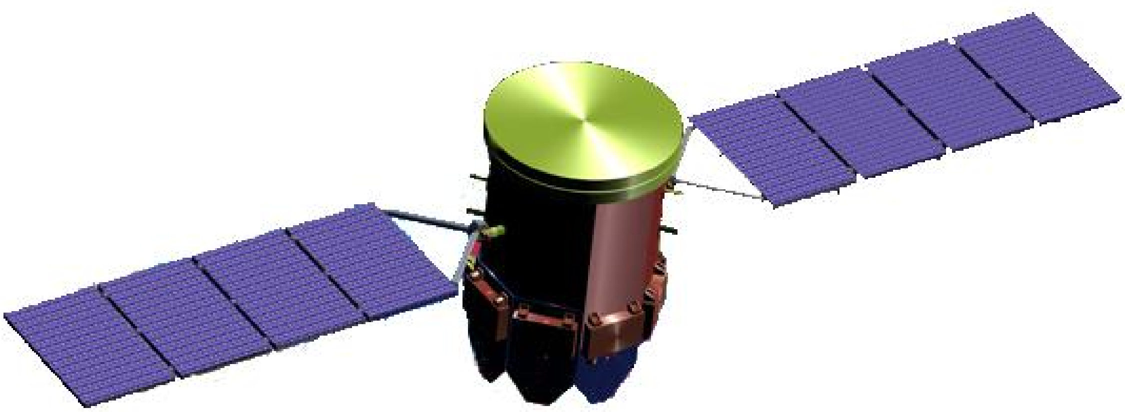
National Aeronautics and Space Administration (NASA)

Vegetation Canopy Lidar (VCL)
Case Story & Lessons Learned



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Academy of Program and Project Leadership
and
the Systems Management Office - GSFC

This case was developed jointly by NASAs APPL and GSFC System Management Office for the purpose of discussion and learning. It is not an official or comprehensive account of the VCL project. Jim Barrowman assisted in the production of this case. Other cases are available at: www.APPL.nasa.gov.

The Vegetation Canopy Lidar (VCL) was selected in March 1997 as the first Earth System Science Pathfinder (ESSP) spaceflight mission. It was scheduled for launch in January 2000. As of this writing, it has yet to fly.

At confirmation, VCL was described as, "…an imperative mission on the basis of its unique measurement set." It was also stated that, "The VCL instrumentation is evolutionary, grounded in space-born laser altimeter heritage established by NASA's GSFC (MOLA, SLA)." The first statement is still true today. The second proved to be woefully inaccurate.

All concerned, including NASA's Earth Science Enterprise, the Goddard Space Flight Center (GSFC) Earth Sciences Directorate, and the Earth science community, considered VCL to be imperative because its principle goal was nothing less than the three-dimensional mapping of the land surface structure of the entire Earth. This mapping encompassed both the Earth's land cover canopy vertical and horizontal structure and its land surface topography. VCL promised to provide for the first time global data that would allow Earth scientists to model, monitor, and predict the state of Earth's ecosystem and provide key inputs for climate modeling and predictions. With such a dramatic increase in global knowledge promised, everyone wanted VCL to succeed.

The VCL proposal was developed as a collaboration between the University of Maryland, College Park (UMCP) and the GSFC Laboratory for Terrestrial Physics (LTP). The Principle Investigator (PI) was from the UMCP. While two co-investigators were from the University of Central Florida and the University of Missouri – St. Louis, the majority of the co-investigators were from the GSFC LTP. The GSFC LTP also took responsibility for the development of the single instrument on VCL, the Multi-Beam Laser Altimeter (MBLA).

Under the terms of the ESSP Announcement of Opportunity (AO), the PI was responsible for the science integrity and success of the mission and led the VCL mission development team. Being inexperienced in spaceflight hardware development, the PI chose to contract for the project management of the mission with Omitron, Incorporated. Omitron also had responsibility for the mission systems engineering, ground system development, and performance assurance. For the spacecraft development and mission integration and test, he selected CTA Space Systems, which later was bought out by Orbital Sciences Corporation (OSC). The PI kept mission and science operations as well as data processing and distribution at UMCP. The launch was to be on a Pegasus via the NASA SELVS contract.

The first ESSP AO offered two mission opportunities: a $60M life-cycle cost mission to be launch ready within 36 months of selection and a $90M lifecycle mission to be launch ready within 48 months of selection. The life-cycle costs were defined to include definition, development, launch service, operations, data analysis, and data distribution/archiving. The VCL team decided to go for the first launch and felt they could do the mission within the $60M cost cap. Repeated cost increases beyond this cap ultimately led to the termination of the VCL mission development and the instrument being relegated to a technology development program.

