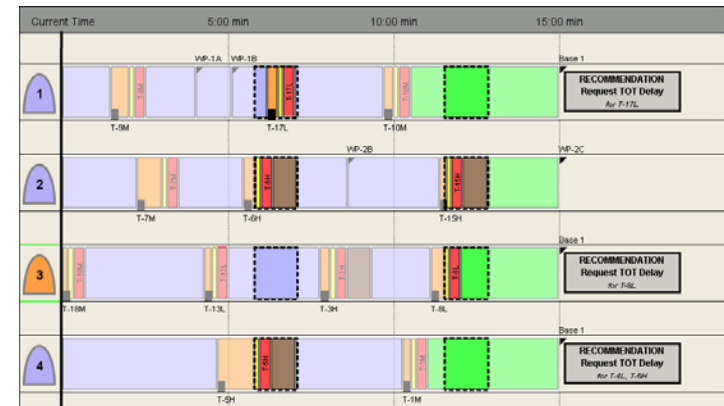


Figure 5-1: Performance Scores Across Levels of Automation and Re-planning



Experiment Overview

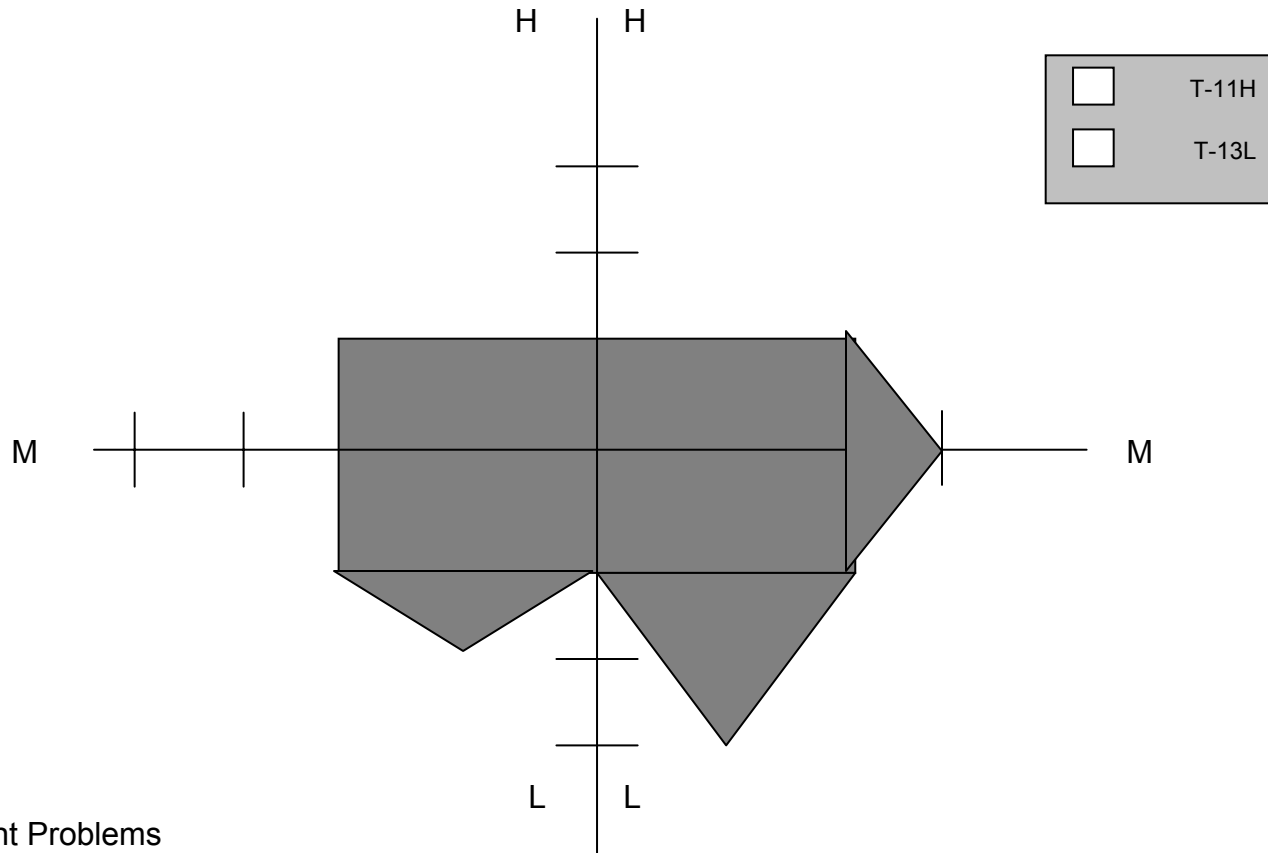
- Active Automation: Operator arms & fires UAV weapon at scheduled Time on Target (TOT)
- Miss targets in two ways
 - Arrive to target late
 - Have multiple actions to perform at once for multiple targets
- Solve by requesting TOT delay to manage schedule – make future worse?
- Provide Decision Support to optimize schedule – StarVis configural display



