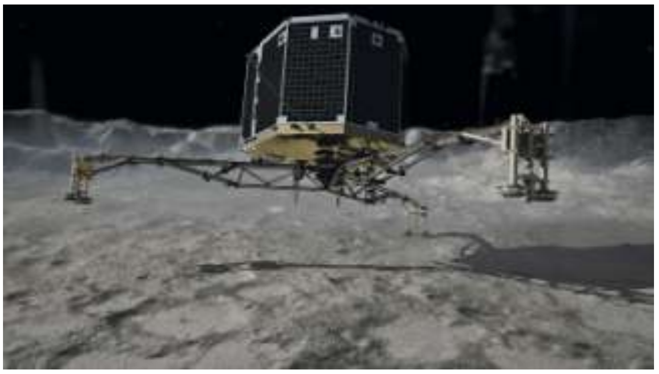
APS: Project Management

Project Title: Rosetta Lander Mission



Project Members:

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May 25th, 2015

Executive Summary

The Rosetta Mission is an international project led by the European Space Agency which aimed to land a space vehicle on the surface of a comet to conduct scientific experiments. The project was initiated in 1993. An orbiting and landing vehicle were constructed by 50 contractors spanning 14 independent countries. It was launched on March 2, 2004 reaching its destination in 2014 and deploying its lander on November 14. It completed its mission objectives $500 million above its initial budget of $900 million. The spacecraft missed its initial launch date due to rocket failure. This delayed the mission by 11 months and resulted in a major scope change in the project.

The lessons learned from this mission have been positive and negative. The organisational structure and communication planning were, in general, a success and have already been applied to other missions such as the Mars Express. This is especially the case for scope control through technical requirement planning. The major negatives have been identified in its cost, risk and stakeholder management. Cost over-runs were attributed to poor contingency planning at an overall scale. In addition, poor stakeholder management and poor planning for cultural conflicts at an international level reduced efficiency. Differences in project management styles between organisations need to be accounted for. In terms of mission operations, risks were not adequately identified and classified. Risk response was also deemed too slow to account for the unknown-unknowns related to space operations.

Overall, the project management principles applied reduced the overall technical and schedule risks resulting in a successful mission which met its scientific and business objectives.

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Introduction

Rosetta is an international mission that was led by the European Space Agency (ESA). Its key support and instrumentation were provided by the National Aeronautics and Space Administration (NASA). The prime objective of this mission was to analyse the composition of comets which have been speculated to contain information on the origins of our solar system. In this report, we present lessons learned from the project management procedures employed on this 22 year-long mission.

Background

The Rosetta mission aimed to launch a space vehicle, the Rosetta Orbiter, which could be maneuvered to precisely match the speed of a comet. A lander vehicle, known as Philae, would then be deployed onto the surface to conduct experiments and analyse the properties of the nucleus. Images of the spacecraft and lander are provided in Appendix Item 1 with the names of the 32 scientific instruments on-board.

The mission is a massively coordinated effort between ESA, NASA and various European national space agencies and research institutes like the Irish Space Technology Institute, Finnish Meteorological Institute, Rutherford Appleton Laboratory, KFKI Research Institute for Particle and Deutsche Forschungsanstalt für Luft- und Raumfahrt (DLR) etc. [1]. DLR was given project management responsibilities for construction of the Philae Lander. The Rosetta spacecraft was produced by the company Astrium GmbH and was the prime contractor leading the 50 sub-contractors from 14 European countries and the USA [2]. Industrial involvement of the spacecraft is depicted in Appendix Item 2.

Funding was obtained from ESA, NASA and contributions from many other space organizations in terms of cash and resources [3].The budget of the project is estimated at

$900 Million [3] but final operational costs have exceeded $1.4 Billion **Invalid source specified.**. The major cause was due to some schedule delays due to technical failures as well as major changes in scope [3].

The project can be divided into three phases: planning; construction of the orbiter and lander; and operations during the journey itself[1] [3]. The first was scheduled to begin in 1995 with the proposal being finalized in 1996. The construction and integration of the systems was scheduled to begin in 1998 and be completed by April of 2002. Construction finished late in December 2002, just in time for launch to the comet, 41 P/Wirtanen on 21st January 2003. However, Rosetta still missed this launch date due to the explosion of the Ariane5 rocket on December 11, 2002, which was supposed to carry it into space. The risks of transporting the spacecraft to an alternative location for launch were deemed too high. Thus, the ESA decided to reschedule the launch to the later date of March 2, 2004. The orbiter was also re-targeted to rendezvous with the comet, 67P/Churyumov-Gerasimenko, in November 2014.

The journey was a decade long taking a circuitous route around the Sun. It employed three gravity assists or slingshots around Earth and once around Mars to acquire enough energy to reach the comet. In addition, Rosetta flew by and studied two asteroids: 2867 Steins and 21 Lutetia [4]. It reached its final destination on January 20, 2014 and deployed the "Philae Lander" on November 14 2014 [4]. The project will complete on December 31st 2015 as an overall success.

[1] A graphic timeline is provided in Appendix Item 3

Lessons Learned

The lessons learned from this mission have been divided into relevant project management sections. The report, initially, investigates the organisational structure and planning of the mission. It then evaluates the management of the mission in terms of the triple constraint of scope, time and cost. Finally, it concludes with risk and stakeholder management.