In light of the VCL history, it is easy to second-guess the selection and confirmation processes. Unhappily, the brilliance of VCL's proposed science overshadowed its flawed management and instrument technology development plans. Because Headquarters focused on the science and virtually ignored the underlying concerns about feasibility, management approach, and ability to perform within the proposed cost and schedule, the selection process didn't recognize VCL's flawed plans. During the evaluation, nobody independent of the VCL team verified that the mission could be done for the proposed amount. During confirmation, the GSFC Resource Analysis Office (RAO) reported to the Confirmation Assessment Review team, not GSFC management. This put the RAO in a project advocacy role and their cost analysis relied on the project's totally favorable assumptions. Predictably, this led to an estimate close enough to the project's to pass muster. The confirmation process attempted to address the need for better management but did not expose the overly optimistic expectations for the instrument technology development. Both the HQ selection and confirmation officials relied on the GSFC involvement, and believed it was significantly greater than just the development of the MBLA by the LTP. While the GSFC Center Director signed the proposal (albeit for the support to be provided by the LTP), it was not considered at the Center to be a GSFC proposal since neither the PI role nor the spacecraft were GSFC's responsibility. When the selection was announced, GSFC's management expressed disappointment that a Goddard proposal had not won. At that time, VCL and the MBLA were not visible to GSFC upper management. Goddard did not have a requirement that its significant contributions, such as major instruments, to projects sponsored outside the Center be reviewed at the Center level – a serious oversight. In fact, management of MBLA was allowed to remain within LTP, while other flight instrument efforts were managed within the GSFC Systems, Technology, and Advanced Concepts (STAAC) Directorate. In the same timeframe, other instruments that Goddard provided in a fashion similar to MBLA also ran into fiscal problems. The MBLA instrument technology and management plans had never been vetted outside of the Laboratory for Terrestrial Physics. The laser altimetry experts in the GSFC Applied Engineering and Technology Directorate (AETD) were not involved with MBLA until it was too late. The ESSP Program Office at GSFC was chartered to maintain insight into the mission, but not direct the PI or manage the MBLA. The Program Office and GSFC management were still attempting to understand their roles and responsibilities under the ESSP "PI-Mode" of mission management. Thus the GSFC institutional oversight and support role was far less than HQ assumed. Both GSFC and HQ have since changed their proposal vetting and selection processes, respectively. Both have strengthened their mission oversight policies and procedures as well.

During definition and development, VCL was beset by a number of problems that contributed to, but were not decisive in, its demise. Soon after selection, the Pegasus SELVS launch service promised in the AO was cancelled. With the help of the Program Office, a new launch vehicle was identified and secured over a period of almost two years. In the meantime, the VCL designers had to maintain dual launch compatibility. At the same time, the launch site was moved from VAFB to Kodiak Island, Alaska. NASA added the costs associated with these changes to the cost cap, but did not add the hidden costs due to dual compatibility and associated management efforts. On the spacecraft side, a larger company bought out the spacecraft contractor early in development, imposing higher rates and overhead costs on the spacecraft effort. The spacecraft development strategy depended on non-recurring engineering from the Orbview commercial spacecraft that, itself, was still under development. As the Orbview schedule lagged behind VCL's, more and more engineering costs accrued to VCL. There were also spacecraft component technical design and delivery issues. For example, the solar arrays were initially sized for orbital average, not peak, power. Once this was discovered and corrected, the larger solar arrays then drove a redesign of the attitude control system. The spacecraft contractor was focused on projects that were more important strategically to the company and had only a lean engineering team and little bench strength to spare for the VCL spacecraft. The spacecraft eventually was delivered two years late and significantly over budget.

These problems and other relatively minor ones were not outside the kinds of problems spaceflight projects have faced before. However, they helped eat up much of the project contingency and schedule slack. Interestingly, they served to highlight for the PI and confirmation review team some of the VCL management problems. Unfortunately, they also served to distract attention away from the instrument technology problem.

The VCL management plan had two major flaws – the inexperience of the management team and the lack of any unifying institution for the mission. The PI had no experience in flight system development. While the Project Manager (PM) named in the proposal was touted as having, "…over 32 years experience with NASA and is a veteran project manager of many high profile science and communications satellites." he actually had never had project management responsibility for developing a flight mission. The Deputy Project Manager/ Systems Engineer did not have mission systems engineering experience for a full flight project. The Instrument Manager at Goddard was strong technically, but lacked management skills or experience. The Business Manager at UMCP had never managed the finances, procurements, or other business functions for a space flight project. Their combined inexperience led to the proposal being bid at the unrealistic $60M. Once selected, the PM and his management team did not proactively manage all elements of the mission development. The development was divided into a set of Integrated Product Teams and Management Working Groups rather than a strong streamlined central management structure. The PM was not collocated with the PI, instrument development, or spacecraft development teams and the PM did not insist on collocation of at least the core team members. When the Program Office provided experienced advice to the project, it often went unheeded.

