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The Cooperative Satellite Learning Project (CSLP) in the Classroom

Volume I: Program Guide

Submitted

by

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March 1999

[NASA Logo] [Allied Signal Logo]

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The Cooperative Satellite Learning Project represents an educational partnership between the National Aeronautics and Space Administration (NASA), AlliedSignal Technical Services Corporation (ATSC), and schools nationwide. The program encourages students of all ages and from all backgrounds to consider engineering, math, and science careers through early hands-on involvement in NASA scientific satellite missions, and it engages students with other proclivities in the knowledge and skill building processes associated with global pioneering in space science and technology.

A version of this program guide is available online at the CSLP home page:

http://joy.gsfc.nasa.gov/CSLP/home.html

Acknowledgments

With the possible exception of serendipitous events, nothing having to do with space science and technology comes about through magic—even the magic of new ideas and new relationships comes about through the directed efforts and involvement of specific people. This section acknowledges the contribution of the dozens of key managers, volunteers, and teachers whose combined efforts have so far produced a successful Cooperative Satellite Learning Project (CSLP) program.

Through years of volunteer effort, AlliedSignal Technical Services Corporation's former Flight Operations Department manager Michael Fatig founded and operationalized the Cooperative Satellite Learning Project (CSLP). The program's first funded director was Michael Rice. In addition to many other strong supporters, key corporate officials, and local leaders, those most responsible for enabling the CSLP implementation process include key program volunteers Paul Klink (ATSC), Kevin Griffin (ATSC), and Larry Hillard (NASA), project managers Jim Watzin, John Catena, and Dick Tagler, and ATSC program management official, Ivan Stern.

Even with the advent of funding, programs like CSLP require the support of numerous volunteers. Of the many hundreds who have worked with CSLP, at least a dozen qualify as "heavy volunteers": Jerri Brown, Leslie Cusick, Bob Chapman, Gerry Daelemans, Jeff Devine, Matt Fatig, Leo McConville, Asma Malik (Ms. Malik started with the program in high school and returned to it as a volunteer through several college summers), Mike Miglin, Pati Peskett, Jody Rawley, David Spergel, and Jeff Volosin.

The briefest list of pioneering CSLP teachers would include Wayne Aring, Tom Bevilacqua, Dan Caron, Lynn Harden, Jim Konnie, Carol Miglin, CJ Rodkey, Bryon Stoll, Ginger Sutula, and David Taylor.

As much as I would like to claim complete responsibility for the development of this program guide, its magic too must be shared with contributing authors Carol Miglin and Asma Malik. Ms. Miglin teaches science courses at Old Bridge High School, Old Bridge, New Jersey, and Ms. Malik, a graduate of the program, as mentioned above, has been a tireless CSLP volunteer and a constant source of observation and insight with regard to its efficacy. In addition, expert editorial guidance and numerous revisions were applied by editor and writer J. S. Oppenheim and The Communicating Arts Agency in Laurel, Maryland.

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Introduction

The Cooperative Satellite Learning Project (CSLP), an educational partnership between NASA's Goddard Space Flight Center (NASA/GSFC) and AlliedSignal Technical Services Corporation (ATSC), encourages students of all ages and backgrounds to consider careers in engineering, math, and science through hands-on involvement in NASA scientific satellite missions, and it engages students with other proclivities in the knowledge and skill building processes associated with the team-based corporate working methods that propel global pioneering in space science and technology.

The vision of CSLP's primary partners responds to the nation's *America 2000 Program* and anticipated workforce needs in a globally competitive and high tech economic environment. CSLP has been designed to foster team communications, planning, and technical skills and to promote science literacy as well as competence in knowledge and skill areas across the curriculum.

Three principles drive CSLP's approach:

$ Motivate learning through hands-on involvement and partnership in NASA satellite missions, e.g., have students process satellite data on computers, build mockups of satellites, and participate directly with mission partners in government and industry;

$ Motivate students by encouraging team contributions to and ownership of specific CSLP program implementations;

$ Motivate through team-based community outreach—i.e., through student development of program activities and presentations designed to inform the public and teach other students about space science missions and programs.

CSLP started out as a partnership between ATSC, NASA/GSFC, and several high schools. Through these partnerships, students were presented with opportunities to participate in scientific missions. The result: having students directly involved in scientific and engineering missions enhanced learning and promoted a high level of enthusiasm and motivation. Moreover, teaching proved an effective learning tool for students. It encouraged creativity in the development of presentations, and it required students to develop a high level of attention and focus on the materials they assembled while teaching themselves about the subject matter.

