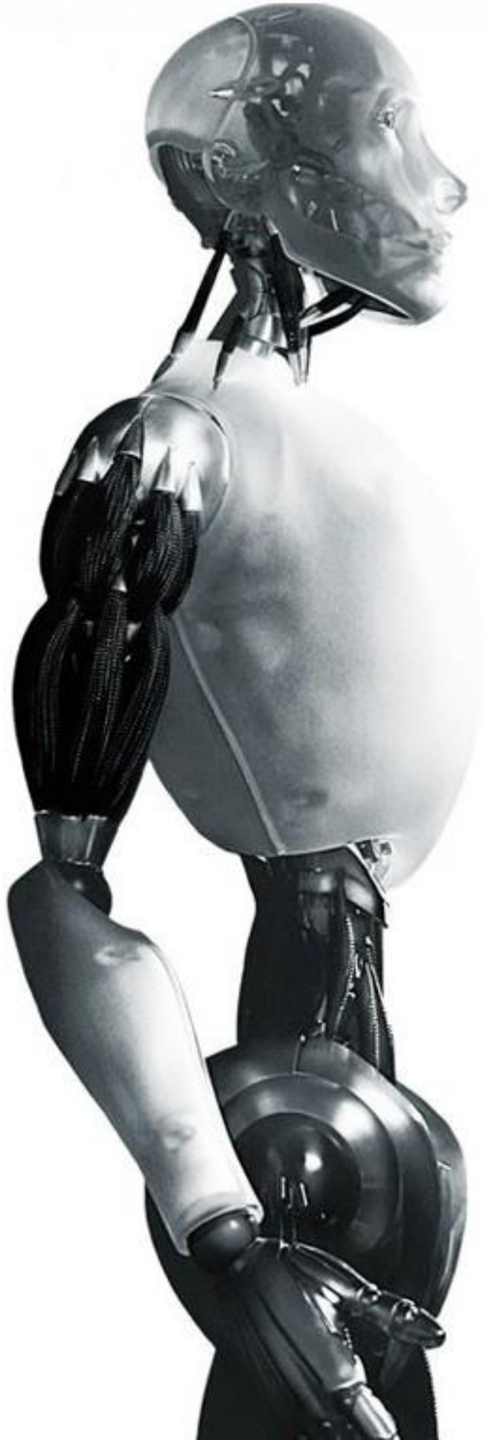
Disclaimer

These slides are intended as presentation aids for the lecture. They contain information that would otherwise be to difficult or time-consuming to reproduce on the board. But they are incomplete, not self-explanatory, and are not always used in the order they appear in this presentation. As a result, these slides should not be used as a script for this course. I recommend you take notes during class, maybe on the slides themselves. It has been shown that taking notes improves learning success.

Reading for this set of slides

- Planning Algorithms (Steve LaValle)
  - 4 The Configuration Space (4.1 – 4.3)
  - 5 Sampling-based Motion Planning (5.1, 5.5, 5.6, also skim the remaining sections)

Please note that this set of slides is intended as support for the lecture, not as a stand-alone script. If you want to study for this course, please use these slides in conjunction with the indicated chapters in the text books. The textbooks are available online or in the TUB library (many copies that can be checked out for the entire semester. There are also some aspects of the lectures that will not be covered in the text books but can still be part of the homework or exam. For those It is important that you attend class or ask somebody about what was covered in class.



