For my first co-op term, I worked in the Mechanical Systems Engineering department at Space Systems/Loral (SS/L). A major manufacturer of commercial satellites, SS/L’s customers include both companies that have never bought a satellite before as well as well-established companies such as DirecTV, Dish Network, and Sirius XM Radio. And, from initially understanding the customer’s requirements at the beginning of the process to verifying and validating that they have been met by the finished satellite at the end, Mechanical Systems Engineering is there the whole way.

Most systems engineers are assigned to a specific satellite program and follow it through the entire course. However, as an un-experienced co-op (who would not be there for an entire cycle) I worked mainly on cross-program projects instead. My main project for the semester involved writing a report on the shock environment for our satellites. As they are being launched, shock is transmitted through the satellites from the launch vehicle, mainly during fairing separation. Because of this, we must determine the shock levels at different places on the satellite in order to ensure that components placed there are properly tested and will not fail due to shock. My job was to document our process for doing so as well as to analyze the shock tests that have been performed on various satellites in order to provide evidence for our requirements. During this process, I got the opportunity to speak to a lot of people who had been doing this for years and were extremely knowledgeable about it, which was very interesting. Also, I enjoyed many of
the side-projects that sprouted out of this as I became more knowledgeable about the subject and was able to give meaningful input.

Life outside of work was pretty good as well. The other SS/L co-ops and I had housing provided for us, which was fully furnished and located right off of Castro St., in Mountain View. This area was really nice, with a lot of restaurants, a public library and a huge park all nearby. Although both the Caltrain and a shuttle to SS/L were within walking distance, it was definitely convenient that one of the other co-ops had brought a car. While it was definitely not necessary on a day-to-day basis, the car made things like going to the grocery and weekend trips to San Francisco and Stanford much easier.

Overall, I definitely enjoyed my first co-op term. The work itself was interesting, and I feel like I have learned a lot; not just about the satellite industry, but about engineering in the real world in general.
Co Op Job Summary

As an employee at Space Systems/Loral, I worked as a member of the systems engineering division in the electrical department. I was given in-depth engineering tasks that allowed me to draw from creativity I developed in the classroom as well as explore the technical education available inside the company. In this review, I will address some specific tasks and projects I worked on, assess my own personal learning and development, and evaluate the overall Co-Op experience at Space Systems/Loral.

The systems division at SS/L works to synthesize all parts and subsystems of the spacecraft while being conscientious of the overall program goals and requirements. We apply interdisciplinary technical skills to build a spacecraft system using the building blocks provided by more specialized engineering efforts. As a member of systems electrical, I was able to work on several different tasks so that I could develop a broad understanding of how a satellite works. Specifically, I wrote code to analyze telemetry to identify specific errors during spacecraft testing, designed worse case analysis tools to quantify thermistor telemetry error, and designed a tool to analyze battery discharges during solar array shadowing and station keeping maneuvers. Besides these three major projects, I also worked on smaller tasks such as creating command & compliance scripts to put the spacecraft into launch configuration and assigning interface to instrument wiring configurations. To complete these tasks I needed to become competent in navigating company databases which takes time and effort. I also needed to be very experienced with the capabilities of Microsoft Excel. It was be necessary for me to learn new skills such as programming languages to thoroughly finish tasks that needed to be done. Although new knowledge was expected of me, the demands did not come without sources for success. The systems engineering division has its own “Wikipedia” to reference for design templates, work instructions, and solutions to frequently encountered problems. Along with this knowledge database, tutorials and seminars are also provided to all new hired staff. Finally, all staff that I interacted with showed a vested interest in my own growth as an SS/L employee. Co-workers were quick to help with any free time that they had and were very easy to approach. These resources make it easier to be brought up to speed with the skills and knowledge necessary to work at SS/L.

