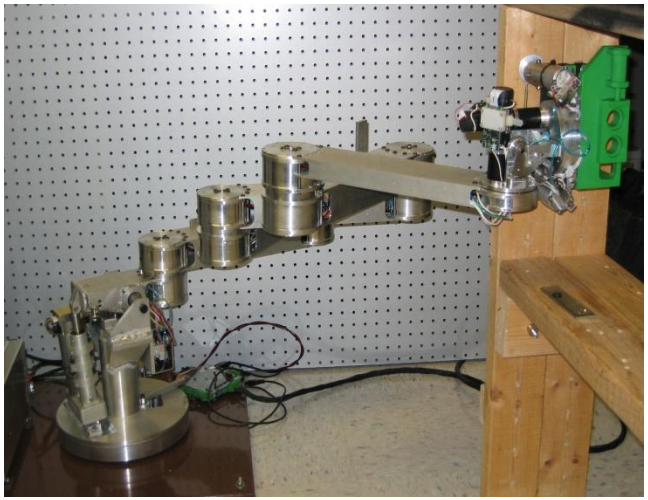
Howie Choset

http://biorobotics.org

THE ROBOTICS INSTITUTE

Free Crawling Snake Robots

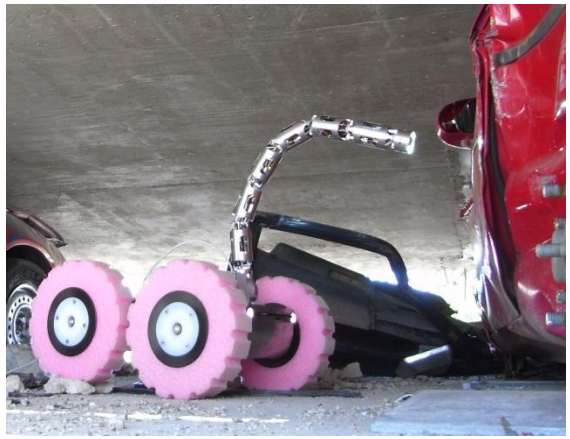


Manufacturing in Confined Spaces

Basic Research

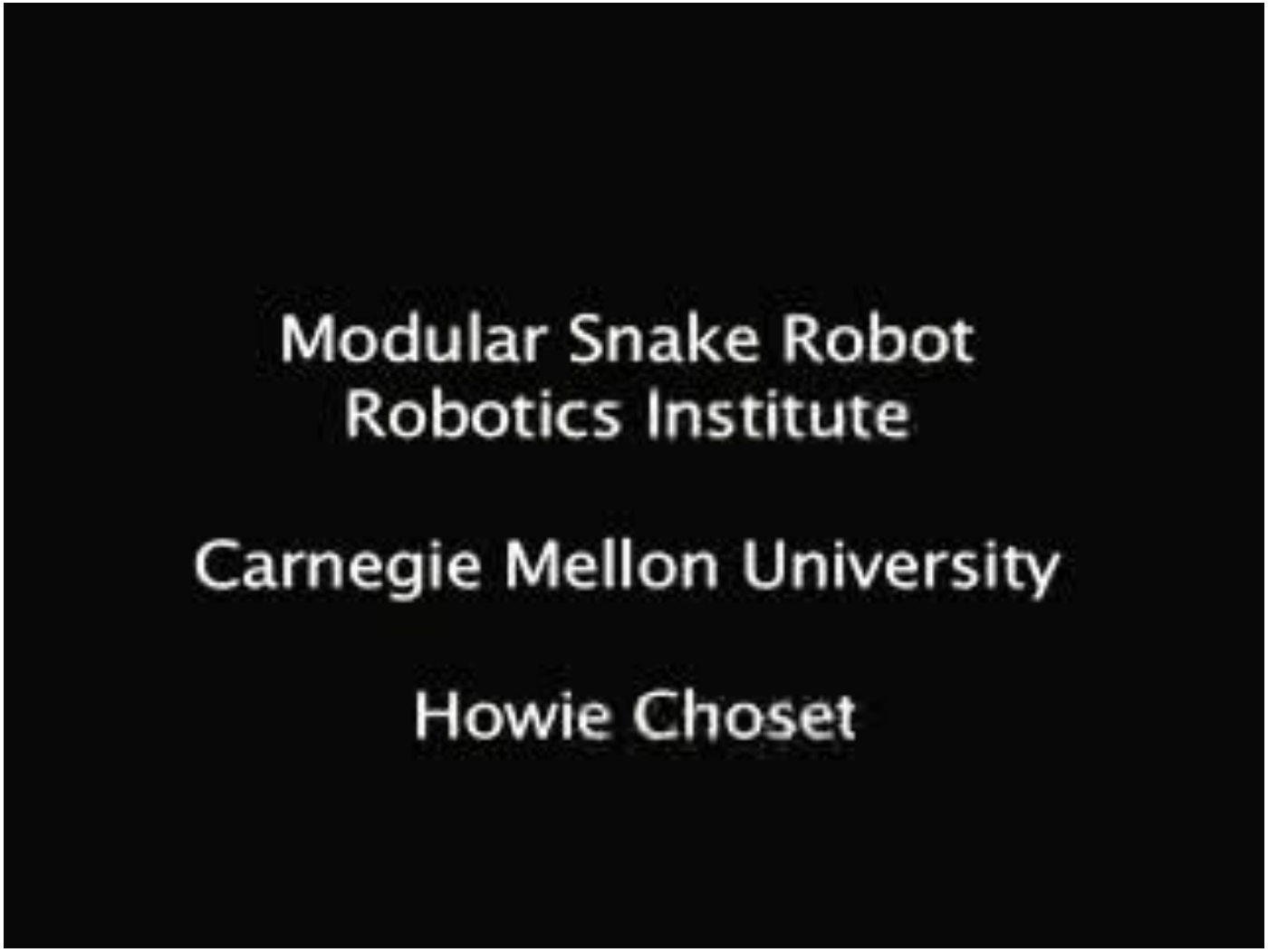
Mechanism Design: snakes, climbers, spiders
Path Planning: Topology, Multi-robot (fast)
Motion Planning: Snakes, swimmers, runner
Estimation: SLAM, Body pose, Multi-robot

