An Overview of MOOS-IvP Usage at SSCI

Kai-yuh Hsiao

July 31, 2013

SSCI Company Overview

- Scientific Systems Company, Inc.
- www.ssci.com
- Small (~40) R&D software company
- Woburn, MA (Boston area)
- Mostly defense-related, with some NASA and commercial funding
- Mix of SBIRs (Phases 1-3), BAAs, others
- Work extensively with academic partners, esp. MIT

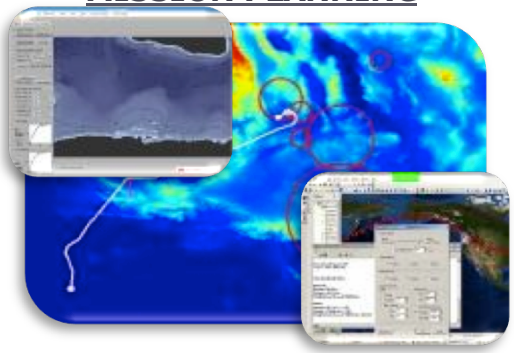
MISSION AUTONOMY

Mature and demonstrated onboard, collaborative mission autonomy with rapid development, prototyping, and deployment tool-chain.

UAS SENSE & AVOID

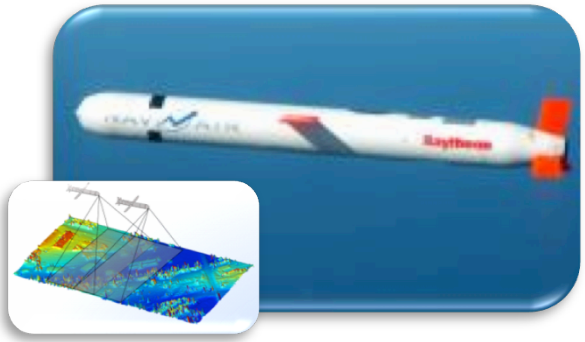
Demonstrated completely passive, end-to-end, In-Air Sense & Avoid. Provides 30-60sec Time-to-Collision warning.

MISSION PLANNING



Path planners, autorouters, and multi-vehicle mission-level planning tools for optimal mission execution.

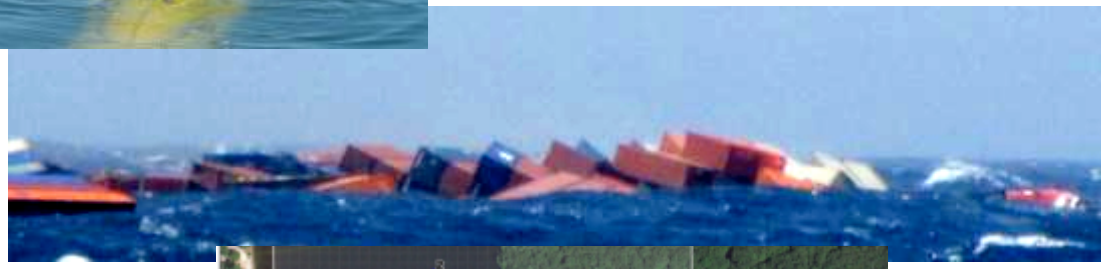
VISION- AIDED GNC



GPS-Denied Navigation and Targeting; Shipboard Optical Landing; Optical Fusing. Delivering GPS-denied navigation to Tomahawk program.

4 Years of MOOS-IvP at SSCI

- DARPA DSOP
- DARPA MSD
- COLREGS effort
- Kingfisher autonomy
- Bobcat autonomy



R2C2: Robotic Range Clearance Competition

SCIENTIFIC SYSTEMS

- Grand Challenge-style contest (AFRL/Army)
  - Vegetation removal
    - Clear/mulch trees and brush on 5 acres
  - Geophysical mapping
    - Find buried metal objects
  - Surface clearance
    - Retrieve metal objects, place in piles
  - Subsurface clearance
    - Dig up objects given locations
- SSCI's team won vegetation clearance and surface clearance

Autonomous Bobcat pushes down a tree in the vegetation clearance challenge

MOOS in the R2C2 Bobcat

SCIENTIFIC SYSTEMS

- MOOS used as central middleware for mission/platform autonomy
  - Connected via JAUS over in-vehicle network to pre-existing low-level vehicle control module
  - Helm-IvP behaviors guide vehicle along auto-generated waypoint paths
  - Extremely quick turnaround; no mods to existing vehicle control module
- Mix of teleoperation (for tree-cutting) and autonomous waypoint control (for lawnmower patterns)
  - Permitted under subjective judging of autonomy levels