I am very happy to say that working at SS/L allowed me to draw from almost all of my Cornell technical classes. I was excited to apply my classroom knowledge of everything from numerical integration to circuit analysis while working as a systems engineer. My long term career goals involve tackling the unique engineering problems brought by interaction with the space environment. My Co-Op at SS/L was the perfect job for me to experience that type of engineering in a workplace setting. Apart from learning the technical skills needed for this type of engineering, I also learned how to effectively work as a member of a team and conduct effective communication throughout
the office. I was able to develop my skills of working as an individual as well. The problem solving and information gathering skills I learned allowed me to complete work independently and present the completed work successfully to my coworkers without needing constant instruction. The self directed work style I was able to develop while working at SS/L is something I look forward to applying to future research opportunities back at Cornell.

Overall, my experience at SS/L was a very positive one. SS/L provided housing and transportation to and from work everyday. The coworkers I interacted with were kind, down to earth, and very smart. One of the best parts of the experience is the availability of an enormous amount of satellite engineering knowledge. All employees are able to read operating manuals of all satellites, design specifications, and testing procedures. Personally, I got a great sense of pride that my work was contributing to the engineering efforts at the forefront of human technical achievement.
Space Systems/Loral is based in Palo Alto, California, and is the leading communications satellite manufacturer today. I was assigned to the Payload Systems Engineering department. Everything on the satellite can be put into one of two categories: the part that the customer is paying for (the “Payload”), and the part that supports the payload – everything from the power subsystem to the thrusters to the mechanical design to the solar panels (the “Bus”). Although the bus is more or less the same from satellite to satellite, the payload is always different because it has to be optimized for specific orbital slots, frequency bands, and customer needs. Maybe this is just hindsight bias speaking, but I think it’s more exciting to work in payload.

Work Experience

My first two weeks at Loral were mostly filled with orientation, training, and lots of reading. However, I did get a bit of hands-on learning in my first couple weeks when I helped out with In-Orbit Testing (IOT) on AsiaSat5, a satellite providing coverage in the C (4-6 GHz) and Ku (12-14 GHz) frequency bands over much of Asia. After any satellite is launched, it spends about a month in IOT, a rigorous testing regimen to assure that the rough launch environment has not degraded the performance seen in pre-launch testing. I sat in on mission control a few times, and slowly learned about the components, tests, and parameters integral to the payload.

After AsiaSat5 IOT, I was assigned to Telstar-14R, which I worked on for the rest of the term. Telstar-14R will provide Ku-band coverage to much of the US, South America, and even to a small base in Antarctica. The main use will be for digital video, like DirecTV. The unique aspect of this satellite was that the customer wanted it in two years, not the usual three. I worked on the program from month 4 to month 8.

Payload design is an iterative process: Make a sketch of the design, do some back-of-the-napkin calculations, see where your design falls short, and improve it. Repeat. I was greatly involved with the higher level iterations of the design. I took the old calculations (we call them budgets), and made them more complex, analyzing out certain assumptions, and considering effects that were too detailed for the first few iterations. This then fueled changes in the design, which fed into a whole new set of budgets. I spent a lot of time creating excel spreadsheets so that the budgets would be automatically updated after a design change. This served well as a design tool, because we could make trial changes to the design and see the impact on performance in real time. It also served as a tool for deriving testing predicts, which are a type of a sanity check (If your test produces a value that is way off from the predict, this could be an indication that something is wrong). During this time, I gained invaluable experience with Excel and VBA.

Because this was such a rushed program, there was a big push from the big-wigs to reduce testing time. Testing happens at every stage throughout the build process: from component level to subsystem level to spacecraft level. Subsystem and spacecraft level testing will not happen until mid-to-late 2010 (We are only just beginning to manufacture components), but I was involved with developing
a detailed test plan as early as October 2009. Our gain and frequency response tests are particularly lengthy, and are done at almost every test phase, so I gave special attention to cutting out as many of these tests as possible. Of course, we couldn’t just ignore a test. These tests produce data that the customer requires us to show. For every test we cut, we must be able to reasonably use other test data to come up with an analytical value for the skipped test. I developed the test plan for gain and frequency response, along with a tool that automates the analysis for skipped tests. I saved approximately 60 hours of testing time over the standard, full test plan.

