# Landmines

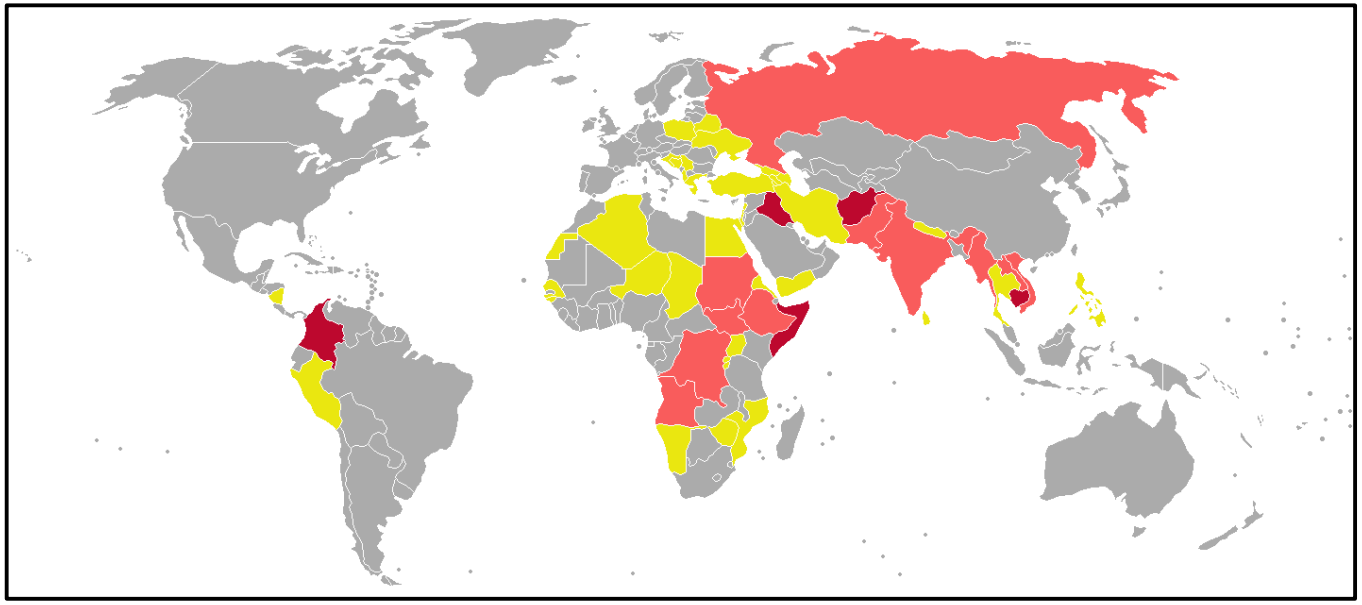
## can we find them?

