Activated Aluminum for Operational Energy

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Briefing to the National Academies'
***Powering the U.S. Army of the Future* Study**

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The Expeditionary Risk from Petroleum Dependence Has Not Improved in 80 Years

World War II: "Admiral Halsey [COMSOPAC during Guadalcanal] sent a long memorandum to Nimitz demanding more of everything, above all '[fuel] tankers and more tankers and more tankers.'"

– James Hornfischer, Neptune's Inferno

A *Tokyo Express* run resupplying Japanese infantry burned 1,200 tons of oil per night.*
A Japanese battleship division, repurposed for resupply, was decimated at Battle of Cape St. George; 647 Japanese killed

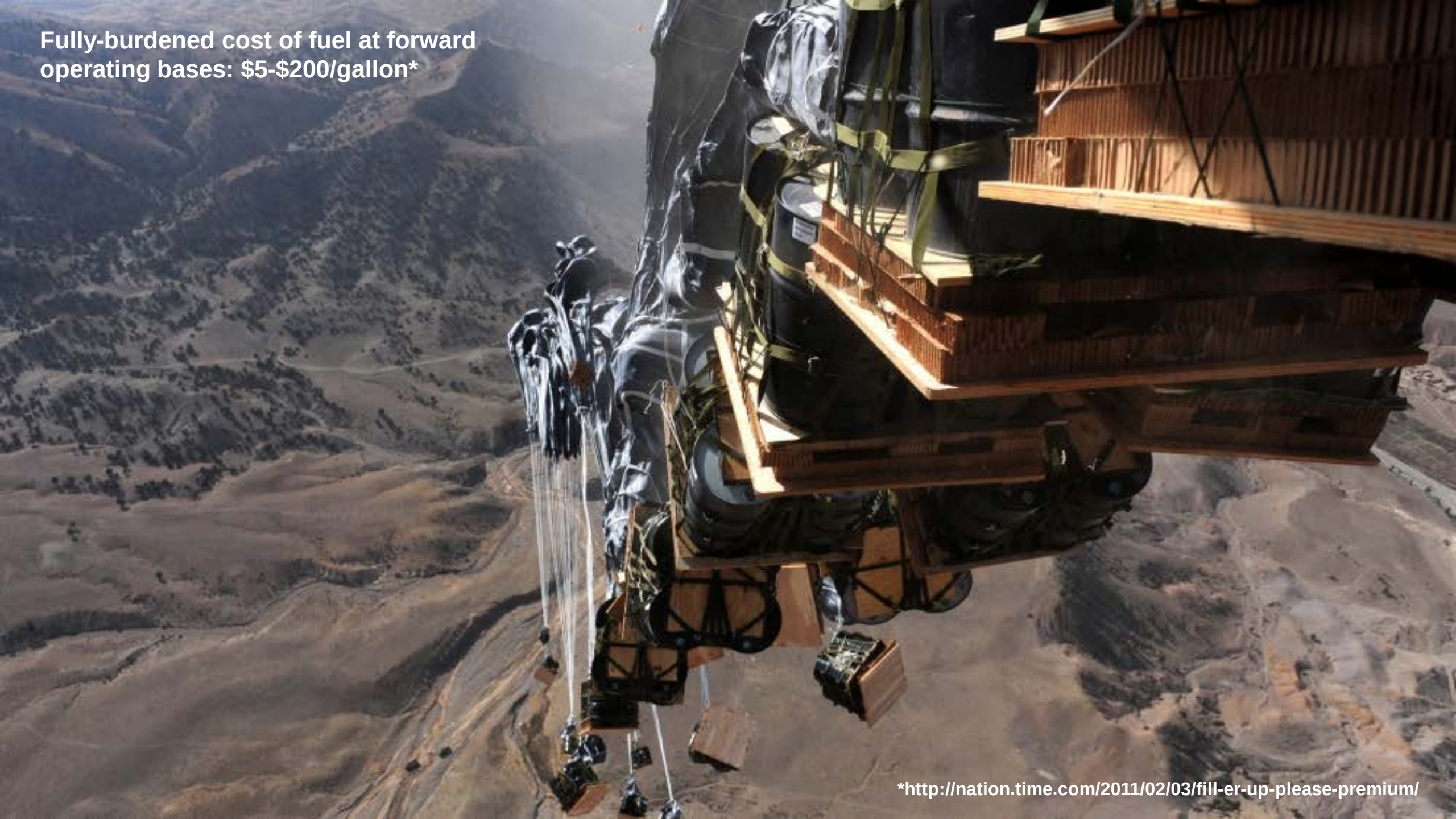
Falklands War: "The vast majority of casualties during the war occurred not on land but at sea…Casualties on ships were often quite severe because of exploding fuel."

