

IMEKO TC17 - Workshop VRISE'2021
October 8 2021

Mobile Robots Supporting Risky Interventions, Humanitarian actions and Demining, in particular the promising DISARMADILLO Tool

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INTRODUCTION

Mobile Robotics facing risky interventions during disasters

- ▶ **“Resilience is critical to allow authorities to take proper measures in response to severe disasters, both natural (including climate-related extreme events) and man-made. Innovation for disaster-resilient societies may draw from novel technologies, provided that they are affordable, accepted by the citizens, and customized and implemented for the (cross-sectoral) needs of first responders [European H2021 Societal Challenges]”**
- ▶ **Cooperative multi-robot systems based on UAV and UGV (possibly UUV-USV too) equipped with modular sensors and intervention tools (robotic arms with special hands/grippers) will carry out the screening, searching and collection of samples in the “hot zones” where the first responders could be exposed to dangerous and hazardous agents.**

Mobile Robotics facing risky interventions during disasters

CBRNE Issues (IED included)

- ▶ Nuclear Plant , **SEVESO sites**
- ▶ (Toxic and/or Bio-toxic agents)
- ▶ 1997, **Chernobyl**
- ▶ 2017, **Fukushima**
- ▶ **Terrorism**
- ▶ **Pandemy (Ebola, Covid,...)**

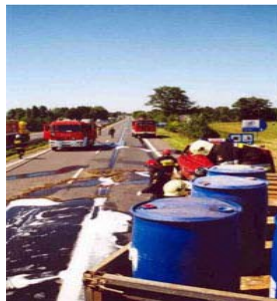
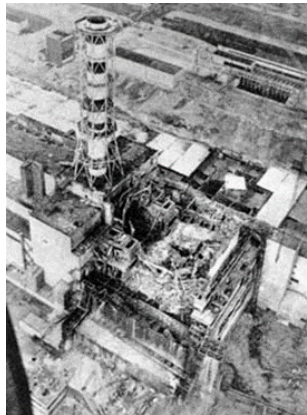
Implied:

Removal of radioactive containers/material (UGV- multi-Manipulator)

Multi-robotics cooperation (UGV and manipulation)

Training of remote- Intervention Personnel

Localization of the CBRNE sources
(UAV-UGV)



Earthquakes, Cyclones, Hurricanes, Fires

- ▶ Earthquake - Magnitude 7
- ▶ **Haiti** type (7.1 and 5 replications > 5): Jan
- ▶ 2010, August 2021
- ▶ **Amatrice (Italy, 2018), Mexico 2021**

Implied:

Intervention Area delineation
and prioritization (UAV)

Victim detection/localization/S&R
(3D vision) (UGV, UAV)

Stability of buildings evaluation (3D vision,
UAV)

Identification of Harbour floating objects, a.o.
(USV, UUV)

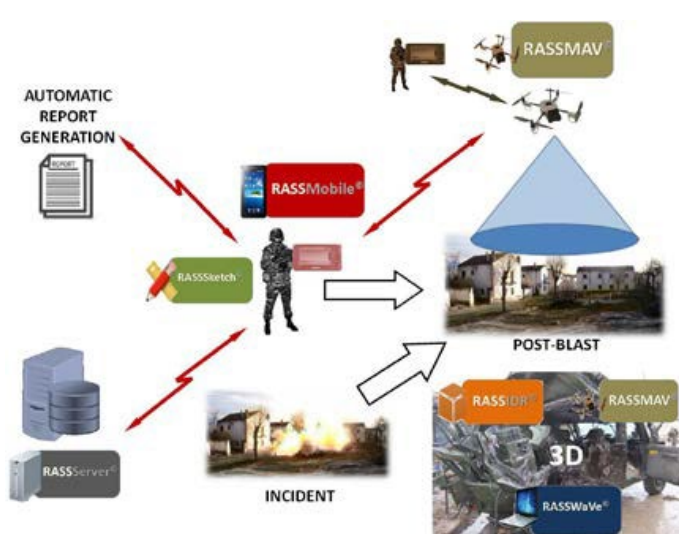
Mobile Robotics facing risky interventions during disasters

Most Crisis-Managements consider search and rescue operations as primary objective.