This program guide has been written for those wishing to develop similar educational programs. It presents CSLP philosophy and acquired wisdom as well as some of the methods used so far to inspire students and grow their skills in participatory team-based project development, management, operation, and review, the essential building blocks of 21st Century careers in virtually every field. Toward that end, this guide covers the following:

$ Potential classroom activities and CSLP program elements;
$ Student development and responsibility for program projects.

In addition, CSLP helps initiate and nurture partnerships between schools nationwide and the nation's space science program. Within the context of these partnerships, the creativity of classroom instructors and program volunteers have led to scores of innovative activities that encourage science literacy, promote teamwork toward desirable goals and objectives, produce community-wide awareness of institutional and student achievement, and, most importantly, motivate and support students as they move along their uniquely evolving career paths. The simple truth is there are as many activities for students to do as there are students participating in the program.

What is possible in a CSLP program? Here are a few examples:

Hands-On Activities

Through hands-on activities, students have the opportunity to participate and become actively involved with science and engineering issues and processes.

> ***Data Analysis:*** As a CSLP volunteer, the principal investigator for the Submillimeter Wave Astronomy Satellite (SWAS), Dr. Rene Plume, developed an astronomy package for students and made preliminary science data available on the world wide web for student use. The radiation observed by SWAS instruments, the first of their kind for the target frequency, is a kind absorbed by earth's atmosphere and detectable only in space. CSLP students who have involved themselves with the SWAS mission participate first-hand in the examination of satellite data, which Dr. Plume has made available to them in concert with distribution to the international professional space science community. The buy-in for students is more respectful than precocious, and CSLP knows of no other opportunity like it for high school students anywhere else in the world.
>
> ***Weather Stations:*** AlliedSignal's Matt Fatig, Sr., a systems analyst specializing in human-computer reengineering, took personal interests in meteorology and World

Wide Web weather reporting and turned them into a weather analysis and prediction program for students at Laurel High School in Laurel, Maryland. Students now collect satellite images and weather data to produce their own systematic predictions about the weather—on the way, they've had to learn about natural earth processes and scientific approaches to predicting natural phenomenon.

Research

Research provides students with opportunities to manage projects from their conception and to participate in every phase of project implementation, presentation, and review.

> ***NASA History Office:*** The NASA History Office recently worked with students from South Fayette High School, South Fayette Township District, McDonald, Pennsylvania, to convert several space history books to HTML (the HyperText Markup Language, which is used to present documents on the World Wide Web) for the NASA History Office homepage. In a similar vein, students at Keystone Oaks High School in Pittsburgh, Pennsylvania are using multimedia techniques to present history data while students at Old Bridge High School, Old Bridge, New Jersey, are engaged in project research for the office.

Outreach

Outreach turns students into teachers. Such activities motivate students by making them responsible for educational programs involving other students and the community at large. Here are several examples of student-designed CSLP outreach programs:

> ***Teaching Orbital Dynamics:*** When students at Old Bridge High School in Old Bridge, New Jersey were challenged with teaching Orbital Dynamics to children at a local elementary school, they drew on their own creativity. They built an obstacle course in the cafeteria to represent the solar system and contain the various forces of the universe. One by one, each elementary student pretended to be a satellite on a mission through the solar system to a rendezvous at the other end of the cafeteria. With the lives of satellites no less exposed to friendly forces and hazards than those of children, the Old Bridge High School students, pretending to be the various phenomenon encountered by satellites, held their pupils' hands and swung them around for gravity assists, pushed them along to represent solar pressure, and demonstrated escape velocity by having them run in circles until they were fast enough to escape their grasp. Results—the Old Bridge High School students had to study orbital dynamics in depth to design their

program, and the elementary students who went through it will never forget what orbital dynamics are about!

News Conferences: Students at several high schools in Maryland and Pennsylvania have held press conferences supporting the launch of satellites put in space as part of what is known as NASA's "small explorer series." They have created satellite models and displays, put together press kits, produced presentations, and held briefings. Because such time-sensitive approaches coincide with the roll out of NASA mission schedules, students find them naturally engaging and exciting.

Home Pages: Students at Woodlawn High School in Baltimore, Maryland are developing a series of home pages for the World Wide Web using the medium's scripting tool set, the HyperText Markup Language (HTML). Their subject: the Solar Anomalous and Magnetospheric Particle Explorer. The main page contains a picture of the satellite. By clicking on any one of the sub-system components, a browser may link to additional information about that system. To support learning about the satellite, NASA donated to the school its SAMPEX engineering test unit, which is identical to the satellite but built to test all of the subsystems and not space qualified.