Hybrid Control/Estimation: tie together

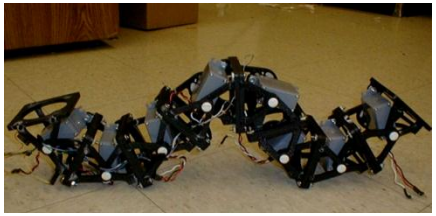
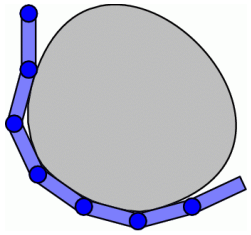


Mobile Base Trunkbot

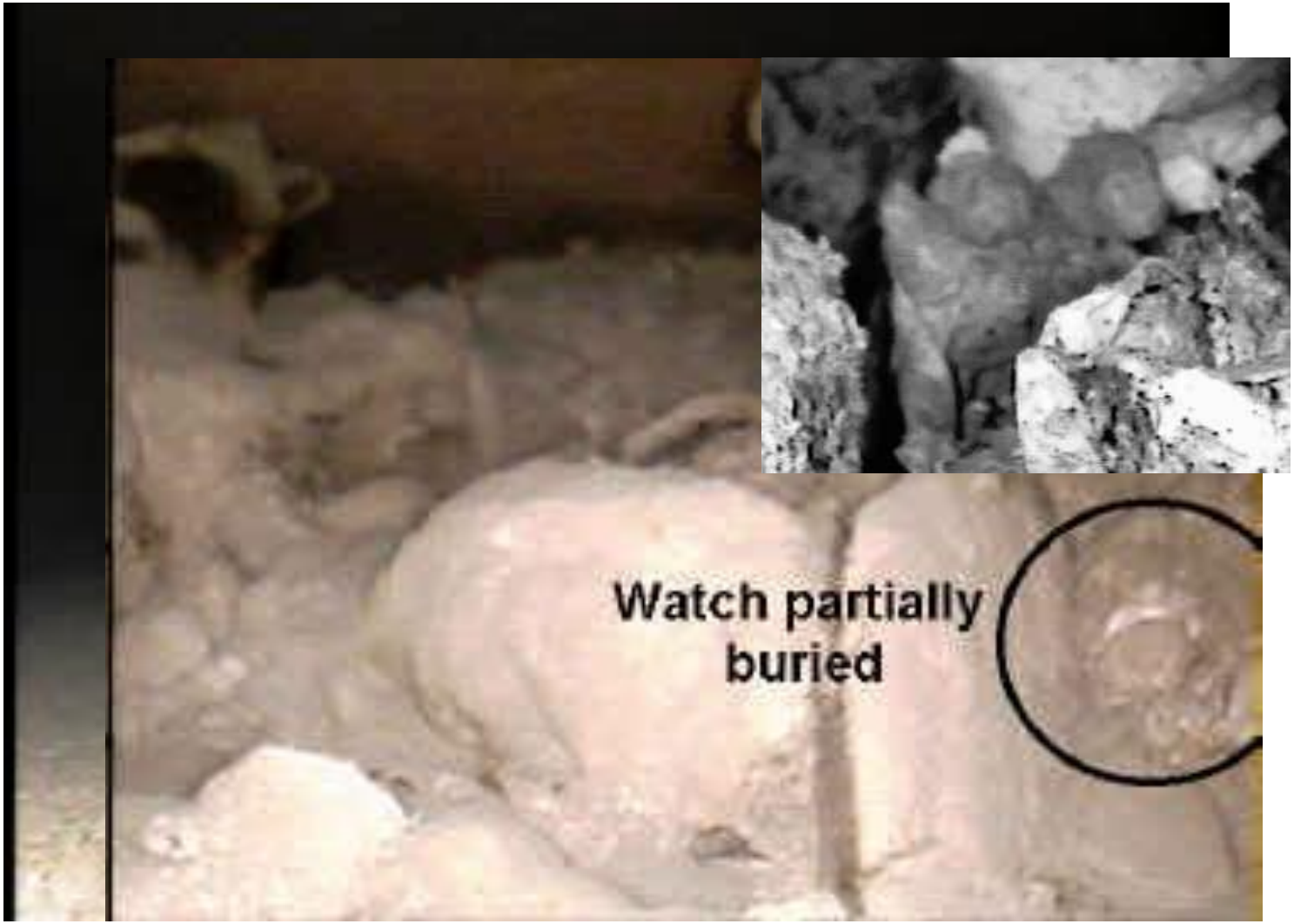
Snake Robots



Hyper-redundant Mechanism

	Mobile-trunk	Free-crawling	Manipulation
Biology			 
Robotic			
Research	Path Planning Estimation/SLAM	Geometric Mechanics Gait generation Hybrid Controls	Climbing Distributed Manipulation