Particular Mine-Actions (Demining) follow military or civilian conflicts

European Projects focus on such topics:

RAS-MAV (**E&Q Engineering (Spain)**) – ICARUS (**UKL-Germany**)- TIRAMISU (**U.Genoa/Snail-Aid-Italy**)





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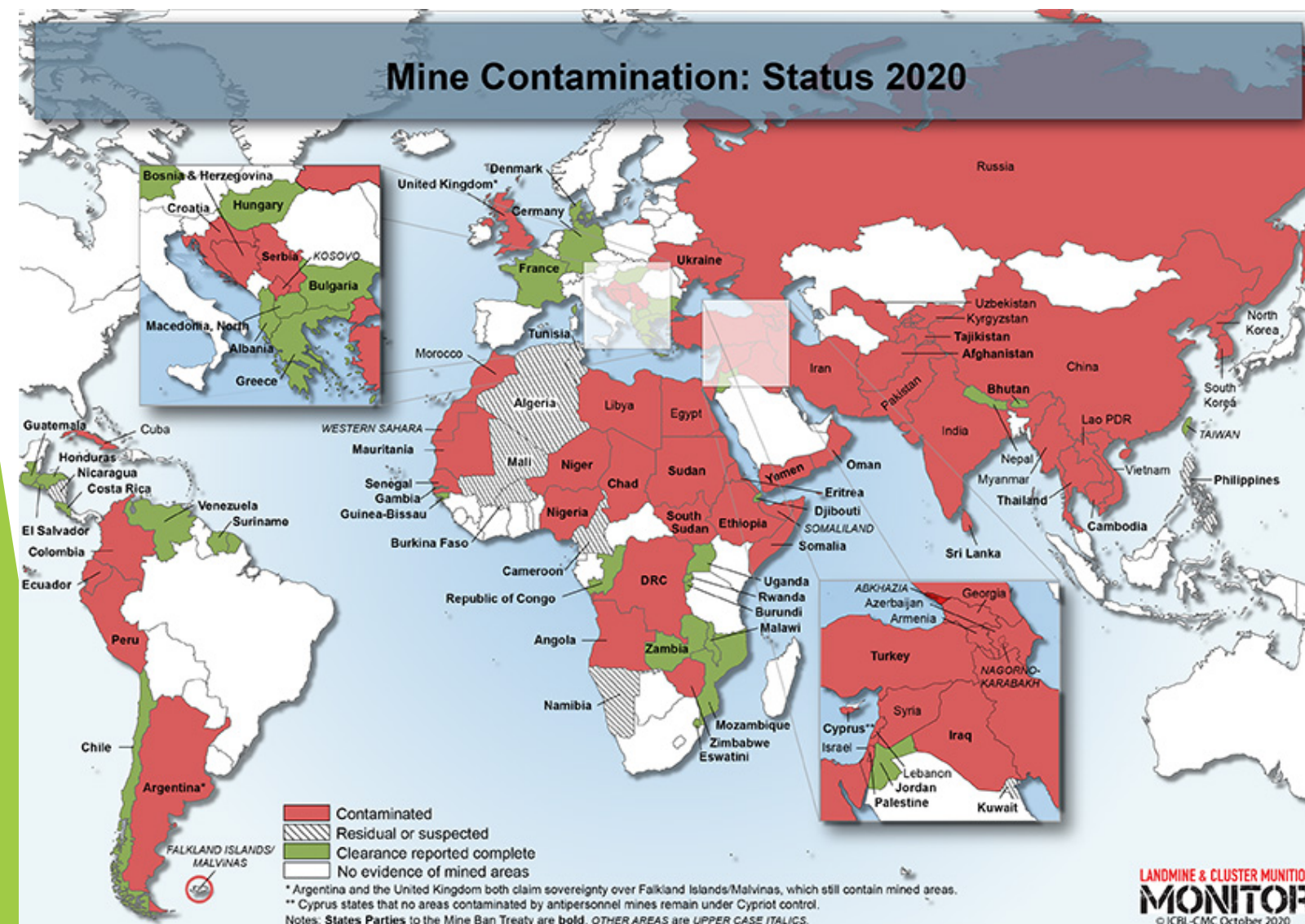
Humanitarian Demining

DISARMADILLO+,

Snail-Aid - Italian Institute of Technology

Context

Mine Contamination: Status 2020



CONTAMINATION

over

60

countries and territories contaminated by mines, cluster munitions and explosive remnants of war