– Maj. Gen. Ken Privratsky, *Logistics in the Falklands War*

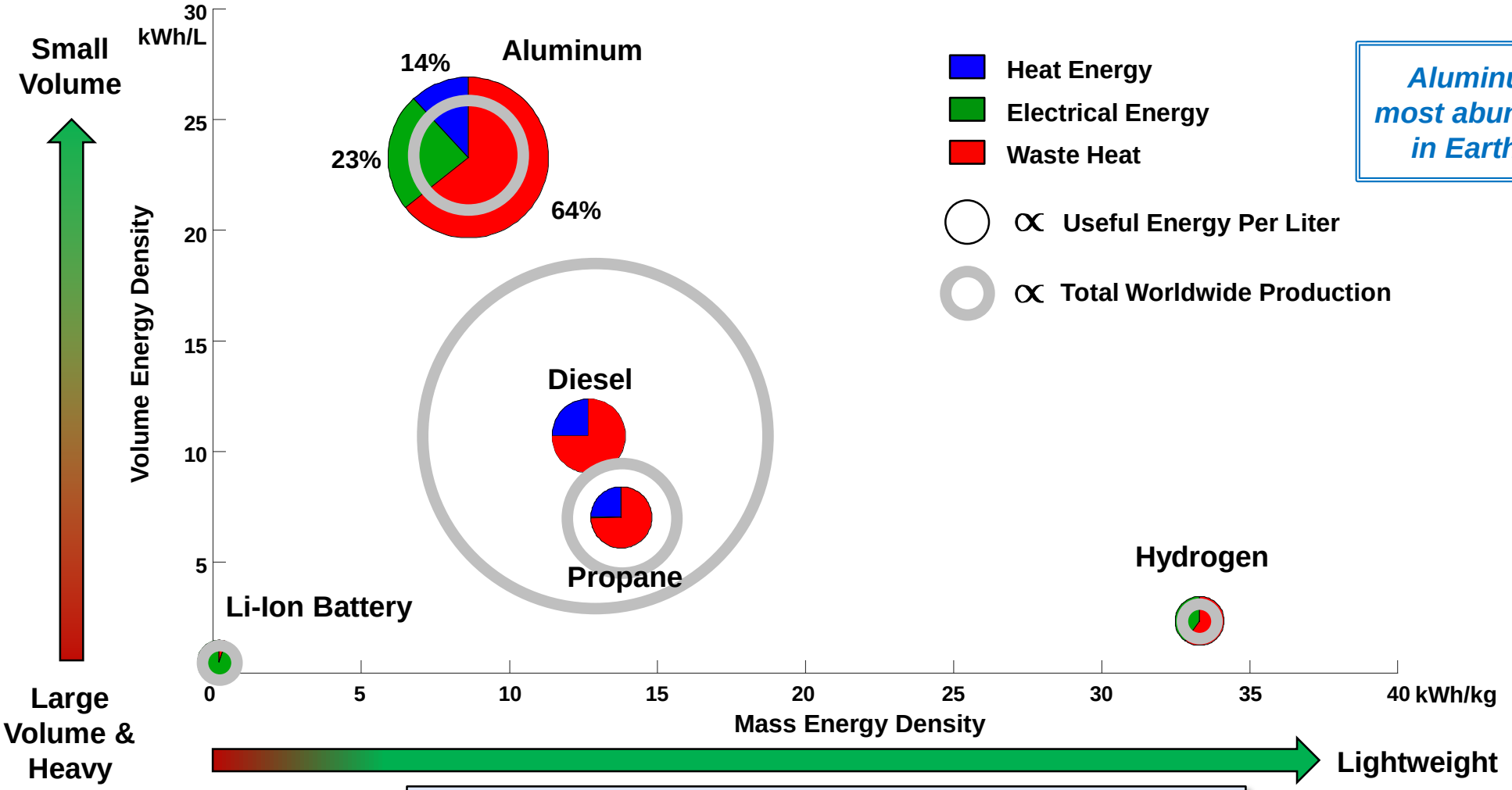
Landing Ship Logistics (LSL) *Sir Galahad* burns at Fitzroy;
48 British killed, hundreds of burn casualties

*http://www.combinedfleet.com/guadoil1.htm


“Fuel convoys are easy targets for roadside bombs, which have accounted for nearly ½ of American deaths in Iraq and almost 40% of deaths in Afghanistan.”
-Forbes.com


Fully-burdened cost of fuel at forward operating bases: $5-$200/gallon*
*http://nation.time.com/2011/02/03/fill-er-up-please-premium/

Comparison of Operational Energy Options



Aluminum is the most abundant metal in Earth's crust.