Search and Rescue

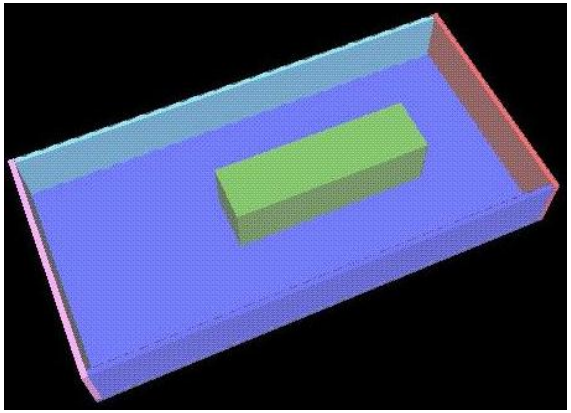


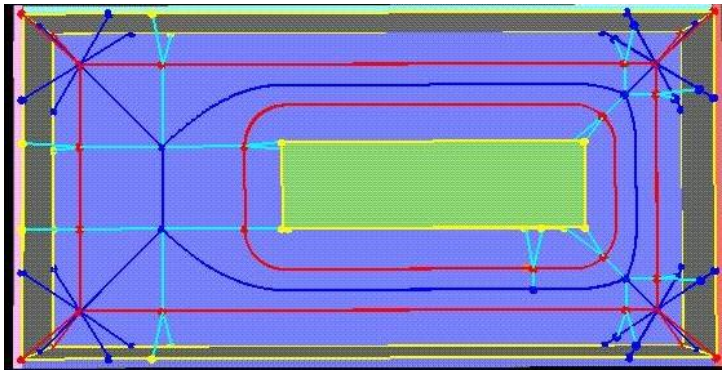
Thanks to Robin Murphy, Texas A & M

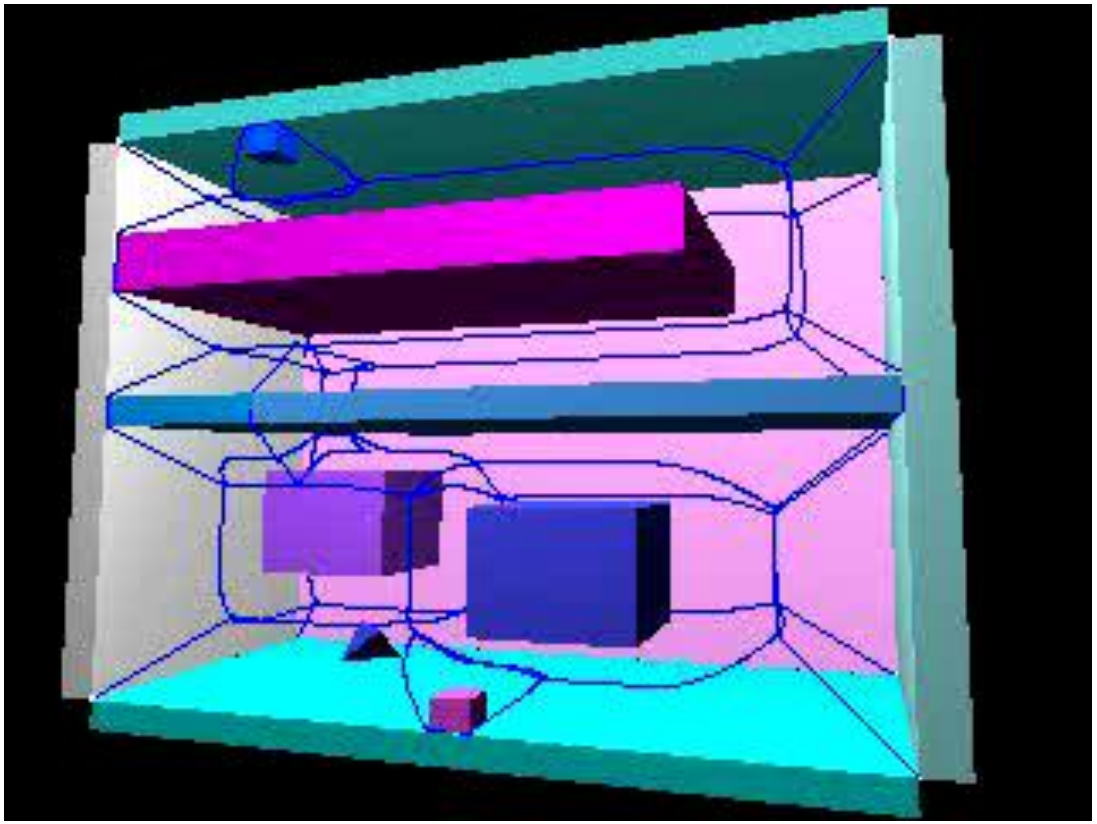
Field Deployments

Lebanon, Indiana

Voronoi Graphs

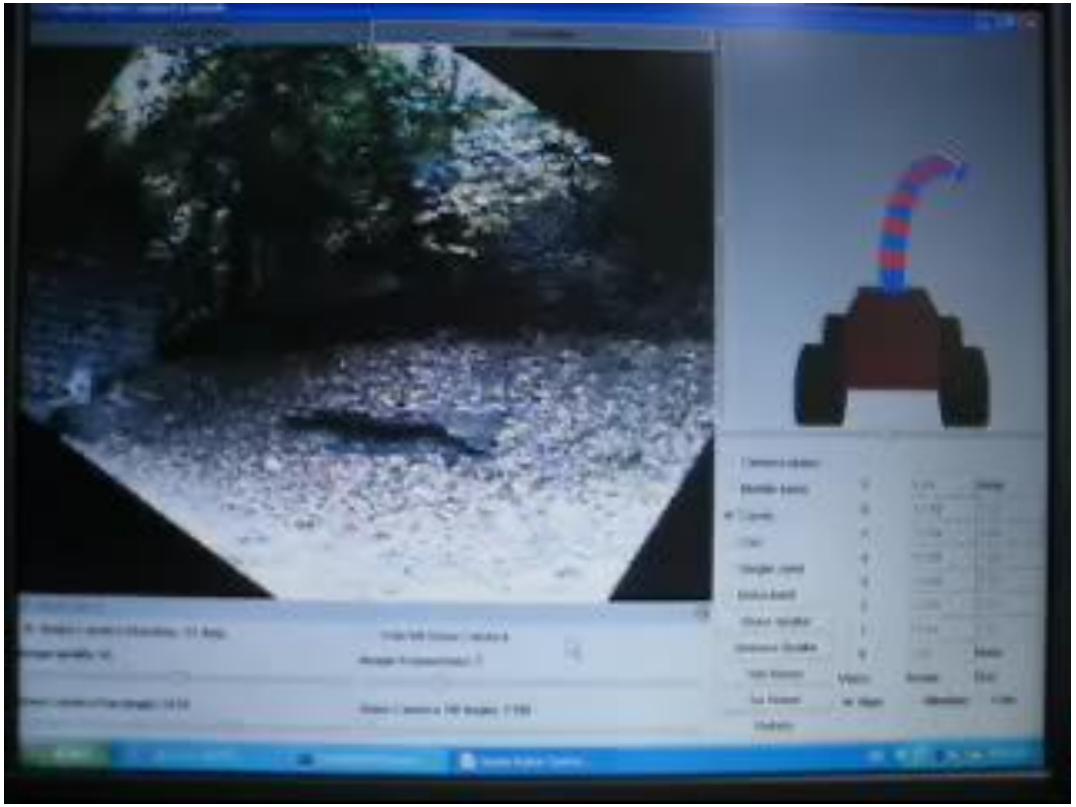