Stephen Brown
MIT/ERL

# Problem

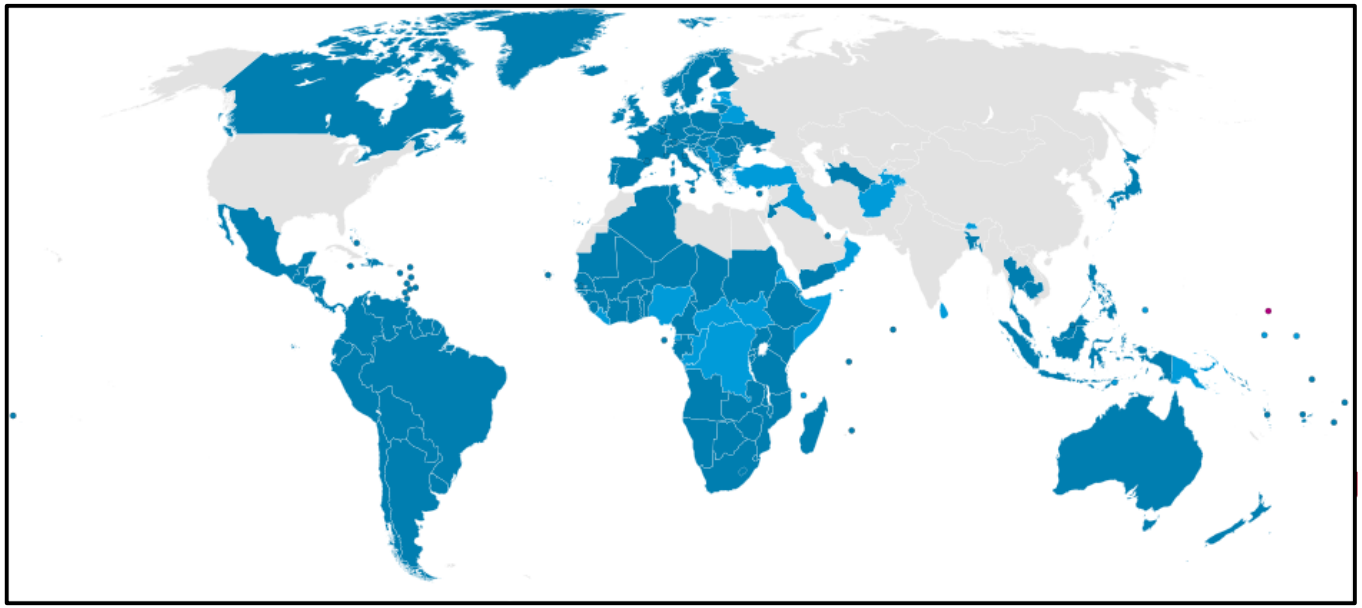
- There are approximately 110 million landmines in 70-90 countries killing or maiming 15,000-25,000 people per year.
- More than one million children, women and men have been killed or maimed for life by exploding landmines since 1975; 80% are civilians.
- It is reported that there were 8,605 casualties, including 2,089 deaths, from mines just in 2016.
- Afghanistan has 10 million anti-personnel landmines; Angola 9 million; Cambodia 4 million; Mozambique, Somalia and the Sudan each 2 million; Ethiopia and Eritrea 1 million.
- Despite a treaty banning them, an additional 2 million mines are produced each year.

# Summary in pictures



Countries with very high (r), high (o), and moderate (y) casualties

Parties to the Ottawa Treaty of 1999



# The time and cost

## WHAT THE WORLD WANTS

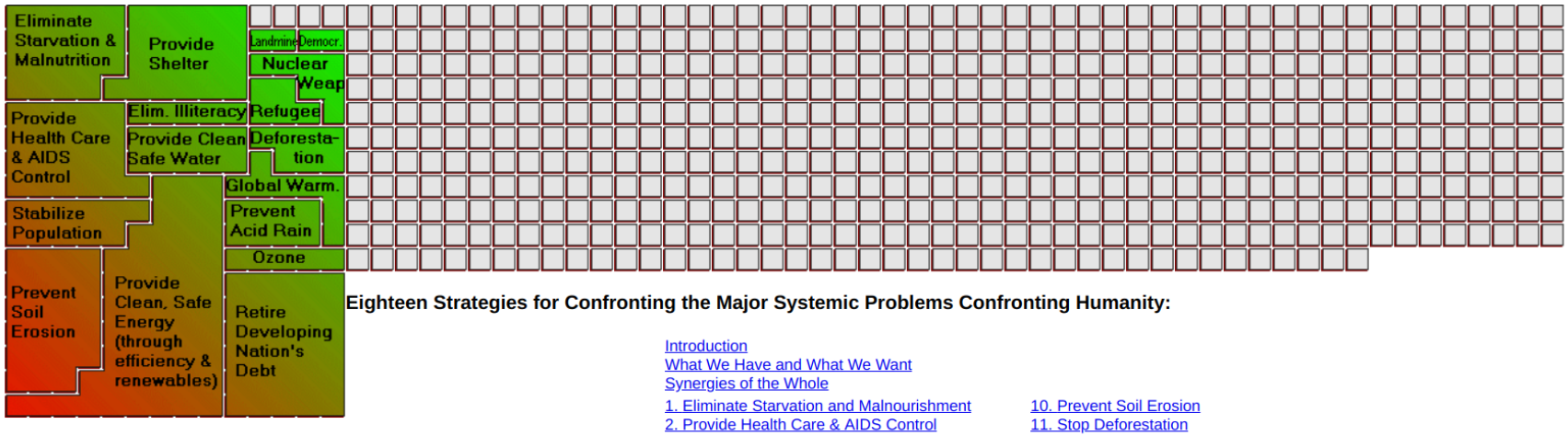
### AND HOW TO PAY FOR IT USING MILITARY EXPENDITURES

Below are annual costs of various global programs for solving the major human need and environmental problems facing humanity. Each program is the amount needed to accomplish the goal for all in need in the world. Their combined total cost is approximately 30% of the world's total annual military expenditures.