Aluminum as a fuel is a breakthrough capability

Activated Aluminum Operational Energy Source

2013 MIT undergraduate discovery

Activate → **React** → **Tactical Uses**

Electrical wire

Activate (90 minutes in oven)

Scrap aluminum

Solid fuel

Mineral oil

Paste fuel

Mineral oil

Liquid fuel

Scavenged fuel

Scavenged Water

(tap water, urine, sea water, coffee, gray water, etc.)

Hydrogen

Heat

Byproduct

Air (Oxygen)

Fuel cell → **Electricity (Ground)**

Combustion engine → **Mechanical Power**

Hydrogen tank

Fuel cell → **Electricity (Aerial)**

Hydrogen balloon → **Aerial Lift**

Scavenged Water →  Reverse osmosis → **Potable Water**

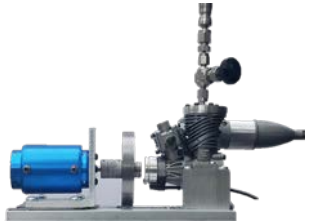
Field Mess

Aluminum hydroxide
(benign, disposable; active ingredient in antacid)

Key Work to Leverage

Aluminum-fueled prototypes developed at Lincoln Beaver Works and MIT-LL

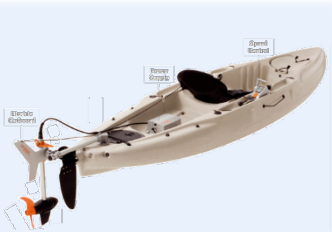
Aluminum BMW



Hydrogen generator

Soldier power source

Emergency desalinator

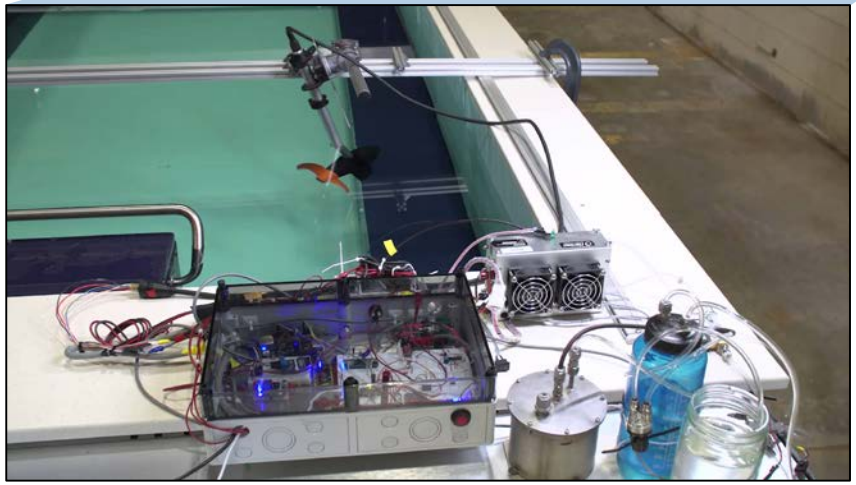


Outboard motor

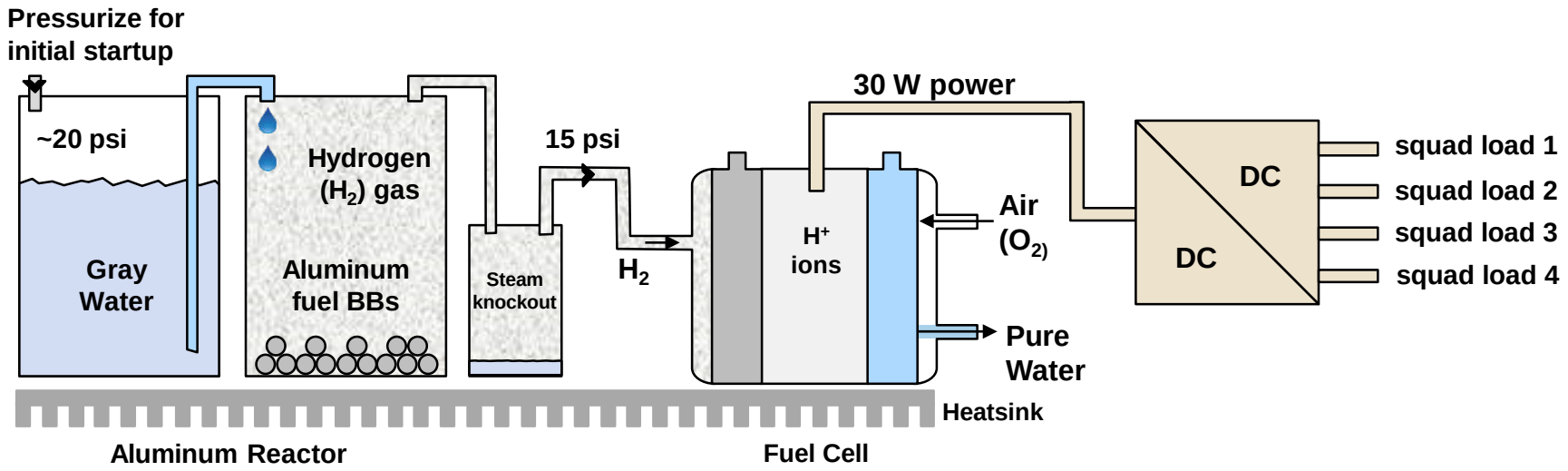
Paste / liquid fuel

MIT student “capstone” projects through Lincoln Beaver Works

MIT-LL Projects



Aluminum-powered Prototype Concept for Individual Dismounted Infantry



Simple, two-chamber aluminum reactor

- Only two moving parts
- Can be significantly reduced in size
- Requires mechanical redesign for field use

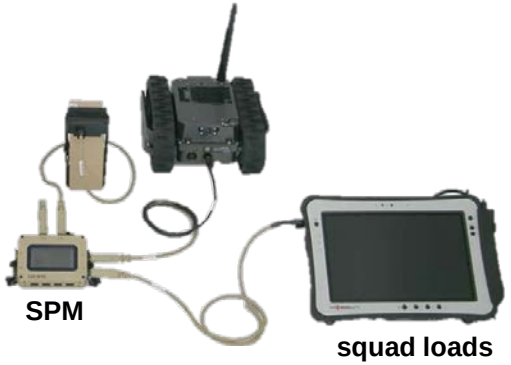
COTS hydrogen-to-power conversion

- Fuel cells come available in various power ratings
  - Enables future scale-up
- SPM is an Army program-of-record
  - Easily adapted to power any infantry-carried load

"Breadboard" Aluminum Reactor

Fuel Cell

Army Squad Power Manager (SPM)