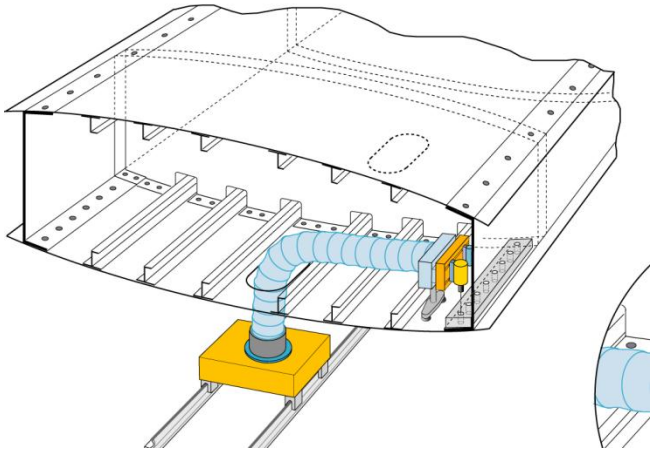
Situational Awareness

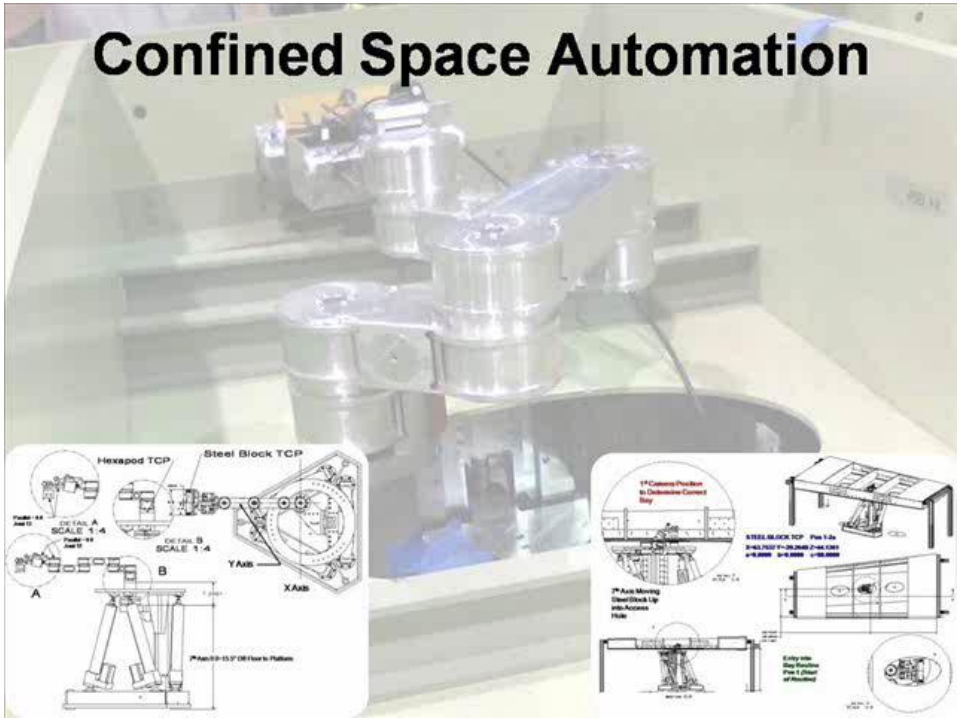
Which way is up?



System Interface enables situational awareness

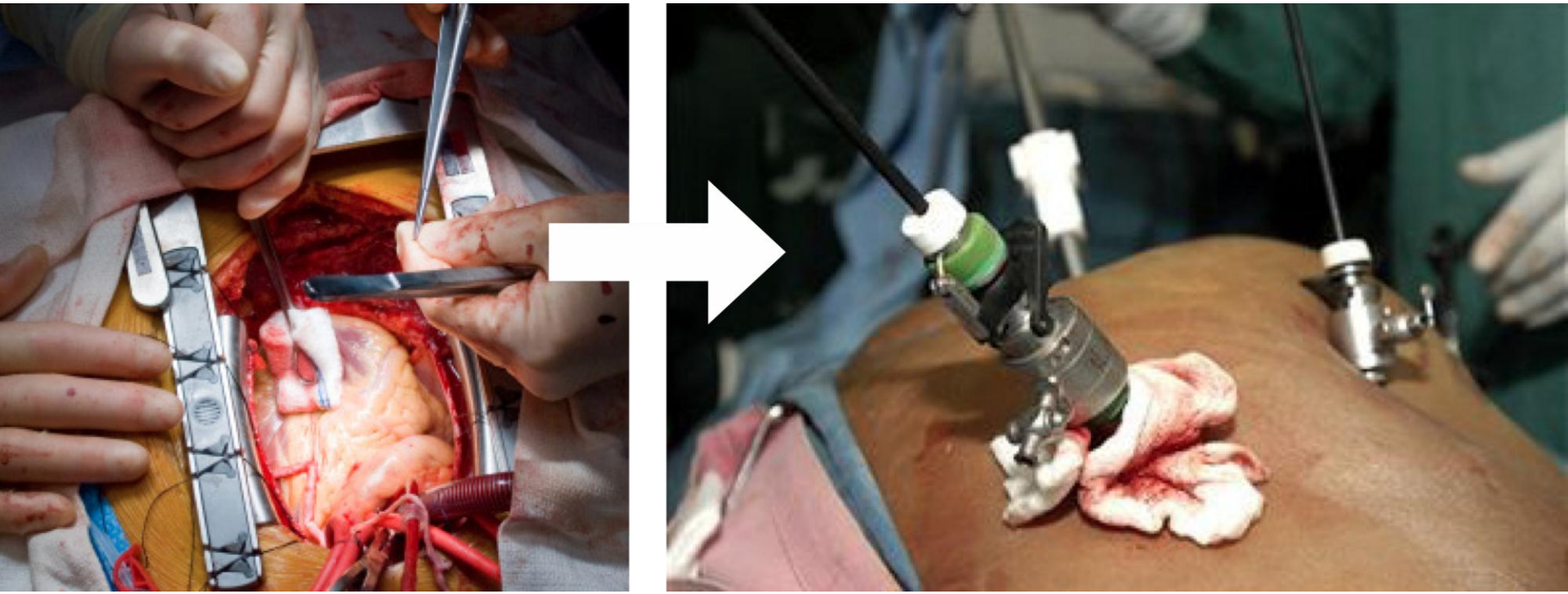
Aircraft Automation (Boeing)