The UMCP was the PI institution for the VCL Project. The University saw VCL as a feather in its cap and spent $700,000 on renovating and creating a VCL control center and data management center. It provided the PI with staff and offices, no small commitment on a crowded campus. Yet, the university was not set up institutionally to lead the VCL mission. It had to rely on other organizations' capabilities to manage and integrate the project. Omitron did not have the depth of project management or hardware engineering experience to take responsibility for VCL. The misunderstanding of the GSFC role by others was discussed earlier. Clearly neither GSFC nor its Laboratory for Terrestrial Physics took responsibility for the VCL project. The spacecraft contractor was providing a product and service. It took responsibility only for its supplied elements of the mission. Without any institution really able to take responsibility for the mission, there was no place to turn to for bench strength, expert advice, or the leverage needed to help solve developmental or managerial problems. Except for the limited support provided by the ESSP Program Office, the PI and his team were on their own.

The PI recognized the managerial weakness in the project during the definition phase and changed the project management team just prior to confirmation. Although the Program Office concurred with the replacement candidate recommended to the PI by the Independent Confirmation Review Team Chair, the new project manager proved to be only slightly better than the first. While stronger technically, he lacked strong project management skills. In fact, he attempted to be both project manager and mission systems engineer. He apparently spent most of his time on the latter role, his real forte. In addition, his project experience was with large, high-cost, missions that provided a deep support staff. He didn't understand how to run the kind of effective, streamlined, fast-paced project VCL demanded. His company, Swales Aerospace, had significantly more depth and technical experience, but there wasn't funding to bring it to bear adequately.

The new project manager assumed the MBLA to be Government Furnished Equipment (GFE). As GFE, he assumed GSFC would deliver MBLA under the terms of the Program Office mission contract with the PI, and thus it was not subject to management by the VCL Project. By virtue of the GSFC Director's signature on the proposal, GSFC was, in fact, legally bound to deliver the instrument to UMCP. However, under the terms of the AO, the GSFC LTP was effectively operating as a subcontractor to UMCP. Thus, the MBLA was not GFE under the mission contract between the ESSP Program Office and UMCP. In an attempt to reconcile this situation, the Program Office had developed an MOU to document the relationship between the LTP and the PI soon after selection. However, the Center Chief Counsel determined that the MOU would not be a binding document and that the contract between the UMCP and GSFC for the mission should be written to provide MBLA as GFE. The Program Office considered this approach to be inconsistent with the PI-mode as defined in the AO. The VCL proposal left no doubt that the VCL Project Manager was responsible for managing MBLA. However, GSFC management failed to recognize its role and responsibilities as a subcontractor to the VCL PI. Without any formal recognition of the Center role through some form of subcontracting agreement, neither project manager had the leverage to gain real insight into or manage the instrument development.

The overarching cause of the VCL failure was that the MBLA instrument technology simply was not ready for flight mission development. The GSFC LTP developed two successful laser altimeters in the early 1990's, the Mars Observer Laser Altimeter (MOLA) and the Shuttle Laser Altimeter (SLA) as well as a number of similar research aircraft instruments. Although it was sold as an incremental technology based on the SLA, the MBLA laser was a major technology jump beyond the SLA. While the laser pulse energy was about half that of SLA, the required pulse rate was an order of magnitude higher than SLA and the beam divergence was an order of magnitude tighter. The lifetime requirement was nearly two orders of magnitude longer for MBLA than SLA. All this added up to a dramatically greater energy flux density within the laser and a need for much finer tolerance, higher quality, construction. A comparison of the two lasers is given in the table below.

	Wavelength (nM)	Pulse Energy (mJ/pulse)	Pulse Rate (pps)	Pulse Width (ns)	Beam Divergence (mrad)	Surface Footprint (M)	Lifetime (days)
SLA	1068	20-35	10	20-15	0.25-0.4	100	10
MBLA	1064	10-15	290	10	0.06	25	730

The Instrument Manager (IM) within the LTP played a major role in the development of the SLA and had established Small Business Innovation Research (SBIR) grants with a group of small research companies to develop a follow-on instrument of greater capability. This group included Fibertek, Inc., which was later selected to develop the MBLA laser transmitter. In fact, it was the LTP IM who initiated the VCL mission concept, based on this follow-on instrument idea. There were differing opinions within the GSFC Earth Sciences Directorate as to the viability of the MBLA as a flight instrument due to its very low technology maturity level. The Earth Sciences Directorate did not support the VCL proposal with bid & proposal funding. This drove the effort toward UMCP as the PI institution and led to the misunderstanding of Goddard's role discussed earlier.