Star Configural Display

Late Arrival

TOT Conflicts



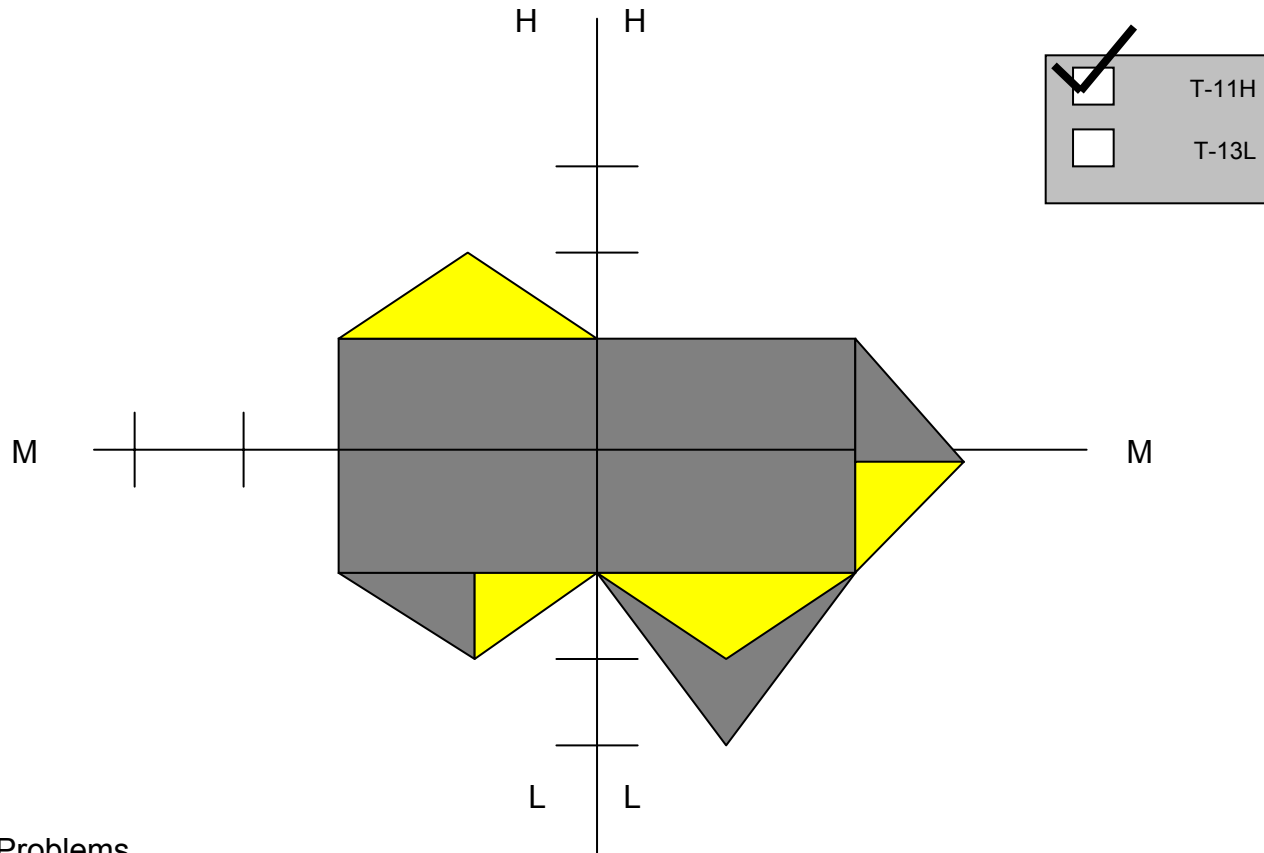
 Current Problems





