# Design and Manufacture of a Prototype for UXO Detection

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## ABSTRACT

Fourteen years ago Kosovo came out the war with about 4500 sites filled with different types of unexploded ordnances (UXOs) such are cluster bombs, anti-personnel and anti-tank mines etc., presenting a potential threat to the life of citizens. Demining started immediately and was carried by international specialized organizations and later on by Kosovo Security Force, but unfortunately the consequences were quite severe, with 115 people killed and over 450 others lightly or seriously injured, many of them remaining disabled forever.

Marking the contaminated areas, detection and clearance of UXOs are phases of a very difficult and heavy risk in the process of demining, in which the involvement of human is crucial. Therefore, it is very important minimization of human role and his replacement with technical devices.

As a result of survey on existing equipment for detection of UXOs and according to the configuration of our country, the idea for designing a prototype of a device for detection has been built and developed at the laboratories of the Faculty of Mechanical Engineering of University of Prishtina.

The phases of design, from initial idea to the design presentation including the adopted methodology of decision making at each phase, motion, detection and device's control are described in this paper.

As a result of the design process with a clear task - to 'eliminate' the human role during the detection of UXOs, the prototype of a device has been constructed and named RoboDet – Robot for Detection of unexploded devices.

The test of reliability for RoboDet in improvised 'minefield' resulted successful and satisfactory.

## 1. INTRODUCTION

A number of about 4500 sites in Kosovo marked as contaminated with different UXOs in 1999, Fig.1, specialized teams of NATO forces and the Kosovo Security Force (KSF), various international and national organizations have since reduced to identified 60 high-risk and 50 suspected sites , Fig.2 after cleaning about 47 million square meters of mines. These sites still pose a serious threat to the population.

*Fig.1 Contaminated sites in 1999 (Source: UNMIK)*

*Fig.2 Contaminated sites in 2011 (Source: KSF)*

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The most common methods for detection are manual or combined (using metal detectors, area excavation, dogs or mechanical equipment) and include the use of manual de-miners because to date there is no fully mechanised method of ground processing that can find and remove mines and UXOs.

Having in mind all the methods and facts on contamination of the country, a prototype of a device for detection of the unexploded ordnances in marked mine fields has been designed and manufactured. The design process, from idea to prototype, and its manufacture with control system I elaborated in this paper.

## 2. DESIGN PROCESS AND DECISION MAKING METHODOLOGY

The design is a process with many questions coming up one after another, starting from problem/task introduction, design process itself and those related directly to technology or science, Fig.3. The designer needs to think, wonder and decide when solving design problems. This complex task should be put through a procedure/methodology with certain phases that can be used during all design process with needed accuracy that will bring to successful finalization of the design.

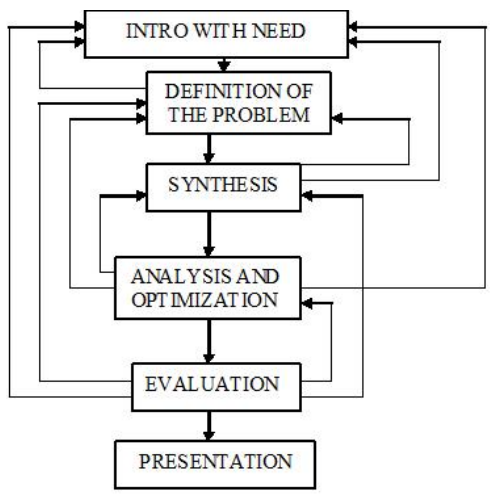



*Fig. 3 Phases of a design process*

The problem resolution during the design process arise a number of questions such are, [2]:

- Where and how to start?
- What is the procedure that needs to be adopted or implemented?
- Is it new or former/existing design?
- Can be followed procedure from manuals or standards?
- What is a procedure for making a new design?
- How to define design problem and set design goal?
- What are quantities and what variables – free or dependent?
- How do we set constraints?
- How each item designed looks/should look in drawings?
- What shape and structure would have a product based on a design?...

A design process presents a “challenge” for an engineer – designer/constructor, who among many tasks needs to make many decisions for getting “the best” solution.

Less “creativity” is needed if design problem is “old” or “former” design. In these cases start of design is known, only the “design procedure” needs to be followed and it easy to complete the design.

In creating the “new” design, there is no sample, no manual and no former design. The engineer – designer has to produce and decide on everything by himself. He must take into account geometry (dimensions, shape), structure (material), functionality and constraints (technical, economic, social, environmental, ethical etc.). So, the way how/what decisions are made are of most importance.

The decision concerns on:

- Carefully definition of design problem
- Searching and generating for alternatives
- Selecting the best based on evidence
- Making sure by checking that the best has been chosen

This four concerns would be adopted respectively as Task (T), Alternatives (A), Evaluation (E) and Challenge(C) and would represent the adopted methodology named TAEC and will be used on elaboration and analysis of design process, [2].

## 3. DESIGN AND MANUFACTURE OF THE DEVICE FOR UXO DETECTION

### *3.1 Idea*

Based on the above mentioned facts and statistics on mine fields and victims; noting that mostly of detection and de-mining/clearance methods involve manual deminers and are slow and dangerous, an idea to design a device which will facilitate work to specialist teams for detection has been born and would be able to [3]:

- Assist and expedite the detection of UXOs and clearance;
- Decrease the risk for users of equipment for demining;
- Contribute to making Kosovo a safer place for the life of its citizens;
- Enable farmers, growers and farmers work without fear in their pasture fields.