Sarh, Freeman,
Brown, Hamilton, Schwerin, Wagner

Minimally Invasive Surgery



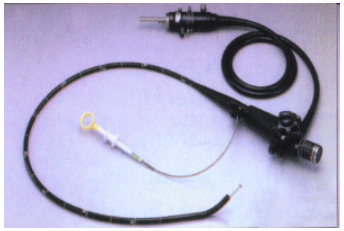
Reduce discomfort: no crack chest

Reduce cost: shorter hospital stay

Disseminate care: more can be done

Surgical Snake Robot

vs.



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[redacted]

Reduce discomfort: no crack chest

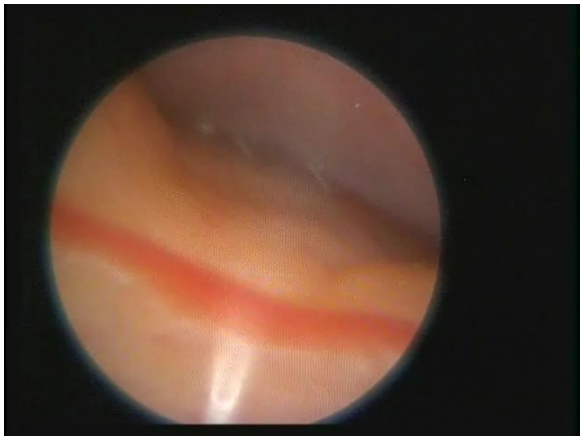
Reduce cost: shorter hospital stay

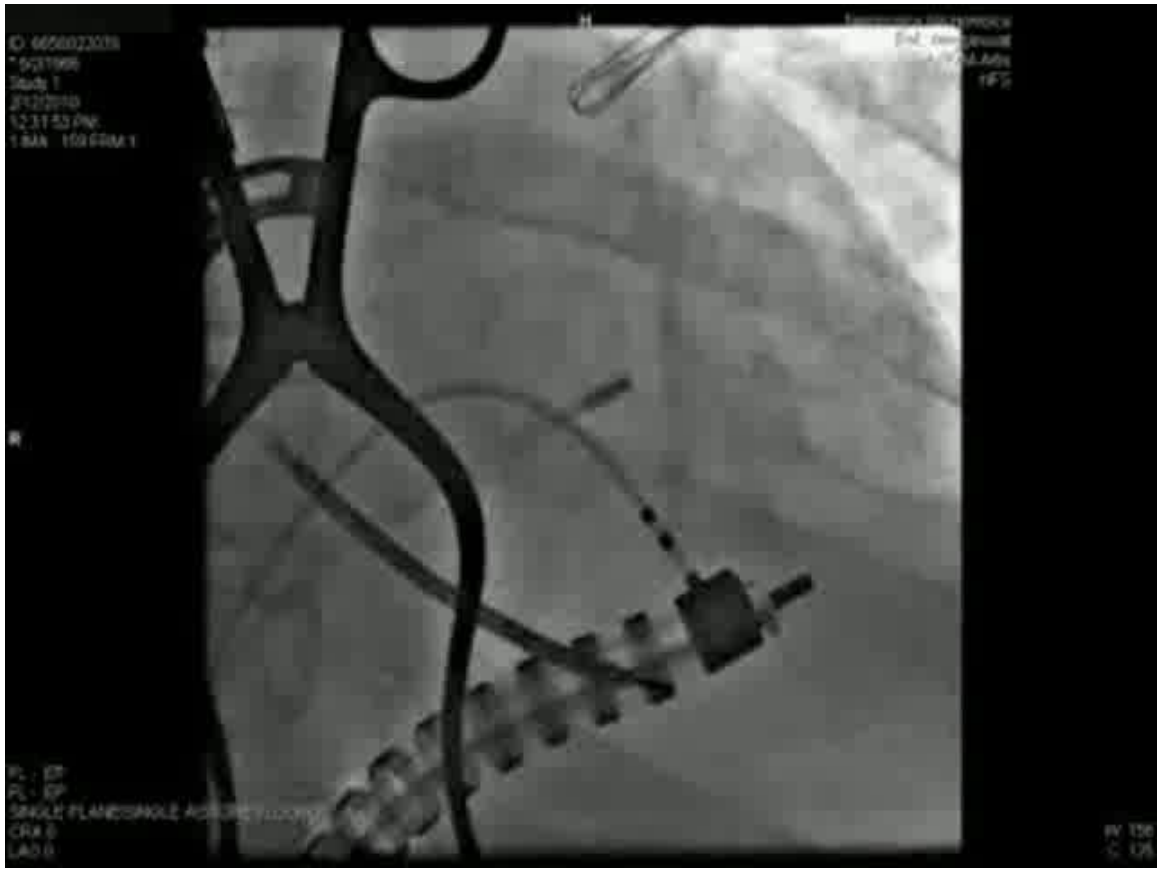
Disseminate care: more can be done

[redacted]

Medrobotics™

First Human Use



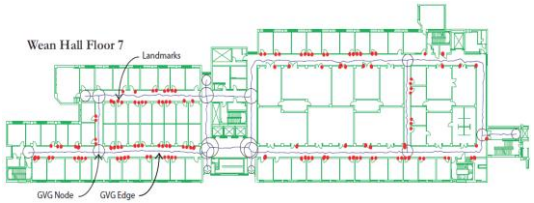


Patient discharged one day later without clinical sequalae!