Star Configural Display

Late Arrival

TOT Conflicts

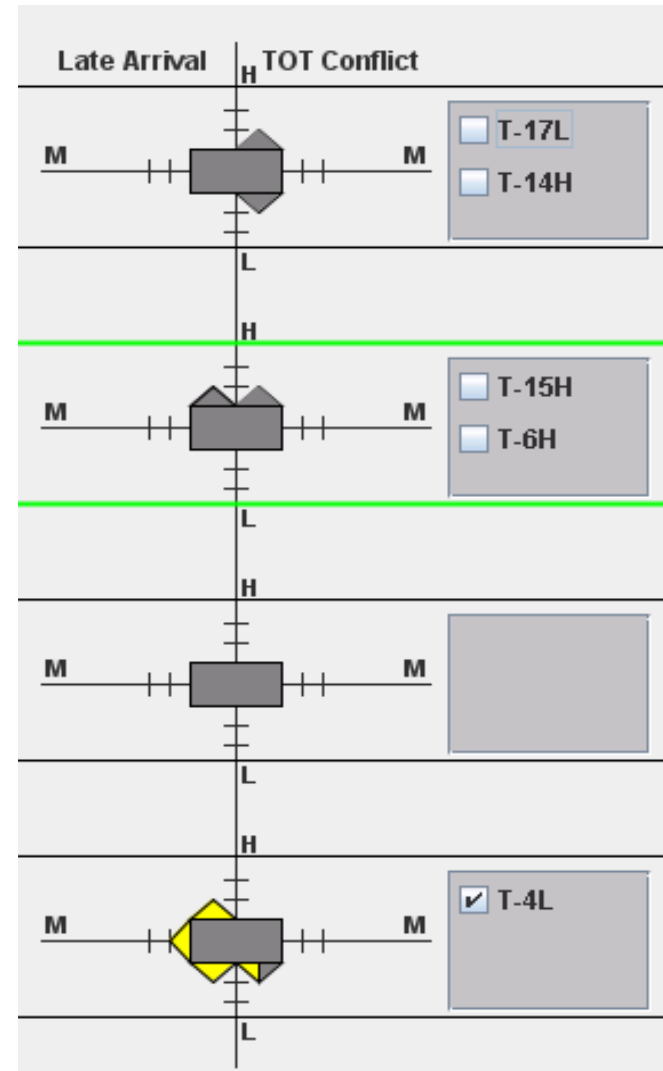
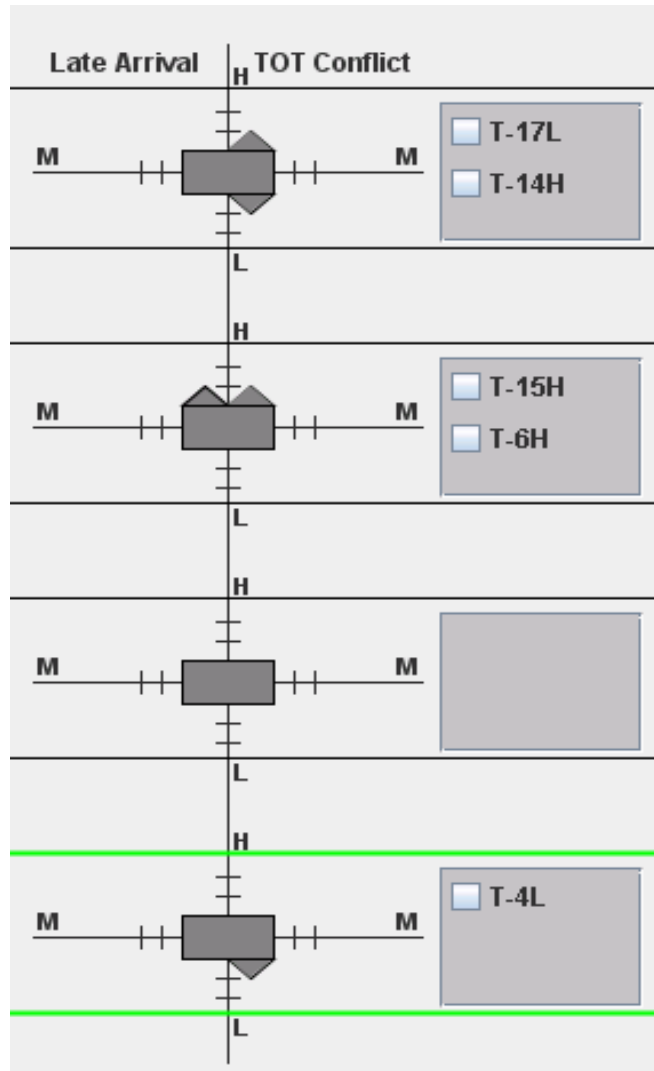