= $1 billion. = Amount that was needed to eradicate Smallpox from the world (accomplished 1978): $300 million.

**Total Chart represents Annual World Military Expenditures: $780 billion**

Click on color chart to see strategies




**Eighteen Strategies for Confronting the Major Systemic Problems Confronting Humanity:**

Introduction
What We Have and What We Want
Synergies of the Whole

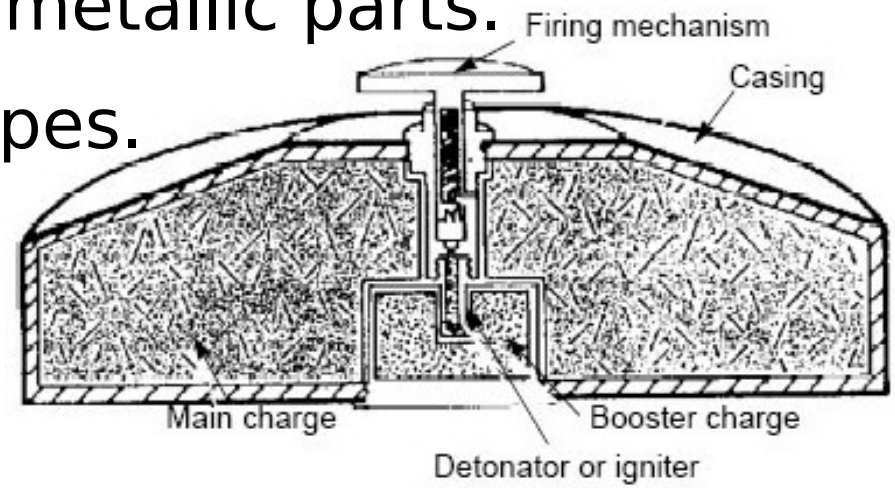
1. Eliminate Starvation and Malnourishment
2. Provide Health Care & AIDS Control
3. Provide Shelter
4. Provide Clean Safe Water
5. Eliminate Illiteracy
6. Provide Clean, Safe Energy: Efficiency
7. Provide Clean, Safe Energy: Renewables
8. Retire Developing Nations Debt
9. Stabilize Population
10. Prevent Soil Erosion
11. Stop Deforestation
12. Stop Ozone Depletion
13. Prevent Acid Rain
14. Prevent Global Warming
15. Remove Landmines
16. Refugee Relief
17. Eliminating Nuclear Weapons
18. Build Democracy

UNESCO says …
there's plenty of money

But … given the number of mines already in place and the current methods for finding and clearing them it will take 450-500 years!

# What they are

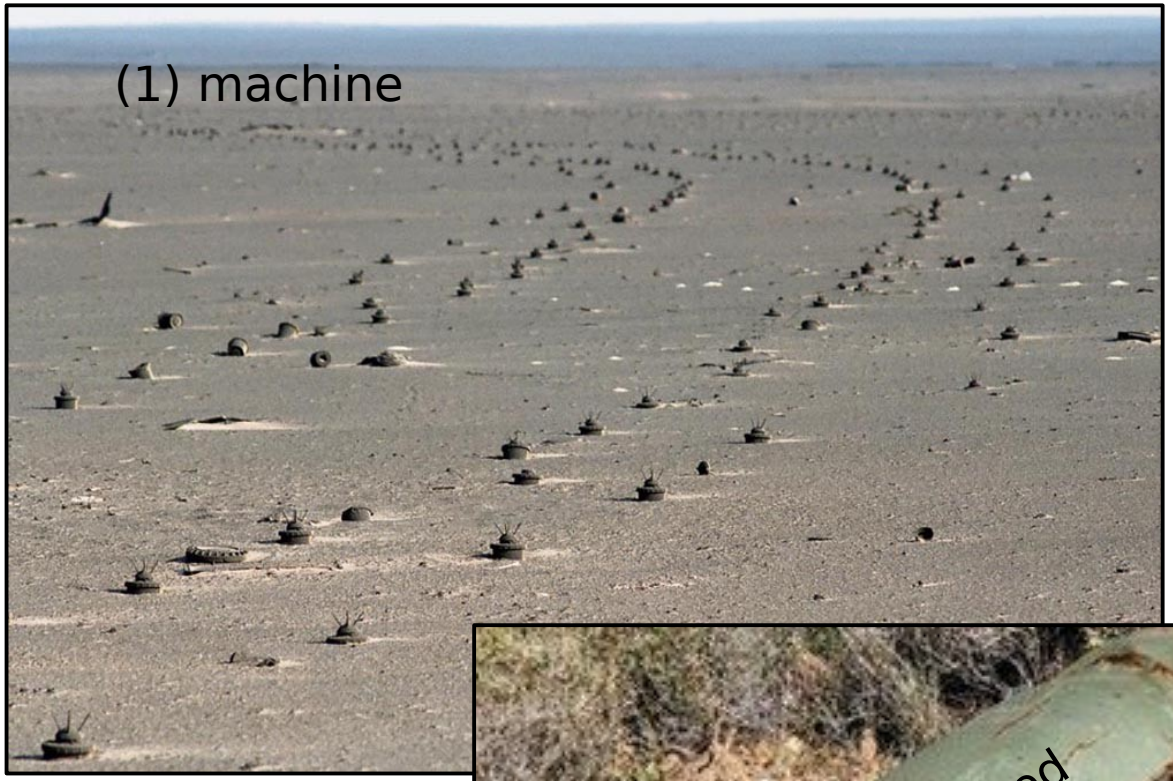
- Manufactured devices meant to detonate via a trigger and cause harm (death!).
- Types: On land anti-personnel and anti-vehicle mines. We also include unexploded ordinance (UXOs), but not improvised explosive devices (IEDs).
- Components: a case, detonator or igniter mechanism, and explosives.
- Newer mines have fewer metallic parts.
- Come in all sizes and shapes.
- Small ones might cost $3



