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Out-of-Water Test Methods to Accelerate Implementation of Autonomous Rendezvous in the NPS ARIES AUV

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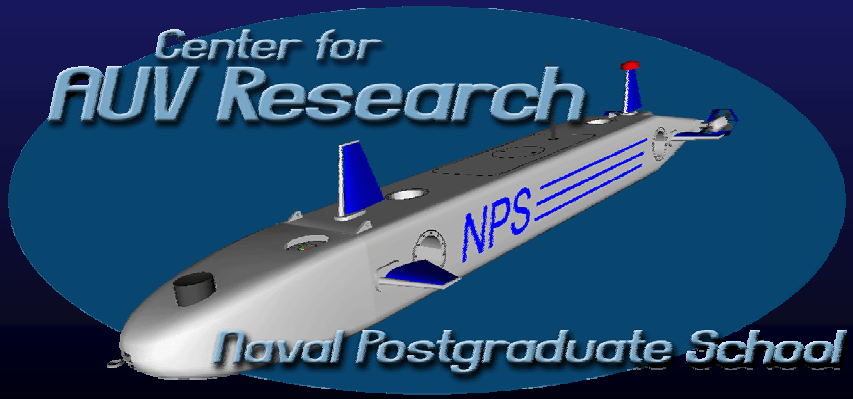

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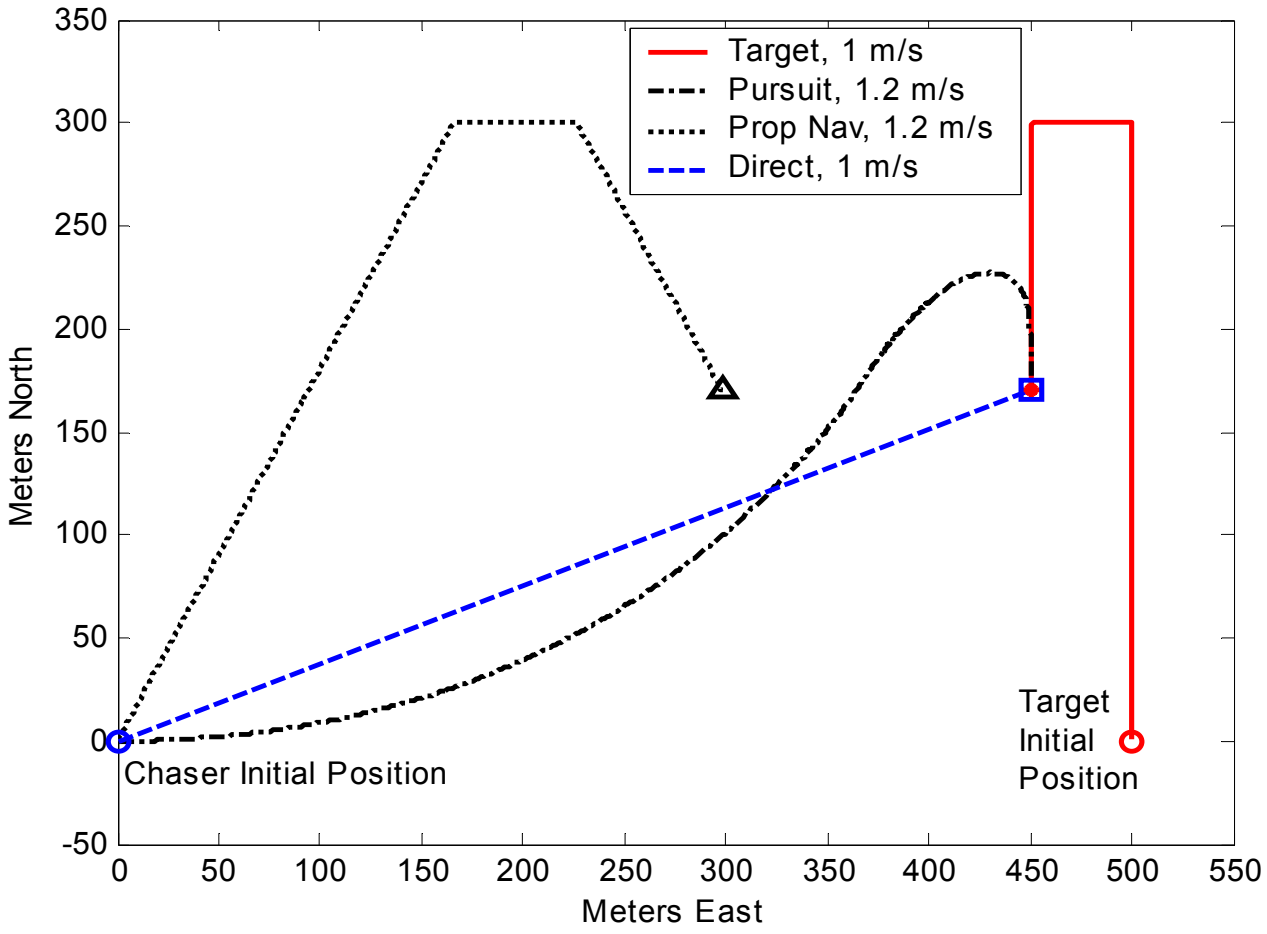
Development: Server Vehicle Rendezvous



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Challenges (As Always)

- Significant software changes requiring…
- Significant debugging
- Limited time, money, in-water opportunities

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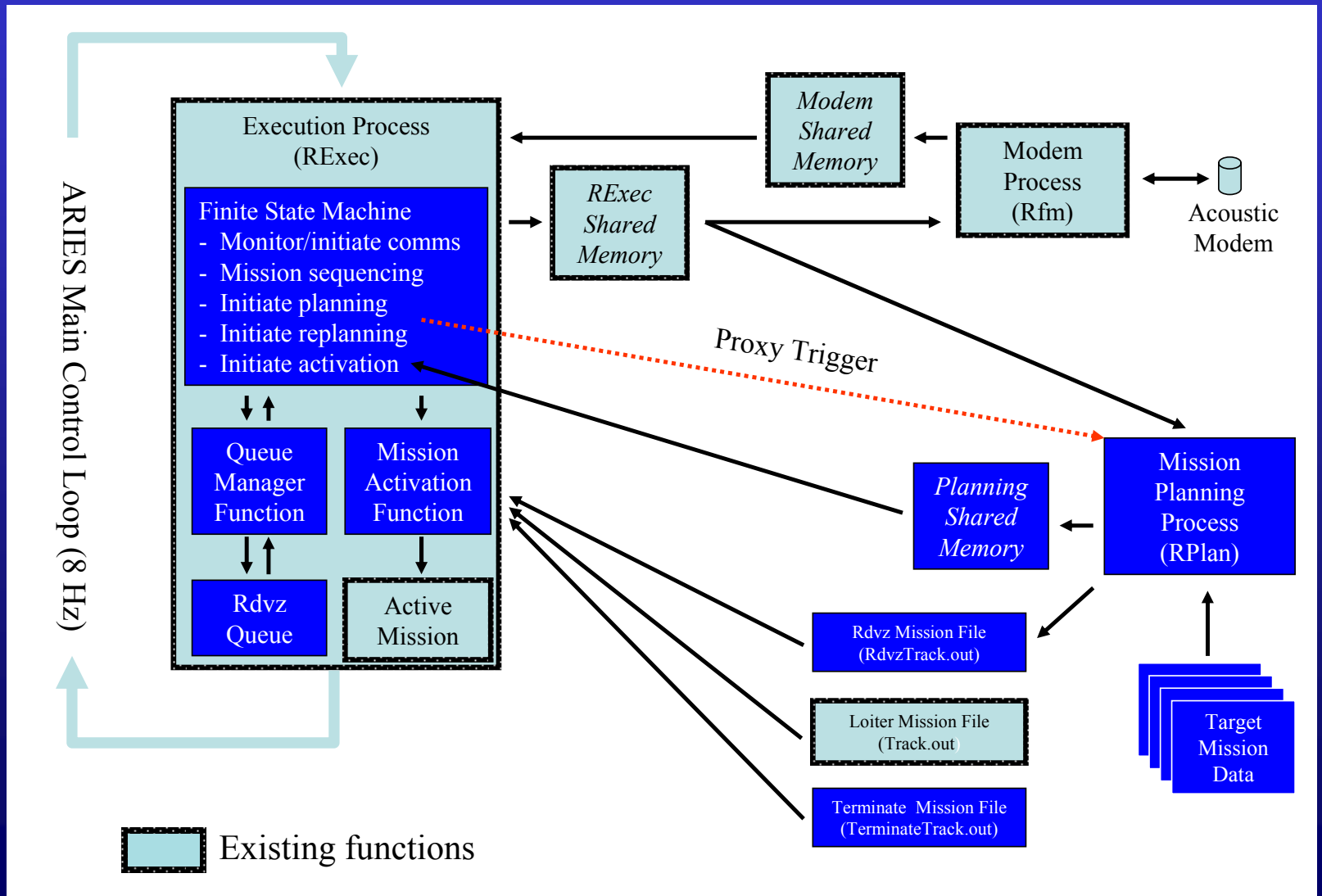
ARIES Software Modifications