-  Current Problems
-  Action Generated Problems



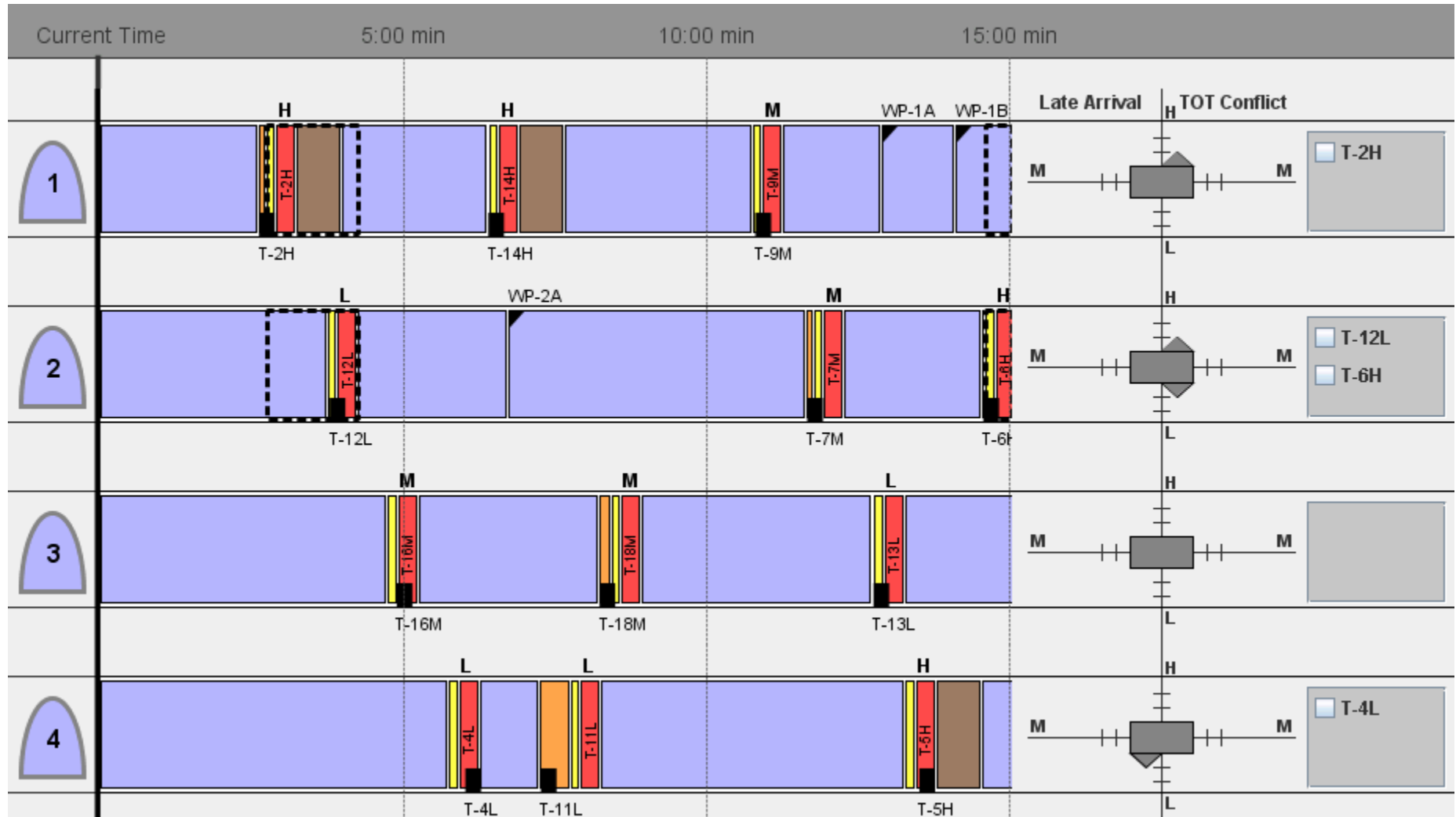


Local Design in MAUVE





Video Example



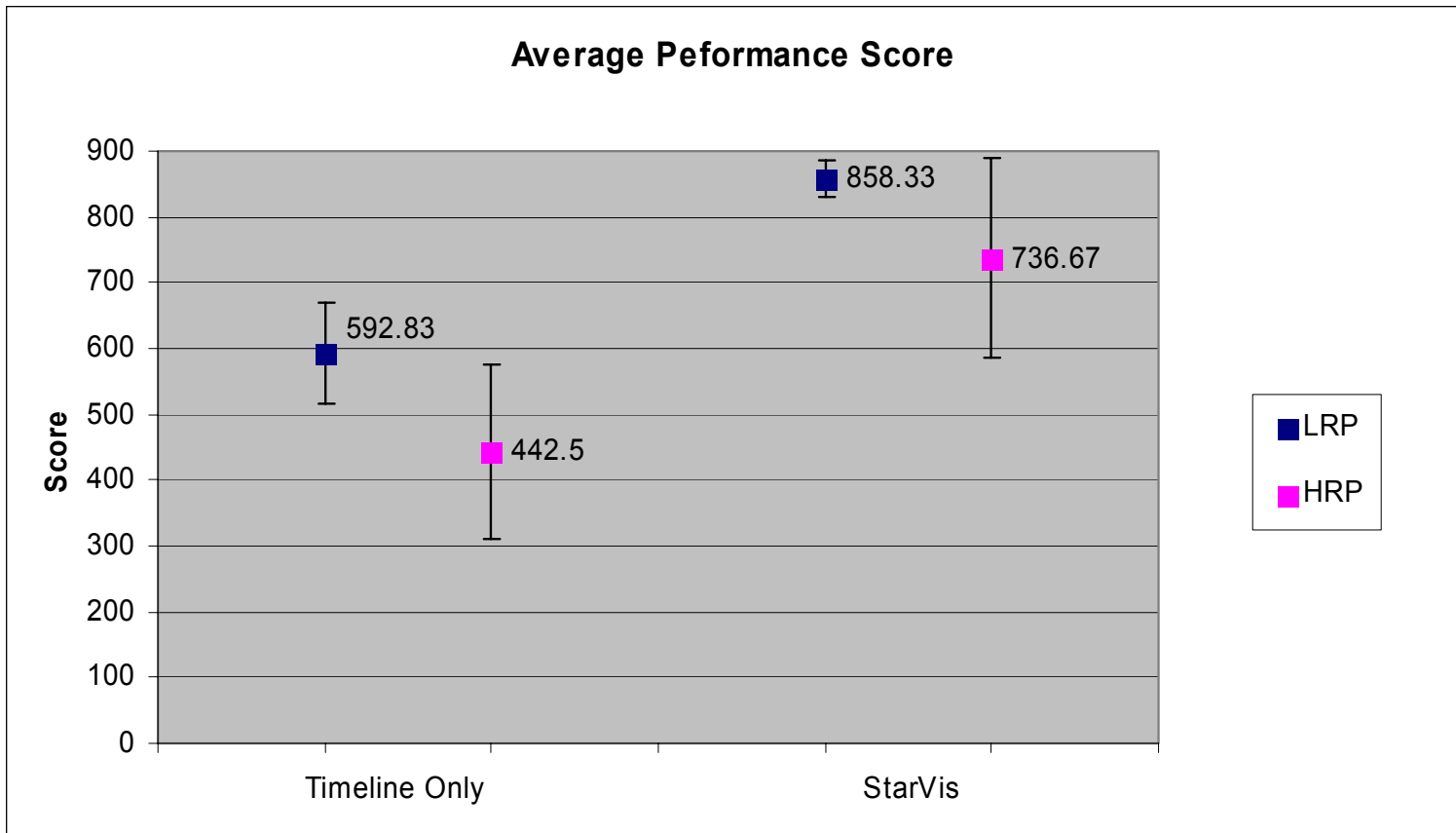


Experiment Design

- Independent Variables
 - Decision Support Visualization: no visualization, StarVis display (Between Subjects)
 - Level of Scenario Re-planning: high, low (Within Subjects)
- Dependent Variables
 - Performance Scores – Optimistic & Pessimistic
 - Number of TOT delay Requests
 - Incorrect Firing Events
 - Workload - Objective & Subjective