For the majority of my time working on Telstar-14R, there were 2-3 other payload engineers and a payload manager also working on it. However, in early November, a couple other programs got started, so people got pulled off of T14R. Soon it was only me and one other payload engineer under the payload manager. A couple weeks later, the payload manager had to leave for a few weeks! Needless to say, we had a lot on our plate. Nevertheless, it was very rewarding to be given such responsibility. I was often the first point of contact for many of the other departments with questions about the T14R payload.

I must admit, before I started working, I had low expectations for how much I could apply what I learned in the classroom. However, I was pleasantly surprised. Even though I would classify 90% of what I did as applications of critical thinking and common sense, a lot of this reasoning was on top of a baseline understanding of the theories and principles at work, a baseline understanding I would not have had without the classroom. The class that has helped me the most for this job is ECE 3030 – Electromagnetic Fields and Waves. Any systems or RF design class would also have been helpful.

I loved working in Payload Systems, and plan to continue working part time from Ithaca next semester. This experience gave me valuable insight into the real world of engineering and of the corporate world in general. I feel like I was given just the right amount of responsibility and was able to become somewhat of an expert in certain areas, albeit very narrow areas. To anyone interested in communications systems, the aerospace industry, or just living on the west coast for a while, I would highly recommend a co-op at Space Systems/Loral.

Outside of Work

Palo Alto is in Silicon Valley, about a half hour southeast of San Francisco. There is no lack of things to do in the bay area. There were four of us co-ops at Loral, so we often played basketball or football. I also went on a number of hikes around the area. I saw the 329-foot tall redwood in the Big Basin, climbed 1200 feet to the top of a mountain, hiked 8 miles to a hidden waterfall onto a beach, and saw spectacular views of the Pacific, Big Basin, and Monterey Bay from Castle Rock. A few other fun day-trips were to the Santa Cruz boardwalk and the world famous Lick Observatory (known for the development of adaptive optics). We ventured into San Francisco a couple times to visit Fisherman’s Wharf, the California Academy of Sciences, and of course the Golden Gate Bridge.

While having a car for work isn’t absolutely necessary (though it is more convenient than taking the shuttle), I found that having a car for other excursions is undeniably worth it and highly recommended. Even though the drive is long, there are plenty of American “must-sees” along the way, and it makes for a great vacation (especially since gas and hotels are covered!). As far as housing, Loral set us up in a beautiful apartment complex in Mountain View, only ten minutes from work.
Co-op Job Summary
Jim McMullen
NetID: jam588
Major: Mechanical Engineering
Employer: Space Systems / Loral
Term: Fall 2009

A. Co-op Work Assignment

I was assigned to work in Mainbody Structure Design, a department that designs a significant amount of the structural components for every satellite program. The structure design of the satellite is one of the first stages in the development of a new satellite, creating a backbone for all other departments to add their components to. Structural design works very closely with the company’s structure manufacturing and structural analysis groups to ensure that all structural components meet cost, schedule, and operational requirements. Since the structure of a satellite has to be designed very early in a program, locations of essential non-structural components that need support structures are estimated elsewhere in the company and relayed to us as design requirements.

Training was provided to me in the form of department-specific work instructions, online training programs, and friendly employees willing to answer my questions. The company also sponsors new-hire seminars open to new employees where you can learn what roles different departments have in the company.

As a part of structures design, I was involved with projects that were designed to facilitate communication between us and other parts of the company to improve the design and manufacturing process for future satellite programs. My first project was to expand a tool used to estimate the structural mass of a satellite so that structural design stayed within its allocated mass budget and so that systems engineering would know if their initial mass budget estimates for the structure were inaccurate.

I also worked with an experienced engineer to create a generic product structure, which is used to organize the design and assembly of a satellite’s physical structure. Historically, the product structures of different satellite programs are very similar, so we were tasked with forming a generic product structure as a template for future programs in the hopes of reducing the time and cost it takes to generate a new program. Working with an experienced engineer who knew the best ways to work with other parts of the company made this project go very smoothly and was a much more valuable experience overall than if I had been working on smaller projects by myself.