Communication Activities

Newsletters: To inform schools and communities about CSLP activities, many groups produce newsletters reporting on their projects. The communication itself requires basic business, computing, writing, and publishing skills

CSLP Video Project: Students from several mid-Atlantic schools have visited the Goddard Space Flight Center to script, story board, film, create animation, and assist with the off-line editing of a CSLP pilot video. They directed, worked lights, and provided on-camera talent, an experience in industrial and educational film production none will soon forget. Such projects enjoy a continuing life in the lives of other students, and students who work on them know they're producing something for those following in their footsteps. As with other outreach and presentation activities, student involvement and motivation rises with the knowledge of the impact their hands-on efforts will have on the immediate success of the project *with others* as well as its value as an element in the CSLP legacy.

Mission Statement

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The Cooperative Satellite Learning Project (CSLP) will encourage all students to consider careers in science and technology fields, to become literate with regard to space science, and to prepare for 21st Century careers through hands-on, team-based involvement in NASA science missions.

Goals:

1. CSLP will provide students with opportunities to become involved with NASA space science missions.

2. CSLP will support learning through outreach projects where students learn by teaching.

3. CSLP will use new technologies to promote education and develop in students new technical skills.

4. CSLP will encourage the development of partnerships with businesses, educational institutions, students, and the community at large.

5. CSLP will prepare students for the future work force by developing the skills required for professional careers.

6. CSLP will support local, state, and national efforts to reform science, mathematics, and technology education.

7. CSLP will encourage community involvement in education through the distribution and presentation of information about space science.

8. CSLP will provide teachers with resources for developing space science education programs and partnerships.

9. CSLP will provide the science community with resources for developing space science outreach programs and partnerships.

Chapter 1

Overview

The Program

In order for this nation to compete in a complex systems-oriented business world, all students need to achieve math and science literacy and to develop strong work skills. The Cooperative Satellite Learning Project (CSLP) prepares students for entry into the work force by building through hands-on involvement in NASA space science missions the team-based project development, management, performance, and review skills expected to prove pivotal in the 21st Century. As a reform initiative in education, CSLP has proven successful through six years of pilot program development, implementation, and review.

CSLP program participants, partners, and sponsors include the following:

- Core Group Students—special classes drawn from grades 9 through 12.
- Core Group Teachers
- Principal School Student Population
- Cooperating Community Businesses and Volunteers
- Surrounding School Populations
- The Community at Large
- AlliedSignal Technical Services Corporation (ATSC)
- NASA Goddard Space Flight Center (NASA/GSFC)

CSLP partners—NASA/GSFC and ATSC—provide project planning, management, technical training, materials, and guidance to Student Core Groups, which in turn promote through school and community outreach their interests in science and technology fields in general and space science in particular.

CSLP programs produce win-win relationships between all of their participants. Government and industry together provide schools with career mentors, role models, and resources, and motivated students often inspire in adult volunteers renewed enthusiasm for their own professional crafts and interests.

CSLP goals include the following:

- Encourage the development of skills that contribute to the preparation of students for life challenges and professional careers;

- Develop partnerships between industry, government, and schools;
- Improve community-wide scientific literacy.

When technology is incorporated into learning it can teacher effectiveness and student understanding. The CSLP uses hands-on and outreach activities to motivate students. Below are four elements that make up CSLP programs:

- Group projects;
- Special projects with partners;
- Technical programs;
- School to work transition programs.

Group Projects

In all CSLP programs, students develop ownership of the educational experience through team planning, hands-on participation in NASA science missions, and community outreach projects (Appendix D contains a menu of projects students in past programs have used—many of them were developed by the students themselves).

Special Projects

Students with special projects work directly with CSLP partners. For example, students at Laurel and South Fayette High Schools (Laurel, Maryland and McDonald, Pennsylvania respectively) developed lab view software programs to monitor data for NASA's Small Explorer (SMEX) flight operations team. Because special projects require one on one relationships with partners, they are often difficult to duplicate (other special projects are noted in Appendix E).

Technical Programs

Technical programs build strong organizational and technical skills in students. They provide functional overviews of end-to-end systems and processes associated with successful space missions. Several CSLP programs involve business and university volunteers who visit the partnering school and provide presentations on one technical aspect or another of a live NASA mission. Finally, all CSLP technical programs are unique in that they match student initiatives and interests with CSLP resources and volunteers. No combination is ever alike.

In addition to volunteer experts, who may not always be available, CSLP programs enjoy outstanding information resources through the CSLP office, NASA, and the Internet.

