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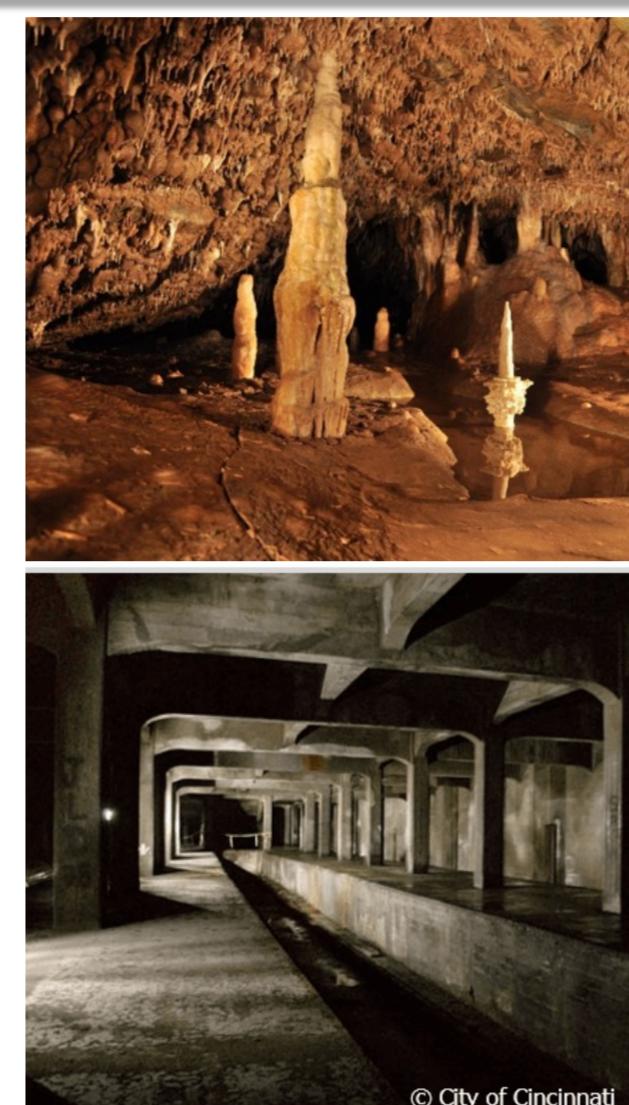
# PLGRIM: Hierarchical Value Learning for Large-scale Autonomous Exploration in Unknown Environments

Sung-Kyun Kim\*<sup>1</sup>, Amanda Bouman\*<sup>2</sup>, Gautam Salhotra<sup>3</sup>, David D. Fan<sup>1</sup>,Kyohei Otsu<sup>1</sup>, Joel Burdick<sup>2</sup>, Ali-akbar Agha-mohammadi<sup>1</sup><sup>1</sup> NASA-Jet Propulsion Laboratory, <sup>2</sup> California Institute of Technology, <sup>3</sup> University of Southern California

