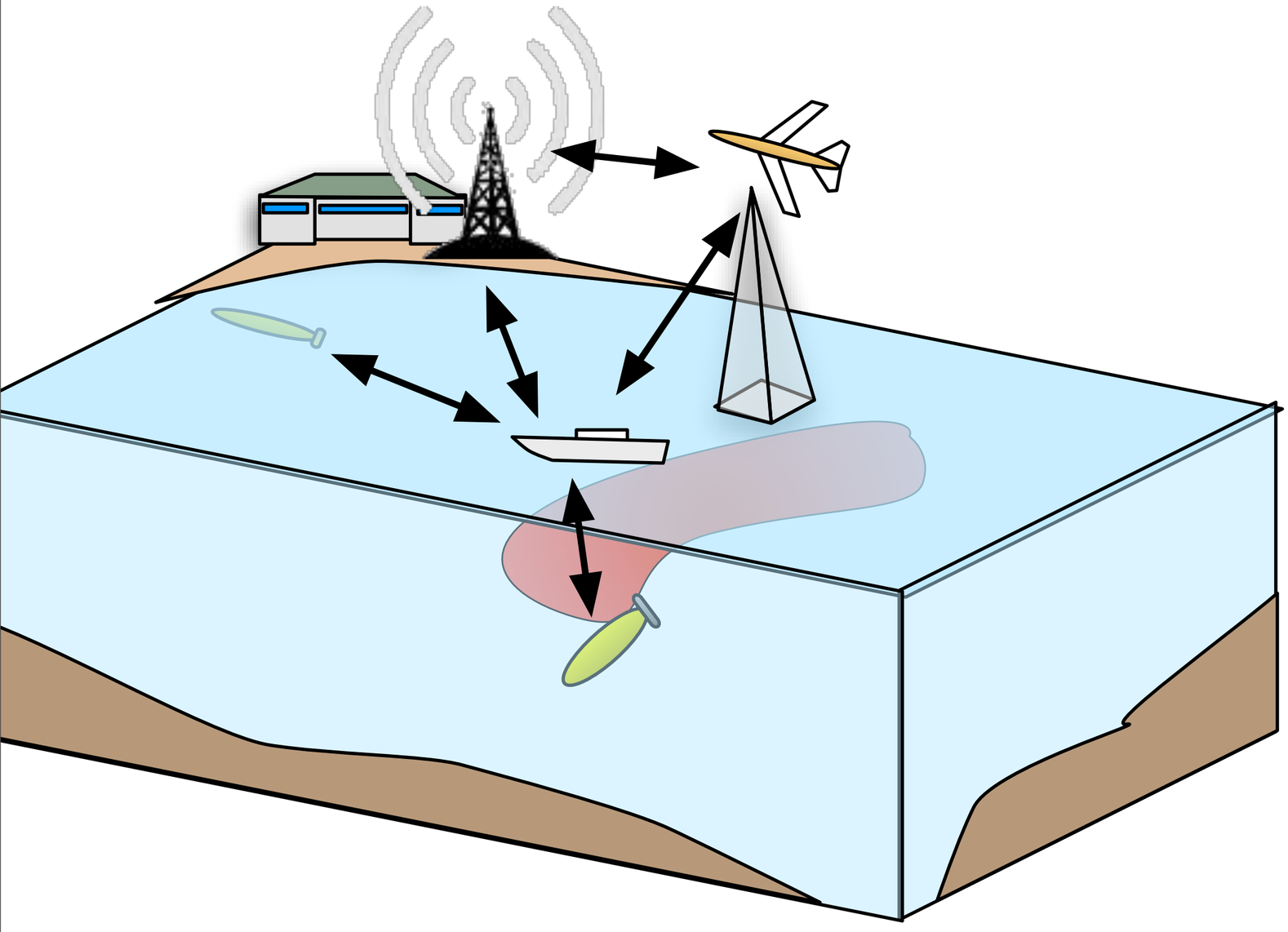
Characteristics for Distributed Autonomous Control for CANON

- Goal oriented commanding
- Hybrid (human/machine) decision making
- Distributed reasoning
- Heterogenous mobile assets
- Poor to limited communication with most assets
- Desk-based synoptic views