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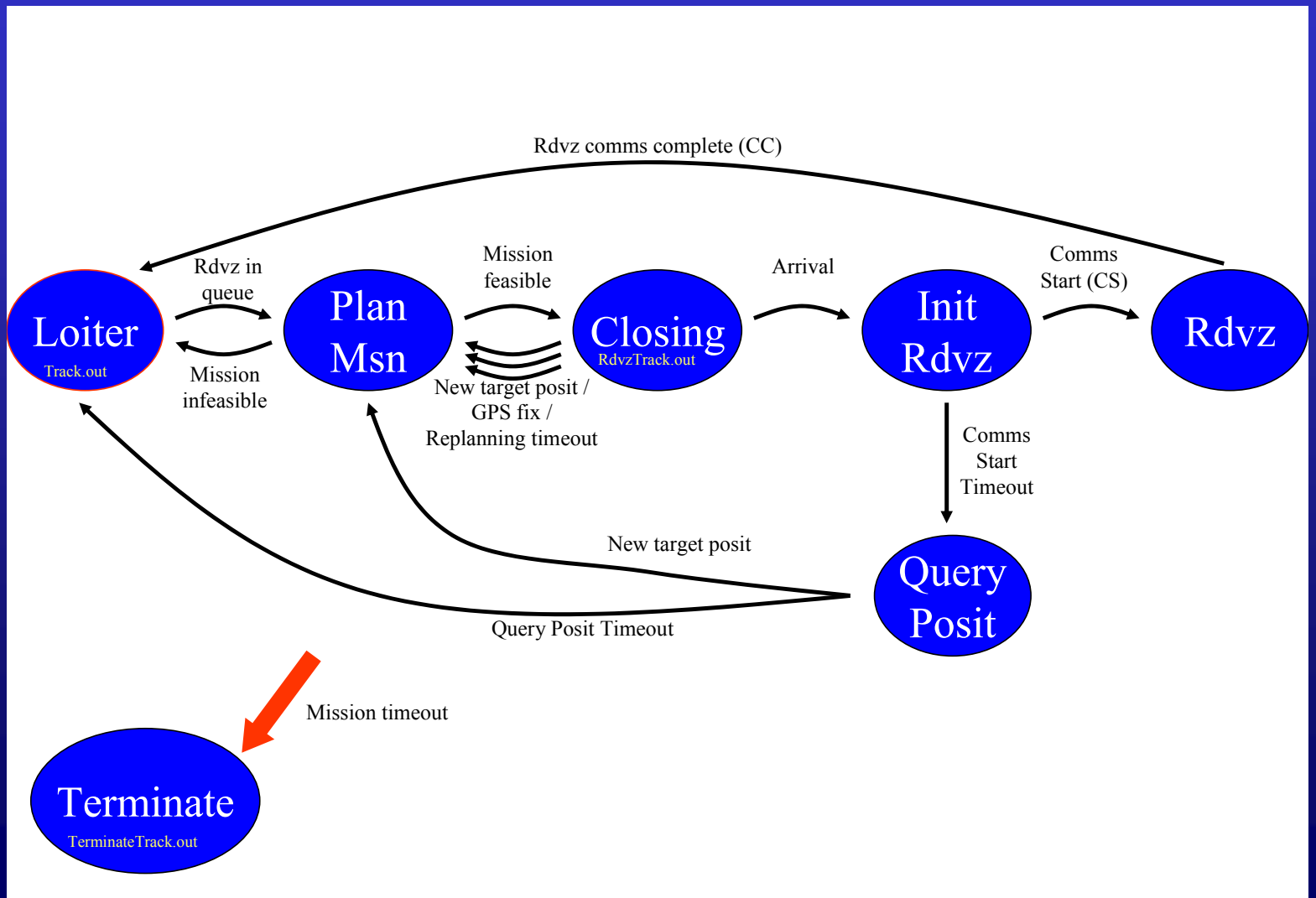
ARIES State Machine



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ARIES Control Architecture

STATE MACHINE
(Strategic Level)

MISSION CONTROL
(Tactical Level)

AUTOPILOTS
(Execution Level)

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Solution: Laboratory Test Program

- Hardware-in-loop software development / debugging
- Install the capability to run missions in laboratory (dry)
- Benefits
  - Time efficient
  - Cheap
  - Enhanced ability to monitor vehicle operation
  - Shortened run-debug cycle
- Barriers
  - Vehicle protective functions (abort signals: prop speed, minimum altitude)
  - Risk of equipment damage, inadvertent loss of protective functions
  - Providing simulated sensor inputs

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Overcoming the Barriers to Lab Testing

- Control all modifications with a common, reliably set and cleared signal
- Block unnecessary protective signals
- Reduce prop speed by factor of 10
- Inject simulated X-Y position and GPS reception data

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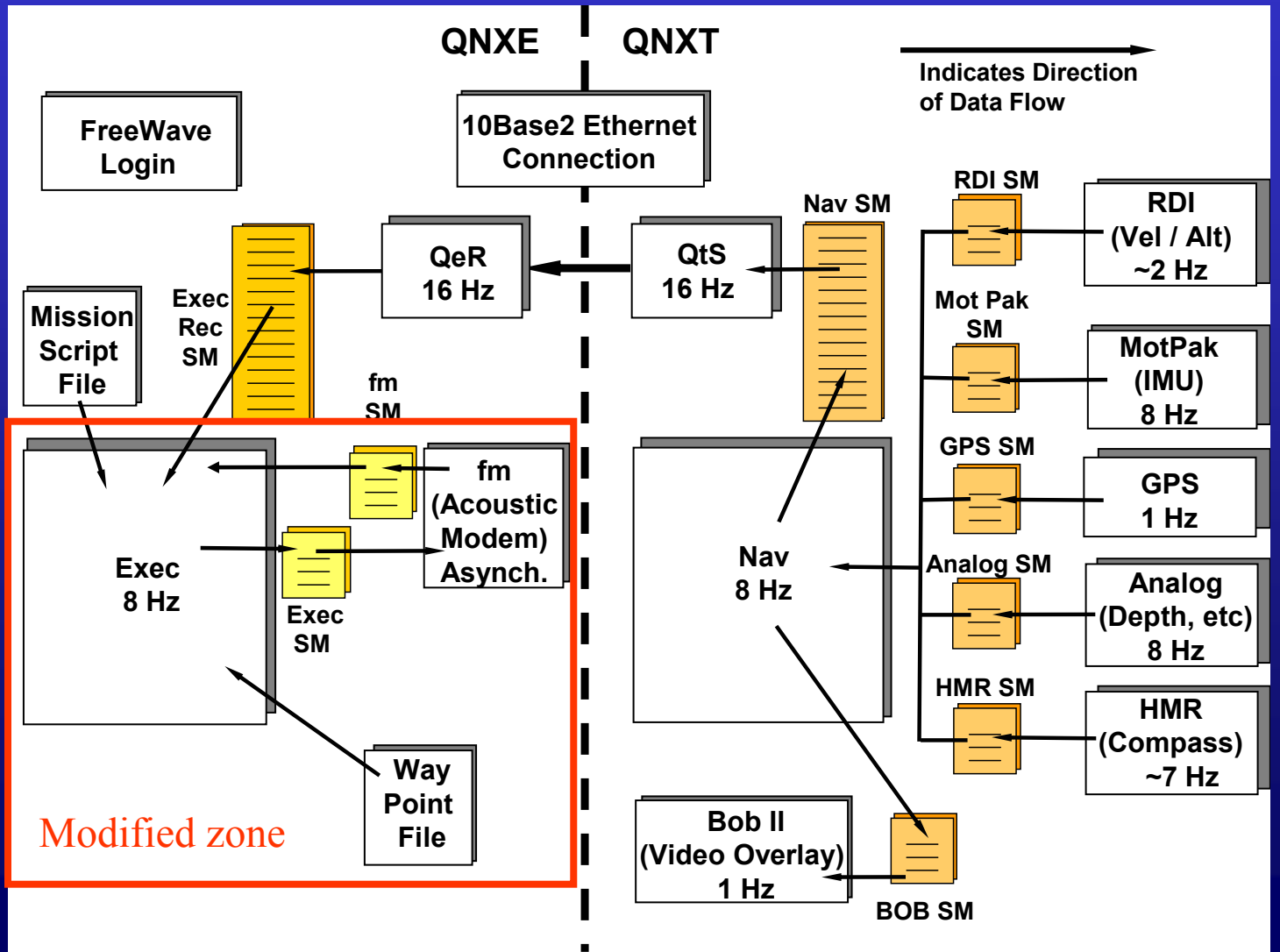
Original ARIES Software Architecture



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Initial (Stand-alone) Software Testing

- Acoustic modem
  - Minor modification of existing software and shared memory
  - Test on ARIES using actual modem software / hardware / inputs
- State machine and queue manager function
  - Logic intensive operations, but little math
  - Exhaustive testing of inputs versus states
  - Embed into existing function (Exec.c)
  - PC (MATLAB), translate into C on ARIES
- Mission planning module
  - Math / optimization / shared memory intensive
  - Could develop on PC, but translation to C and integration in ARIES would involve a second round of significant debugging
  - ARIES (C)

