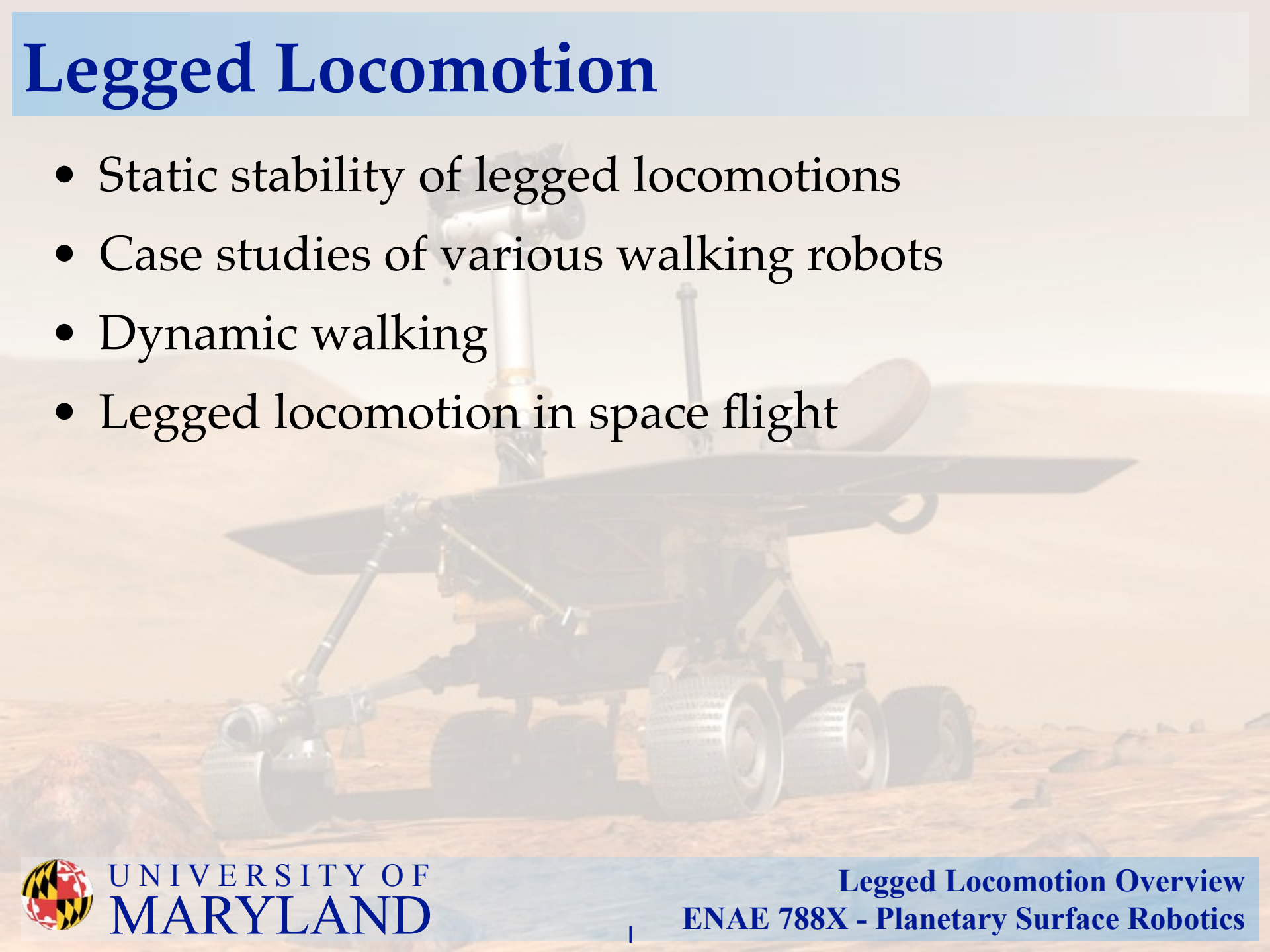
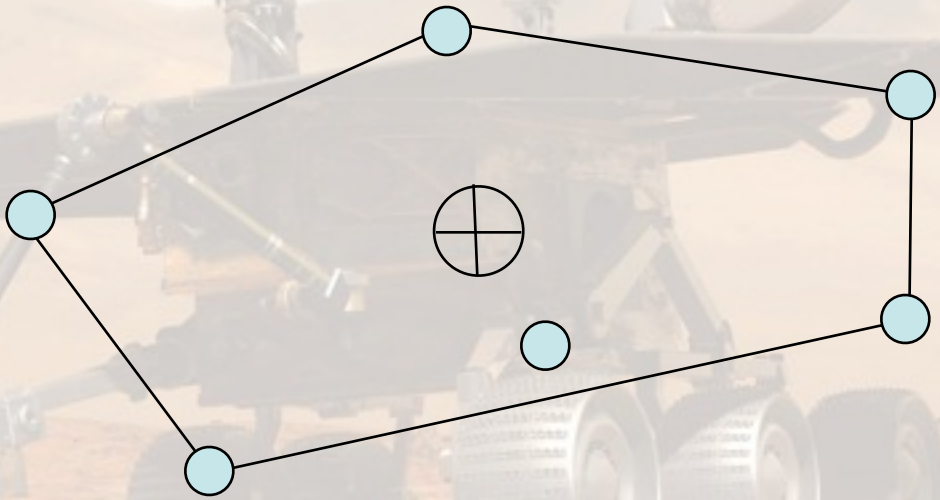
Legged Locomotion

- Static stability of legged locomotions
- Case studies of various walking robots
- Dynamic walking
- Legged locomotion in space flight

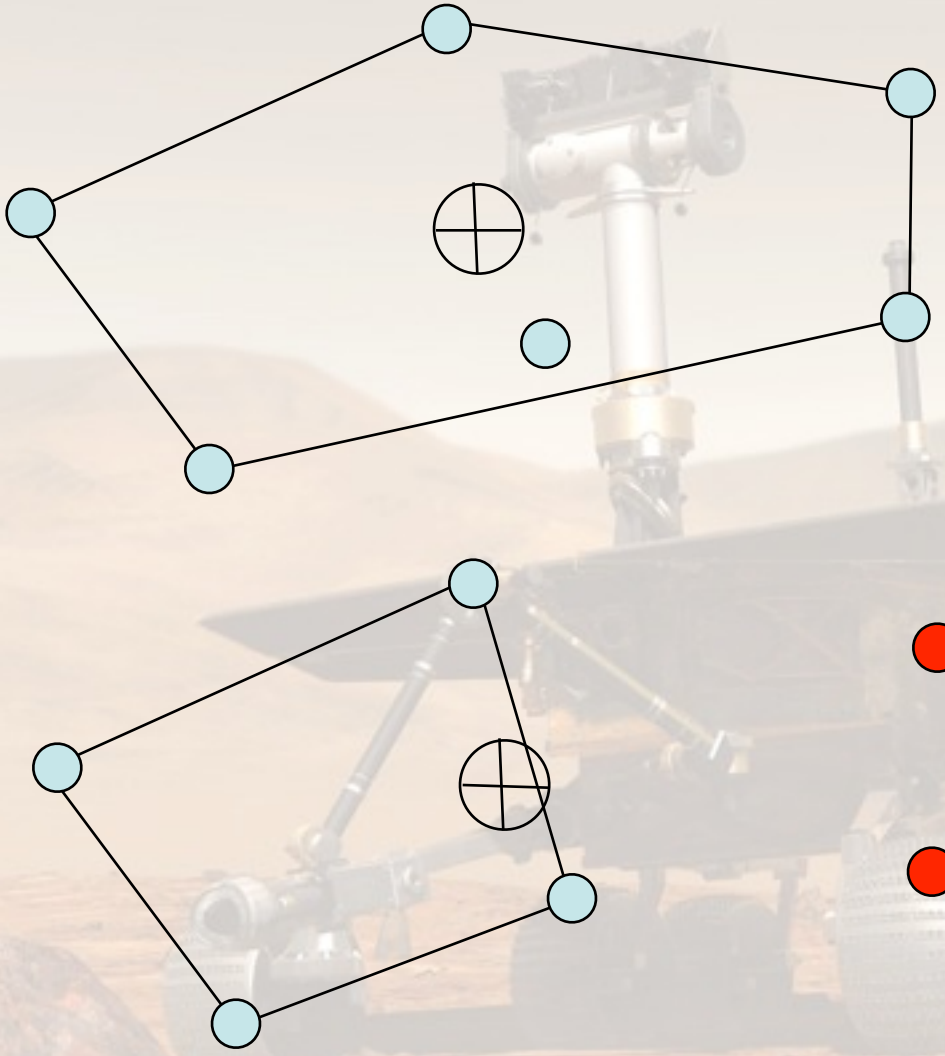


Legged Stability

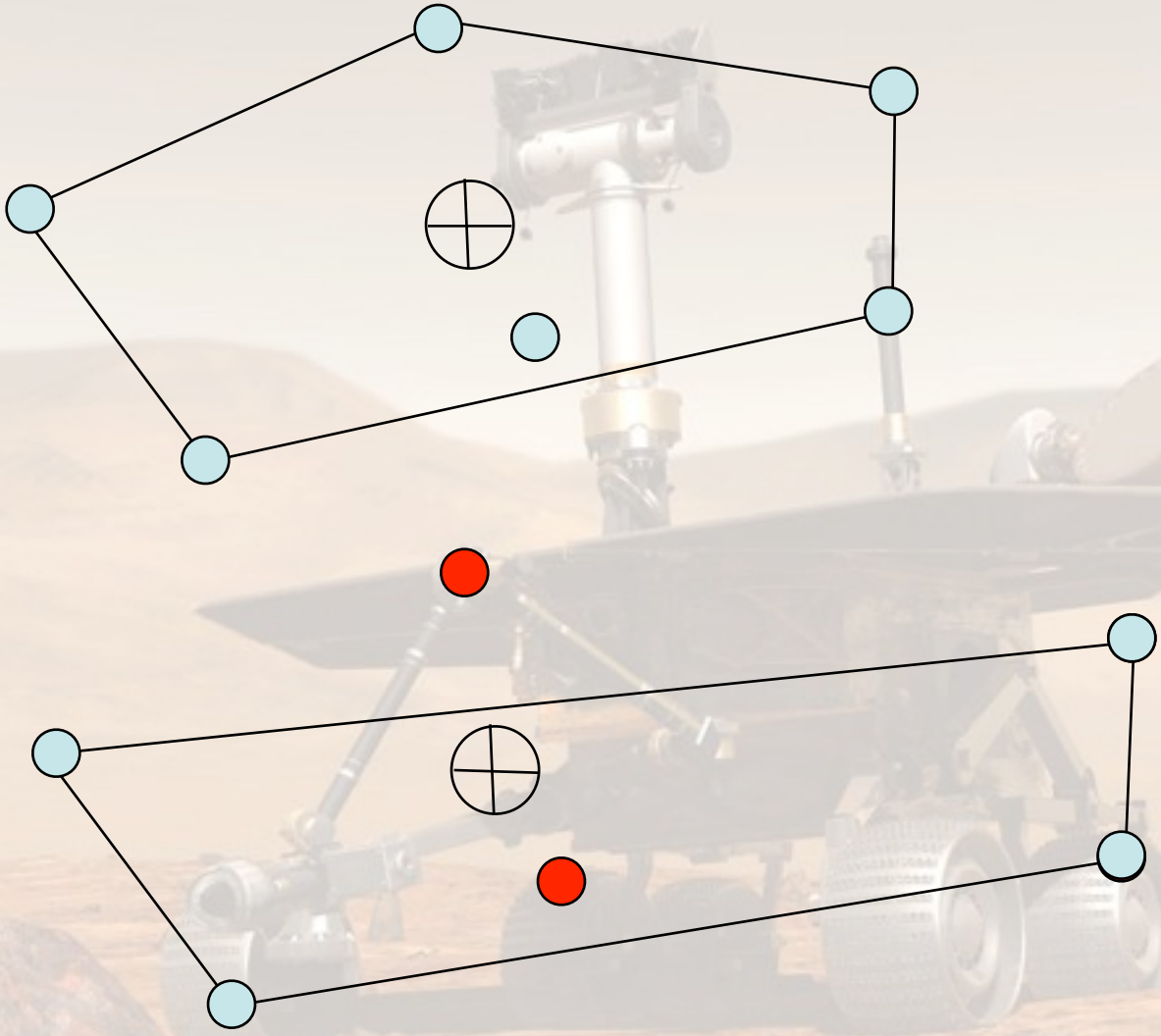
- Define the support region as the convex polyhedron formed by supporting leg tips (“feet”)
- System is statically stable if gravitational force vector from CG passes through stability region