IMPACT

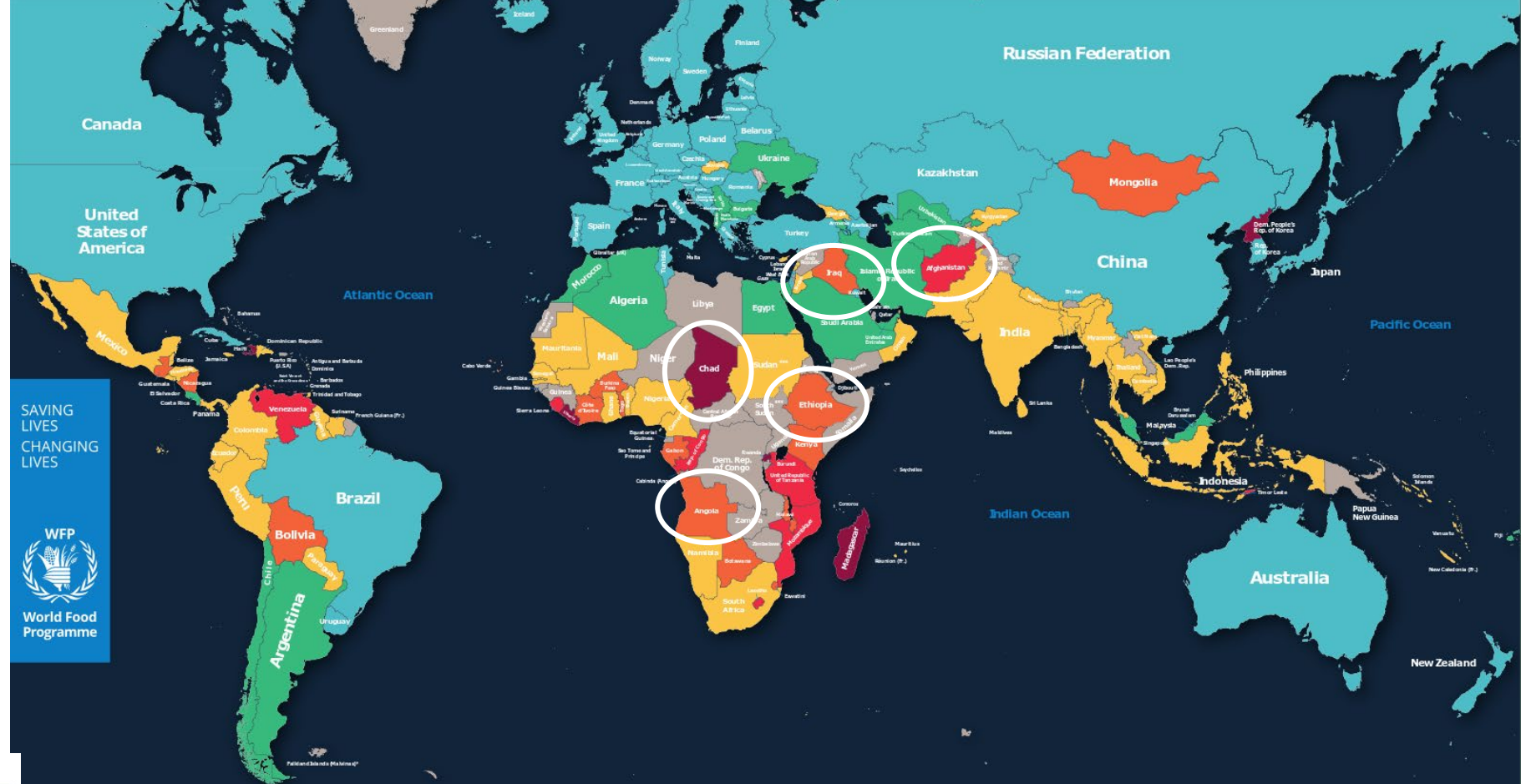


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Daily life, resettlement for communities after conflict and development impeded



Context



Estimated area of antipersonnel mine contamination in States Parties

Region	Over 100km ²	20-99km ²	5-19km ²	Less than 5km ²
Sub-Saharan Africa	Ethiopia*	Angola Chad Eritrea Zimbabwe	Mauritania Somalia South Sudan Sudan	DRC Niger Senegal
Americas			Colombia	Argentina*** Ecuador Peru
East and South Asia and the Pacific	Afghanistan Cambodia Thailand	Sri Lanka		
Europe, the Caucasus, and Central Asia	BiH Croatia Turkey Ukraine**		Tajikistan	Cyprus**** Serbia UK***
Middle East and North Africa	Iraq Yemen			Oman Palestine

