June, 2013

The Multi-Tier Mission Architecture and a Different Approach to Entry, Descent and Landing

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Available at: https://works.bepress.com/jeremy_straub/121/
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Overview

- Traditional Mission Approach
- Multi-Tier Mission Approach Overview
- Progressing Interest Creates Progressive Commitment
- Selection of Targets
- Iterative Deployment
- Data Collection and Goal Refinement
Introduction

- The Multi-Tier Autonomous Mission Architecture (MTAMA) is an alternate approach to mission design that necessitates changes in all phases of a mission.

- It is an extrapolation of work in several areas:
  - Fink’s “Tier Scalable” Mission Architecture\(^1\)
  - Sensorwebs
  - Work on collaboration between robots with heterogeneous capabilities
Traditional Mission Approach

- Well planned out
  - Mission science targets are key drivers to mission design, generally most (all) targets are known before launch
  - Changes may occur due to the unexpected: vehicle failure, terrain issues, etc.
  - These changes are generally negative …

- Additional targets of interest may be added if the vehicle survives beyond its planned mission duration
Multi-Tier Mission Approach

Overview

- With a multi-tier mission, science goals are identified – not specific locations where these goals must be satisfied.
- For a planetary mission, the spacecraft arrives at the planet and conducts an initial survey.
- Based on this survey, aerial and/or ground craft are tasked to locations where it is predicted that the best change of meeting science objectives exists.
What is MTAMA?

Characterized by:

- Autonomous mission – controllers define goals, not tasks
- Low-level decision making – decisions are made as close to the performance of the work as possible
- Management by exception – craft and the mission are allowed to proceed unless an exception condition occurs. Exceptions are asserted by the node that identifies them.
- Limited staffing needs, as compared to traditional style missions
- Multiple Craft
Partial MTAMA

- Some technical capabilities required for a completely autonomous mission (for some mission types) are still under development.

- Partial implementations of the MTAMA concept can be conducted:
  - Limited tier involvement
  - Limited autonomy
  - More controller involvement
Benefits of MTAMA

- Lower cost
- Mitigates risk of mission failure via the use of multiple craft
- Craft can take greater risks in the pursuit of data as craft failure doesn’t equate to mission failure
- Potential to conduct multiple concurrent (perhaps synergistic) investigations
- Potential for multiple missions to collaborate, sharing resources
Progressing Interest Creates Progressive Commitment

Typical Survey

Adaptive Survey
Decision Making Process

1. Tasked with Goal
2. Identify Sub-Goals
   - FOR EACH SUB-GOAL
     - Delegate Sub-Goal?
       - Yes
         - Delegate to Where?
         - Yes
           - Identify Target
           - Delegate Sub-Goal
         - No
       - No
         - Identify Tasks
         - Order of Tasks?
         - Task List to Execute
Selection of Targets
Decision Making

1. Difference Current vs. Previous
   - Value
   - Likelihood
   - Projected Value

2. Results of Previous Similar Actions
   - Cost of Previous Similar Actions
   - Attributed Cost
   - Summed Cost of All Data Collection for Rule

3. Difference Current vs. Previous
   - Other Rules That Can Use Data
   - For Each Data Element (Fact) Required

Value as Function of Cost Units
Iterative Deployment

- Craft are deployed upon their first use.
- Deployment considers both immediate need and cost of flexibility (not being able to deploy) to the mission.
- Fink\(^1\) had proposed orbital deploying aerial deploying ground; however, other scenarios are possible.
Data Collection and Goal Refinement
Multiple Collection Approaches
Collection Utility Assessment
An approach to mission flexibility through adaptive deployment of craft has been presented.

This approach can reduce mission cost, through autonomy, and increase science benefits.

There remains much that is require to bring this mission type to fruition.
Thanks & Any Questions

Figures sourced from: Straub, J. 2013. A Localized Autonomous Control Algorithm for Robots with Heterogeneous Capabilities in a Multi-Tier Architecture