As they struggled to build a flight instrument to the extremely demanding VCL specifications, Fibertek never was able to move beyond the research mode. They did not have the background or discipline to build flight hardware. They had no configuration management, quality assurance, traceability, flight parts selection, or documentation. As lasers were burning up in thermal-vacuum tests, the Fibertek engineers were reduced to design by trial-and-error, a very time-consuming process. The IM eventually decided to adopt a promising design developed at the American University. This was no panacea since it, too, had to be taken from a laboratory design to a space-qualified device. Also, Fibertek resisted building someone else's design, leading to further time lost in the transition. The laser development ultimately was pulled in-house at Goddard, but only after other management changes took place.

During definition and development, the IM neither sought nor accepted support from the Goddard Engineering Directorate. This may have been due, in part, to the sense that the Center felt no commitment to VCL. He and his lab management were very insular, held the project and program offices at arms length, and tried to provide minimal information on the status of the development. The IM was focused on the technical aspects of the laser and did not pay attention to other design issues, such as the receiver electronics and packaging. Nor did he manage the instrument budget or schedule. Since the instrument was being managed within LTP, it didn't benefit from the built-in AETD/STAAC monthly oversight that STAAC-managed instruments received. At the instrument CDR, it became clear that the MBLA was nowhere near a CDR level of design maturity. Goddard management was waking up to the seriousness of the problem. The IM was replaced with a manager with broader experience and a greater willingness to work with the project. Although there was improved management, the technical problems with the instrument did not abate. The receiver and telescope continued to have problems that led to a change in contractors. As laser work was pulled in-house, it became apparent that the LTP was oversubscribed. The GLAS and MLA laser altimeter instruments were being developed at the same time and had their own problems. The journey from laboratory design to space-qualified hardware was stretching ever longer and more expensive.

As the schedule stretched and the cost cap was threatened, the ESSP Program Office called a Program-level review of the VCL project. This was a warning shot that the project could face termination. The PI had expected the GSFC LTP would deliver what it promised and saw that it had failed to do so. When the PI laid out his concerns to the GSFC Deputy Center Director, an engineering assessment of the instrument was constituted. This was the start of serious GSFC AETD involvement in the MBLA. A major finding was that the design was questionable in a number of areas and that the instrument design had undergone no peer reviews. Having been sensitized to the seriousness of the instrument and project problems as well as the increasingly risk averse NASA environment precipitated by the two MARS failures in 1999, Goddard management followed up with a project-wide review by a Tiger Team of independent senior Center project managers. Based on their findings, GSFC management recognized that the project could only be saved by major intervention and volunteered to take management responsibility for the project. With the PI's agreement, GSFC named an experienced civil servant project manager to take over VCL. The new project manager devised a recovery plan that minimized the cost overrun while establishing discipline and control across all project elements. The GSFC AETD took over responsibility for the instrument development. When GSFC and UMCP took this plan to NASA Headquarters, the credibility of the new project manager and the strength of the science allowed the project to continue even though the cost cap had been broken. However, HQ required the project to return after doing a more thorough reassessment of what it would take to finish the mission. As the spacecraft started through its integration and test cycle, the instrument engineers continued to chase laser space qualification problems. In its reassessment of the cost, GSFC then tried to cover all bases and came up with a price tag that nearly doubled the cost of the mission. Even though the revised mission cost was less than the minimum mission funding for the next round of ESSP missions, the cost increase was unacceptable to NASA Headquarters management. The Office of Earth Science ordered that the VCL mission be terminated. Fortunately, the new project manager's plan was so compelling that the MBLA was continued under an instrument technology development program. As of this writing, a prototype laser completed a year of life testing and the current flight design is meeting VCL requirements. The outstanding VCL science may yet fly on a reconstituted mission.

LESSONS LEARNED

There are a number of lessons learned from the VCL failure. They are valuable to both program/project managers and institutional managers. The first two and most important, regarding the need for rigor in the project proposal and selection processes, have already been recognized and addressed by senior management at the HQ office of Earth Science and the Goddard Space Flight Center.

- A formal process utilizing a team of independent recognized experts for reviewing and approving project proposals is crucial to assure that only viable proposals are submitted.
  - This includes the vetting of significant institutional contributions to a proposal, such as an instrument, when another institution is proposing the project.