Wave Gait



Wave Gait



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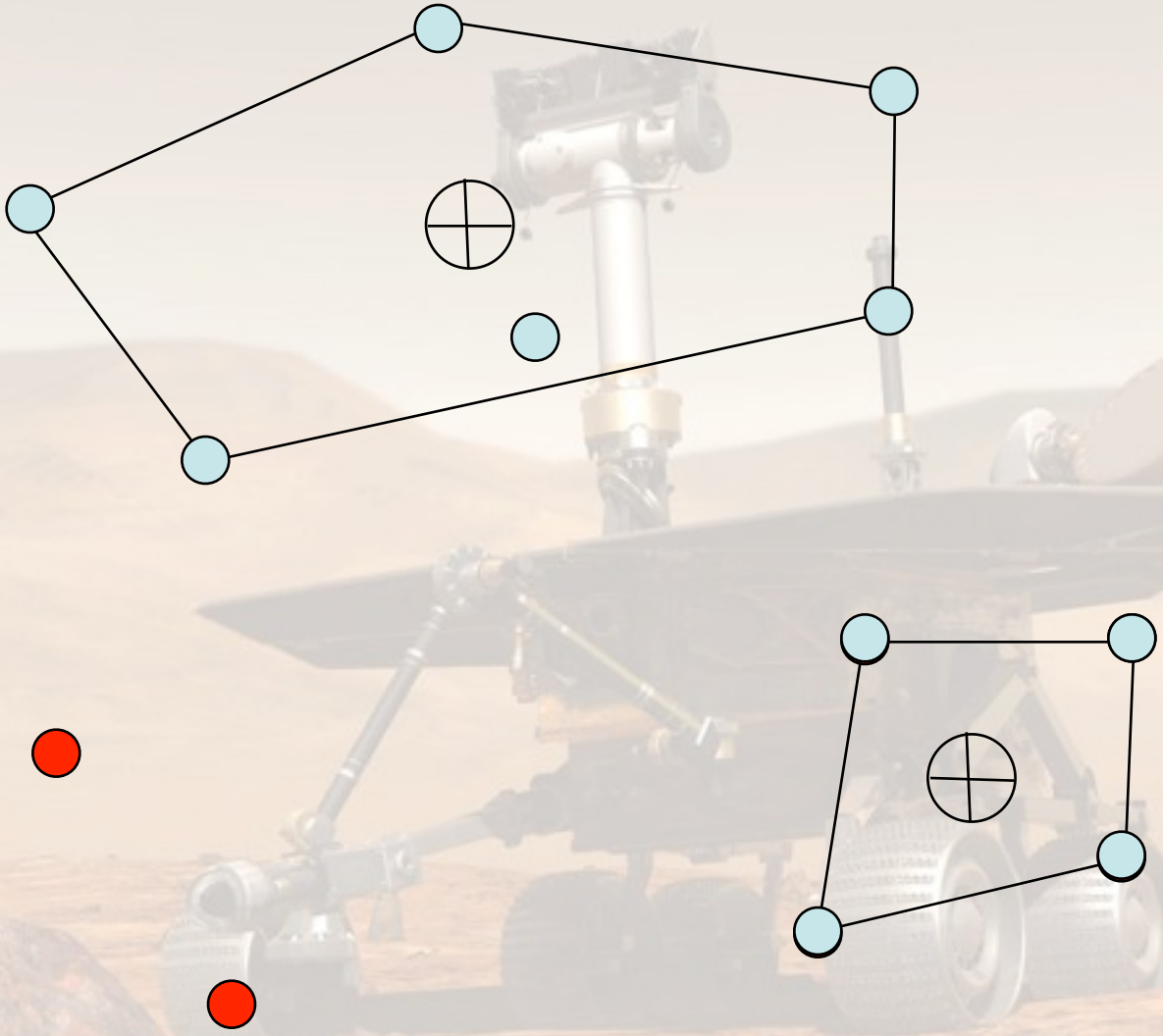
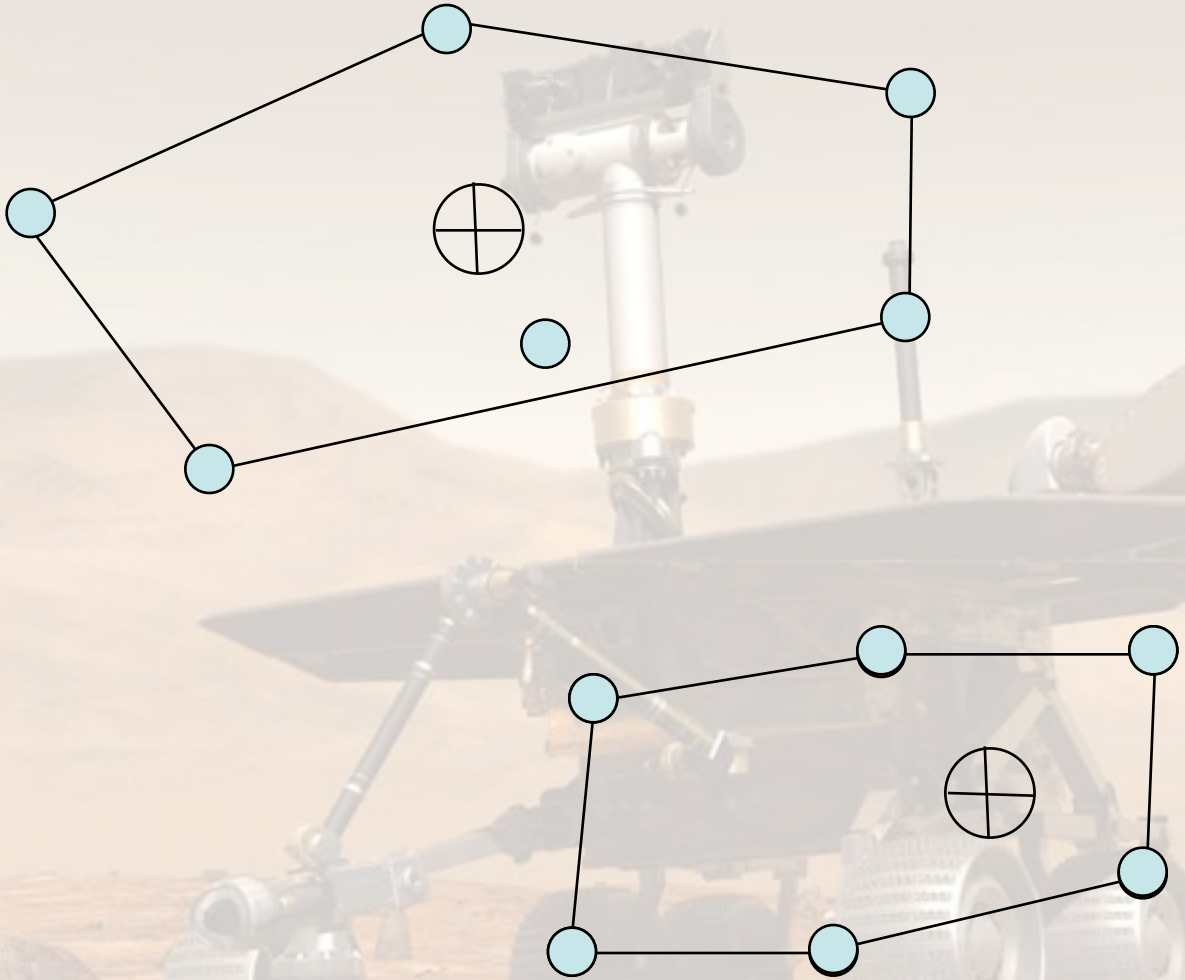
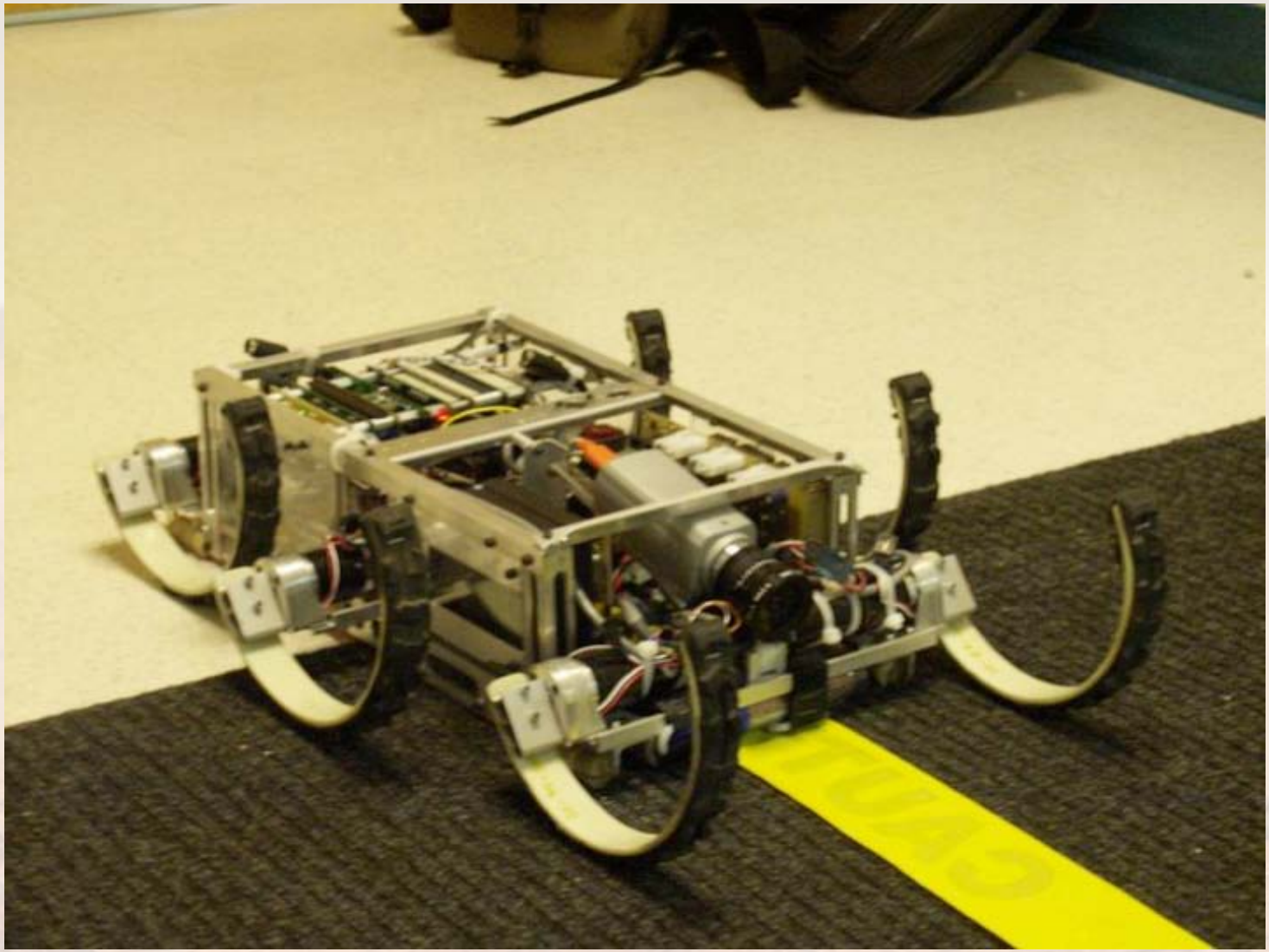


Wave Gait



RHex - A Simple "Walking" Robot (CMU)

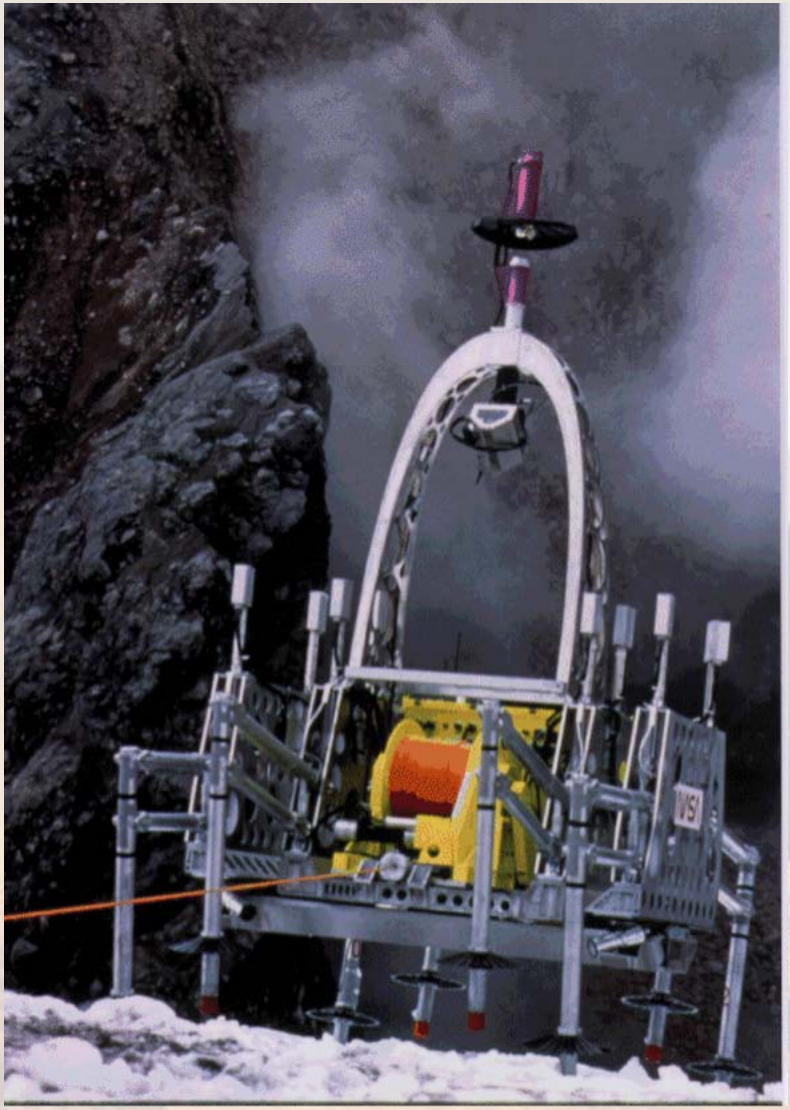


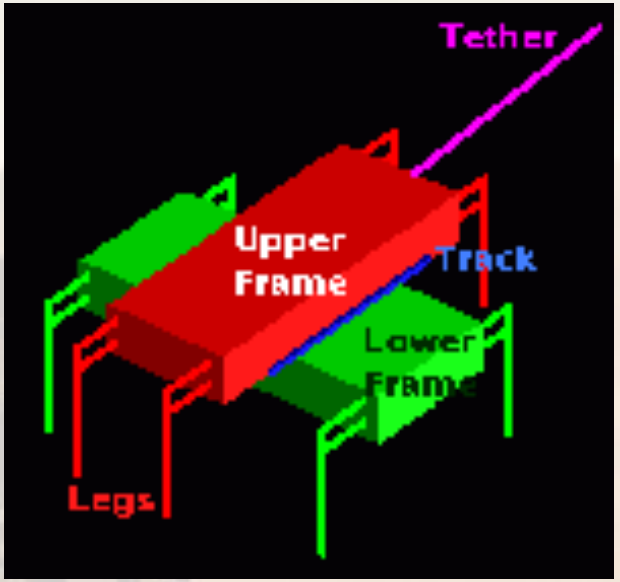
RHEX Video

Frame-Walkers

- Two fixed sets of legs creating fixed stability regions
- Legs move past each other and keep CG in stable region
- Can steer by rotating frames with respect to each other