# A staggering variety


https://en.wikipedia.org/wiki/List_of_land_mines

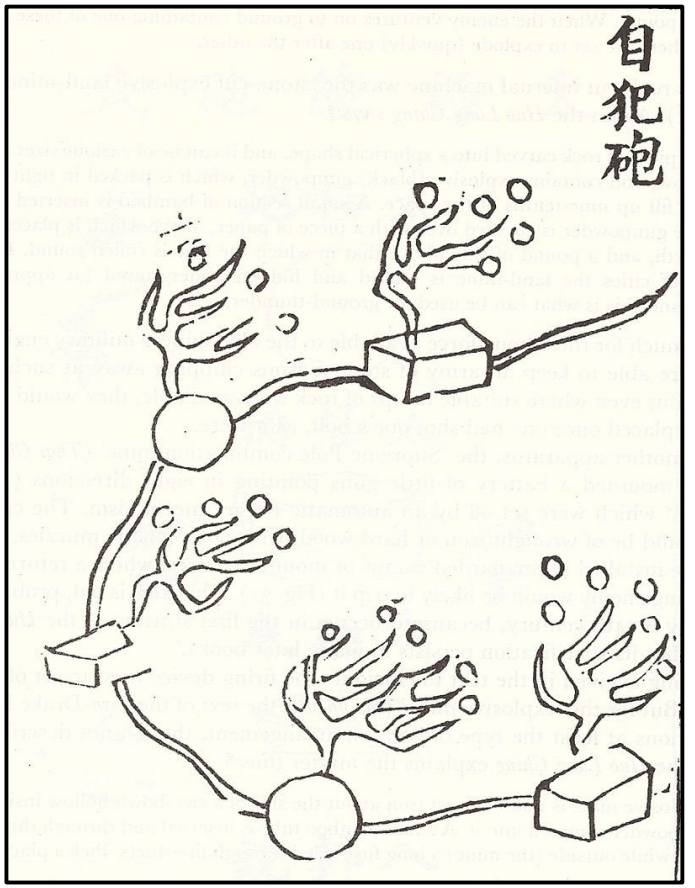
# Neither rhyme nor reason





# History

- Explosive land mines were used in 1277 by the Chinese during the Song dynasty against an assault of the Mongols.
- The first known land mine in Europe was created by Pedro Navarro (d. 1528), a Spanish soldier and engineer.
- The first modern mechanically fused high explosive anti-personnel land mines were created by Confederate troops during the Battle of Yorktown in 1862.
- Improved designs of mines were created in Imperial Germany, circa 1912, and have become an art form ever since.