COTS: commercial off-the-shelf

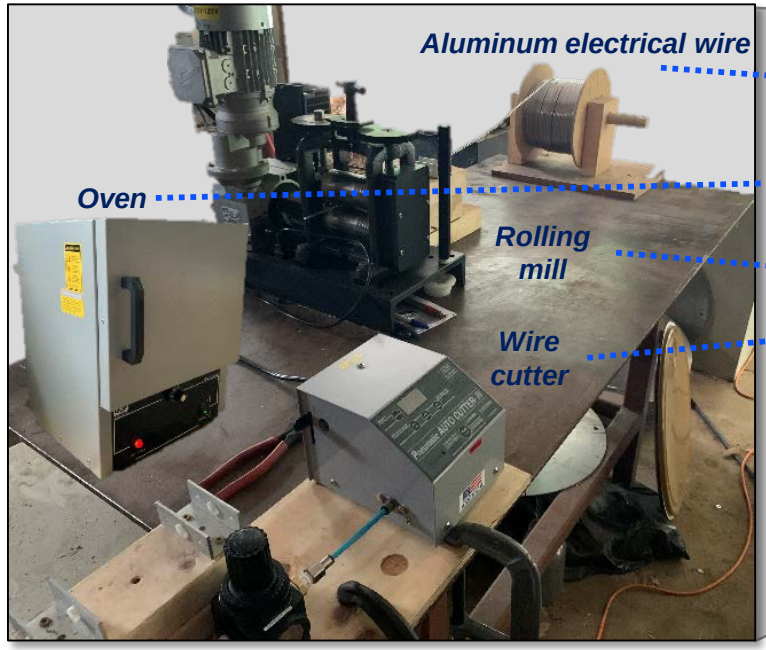
Required Quantities & Cost

		Platform Consumption Estimate	*R&D Cost*	*Materials Estimate*
			Commercial Supplier	U.S. NAVAL RESEARCH LABORATORY
Cost			**$34 / lb**	**$3.17 / lb**
Cost Contributors			**U.S.-sourced wire, labor***	**Scrap aluminum**
	**Stratospheric Balloon**	**17 lb**	**$630**	**$56**
	**Group 2 UAV hydrogen tank**	**4 lb**	**$136**	**$13**
	**Infantryman's Kit (per day)**	**½ lb**	**$20**	**$2**

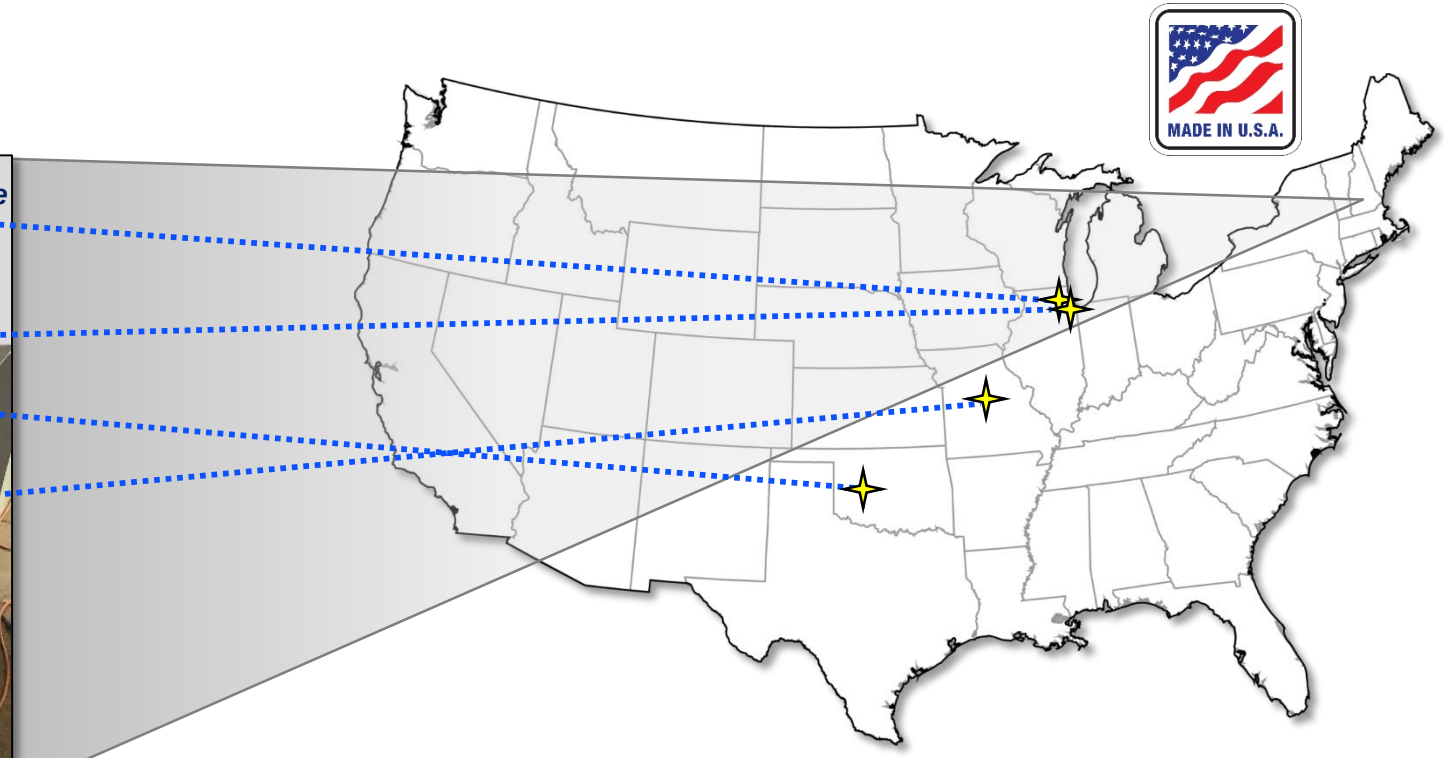
*packaging cost not included

Production of Activated Aluminum

- **Aluminum activation equipment is compact and low-cost**
  - **Total capital cost: $7,000**
  - **Fits on a table**
- **U.S.-sourced aluminum wire**
- **Activation metals:**
  - **Canada, Europe, China**