Organisation Structure

Lesson #1: The governance, management, and supervisory structures must have clearly defined and differentiated authority and responsibilities

The Rosetta mission is an international undertaking, and as such there are many stakeholders and project members. The main governing bodies in this project were The National Aeronautics and Space Administration (NASA) and The European Space Agency (ESA). Both these agencies have different design, development, and project management styles that clashed during the creation of the Rosetta space probe and Philae lander. For example, the Jet Propulsion Laboratory (JPL) had to balance competing requirements from NASA and ESA during the development of the Microwave Instrument of the Rosetta Orbiter (MIRO). JPL had to conform to NASA's "faster, better, cheaper" design philosophy; this philosophy directly clashed with ESA's rigid approach to development, testing, and extensive documentation, causing JPL to do a balancing act between the two governing bodies, creating unnecessary challenges [5]. The lesson to be learned is that partnered governing agencies must present a clear structure, authority, and philosophy to workers to prevent unnecessary hardship, as was the case with JPL during the creation of MIRO.

Positively, the Rosetta mission handled the complex and sprawling nature of the project very well. The mission had to be divided up based on each member's expertise and interest. For example, the Italian space agency ASI created Rosetta's Sample Drill and Distribution system because Italy's National Space Plan had a goal to study comet formation and evolution [6]. Also, France's space agency CNES participated in the Rosetta mission in several levels, from Systems Engineering (lander architecture) to instrument procurement because CNES was partnered with several scientific laboratories with experience [6]. Finally, the German Aerospace Center (DLR) provided management expertise and substantial instrumental and engineering assistance. DLR led the design and construction of Rosetta's landing module due to their experience in the field and their many partners such as the Institute of Solar System Research, who designed Philae's landing legs [7]. Later projects can learn from the success Rosetta achieved by dividing up the mission components and handing them off to be managed by members who had expertise and interest.

Communication Management

Lesson #2: Effective and extensive communication channels within the organization should be established during mission planning

For an international project like the Rosetta mission, robust communication channels are needed to ensure proper collaborative efforts, easier and more cross-disciplinary dialogue, and conformation with international NDAs and state rules. The MIRO project specifically was communicating from the USA to multiple non-US based partners, so effective communication was a must. NASA, ESA, DLR, and other Space Administrations established Letters of Agreement which formalized the relationships between these agencies, and allowed the exchange of information within Customs and State Department Rules. In parallel, the MIRO team worked with JPLs International Relations office to ensure all information exchanged conformed to foreign regulations [8]. With the regulatory bodies in places, the communications infrastructure of the MIRO project was achieved by using a secure electronic library for all team members to share and archive documents. Weekly teleconferences to keep all international parties in the loop, as well as individual phone calls and faxes as needed were also implemented [8].

On a more high level, parties within the Rosetta mission were created to ensure proper communication about long and short term plans and goals within the whole project, to avoid the pitfalls of a matrix organization. The three main parties involved were:

- PI Teams: Experimenter teams, which support the long term scientific planning of the mission. They also perform maintenance of instruments, analyze results and prepare data to be stored in ESA's archive.
- Rosetta Science Operations Centre (RSOC): Coordinate long term planning of the mission. Also prepares operational timelines and perform resource checking. Supports PI teams in the long-term.
- Rosetta Missions Operations Centre (RMOC): Responsible for spacecraft related issues. Also Consolidates payload timeline provided by RSOC with all commands needed to control the spacecraft

The Rosetta mission is divided up in mission phases, which are further narrowed to mission scenarios. The RSOC communicates these scenarios to the Science Working Team (SWT), which is a collection of all PI teams. These parties create a time ordered list of scenarios called the Science Activity Plan (SAP), which RMOC requires.

These parties support each other and thus need structured communication to prevent mishandling of these time sensitive plans as shown in Appendix Item 4. To facilitate this, Rosetta Science Operations Working Group (SWOG) meetings take place where long, medium, and short term goals are discussed amongst the SWT, RSOC, and RMOC. Long term planning involves creating the SAP and scenario descriptions (the Master Science Plan, or MSP. Medium and short term planning goals are to actually perform the operations that were planned for and monitor the SAPs and MSPs. These occur after the comet is reached up to the end of the mission. Detailed plans for each scenario are prepared here [9].

These meetings are very detailed, with several iterations of planning and extensive documentation; communication is required to perform the many scenarios and operations before, during, and after Rosetta has launched. The lesson to be learned by the Rosetta mission's detailed communication plan within itself is to always have open and clear communication channels and structured meetings and plans to ensure effective delivery of objectives.

Project Initiation and Planning

Lesson #3: Develop a generic "Planning System Framework" at the beginning of large scale conceptually complicated projects that categorizing types of operations and life cycles of planning phases.

In order to reduce the substantial development costs of Mission Planning System, European Space Operations Centre (ESOC) implemented elements of a Mission Planning System Framework (MPSF) that was intended to be used by any of the mission types operated [10]. To do this, requirements were obtained from the Flight Control Teams (FCT) of missions in operation and development. From these, it then proved possible to identify a workflow that was largely applicable to most of on-going missions. The motivation of having a MPSF was from the initial failure of an Ariane which was initially scheduled for December 2002 but got postponed till January 2003. Since then, the MPSF was decided to be a generic start-point of planning and design which will serve future missions as well. For instance, BepiColombo which is currently being built and tested as one of ESOC's cornerstone missions, will benefit from this MPSF. In order to serve similar missions, the common elements of MPSF includes requirement analyses of understanding the composition, geophysics, atmosphere, magnetosphere, and history of planets or comets or objects being investigated. Another advantage of MPSF is that it is capable of integrating external data, rules and constraints to validate and adjust the mission plan.