Hunger Map 2020

CHRONIC HUNGER

If current trends continue, the number of hungry people will reach 840 million by 2030



Undernourishment is defined as the condition in which an individual's habitual food consumption is insufficient to provide the amount of dietary energy required to maintain a normal, active, healthy life. The indicator is reported as the percentage of undernourishment (PNU), which is an estimate of the percentage of individuals in the total population that are in a condition of undernourishment. To reduce the influence of possible substitution within income of the underlying per capita, national estimates are reported as a three-year moving average. Source: FAO, IFAD, UNICEF, WFP and WHO, 2020. The State of Food Security and Nutrition in the World 2020. To accelerating food systems for affordable healthy diets. Rome, FAO. Further information is available at: <https://www.fao.org/state-of-food-security-nutrition> and <https://www.wfp.org/publications>

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*** The data for the Republic of Serbia and Montenegro are based on the data for the Republic of Serbia and Montenegro.

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Legend: International Boundary, Armistice or International Administrative Line, Other Line of Separation, Special boundary line

Context

- ▶ Large variety of explosive hazards: more than 750 types of AP and AT mines (many more when considering improvised explosive devices)
- ▶ many different types of vegetation (from desert to tropical regions)
- ▶ Many different types of soil (from clay to sand)
- ▶ Many different types of conditions (urban/mountain areas, extremely hot or cold weather)



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Context

- Humanitarian demining is mainly carried out MANUALLY using simple tools such as gardening equipment:



- Sometimes, when it is possible, metal detectors are used to check for the presence of metal contained in mines, before excavating manually.

Demining machines: trends

Land Release in Action; practices in use in six countries,
TIRAMISU, March 2013

- ▶ Limitation to their practical in-field use
(related to their high cost and limited availability?):
 - ▶ if there are AT mines, generally they are not used
 - ▶ they are always followed up
 - ▶ no machine is expected to detonate or crush all mines, in particular metal cased mines

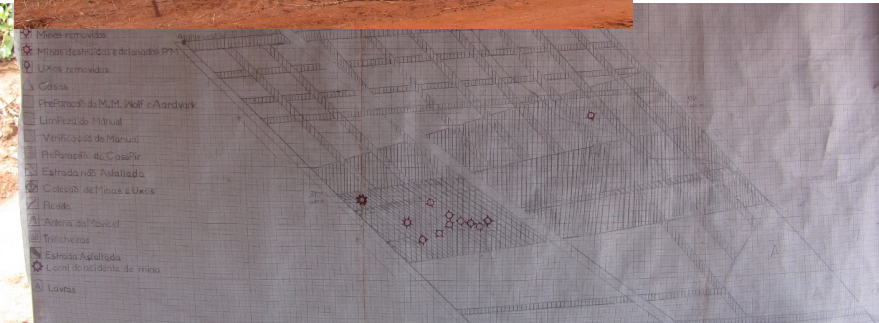


Results in Germany **test lanes** (2007):
test (WORM) AP mines 0-20cm deep: 98,22%
neutralized

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Results in Angola **in the field**
(2012):
10 (POMS or PPMISR) mines
processed and left live intact



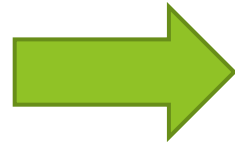
Demining machines: trends

- Demining machines are all machines designed to be used in hazardous areas

detonate hazards

ground preparing machines

detect hazards



improve efficiency of
demining operations by
reducing or removing
obstacles

physically or by carrying a
detection technology, i.e.
sifters and rollers

Reduce the size → Remotely controlled

Diversify the tasks → multi tool

Reduce the cost ?

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7th Mine Action Technology Workshop, Basel, Nov 2019

Demining machines: DISARMADILLO - an agricultural technology



Agricultural machines are originally conceived for ground processing



Low-cost and easy to repair in not specialized workshops



Can be reconverted to original use after clearance and stay in the country to cope with food insecurity and increase benefits of mine action



Mature and modular



Local re-design can favour human development, empowering end-users

DISARMADILLO



THE FIRST OPEN SOURCE ROBOTIC PLATFORM
FOR MINE ACTION

DUAL USE: FOR DEMINING
AND AGRICULTURE



DESIGNED IN A PARTICIPATORY WAY
WITH END-USERS, ENGINEERS,
STUDENTS, MECHANICAL
WORKSHOP EXPERTS,...

