In order to meet the needs of new and more ambitious space missions, a new form of space propulsion must develop. The method of propulsion with the greatest potential to influence the space industry is the RF Resonant Cavity Thruster. This thruster is a new type of technology that was developed by Roger Shawyer and Guido Fetta as a way of producing small amounts of thrust without any onboard reaction mass. This project focuses on learning from the experiments conducted by NASA and the Chinese on this form of propulsion to design and build a new version of the thruster. These previous results and conclusions, combined with other equations and design methodologies for building a resonant cavity/waveguide will be used to design a different variation of thruster. The research is primarily focused towards a conceptual design projected over the next year, but there is potential to build and test the device. The research is based on topics such as resonant cavity/waveguide particle accelerator design, quantum mechanics, and superconductivity.

Are RF Resonant Cavity Thrusters a feasible method of propulsion? If so, is there a better way to produce more thrust than has already been seen in previous experiments?

Although the previous tests of radio frequency resonant chambers have produced minimal thrust, this is primarily because the chambers have been designed and built only as proof of concept. The purpose of this research project will be to take this concept and optimize it to prove the viability of the technology. The optimization will focus on the equations behind the design, which stem from waveguides and pillbox cavities, and the material with which the chamber is made. Different techniques will also be utilized to power the device compared to conventional methodologies.

**Hypothesis**

This new form of propulsion offers to greatly reduce the travel times for missions in deep space. Other applications also include satellite deployment and the possibility of multiple missions and destinations for a single space probe. More detailed applications have also been described by NASA's Report on RF Cavity Design. Based on test data and theoretical model development, the expected thrust to power for initial flight applications is expected to be in the 0.4 newton per kilowatt electric (N/kWe) range, which is about seven times higher than the current state of the art Hall thruster in use on orbit today. The following figures show the value proposition for this class of electric propulsion. Figure 23 shows a conservative 300 kilowatt solar electric propulsion roundtrip human exploration class mission to Mars/Deimos. Figure 24 shows a 90 metric ton 2 megawatt (MW) nuclear electric propulsion mission to Mars that has considerable reduction in transit times due to having a thrust to mass ratio greater than the gravitational acceleration of the Sun (0.6 milli-g’s at 1 AU). Figure 25 shows the same spacecraft mass performing a roundtrip mission to the Saturn system spending over a year around two moons of interest, Titan and Enceladus. Even in this last class of mission which requires only a single heavy lift launch vehicle, the mission has less mission duration than is common with a current conjunction-class Mars mission using chemical propulsion systems and which would require multiple heavy lift launch vehicles.

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<th>Portion of the Introduction and Abstract Found In NASA Report</th>
<th><strong>Applications</strong></th>
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<td>During 2013, Eagleworks Laboratories shifted from investigating previous QVPT designs to investigations involving RF resonant cavities. The first portion of the resonant cavity campaign (Cannae) was conducted during the summer of 2013 and was followed by a subsequent campaign (tapered cavity) that commenced in early 2014. Both resonant cavity designs were evaluated using a low-thrust torsion pendulum that is capable of detecting force at a single-digit micronewton level. During the first (Cannae) portion of the campaign, approximately 40 micronewtons of thrust were observed in an RF resonant cavity test article excited at approximately 935 megahertz and 28 watts. During the subsequent (tapered cavity) portion of the campaign, approximately 91 micronewtons of thrust were observed in an RF resonant cavity test article excited at approximately 1933 megahertz and 17 watts. Test campaign results indicate that the RF resonant cavity thruster design, which is unique as an electric propulsion device, is producing a force that is not attributable to any classical electromagnetic phenomenon and therefore is potentially demonstrating an unexplained electric propulsion roundtrip human exploration class mission to Mars/Deimos.</td>
<td>This new form of propulsion offers to greatly reduce the travel times for missions in deep space. Other applications also include satellite deployment and the possibility of multiple missions and destinations for a single space probe. More detailed applications have also been described by NASA’s Report on RF Cavity Design. Based on test data and theoretical model development, the expected thrust to power for initial flight applications is expected to be in the 0.4 newton per kilowatt electric (N/kWe) range, which is about seven times higher than the current state of the art Hall thruster in use on orbit today. The following figures show the value proposition for this class of electric propulsion. Figure 23 shows a conservative 300 kilowatt solar electric propulsion roundtrip human exploration class mission to Mars/Deimos. Figure 24 shows a 90 metric ton 2 megawatt (MW) nuclear electric propulsion mission to Mars that has considerable reduction in transit times due to having a thrust to mass ratio greater than the gravitational acceleration of the Sun (0.6 milli-g’s at 1 AU). Figure 25 shows the same spacecraft mass performing a roundtrip mission to the Saturn system spending over a year around two moons of interest, Titan and Enceladus. Even in this last class of mission which requires only a single heavy lift launch vehicle, the mission has less mission duration than is common with a current conjunction-class Mars mission using chemical propulsion systems and which would require multiple heavy lift launch vehicles.</td>
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**Portion of the Introduction Found in the Chinese Academy of Sciences Report**

Roger Shawyer of British Satellite Propulsion Research Co., Ltd. (SPR Ltd.) conducted important research into propellantless microwave thrusters. Roger Shawyer called the propellantless microwave propulsion devices the “electromagnetic drive” (emdrive). In 2003, he developed the first emdrive. Its diameter is 160mm, and its microwave power consumption is 850W. Using a balance beam method, the obtained actual thrust value was measured at 16mN. In 2006, Roger Shawyer developed a second emdrive. Its diameter is 280mm, and its power consumption is 1200W. Using horizontal and hanging measurement programs to measure the thrust, the obtained actual thrust value was 250mN. In 2007, Roger Shawyer carried out dynamic testing in a low-resistance suspended rotating platform. The results of the experiment were that when the second emdrive consumed microwave power of 1000W, thrust reached 287mN and the 100kg air suspension platform was accelerated to 2cm / s. 

**Works Cited**


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