  Based on all records and recollections, no such review of the VCL proposal took place either at GSFC or UMCP. While the Earth Sciences Directorate decided that the MBLA technology readiness was questionable, no other independent review of the instrument technology readiness took place at GSFC to advise the Center Director before approving the proposal.

- The project selection process must not stop at the desirability of the science being proposed. It must include the viability of the mission implementation plans as well. Particularly:
  - Key mission enabling technologies must be identified and adequate maturity for flight mission development confirmed.
  - Cost and schedule estimates must be independently confirmed.
  - The proposal must have a primary implementing organization that takes responsibility for the success of the mission, demonstrates its commitment to the project, and has the capability to appropriately support it with facilities, expertise, and upper management intervention, when needed.

  By all accounts, the HQ scientific peer review was very effective. However, the evaluation of the technical, management and cost was only cursory. The selection of VCL was made more on faith than knowledge.

- Managers leading a proposal effort must address the above considerations as part of their proposal preparation process.
  - Challenge technology, cost, and schedule claims.
  - A proposal/project manager cannot be expected to have the knowledge to question instrument experts, but other, independent, experts can be called upon to assess the technical and programmatic claims of an instrument, spacecraft, or other elements of the mission.

  Apparently, such challenges did not take place within the VCL proposal team. As a professional manager, the proposal manager should balance advocacy with a healthy skepticism to help avoid the kind of downstream dislocation and agony that occurred on VCL.

- The project management of a fast-paced low-cost mission requires a strong, yet streamlined, central management structure with short communication paths.
    - The project management team, including systems engineering, must be proactively involved with all elements of the mission development.
    - Collocation of the project team is highly desirable to assure quick, effective communication. At least the core team, including the managers responsible for each of the major project elements, should be co-located. There is an order of magnitude greater interaction, communication, opportunity for understanding, and trust in a collocated team. This allows problems to be identified and solved before they become big deals. It allows for mutual planning and reconsideration on a near real-time basis without the need to call meetings or special telecons. The project manager can keep his finger on the pulse of the project and quickly steer things in the right direction. All of this is particularly important in a project that is highly resource constrained.
    - The PI or designated representative should be collocated with the core team, particularly during formulation, to allow quick decisive science trade-offs with respect to the system design, cost, and schedule. Alternatively, there must be means for regular and effective communication between the PI and the core team.
    - This is especially true if there are a number of different institutions involved in the project.

  This lesson comes from what didn't happen on VCL due to the inexperience of its early project managers. A number of successful small projects have been managed in the manner described above. The management failure on VCL illustrates once again that this is a valid lesson for future small fast-paced projects.

- The management of a fast-paced, low-cost project still requires the project discipline necessary to assure that the project meets its technical and programmatic objectives, e.g.:
    - Systems engineering, product assurance, business management, risk management, scheduling, configuration management
    - These capabilities must be included in the project budget. They cannot be shortcut.

  The VCL team tried to fit the project into a very tight fiscal box. As a result, a number of important project management disciplines, such as those described above, were not implemented effectively. The need to focus funds on the hardware problems coupled with little appreciation for the importance of these disciplines, even on a low-cost project, exacerbated the VCL difficulties. This was particularly true of the attempt to develop the MBLA as a space qualified instrument.

- The above two lessons learned imply that an experienced project manager is highly desirable for any fast-paced low-cost project. This is driven by the need for strong management of highly limited resources and small support staff. Indeed, the PI for VCL identified this as his primary lesson learned.

- Institutions often view small projects as learning experiences for young project managers. This approach can be successful if the project and its manager are located within an office that can provide mentoring and support, such as a program office.

Experienced, capable, project managers are hard to find. Unfortunately, VCL was twice bitten by inexperience in this area. Once an experienced project manager took the helm, VCL was already in a fight for its life. Had an experienced project manager been on board earlier, (s)he may have been able to establish a realistic cost and schedule with which HQ could live that would have given VCL, particularly the MBLA, the funding, effective development team, and more positive political environment needed to succeed.

- Projects involving a U.S. government entity, such as a NASA Center, as a subcontractor to an outside PI must formally document this subcontracting relationship. Otherwise, the project has no basis for overseeing and managing the contribution of the government institution.
  - Although the MOU developed by the ESSP Program Office for the MBLA would not have been a legal document it would have established a written set of ground rules and guidelines between the UMCP and GSFC.
  - Formal documentation is critical to establish the government institution's responsibility to the project. The mission contract should define, and perhaps incorporate, this formal documentation.
  - As with VCL, the program office should play a strong role in establishing these agreements, just as it would for establishing cooperative agreements with a foreign government.