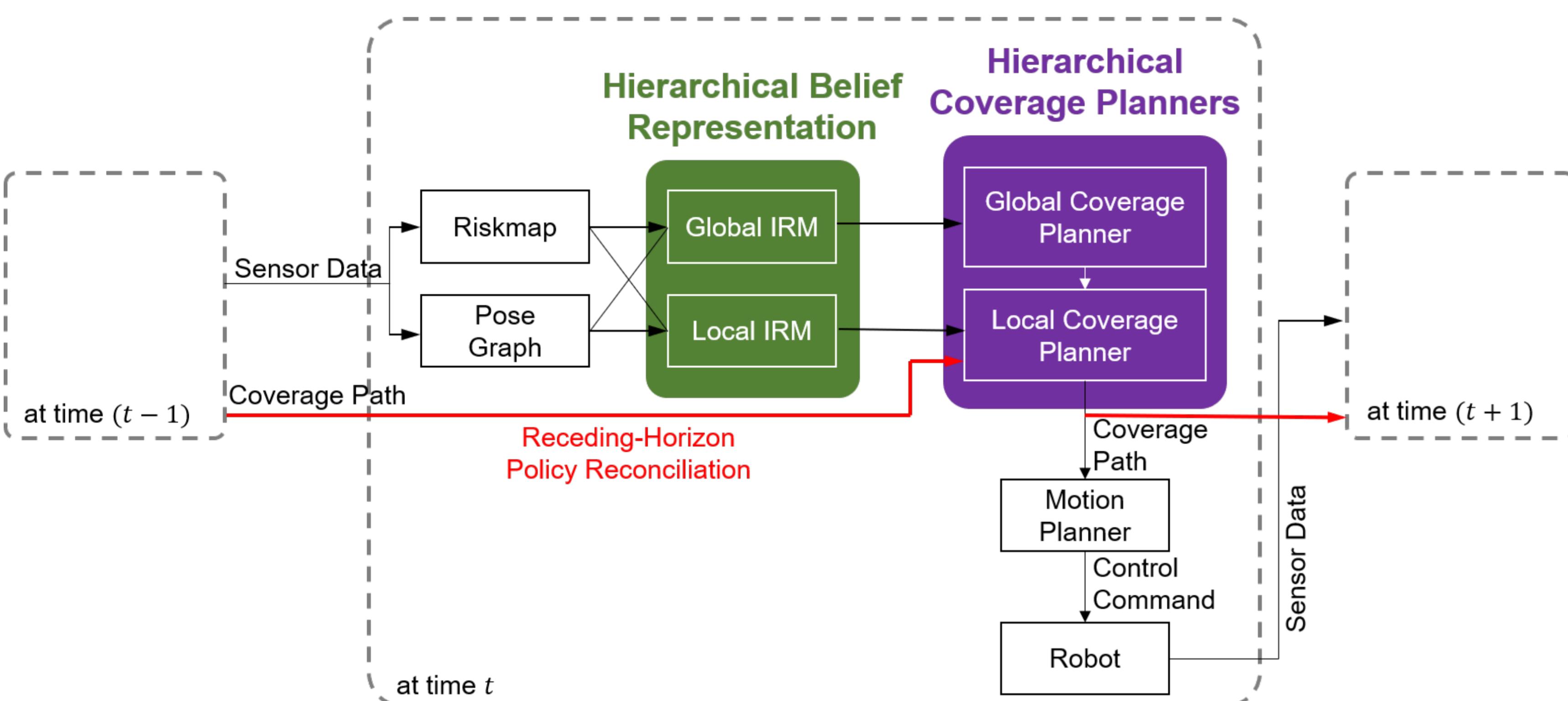
## Problem Description

**Exploration of an unknown, large spatial (>1 km) environment with complex terrain over long temporal horizon (>1 hr):**