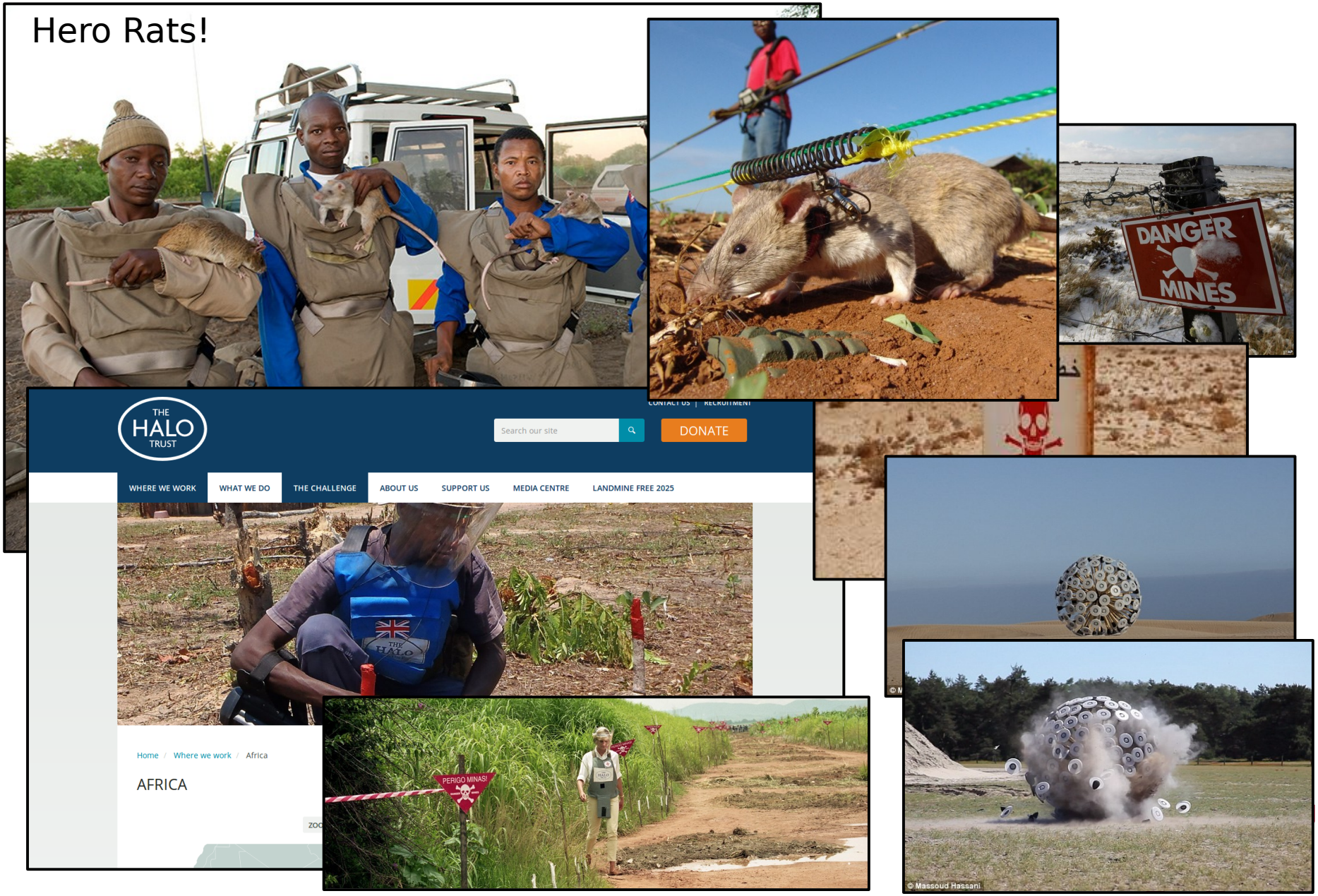

The Chinese 'self-tripped trespass land mine' from the Huolongjing, compiled by Jiao Yu and Liu Bowen in the mid 14th century.