Robotics

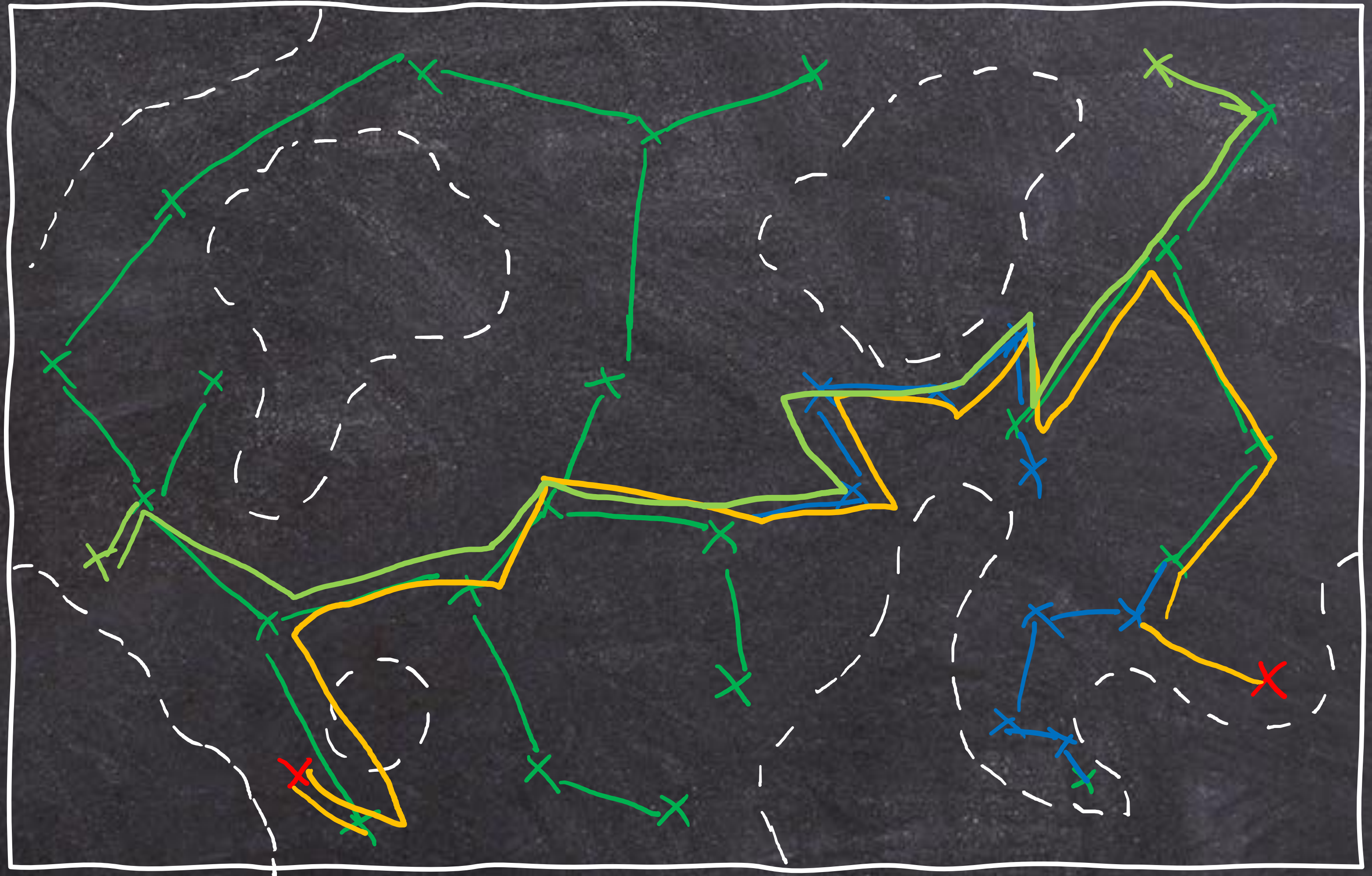
Sampling-based Motion Planning:
Probabilistic Roadmap Methods (PRMs)

TU Berlin

Oliver Brock

PROBABILISTIC ROADMAP (PRM) PLANNER MULTI-QUERY

CONSTRUCT R = (V, E) EXPANSION QUERY



$q \overset{?}{\in} C_{FREE}$ → YES / NO

COLLISION CHECKER

Probabilistic Roadmap Planner

- Roadmap Construction
  - Generate random configurations
  - Eliminate if they are in collision
  - Use local planner to connect configurations into a roadmap
- Expansion
  - Identify connected components
  - Resample gaps
  - Try to connect components
- Query
  - Connect initial and final configuration to roadmap
  - Perform graph search