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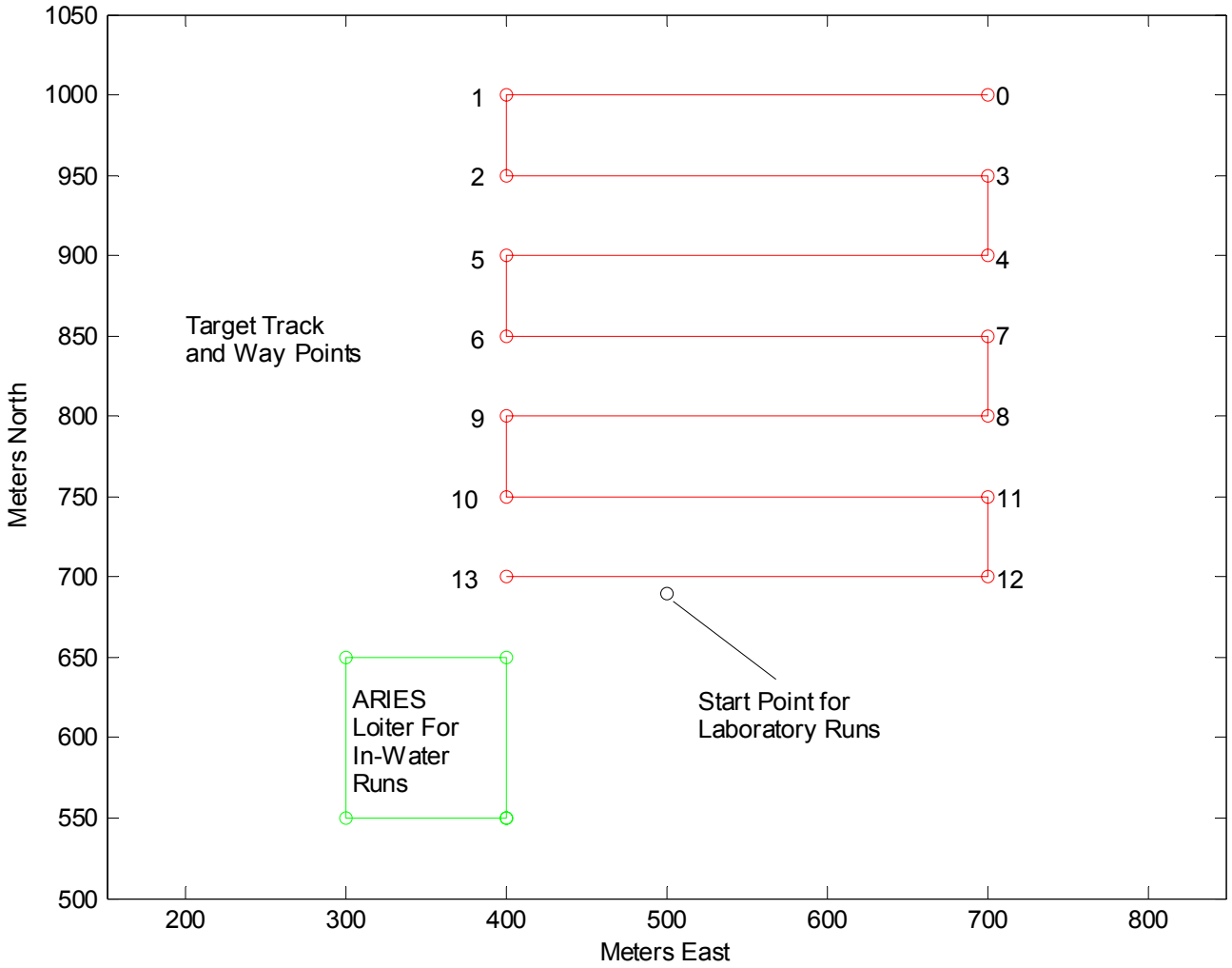
Integrated Software Testing Set-up



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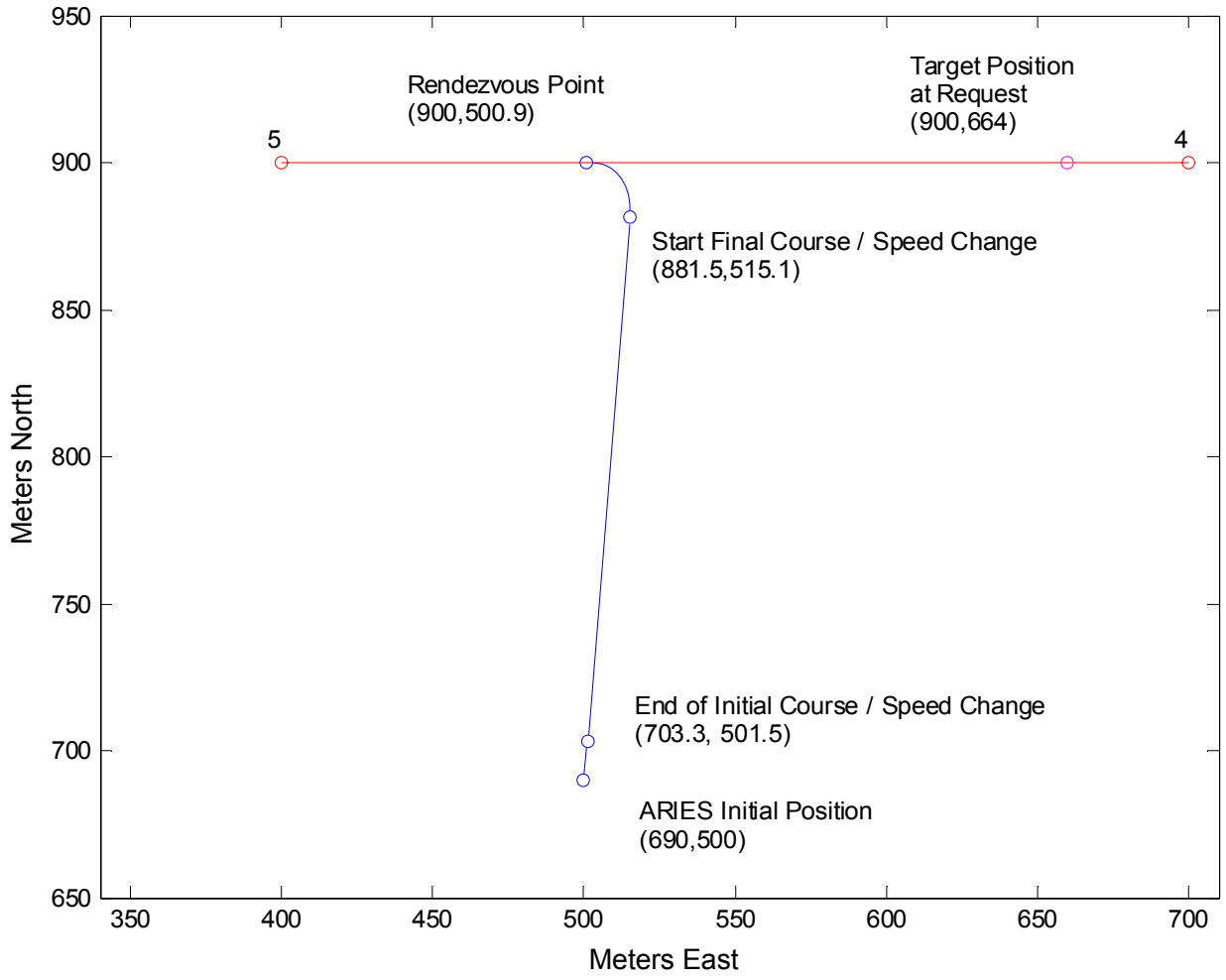
Time-Optimal In-Lab Track



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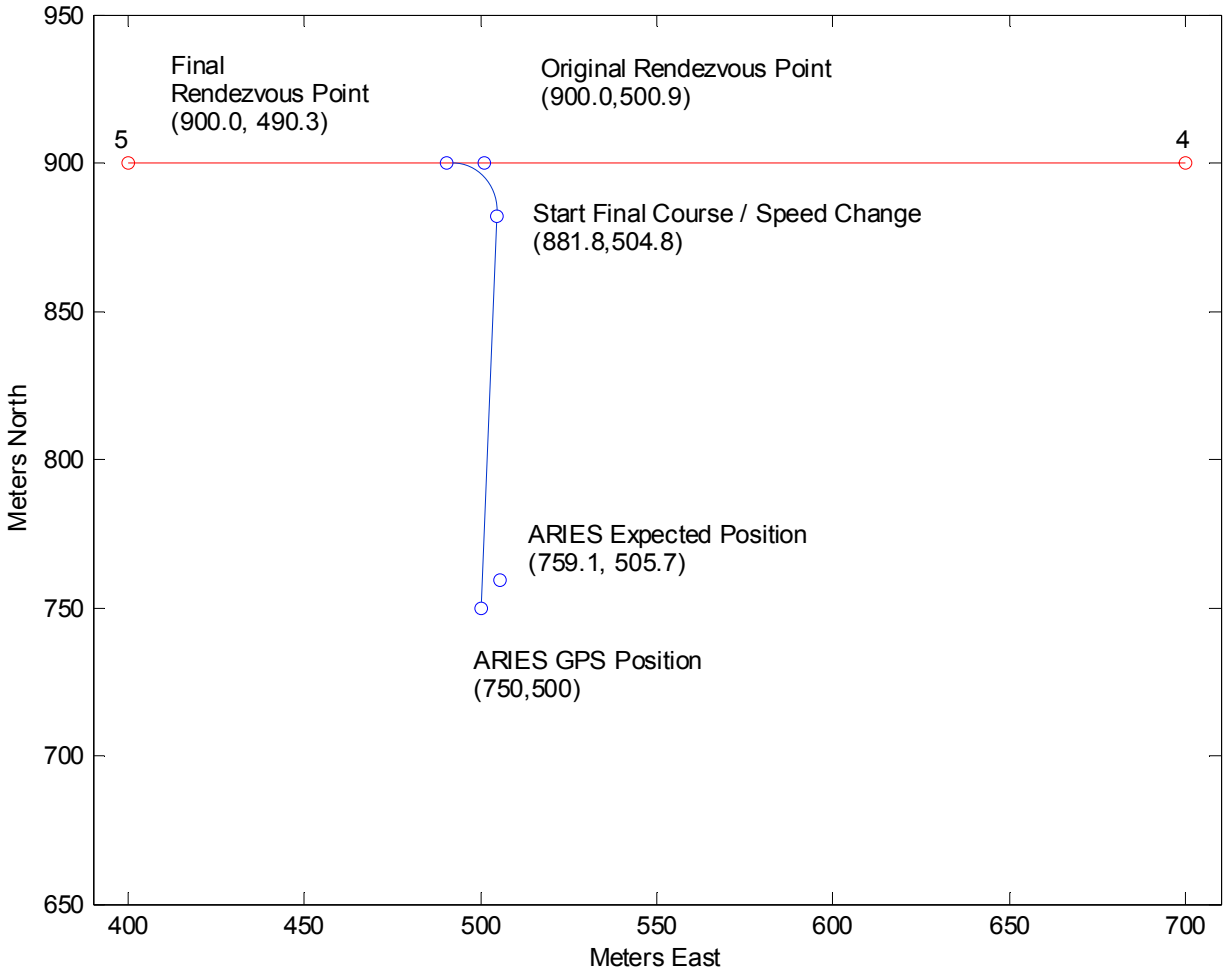
Replanned Time-Optimal Track