Dante II Repelling Robot (CMU)





AMBLER Characteristics

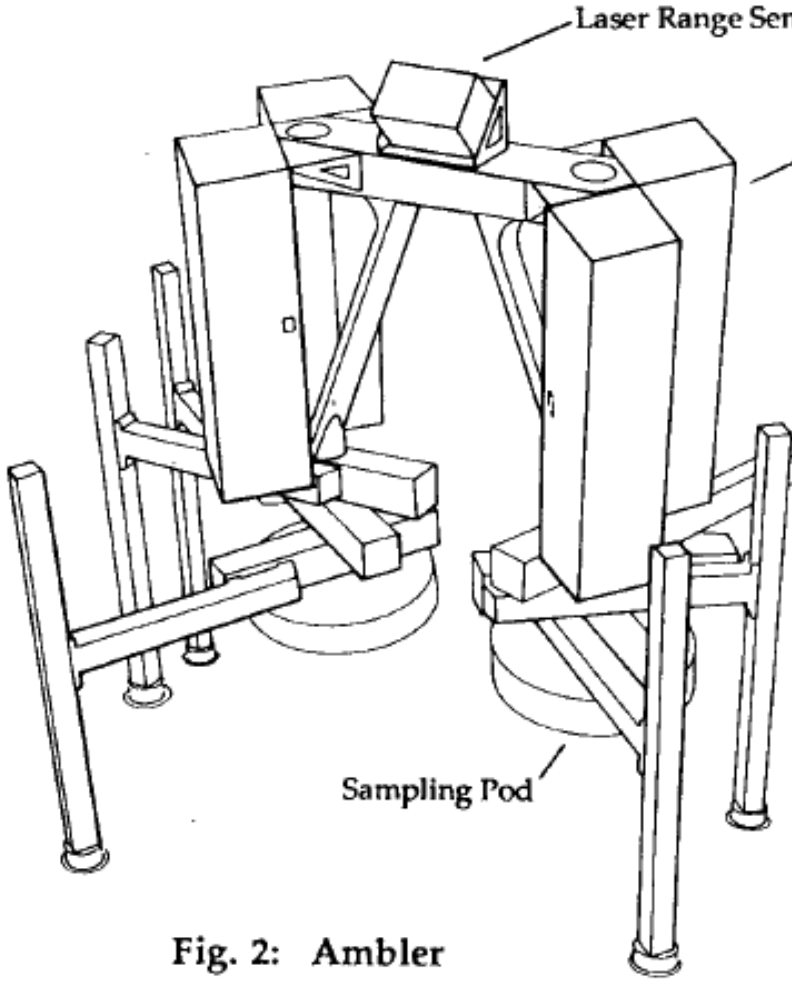
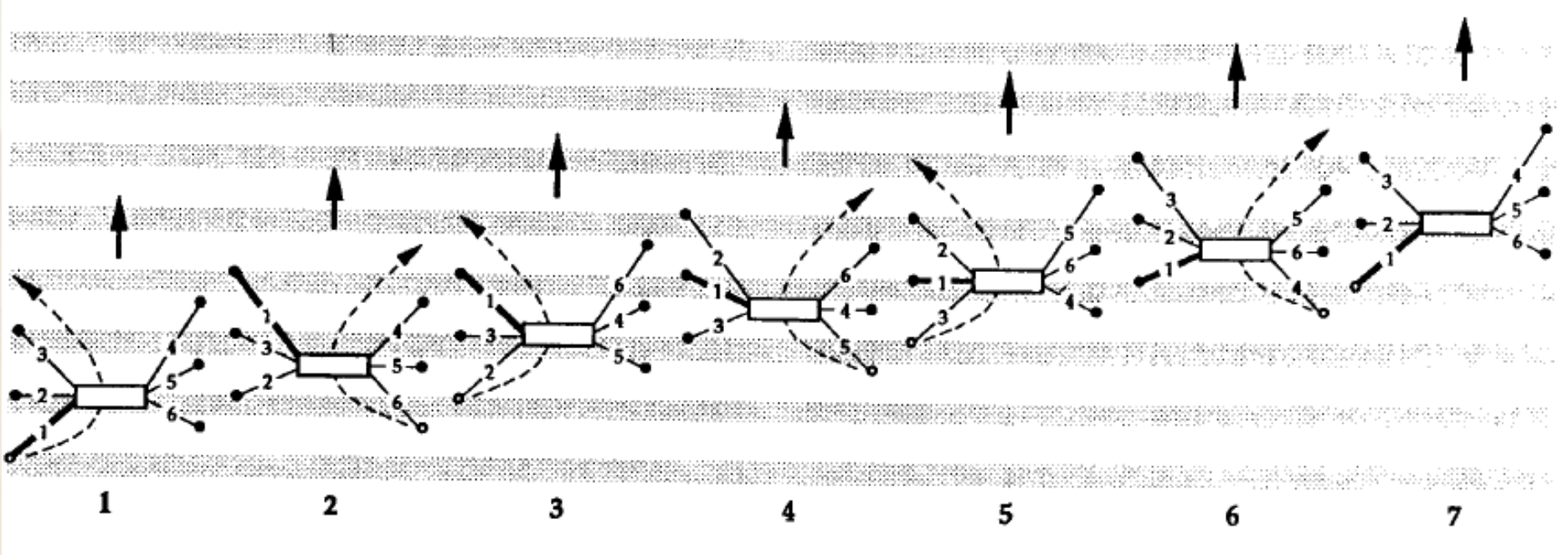


Fig. 2: Ambler

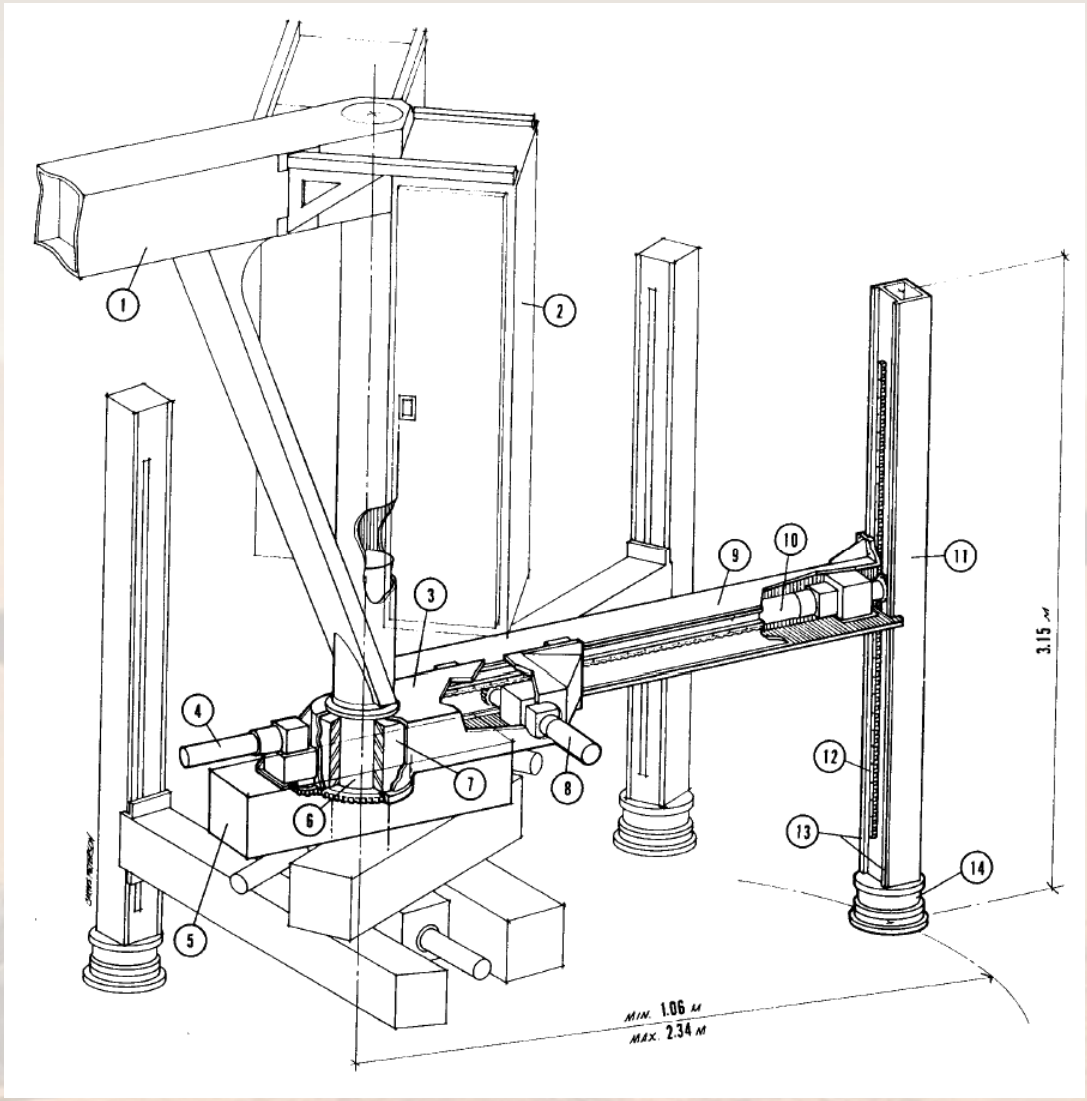
Table 1: Ambler Specifications

Dimensions	
Typical walking width:	4.5 m
Typical walking length:	3.5 m
Typical foot spacing in direction of motion:	1.5 m
Height:	4.1-6.0 m
Mobility	
Maximum step crossing:	1.9 m
Maximum ditch crossing:	1.5 m
Maximum slope with 1 m wide ditch on slope:	30°
Weight [2]	
Legs and body structure:	2050 kg
Vehicle design weight (with payload):	3180 kg
Power [3]	
Body propulsion at 2 m/min:	650 watts
Leg recovery:	150 watts