CANON: An Overview



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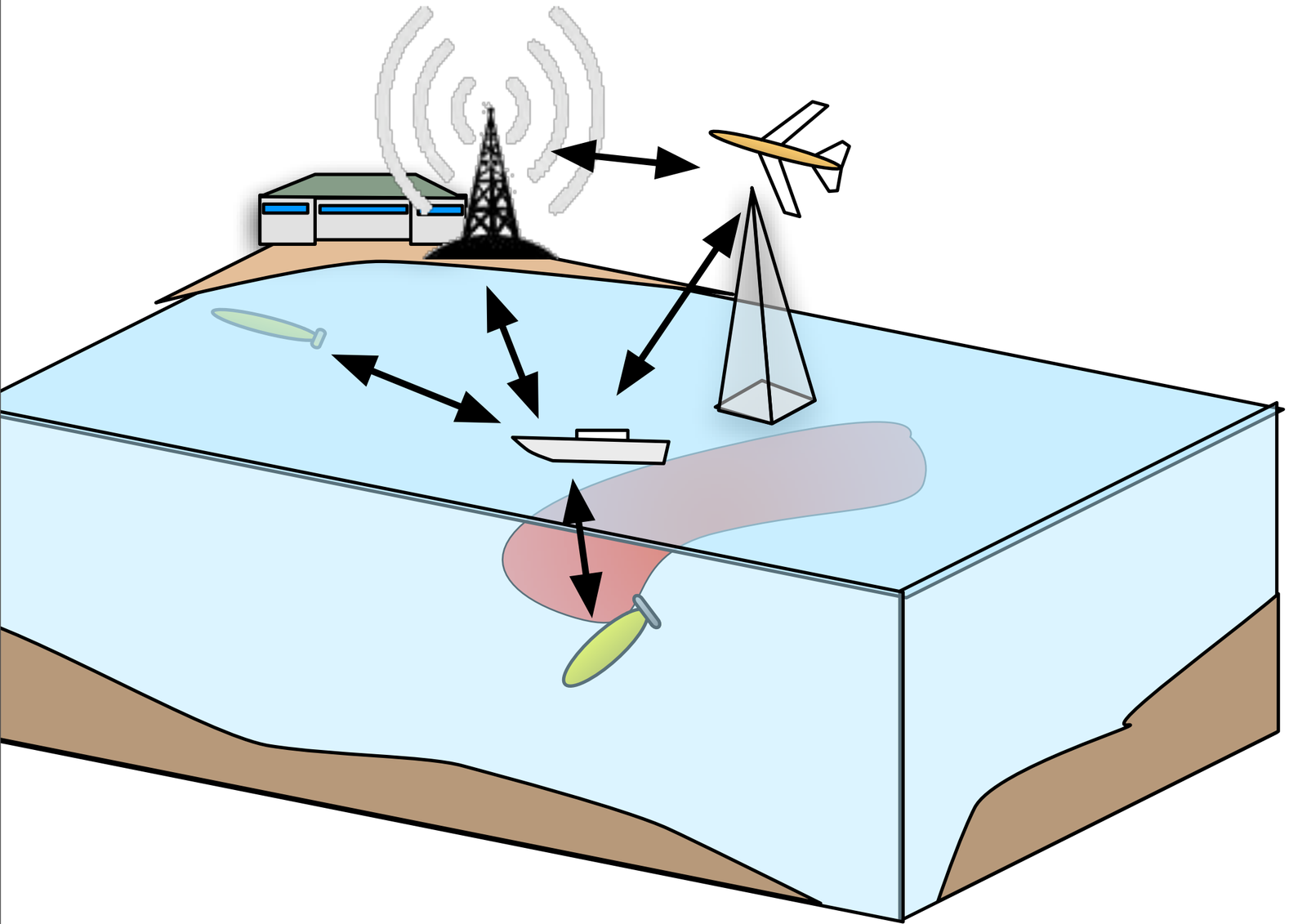
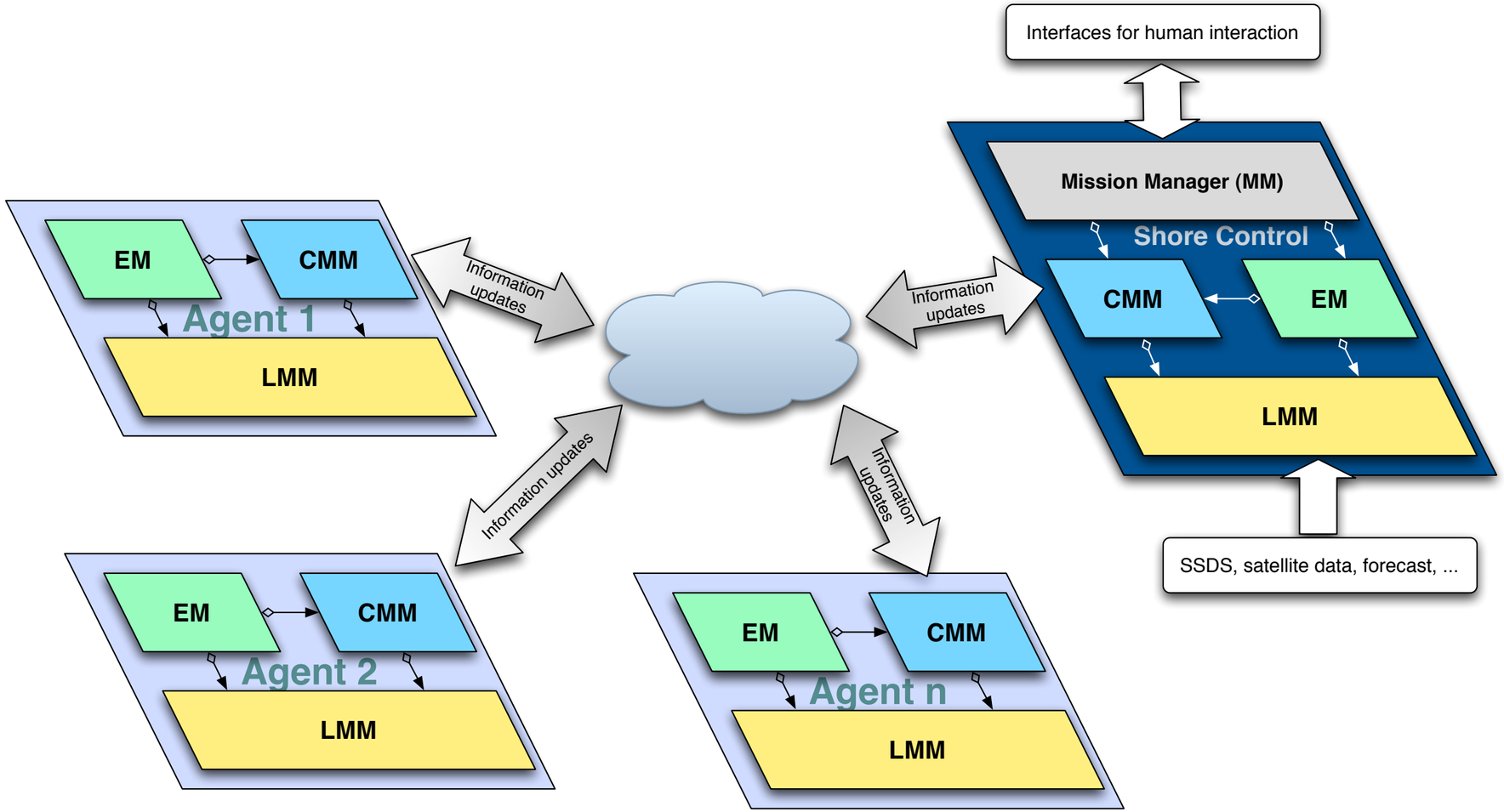