Learning

Lydia Kavraki

Learning Phase

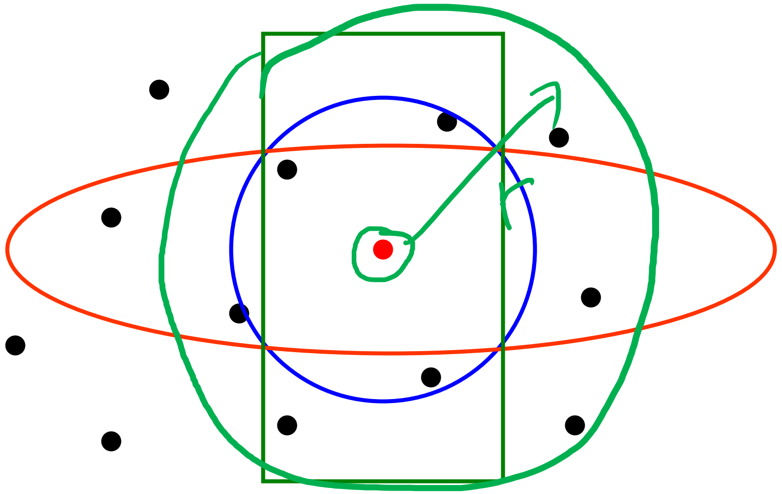
- Construction
  - $R = (V,E)$
  - repeat n times:
    - generate random configuration
    - add to V if collision free
    - attempt to connect to *neighbors* using *local planner*, unless in same connected component of R
- Expansion
  - repeat k times:
    - select *difficult* node
    - attempt to connect to neighbors using *another local planner*

Query

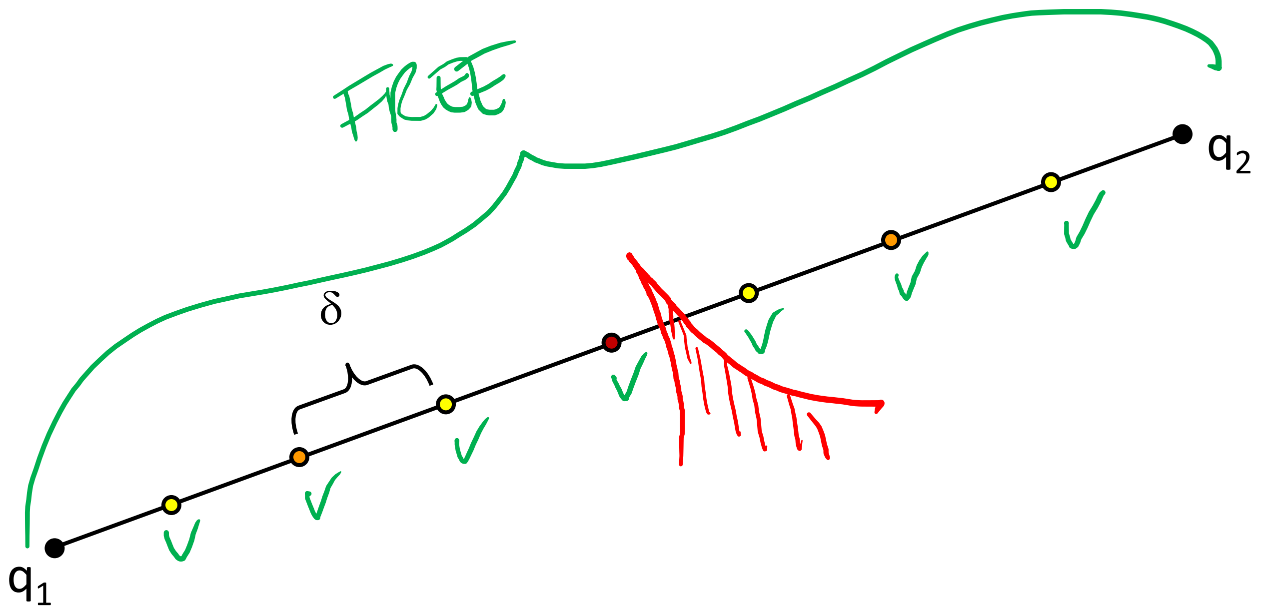
- Connect start and goal configuration to roadmap using local planner
- Perform graph search on roadmap
- Computational cost of querying neclegible compared to construction of roadmap

Neighbors TO BUILD GRAPH

- Use distance metric to determine neighbor
- Euclidian distance oftentimes used r
- Others possible:
  - maximum Euclidian distance
  - maximum joint difference