Note: although space science and engineering have proven interesting to many students, the CSLP format may at the requests of students and teachers be expanded into other fields where there are prospects for continuing strong partnerships with government and industry. AlliedSignal, for example, has considered expanding the program to the automotive areas of the company. The model could as easily produce project partnerships with the banking, information technology, or other key U.S. industries.

School to Work Transitions

CSLP programs prepare students for professional careers. They provide an introduction to group communication and leadership skills, team management and planning techniqueas well as such concepts as the continuous improvement process promoted by Total Quality Management standards.

In science and technology in general, educational partnerships improve educational quality by involving the whole community in the teaching process. They produce opportunities for students to interact with practicing professionals, to obtain hands-on experiences otherwise unavailable in the classroom, and to develop the habits and want of habits that accompany life-long learning. For CSLP, NASA/GSFC has contributed significant talent and time to the program's success. In addition to funding and volunteers, NASA has provided access to a substantial volume of space science publications and other sources of information, and it has produced a number of teacher resources centers as well as traveling exhibits in support of CSLP programs. AlliedSignal Technical Services Corporation (ATSC) and its employees have similarly provided substantial funded and volunteer hours as well as program supporting hardware and software.

Student Core Groups

Student Core Groups (SCG's) provide the focus for CSLP programs. They may either represent the participants in a "full up" class within a dedicated curriculum program or a collection of enthusiasts in an extracurricular activity. Whether the SCG meets during or after school, its hands-on and outreach activities ensure a high level of engagement and learning with regard to the key objectives of the CSLP program (e.g., encouragement along associated career paths, for the learning of team-based management skills, improvements in science literacy, etc.). Benefits to schools include improved student motivation and teacher morale, career enhancement for math, science, and otherwise technically minded students, workplace experience for all participating students, and improved science literacy for the school body at large. Benefits to business and the community include deeper involvement in the American space program as well as an improved graduating workforce, the effects of which tell over time in the siting of new businesses and overall local economic development.

Note: Although CSLP began with industry and government partnerships, school systems that do not have convenient or immediate access to partners may still participate by choosing to develop projects that can be launched without established partner relations. Both the information resources supported by NASA/GSFC and ATSC as well as available technology may be obtained by interested parties throughout the United States.

CSLP Program Development

Cooperative Satellite Learning Project (CSLP) programs may be developed in many ways. Students and teachers take the lead in choosing which NASA science projects they would like to involved, the level-of-effort they wish to apply to that involvement, and the affordability of equipment or other costs associated with project concepts. The first nine CSLP programs were in fact developed one small step at a time, starting either as afternoon space science clubs or as small units within existing science classes. They were also established by AlliedSignal and NASA volunteers, and only relatively recently has CSLP become a funded program contributing to dedicated and equipped CSLP-based courses. Today, of course, schools may plan for the implementation of a full-up CSLP program from the start, but that potential represents just one possibility along a spectrum of interest that still begins with student curiosity and enthusiasm at much less invasive levels.

Chapter Seven of this guide covers procedures for developing a CSLP program. Selecting an approach as well as a level of commitment and effort come first: everything else—equipment costs and funding, professional volunteer participation, etc.—follows from those key variables.

Outcomes

As noted, CSLP provides students with competitive and relevant career and life-long learning skills. Its intended outcomes for students include the following:

- Improved basic computer, telecommunications, and science literacy;
- Improved experience and information for making career choices;
- Improved craft and general employment skills for the next century;
- Improved project development, management, planning, and review skills;
- Improved empowerment and personal responsibility for applying acquired

knowledge and skills to career and personal challenges.

Facilities

Several schools have developed CSLP facilities—either Mission Monitoring System (MMS) locations or Space Awareness Centers (SAC's).

Students at MMS locations use computers and telecommunications equipment to receive and process satellite data—i.e., to observe and participate in NASA science missions in progress—and to produce outreach publication and presentation materials.

Student-built SAC's display space-related models and pictures that increase awareness of the latest developments in space science and technology. They are often used as sites to host CSLP outreach events, including real time space vehicle launch coverage.

Chapter 2: CSLP History

In September 1990, Michael Fatig, manager of ATSC's Flight Operations Department, committed himself to giving something back to the community and started by volunteering his personal time to start a science project at Laurel High School in Laurel, Maryland. His goals were to encourage student interest in space science and contribute to student preparation for careers. From his engineering point-of-view, he saw the business world as a complex interrelated system that was becoming more complex at an alarming rate, and one way to address that burgeoning complexity was to transfer a part of the corporate training process into school systems to produce a higher skilled and better prepared graduating high school workforce.

