Canadian Micro Satellite Launcher (CMSL). Phase one.

Estimates and supporting technologies.

Adobri Solutions Ltd.

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Introduction

Adobri Solutions Ltd. is a privately funded Canadian company specializing in technology and software. As a "Team Plan B" we vetted to participate in the Google Lunar X Prize international competition. After nearly two years of our project and being close to the moment of choosing launch vehicle for lift-off, we are looking for opportunity to work together with different organizations / companies with primary business interests in the Space Industry.

Project abstract and Feasibility

Primary goal of our team is to win the Google Lunar X-Prize (GLXP) competition. Next to the primary goal there is a strategic goal to establish self-sustained base on The Moon. Both goals sound non-realistic, but choosing high targets always allows look differently at problems and bring new unpredictable solutions worth trying.

Recently our team found that market of space launchers has not improved in last 2-4 years. This project is our attempt to respond to such situation. It will be beneficiary if Canadian team wins competition using Canadian satellite launcher, not just because of ambitions, but obviously because internal investment is better then one time external spending.

For a launch vehicle it is necessary to have (a) clear goal as to what it is for; (b) reliable gyro-platform; (b) communication/command system; (c) orbit calculation; (d) engine; (e) as short as possible testing cycle.

Let us check the goal. Main problem in Space exploration is lack of natural resources on earth orbit. Business is actually managing and distribution of resources. Space does not have any natural resources it is vacuum by itself, therefore it is not of any interest to businesses.

50 years if technological progress changed our point of view on the way how we operate in space. As a result of the progress we can replace old big satellites with smaller but more efficient ones. If we avoid/replace human presence on the board with remotely controlled specialized equipment then we will definitely make it less resource heavy. First satellite was complete at a fraction of costs in just 30 days, and first satellite launched by Von Brawn was build (including rocket) in 84 days, to compare with gigantic costs of first man in a space and first steps on the Moon.

The cost of delivery of nano-satellites to the orbit using micro satellite launcher comparable to a price of a car can attract business. But having such inexpensive launcher by itself is not enough to make lift-off. A clear goal understandable by business and by scientific community is needed. We as a team involved in Google Lunar XPRIZE competition Adobri Solutions Ltd. see that strategic goal in self-sustained base on The Moon.

Reliable remote control is a key and a core part of the development. Use of remote control at the early stages gives unique opportunity to reduce risk of work with explosive and combustive substances and equipment. In 1942-1945 team of V2 designers used ratio of one technology experiment launch for 2 military launches. With 3 launches per day Von Brawn team conducted one experiment per day. Since 1945 such intensive researches have not been done anywhere. Creation of an automated/remote manufacturing and testing facility would completely eliminate human presence at launching facilities, and therefore remove major delays in rocket and propulsion development.

Remote manufacturing/testing would also help to make competition between teams of designers more organized and less expensive. Same facility for manufacturing/tests/launch can be re-used by different teams.

To prepare for such task, one needs properly select equipment and choose proper location. Canada situated north off Cape Canaveral, but Toronto and Halifax are located more south from Baikonur cosmodrom. Location needs to be in least populated area, preferably on some elevation from the sea level. First stages of launcher should fall down not to the sea where it cannot be recovered, but on land where it can be collected for analysis and improvement of technologies. Rocket's trajectories have to avoid airliners routes. Making estimates and publishing report is an essential phase in micro satellite launch development.

What will be next after report? In second phase of CMSL remote controlled equipment has to be assembled and testing / manufacturing should go ahead. Second phase can be done in 2-3 months. Equipment including manipulators, cameras, specialized 3Dprinters (for production of solid-state engines), heavy lifting devices should be assembled onsite. Access to the facility from then on must be restricted only to delivery of new equipment and materials via “locked gates”. Operators / designers can work in regular office space at time of rocket equipment manufacturing testing and launching.

In third phase of CMSL different experiments to improve / repeat (copy, duplicate, re-produce) engines / rocket technology need to be performed. For solid state engines advanced methods can be used such as - printing solid engines with different profiles to achieve precise burning and better impulses; - variable nozzles for different altitude of trajectories in atmospheric / non atmospheric path. Any equipment that is not dangerous to manufacture (including software and electronics) can be made/assembled on separate existing industrial facilities. At that phase intermediate goal will be to make 6 test flights of CMSL. It is not expected that first flight gets to orbit. Critical factor at this stage is personnel. They must possess wide spectrum of knowledge and experience to be able to learn quickly. Replacements of operator and designer by one engineer performing both duties will give main advantage in development. Having shifts covering 24 hours also will reduce testing cycle. Achieving cycle of 2-3 days instead of months is also intermediate goal. If that goal will be reached then it is possible to get flying vehicle in a time frame of 6-9 months. Simultaneously marketing of a service provided by CMSL has to be started to promote CMSL and to get customers for first 12 orbit launches.

