World Academy of Science, Engineering and Technology
International Journal of Economics and Management Engineering
Vol:6, No:7, 2012

Project Management in Student Satellite Projects: A University – Industry Collaboration View

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***Abstract*—**This research contribution propels the idea of collaborating environment for the execution of student satellite projects in the backdrop of project management principles. The recent past has witnessed a technological shift in the aerospace industry from the big satellite projects to the small spacecrafts especially for the earth observation and communication purposes. This vibrant shift has vitalized the academia and industry to share their resources and to create a win-win paradigm of mutual success and technological development along with the human resource development in the field of aerospace. Small student satellites are the latest jargon of academia and more than 100 CUBESAT projects have been executed successfully all over the globe and many new student satellite projects are in the development phase. The small satellite project management requires the application of specific knowledge, skills, tools and techniques to achieve the defined mission requirements. The Authors have presented the detailed outline for the project management of student satellites and presented the role of industry to collaborate with the academia to get the optimized results in academic environment.

***Keywords*—**Project Management – Academia-Industry Collaboration – Satellite - Aerospace

Open Science Index, Economics and Management Engineering Vol:6, No:7, 2012 publications.waset.org/14023/pdf

I. INTRODUCTION

THE miniaturizations of technology and advancement in the field of computational abilities with the advent of nanotechnology and nano-materials have paved the way for academia to introduce the hi-tech aerospace technology at the university premises. Many undergraduate and graduate students all over the globe have the option to get hands on experience for the latest satellite technology experiments.

The concept of Nano-satellites especially the CubeSat initiated by Bob Twiggs have made satellite projects easy especially for academia. At present, more than 100 CubeSat projects have been completed and launched successfully into the space and many similar projects are in the queue to join the cube sized satellite family in space. The concept of small satellites encompasses not only the CubeSat but all other satellites having mass less than 100 kg and this is an interesting option for the satellite developers especially for the upcoming concept of formation flying for communication and earth observation purposes.

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The concept of small satellites triggered the satellite industry to collaborate with the academia and to maximize their technological gains by sharing the human and technical resources of academia as universities are considered as the nucleus of latest tools and technology. Recent past has witnessed many such collaborations and joint ventures not only for the small satellite projects but also for the mega aerospace and many other projects too. There are many Achilles' heel for both academia and industry for collaboration but the mutual gains always surpass the hurdles and they go for joint ventures. Academia supports the industrial giants with cheap but dedicated and learned workforce along with the state-of-the art laboratories and on the other hand gains the financial and experimented technological solutions and guidance from the industry. This two-way technological and academic sharing has opened the success paradigm of academia-industry collaboration and has become quite mature in many sectors.

Small satellite projects vary from the normal non-technical projects as it requires highly technical and specific state-of-the art expertise and knowledge but like all other projects, they need the proper project management for the successful execution. Authors have presented the basics of Project management principles for executing the small satellite projects at universities and mark out the role of academia-industry collaboration for the success of such projects. The different phases of Project Management like initiating, planning, executing, closing and controlling are addressed in the backdrop of student satellite projects at academia with the collaboration of aerospace industrial tycoons.

This research paper is drafted in a sequential manner. Section II describes the details about student satellite project management phases while discussing the mission requirements and system engineering phases too. Section III addresses the university-Industry collaboration paradigm for the satellite industry and presents the success stories from the recent past. Section IV gives the model for University-Industry satellite project management developed by the authors while deliberating the literature and experience. Finally the paper concludes with some recommendations in section V.

II. STUDENT SATELLITE PROJECT MANAGEMENT CYCLE

Project is unique endeavor with a definitive beginning and an end, having definite goals, cost, schedule and quality [1] and consumes limited resources to meet defined objectives [2]. Application of knowledge, skills, tools, and techniques to project activities to meet the project requirements is called project management.

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It includes five processes as Initiating, planning, executing, controlling, and closing [2] and are executed to complete the life cycle of every project [3]. Small satellite projects include many phases and sub-process which makes their execution more complex [4]. Authors have used the above given references as the premise for developing the project management schedule for the small satellite projects. Fig 1 has clearly depicted all the phases for the successful accomplishment of student satellite projects. The various phases have been discussed in the following lines.

a. Initiating

The *Initiating* phase of the small student satellite project involves the defining of objective for developing the satellite that may involves the development of human resource for the satellite industry or to give the hands-on experience to the undergraduate and graduate students of the university. It also includes the definition of mission that either the satellite will be the communication or the earth observation one. It also includes the goal setting in terms of images or beacon receiving. This phase of the project management also involves the identification of donors, sponsors, funding agency, industry, stake holders, government regulatory bodies, launch providers, ground and control segment centers, public research organizations and other partner universities. It is required to define the roles and responsibilities of various stake holders involved and especially the main governing body that is the university itself and the main execution body that is the specific department/faculty dedicated for this student satellite project.

b. Planning

The *Planning* phase involves two major tasks namely the technical and administrative planning. The technical task starts with the mission requirements according to the objective and goal defined in the initiating phase. It outlines the specific requirements of the mission in qualitative and quantitative terms. It triggers the technical mission design that involves the orbit and path definitions. It also includes the selection of payload for the required mission and the life of overall mission with required accuracy and precision.