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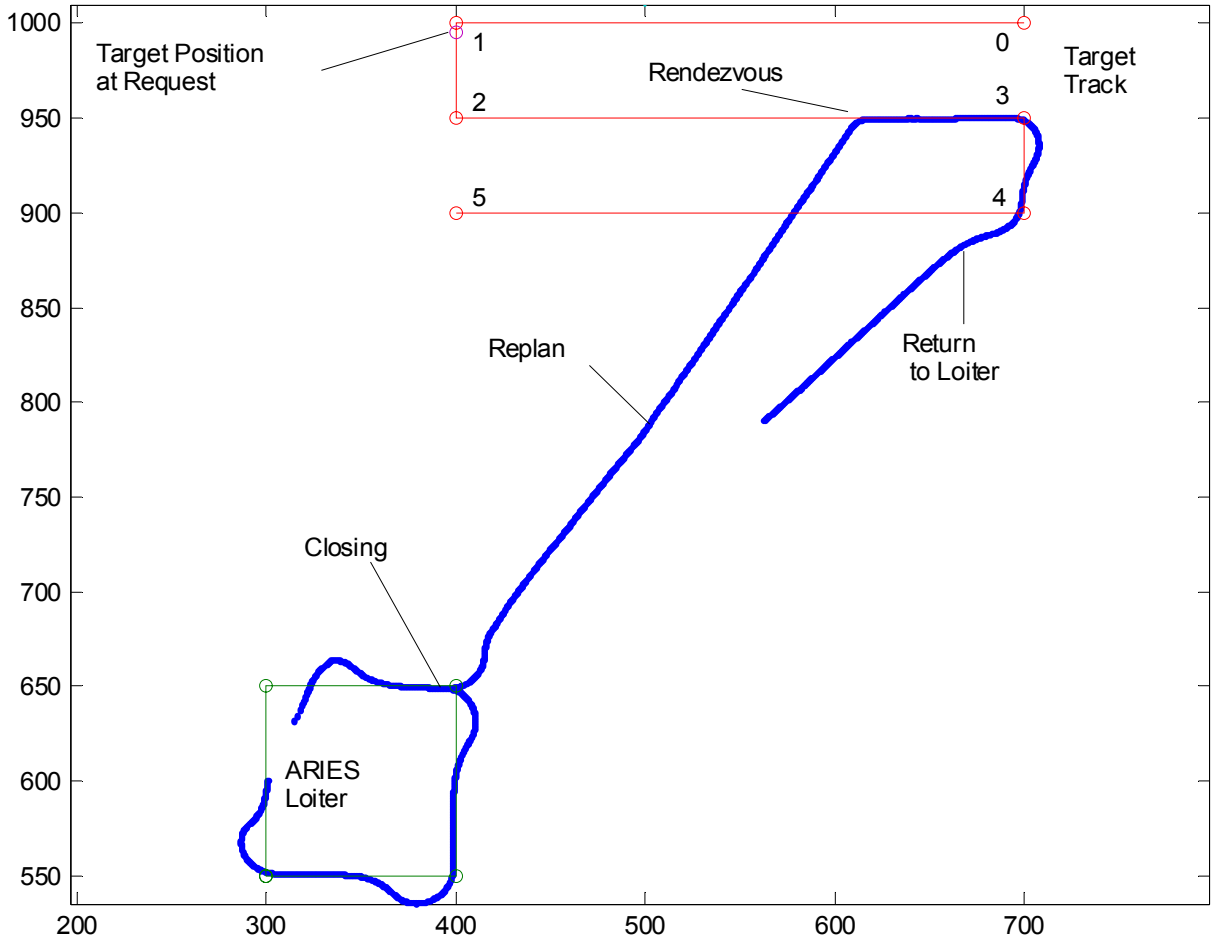
First In-water Run: Time-optimal Rendezvous



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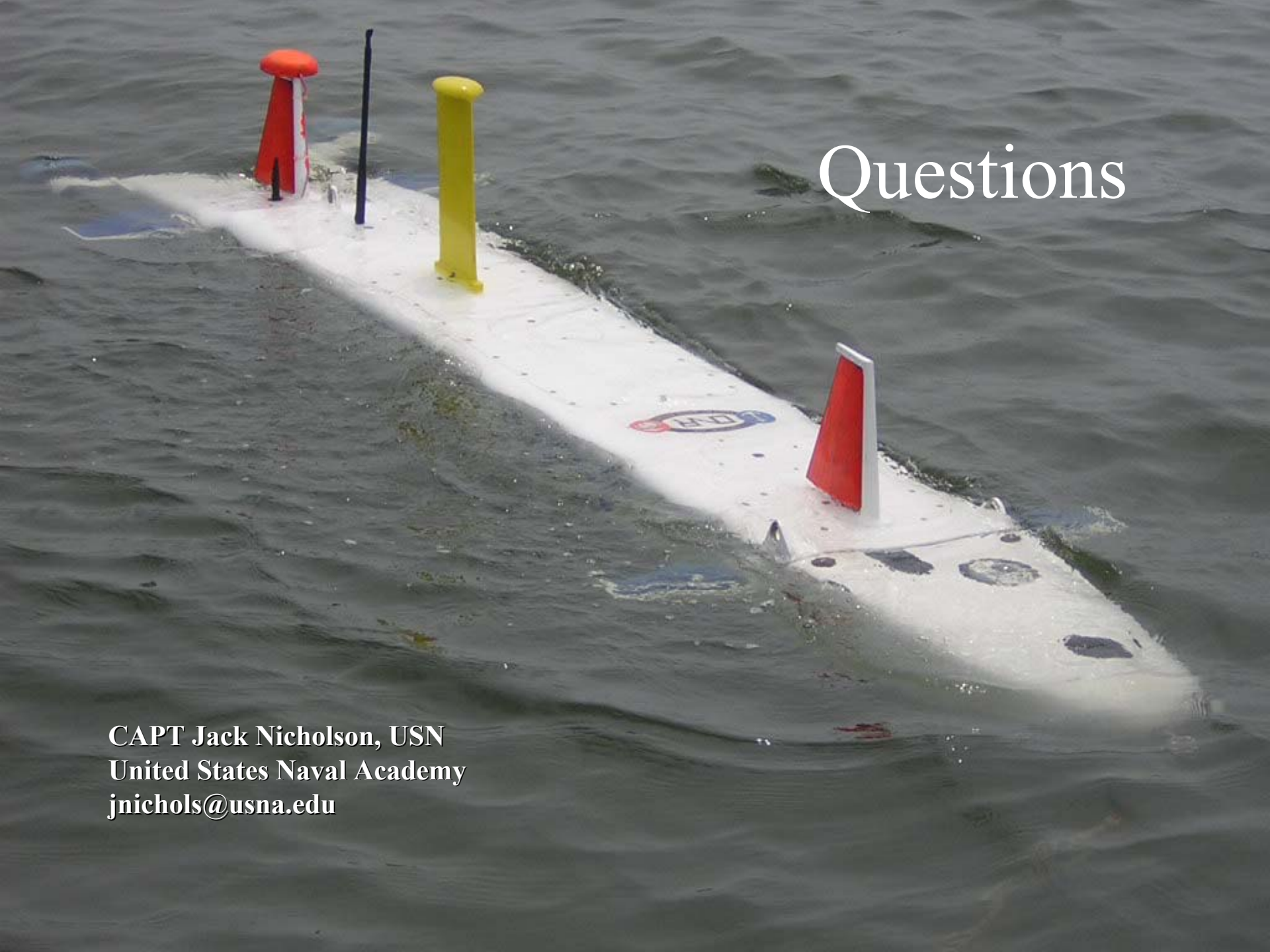
Summary

- Significant savings in time / effort / money
  - Several hundred runs, in days (vice months)
- Enhanced fault diagnosis, rapid correction
- Simulated sensor inputs need not be complete set, or high fidelity (judgment / trade-offs)
- Care in blocking / restoring / retesting abort and other protective functions
- Power down unnecessary vehicle components to avoid wear and tear (nav / comms equipment)
- Nominal performance first time in the water