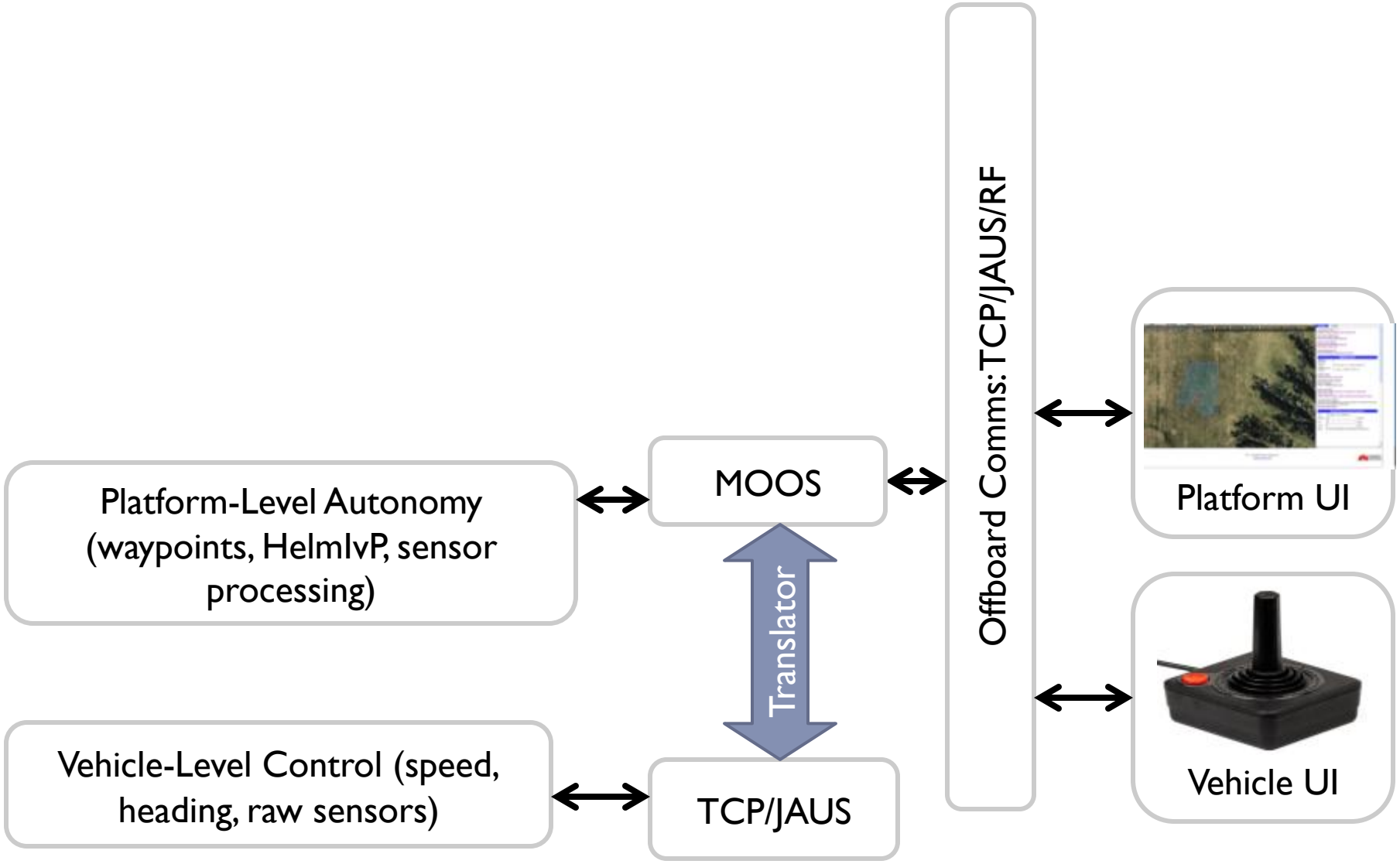
Autonomous Bobcat traverses a lawnmower waypoint pattern