This mission definition steers the system engineering that involves the designing of different subsystems like structure, thermal, attitude and orbit determination and control system (AODCS), power, tracking, telemetry and telecomm and, on-board data handling, antenna and payload. It also involves the power and mass budget too.

The second administrative task defines the financial plan and budgeting, the communication plan and the quality plan. It also involves the team building and tasks assignments with schedules and work breakdown structures and Gantt charts.

c. Executing

The *Execution* phase is the most critical one in any project and especially in student satellite projects it involves many intricacies and supervision issues. The main task of this phase is to practically develop the different subsystems of the satellites according to the mission requirements and the system engineering guidelines. It also includes the procurement issues and the resource management using the facilities available at the university premises and also at the collaborating universities, industry or public research organizations.

The second step after the development phase is the testing and validation of each subsystem according to the defined quality instructions and finally integrating the all subsystems.

d. Controlling

The *Controlling* phase for student satellite projects involves testing and validation of the complete satellite that includes the thermal and vacuum tests. Performance evaluation is also performed at this stage with the applications of risk analysis and making the risk registers. This phase also demands for the final negotiations with the government and international regulatory bodies and finalizing the contracts and timings with the launch providers and control stations.

e. Closure

Kotnour has incorporated the last phase of project management with "act" phase of his model. This is the last step to close the project management loop. At this stage decisions are made for a specific project to terminate or continue the process [5]. The final *Closure* phase of the student satellite projects manages the satellite launch and initial in-orbit operations with the help of public research organizations or national space agency. It also includes the ground segment functions like retrieving the data and monitoring the health status of the satellite. The final phase covers the documentation and feedback analysis and to validate the required technical and qualitative mission goals and achievements.

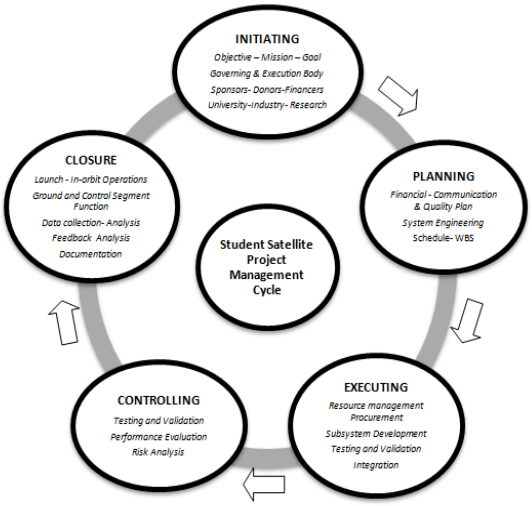


Fig. 1 student satellite project management cycle

III. Uni-Industry Collaboration Paradigm In Satellite Industry

Aerospace Industry and specifically the satellite industry is collaborating with academia since last three decades and a prominent example is of Surrey Satellite Technology Limited (SSTL) [6], located at the surrey university research park [7] along with other 115 industries, is the recognized world leader in the design, build, launch and operation of small satellites and has been doing so for 25 years.

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The academia-industry collaboration in the aerospace sector has some major names like Boeing has Georgia Tech University USA as an academic partner and Lockheed Martin has University of Maryland USA as her academic alliance for the research and development activities. Aeronautics and astronautics industry in China has contributed a lot in the national economy and major projects have been executed with the help of research at academes.

The concept of collaboration and alliances between the academia and industry is in air since many years but this collaborating environment also suffers from many hurdles and obstacles that impedes or sometimes bars the effective culmination of such alliances. By sharing the intellectual property generated at academic institutions, this industry can flourish in a brief period of time. Knowledge sharing forces the business jargons to come across academic collaborations [8]. Powerful and world's developed economies have been reported the same arguments. Corresponding R&D knowledge reserves and sharing this knowledge for specialized skill have been analyzed as motivating factors in Japanese firms [9]. In his research, [10] delineated that exchange of technological knowledge for synergistic gains is the most important engine to establish R&D collaborations in German firms.

Motives for research vary among the collaborating partners. Industry oriented research is mostly used for the development of commercial applications and academic oriented research is used for knowledge generation and further developments [11]. The major points of concern and conflict are the secrecy, copyrights and patenting of the technology and products from the both sides and especially it is the concern of the Industry. The organizational and cultural differences of two sectors also sometimes filter outs the option for collaboration but the availability of academic resources and pool of researchers instigates the industry for collaboration with academia while academia switches to industry for testing and validation hi-tech facilities along with the funding possibilities. Most important among the factors for sustainability of R&D joint ventures is trust [12]. Trust can enhanced through, collaboration repetitions. Cooperation echoes enhance reciprocal trust that leads towards partners' reputation [13]. Similar arguments are supporting the evidence for trust among the U-I collaboration partners by [14] that previous collaboration experiences for joint research.