Activation Equipment Assembly in Garage



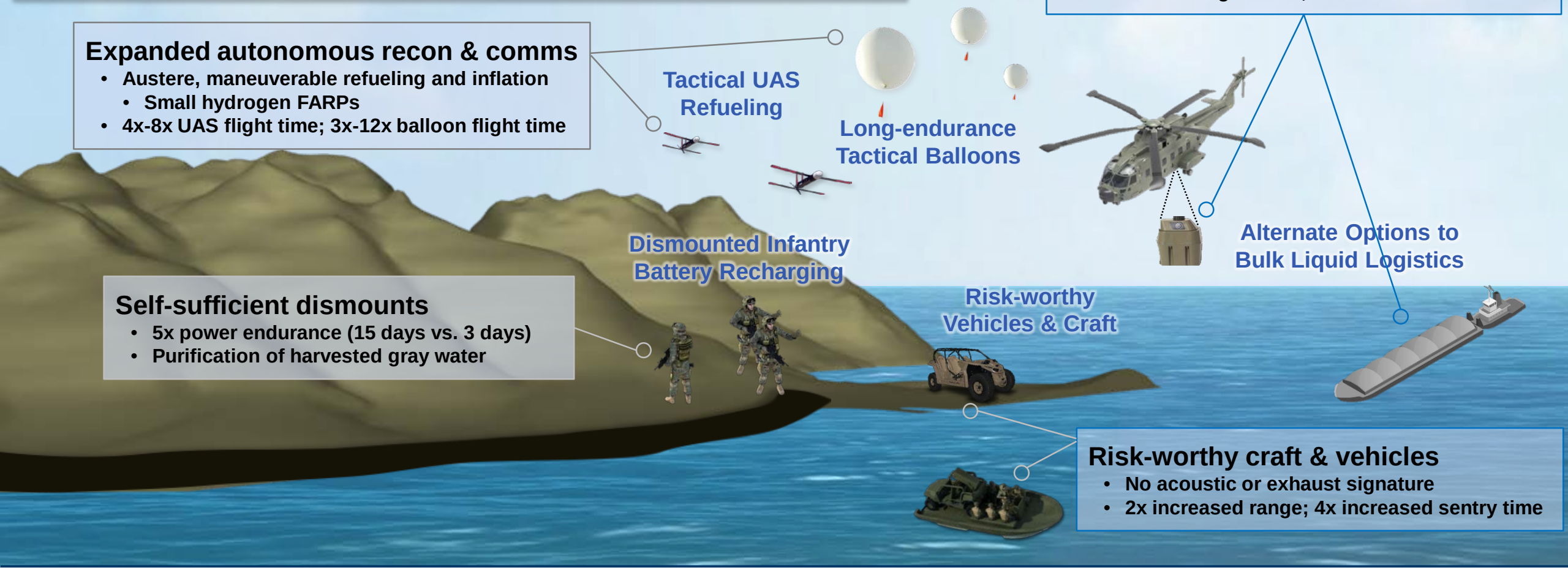
Metal source data: U.S. Geological Survey, National Minerals Information Center, 2020

Activated Aluminum Extends Range and Provides Commanders New Logistics Options

"Insights from recent war games indicate that sustainment is the pacing function for [expeditionary operations], with fuel being the pacing commodity."
– U.S. Marine Corps EABO Concept, 2019

Distributed, maneuverable logistics
- Air-drop solid or paste fuel (no bulk liquids)
- Convert scrap aluminum into fuel
- Smart caching: Stable, non-combustible

Expanded autonomous recon & comms
- Austere, maneuverable refueling and inflation
  - Small hydrogen FARPs
- 4x-8x UAS flight time; 3x-12x balloon flight time



Self-sufficient dismounts
- 5x power endurance (15 days vs. 3 days)
- Purification of harvested gray water

Risk-worthy craft & vehicles
- No acoustic or exhaust signature
- 2x increased range; 4x increased sentry time

FARP: Forward arming and refueling point
EABO: Expeditionary advance base operations