The mission planning process of Rosetta was split into three cycles: Long-Term Planning, Medium-Term Planning and Short-Term Planning on the operations plan [11]. Each of these cycles consisted of work flows to generate operational products. According to the ESOC team, the planning systems has been reasonably successful and has helped the development of the planning systems to be delivered more or less on schedule though there were considerable number of modifications in the planning system framework. Therefore, an early planning system framework can be enhanced by its use in real-world planning systems and thus can provide a significantly improved starting point for the development of future planning systems for large scale and conceptually complicated projects.

Scope Management

Lesson #4: Requirements should be clearly defined to prevent unnecessary changes to the project during implementation

The Rosetta mission requirements were not completely defined at the start of the project, and continued to change deep into the mission. For example, requirements were changing even after MIRO had been fabricated and assembled [5]. This, along with NASA's "faster, better, cheaper" environment caused unnecessary challenges for MIRO's team. The team had to negotiate MIRO's requirements to meet NASA's funding [12]. This also led to cost overruns due to redesigning and retesting, which the management team could only partially control. MIRO had to be given more funding to complete the design, fix development problems, and to meet ESA's implementation requirements [12]. The lesson to be learned from Rosetta's mistake is that requirements and objectives should be clearly defined early on in the project development cycle to prevent unnecessary challenges to project developers and to prevent increased cost and risk.

Lesson #5: The organisational reporting structure should aim to separate scientific requirement planning from operations to ensure optimal allocation of resources and completion of project objectives.

The project requirements for the individual experiments were reduced from general ‘science themes’ in to quantifiable scientific objectives linked to physical parameters as shown in Figure 1 [13]. These research goals were proposed to the Research

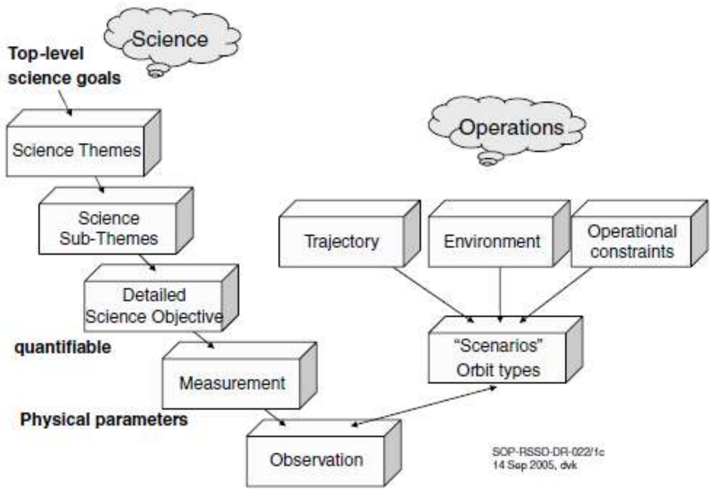

Figure 1 - Project Requirements Descriptions process and relationship with Operations

Science Operations Centre (RSOC) that would work with the experiment teams to create ‘mission scenarios’ under resource constraints. Mission scenarios are pre-planned work packages that are created for each phase of the mission. For medium to short term planning, they can be assembled to create a detailed work schedule by the RSOC for approval by the Science Working Team (SWT), the combination of all science teams [13].

The separation of science plan from the spacecraft operations is emphasised in the organisational structure of the ESA. This ensured the completion of the scientific project requirements but allowed for greater flexibility in operations. Thus, the risks of unknown flight circumstances could be mitigated more effectively while maintaining a clear overall mission objective. In addition, it allowed for a systematic way to determine the project requirements and their level of importance. Project scope could, therefore, be controlled more effectively, which is a major issue for long-term government-funded research projects.

Therefore, the lesson learned for future research projects is that the creation of project technical requirements and the implementation of these requirements should be carried out by different entities. Collaboration between these parties should be well planned to achieve an optimum solution that utilises resources efficiently to achieve project goals. Finally, control strategies, in this case implemented by the Science Working Team approval stage, should be incorporated to monitor and control scope.

Time Management

Lesson #6: Set milestones, carefully sequence activities and specify variance thresholds for monitoring schedule performance established in the baseline plan for large scale projects.

Due to the strict initial deadline for launch in 2003, time management was a major priority, often at the expense of cost. In order to control the schedule and cost risk, the Rosetta mission was conducted using a heavily phased approach to management with specific milestones, clearly defined control gates that influenced the way their activities were sequenced. Appendix Item 5 shows the initial milestones for the construction of the Rosetta lander found in the Initial Project Plan [14]. Detailed scheduling of each phase was conducted by the subcontractors and individual instrument teams. The clear milestones and review meetings ensured control of the schedule baseline; a critical path analysis was conducted and kept updated until launch.

Due to the high technological risks involved, the project scope was inherently unstable. Construction of the spacecraft and instruments started around 1998 after a detailed work breakdown structure could be created through 5 years of mission planning. The well-defined scope allowed for rigorous scheduling. According to the schedule shown in Appendix Item 6, most tasks are planned to a daily level. Working hours were also specified, either, ‘long day’, ‘shift working’ and ‘weekend working’ [15].

The responsibility for each of the 34 instruments aboard the lander and orbiter was delegated, on project onset, to individual organisations, led a lead principle investigator. Thus, the work packages could be assigned to individual organisations. This ensured timely completion of the project as there was little to no total float available for most tasks. The total float for integration tasks was either 0 or 1. It can also be seen that a marginal contingency of 6 days was incorporated in 2002 for a 6 month scheduled timeline[2]. However, most tasks were completed on schedule and evidence for fast-tracking can be observed, when this is not the case. The complete project was delivered in December 2002, 1 month before launch [16].

In summary, a phased approach with clearly defined milestones is needed to constantly monitor conformance to the schedule baseline. The work packages should be clearly defined with clear accountability.