CUBESAT projects are one of the best billboards of university-industry collaboration in the field of Nano-satellite projects. In small student satellite projects, the requirement of space qualified equipment and facilities cannot be managed by the single academic institution without the support of private or public satellite/aerospace industry. It also involves the collaborating efforts from the national space agency in case of developing nations where the satellite industry has not been fully commercialized yet. The satellite projects involve two major phases that are the launch and control along with the in-orbit operation and maintenance that involves the collaboration of industry at all costs. The system engineering can be done academically but the involvement of industry can validate the design, development and testing. Industry can better estimate the risk analysis and assure the quality within available resources. Satellite projects involves a high capital even if it is micro or nano-satellite project so the alliances with the satellite industry , public research organizations or the National space agency can guarantee the success of such projects. The industry other than satellite industry can also be the partner for the bus development as it involves the payload, antenna, sensors, actuators, solar cells and penal, digital electronics and structure too. The testing and validation facilities like of structure and thermal can be shared with other automobile or manufacturing industry.

IV. University-Industry Satellite Project Management Model

Authors have presented a unique model for satellite project management under the umbrella of academia-university collaboration presented in Fig 2. A horizontal level hierarchy is proposed where the Liaison office act as a mediator and catalyst for enriching the mutual relationship between academia and industry. Transfer of technology and sharing of skills are the two streams of collaboration paradigm. The sole responsibility of developing the trust and maintaining the bilateral information and technology flow is controlled by the Liaison office and it is considered as the control centre for all joint ventures and relationship growth among the partners.

The two main units of the model are the University and Industry. Each unit is autonomous in her own capacity and complements each other for the mutual benefits. The university unit has one sub unit of faculty and laboratories that are considered to be the hub of technology enhancement. The development, integration, and testing and validation tasks are executed in this unit for the small satellite student projects.

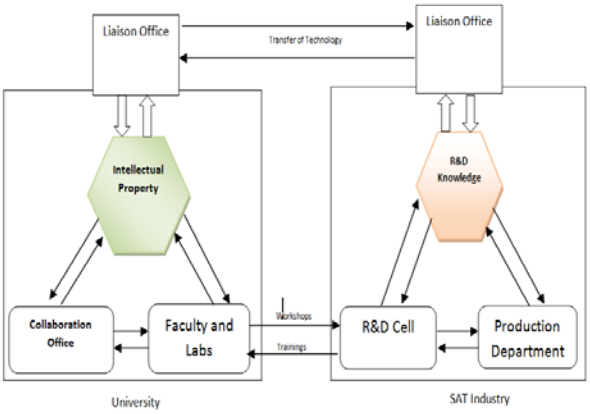


Fig. 2 U-I satellite project collaboration model for student projects

The intellectual property unit preserves the research and development outcomes that are the flowed through the faculty and laboratories along with the coordination office. The information and knowledge flow is bi-directional in all the sub-units of university / Academia block. Collaboration office steers all designing and administrative tasks for development and collaboration. The industry provides on-the-job trainings for the students and faculty at academia on the latest and hi-tech equipments while academia shares their valuable assets of knowledge and technological findings in the workshops that are offered to the professionals at the industry. This two-way traffic of latest and required skill sharing paves the way for mutual collaboration and cements the bonds for long lasting research and development scenarios.

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Inside the Industry unit of the model as shown in fig 2, the Research and development knowledge management is supported by the R&D cell and the production department. Both the main cells share their expertise on mutual grounds and benefit from each other and finally contribute in the intellectual and technical property of the industry itself. The R&D Knowledge pool of Industry interacts with the intellectual property of the academia via liaison office holders to ensure secrecy and confidence building and this result in win-win sharing paradigm of success for both the team players.

Small student satellite project executed by the model given in fig 2 can result in technological and intellectual gains by the all stake holders of the whole system. The university-industry collaboration is essential for small satellite student projects and industry can achieve their targets by utilizing the academic human and technological resources in an effective and an efficient manner.

V. Conclusion and Recommendations

This research venture is an attempt to develop the binocularity for the small student satellite project management through the lens of University–Industry collaboration. Authors have presented the life cycle of student satellite project management and have given an overview about the collaboration of academia and industry in the satellite sector. Finally a collaboration model is presented with possible outcomes and sharing between the academia and industry for gaining bi-directional benefits and bounties. An intellectual property and R&D sharing scenario has been coined out through the involvement of Liaison office for confidence building and trust-based intellecto-technical sharing. This model can be a guiding principle for academia and industry to collaborate in any project and especially the small student satellite projects at academia.

Acknowledgement

The authors are thankful to Northwestern Polytechnical University, NPU, Xi'an, China and Institute of Space Technology, Pakistan for research support.

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