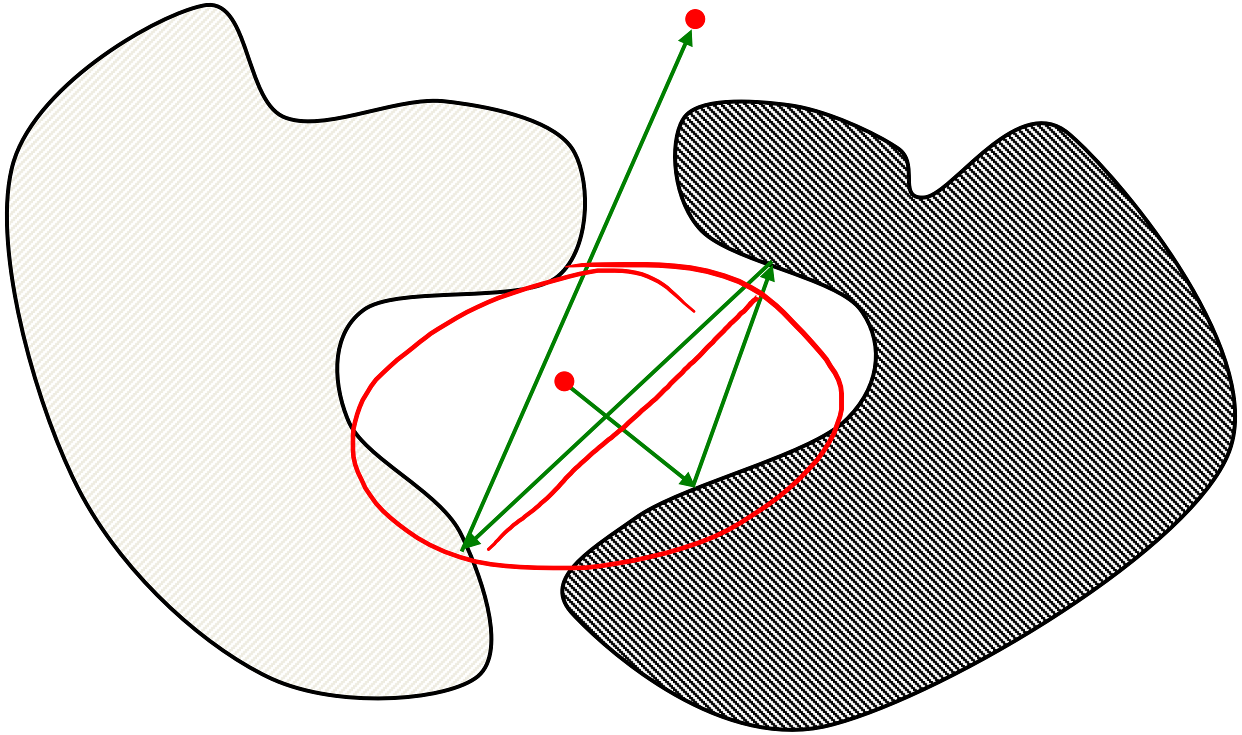


Simple Local Planner



tests up to a specified resolution δ!