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Back-up Slides

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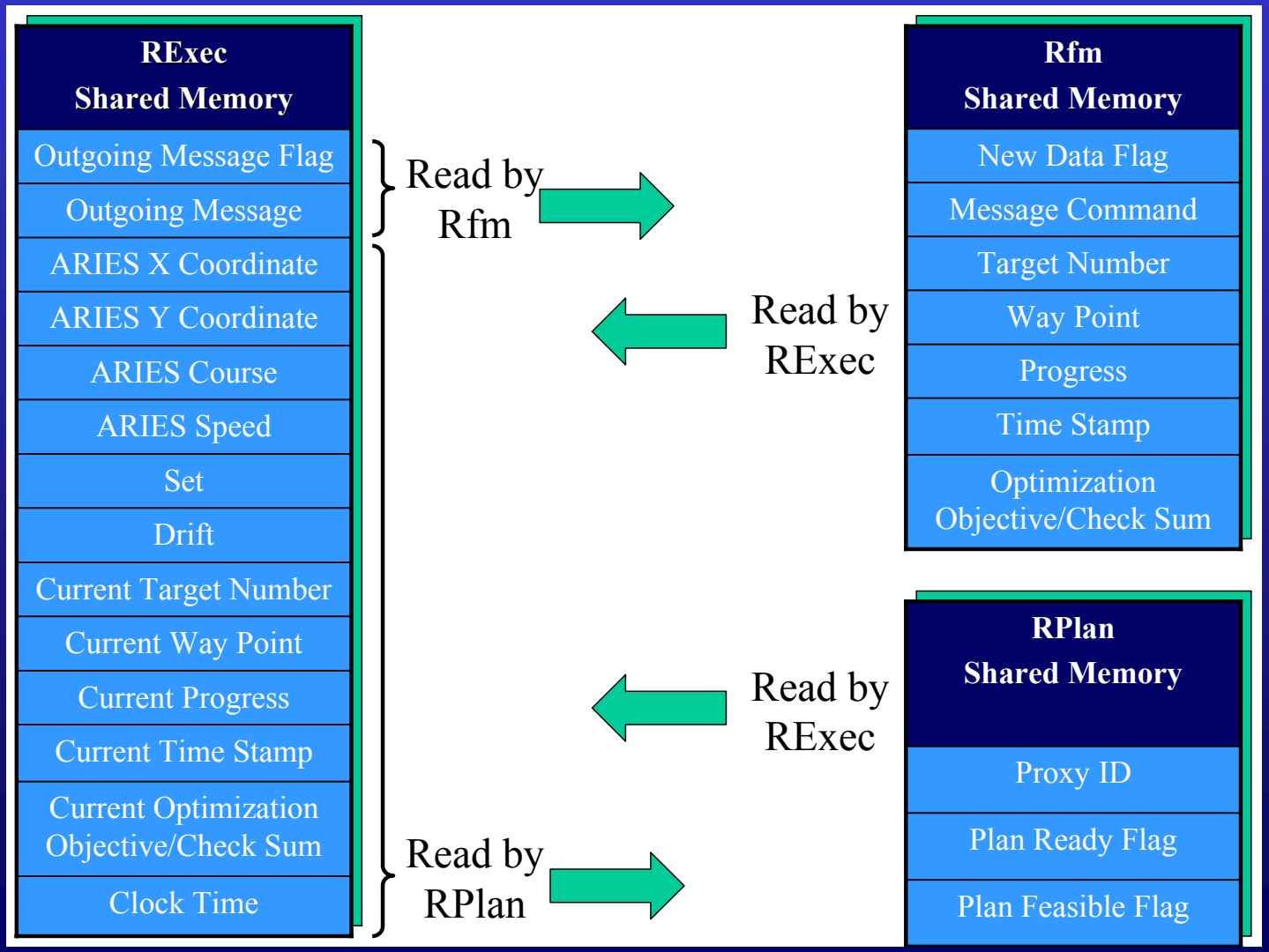
RENDEZVOUS SHARED MEMORY



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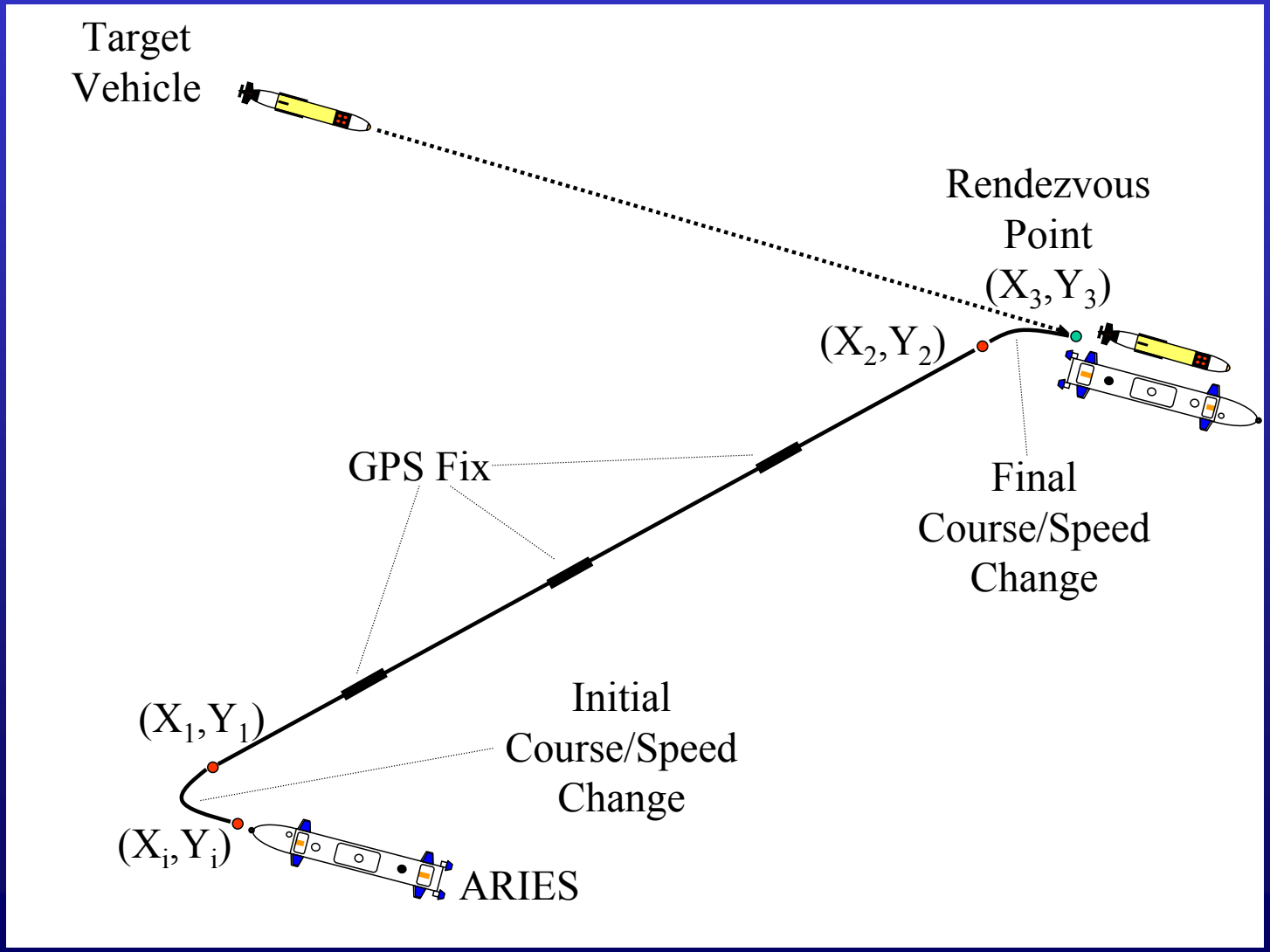
RENDEZVOUS TRAJECTORY



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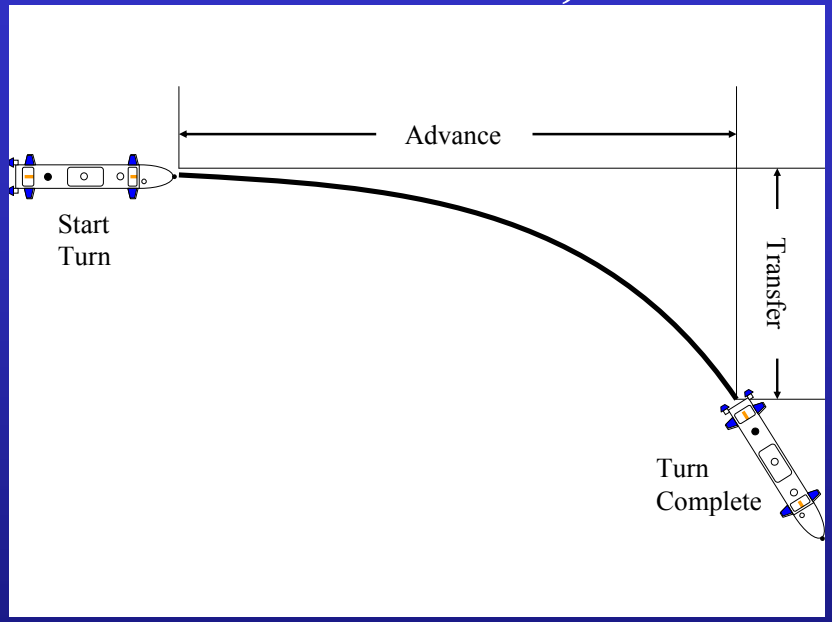
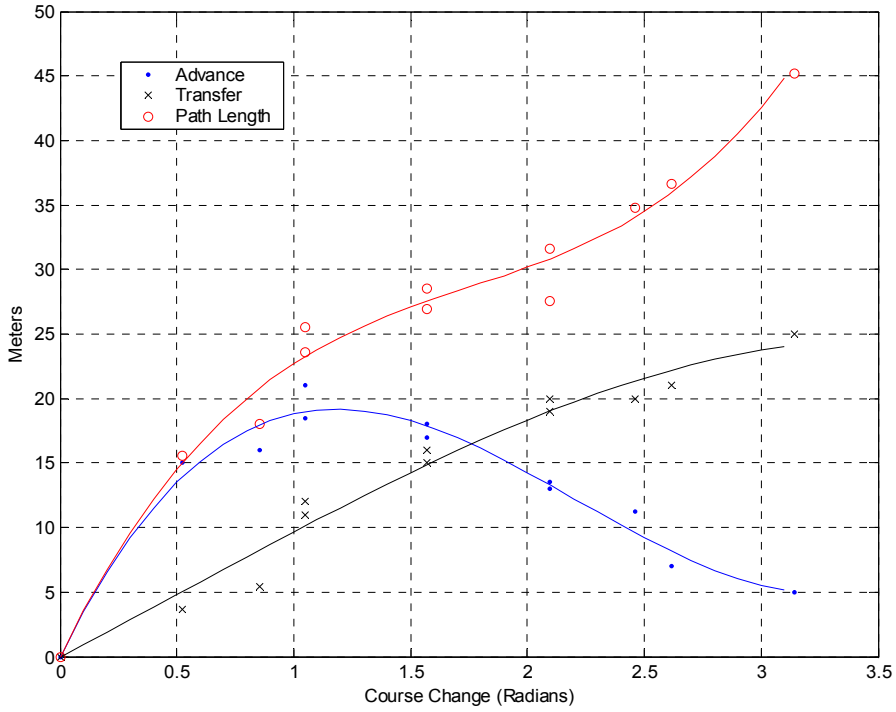
ADVANCE, TRANSFER AND PATH LENGTH



