ORNL Manufacturing Demonstration Facility
Technical Collaboration **Final Report**

Exploring the Feasibility to Use Additive Manufacturing for Light Weight Ground Robotic Platforms[1]

Northrop Grumman Remotec

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Completion Date: 10/31/2013
Company Size: Large business, 46,000 employees

Summary
ORNL and Northrop Grumman Remotec collaborated to determine the potential for polymer additive manufacturing on end use robotic parts. Northrop Grumman Remotec provided the design, installation and testing results. Tests parts including wheel pods were printed by ORNL using Fused Deposition Modeling (FDM) and demonstrated a factor of 4X reduction in component weight. Printed parts were successfully demonstrated during field trials for performance on a mobile robotic platform. Further, based on this collaboration, Northrop Grumman Remotec has commercialized this technology.

Background

Additive manufacturing can revolutionize the design and manufacture of robotic platforms. Oak Ridge National Laboratory has over 12 years of experience exploring the utility of metal and polymer additive manufacturing for robotics. Some of these benefits are clear, e.g., weight reduction, part consolidation. However, there is a growing need for field robotics (robots deployed in remote areas of the world) to have the ability to rapidly manufacture replacement parts rather than maintain a local inventory or wait for days to weeks for shipment of replacement parts. Subsequently, there is a growing movement to explore the potential for "printed robotics". The idea is to use additive manufacturing to manufacture critical and complex components on robotic platforms. The US Army Rapid Equipping Force is now developing expeditionary laboratories (ExLabs) that have machining capabilities including 3D printers. The objective is to be able to manufacture replacement parts in the field rather than maintain an inventory.

[1] Research sponsored by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Advanced Manufacturing Office, under contract DE-AC05-00OR22725 with UT-Battelle, LLC.

The objective of this project was to select a challenging component on an existing robotic platform and explore the use of additive manufacturing for the fabrication of the part. One of Remotec's most popular platforms is the Titus (Figure 1). These robots must move over a wide range of terrain (rocks, curbs, stairs…). Subsequently, the wheel hubs experience shock loads that lead to failure. This project explored the use of additive manufacturing for the fabrication of the wheel hubs.

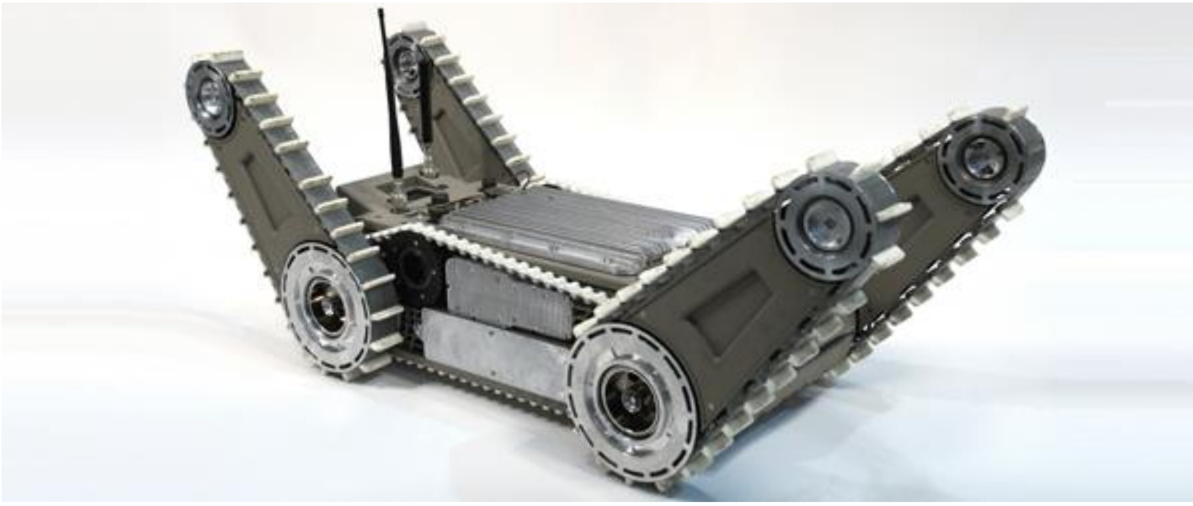

Figure 1: Titus Robotic Platform

Technical Results

The specific goal of this project was to identify a specific part on an existing robotic platform that could benefit directly from additive manufacturing. The goal was to modify the design for additive, manufacture and field test the part for reliability. One of the fundamental questions this project addressed concerned material properties. Are polymer materials sufficient or are metals essential for performance targets? Engineers at Northrop Grumman Remotec identified the wheel pods on their Titus robotic platform as an ideal candidate. These wheels experience high loads and upon failure, the system is completely disabled.

The wheels were redesigned and printed on a Stratasys Fortus 900mc at the ORNL MDF. One wheel pod set was manufactured in less than 10 hours and subsequently tested (see Figure 2 and Figure 3). Upon successful integration onto the platform, a total of four wheels were manufactured in 40 hours (less than 2 days) and integrated on the robot for field testing. The system was tested under a wide variety of operations, running at high speed over rough terrain, maneuvering in tight spaces, accurately positioning the vehicle during inspection exercises (see Figure 4 and Figure 5). By using polymer additive manufacturing, the total weight of the wheel pods dropped by a factor of four. Other parts were manufactured and tested for form, fit and function, but the wheels proved to be the most demanding application.