B. Assessment of Learning and Development

Going into this position, I wasn’t sure what my career interests were. The co-op didn’t help me nail down any one career path, but working in an engineering company gave me a much better idea of what my options are and where mechanical engineers fit into a company. I also realized that there is much more to working in a company than what you learn in school. If you don’t understand how different groups in the company relate to each other it is hard to accomplish anything, especially in a company that works with large and complex projects. Finally, I learned how important it is to get along with the people who you work with. It makes work much more enjoyable and also makes you more productive.
My role related to some Cornell class work, mainly MAE 2250: Mechanical Synthesis. This class showed me first-hand all of the difficulties of creating a product line from the initial design all the way to manufacturing and assembly. My department at SS/L was one small part of a huge product line, so working here showed me how a company can overcome some of these difficulties, such as staying on schedule, managing cost, and communicating information between different groups of people. The projects I worked on were created to improve the design and manufacturing process, and even in a professional company there are still hundreds of improvements to be made. Learning some of the ways that companies can improve, especially companies based on a product line, is a highly transferable skill which will be valuable in my career development.

C. Life Outside of Co-op

Housing in Mountainview was provided to us by SS/L, about 10 minutes from work by car. One of the Cornell co-op’s drove to California for the work term, so we used his car for most of our transportation needs. The company also provided a free shuttle service between SS/L’s campus and the Mountainview Caltrain station within walking distance of our apartment. Although I didn’t use public transportation much, it appeared as though you could easily get to Wal-Mart and other stores using public buses. Getting to San Francisco is easy using Caltrain, although once there you need to rely on other public transportation to get around the city.

Our apartments were right next to downtown Mountainview, which has a ton of restaurants and shops to check out. Our weekend excursions included frisbee golfing near San Jose, visiting Fisherman’s Wharf, the Golden Gate Bridge, and the Academy of Sciences Museum in San Francisco, and going to Stanford to see football games.
A. Co-op Work Assignment

I worked at Space Systems / Loral in the Mainbody Structure Design Group. My group worked closely with the other structure design, analysis, and manufacturing groups to make sure that composite satellite structures were built and delivered to the next manufacturing group on schedule.

My main project was to develop and test a new manufacturing process for electrically grounding metal brackets for charge-bleed off purposes in space. This involved talking to project ‘stakeholders’ in different areas of the company, defining charge-bleed off requirements, developing new manufacturing processes, manufacturing a test coupon, and putting the coupon through tests to determine how well the new processes would perform in space.

A side-project given to me was to design and build a scale-model of a typical satellite structure to be used as a design tool. The model featured interchangeable parts and acted as a platform for people to express their ideas to others without using computer graphics. Using pre-made structures, designers can also express some ideas more quickly than modeling their ideas in CAD.

For both of these projects, I had a mentor to help point me in the right directions and make sure I was on schedule to complete the projects before the end of the summer term.

B. Assessment of Learning and Development

The biggest change from school has been learning how to work in a much more specialized environment. School offers a little bit of background about many different fields, and you become used to working with many different topics at once. At work, however, your project may only involve the skills you learned from one class, but those skills become extremely important. School has trained me to become interested in a lot of different things, but it hasn’t helped me nail down what career path I want to take. Co-op has shown me a lot of potential career paths, but there are still many more to choose from. I never expected to know all of my career preferences after doing 28 weeks of co-op work.

Most of what I’ve learned from work has not been technical knowledge, but an understanding of some of the challenges engineering companies face on a daily basis. Keeping on schedule is the ultimate goal for every company, but it’s been very interesting to see how SS/L manages its schedules while still maintaining very high standards in workmanship (extremely necessary for the satellite industry, where you can’t go up and fix anything in space).

Co-op has also taught me that the answers to my questions aren’t always in my department, and talking to people in different parts of the company can give you ideas that you never would have thought of otherwise. Working on a multi-disciplinary project has proved to me that cross-department communication is necessary to find the most efficient ways of doing business.

C. Life Out-side of Co-op

We were fortunate enough to have been given housing through the company in Mountain View, CA. Another co-op had a car, so we used that to carpool to work and explore the area. When the car wasn’t available, the company provided a shuttle service
from the train station close-by, and other public transportation in the area was easily accessible (see Valley Transportation Authority).

