Heterogeneous Group Control
DCIST CRA, RA2

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Autonomous, Resilient, Cognitive, HEterogeneous Swarm (ARCHES)

- Swarm capabilities & task requirements encoded as abstractions
- Group-level autonomy composed from abstractions

**Architectures** (RA2.B1-2):
- Synthesize behaviors and interactions
- New interaction architectures for human engagement
- Diversity of communications strategies.

**Algorithms** (RA2.C1):
- Realize coordination, cooperation & collaboration
Lessons from Biology

The diagram shows a comparison of different species based on group size and specialized roles. The x-axis represents EQ (possibly indicating efficiency or effectiveness), and the y-axis represents group size.

- Ants and Moths are positioned towards the top left, indicating small group size and possibly lower EQ.
- Baboons and Lions are at the bottom right, indicating larger group size and possibly higher EQ.
- Ants and Bees are at the bottom right, indicating smaller group size and possibly lower EQ.
- Humans, Dolphins, Lions, and Hummingbirds are positioned towards the top right, indicating larger group size and possibly higher EQ.
RA2 Outlook

- Homogeneity allows for coordination & cooperation; Heterogeneity allows for “true collaboration”
- Focus is on how to compose and recompose teams or teams of teams of autonomous, human (in a diversity of roles), and computing assets in order to accomplish a mission

Task-driven Planning (Set of Agents pre-defined).
“You go to war with the Army you have.” Online, real-time, deal with attrition.

Team-driven Planning (Set of Tasks predefined).
Designing hierarchies & agents. What traits should the species have? Suited to the way Humans training.
• Heterogeneity of **Traits** in terms of sensing, actuation, computation, communication, locomotion, roles

• **Agents (or Species)** include robots, humans (commanders, peers, bystanders, advisories), computational resources

• **Missions (or Tasks)** might include localization, mapping, object/target ID, ad hoc networking, tactile movements (deliver, amass, scatter, approach, follow, cordon, surveil). *Force Multiplication & Force Protection*

• **Objectives** might include agility, speed, robustness, cost, redundancy, responsiveness
RA2.A1: Abstractions of Task Diversity \((Kumar, \ Egerstedt, \ & \ Hsieh)\)
**Objective:** Develop abstractions of species (particularly non-humans) by decomposing them into a collection of composable traits. [Near term: perimeter defense, resilient comms]

RA2.A2: Modeling Human Traits \((Chernova, \ Christensen, \ Egerstedt, \ Shah)\)
**Objective:** Develop abstractions of composable human traits, which accommodate general and evolving individualized profiles. [Near-term: shared human/non-human control and role discovery]

RA2.A3: Composable Autonomy in Heterogeneous Groups \((Egerstedt, \ Ayanian, \ Hsieh \ & \ Kumar)\)
**Objective:** Develop means of mapping high-level mission requirements to abstractions (traits) used to synthesize action plans & task requirements. [Near term: target scenario]
RA2.B1: Human-Agent Collaborative Control of the Swarm (Shah, Bassett, Chernova, Egerstedt, & Tsiotras)

Objective: Interaction architecture that makes large scale swarms amenable to human control in dynamic, stochastic, and partially observable environments. [Near term: human data from use cases]

RA2.B2: Heterogeneous Hierarchical Autonomous Networks (Ribeiro, How, & Hsieh)

Objective: Develop the tactical cloud through the exploitation of heterogeneous communications strategies & computing capabilities. [Near term: test-bed definition and development]
RA2.C1: Task Assignment *(Hsieh, Ayanian, Chernova, Kumar & Shah)*

**Objective:** Given a formal framework of trait models, develop algorithms to realize coordination, collaboration, & cooperation b/t heterogeneous agents. [Near term: Cost metrics and connection to motivating scenarios]
RA2: To Conclude

Heterogeneous robots

Different roles

People and robots