- Parameterization of turn characteristics



- Used to compute spatial and temporal turn effects

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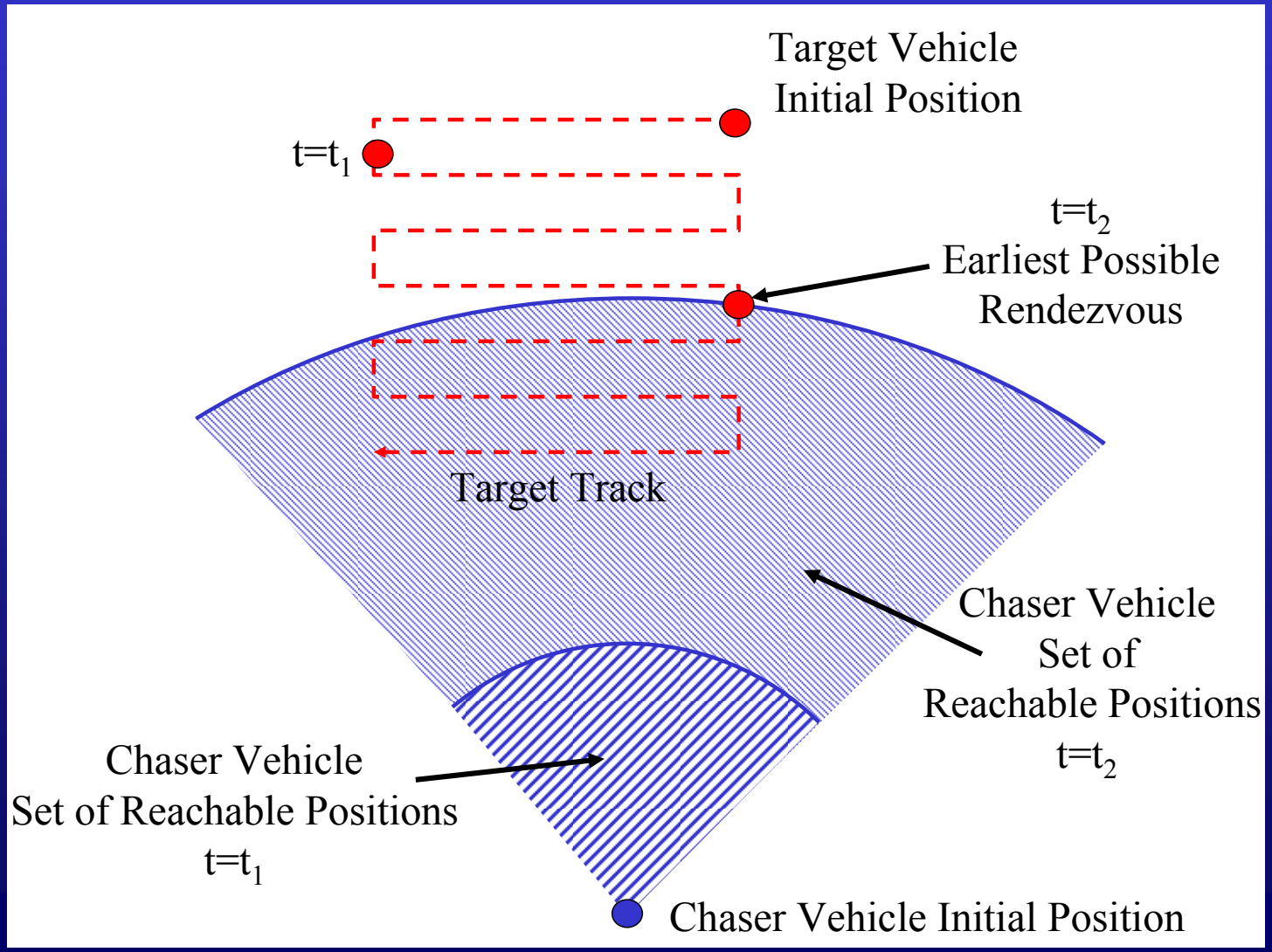
SET OF REACHABLE STATES



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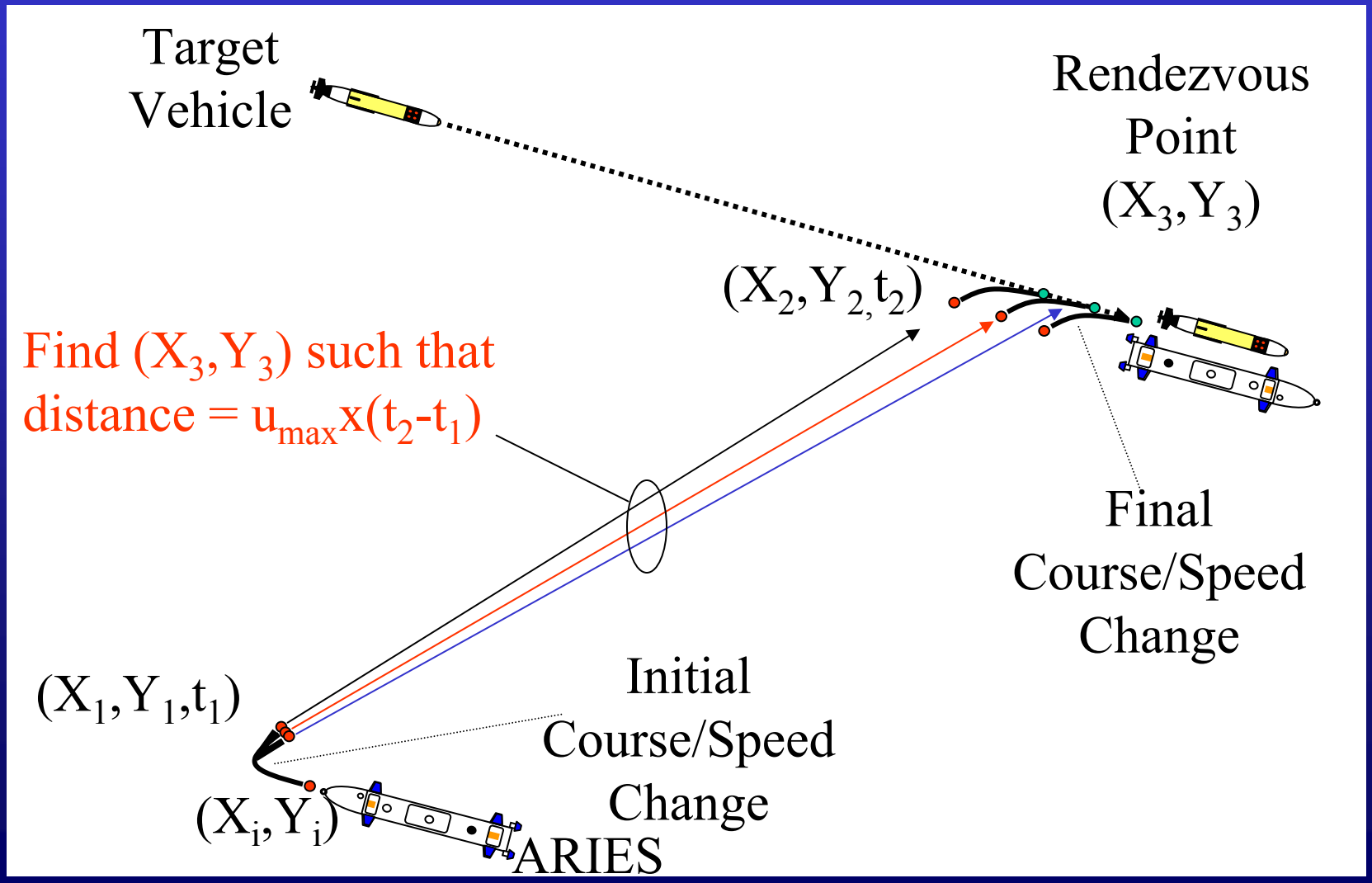
TIME-OPTIMAL RENDEZVOUS POINT