A word about middleware

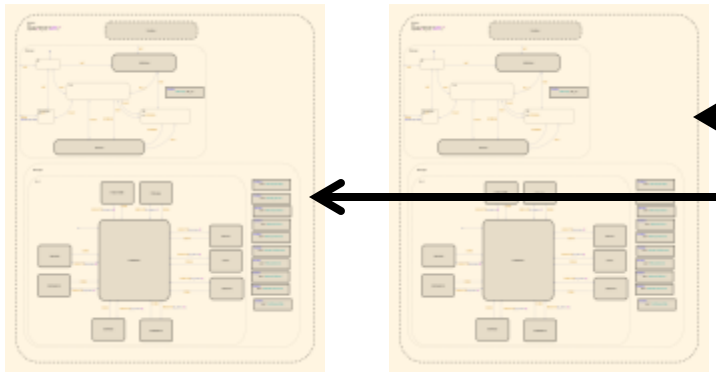
SCIENTIFIC SYSTEMS

- We spent a long time middleware-shopping
- Hoping for the "perfect" middleware is like hoping for the perfect OS, programming language, etc.; each is a tool best for some tasks
- You can't convince the whole world to speak the same language, and you can't convince your (funding-limited) customer to speak your middleware
- MOOS-IvP is good where it's good (lightweight, easy, marine apps, HelmIvP), but we've had to learn lots of middlewares regardless

Bobcat System Architecture



System Architecture



Collaborative/Mission-Level Autonomy

MOOS

Translator

Middleware 2

Platform-Level Autonomy (waypoints, HelmIvP, sensor processing)

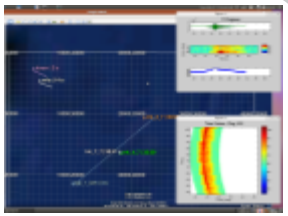
Translator

Middleware 3

Vehicle-Level Control (speed, heading, raw sensors)