NASA HQ normally views NASA Centers as the responsible parties in the development of space missions. In the PI mode of mission management under which VCL was proposed and selected, the PI bears this responsibility. Any work a NASA Center, such as GSFC, does for the PI is done essentially as a subcontractor. Unfortunately, there is no standard contractual means for documenting this relationship. In a similar situation on the IMAGE project, the Explorer Program mission manager formally accepted the responsibility to manage the GSFC contributions to the mission as part of the Program's contract with the PI. This gave the PI's project manager an on-site management presence and leverage with the organizations within GSFC that were providing elements of the IMAGE mission.

- Independent cost estimates or assessments must be done in conjunction with independent technical and managerial reviews. Cost estimators should attend the technical/managerial review and interact with the independent technical and managerial experts to establish their costing assumptions independently of the project. However, the cost estimators should not report to the review team chairman in order to assure complete independence.

Apparently, the structure of the VCL Confirmation Review process did not provide for the appropriate independence or interaction. That left the GSFC RAO reliant on the project's technical and managerial assumptions, e.g., the MBLA was supposed to be a minor modification of an instrument currently flying on a research aircraft.

GSFC has changed its policy to have the RAO report its findings on cost and schedule directly to the Program Management Council. The RAO maintains its independence by relying on the technical expertise of the Independent Review Team.

VCL Chronology

Date	Event	Est. Launch	Est. Cost
July-96	First ESSP AO issued, AO 96-MPTE-01		
August-96	VCL Step 1 proposal submitted to NASA		
December-96	VCL Step 2 Proposal submitted to NASA - **Project Manager**	January-00	$60M
March-97	VCL selected as the first ESSP mission		
May-97	Definition Phase start		
August-97	VCL notified that the NASA SELVS Pegasus launch service is not available. Directed to maintain dual launch vehicle compatibility.		
October-97	Mission Concept Review		
January-98	Spacecraft and instrument Preliminary Design Reviews		
February-98	Mission Design Review - **Acting Project Manager**		
March-98	Confirmation Review - **Project Manager**	April-00	$60M
April-98	Athena Launch Service approved for VCL	May-00	$63M
May-98	Implementation Phase start		
June-98	Launch Site moved to Kodiak Island, Alaska from VAFB	September-00	$67.5M
August-98	Spacecraft and Instrument Critical Design Reviews		
September-98	Ground and Data System Critical Design Review		
June-99	ESSP Program Review - Mission viability concerns		
July-99	Instrument reliability assessment done by GSFC Engineering Directorate		
November-99	GSFC Tiger Team Review		
December-99	Mission Operations Review		
January-00	Recovery Replan, GSFC takes responsibility for managing the mission - new **Project Manager**		
February-00	GSFC and HQ Replan Reviews	March-01	
March-00	GSFC Peer reviews of Spacecraft		
April-00	GSFC Peer review of Instrument, GSFC Engineering Directorate takes over responsibility for Instrument development		
August-00	Instrument status review and assessment by GSFC and LaRC	May-02	$115M
December-00	GSFC Recommends continued development to HQ Earth Sciences AA	December-02	$140M
December-00	HQ Earth Sciences AA Recommends Termination to NASA PMC - not accepted		
September-01	Spacecraft Level Ambient Test Performance Completed (accepted at OSC)		
October-01	Funding reduced to support instrument technology development only		
June-02	Decision to cease VCL as a mission/continue MBLA and science data analysis		

This case was developed jointly by APPL and the Goddard Systems Management Office for the purpose of discussion and training. It is not a comprehensive account of the VCL project and should not be quoted as such. A more complete story of VCL is available on the APPL website: **www.appl.nasa.gov**

READ THIS CASE AND DISCUSS IN SMALL GROUPS

Lessons in Project Management: The Vegetation Canopy Lidar (VCL)

Thrilling Science

A thrill of excitement rippled through the entire earth science community when the VCL project was announced. Imagine…mapping the vegetation of the entire Earth in three-dimensional detail, including vertical dimensions of forests. Information supplied by the Vegetation Canopy Lidar (VCL) mission would provide a direct way to identify degraded areas, pinpoint areas of regrowth, explain how a forest ages, and monitor important habitat areas.

An AO had been issued for the first Earth System Science Pathfinder (ESSP) spaceflight mission with a launch date of January 2000. In response, the University of Maryland, College Park (UMCP) and GSFC Laboratory for Terrestrial Physics (LTP) offered a joint proposal – the VCL – with split responsibility for its creation. The VCL was to provide five to 10 times more accurate estimates of canopy height, which would be used to estimate total biomass, the major reservoir of carbon in terrestrial ecosystems that can be quickly released by disturbances such as fires or land usage changes. The area of tropical land surface surveyed would increase by more than 200,000 times as the VCL sampled closed-canopy forests from 65 degrees north latitude to 65 degrees south latitude in its two-year lifecycle. In addition, VCL would offer a new measurement of the texture and the aerodynamic properties of Earth's surface, a critical factor in climate modeling and weather prediction.