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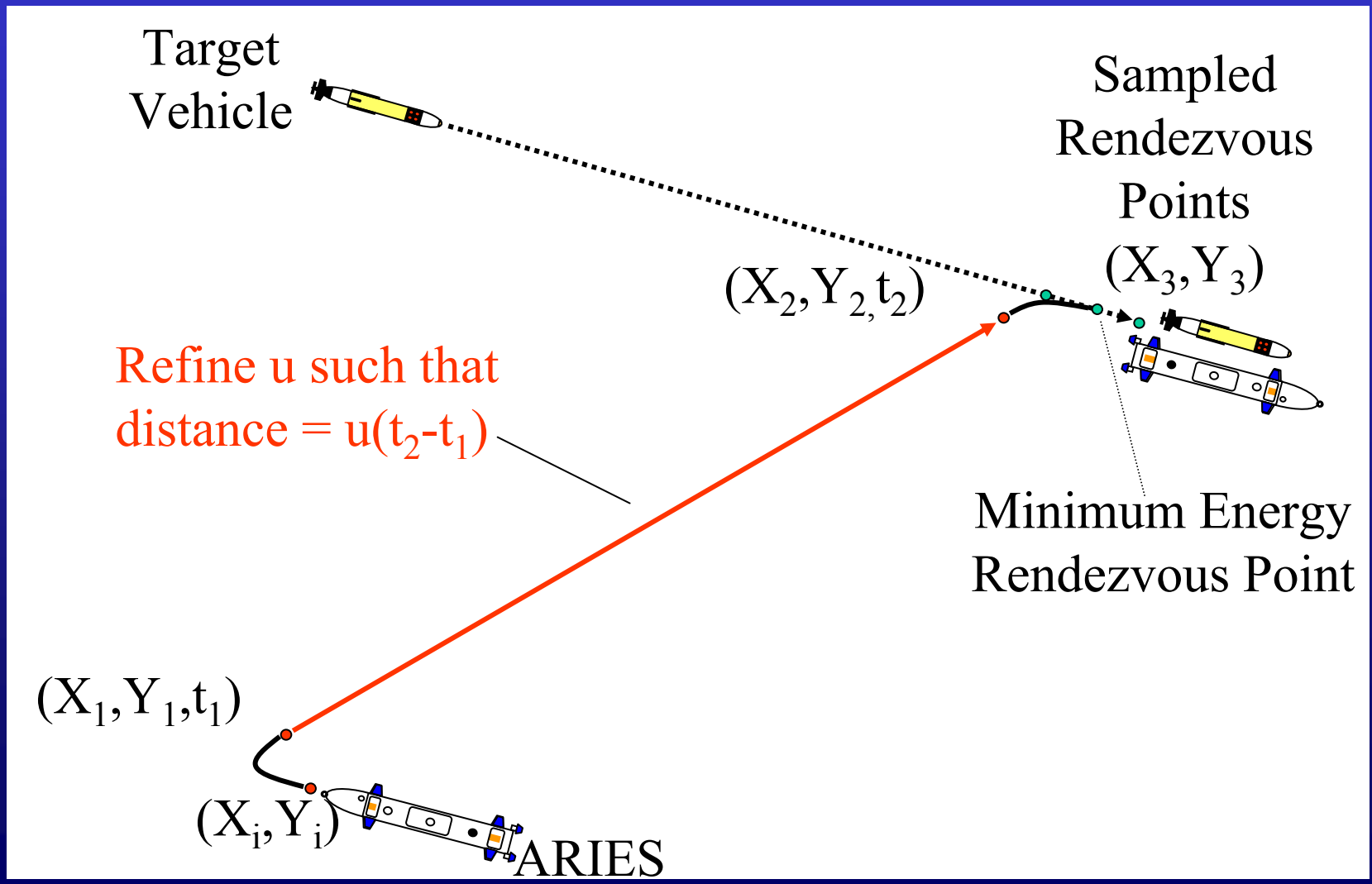
ENERGY-OPTIMAL RENDEZVOUS POINT



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IN-LAB RUNS

- Rendezvous request:

RVS,REQ,0,5,120,30,+/-155

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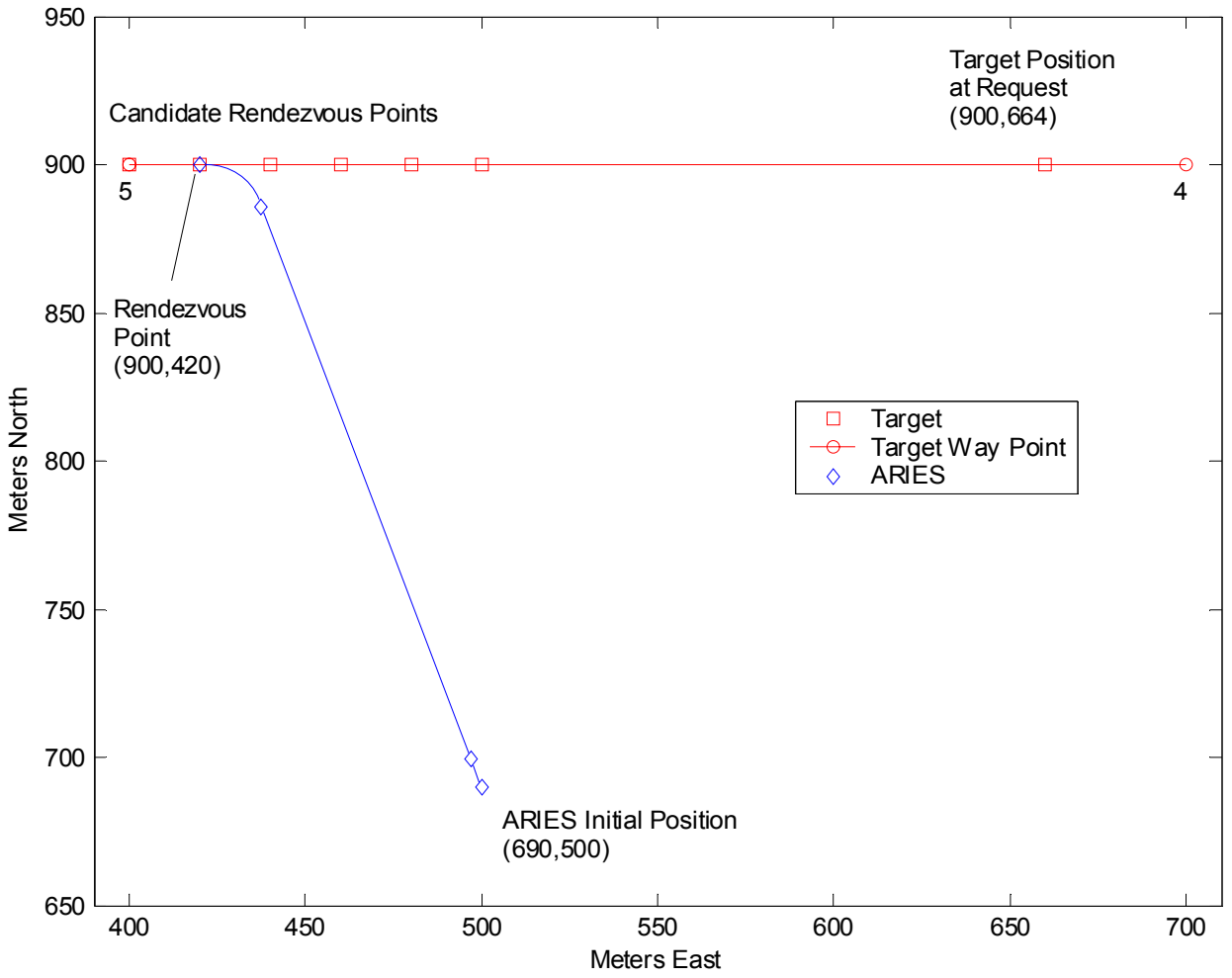
ENERGY-OPTIMAL IN-LAB TRACK



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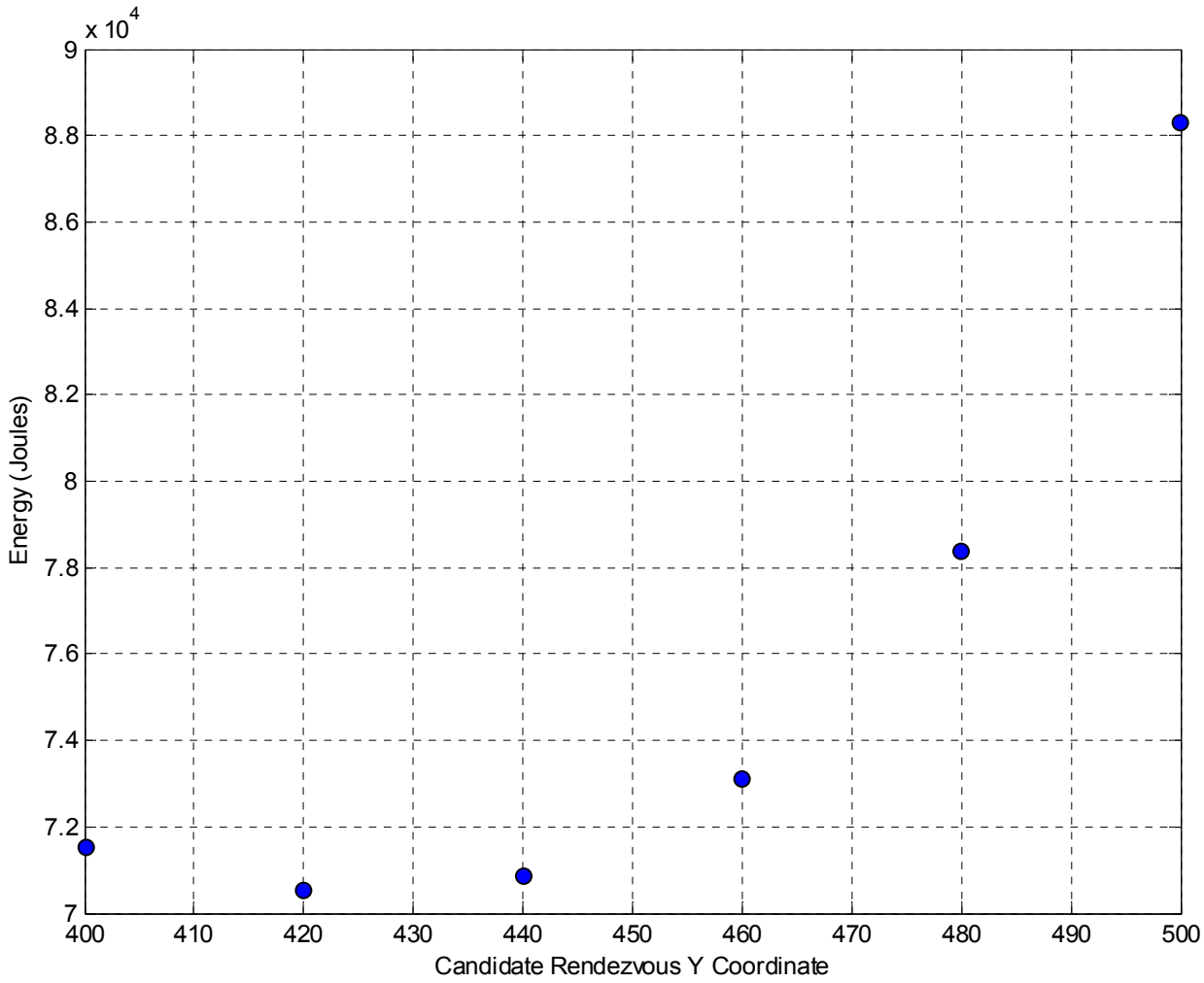
ENERGY-OPTIMAL CALCULATIONS