Offboard Comms

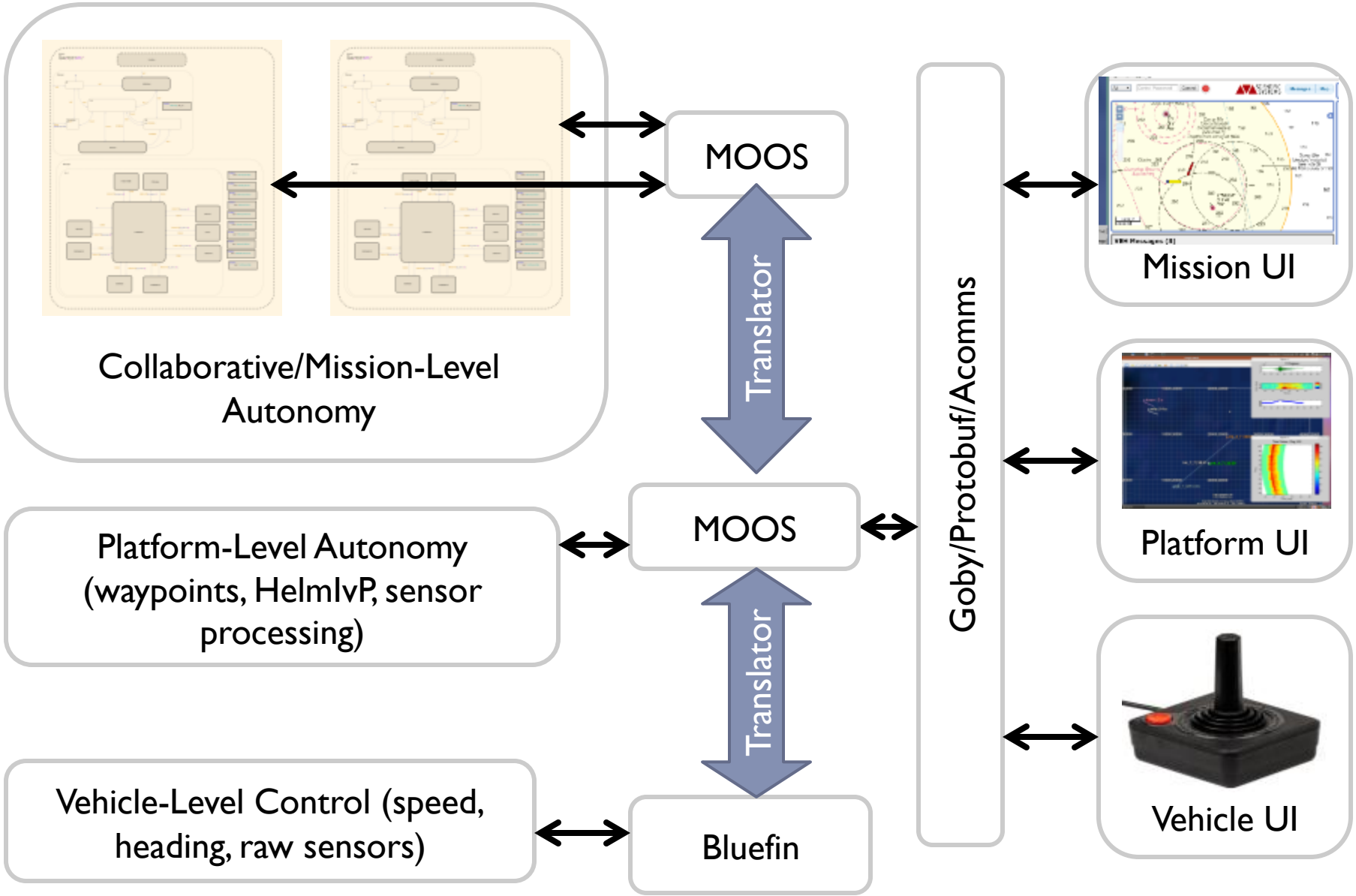
Mission UI



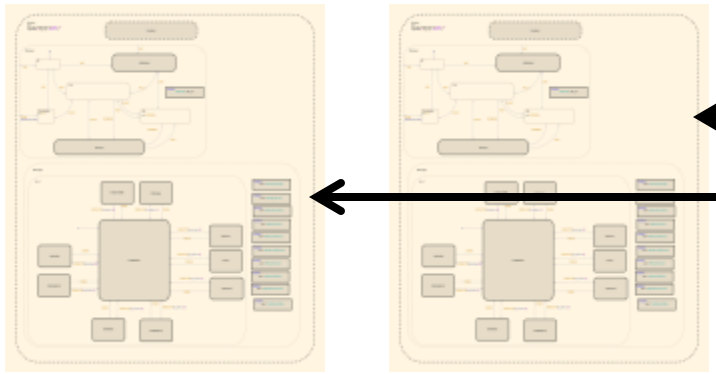
Platform UI

Vehicle UI

DSOP System Architecture



DSOP Simulation Architecture



Collaborative/Mission-Level Autonomy

MOOS

Translator

Platform-Level Autonomy (waypoints, HelmIvP, sensor processing)

