

# ID41 - DESIGN, VALIDATION AND MANUFACTURING OF AN ANTHROPOMORPHIC MANIPULATOR FOR ROVS USING TITANIUM RAPID PROTOTYPING

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## Abstract

It is at least two decades since the conventional robotic manipulators have become a common manufacturing tool for different industries, from automotive to pharmaceutical. The advances in manipulators and sensors have given robots the opportunity to become useful for more and more applications. Engineers have taken advantage of the extra mobility of the advanced robots to make them work in constrained environments, ranging from limited joint motions for redundant manipulators to obstacles in the way of mobile (ground, marine, and aerial) robots [1]. However, the incorporation some of these abilities and capacities that are already being used in land, have not made their way to the sea domain. This Abstract describes the project consisting in the design, development and manufacture of a prototype manipulator arm for ROVs introducing innovative fabrication technologies. The work has been done collaboratively among ACSM Maritime Agency SL, CIMA Group and the University of Vigo

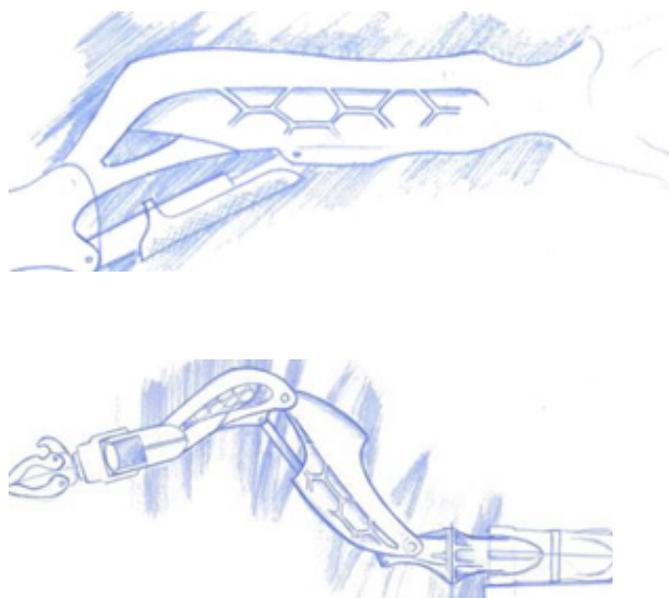
*Keywords - anthropomorphic manipulator, ROV, titanium rapid prototyping.*

## I. INTRODUCTION

The main objective of the project Titanrob (<http://www.titanrob.com/>) is the design of the prototype manipulator, using titanium rapid prototyping, for ROVs. In fact, different prototypes were development based on a titanium built hydraulic manipulator designed for heavy duty subsea applications in ROV (Remote Operated Vehicle) submarine operations. In this paper is showed the successive phases of the development of those product: an original concept was developed in order to fulfil the gap between the big and heavy manipulators. Prototyped were fully designed and simulated (FEM) and the, manufacturing for the final tests.

## II. CONCEPTUAL DESIGN OF THE TITANROB MANIPULATORS

This project starts with the development of a conceptual design of the prototypes taking into account an anthropomorphic shape and appearance (Fig. 1).



**Fig 1. Prototype anthropomorphic shape and appearance**

Based on those basic conceptual designs, a more detailed conceptual definitions were development (Fig. 2).



**Fig 2. Conceptual definitions for the manipulators**

## III. TITANROB DESIGN AND SIMULATION PHASES

Titanrob prototypes were fully design in order to be manufacturing using titanium rapid prototyped. Before manufacturing phase, the design was validated structurally using FEM software. Next figure (Fig. 3) shows the mesh and simulation process and the results obtained.

## IV. TITANROB MANUFACTURING PHASE

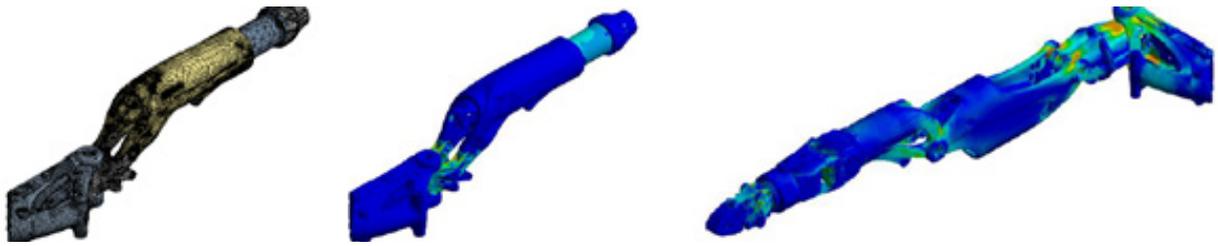
For the fabrication of the various components they were necessary different procedures such as milling, lathe works, metal fabrication, machining and surface treatments for parts. The fabrication of the arm itself, in order to minimize the weight and achieve the desired anthropomorphic forms, is held by implementing new manufacturing technologies. Finally, it was manufacturing with EBM (Electron Beam Melting) which allowed us to get any complex geometry and simplify some assemblies in a single piece. EBM manufactured parts were then treated by different processes to achieve their desired appearance (see Fig. 4). Once the different pieces of the manipulator were manufactured, the assembly of the various mechanical subassemblies machining operations (see Fig. 5).

## V. FINAL INTEGRATION AND OPERATIONAL TEST

Finally, manipulator prototypes were integrated and tested using a ROV (see Fig. 6) to test the Titanrob arms under real operational conditions. As the results of this test, Titanrob arms designs were validated to their operation during sea trials were performed with excellent results.

## REFERENCES

[1] *Autonomous Robots: Modelling, Path Planning, and Control.* Springer Science + Business Media, LLC 2009 ISBN 978-0-387-09538-7



*Fig 3. Mechanical validation FEM simulation*



*Fig 4. Manufacturing phase: parts manufacturing using EBM process*



*Fig 5. Manufacturing phase: post-machining phase*



*Fig 6. Integration and final operational tests*