Situational Awareness

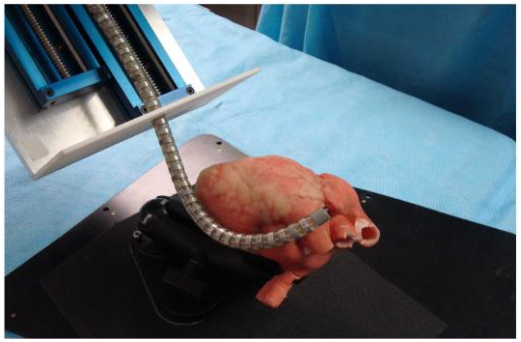
SLAM for Mobile Robots

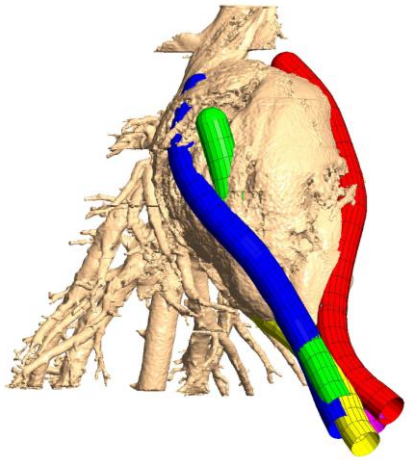
$$p(X_k^h, G_k^h | z_{0:k}, u_{1:k}) =$$
$$\eta\, p(z_{0:k} | X_k^h, G_k^h, u_{1:k})\; p(X_k^h, G_k^h | u_{1:k})$$
$$\eta\, p(z_{0:k} | X_k^h, G_k^h, u_{1:k})\; p(X_k^h | G_k^h, u_{1:k})\; p(G_k^h | u_{1:k})$$
$$\eta\, p(z_{0:k} | X_k^h, G_k^h, u_{1:k})\; p(G_k^h | u_{1:k}),$$

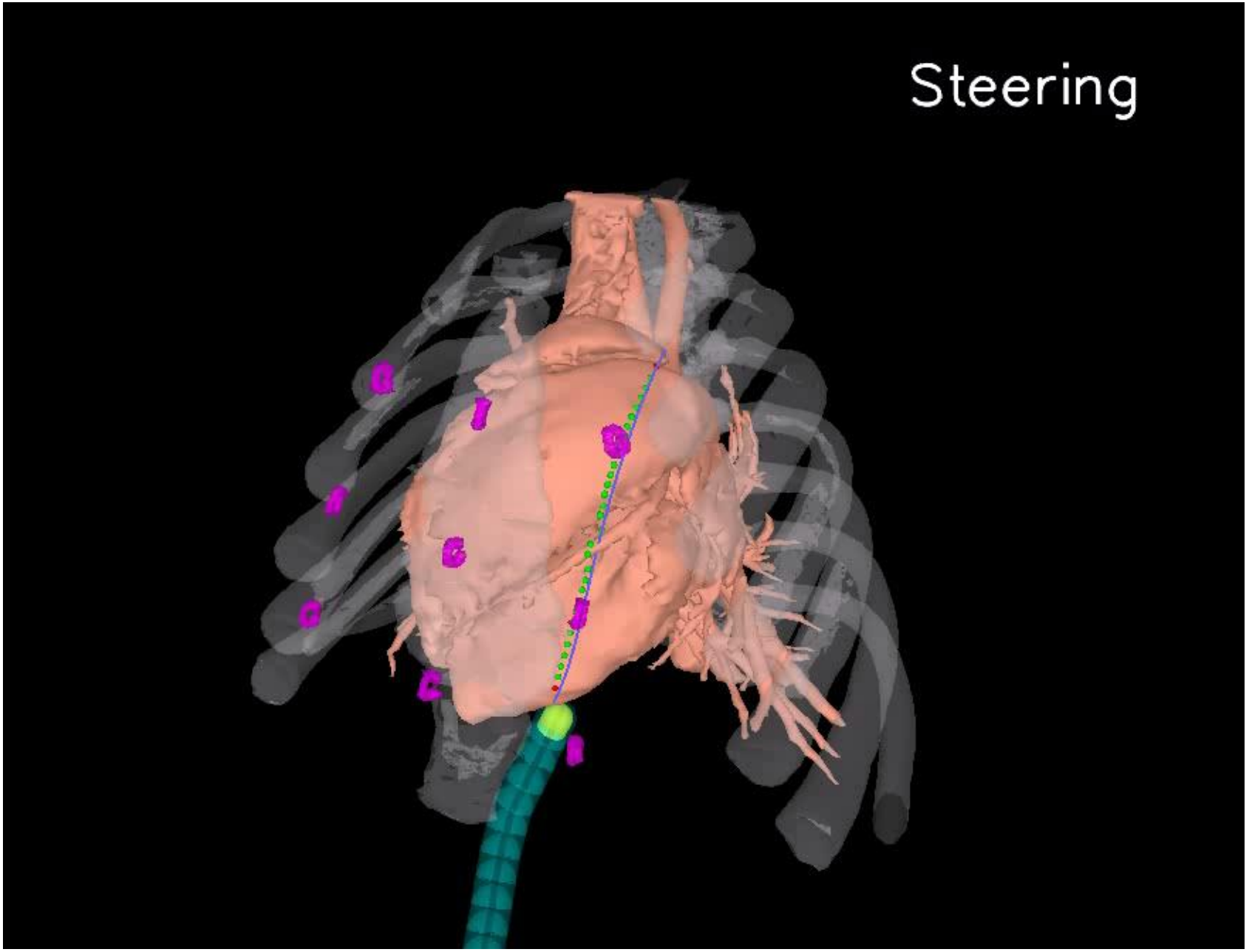


(Tully 2007)