I lived with 3 other Cornell co-ops, and we generally spent most of our time outside of work together in some combination. Since a lot of interns were in the bay area for the summer, we were able to meet up with friends who worked for other companies. I also had some family out here that I visited frequently.

D. Evaluation

The best aspect of this job was how much freedom I was given to develop my projects and how helpful everyone was when I did seek out feedback. I worked on my projects with a mentor, but everyone else I met who weren’t specifically assigned to help me were still able to take time to give me valuable help and feedback. I could not have completed my projects without this kind of atmosphere.

Overall, I don’t have any serious complaints about the work environment here. It’s a little disconcerting to come right out of school into a highly specialized work group, whose main functions could be summarized in one college class. However, this seems to be how most engineering jobs are, and there are also benefits to having a lot of depth in your field if you’ve found one that you enjoy.
For my second co-op term, I continued my work in the Mechanical Systems Engineering Department at Space Systems/Loral (SS/L). Overall, it was a smooth transition back, and I picked up right where I had left off at the end of my first term.

One of the larger projects I was assigned was to create tools to aid in unit shock evaluation. There are several events during spacecraft life that induce high levels of shock on the components of a satellite, and thus a given unit must be tested to ensure that it is qualified to meet the shock levels in the location that it will be placed. However, these tests normally do not directly replicate the expect shock for the unit, so a Mechanical Systems engineer must analyze the results to determine if the unit passed or not. Since there are many satellite locations and thus shock levels where a unit might be placed, this can be a cumbersome process. To make it easier, I built several tools and user interfaces in MATLAB that enable the user to quickly learn if a set of test data for a given unit meets our requirements for a given specification or satellite location.

Of course, the shock specifications for different satellite locations have to come from somewhere, and that is where another large project that I worked on came in. Many tests have been performed by SS/L to simulate the response at different locations to a given shock input. Organizing the results from these tests and analyzing them is complicated, so I created a program to simplify this process and allow easy integration of data from any new tests that we might perform. Furthermore, I wrote a memo that documented SS/L’s process for deriving shock requirements from these tests.

Another large project I worked on was coordinating deployment testing for Intelsat 17. In this test, small, focused explosives are fired to release stowed reflectors and solar arrays. Since a significant amount of shock is produced by these firings, accelerometers are placed in strategic locations across the satellite and the responses measured. Since it is in the interest of the company to know as much as possible about the shock response at a given location, it was my job to coordinate with the Dynamic Test Operations Department to ensure that the necessary data was gathered in a useful format. Part of this project involved writing MATLAB code to process the accelerometer data and automatically create the relevant plots.

Besides the fact that it slipped by far too quickly, it was really nice to be able to jump right back in to work. I also really appreciated being able to focus in on one area and become something of an expert in it, as it allowed me to be more confident in making suggestions and bringing up potential problems. It really felt like I learned a lot about being an engineer and I have to say that my second co-op term at SS/L was an overwhelming success.
Space Systems/Loral is the world leader in the high-power communication satellite industry. I work in the Payload Systems Engineering Department. This means that I work on the communications system, which is what the customer pays for. The communications payload includes the antennas, amplifiers, frequency converters, filters, switches, coax, waveguide, and other various components that comprise the signal path from receive to transmit. This signal could be internet traffic, video, HDTV (e.g. DirecTV), satellite radio (e.g. Sirius/XM), or even new satellite cell phone traffic.

**Work Experience**

After my first term working on the team for the Telstar 14R payload, I was asked to work part time from school. I was to help develop a new initiative in the department – the Active Block Diagram Tool. The Active Block Diagram Tool (ABDT) aims to replace AutoCAD as a drafting tool. Instead of investing in a tool such as Visio or something more complicated like Matlab’s simulation tools, we wanted to create this tool in-house so that we have close control of the features and support. I worked 7 hours a week in the spring semester, and have continued on this project full time since my return to the Loral campus in June.

To give a little background, a block diagram of a payload is the defining document for that payload. Some are as large as 40 pages and have as many as 10,000 components. The end product of drawing a block diagram in AutoCAD is essentially no different than drawing it in MS Paint – it is just a picture. As such, a Payload Engineer often spends many weeks building custom analysis tools in Excel tailored to a specific payload. This usually involves a large amount of tedious and error-prone data entry straight from the block diagram. Since the ABDT is “smart” enough to understand connectivity and can contain the data associated with all the components, we can write software to automate these analyses.