Ambitious Objectives

In the AO, the VCL collaborative team said they could build the spacecraft within 36 months at a cost of $60 million. With the combination of great science offered at a reasonable price in a quick timeframe, the AO was awarded to the VCL team in March 1997.

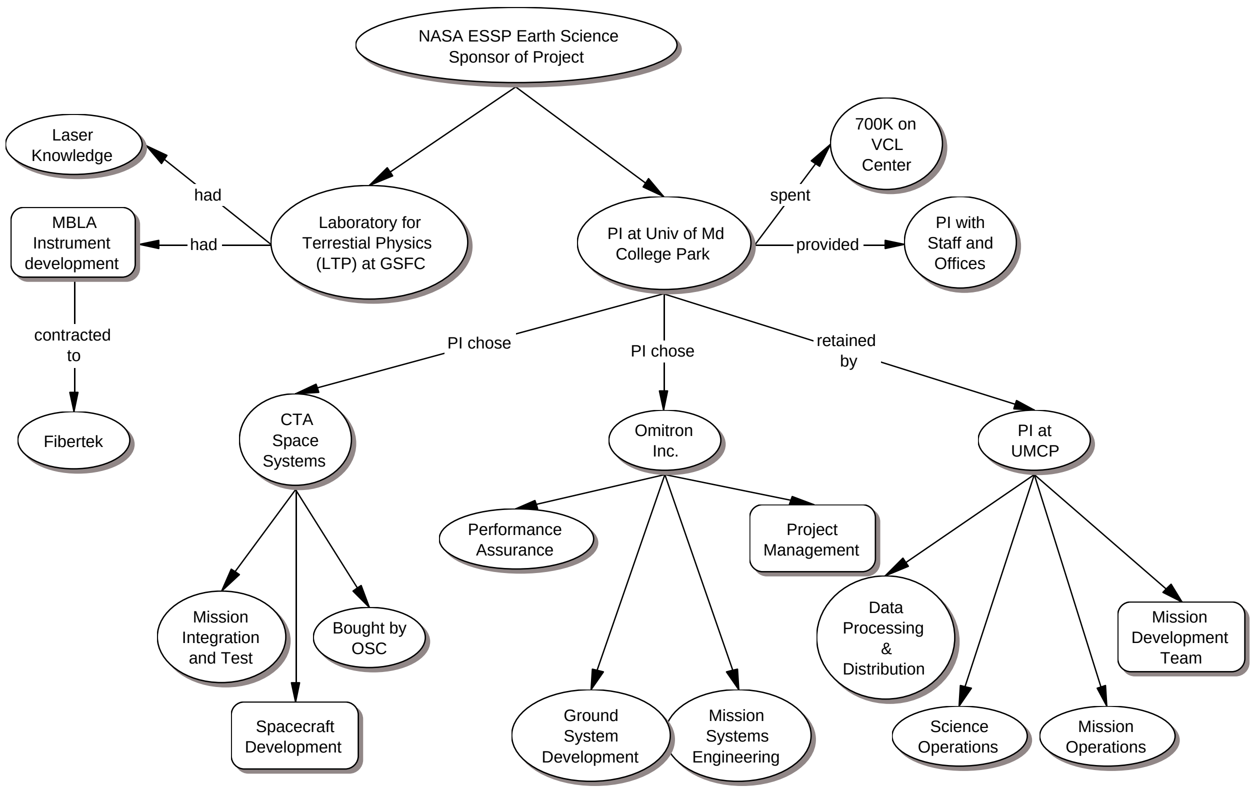
The VCL mission was a category 1 science. The main instrumentation, to be built by LTP, depended on lidar technology. Lidar, or laser altimetry, had been used since the early 1970s. But only in the last decade had technological advances resulted in the development of reliable and accurate spaceborne sensors, including the Mars Observer Laser Altimeter and the Shuttle Laser Altimeter.

VCL's Multi-Beam Laser Altimeter (MBLA) would advance lidar technology by also recording the "waveform" of the returned signal. VCL would be the first multi-beam waveform-recording lidar to fly in space. The VCL was planned to hold five lasers, each sending a beam to cover an area 75 feet across. By spacing the five beams a little over a mile apart, each VCL orbit would sample an area five miles across.

Complex Organization

The work was divided between two main areas: the PI and his team at the University of Maryland (College Park) were responsible for mission operations, science operations, and data processing/distribution; GSFC's LTP was responsible for building the MBLA.