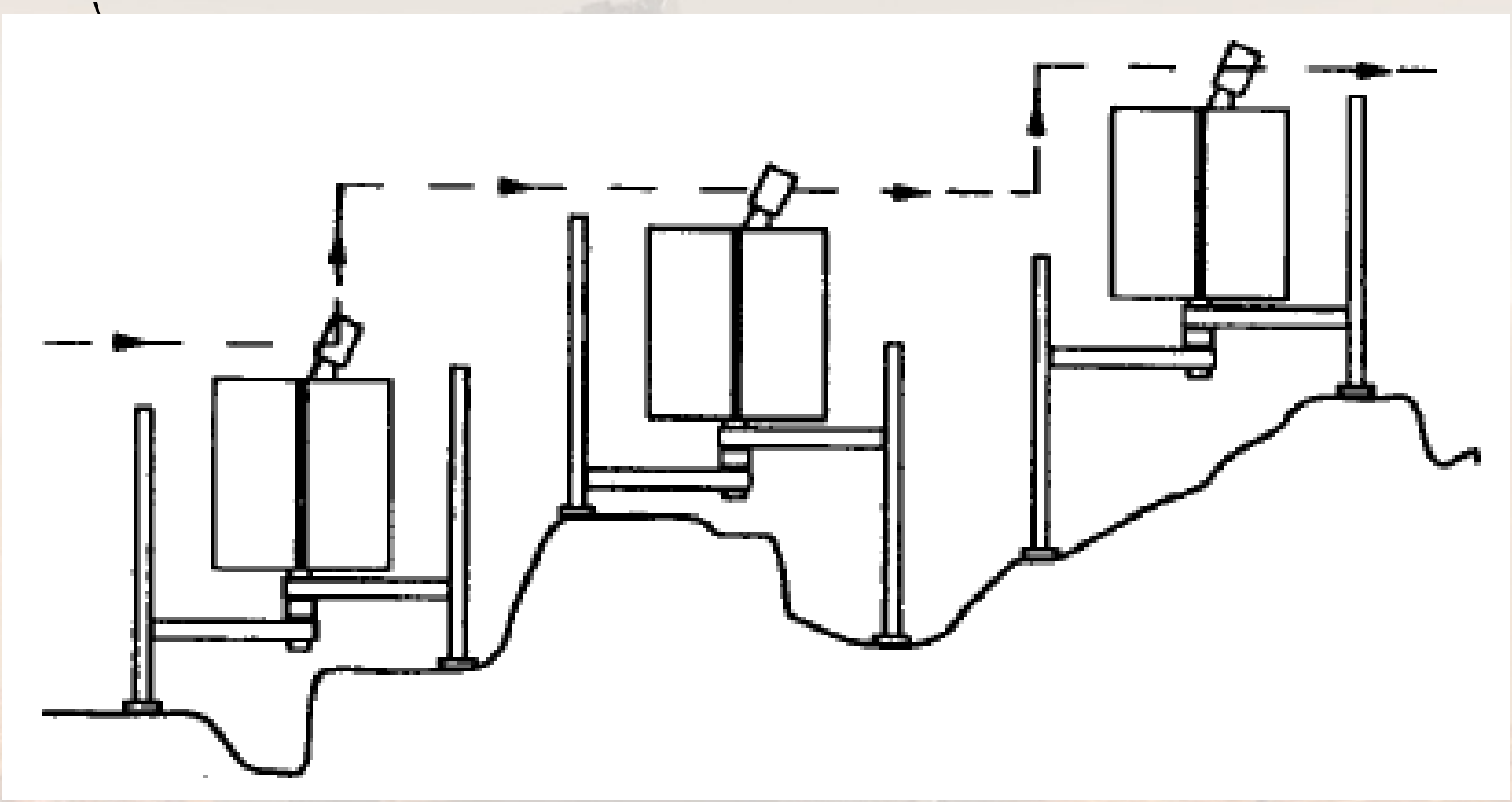
AMBLER Walking Gait



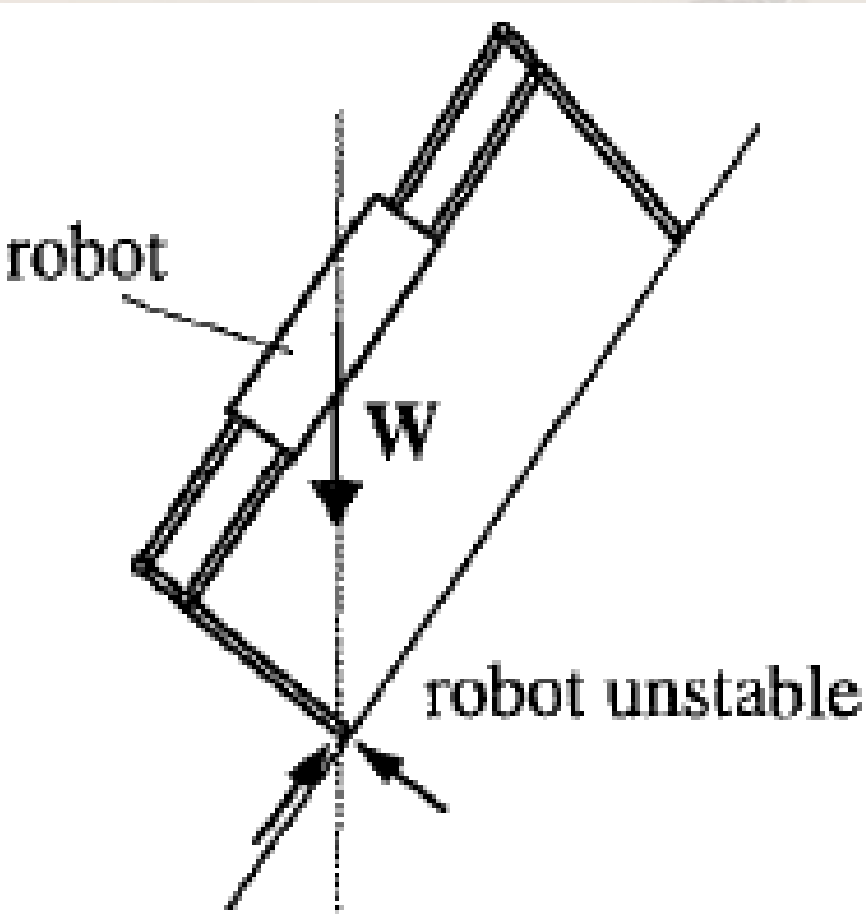
AMBLER Mechanisms

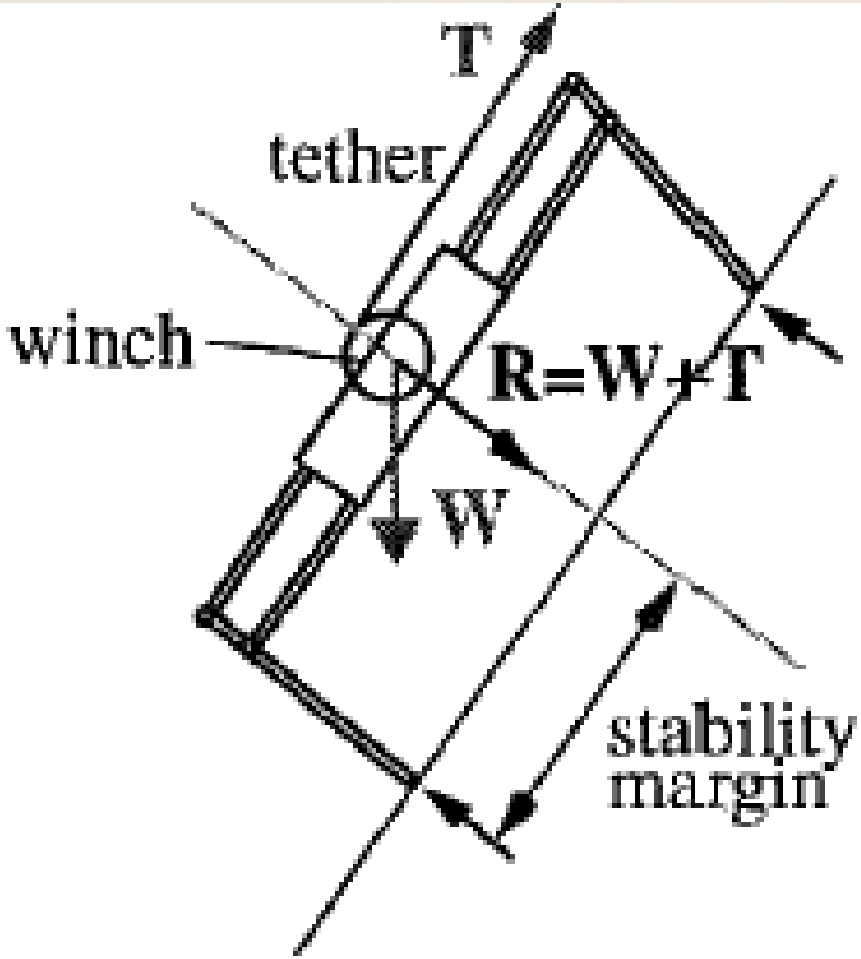


AMBLER Maintaining Even Orientation

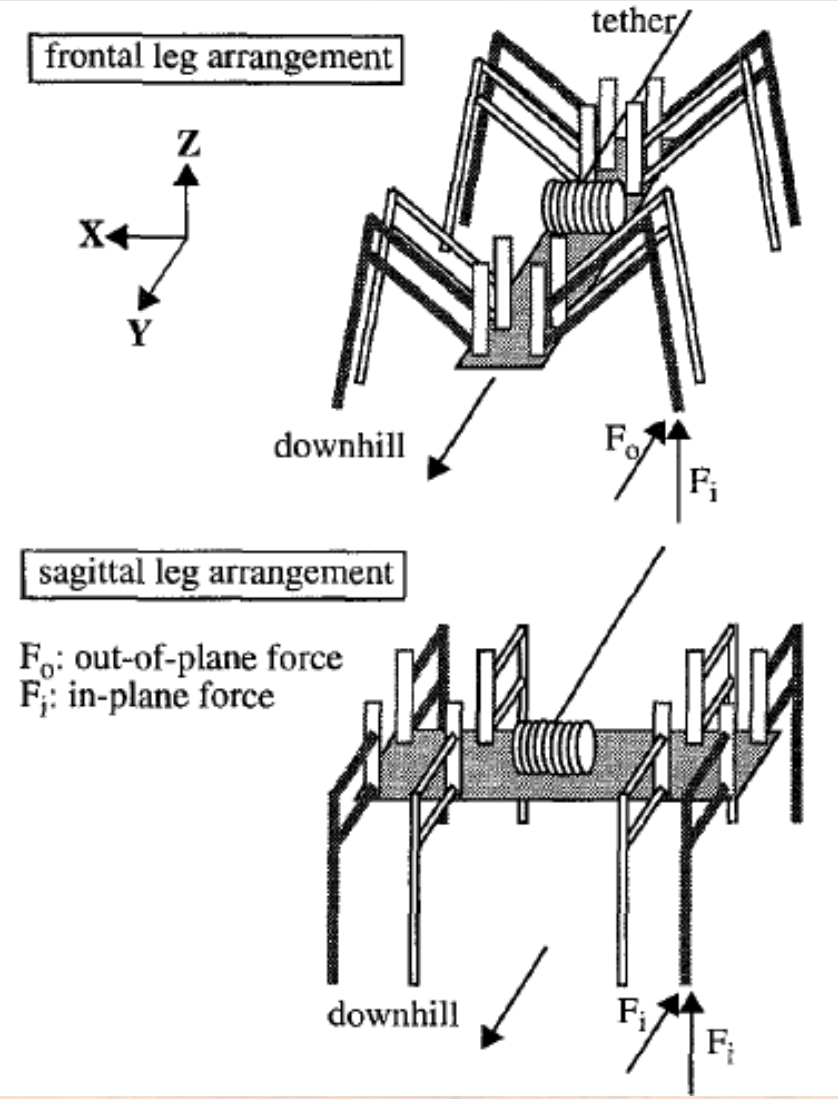


Rappelling Robots - Free-Body Diagram

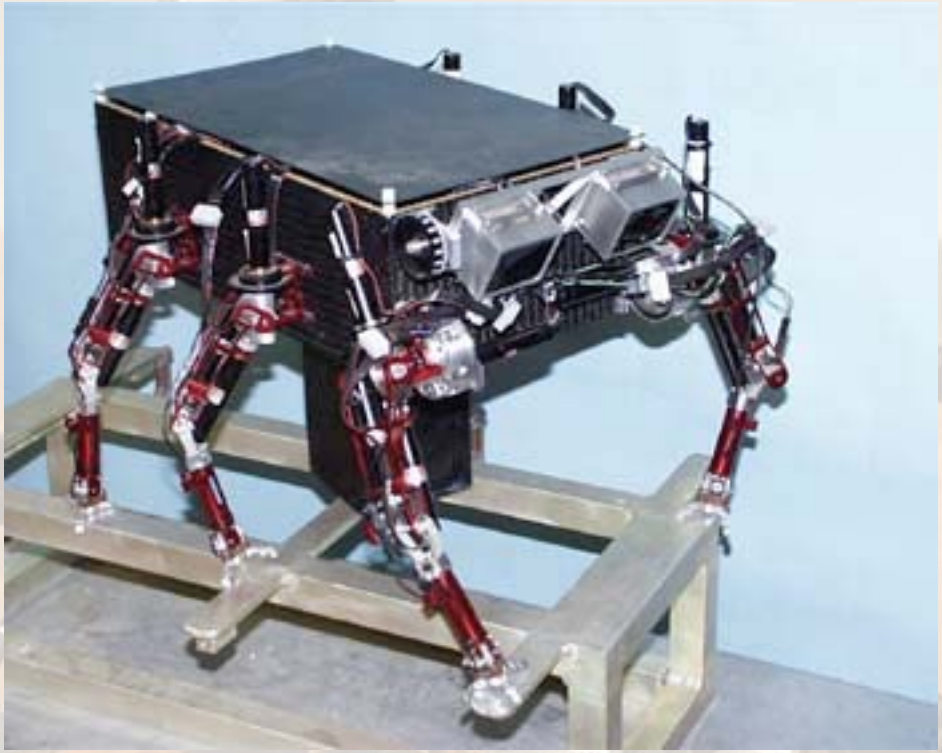




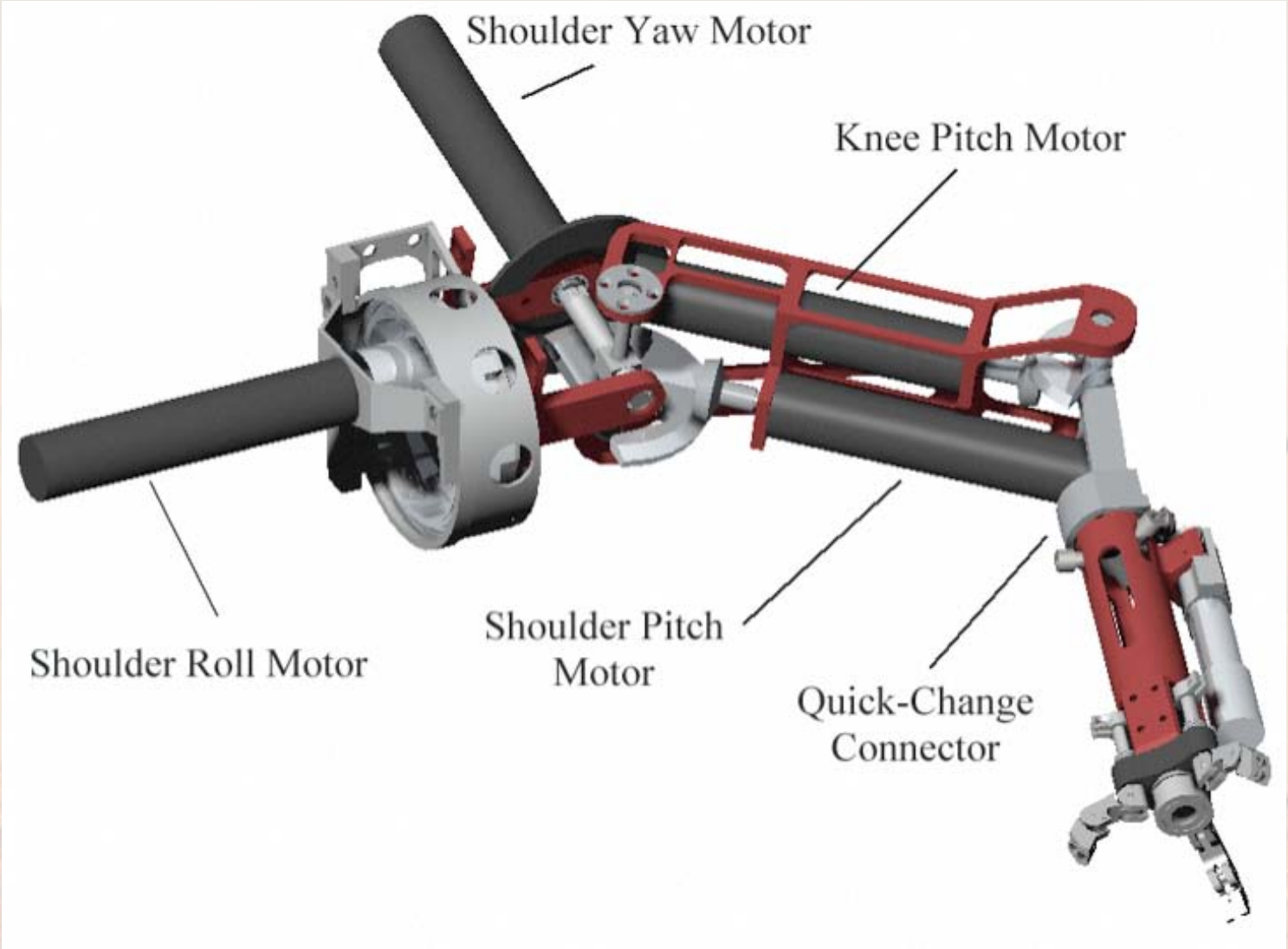
Leg Arrangement for Rappelling



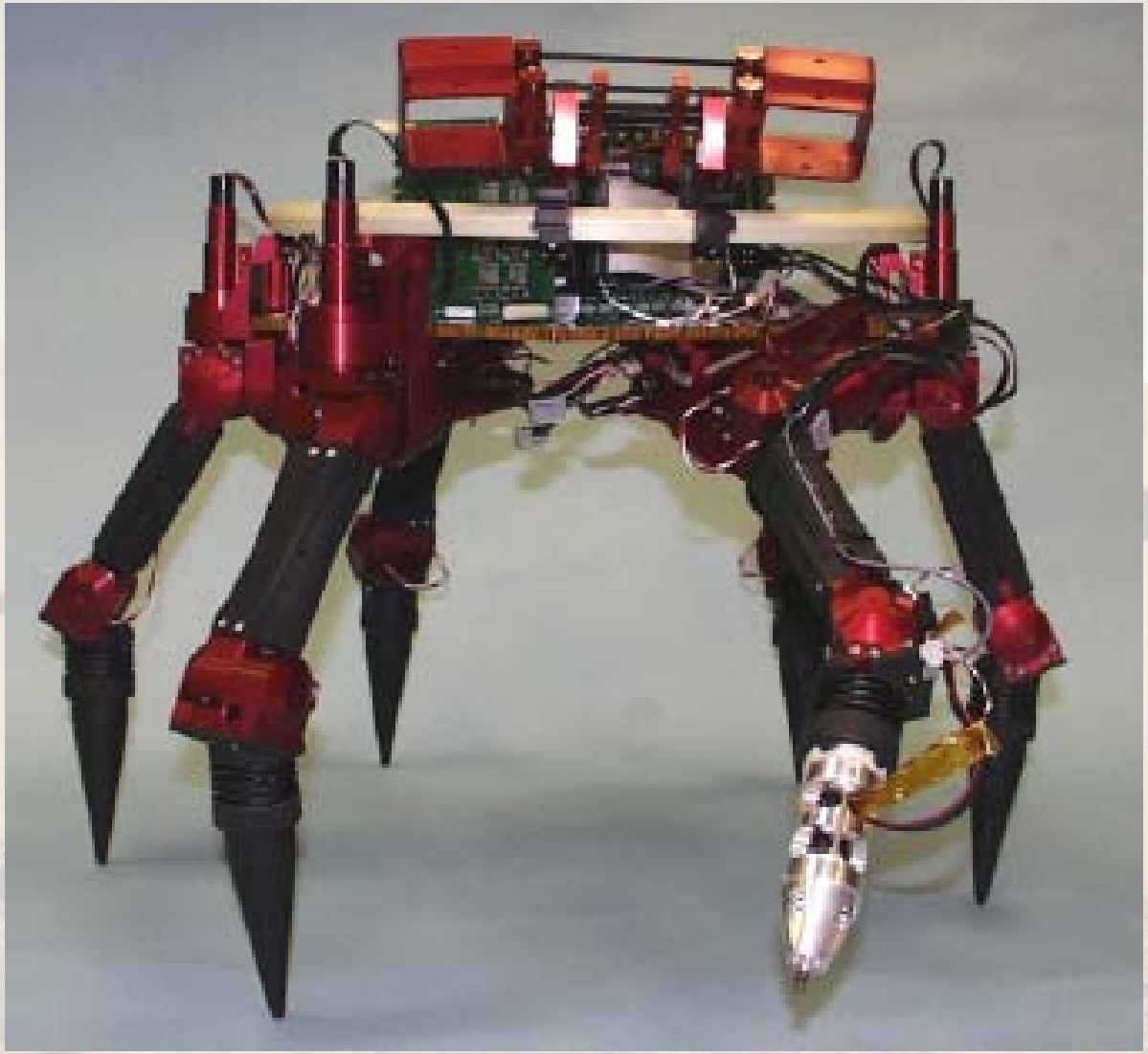
LEMUR (JPL)