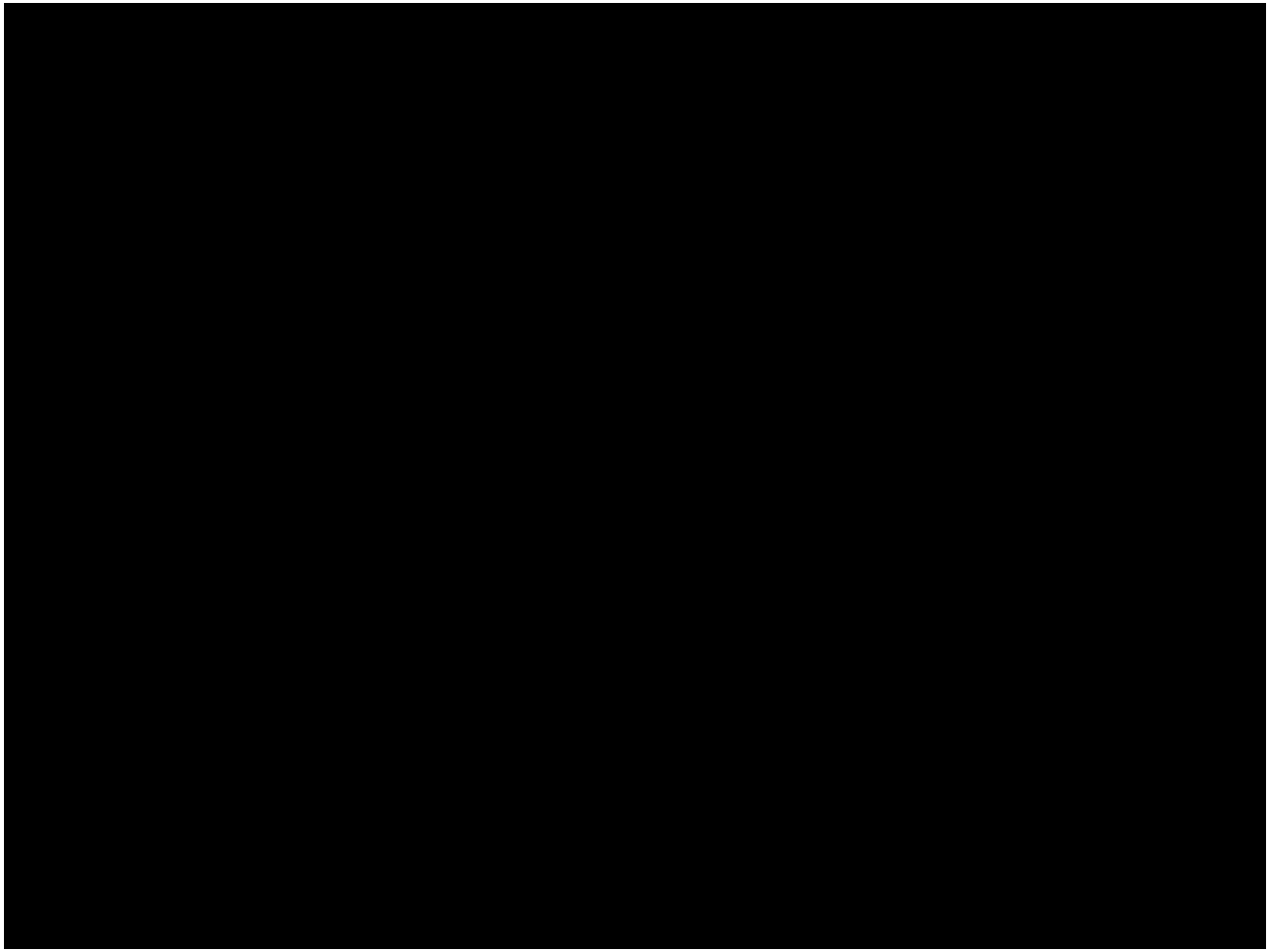
BodySLAM






Steering

Locomoting Snake



Search and Rescue (Murphy)

Disaster City™

Archeology (Bard, Fattovich, El-Maguid,Hawass)