Cost Management

Lesson #7: Establish clear responsibilities for budgets for different organizations and perform independent professional auditing of performance

Rosetta is funded by the European Space Agency, NASA and a number of space organizations. The total mission cost of Rosetta, according to ESA, is close to 1.4 billion euros ($1.7 billion), with the total cost of Philae amounting to 220 million euros .This was a fixed price contract with Asterism. This includes the costs of a one-year launch delay. This also includes the entire 20-year span of the mission, from the start of planning in 1996 to the end of the mission next year. According to NASA, the total cost of the mission was about

[2] As shown in Appendix Item 7

$900 million before the one-year launch delay, which occurred in 2003 after problems arose with the Ariane rocket.

There are various reasons that can be attributed to this. Firstly, the mission was a massively coordinated effort which involved so many space organizations and contractors. There wasn't clear responsibility delegation which invariably led to a lack of proper accountability in the project [1]. Secondly, we see that due to a technical failure in the launch vehicle the 2nd phase of the project was completely scrubbed a new plan was prepared. This is a major scope change .The documented cost incurred by this change is $70 – 80 Million but the budget was not prepared with appropriate accuracy which makes reporting in-efficient and cause further cost over-runs [3].

These failures clearly help us understand how it is important to have clear responsibilities in place. In future project of similar scope we should implement process that clearly defines responsibilities of various participating members. Along with it we should also make it mandatory to re-estimate cost and schedule with appropriate accuracy in cases of major scope changes and include new estimates in the project plan which can be used by external auditors or PM's to calculate parameters like Cost Variance and Schedule Variance to take preventive action.

Lesson #8: Adopt common project management approaches wherever possible in order to benefit from the weaknesses of earlier projects.

Two different styles of project management were employed by the ESA: "*hands-on*" and "*hands-off*". "*Hands-on*" approach involves cost-reimbursable contracts with an open communication channel with project teams to allow for continuous monitoring and changing of scope definition. "*Hands-off*" approaches involve a fixed-price contract and minimal interference by the project teams; it is managed by quarterly progress meetings, ESA independent reviews, joint management boards, and contract change boards. This approach is only undertaken when there is a well-defined set of requirements and plans at the systems requirement review, a well-understood risk register with sufficient provisions for risk mitigation, and a competent and trusted industrial organization. ESA projects contracted to a prime contractor ideally on a fixed-price contract to transfer risk and manage budget effectively [17]. The prime contractor can then hire numerous sub-contractors to further dilute the risk. The Rosetta mission required a more "*hands-on*" approach project management with cost-reimbursable contracts in early stages of design to allow for scope changes necessary for complex, technical problems [17]. However, there should have been an aim to create a stable and complete scope as soon as possible to move towards fixed-price regimes. The ESA confirmed a fixed price contract with Astrium GmbH, its main sub-contractor for the Rosetta spacecraft, in 2000 for all outstanding work [18]. This was an effective method of managing the risk and cost of the project; however, it did lead to failure when the Ariane5 rocket malfunction delayed the launch.

Risk Management

Lesson #9: Adequately evaluate the severity of risks at the project inception, especially those dealing with the integrity of the collected data.

An example of a risk that the management team avoided trying to make was related to decisions related to the Philae Lander. There were differing views within the project team as to whether a '*Go*' or *'No-Go'* methodology should be adopted regarding the occurrence and location of the landing segment of the Rosetta mission. The decision to land was taken based on the assumption that it would be impossible to correct for location-based issues if the landing had failed given that the time period to do so was short This decision resulted in uncertainty regarding the final position of the lander, and as a result, only the data from the

First Science Mission was available after the landing mission had completed. Since the project was a ten year mission, it would make sense to evaluate the probability of risks to the fullest extent via the conducting of experiments on earth.

Lesson #10: Identify project constraints and known-unknown risks as early as possible during scope design

At the beginning, Rosetta was an ambitious and to some extent uncertain in terms of goal achievement, mission. Constraints were identified in the design phase. For instance, they found that the times delay necessary to transmit (or receive) data to the Orbiter from Earth is roughly half an hour; thus immediate decisions driven by received data as input had to wait accordingly. In addition to this, the visibility between Lander and Orbiter was not permanent due to the Orbiter moving around the comet [19]. Moreover, the high probability risk factors were identified at the beginning of the mission. For example, "It is impossible to drill while the Lander is rotating around its z axis. - SESAME activities shall not be scheduled during any mechanical activity" etc. [19]. Risk and uncertainty are greater at the beginning of any project. These factors decrease over the life of the project as decisions are reached and deliverables are accepted. Indeed a set of parameters would remain unpredictable for projects like these, so a degree of flexibility is required during operation to insure the scientific a valuable return. Nevertheless it should also be possible to de-scope some activities that are no more relevant or compromised. The high probability risks were accepted as constraints to mitigate the impacts during Rosetta mission.

Lesson #11: Establish a time constraint on risk response processes to ensure mission critical events are handled swiftly

The Rosetta mission being a space project is bound to be wrought with uncertainties as there is very little knowledge about the project's working environment. As expected the Rosetta mission had its fair share of surprises. Rosetta orbiter gave rise to a lot of events that were planned for putting the team in a tight spot quite often .The batteries that powered the orbiter and lander was not charging fast enough or at least not as fast as they had hoped for [20]. The lander's harpoon and thruster failed a day before it was supposed to land [21].The unstable landing due to wrong assumptions of the comets surface.