- Information-theoretic control driven by entropy measurements
- Loosely coupled *heterogenous* vehicles
- Each vehicle has onboard plan synthesis capability
- Limited information exchange
- Human as a separate 'agent' brings substantial cognitive capability
- Synoptic views are generated by the fusion of disparate map data, combined with onboard autonomy

Key Technical Challenges

- Representational:
  - How does one provide a compact means to represent a large geographic extant which integrates distributed sensor data available to (nearly) all assets?
  - How is such a formalism keep 'current' given poor comms?
  - How does this tie into the 'belief' of the environmental state/context each asset needs to have and consequently tie its 'local' decision making to the goals of the entire system?
- Computational : How to efficiently compute environmental state 'locally' to ensure some measure of consistency in platform adaptation?
- Adaptive Sampling (with Jim):
  - Where and when should an asset sample to generate the maximum information gain?
  - Where should all the assets be positioned with respect to each other for maximum gain?
- System-wide (with Jim, Z, John):
  - How will the system adapt to failure conditions both locally on specific assets and globally for coordinating critical observations?

Overview of Potential Architecture



- Extending current T-REX framework to include multi-asset control
- Each asset is "smart" on its own; but aided by other assets' view of the environmental context
- Loosely coupled to deal with communication problems
- Inclusion of human-in-the-loop Mixed-Initiative control

EM = Environmental Manager: in-situ stochastic model of feature of interest
CMM = Collaborative Mission Manager: balances when to ask for more information from external source
LMM = T-REX variant for local decision making

How to deal with Representational Sufficiency?