# Finding them

# Removing them




# Humanitarian demining



# New research

| Technology | Strengths | Limitations |
|---|---|---|
| **Electromagnetic:** | | |
| electromagnetic Induction | range of environments | metal clutter, low-metal content |
| ground-penetrating radar | all anomalies, not just metal | roots, rocks, water |
| electrical impedance tomography | all anomalies, not just metal | dry environments, can detonate mines |
| x-ray backscatter | advanced imaging | slow, radiation emissions |
| infrared / hyperspectral imaging | safe standoff, wide area, fast | poor resolution if too far away |
| **Acoustic / seismic:** | low false alarm, not electromagnetic properties | depth, frozen ground, vegetation |
| **Explosive Vapor:** | | |
| biological: dogs, rats, mongoose, bees, plants, bacteria | confirms explosives | dry environments |
| fluorescent | confirms explosives | dry environments |
| electrochemical | confirms explosives | dry environments |
| piezoelectric | confirms explosives | dry environments |
| spectroscopic | confirms explosives | dry environments |
| B**ulk Explosives:** | | |
| nuclear quadrupole resonance, stimulated neutron emissions | elemental or molecular composition | moisture, soil minerals, rf interference |

# A variety of issues

- Depth, resolution, speed, soil properties, natural clutter, vegetation, too much moisture or too dry, mine type, mine material, mine shape
- Therefore  - no single technology is sufficient for all cases.

A universal recommendation
from expert committees, reports, and surveys
of the problem of landmine detection is -

use multiple and overlapping technologies
accompanied by machine learning or data fusion

# Technology growth

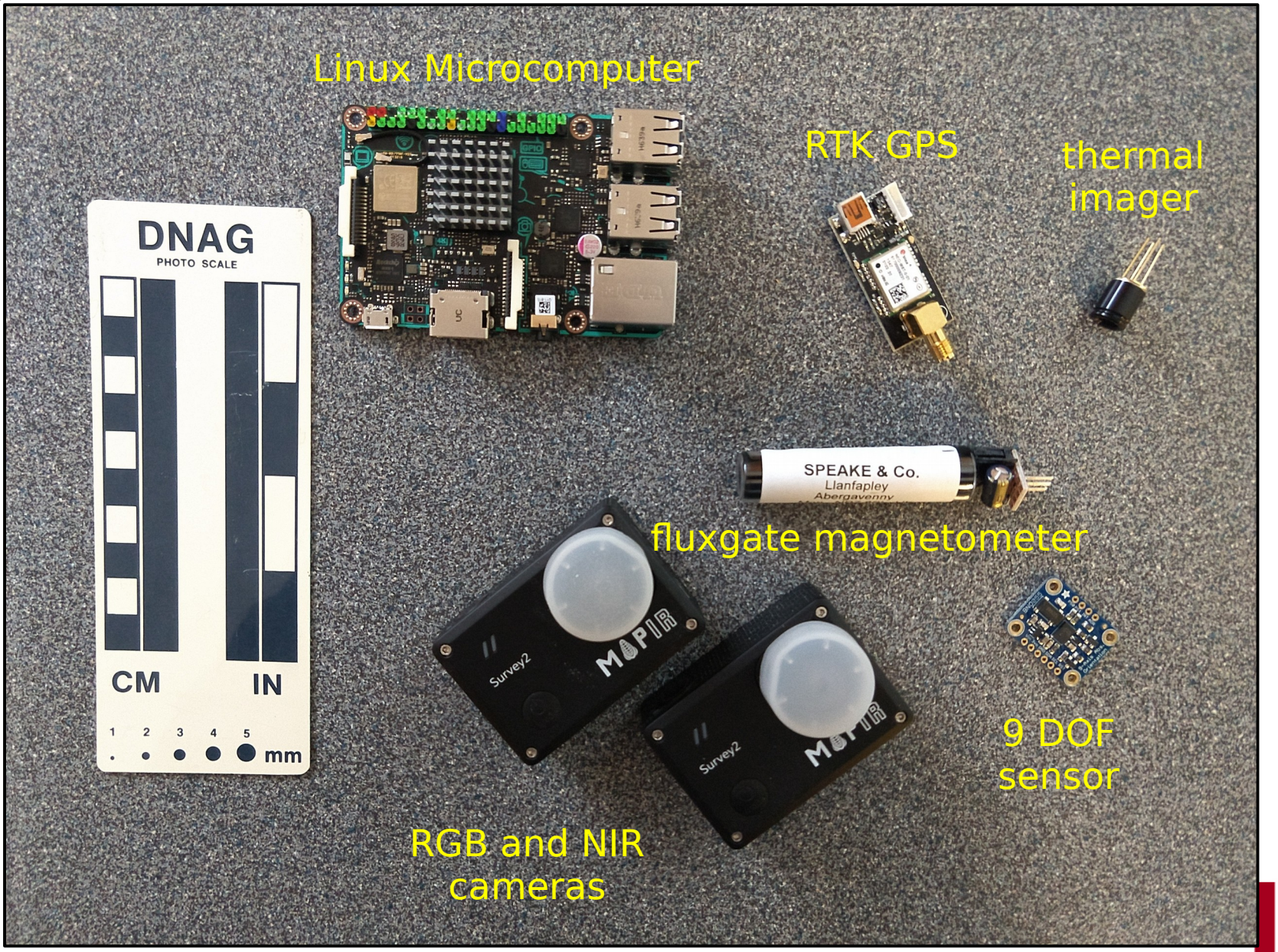
- Present day situation:
  - No universal approach
  - Old methods prevail
    - Slow, close-in, require men/women on the ground, dangerous, high false positives
- 5-10 year old studies and technologies have often been bulky, impractical
- But, we have continuing new possibilities from rapid technology advances
  - Miniature sensors, small computing hardware, machine learning software