SIMPLE AND CHEAP



VERSATILE:
ABLE TO HOST DIFFERENT IMPLEMENTS



TECHNICAL DATA (based on Grillo G131 powertiller)



DIMENSIONS

length: 2500mm
width: 1000mm
height: 1300mm
mass: 500kg

ENGINE DATA

type: Lombardini Diesel
3 LD 510
4-stroke air cooled
power: 9kW - 12,2hp
fuel consumption: 250g/kWh

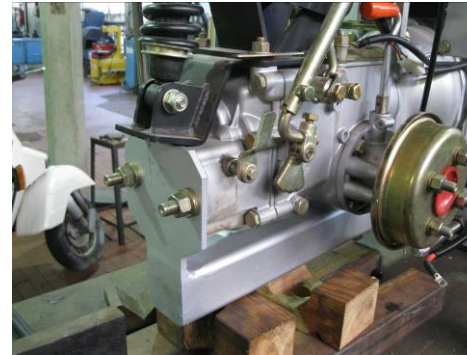
FEATURES

control system: remote and manual
(safe areas)
power take off
differential skid steering
reversible drive
4 forward gears, max speed 7km/h
2 rear gears, max speed 3,5km/h

DISARMADILLO modules

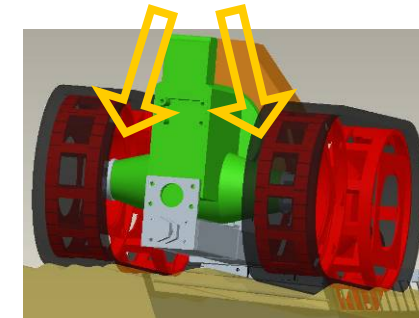
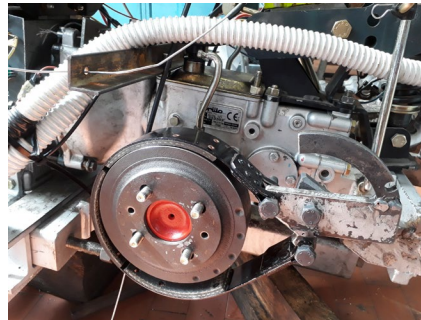
Frame:

- Embedding track tensioning system
- Supporting two more idler wheels at front
- Rubber tracks



External brakes:

- Differential skid steering
- Strap brakes at rear



Wheels:

- Sprocket/supporting wheels
- Iso-diameter



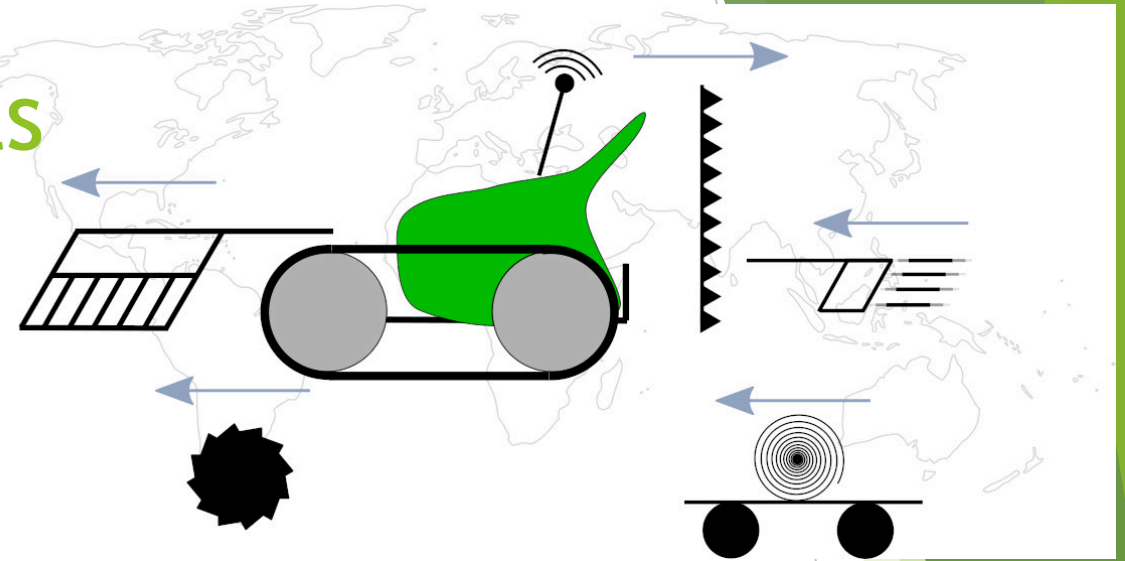
DISARMADILLO remote control

Remote control:

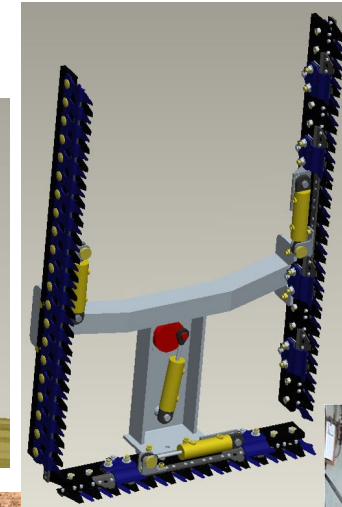
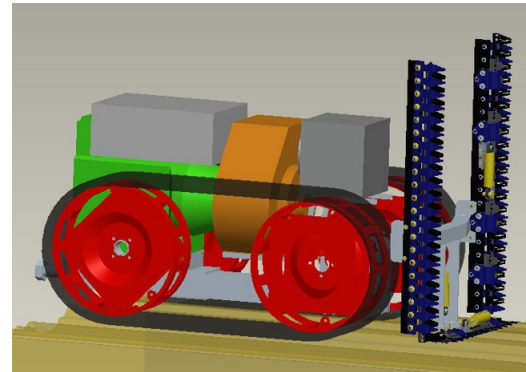
- Dual: no manual controls are removed
- Actuating only:
 - o Brakes
 - o Clutch
 - o Accelerator
 - o Direction change (forward/backwards)
 - o Winch
 - o ignition/stop
- Industrial type using COTS electrical motors

DISARMADILLO implements

- ▶ Vegetation cutting unit
- ▶ Roller
- ▶ Rake/sifter
- ▶ ... new implements and old (upgraded)



+



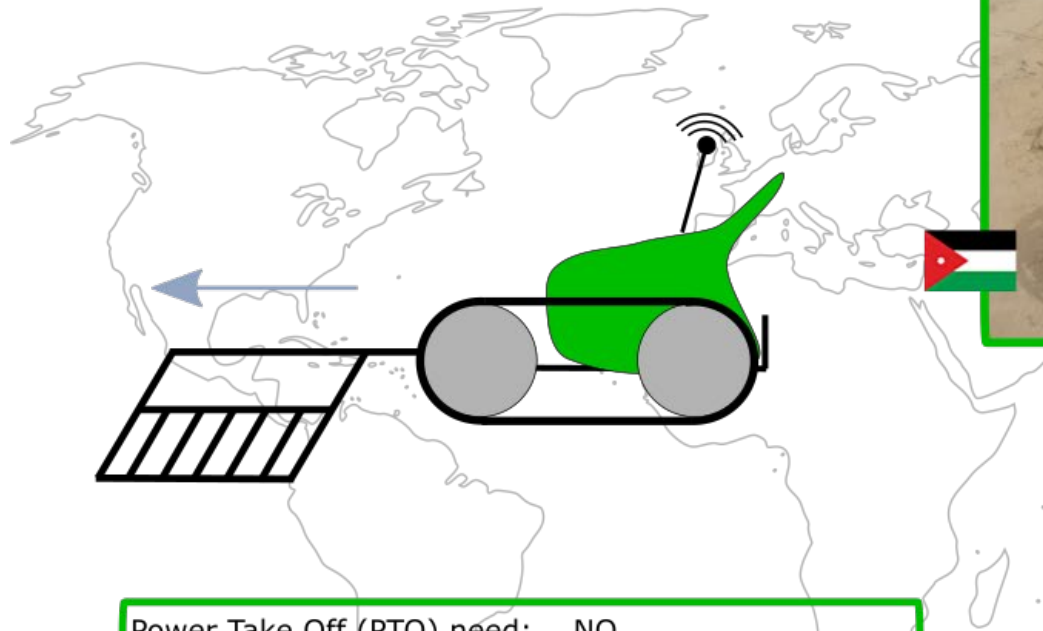
DISARMADILLO implements

RAKE

Originally named Ground Processing Tool (GPT), it has been designed and firstly prototyped in Italy and later on manufactured, prototyped and tested in Jordan.