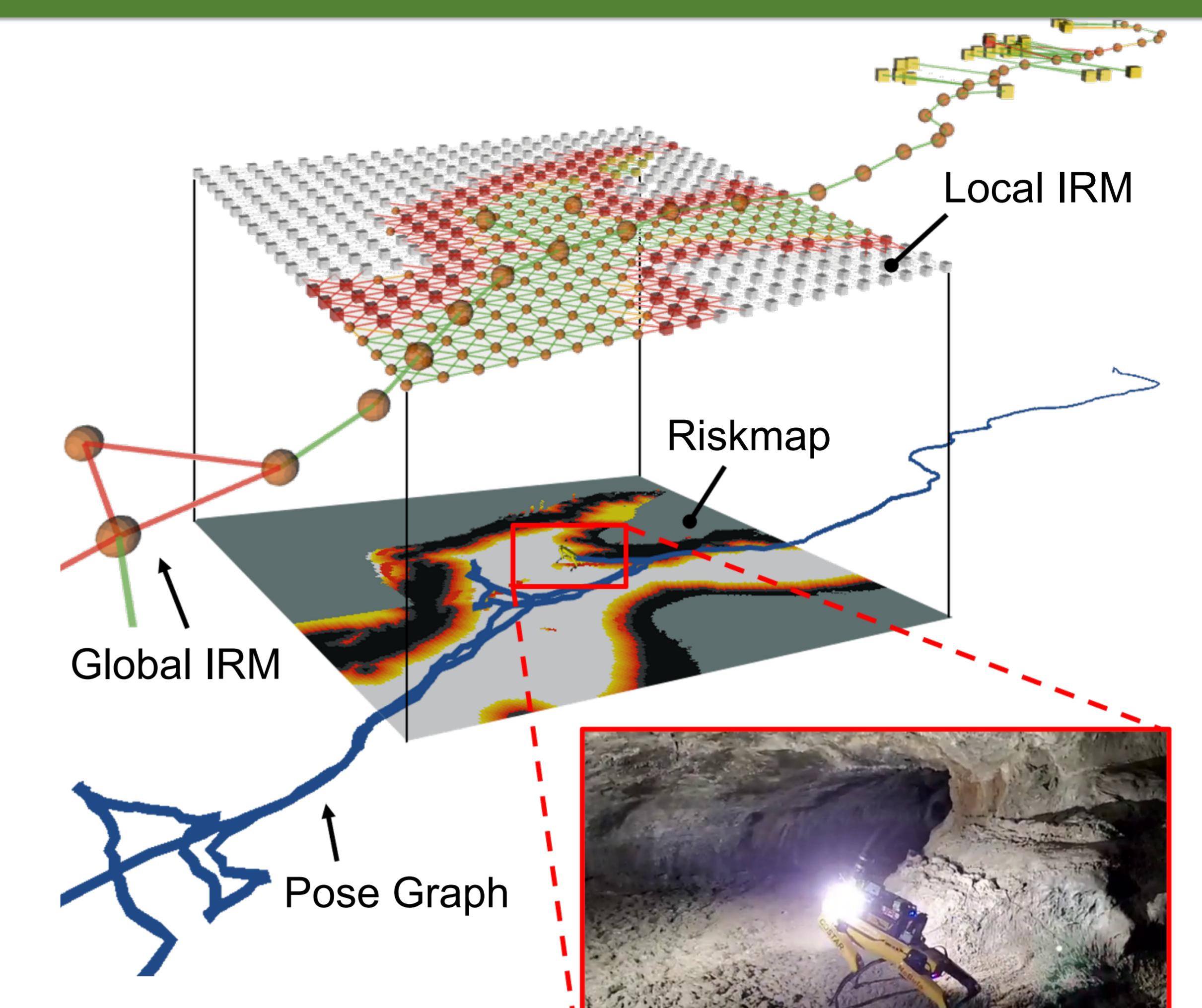
- Requires policy construction over belief space to account for traversability and motion uncertainty. However:
  - Belief space planning suffers from severe computational challenges.
  - Policies must adapt to unexpected changes in belief at runtime.
- We propose a hierarchical POMDP framework - **PLGRIM** (Probabilistic Local and Global Reasoning on Information roadMaps).



## PLGRIM Architecture



## Hierarchical Belief Representation



World Belief is decomposed into **Information Roadmaps (IRM)**:

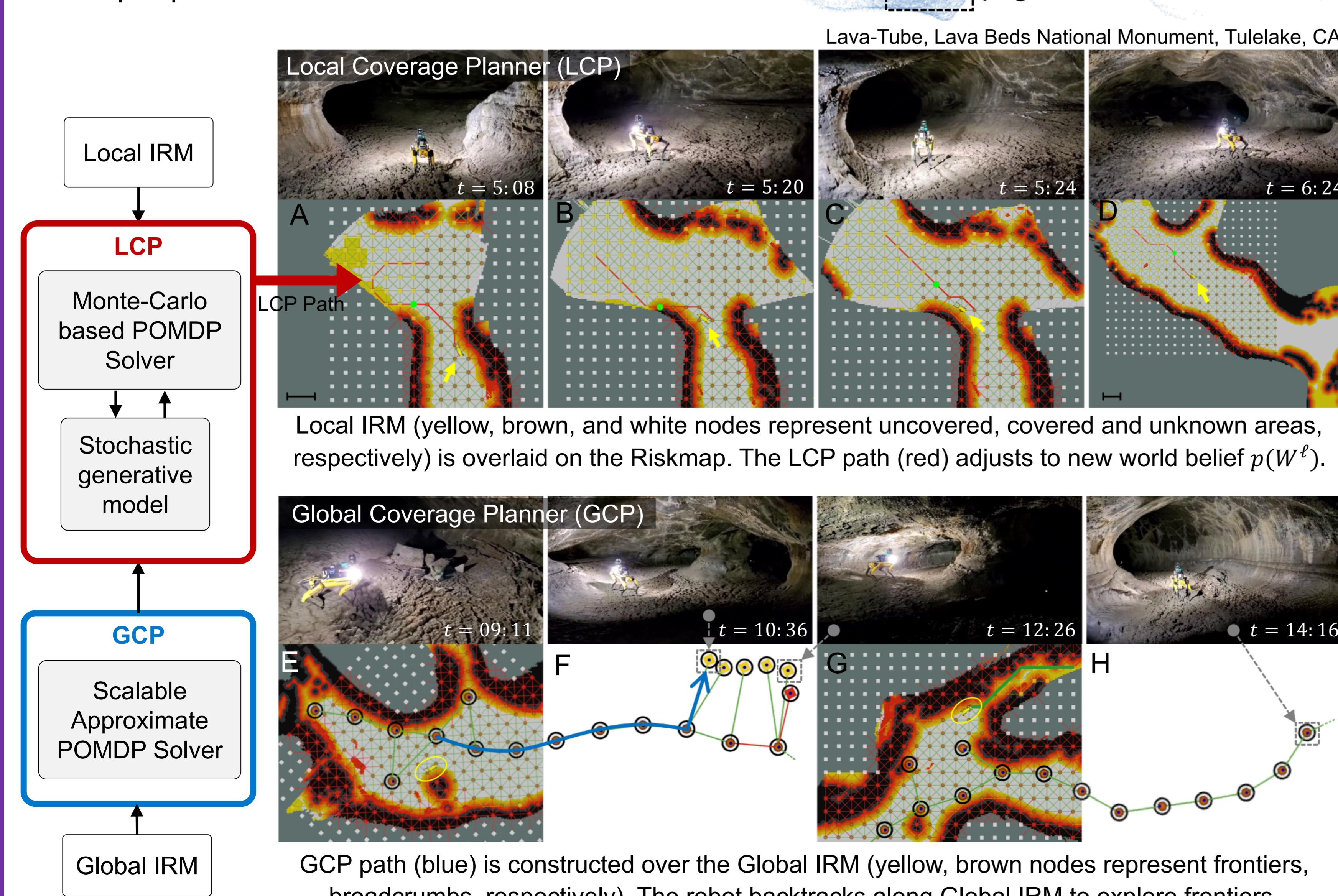
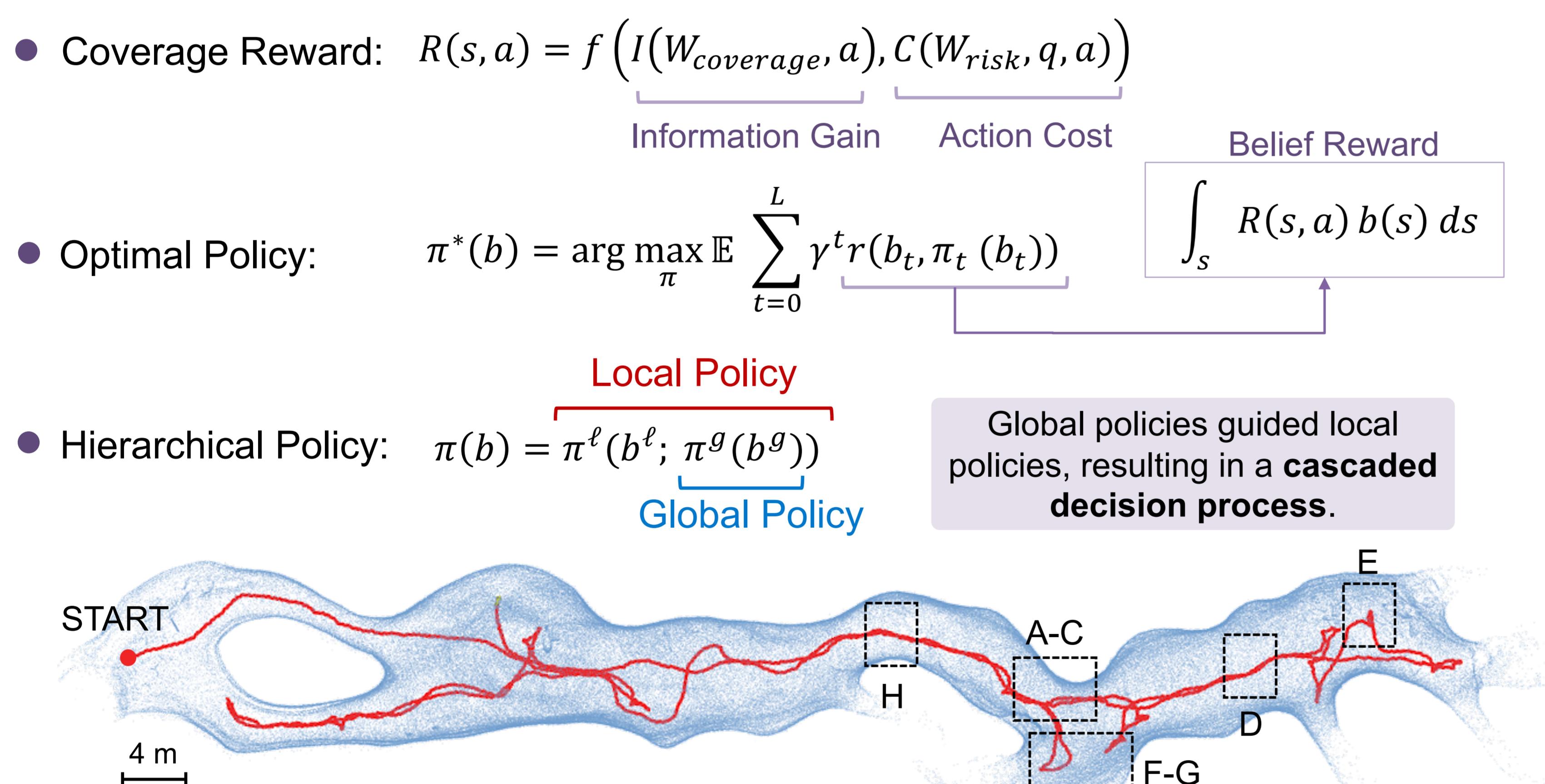
Local IRM  $p(W^\ell)$ : robot-centric, rolling, high-fidelity world belief.