Albeit all these unplanned events the Rosetta team did a great job of mitigating the impact of these events and achieving the mission objectives. The Rosetta team took careful decisions throughout the duration of the project weather it was deciding to hibernate the orbiter instead of risking to run out of power while landing. The success of the project is not only because they took the right decisions but also because they were quick about it. The lesson learned here is that there should be a time constraint imposed on resolving unknown risk events that have high impact. The more time taken to resolve such issues increase the impact they have on the project which can be critical to mission objectives.

Stakeholder Management

Lesson #12: Always strive for open collaboration amongst stakeholders, and it is essential to choose those who are willing to do the same.

Not everyone in the small ESA Columbus team of fewer than twenty people was happy with the lack of visibility provided by the hands-off approach by Astrium Les Mureaux. The quarterly progress meetings were conducted at a fairly superficial level, and it was difficult for the ESA subsystem specialists to get information from subcontractors. This lack of visibility did prevent some issues from being identified at an early stage, notably problems in the data management software design. The same approach was adopted by Astrium during the Rosetta project as well, and questions did arise as to why ESA had chosen to proceed with the above manufacturer, given the latter's refusal to openly collaborate with the project team [22].

Lesson #14: Upon project initiation, the key political stakeholders should agree upon the scope, schedule and cost and formulate contingencies for the effect of uncertainties

The NASA Project manager suggests in a TV interview that ESA's approach to space exploration is using resources to meet a 'nominal plan' whereas NASA invests in investigating risks associated [23]. This is certainly the case when you consider Rosetta was ready in time for the initial launch window but was postponed as joint decision between Arianespace and the ESA at an expected cost of €50 to 10 million [24]. Subsequently, due to political and economic commitments, the ESA had to invest €70 million to remain on target with its industrial development plan and an extra €50 million due to a depressed satellite market demanding forthright payments [25]. The risks and contingency planning using a bottom-up approach to identification of risks resulted in a poor planning for larger external influences on the project. The ESA has, consequently, started to plan for alternative target locations in the early planning stages of its other missions [26]. Nevertheless, a concrete plan should have been devised with political and financial stakeholders prior to project initiation in the case of scope or cost changes due to an unforeseen event [27].

Lesson #14: When working in international projects, parties should identify and record cultural differences upon project initiation to create a mutual understanding and prevent conflicts

The definition of ATV (Autonomous Transfer Vehicle) in the initial phases was done by Astrium Bremen (then DASA). Then, in order to provide French interest in the ISS program and to ensure an adequate return to French industry, Astrium Les Mureaux (formerly Aerospatiale) was made the prime contractor for subsequent phases. This was aggravated by

German–French rivalry within EADS, and resulted in significant demotivation of staff in Astrium Bremen. Astrium Les Mureaux was also inexperienced and inefficient in leading subcontractors since it was accustomed to having CNES, the French space agency, in such a role, particularly for launcher developments. Consequently, problems emerged in configuration management, management of subcontractors, and the design process itself. The same issues were evident in the Rosetta mission as well, particularly in the segments controlled by ESA. The latter's operations were spread over 9 countries, and feelings of competition and insecurity amongst these members was very high, since they felt that they benefits they would receive from the program would be directly proportional to their investment/similarity in work culture [22]. A classic example is Hungary, whose contribution to the program was never mentioned, because of lack of expenditure by the former due to its poor GDP. Thus, when working with cross-cultural teams, cultural differences should be established on project initiation and methods of preventing and mitigating conflict should be established.

Conclusion

There were many failings and shortcomings with the mission but overall it was a success as they have successfully deployed the "The Philae Lander" on the comets surface and as of latest updates we know that the Lander is back online and is transmitting data back to Earth.

	Cost	Schedule	Scope
Planned	$900 Million	January 2003 - 2012	Landing on 41 P/Wirtanen
Actual	$ 1.4 Billion	March 2004 – November 2014	Landed on 67P/Churyumov-Gerasimenko

It is observed there a lot issues which occurred due lack of information, in sufficient planning and lack of sufficient contingency plans. The delay of the launch also cause major setbacks to the project and huge cost and schedule slippages. Albeit poor testing and risk planning the team was prompt and proactive in handling each issue as it occurred with required corrective actions.

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Appendix

Appendix Item 1: Rosetta Orbiter and Philae Lander

Figure 2 - Rosetta Orbiter and the various Experiments on Board [28]

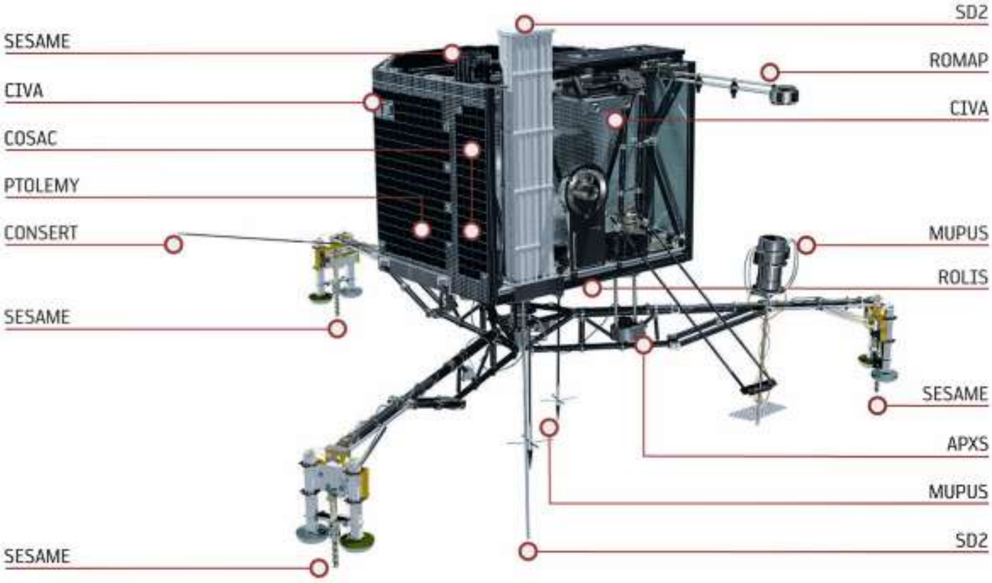

Figure 3 - Philae Lander [29]