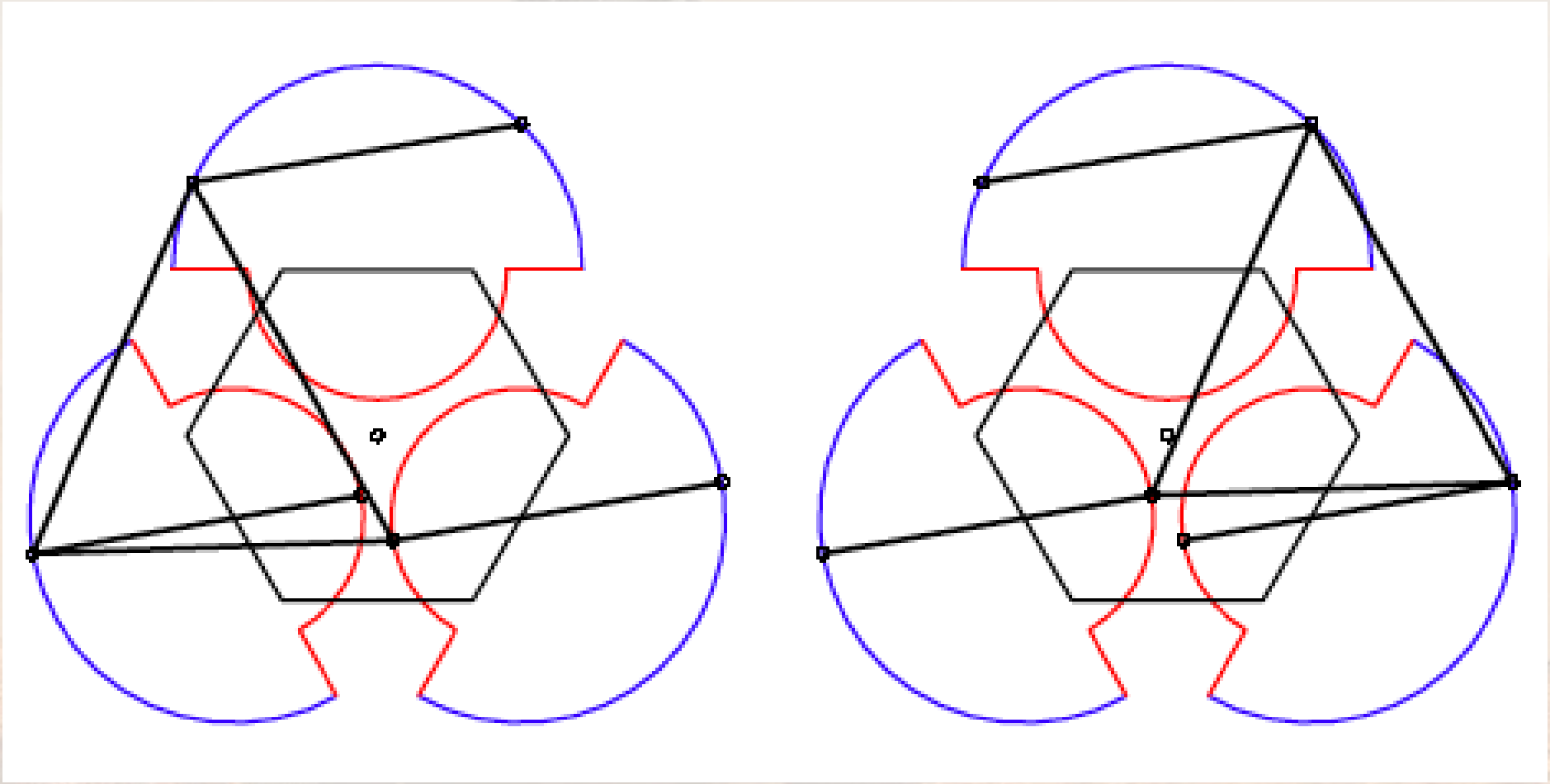
LEMUR Leg Mechanism



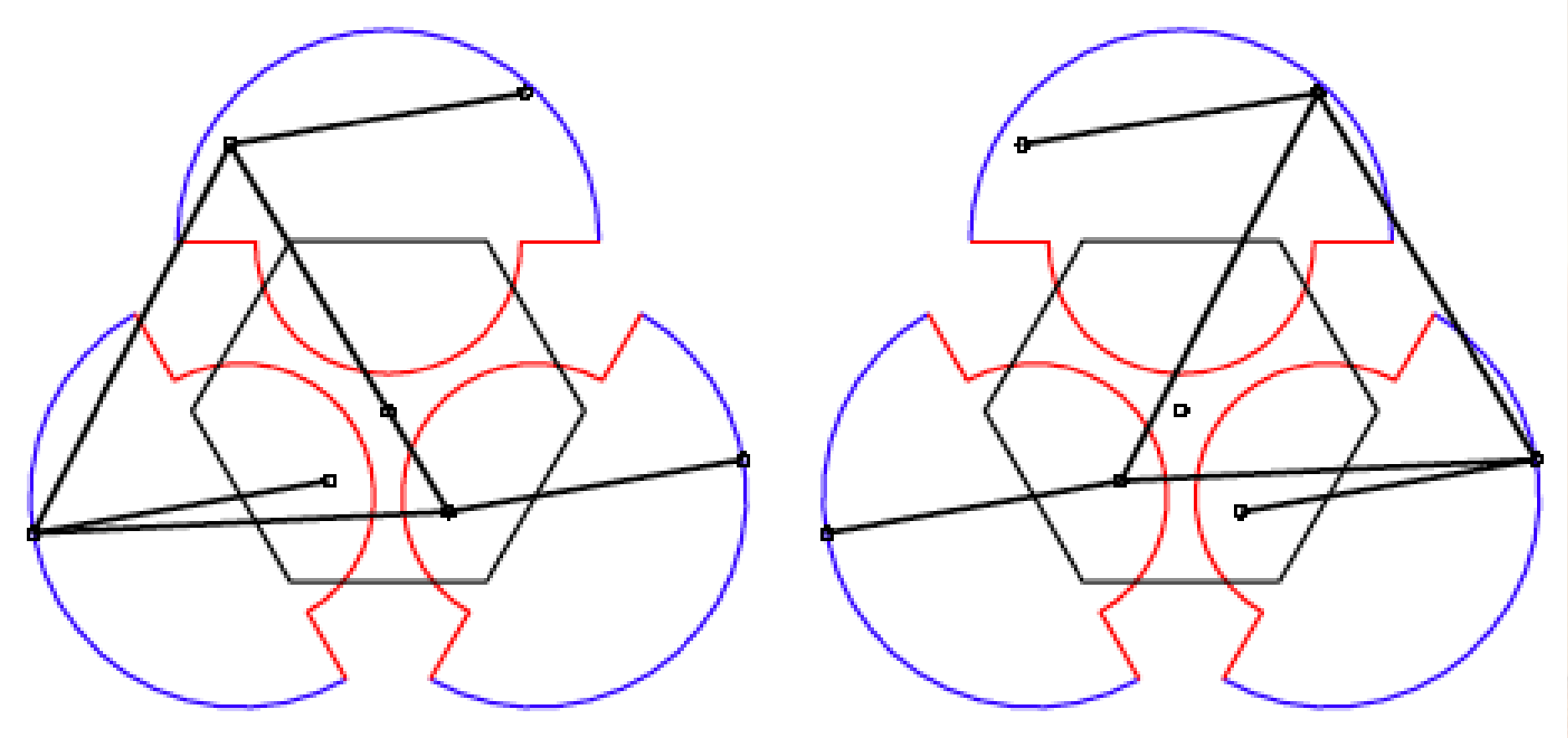
LEMUR II



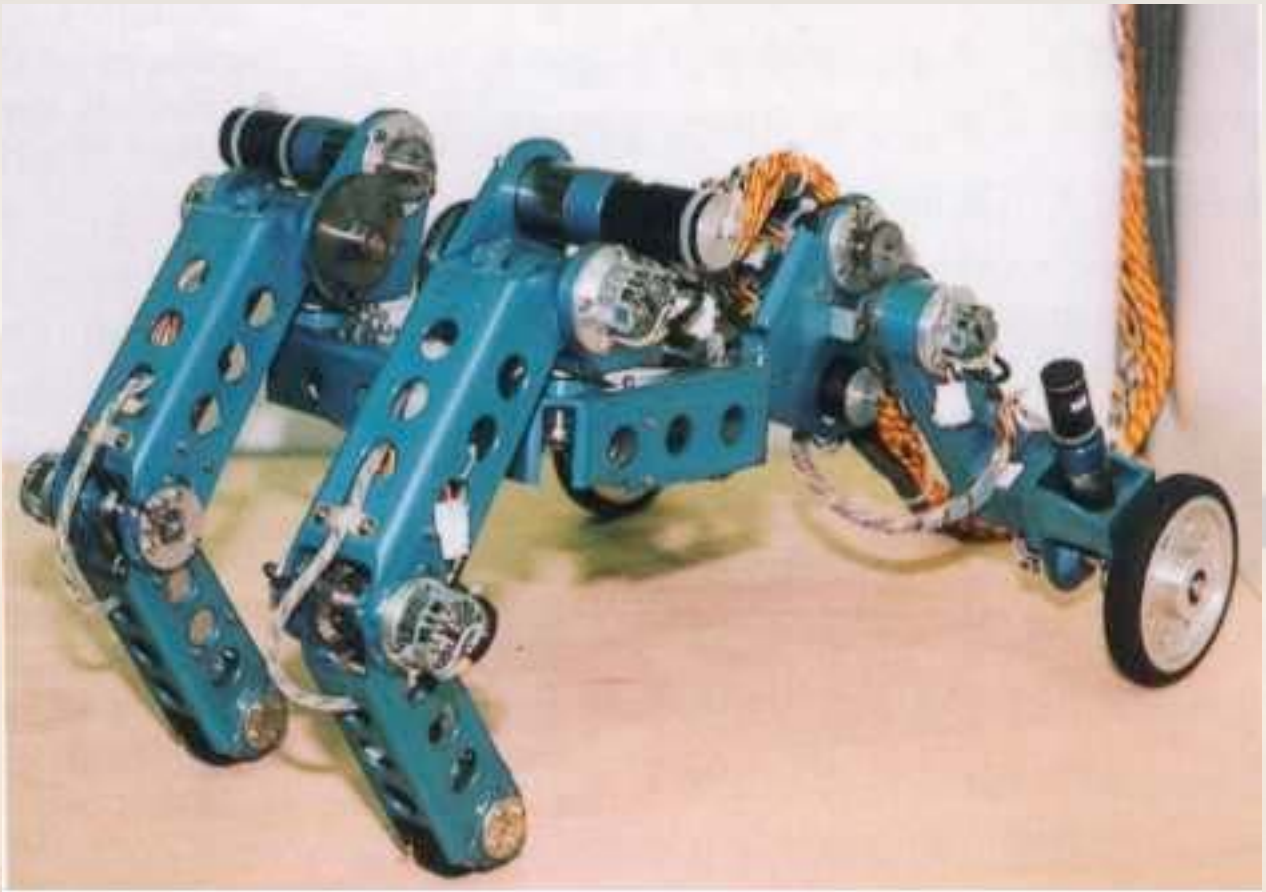
LEMUR II Walking Gait (Unstable)



LEMUR II Walking Gait (stable)



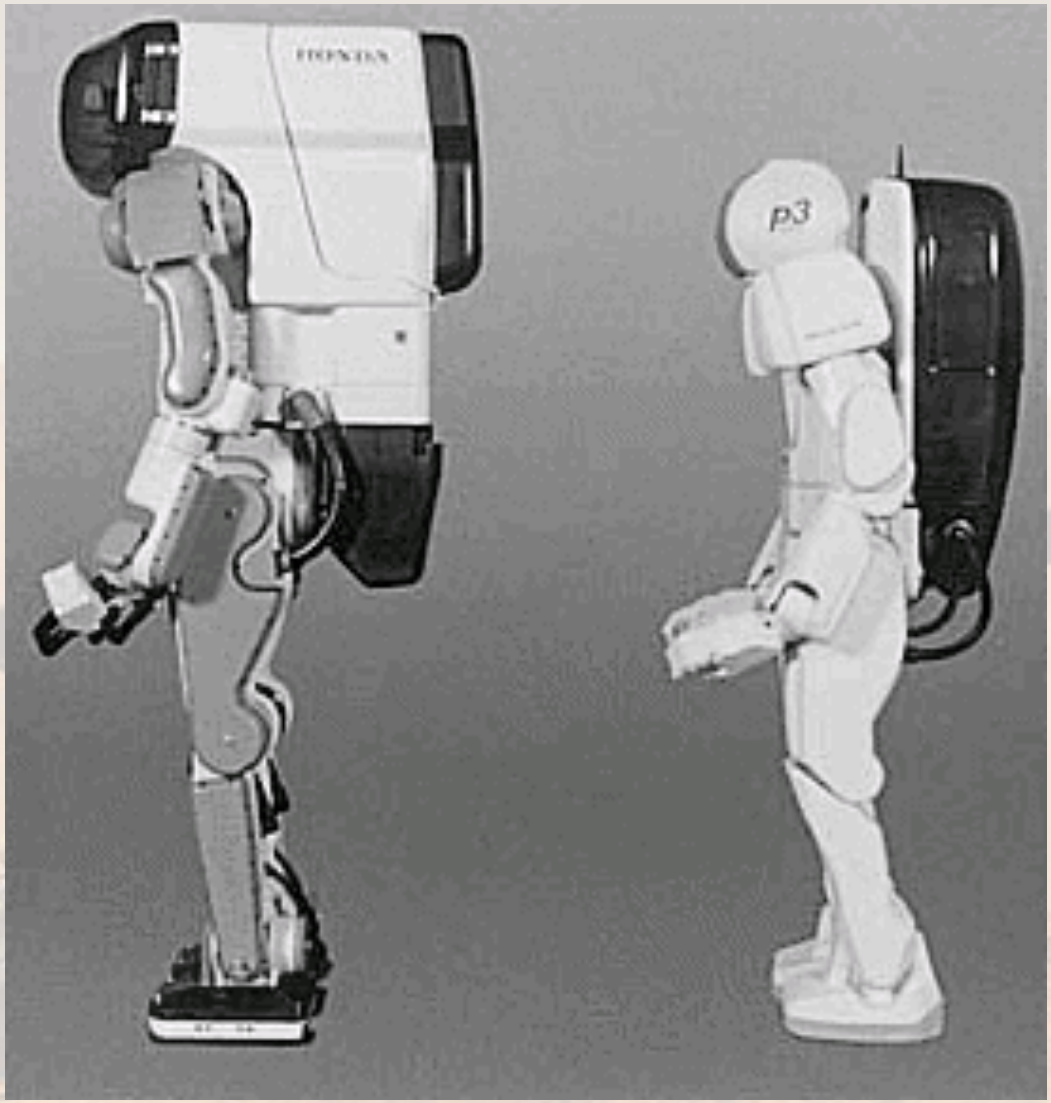