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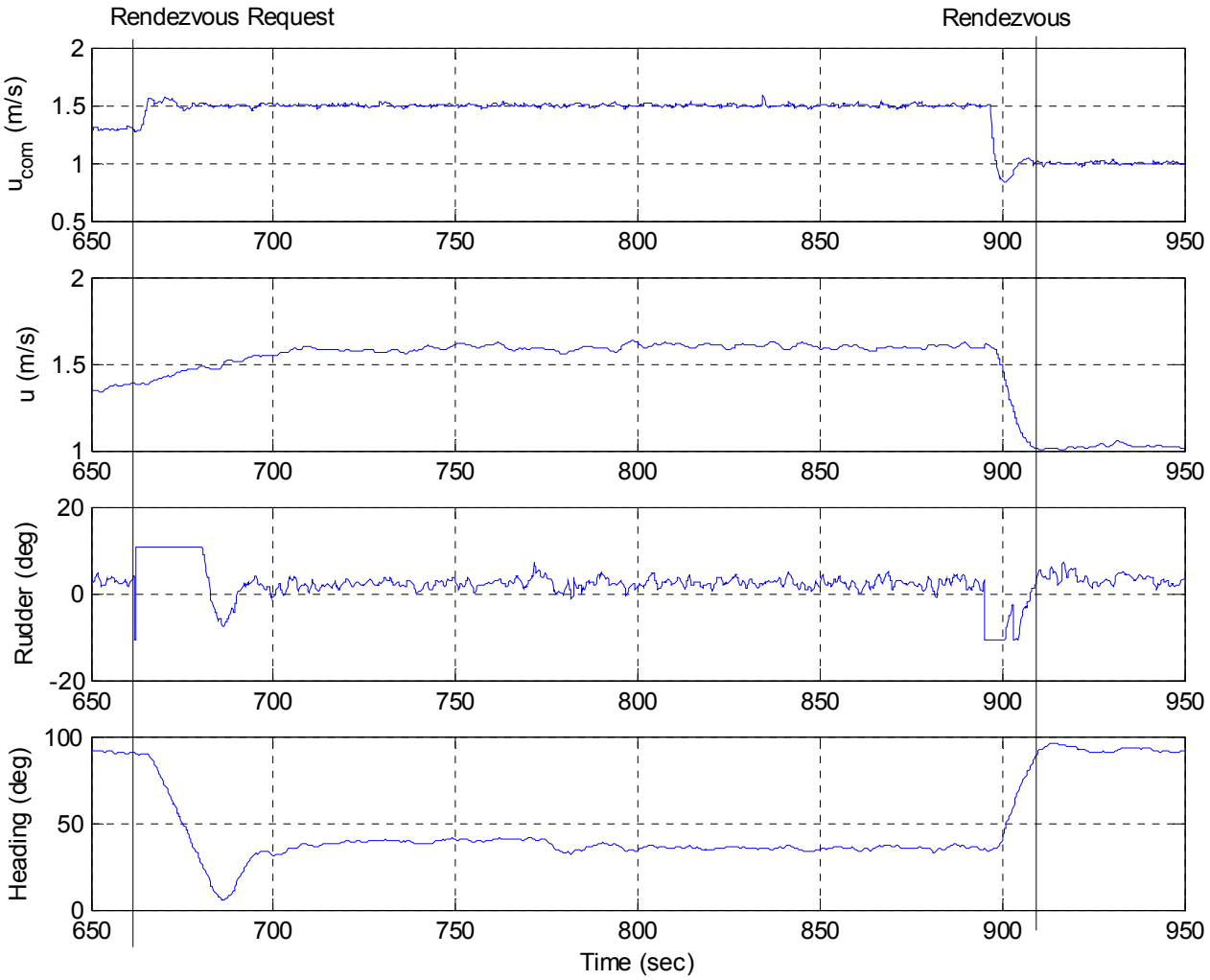
CONTROLS AND STATES



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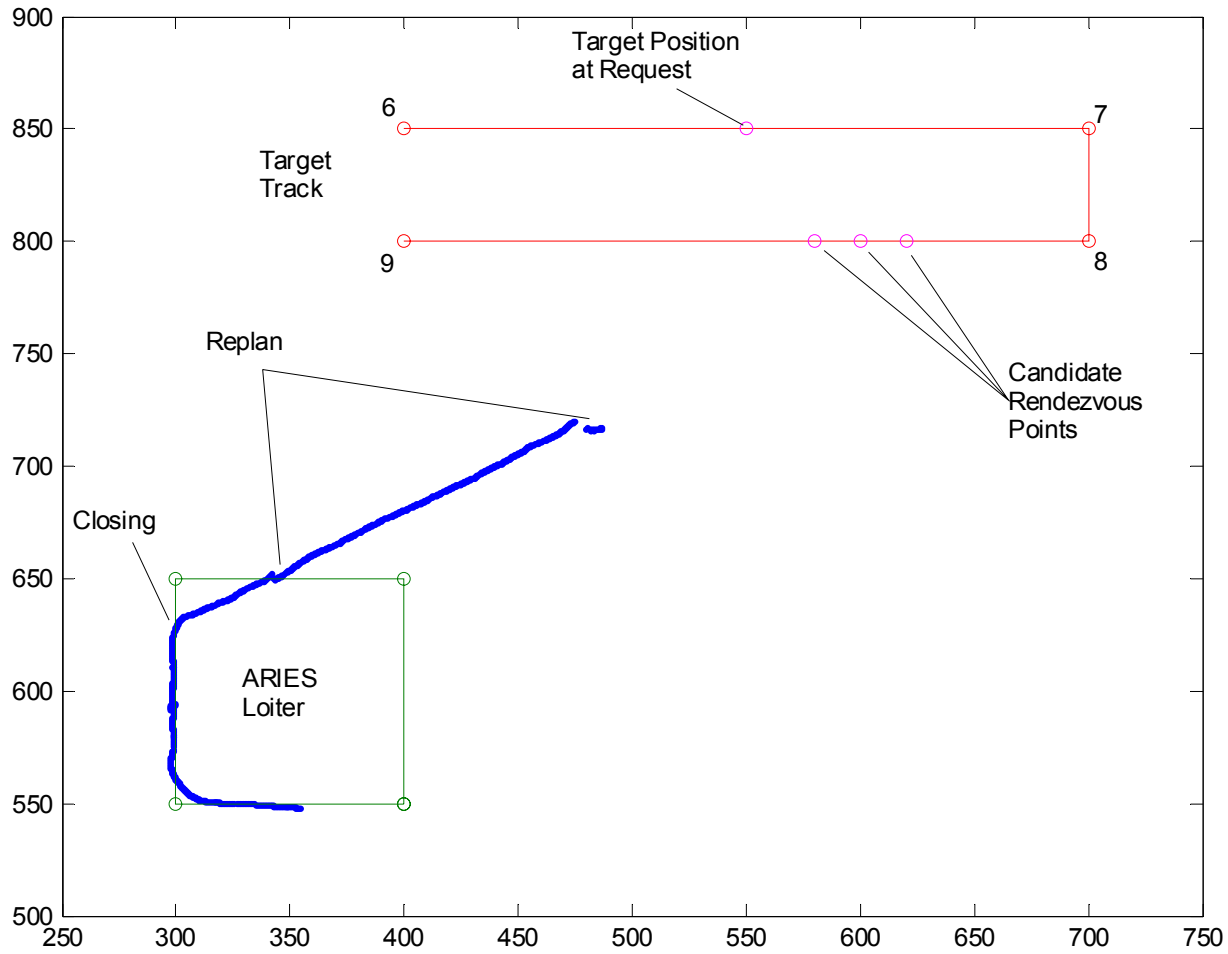
ENERGY-OPTIMAL IN-WATER TRACK



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