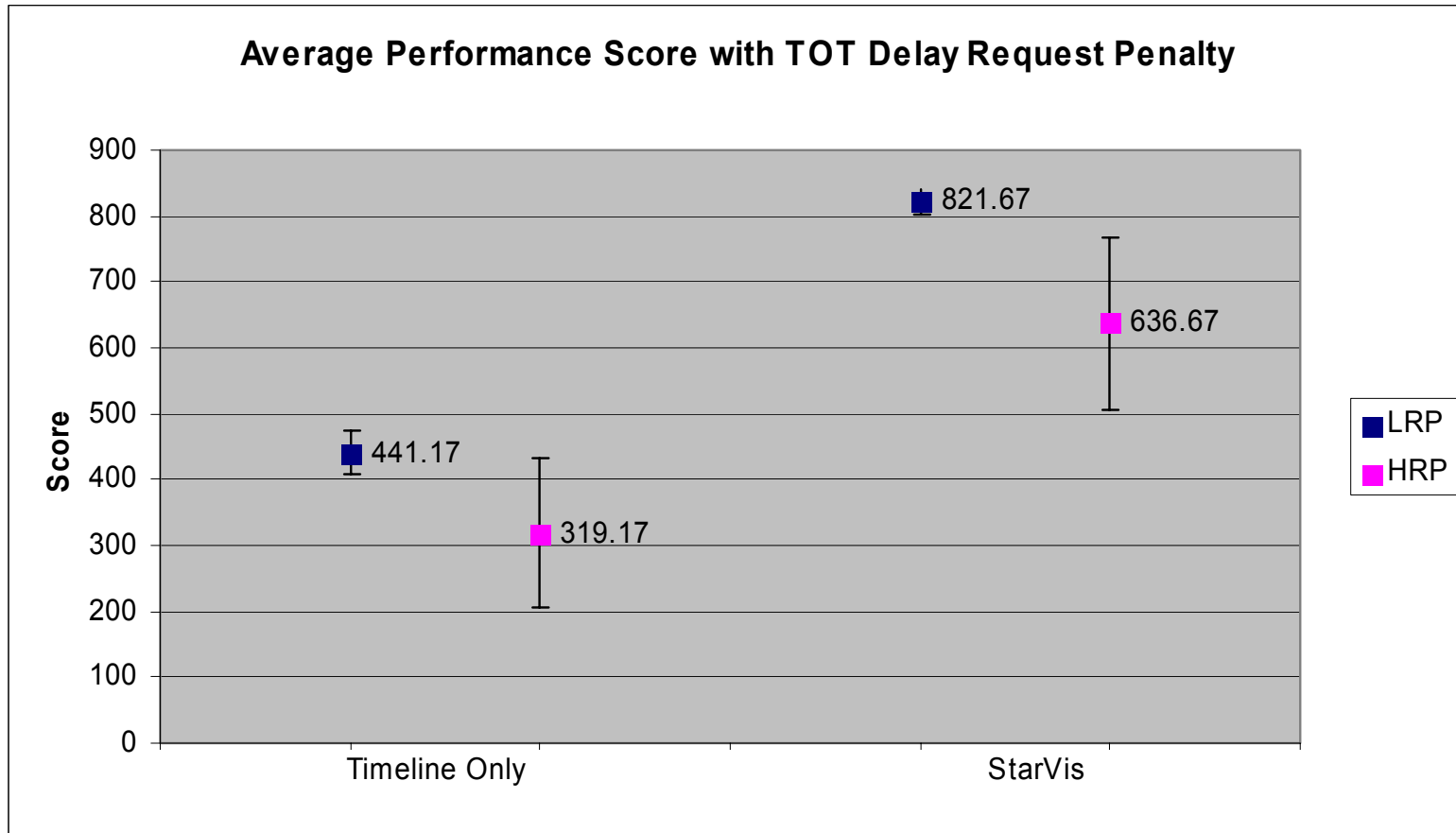


Performance - Optimistic



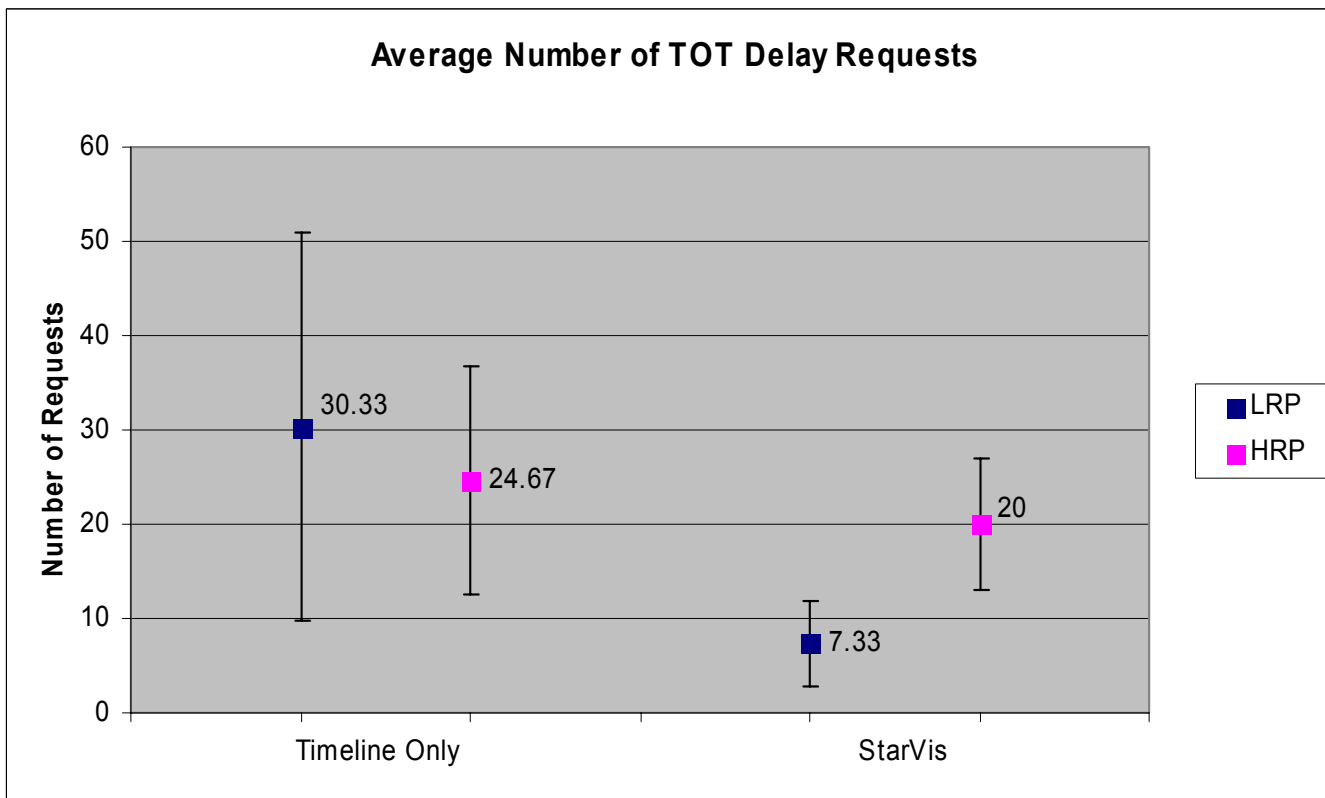


Performance - Pessimistic