Last phase (operations) of Canadian Micro Satellite Launcher is when regular flights will be established on schedule. Maintaining less than one week interval between launches will improve technology, increasing interval bigger than one month will break technology improvements. Reliability statistics of CMSL can be collected, business should be conducted in usual environment, and team can concentrate on a next phase of delivery to The Moon enough equipment to build self-sustained base.

In such painted picture Adobri Solutions Ltd. is looking for ways to make all above described possible by donation of already developed in-house technologies and by producing professional estimation costs for a CMSL phase 1.

Aside from engine and rocket three essential key parts must be developed for CMSL they are (a) orbit trajectory calculation, (b) gyro platform, and (c) communication.

Orbit trajectory calculations usually based on data provided by JPL and available as TLE (Two Line Elements) with algorithms published in Space Track Report 3 (based on FORTRAN source code, two line elements are the data previously located on three punch cards). Software available today for these needs (even commercially available) is sketchy, heavy to use and algorithms not clearly published because of intellectual property/ security reasons. Almost year ago by solving a trajectory calculation for our Moon mission, Adobri Solutions Ltd. developed software based on simulations of a flight using different models of a gravitation potential of The Earth. In semi-automatic mode our software allows to find optimum trajectories for the moon mission. Tailoring the software to the needs of CMSL will allow to make trajectory calculations on the path to the orbit, and will provide web-interface for calculations of impulses performed by a satellite for future CMSL customers. Developing scalable solution for optimum trajectory calculation can be achieved by scalable distributed network of computers. Such solution will extend a service providing by CMSL and as a tool can be used to avoid collision of nano-satellites launched by CMSL.

Gyro platform used to fly to The Moon in Apollo mission was based on V2 gyro-platform. Technology was reliable but heavy. Current advance in solid state gyro allows manufacturing of lightweight and inexpensive equipment. Adobri Solutions developed this technology almost one year ago. Tailoring it to the needs of CSSL, will not only make date of launch closer but also offer it as add-on equipment for a nano-satellites and will extend services provided by CSSL.

Communications space equipment manufactured in the past was made reliable by tripling the transmitting channels. In Adobri solution for communication equipment new protocols and equipment for 2.4Ghz hopping frequencies were developed. This can eliminate needs for transmitter licenses, and makes ground stations less expensive, again it can be attractive for CMSL customers. Adobri Solutions is willing to provide this technology for a CMSL.

Benefits of the project.

To make business get involved in space exploration it is necessary to show them available manageable resources. Estimates will show how to make CMSL, what the costs will be and description of resources involved.

Currently international “space” cooperation involves different countries, ie. NK33 engines to be used on Antaris rockets, launching forced R-7 from French Guiana, and etc. But restrictions for technologies to cross boundaries are still in place. For example, in GLXP competition two teams (more will come) announced that flight will be done on China’s launch

vehicle, and if for Spanish team that can be ok, then for American team it will definitely bring problems with restriction on export technologies to China. To have in North America, in Canada, facility to manufacture CMSL with regular launched schedule is another benefit for Canadian industry.

Micro satellite launcher can be compared to public bus transportation with regular schedule. For sure there is need for a bus as add-on to existing limousine service (NASA), taxi driving (RSA), or Volkswagen (ESA). Eventually that bus transportation will be built, schedule will be maintained, and it will be nice to have this service as CMSL.

Resources for project.

Adobri Solutions Ltd. is a small company. What we have is mainly our experience in software development. That is our resource. For sure experience is a knowledge which may seem useless at time of getting it, but ability to create any software on any platform for any hardware is something. To design mission, craft, vehicle, hardware for our competition's goal we got various experience and advances in communication system design, antenna's design for a craft and ground station, navigation, control system, structural and mechanism design. This intellectual property is another resource available for CMSL project.

Financial resources of Adobri Solution Ltd. based on loans from shareholders. That allowed investment. Investment per year: 2009 47434.26CDN; 2010 33926.14CDN. Keeping financing on low level forced us to be innovative and productive. Personal loans based on home equity allows us to be functional till the official end of the GLXP competition.

GLXP competition required to report financial costs quarterly for each team. Current report for Q3 2012 is attached as required by Announcement of Opportunity. It states that on October 15 2012, Adobri Solution spend on a project 137,121 USD in money, and 800,297 USD in total value of 8883 hours.

Results of CMSL Phase one.

Estimates will be presented in a form of report with a list of equipment and services required in phases 2, 3 and in operation phase. In report there will be analyses with pros and cons

for different available technologies and services. If some of the technologies, like solid state engine's 3D printing will require to be built from scratch then in report there will be included available choices. In report there will be a section with pros and cons for at least two candidates for a manufacturing / testing / launch site. Report will include section with detailed operation expenses on operational phase of CMSL and also estimation will be produced for renting of manufacturing / testing / launch facilities by different designer's teams. Report will be published and available for Canadian companies involved in Space industry free of charge and for addition price for non-Canadian companies.