It is aimed at processing the soil at constant depth and expose landmines by lifting them up on soil surface, without actuating them.

It is specifically targeting areas where soil is loose (soil cohesion $C = 10\text{kPa}$ and angle of internal friction $=30^\circ$), typically found in Sri Lanka (country for which it was originally designed for), Jordan, Western Sahara.



Power Take Off (PTO) need:	NO
Mounted at:	FRONT
Tested:	JORDAN
Main reference:	E.E.Cepolina PhD thesis

Designed by E.E.Cepolina and R.Macmillan

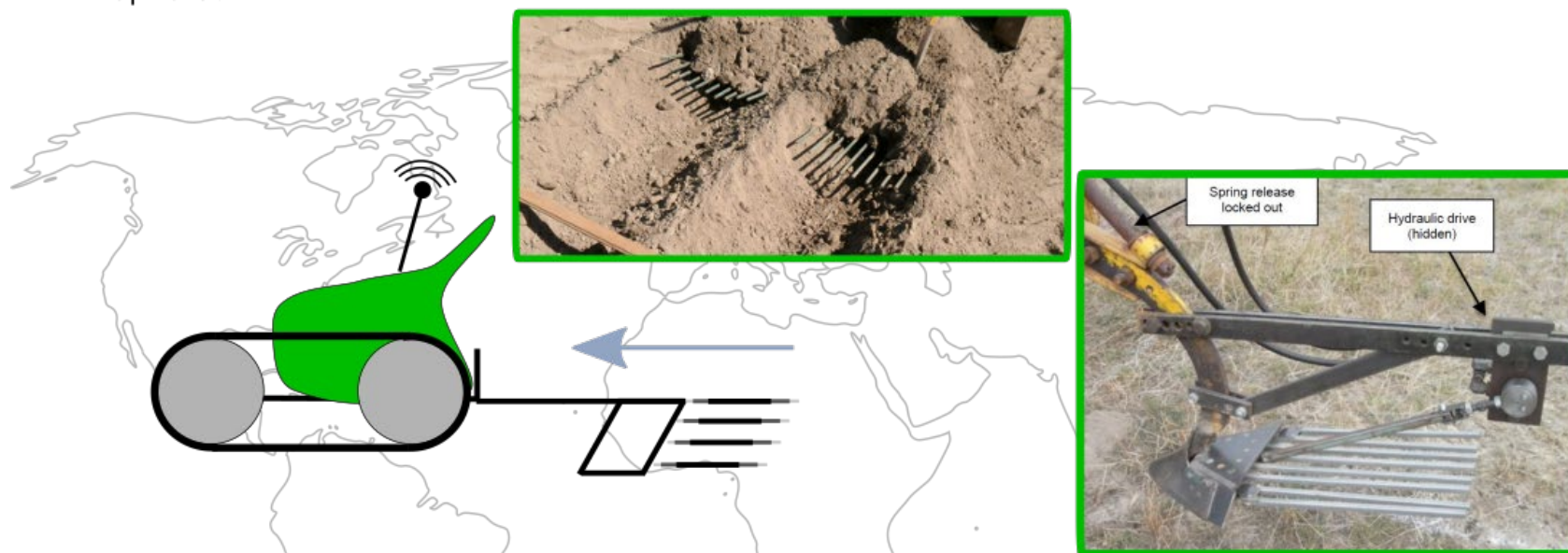
DISARMADILLO implements

VIBRATING SIEVE

The Vibrating Sieve has been designed and firstly prototyped in Australia by Ross Macmillan, Senior Fellow in Agricultural Engineering at the University of Melbourne.

As the Rake, it is aimed at processing the soil at constant depth and expose landmines by lifting them up on soil surface, by means of a vibrating movement, without actuating them.

It is targeting areas where soil cohesion wouldn't allow a fixed rake to sieve the ground and lift landmines upwards.



Power Take Off (PTO) need:	YES
Mounted at:	REAR
Tested:	AUSTRALIA
Main reference:	R.Macmillan reports



Designed by R.Macmillan

DISARMADILLO+

- Pilot project of the Italian Competence Center ARTES4.0, Call for Ideas ARTES@IIT - evaluated positively by IIT and ARTES4.0 technical scientific committees



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