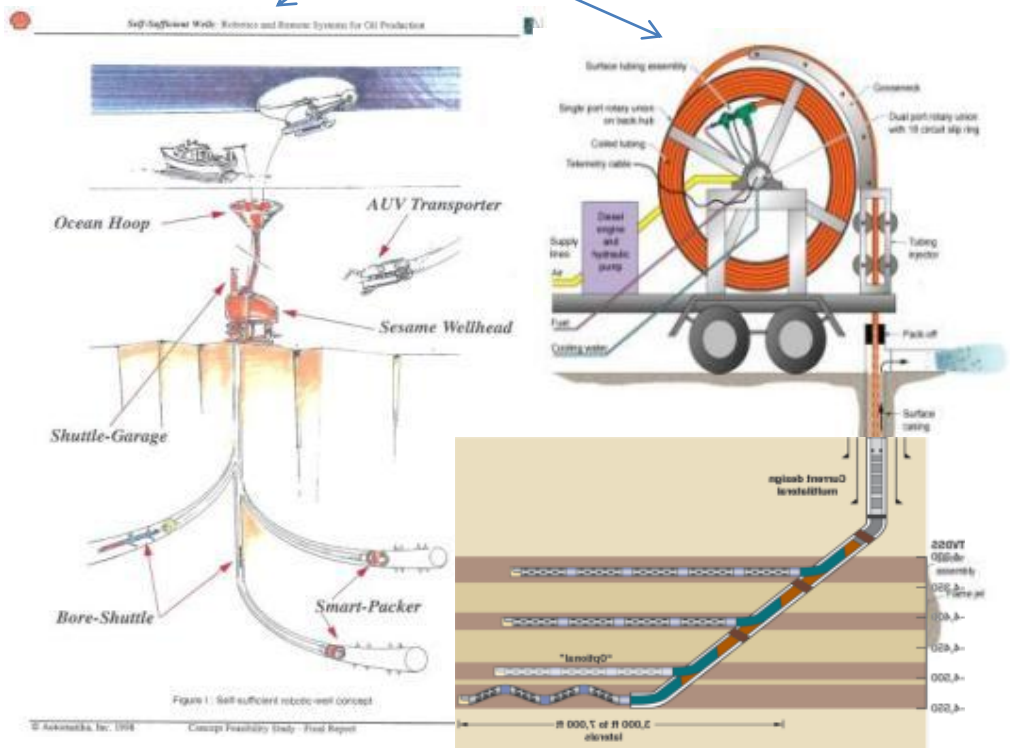
Pipes

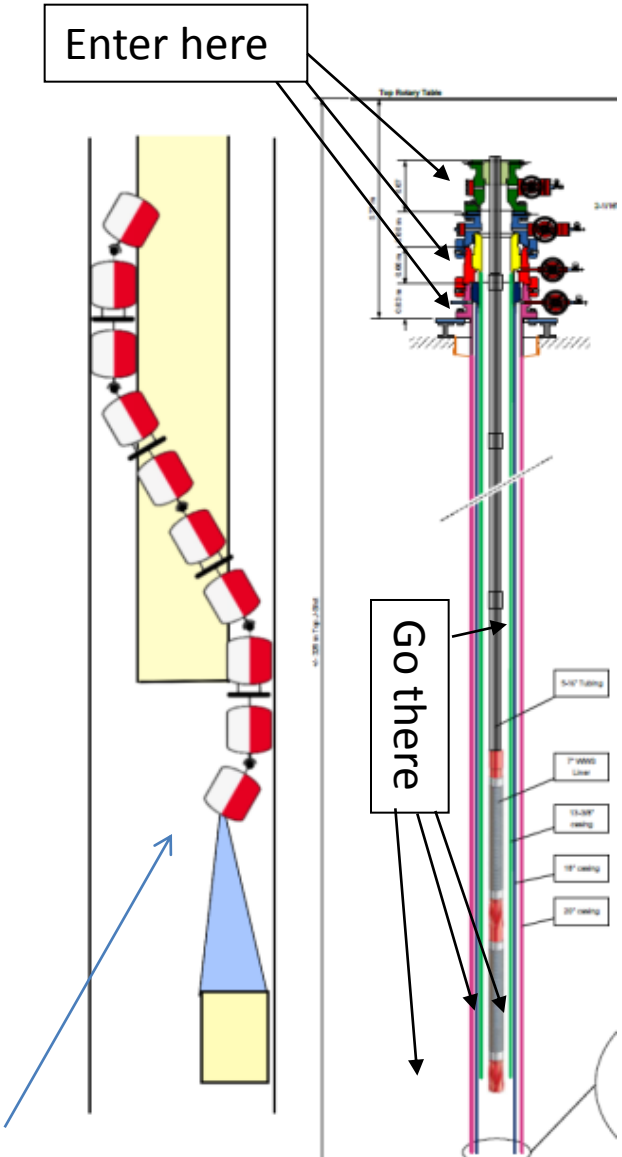

Created with a
non-activated version
www.avs4you.com
www.modsnake.com

Snake Ideas for Tomorrow from Shell

Re/place sensors & tools in wells, fish, isolate:

Direction & best practices today





Subsurface Snake Robots applications

- In-well, in-casing
  - Fishing
  - Sensor (re)placement
  - Tool (re)placement, downhole cleanup
- Wireline / Coiled Tubing / Tractor…. ---→ Snake!
  - Dragon wells: extend reach
  - Multilateral well, freely navigate bifurcating fingers
  - Not just the inner riser, go downhole annular spaces also. Negotiate packers.
  - 90 deg turns, navigate 1-D bends, creep through valves, screens, packers
- Extra-casing, travel into the reservoir
  - Directional drilling – abrasive jet drilling
  - Cavern spaces downhole, space for smart kit, build a mining chamber downhole
  - Sensors, 1000nds of sensors (fibers, smart Dust) in & under the production zone: snakes that dig tiny holes for sensors only (T, P, Q, seismic, tracers)
  - Fraccing: snakes that enter and map the fractured space – how deep, wide are they really?

Snakes in a Pipe

Modeling Snake-like Gaits

Hatton, Tesch, Lipkin, Peck, Choset

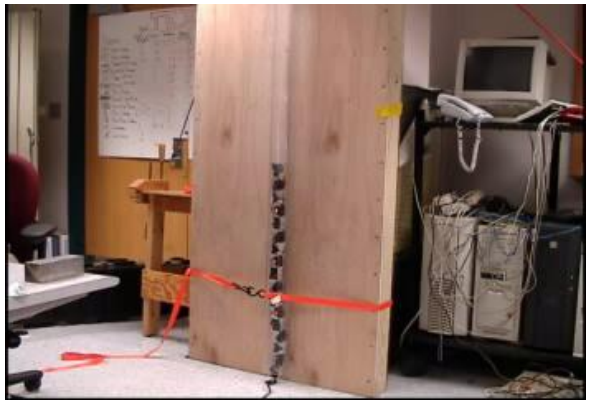
Benefit:
Reduce Dimensionality
Improve paths

Generalized Serpenoid Curve

$$\alpha(n,t) = \begin{cases} \beta_{\text{odd}} + A_{\text{odd}} \sin(\theta_{\text{odd}}) \\ \beta_{\text{even}} + A_{\text{even}} \sin(\theta_{\text{even}} + \delta) \end{cases}$$

$$\theta_{\text{odd,even}} = (\Omega_{\text{odd,even}} n + \omega_{\text{odd,even}} t),$$

e from?



Physics and Biology

Goldman, Hu and Hatton

Snakes in Space

Research Challenges

Design and Deployment of
Novel Mechanism

Biological and Physics
Geometric Mechanics

Control, Planning & Estimation
Hybrid Controls

Multi-DOF Planning

Follow-the-leader Locomotor