# Call to action

- Katya, Harry, and I are answering this call to action.
- We are exploring the detailed mapping of multiple relevant properties via meso-scale mapping drones.
- We are at very early discussion and prototyping stages.

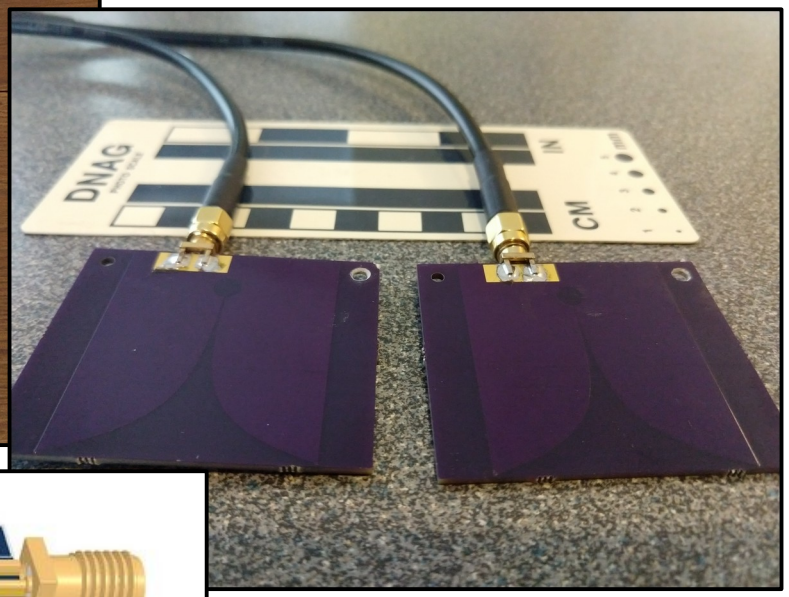
Do you want to help?

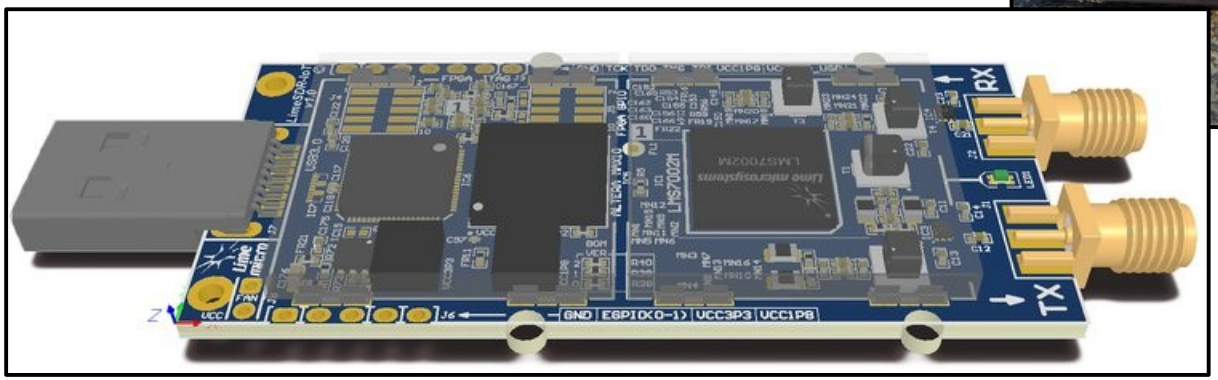
# Useful bits and pieces



# Useful bits and pieces


drones with prescribed flight plan




software-defined radar

# The whole enchilada

Meso-scale mapping drones
- components of an ideal system -