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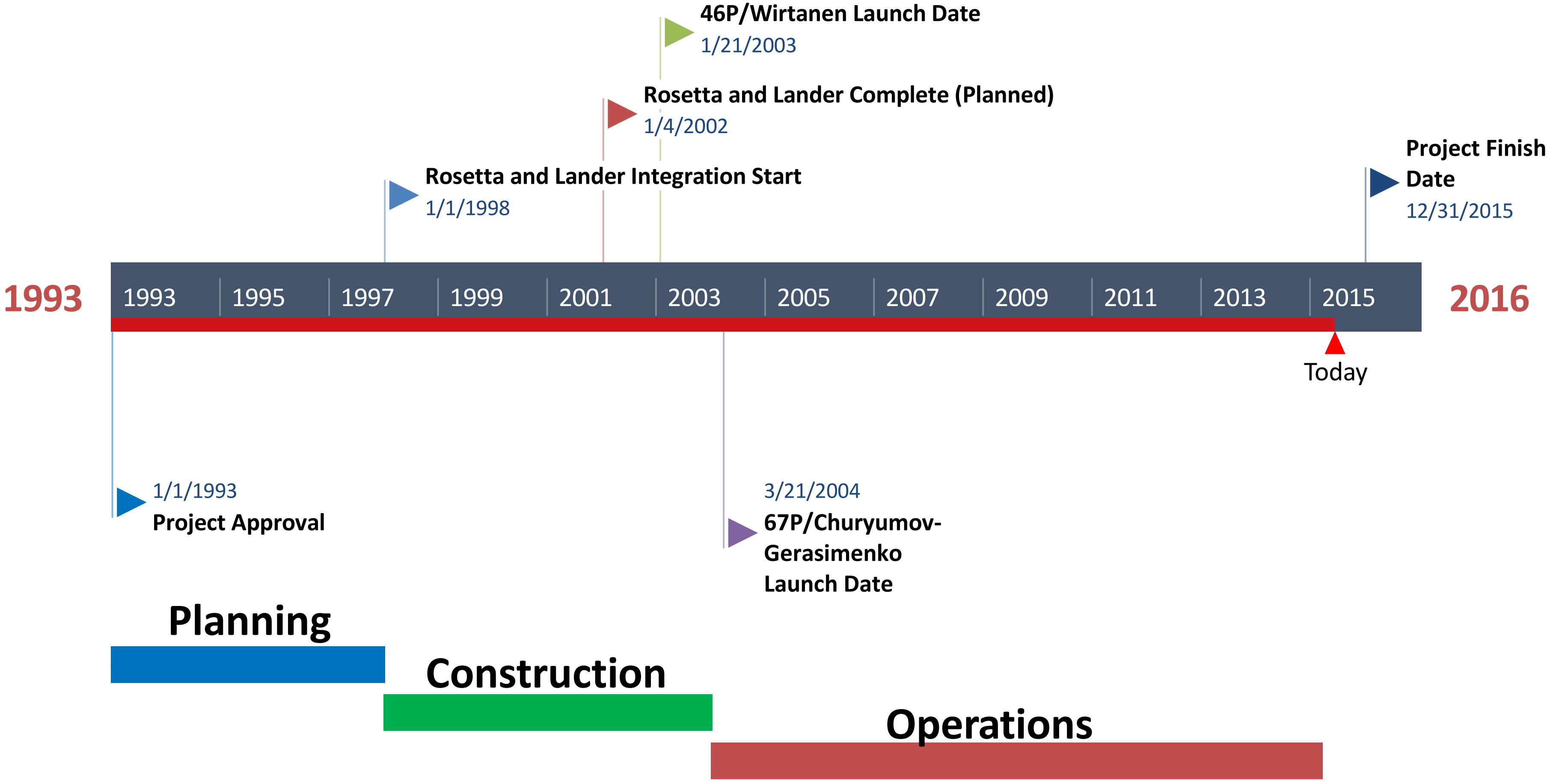
Appendix Item 2: Organisations Involved in the production of the Rosetta Spacecraft

Figure 4 - Organisations Involved in the production of the Rosetta Spacecraft [30]