Leg-Wheel Hybrid System (MEL)



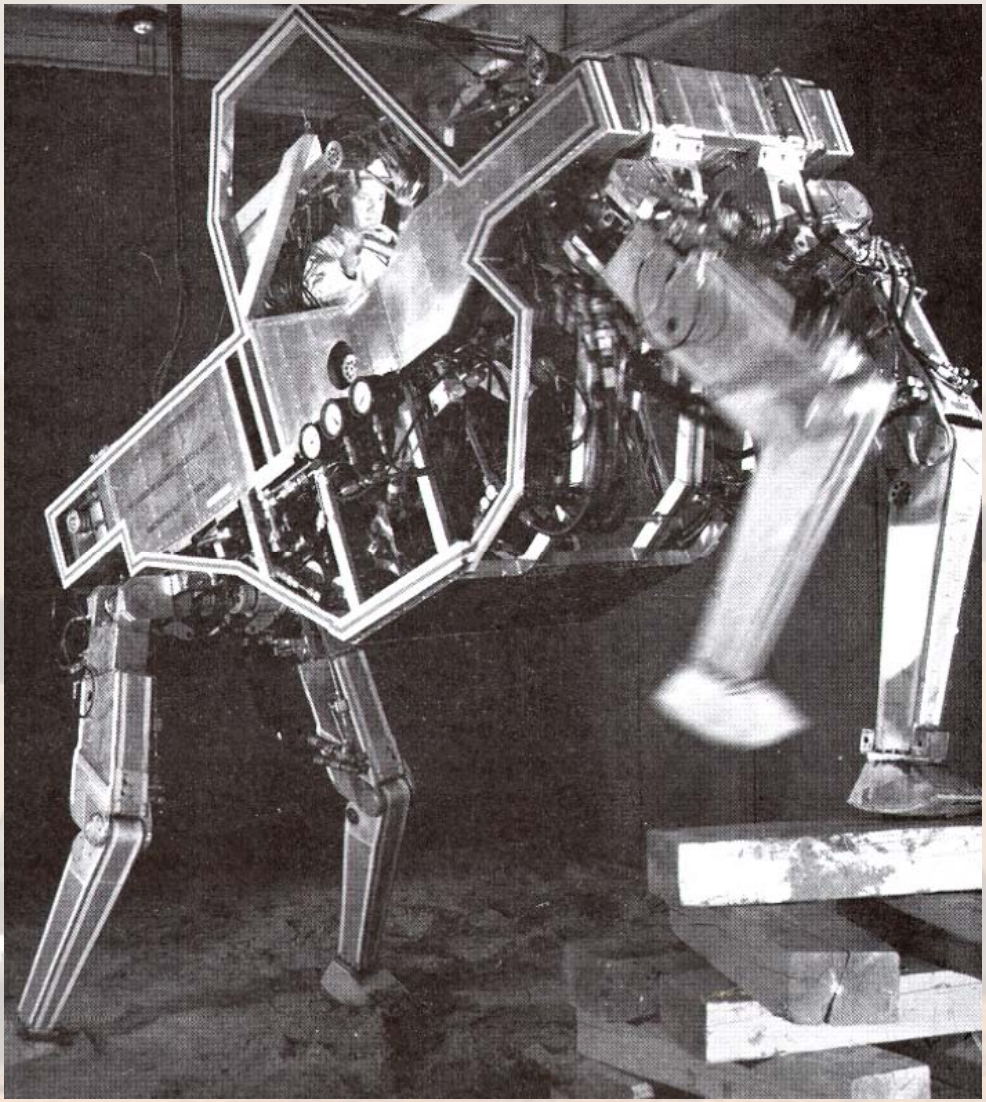
ウォークンロール
Walk'n roll

SPIDER (JSC)

Honda P2 and P3



Walking Truck (GM - 1968)

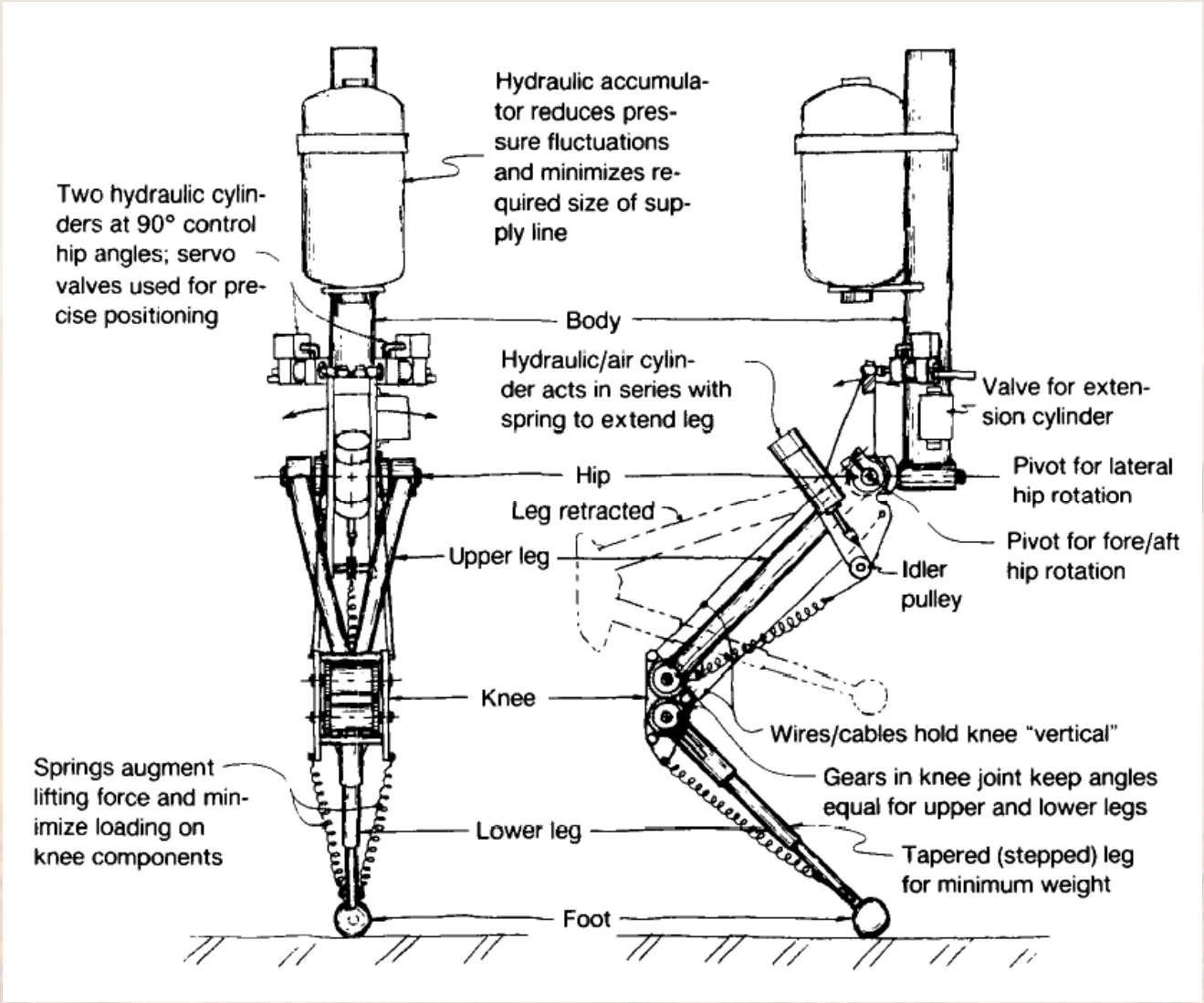


Little Dog (CMU - Boston Dynamics)