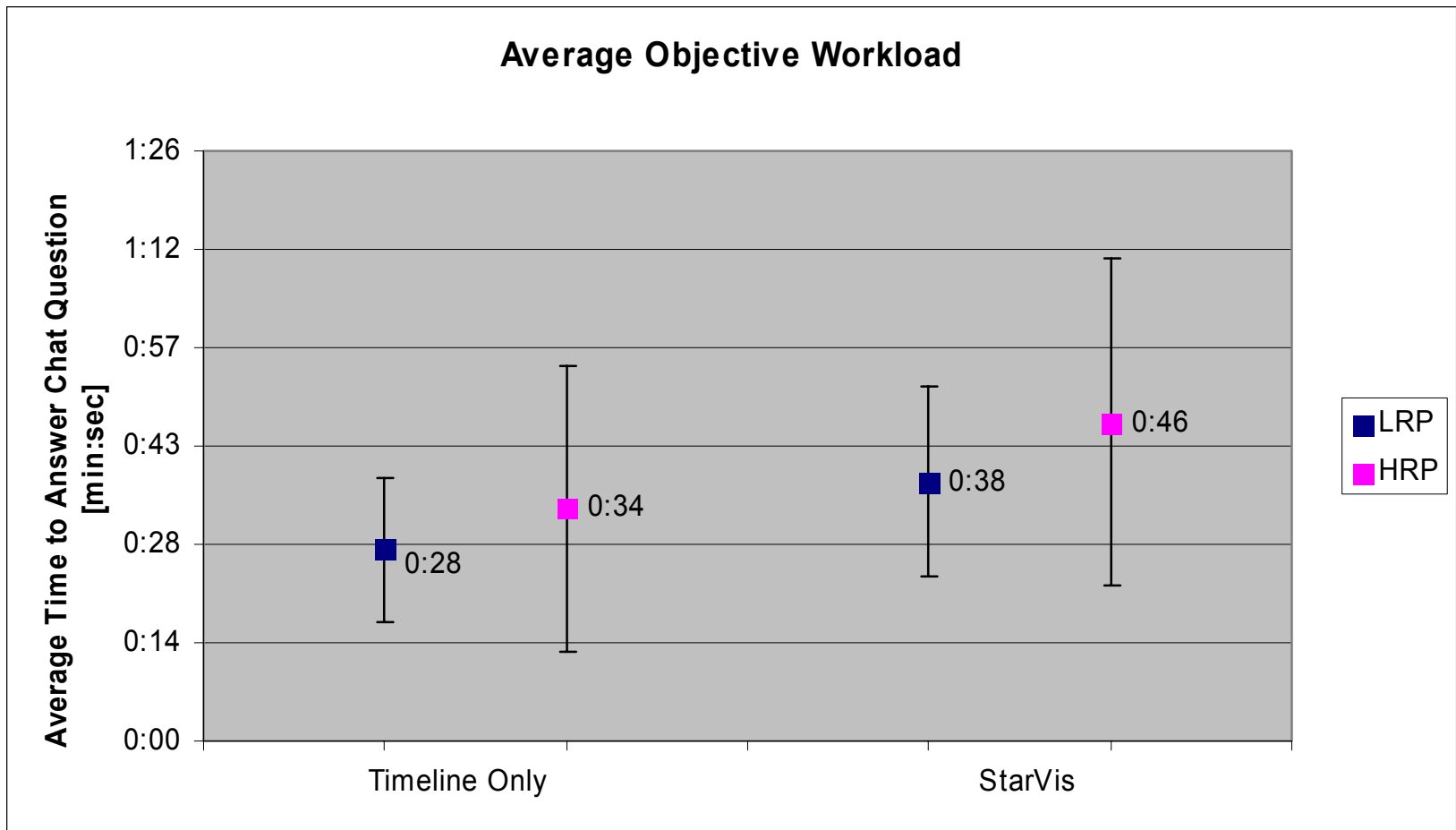
TOT Delay Requests



- Global SA Measure: Incorrect Firing Events
 - Timeline Only: 2 StarVis: 0

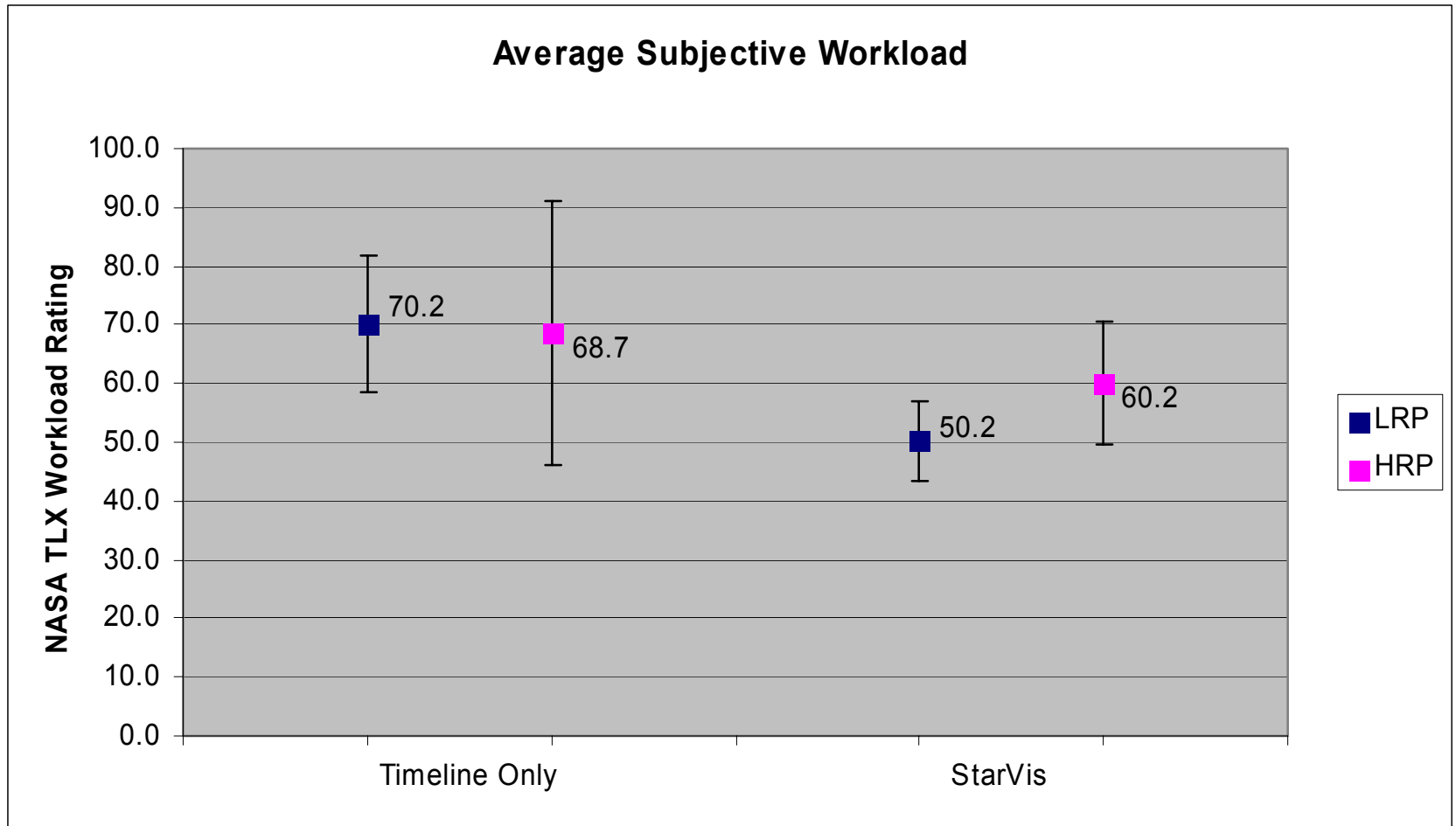