Appendix Item 3: Timeline for Rosetta Mission



Appendix Item 4: Graphical Overview of Long Term Planning Cycle

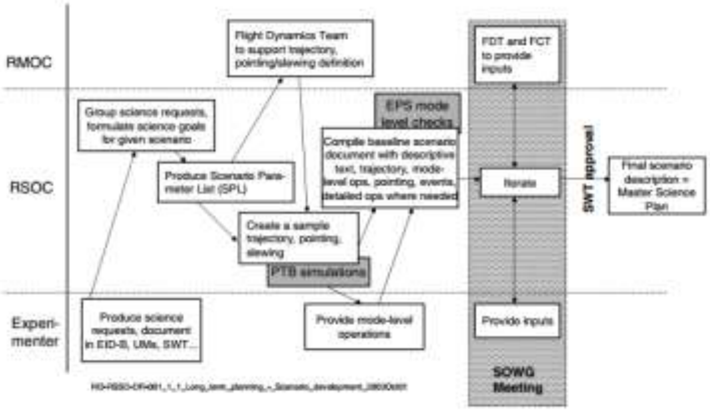
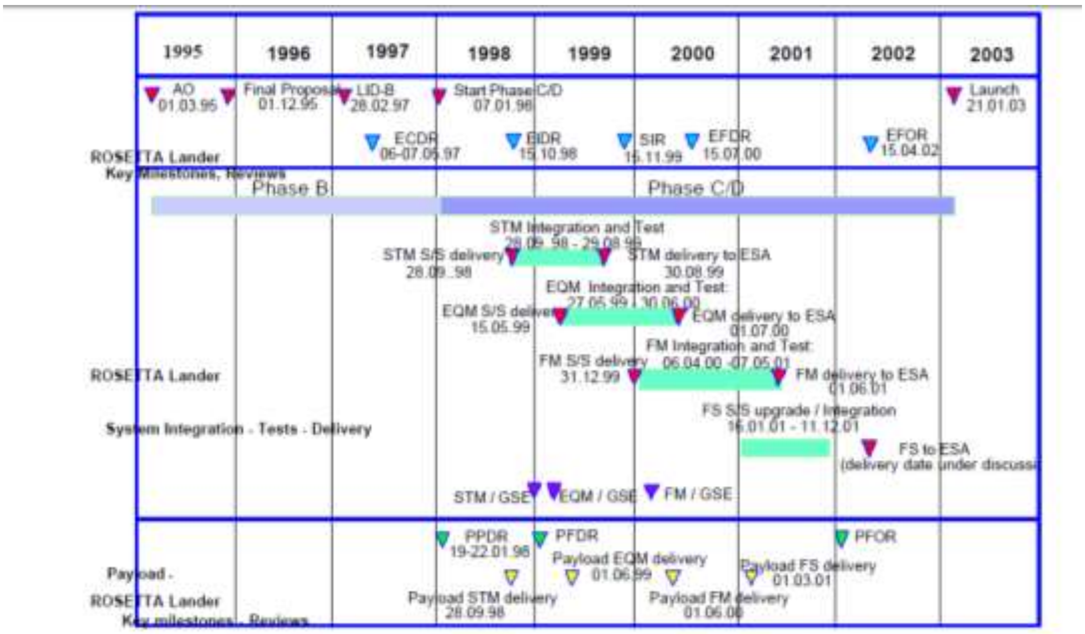


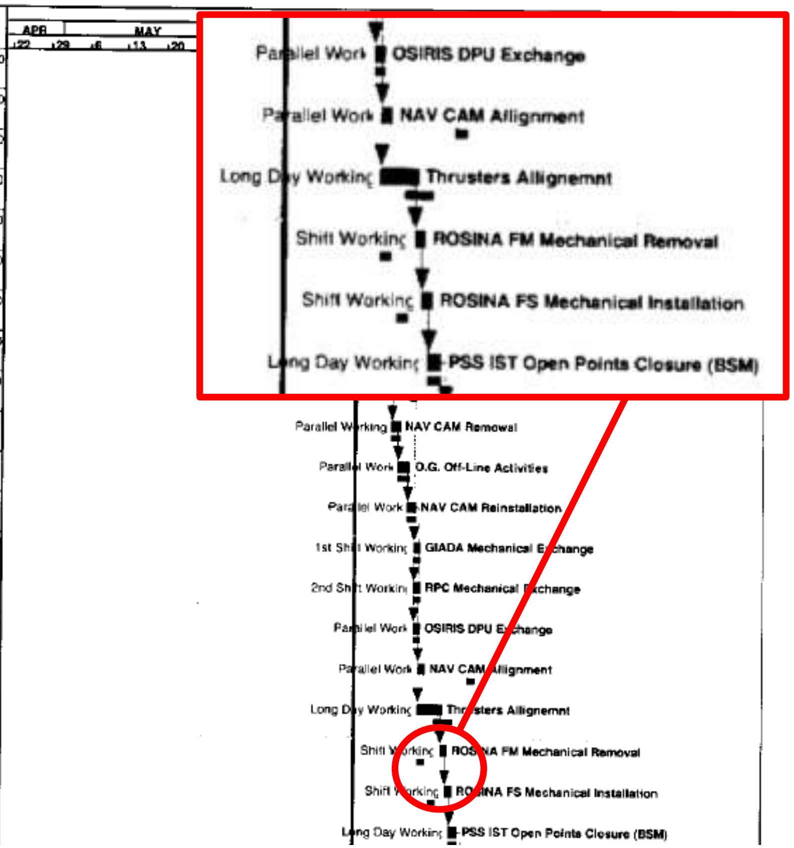
Fig 1: Graphical Overview of Long Term Planning Cycle

Appendix Item 5: Initial Project Plan



Appendix Item 6: Rosetta Spacecraft and Lander Integration Construction schedule: Fast Tracking and Float