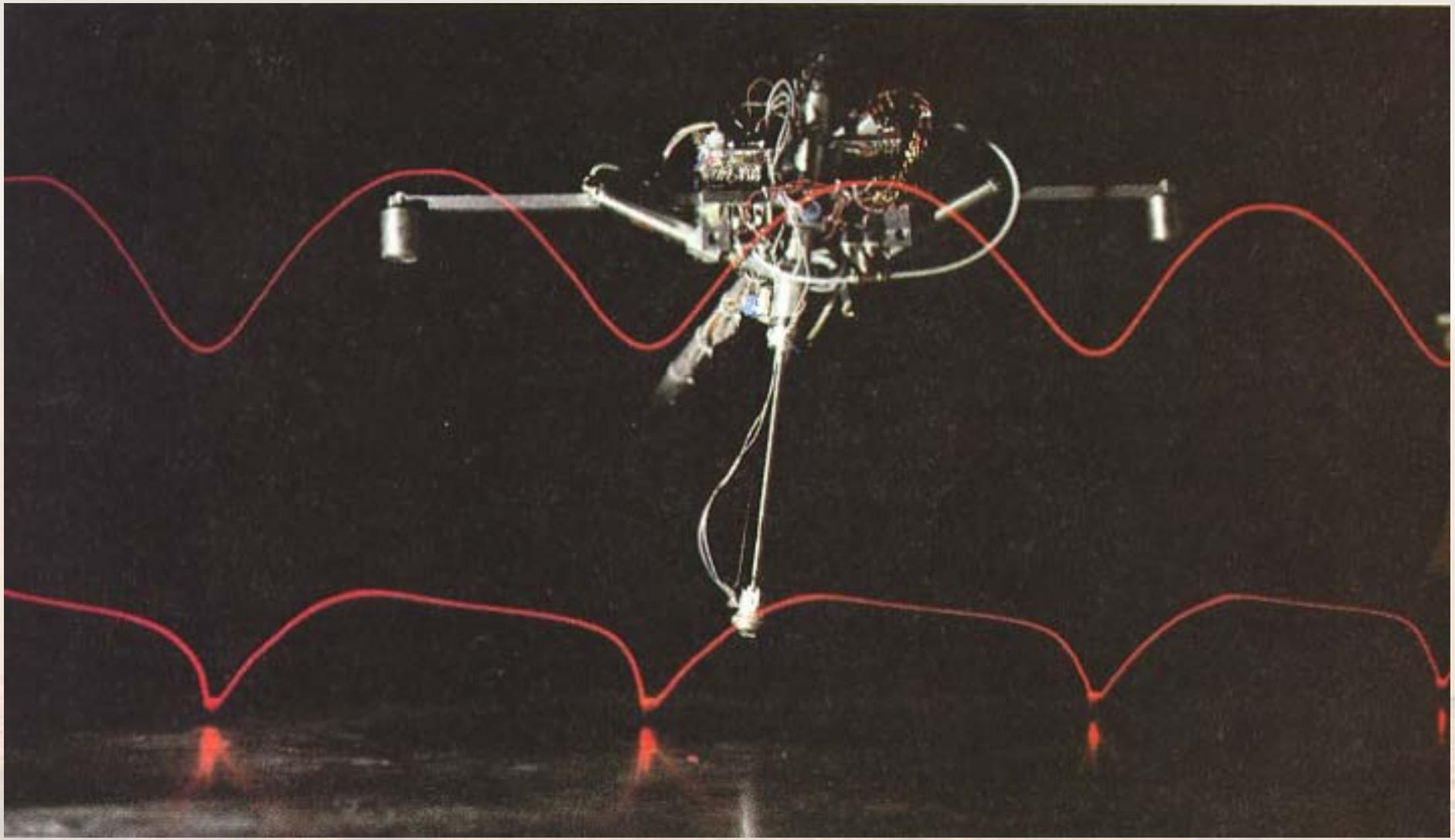
Dynamic Stability for Legged Robots

- Uses reaction forces on ground to maintain orientation
- Similar to trotting and running gaits for animals

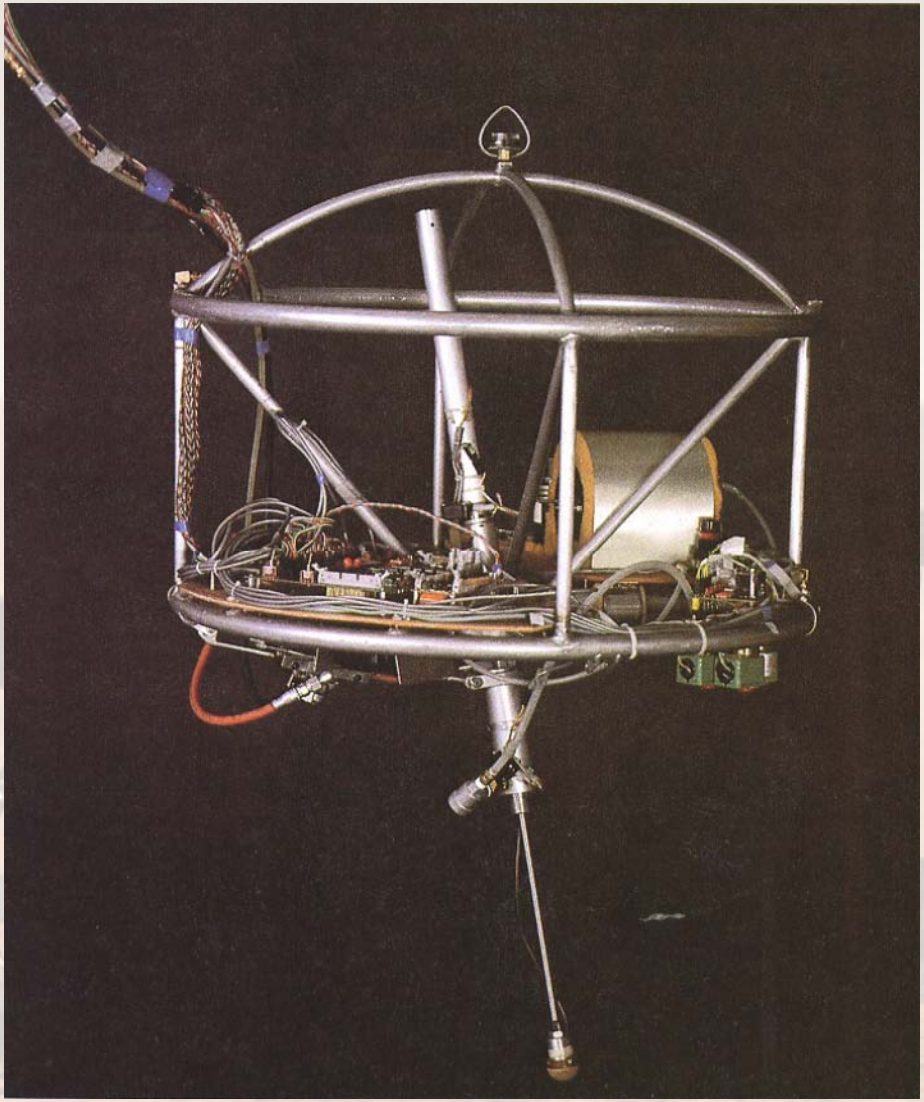
Hopping Robot Concept (Marc Raibert)



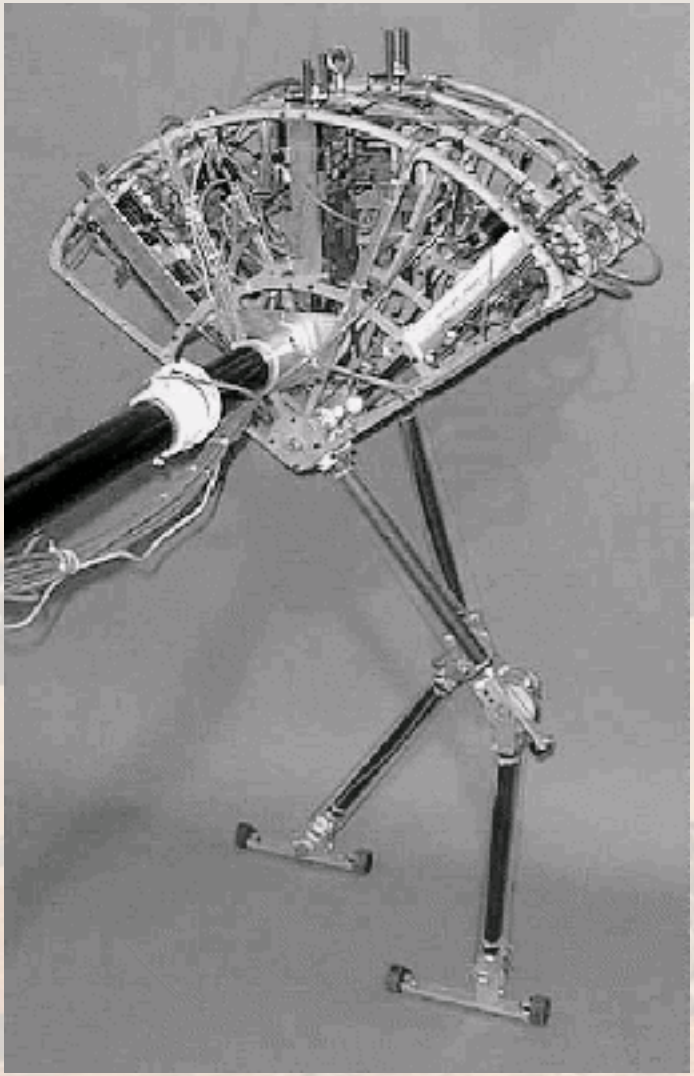
Hopping Robot Motion Visualization



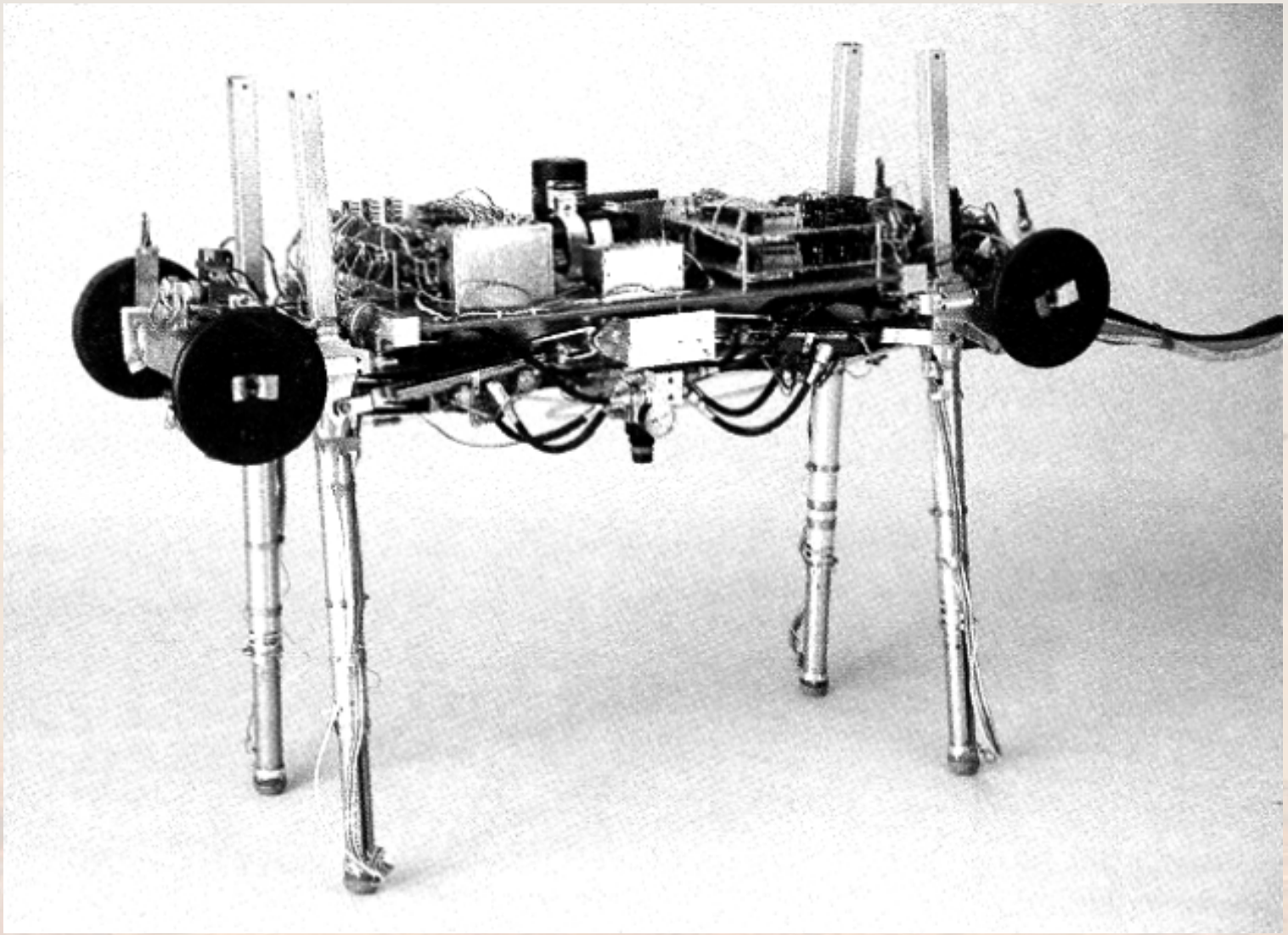
2D Hopping Robot (Marc Raibert)