- Use of Entropy based measurements for determining when/where to sample

- Compact vector representational formalism to ensure state updates from other assets are manageable

- Data/Information-centric view (rather than task centric) of control coupled with deliberation

- Combining Entropy measurements with a longer-term view system goals and platform capabilities will likely produce a coordinated response that is graceful in deploying assets, maximal in coverage and adaptive to dynamic events

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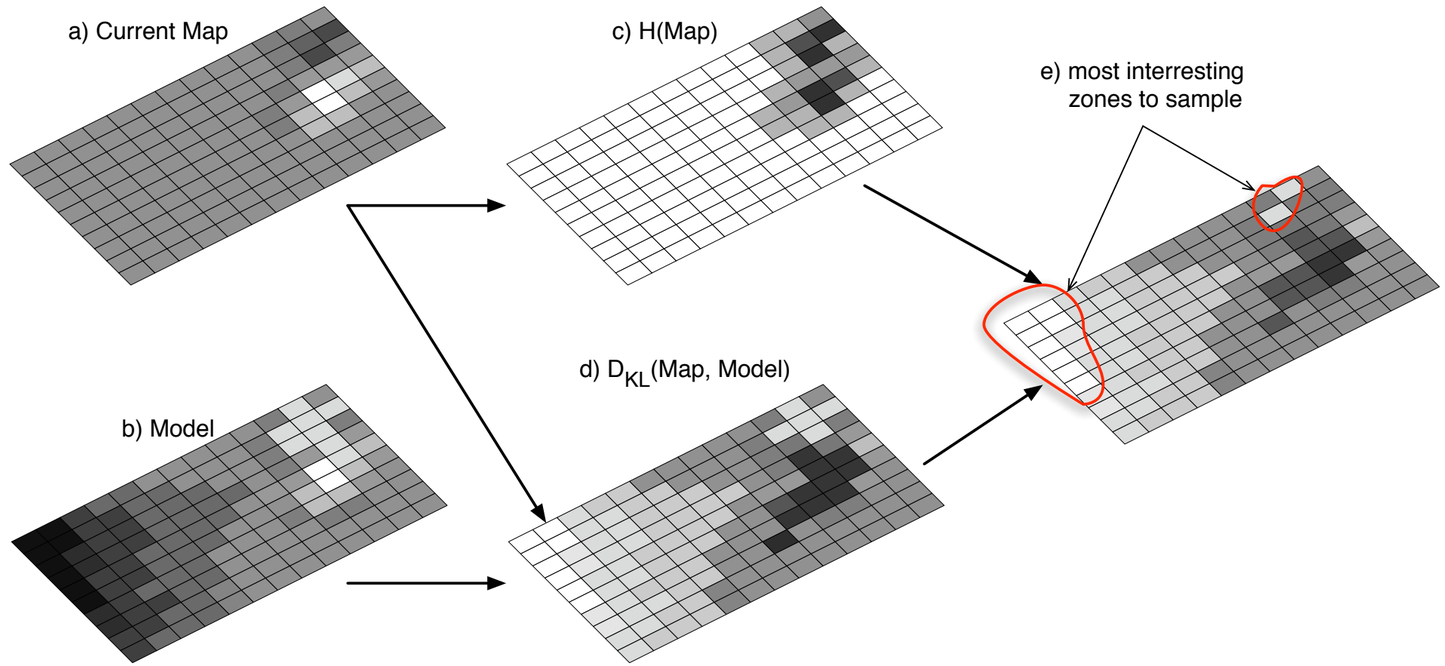

- Synoptic view of the environment could be used to see a view (map) of the feature of interest (a)
- A stochastic model (e.g one from John) would then generate an expectation profile of the feature of interests spatial extant (b)
- Entropy generate known areas explored and a level of expectation of "interestingness"
- A distance/co-variance metric then combines what is known via observations and what the stochastic model generates
- A combined estimate of model driven expectation and anticipated levels of interest potential generates areas of exploration

Potential Collaborators for Autonomy

Gabriel Elkaim, UCSC Computer Eng

- Students, Autonomous Surface Vessel (insured by UC/State), no liability to MBARI
- MBARI summer intern (Elkaim grad. student) works with John and me on getting ASV up, tested and potentially integrated with T-REX

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Other:

- GREX multi-vehicle control at IFREMER/LAAS will use T-REX. PhD student of collaborator visited MBARI for 3 months
- Doug Horner/NPS interested in bringing 2-3 REMUS vehicles with own funds

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