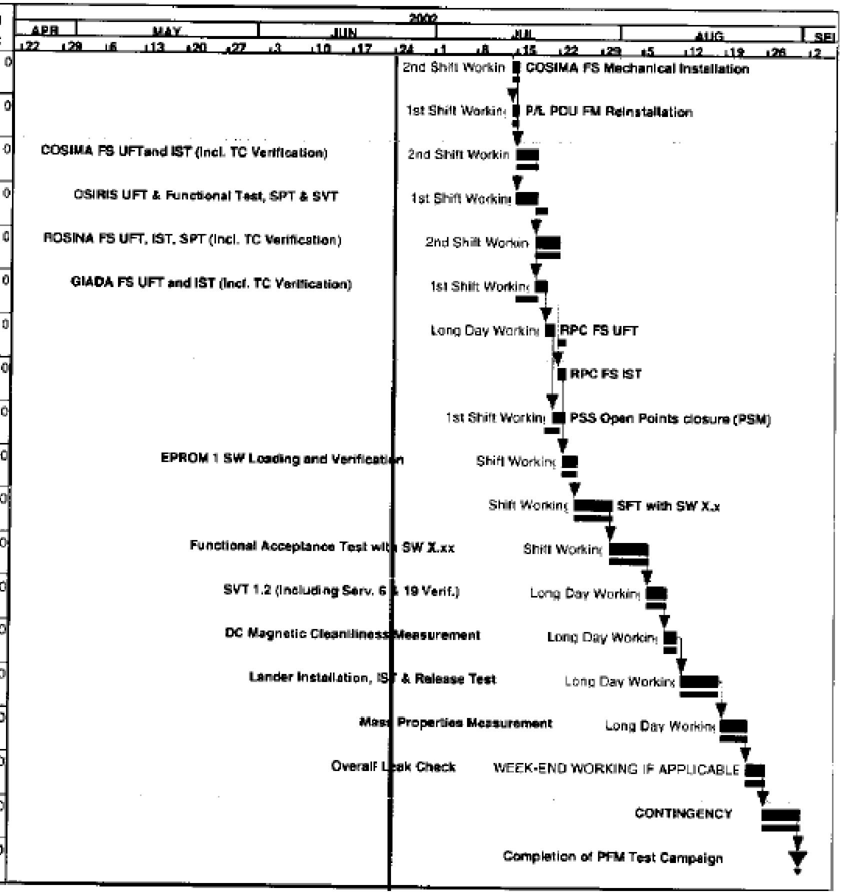
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float
D00001	COSIMA FM Removal	1	28JUN02	28JUN02	0
N03150	P/L PDU FM Removal	1	28JUN02	28JUN02	0
N03170	Battery Exchange Rehearsal, Lander & ESS Rem.	1	29JUN02	29JUN02	0
N02390	HGA-MA Encoder Cable Exchange (HTS)	1	01JUL02	01JUL02	0
N03130	APME - SADE SPT - ORB Test	1	01JUL02	01JUL02	0
N03180	ORB Test Completion & OCM-1 Closed Loop	1	02JUL02	02JUL02	0
N03190	AFM - 1 Closed Loop	1	03JUL02	03JUL02	0
N03250	RSI Test	2	03JUL02	04JUL02	0
N03200	Dust 1 Closed Loop	1	04JUL02	04JUL02	0
N02340	NAV CAM Removal	1	01JUL02	01JUL02	1
N02350	O.G. Off-Line Activities	2	02JUL02	03JUL02	1
N02360	NAV CAM Reinstallation	1	04JUL02	04JUL02	1
D00050	GIADA Mechanical Exchange	1	05JUL02	05JUL02	0
D00070	RPC Mechanical Exchange	1	05JUL02	05JUL02	0
N03160	OSIRIS DPU Exchange	1	05JUL02	05JUL02	0
N02370	NAV CAM Allignment	1	06JUL02	06JUL02	0
N03220	Thrusters Allignemnt	3	06JUL02	09JUL02	0
D00060	ROSINA FM Mechanical Removal	1	10JUL02	10JUL02	0
D00080	ROSINA FS Mechanical Installation	1	11JUL02	11JUL02	0
N03210	PSS IST Open Points Closure (BSM)	1	12JUL02	12JUL02	0



O.G. Off-Line Activities	2	02JUL02	03JUL02	1
NAV CAM Reinstallation	1	04JUL02	04JUL02	1
GIADA Mechanical Exchange	1	05JUL02	05JUL02	0

Appendix Item 7: Rosetta Spacecraft and Lander Integration Construction schedule : Contingencies

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish	Total Float
D00090	COSIMA FS Mechanical Installation	1	14JUL02	14JUL02	0
N03280	P/L PDU FM Reinstallation	1	14JUL02	14JUL02	0
D00020	COSIMA FS UFTand IST (Incl. TC Verification)	3	15JUL02	17JUL02	0
D00100	OSIRIS UFT & Functional Test, SPT & SVT	3	15JUL02	17JUL02	0
D00040	ROSINA FS UFT, IST, SPT (Incl. TC Verification)	4	18JUL02	21JUL02	0
D00010	GIADA FS UFT and IST (Incl. TC Verification)	2	18JUL02	19JUL02	0
D00030	RPC FS UFT	1	20JUL02	20JUL02	0
D00110	RPC FS IST	1	22JUL02	22JUL02	0
N03310	PSS Open Points closure (PSM)	2	21JUL02	22JUL02	0
N03300	EPROM 1 SW Loading and Verification	2	23JUL02	24JUL02	0
N03230	SFT with SW X.x	5	25JUL02	30JUL02	0
02050	Functional Acceptance Test with SW X.xx	5	31JUL02	05AUG02	0
N01880	SVT 1.2 (Including Serv. 6 & 19 Verif.)	3	06AUG02	08AUG02	0
01900	DC Magnetic Cleanliness Measurement	2	09AUG02	10AUG02	0
N01890	Lander Installation, IST & Release Test	5	12AUG02	17AUG02	0
01860	Mass Properties Measurement	4	19AUG02	22AUG02	0
01740	Overall Leak Check	3	23AUG02	25AUG02	0
N 01810	CONTINGENCY	6	26AUG02	31AUG02	0
01910	Completion of PFM Test Campaign	0		31AUG02	0



CONTINGENCY	6