Spring Flamingo (MIT)

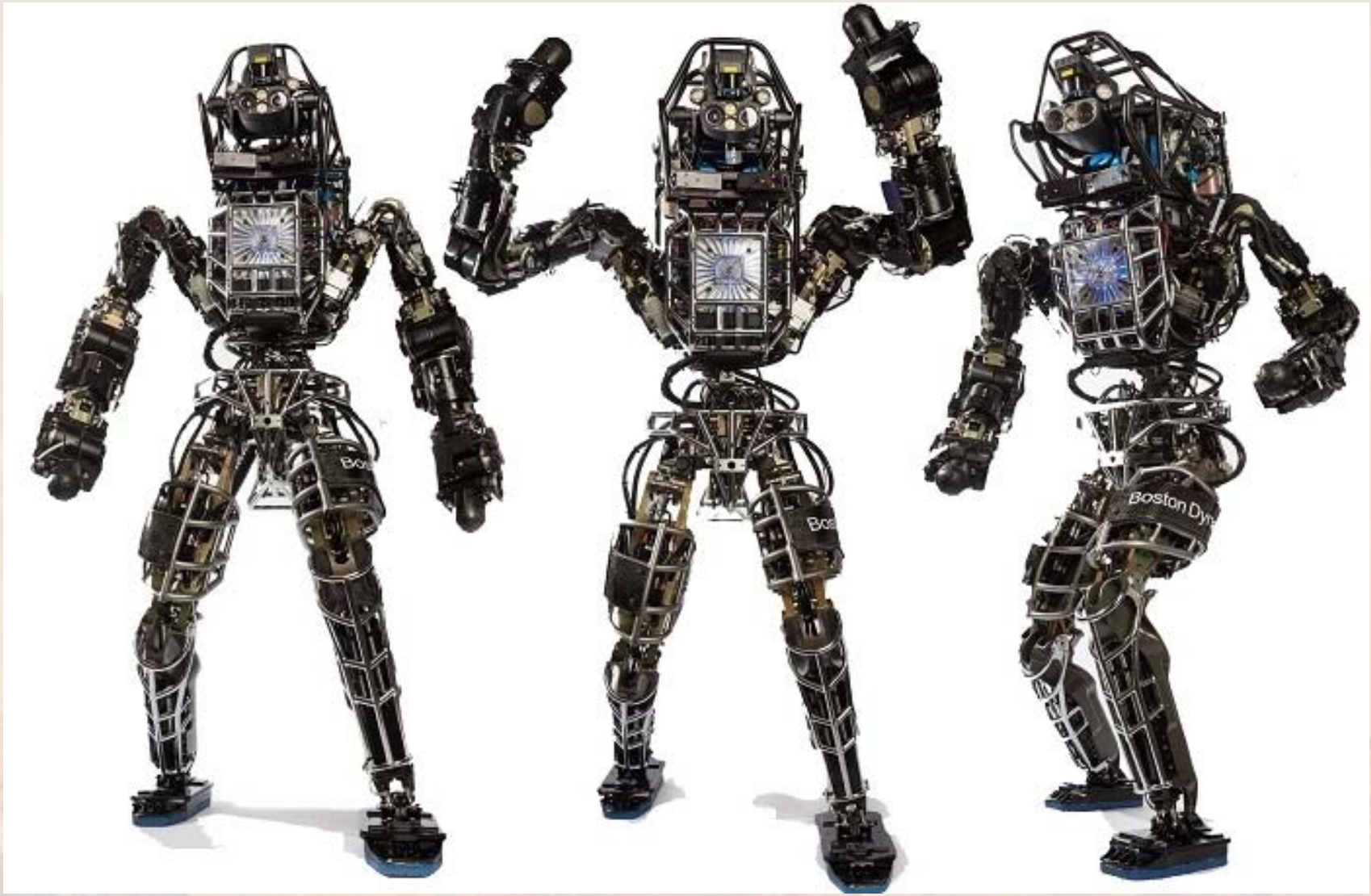


Quadruped Robot (Mark Raibert)

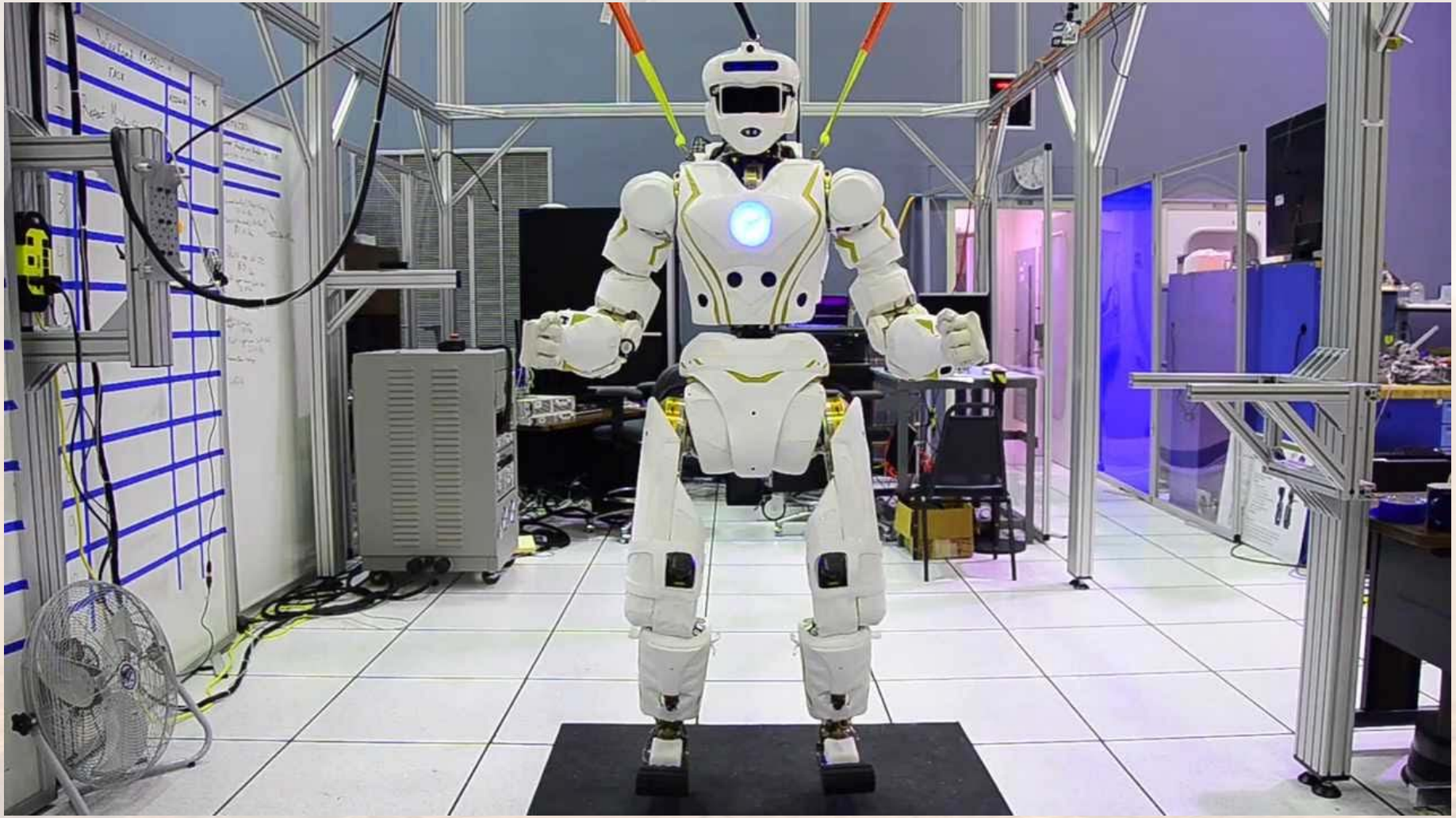


Big Dog (Boston Dynamics)

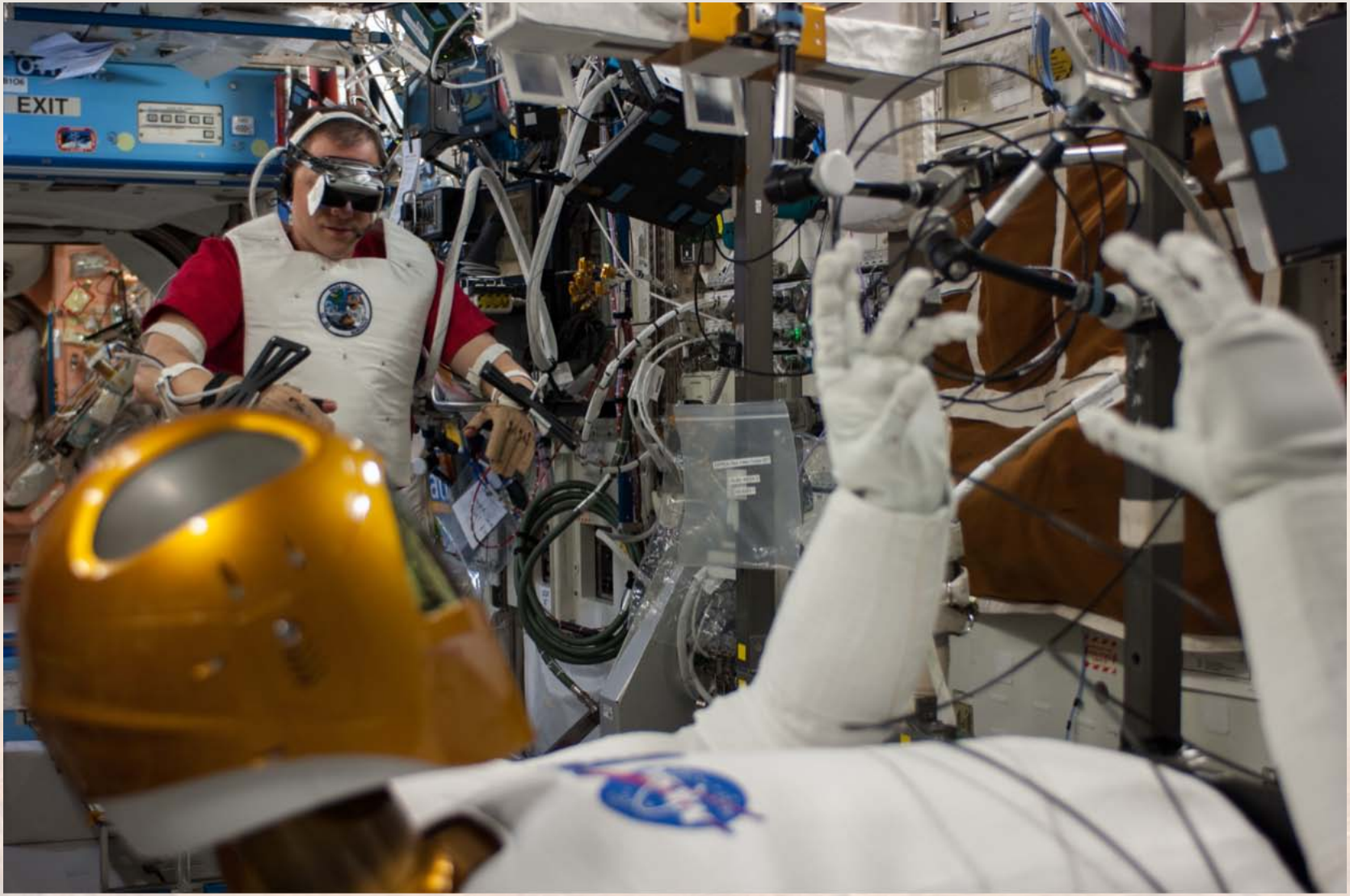
ATLAS (Boston Dynamics)



Valkerie (NASA JSC)



Robonaut 2 on ISS



Robonaut 2 Legs

Project M (NASA JSC)