QinetiQ’s TALON Unmanned Robot Capstone Design Project

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Abstract
QinetiQ North America’s TALON robot is one of the most popular Explosive Ordnance Disposal (EOD) robots in service today. TALON is known for being able to maneuver over and around almost every obstacle it encounters in the field. There are, however, a few weaknesses in its mobility, and conquering some of the obstacles it encounters can be a difficult process. A new add-on system to stabilize the TALON in extreme inclines up to 43 degrees is desired. A thorough examination of existing robotic mobility systems has been conducted to determine design concepts that can be implemented without detrimental effects to existing parts of the TALON. Designs were formulated and ranked to provide a numerical basis for choosing a final concept. A final concept has been chosen as a set of linearly-actuated stabilizer bars mounted to the robot’s chassis. One bar extends to the robot’s front and one to the rear. This design is currently undergoing in-depth analysis and testing to confirm its stability in worst-case scenarios.
The Need for Project

Currently the TALON cannot navigate steep slopes and stairs without some risk to human life and operator efficiency. The TALON Unmanned Robotic System is a robust system that has many uses both for the military and local law enforcement agencies. While the TALON performs well across many diverse environments, mobility issues do exist when encountering steep obstacles, such as stairs. The current procedure for the robot to navigate stairs is a lengthy process that is not always guaranteed to work. This creates a problem for the user, as the robot may flip over and force a team of soldiers to go down range and retrieve the incapacitated robot. The goal of the TALON is always to alleviate the workload of the user, and sending a team into a potentially dangerous environment is counterproductive to the overall mission of the TALON.

The Design Project Objectives and Requirements

The solution is to be a retrofit attachment which must be remotely-deployable. It must not infringe on existing TALON requirements, and must maneuver 43 degree stairs and 45 degree slopes. Since the TALON robotic system is already being used in the field, this project must conform to all of the pre-existing requirements of the TALON. Specifically, the project must focus on a solution that can be retrofit with relative ease in the field. Of the existing TALON requirements, it is essential that the group’s attachment does not infringe on the overall payload capacity (100 lbs) or the tow capacity (250 lbs). There are also several critical requirements specifically relating to the new solution. The robot must be able to maneuver stairs at an angle of 43 degrees and a slope at 45 degrees, both as worst case scenarios. Additionally, the attachment must be remotely deployable.

Design Objectives

Initially, the group sat down with the sponsors at QinetiQ to discuss the requirements for the design. The major concern for them was that the group’s design would have to be able to be retro-fitted to the robot because it would not make sense to have to change the robot entirely with over 3,000 robots already in use.

After some initial testing, it became apparent the attachment solution would have to take up a portion of the ground clearance underneath the robot chassis. After consulting the sponsor, it was
determined that there was no set ground clearance requirement, but that it should be minimal while still optimizing the TALON’s mobility. A final design requirement was decided to be less than half of the available ground clearance.

**Design Concepts considered**

18 separate design concepts were ranked, with the highest score going to a bent ski setup in the front and rear of the robot. Through the use of weighted objective tables and a pair wise comparison, 18 separate concepts were ranked. Each concept was scored independently of one another to ensure that the best possible design was chosen. The top three ideas were the (3) beaver tail-rear, (2) beaver tail/bent ski front, and (1) single bent ski front and rear.

The beaver tail-rear concept involved a spring-loaded, two-piece attachment. When stowed, the two straight pieces would be parallel to one another. When deployed, the two pieces would be past the point of the spring loading, creating a triangle behind the robot. This created a wide contact area, but was determined to be overly complex, moderately heavy and to not be durable.

The second best concept, the beaver-tail rear and bent ski front incorporates the same beaver tail as described above as well as a front ski shaped attachment to the front of the robot. The front ski has a slight curve on the front to help the robot get up the first stair. Again, this concept was determined to be very heavy, and the complexity of the two actuation methods made the whole assembly very complicated to manufacture, and would also not be durable.

The highest scoring concept involved the same ski as described above, but on the front and rear of the robot as seen in Figure 2. The rear ski helps to prevent flipping when climbing stairs, similar to the beaver tail, but it is much lighter and easier to manufacturer. Because of the uniformity of the parts, even if this assembly did break it would be very easy to fix in the field.

**Recommended Design Concept**

The chosen final design was the highest ranking design, a dual bent ski system. When stowed, the skis would sit below the chassis of the robot. When fully deployed, the skis would be sticking out of the envelope of the robot approximately 10 inches front and rear to add
In order to correctly determine the needed strength and dimensions of the ski attachment, a number of calculations had to be made. To estimate the forces acting on the robot correctly, a precise value for the center of gravity was needed. A free body diagram can be seen on the left. After obtaining experimental values, a value for the center of gravity for the robot was determined.

Another critical factor for the attachment is the bending moment that would be seen on the ski when the robot is tipping backwards, as seen in Figure 4 left. This moment was calculated using a dynamic analysis and used to prove the ski will hold up to the stress seen in this situation. Another design constraint was the percentage of ground clearance that the ski would take up. Spacers were used to simulate the attachment, and the robot was driven through an obstacle course to determine the mobility of the TALON with varying ground clearance. After the experiment, it was determined that about half of the ground clearance can be used by the attachment without any negative effects to the performance of the robot.

This concept was the top scoring concept during the brainstorming process. This solution scored well due to ease of use as well as high reliability. The most critical requirement of the attachment is that it improves the dynamic stability of the robot. This was the strongest factor for dual bent ski design, and was the main reason it scored better than the other concepts.

Financial Issues

The initially proposed budget will be met through machining most of the components ourselves and by using the resources provided at QinetiQ.

As part of a proposal to the advisors at QinetiQ, the group initially proposed that this project would cost about $5,000 for a prototype. Because of time restrictions with the delivery date and holidays, the quotes from machine shops were higher than this $5,000 budget. Because of this issue, the group will be making the majority of the parts at QinetiQ to stay on budget.

In terms of this project moving towards manufacturability, it must be considered within the entire scope of the TALON Unmanned robot. Because of the complexity and ruggedness of the robot, the
TALON is upwards of $100k. While the actual manufacturing costs have not been thoroughly examined for the group’s design, the rough estimates of it would eventually cost the end user between $3k and $5k to purchase a full system from QinetiQ.

Recommended Improvements

In future iterations, the attachment must be fully environmentally sealed, and integrated into the existing TALON software. A main issue of concern for the design is dirt and sand getting into the gear rack and interfering with functionality of the rack and pinion setup that is currently being used. In future iterations, there will be some type of cleaning device or brush on the front of the actuator to remove extraneous materials from getting lodged.

Additionally, in order to control the attachment, there must be programming done with the TALON and its Heads Up Display on the controller. This will have to be done later on by the electrical and computer engineers at QinetiQ rather than having the group spend time doing this and having it redone later.