Objective Workload





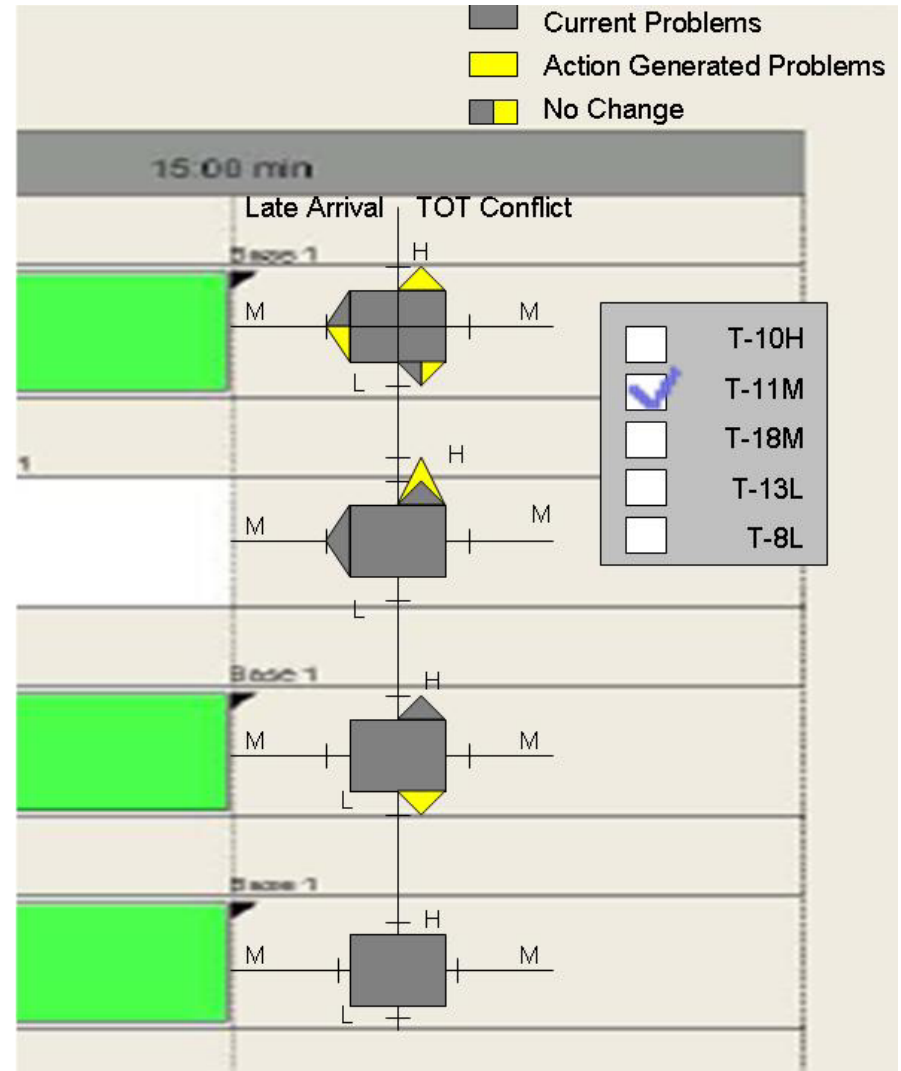
Subjective Workload





Future Work

- More Experiments!
- Local Design
- Quasi-Global Design
- Data Analysis
- Recommendation Algorithm





Acknowledgments

- The MITRE Corporation
- The Boeing Company
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