The actual work went several layers deeper. Because UMCP's PI was inexperienced in spaceflight hardware development, he contracted project management to Omitron Inc., which also took on responsibility for mission systems engineering, ground system development, and performance assurance. For the spacecraft development and mission integration and test, the PI selected CTA Space Systems (later bought out by Orbital Sciences Corporation). LTP, in turn, subcontracted Fibertek Inc. to develop the MBLA laser transmitter.



From the start, this multi-layered management system presented a fair measure of confusion. At first, the Center had not even considered this a GFSC project, because the PI was from UMCP and the spacecraft was being built at LTP. VCL and MBLA were virtually invisible to GSFC upper management. In addition, the UMCP team had assumed that the MBLA would be Government Furnished Equipment (GFE), and that GFSC would deliver it. Although GSFC <u>was</u> legally bound to deliver the instrument to UMCP, under the terms of the AO, the LTP was effectively operating as UMCP's subcontractor. Therefore, the MBLA was <u>not</u> GFE under the mission contract between the EESP Program Office and UMCP.

During confirmation, the GSFC Resource Analysis Office reported to the Confirmation Assessment Review team, not GSFC management. This put the RAO in a project advocacy role and their cost analysis relied on the project's favorable assumptions. This led to an estimate close enough to the project's to pass muster. Although pushing for better management, they did not expose the overly optimistic expectations of the instrument technology development. Both HQ selection and confirmation offices relied on the GSFC involvement, and believed it would be significantly greater than just the development of the MBLA by the LTP.

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September ’98	Ground and Data System Critical Design Review		
June ’99	ESSP Program Review – Mission viability concerns		
July ’99	Instrument reliability assessment done by GSFC Engineering Directorate		
November ’99	GSFC Tiger Team Review		
December ’99	Mission Operations Review		
January ’00	GSFC takes responsibility for managing the mission – **P. Sabelhaus, PM**		

A Question of Experience:

UMCP’s PI had no experience in flight system development. The PM named in the proposal had 32 years of experience, but never managed development of a flight mission. Recognizing this weakness, the PI named a new PM. Stronger technically, he lacked project management skills and tried to be both PM and mission systems engineer. His project management experience was with large, high-cost missions with a deep support staff, and he was unsure how to run a fast-paced, streamlined project like this one. Goddard’s Instrument Manager was strong technically, but lacked management skills or experience. The Business Manager at UMCP had never managed finances, procurements, or other business functions for a space flight project, and UMCP had already committed to spending $700,000 on VCL control and data management centers.

To an outside observer, the teams might have had a chance to overcome even these formidable drawbacks given strong leadership. However, there was no unifying institution to recognize, monitor, and address problems. Development was organized into teams rather than through a streamlined central management structure. The PM was in a different location from the PI and the teams for instrument and spacecraft development, and did not insist on locating the core team members at the same place, despite the advice of the Program Office.

Technology Snags

In August 1997, the teams learned that the Pegasus launch service that was to take VCL into space would not be available. They now had to maintain dual launch vehicle capability, which added considerably to the cost of the project. And in June 1998, the launch site was moved from VAFB to Kodiak Island, Alaska.

Then Fibertek, building the laser transmitter, was unable to move beyond a research mode. Its engineers had no background or discipline in building flight hardware, so they were designing by costly trial and error. The Instrument Manager decided to switch his course, and adopted a promising design developed at the American University. The engineers at Fibertek, although frustrated by their failed efforts, resisted building someone else's design. The spacecraft development strategy also dropped behind schedule. The spacecraft contractor was focused on projects that were more important strategically to the company, and had only a lean engineering team and little bench strength to spare for the VCL.

By June 1999, serious mission viability concerns were raised, and an ESSP Program Review was ordered, followed in the next few months by a GSFC Tiger Team Review and a Mission Operations Review.

The Decision Point: Your Assignment

It's January 2000. Goddard has been asked to take direct control of the project. You are requested to assume the task of Project Manager. After completing a thorough reevaluation of the project, you discover that the cost estimate is 150% more than original projections, the schedule will take a year longer than anticipated, and the risk of technology readiness is considerably beyond project expectations. Your recommendation is due to the Program Office in two weeks. What should you do?

1. Discuss these options within your group. List reasons for choosing each option and decide which one you would recommend.
   a) Push back on the team to give you what's doable with the current resources.
   b) Firm up the new estimates, take it to HQ, and request the additional funding to complete the project "the right way."
   c) Terminate the project as undoable as defined and financed.
   d) Something else – be specific.

2. List two or three key questions you would like to ask the Project Manager at this point in the project that would help you make your decision.