Therefore, the task is that through a constructive work, based on above mentioned data (on human role on demining process and equipment) to design a functional device that may have not only constructive/industrial purpose but also humanitarian.

### *3.2 Definition of the criteria for the design of device*

Once it was decided to design a device from the idea that would be able to detect UXOs, the following criteria have been set:

- The device must have sensors/metal detectors - which will be able to detect unexploded devices (mines);
- Construction to make the move forward, backward, left and right return with a coordinated movement - at a speed less than human movement (in contaminated areas);
- Driving of the respective wheels to be independent;
- To be controlled from distance – in order that human presence be as far away from the device or from danger radius;
- To be able cross the barriers - ie detection device can move across the flat and non-flat surface;
- Links between elements of the construction to be as flexible as possible;
- Have proportionate size and weight as appropriate.

### *3.3 Synthesis and analysis of the design solutions*

Different solutions for device to be designed have to be collected, synthesized, grouped, analyzed, modified etc. Thus some of the steps during these phases include:

- Concept solutions;
- Presentation of ideas through sketches;
- Drawing on the computer (software like AutoCad);
- Definition and design of the parts; find and supply with parts;
- Modification of existing parts and/or design of new parts;
- Assembling and simulation/testing

### *3.4 Decision making*

It is understandable that engineer – designer must make a right decision at each phase before continuing to next one, otherwise must return back and do searching and checking for the reasons why phase solution is not the best or right one (iteration). TAEC methodology was used during all steps of design.

Following is given implementation of such methodology during some design phases of elements or tasks.

WHEELS, Fig. 4:

T - Wheels with caterpillars

A - Pulleys vs Gears

E - Smoother and reliable motion was estimated to be making wheels with caterpillars made by chains driven by gears than by pulleys with profiles

C - Modification of the gears and good balancing.

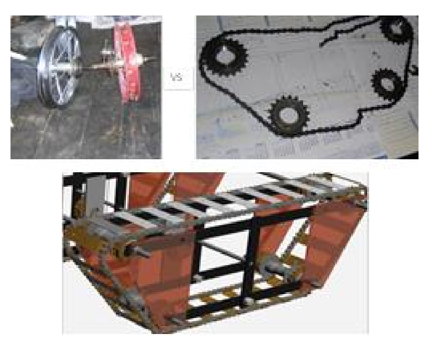
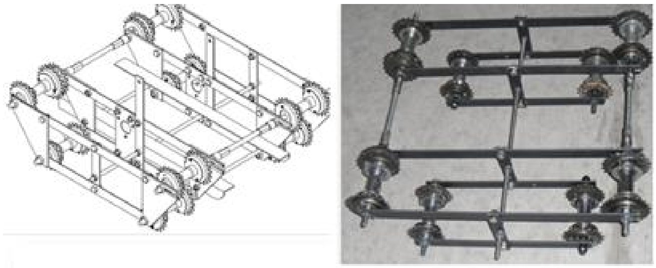


*Fig. 4 Wheels*



SKELETON, Fig. 5

T - Skeleton – Wheels assemble

A - Standard filleted shafts or modified filleted shaft-nut set

E - The set was evaluated to be more proper and constructively accepted because of possibility of positioning

C - Centrality and calibration

*Fig. 5 Skeleton-Wheels assemble with new designed or modified elements*

DEVICE MOVEMENT, Fig. 6

T - Driving of respective wheel to be independent

A - One motor with special system for motion control of wheels or two same DC motors

E – For simpler and easier design and element purchase it was decided two same DC motors

C – Speed calibration and insulation of motors

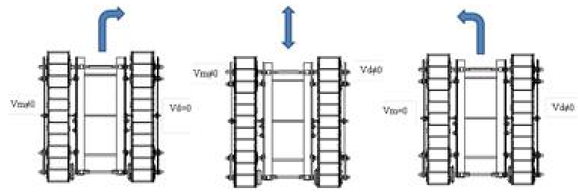


*Fig. 6 Move forward, backward, right and left*

*Fig. 7 Remote control system (transmitter and receiver)*

REMOTE CONTROL, Fig. 7

T - Control of the device

A - Remote controlled or autonomous

E - Because of uncertainty on mine fields it is estimated that would be better human to 'guide' the device from the distance with remote controller

C – Caution for controller to be outside dangerous zone

***3.5 From design to prototype***

After clearly defined design was accepted, the needed elements were assembled constructing the prototype of device named as "RoboDet", Fig. 8., [3], containing three main parts: skeleton, moving hand and control electronics; driven by three DC motors and supplied by two batteries. The RoboDet weight of about 30 kg moves with speed of one km per hour.

*Fig. 8 RoboDet*

**CONCLUSION**

Well defined idea with clear structured design process followed by dedicated decision making procedure at any step leads to a successful design task which results to a prototype. The prototype of the robot for detection of unexploded devices – RoboDet designed and manufactured at the Faculty of Mechanical Engineering laboratory in Prishtina tested in real environment with improvised 'minefield' resulted successful and satisfactory, fulfilling driving, detection and remote control criteria.

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