

Dual-Pin Tool Coupler for Robotic Excavation



Tool: Insulated tank

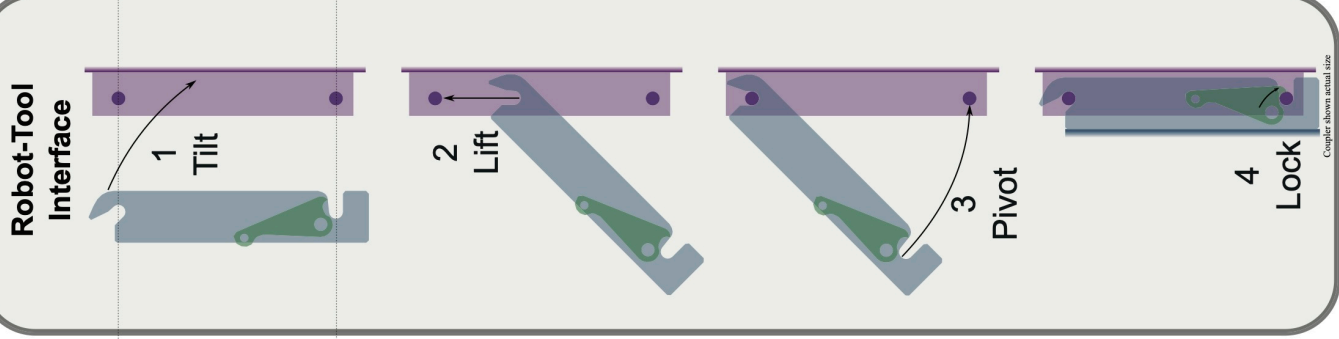


**Aurora
ROBOTICS**

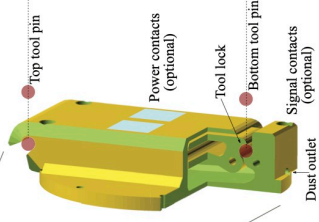
UAF
UNIVERSITY OF
ALASKA
FAIRBANKS

Dr. Orion Lawlor
lawlor@alaska.edu
Aurora Robotics Lab, ELJF 1118
College of Engineering & Mines
University of Alaska Fairbanks

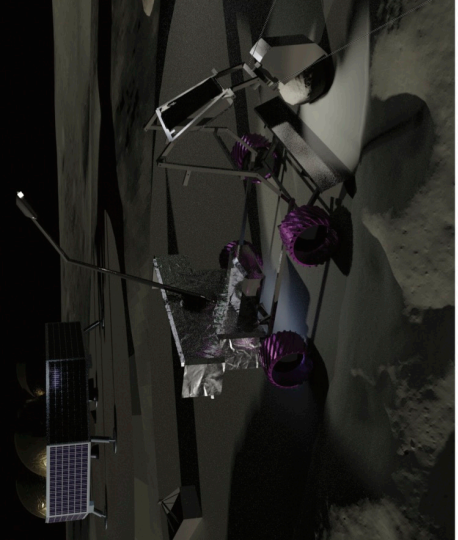
This poster presented at:
LSIC Fall Meeting, 2021-11-03



Robot Tool Coupler



Heavily used 3D printed dual-pin tool coupler prototype, mounted on robotic excavator arm.



Robotic excavation and construction on planetary surfaces would benefit from a **dust-tolerant** tool coupler, to let a robot easily switch between robust end-of-arm tools such as:

- Heavy excavation bucket
- Rock ripper
- Material extruder
- Bulk commodity transport tank
- Gripper / manipulator
- Powered vibrating plate compactor
- Powered rock breaker / rotary hammer drill

We built and robotically tested several approaches for robot-to-tool couplers, and recommend a **dual-pin coupler** for standard use on robots and tools to allow interoperability between missions.

We propose putting two parallel pins on the tool. On the robot a static top hook **self-aligns** the coupler and tool, and a powered locking lug clamps the other pin in the bottom slot, to securely lock the tool to the robot.

This puts all the active parts on the robot, and minimizes the mass of the tool. Four degrees of freedom are constrained by direct contact, and the tool pitch is constrained by the locking lug, leaving only minimal sliding motion along the pins.

Tool-side Interface Specification:
Pin diameter: 8mm Pin axis-to axis distance: 125mm
Minimum clearance along pins: 76mm Behind pin axis: 16mm

As tested: the tool holder was cut from 1.5 mm steel sheet, and steel pins welded in. Tool-side mass is 400 grams with these materials, and proved both robust and easy to couple and uncouple in extensive robotic testing with a variety of tools and operations, including using excavation tools immersed in dusty regolith simulant.

A double-size version with hollow 16mm pins would allow tools to also be lifted by human hands in EVA gloves, which could allow shared robotic or human manipulation of tools or containers.

Trade Study Summary: Robot-to-tool couplers

Tool Coupler	Mass/tool	Dust Tolerance	Ease of Coupling	Load
Dual-Pin (this work)	0.4 kg	Excellent in simulant testing	Good, self-aligning	>500 N
Beveled Box	1 kg	Wide gaps	Tricky to align	>500 N
ISS-WMI	4 kg	Wedge may jam	Wedge self-aligns	500 N
FRGF	8 kg	LEO design	Proven automation	667 N



Our dual-pin system is a scaled down version of a quick-change excavator bucket attachment, like this Cat Pin Grabber (© 2021 Caterpillar), as widely used on construction sites for excavators between 10 and 100 tonnes.



We tested this dual-pin tool coupler system with our Break The Ice robot and a variety of excavation tools.