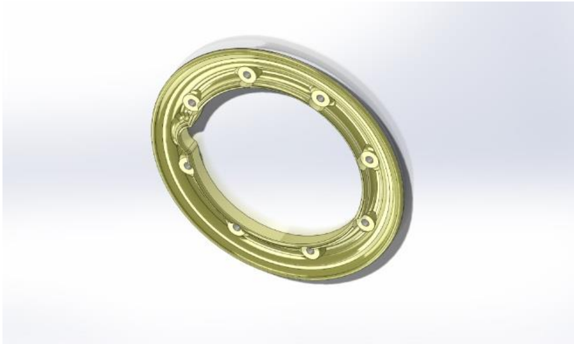

Figure 2: Wheel cover

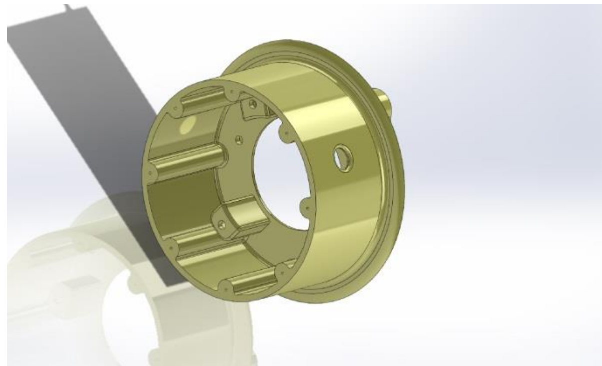

Figure 3: Wheel hub

Figure 4: Printed wheels moving over obstacles

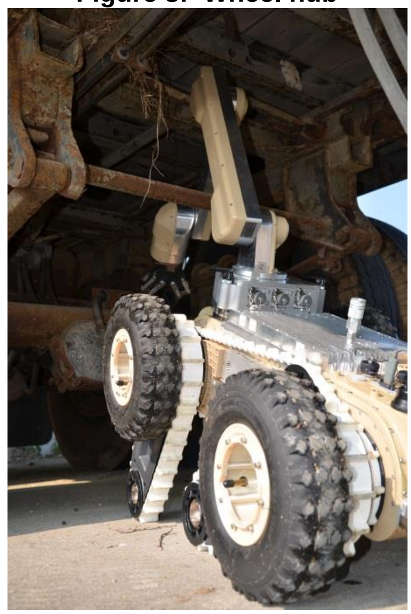

Figure 5: Maneuvering in confined spaces

Impacts

Robotic platforms are growing at an exponential pace. Applications are expanding from the conventional remote handing (nuclear) to new markets in material handling, manufacturing and biomedical applications (prosthetics, orthotics and wearable systems). In each of these cases, energy efficiency is vital. All robotic platforms are manufactured with conventional machining practices. There is great potential to revolutionize the field by exploring new lightweight, compact designs based on additive manufacturing. Weight reduction can have a profound impact on robotic platforms. By reducing the mass of moving parts, smaller (and lighter) actuators can be utilized. Additive manufacturing can have a domino effect in reducing the weight and energy required for robotics systems, both mobile and industrial robotics. Northrop Grumman would not have been able to take the product to production if not for the agility of 3D printing, due to the capital investment and ability for design verification through testing. These benefits saved the company tremendous time and money.

Part Number	Weight (lbs)	Replacement Part Number	Weight (lbs)	Qty/Vehicle	Total Weight Savings (lbs)
1100-0403	1.337	1100-1703 & 1705	0.738	4	2.396
1100-0406	0.622	1100-1706 x(2)	0.388	4	0.936
1100-3915	1.207	1100-7577	0.224	4	3.932
1100-7669 (Aluminum)	2.816	1100-7669 (printed)	1.14	4	6.704
1100-3286 (Aluminum)	0.341	1100-3286 (printed)	0.138	2	0.406

All the wheels are now molded for the product. Without printing, Northrop Grumman Remotec could not have verified the design and therefore would not have spent the money on the molds. The wheel designs for the first three parts listed in the table above did not functionally work. The inexpensive and rapid printing of the final two parts in the table enabled the team to get a working design. After testing the new designs, Remotec had molds manufactured for large scale production.

Conclusions

The primary metrics for success for this project was 1) weight reduction and 2) demonstration of realistic field deployment. The specific parts manufactured for this project demonstrated a 4X reduction in weight. In addition, the parts were installed on an existing robotic platform and were exercised in the field for form, fit, function and performance. In every case, the new additive manufactured components passed the requirements. Northrop Grumman Remotec is now in position to compete for new programs and product lines based on additive manufacturing.

About the Company

Northrop Grumman Remotec is the global leader in mobile robot systems for hazardous-duty operations. Military, first responders and law enforcement agencies worldwide rely on Remotec to help assure a safe, successful outcome for their most challenging missions. Remotec was founded in 1980 to provide remote handling consultation to the nuclear industry, in Oak Ridge, Tennessee. Through experience gained by supporting the nuclear industry, Remotec identified the opportunity to expand and apply core competencies to meet robotic requirements outside of the nuclear field, leading to the purchase of ANDROS technology in 1986. Since acquiring the ANDROS technology, Remotec has remained the industry leader in hazardous duty robotics and is the only company which offers a large family of vehicles to meet the broad range of customer requirements.

Points of Contact

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