I am involved very heavily with writing such software. This is an exciting and apt project for me, since almost everything I learned in my first term is directly applicable. Last fall on Telstar 14R, I spent over a month developing the previously mentioned custom analysis tool in Excel, so I had good experience. To be clear, I am not involved with the low-level programming of the tool – that is left to the software experts on our team that are writing the Java source code that controls the user interface, the drawing canvas, and many other details. Rather, I am writing the higher-level Python libraries and scripts that automate many of the analyses that Payload Engineers routinely perform. However, I feel as if my job is not rote programming. I am very much involved with deciding what the tool should do and how it will be used. I spend a significant amount of time brainstorming and talking with other engineers about the future of the tool. It is often the case that sitting down and writing the code is the easy part.

The core ABDT team includes 2 other engineers from Payload, but they are in management roles and are very busy with other assignments. I am the only one actually writing code, but they act as an invaluable resource for the historical, technical, and company-specific knowledge that is needed to do my job. They also help tremendously with brainstorming during the times we meet once or twice a week.
Towards the end of the summer, the tool was starting to reach a stage where it was ready for a first release. As it stands right now, we expect that if the block diagrams for a satellite are drawn in this tool from the very beginning, we could save up to two man-months of work per satellite. However, once we roll out the first release, we can turn our attention to automating many of the other tasks that were impossible to automate with a “dead” block diagram, and we could save even more time. The possibilities are endless. Before we get ahead of ourselves though, we have to focus on the first release.

At the end of the summer I gave a series of presentations on this first step. The first couple presentations were to the department management. These went very well, and the Executive Director of Comm Systems even wanted to schedule a demonstration for the Vice President! During my last week, I gave this presentation, which was so successful that we have been given more money for development. I also gave a demonstration and status update for the entire Communication Systems directorate. About 40 employees showed up to this meeting and gave some useful feedback. Finally, management decided that I should give a series of tutorials on the tool and how to write scripts for it. During my last week, I taught this class, which met an hour a day every day.

Even though the majority of my time is spent on the ABDT, I have spent approximately 10% of my time on other tasks. I supported the AsiaSat 7 testing effort for a few weeks. This mostly involved reviewing and signing off on data packages, but I was able to spend a bit of time on the assembly and test floor, which is always cool. My other tasks were mostly menial oddjobs that I suspect were given to me because I have some experience with automating such tasks in Excel, and of course, because I am the intern.

I am very pleased with the freedom and responsibility I am given at Loral. Perhaps it is the fact that it is my second term, but I appreciate the fact that as a college student I am given as much respect as a full-time engineer. By this point I am making many of my own decisions, and even have a couple people to whom I am giving tasks. I look forward to once again working part-time for Loral during the upcoming fall semester, though I have cut my hours down to only four per week. This will allow me to remain available for consulting and will ease the transition to the next step for the tool, which is getting more people involved with writing scripts.

Loral has a unique seminar series called New Hire Seminars. Any employee hired within the last two years can attend these seminars, which generally run on 6 month cycles. There is usually one seminar for each department in Loral, and the presenters are usually the directors of the departments. I really enjoyed these seminars since they tend remove you from your “bubble” and reveal what is really going on in the company. Since there are so many specialized aspects involved with designing and manufacturing a satellite, this insight is rare.

Outside of Work

Loral is located in Palo Alto, California, about 40 minutes south of San Francisco in what is known as Silicon Valley. Loral provided excellent housing for us co-ops in nearby Mountain View. Even though I drove from Cornell and therefore had my car, I often chose to bike to work which only took about 25 minutes. There is plenty to do in the Bay Area. We went disc golfing, drove to Santa Cruz for the beach, and went hiking and biking in the Redwood forests and on Pacific coast ridge trails. I even made a trip to the Sierra Nevadas in western California to go white water rafting. Once a week, I played in the Loral softball league. Overall, this area is a great place to live and I highly recommend it.