For a CMSL orbit calculation service there will be an open source software and server providing such calculations and visualization of trajectories and orbits. Component for distribution calculation will be downloadable from the server. Distributed calculations (performed in parallel) of orbits and impulses will be available for additional charge.

For a CMSL gyro-platform and open source schematic and open source software will be produced. Manufacturing facility will be able to process orders for production and certification of gyro-platform for CMSL and nano-satellites. Customers will have a choice to utilize different testing facilities including available in Canada for vacuum, vibration and thermal tests.

An open source schematic and open source software will be provided for CMSL communication system. Hopping frequency for communication is 2.4GHz. Hardware available to order will include ground station for nano-satellite and onboard hardware. For onboard hardware there will be options provided to certify it on existing, preferably Canadian vacuum, thermal and vibration testing facilities.

Results CMSL Phase one. Highly Qualified Personnel.

4 HQP are expected to be involved in CMSL

- Designer for orbit calculation software will be a new person hired as a contractor from a technical college.
- Designer for communication system will be hired as a contractor.
- Designer for mechanical parts of ground station will be hired as a contractor.
- Designer for gyro-platform will be hired as a contractor.

  Estimator will be hired as a contractor. All other jobs will be done by existing personal of Adobri Solutions Ltd.

Results CMSL Phase one. Industrial Positioning.

We strongly believe that creation of testing / manufacturing facility for CMSL located in Canada will be beneficiary for Canadian Space industry. Making this facility rentable for different Canadian and non-Canadian teams of designers can make a difference in space exploration and will support strong position of Canadian Space industry internationally.

Publishing report on Phase One will make clear statement for a Canadian business involved in Space exploration that the goal to be involved exists, and can be archived.

Risk and Mitigation strategies.

For “estimates report” creation the risk of failure is low, basically what will need to do be done is screening of equipment available for purchase from Canadian and non Canadian companies. Analyses of available equipment can be done based on data provided by equipment manufacturers. If company providing equipment will not agree to publish its name in report for some reasons, then in report data provided will be referenced as “commonly available hardware”.

Preliminary screening on 86 available patents for solid state engine was done, and it shows that the critical part for solid state engines is a process of production of steady burning engine components. 3D printers can solve practically all problems mentioned in those 86 patents. To develop such 3D printer one needs to replicate existing open source designs and build easy to assemble scaled version of 3D printers. Risk of failure to get inexpensive design for such printer is low; risk of the failure to produce the estimation report for such design is also low.

Screening sites for manufacturing / testing/ launch facility must be done on place and report can include all pros and cons. Risk of failure is low. If during screening there are objections from the site owner not to be included in the report then proposed site will be excluded from the report.

For CMSL orbit calculation service risk of failure is low. Existing and belonging to Adobri Solution Ltd. software needs to be tailored. If contractor hired to do this development fails to do the job, then funds from planned overhead budget will be used to hire another one.

For CMSL gyro-platform, risk of failure is moderate. Gyro-platform made by Adobri Solution Ltd. was able to detect earth rotation, but has not been certified for space flight yet. Budget for vibration performance tests, vacuum tests and thermal tests planned to reduce risk of failure. Backup plan to achieve required performance by gyro-platform for CMSL is to use series of gyro-devices. In worst case scenario Gyro-platform will be more expensive to manufacture than it was planned.

For CMSL communication system 2.4GHz risk of failure is high. Software for hopping frequency with error correction is complete. Design for reduced size 2.4Ghz antenna is complete. Design for reduced size a ground station 2.4GHz antenna is complete. Design for ground station antenna's orientation is complete. Gyro-platform for ground station is complete. Amplifiers for 1Wt (allowing transmitter power in US) and 4Wt (allowing transmitting power in Canada) is in preliminary stage. Software for transferring packets from ground station over IP is in preliminary stage. Orientation software based on orbit calculation is in preliminary stage. Communication equipment for onboard 2.4GHz transmitter/receiver has not been certified for a space flight yet. Following planned to reduce risk: budget for contractors to re-design amplifiers, overhead budget to perform vibration and vacuum tests. To test communication on the orbit CubeSat type satellite launch planned. Launch of the CubeSat (model 10-A) was already arranged by Adobri Solutions one year ago. If for some reasons launch will not happened/ delayed then vacuum, vibration and range tests (up to 120km) will be a backup plan for a CMSL communication system. Finding the Canadian facility for vacuum and vibration testing / certification with affordable price can be a challenge, in that case partnership with facility will be negotiated. In worst case scenario communication system will not be certified for a space flight but can be available as it is.