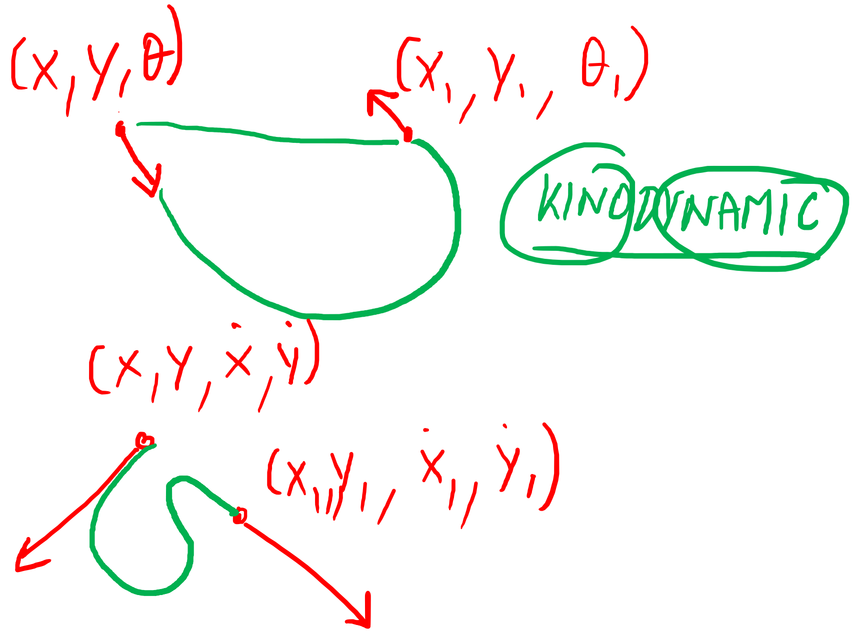
Another Local Planner



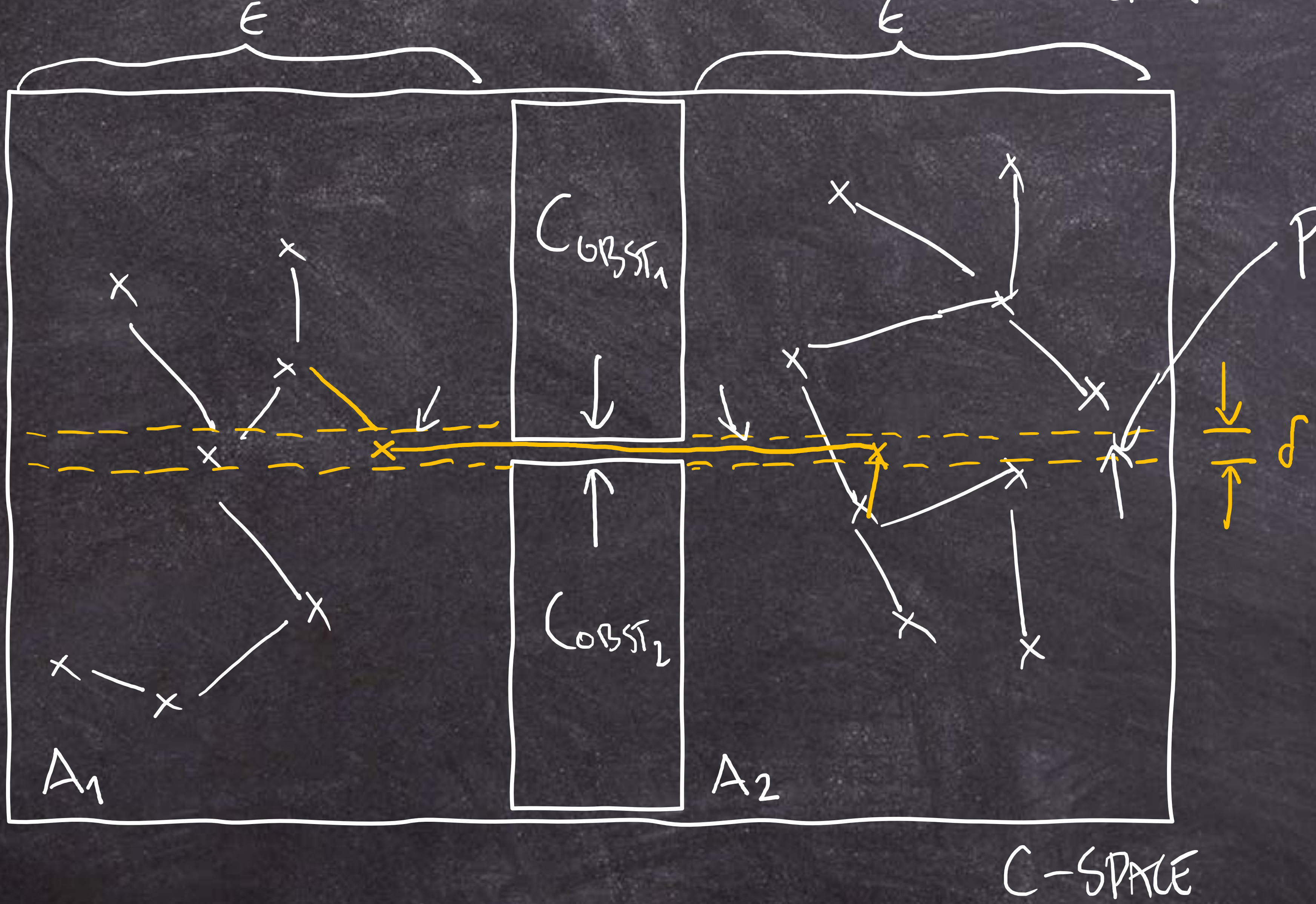
perform random walk of predetermined length;
choose new direction randomly after hitting obstacle;
attempt to connect to roadmap after random walk

PRM Limits Local Planners

- Consider car-like robot
- Connecting configurations might be difficult
- Goal: provide probabilistic method for kinematic and dynamic constraints
  - Car-like
  - Satellite
  - Plane
- Idea: Let local planner choose configurations



NARROW PASSAGE PROBLEM



$$P(s_{\text{HERE}}) = \frac{\delta \cdot \epsilon}{A_2}$$

Summary: PRM

- Algorithmically very simple
- Surprisingly efficient even in high-dimensional C-spaces
- Capable of addressing a wide variety of motion planning problems
- Probabilistically complete
- Multi-query
- **BUT: narrow passage problem!**