Global IRM  $p(W^g)$ : unbounded, approximate world belief.

Local Belief State:  $b^\ell = p(q, W^\ell)$ ,

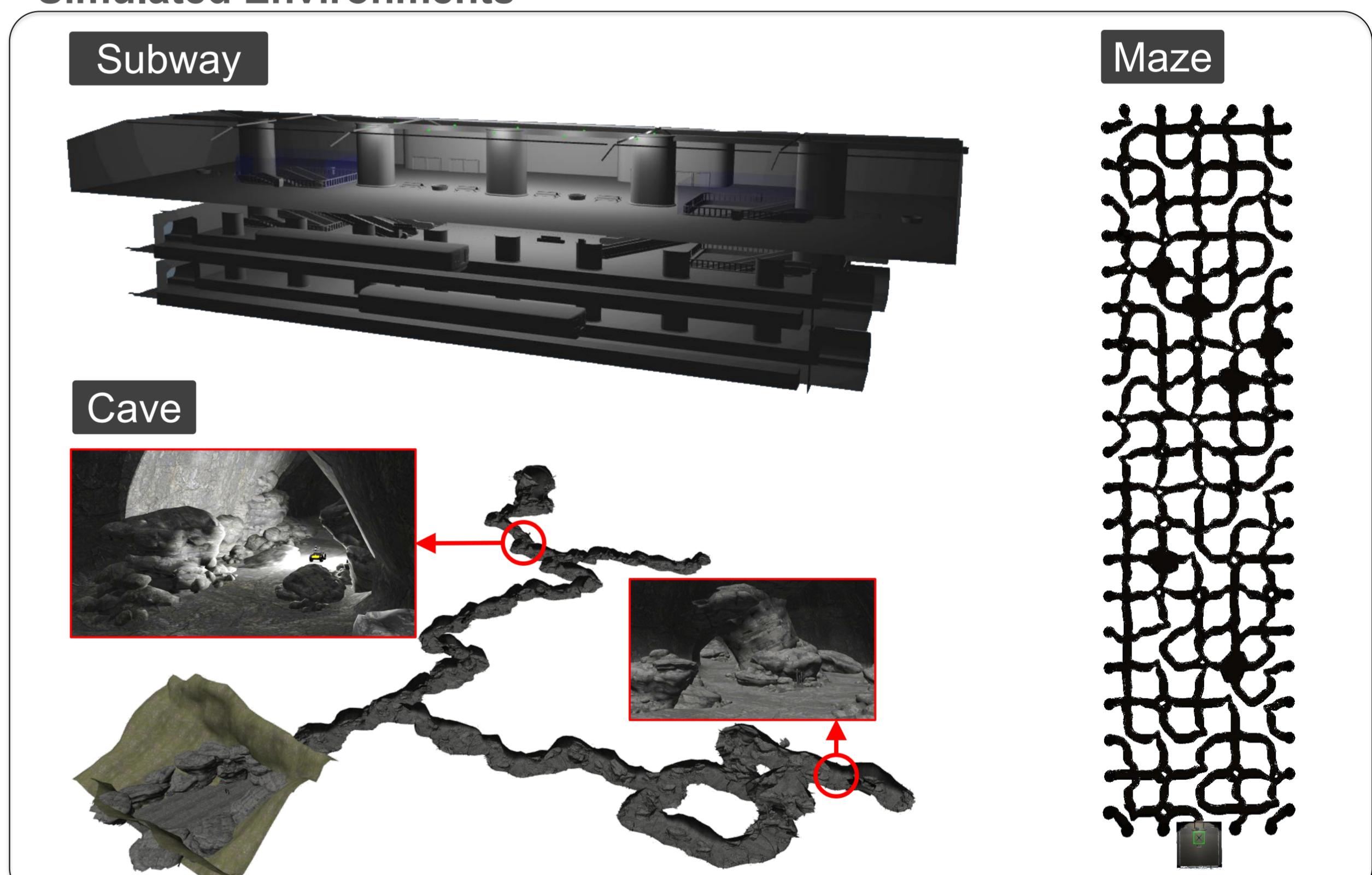
Global Belief State:  $b^g = p(q, W^g)$ , where  $q$  is the robot state.