MOOS

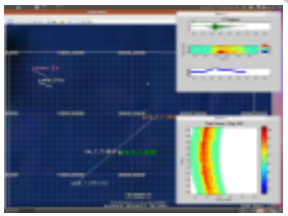
Translator

Simulation

Bluefin

Simulation

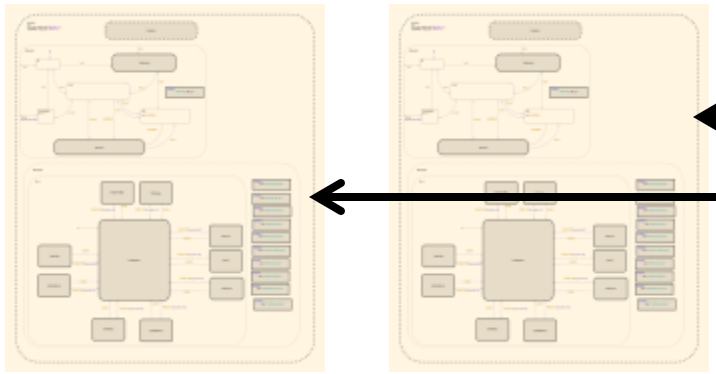
Mission UI



Platform UI

Vehicle UI

DSOP Simulation Architecture



Collaborative/Mission-Level Autonomy

MOOS

Translator

MOOS

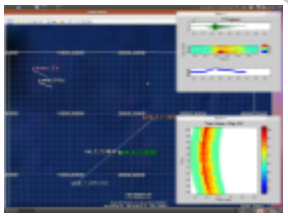
Translator

Simulation

Bluefin

Simulation

Mission UI

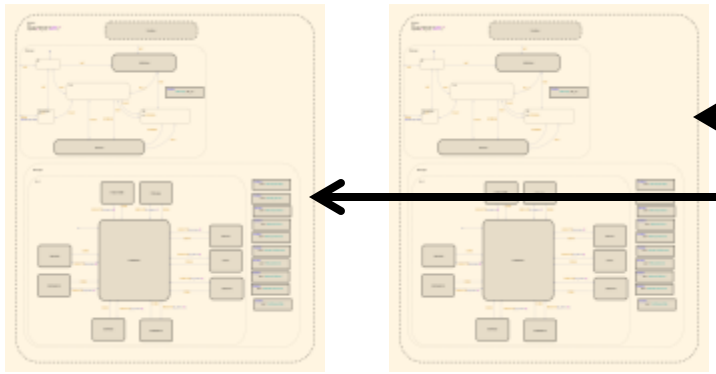


Platform UI

Vehicle UI

DSOP Simulation Architecture

SCIENTIFIC SYSTEMS



Collaborative/Mission-Level Autonomy

MOOS

Translator

MOOS

Translator

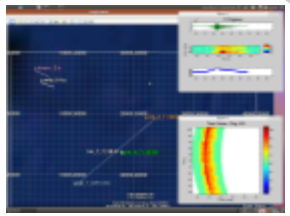
Hardware-in-loop Simulation

Simulation

Bluefin

Hardware-in-loop simulation

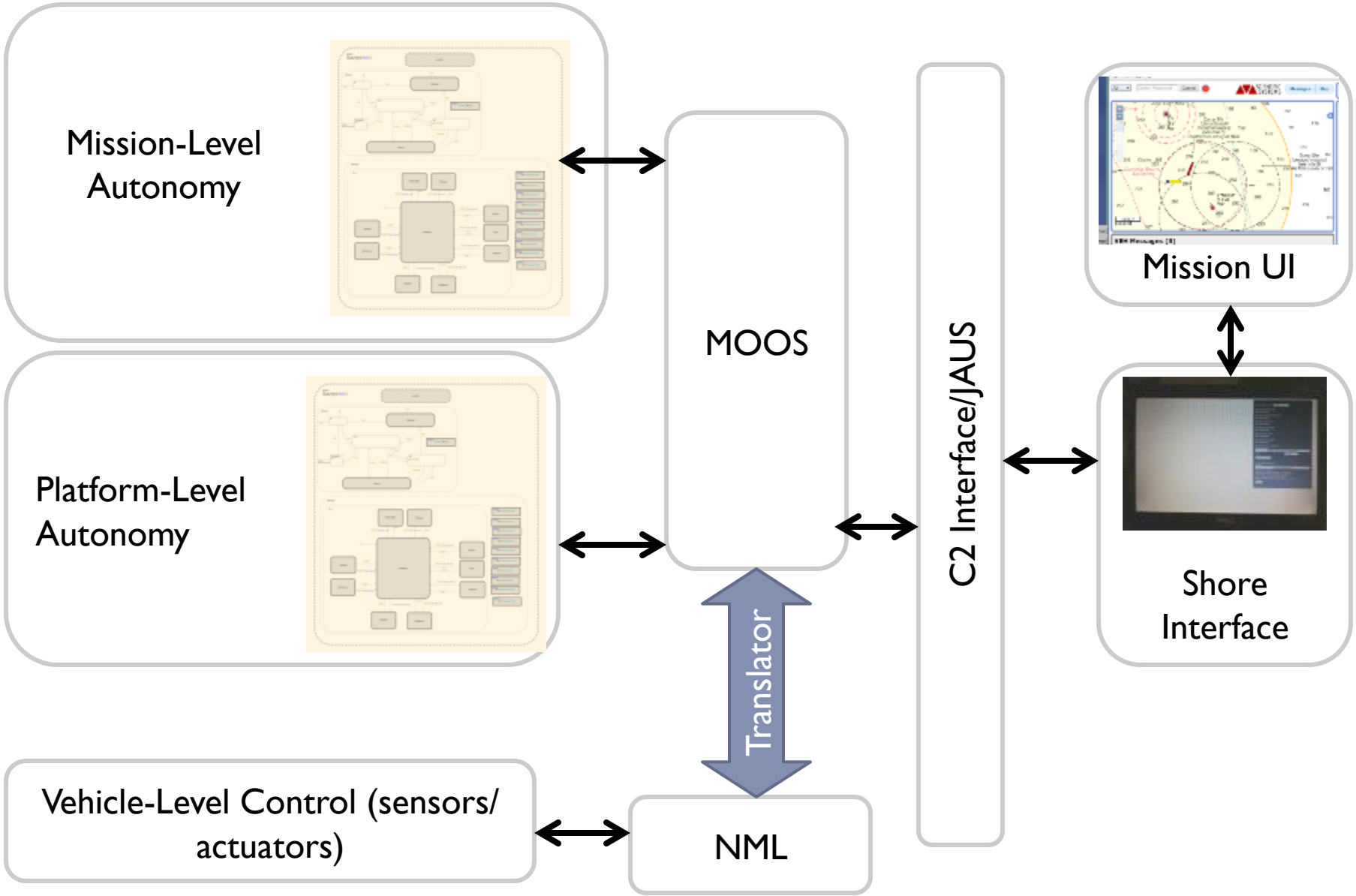
Mission UI



Platform UI

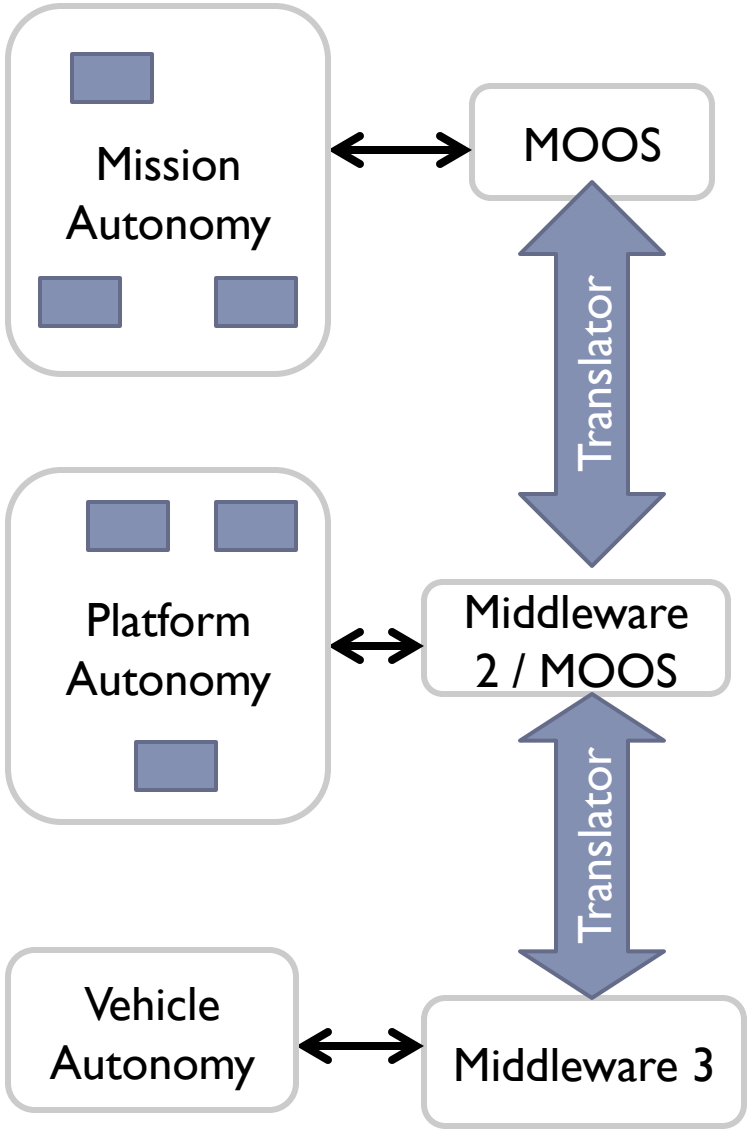
Vehicle UI

MSD System Architecture



Lessons learned so far

- Design for code reuse, but don't go overboard and don't expect anything
  - Every customer/project has significantly different constraints and pre-existing components
  - Arrange components into swappable groups and subgroups, and abstract your layers even if using the same middleware
  - Reuse small cleanly-written code chunks, not necessarily whole modules



Lessons learned so far

SCIENTIFIC SYSTEMS

- Networking takes longer than I expect
  - Teach everyone what a netmask is
  - Bring a couple of different brands of networking equipment
- We like MOOS because it's easy, flexible
  - We're working with others who are using it
  - We've made in-house changes, thanks to it being open-source
  - But it's not the right solution for everyone

autonomy (at) ssci (dot) com

http://www.ssci.com