## Hierarchical Coverage Planners

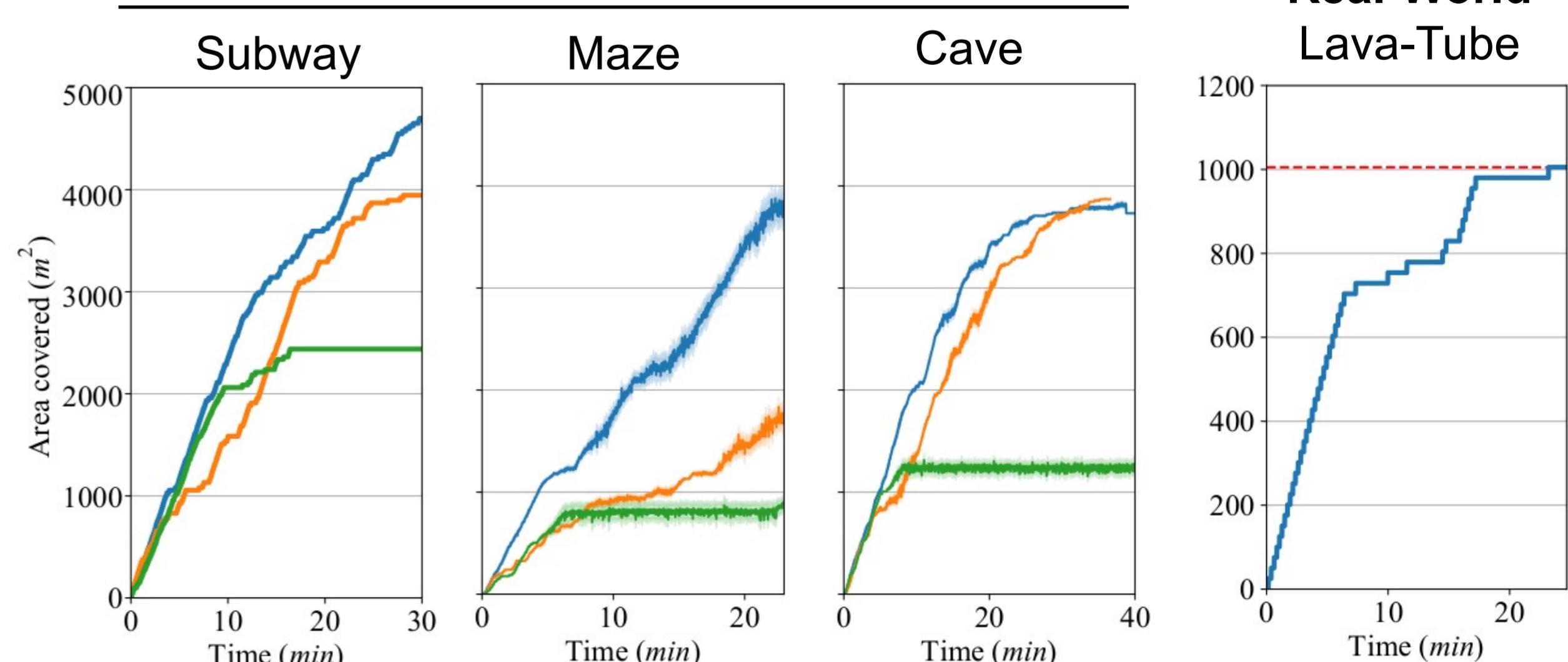


## Experimental Results

### Simulated Environments



### Simulations



<b>Next-Best-View (NBV)</b>	Local, High-fidelity World Representation • Myopic • Sparse Policy Space • Deterministic
<b>Hierarchical Frontier-based Exploration (HFE)</b>	Global, Low-fidelity World Representation • Myopic • Sparse Policy Space
<b>PLGRIM</b>	Global, Varying-fidelity World Representation • Long-horizon • Uncertainty-aware

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