Of all the world's science and technology sectors, the space science industry enjoys high visibility when it comes to making seemingly impossible missions not only possible but so common that few in the world bat an eyelash over, say, a space shuttle landing. Nonetheless, from the launching of Sputnick to the landing of men on the moon to the building of the world's first space station, no other industry has dealt with the magnitude of the financial, political, scientific, and technical issues that the space industry has and come out a global civilian winner. NASA space science missions consistently demonstrate the outer boundaries, always expanding, of human competence and potential. Fatig's vision started appropriately with teaching students how to tackle tasks and build systems that at first glance seemed beyond their capability if not altogether impossible. He wanted the students to experience buy-in by taking on responsibility for planning and managing their own projects; through the application of management tools—i.e., team concepts, time lines, formal review processes, etc.—students would also get a feel for the corporate environment of the 21st Century as well a taste of what it might be like to work in scientific and technical mission environments. Fatig, through business contributions and professional involvement, eventually built a funded government-industry partnership to support associated educational initiatives in individual participating schools.

The First CSLP

Mike Fatig briefed Laurel High School on his ideas in October 1990, and he worked with the school to develop a program partnering commitment through the following January. Starting early in 1991, volunteer students, the Core Student Group (CSG), started meeting to plan what would be their high school's CSLP program. By the following September, Laurel High School had a new CSG as well as a dedicated CSLP class period in which students set out to study the Solar Anomalous Magnetosphere Particle Explorer (SAMPEX) mission. ATSC and NASA/GSFC volunteers taught students about spacecraft flight operations, and when SAMPEX was launched the following year (September 1992) the CSG embarked on the development of the first high school level Mission Monitoring System (MMS).

Laurel High School students briefed Maryland's Governor Schaefer on their project in January 1991. The Governor offered his support, and in March 1992, with students from several elementary schools bussed to the location to learn about special programs in space science, opened the Mission Monitoring System facility space with a formal ribbon cutting ceremony. CSLP students the following year assembled at the Goddard Space Flight Center and briefed then-President Bush on their project (June 1992), and ten months later, finally, and for the first time, operated the SAMPEX satellite through a day of orbital operation.

Additional Schools Join CSLP

South Fayette High School, McDonald, Pennsylvania, became the second school to join the CSLP partnership. As with the program in Laurel, Maryland, South Fayette's program started with after-school student project planning and grew into a dedicated part of the school's curriculum. The timeline:

- Adult seeding—September 1990.
- Student project definition and planning period—October through December 1990.
- Proof-of-concept period—January to May 1991.
- Full scale program implementation—academic year 1991/92.
- Dedication of operational Mission Monitoring System facility—February 1994.

Through their evaluations, students at South Fayette said their CSLP experience taught leadership and work related skills, offered opportunities not available in other classes, allowed them to work hands-on with NASA scientists and engineers, and gave them experiences that would be useful in college and their careers in general.

Woodlawn High School, Baltimore, Maryland joined the CSLP partnership in December 1994 by developing a CSLP-light program. DuVal High School, Lanham, Maryland also formed a CSLP-light program, and it became a dedicated "full-up" part of that school's curriculum in January 1997.

Early participation by Maryland schools in the immediate Goddard Space Flight Center employment area might suggest a regional tint to who actually enjoys the company and leadership of local rocket scientists; however, science instructors and school officials across the country may dispense with that notion: the sixth and seventh schools to adopt

CSLP programs were Old Bridge High School, Old Bridge, New Jersey (a good three hours away from the sprawling federal complexes of the Baltimore-Washington corridor), and Utica High School in Utica, Michigan. The distant partnership has enjoyed the rapid advances in computer-based communications technology. Certainly, the Internet has provided a remarkable source not only for the sharing of NASA mission information but for responsive e-mailing, live conferencing, and other forms of interaction between CSLP volunteers and distant school populations.

Chapter 3: Skills for the Future

Skills for Success

In 1994, the Maryland Business Roundtable and Maryland State Department of Education collaborated in the assembly of a team of more than 40 members representing businesses, government agencies, labor organizations, local school systems, institutions of higher learning, and parents. The team asked a deceptively simple questions: "What do high school students need to learn in addition to the knowledge and skills identified in the curricula for mathematics, English, science, and social studies?" They started by reviewing the work of those who had with more limited agendas and perspectives tackled the question ahead of them. Organizations providing relevant input included the following:

- The American Society for Training and Development
- The National Academy of Sciences
- The National Center on Education and the Economy
- The U.S. Department of Labor (the SCANS report)

The assembly then drafted a set of skills and offered it for review to organizations throughout the state, a process that took several months. The body of work was subsequently submitted to more than 40 experts around the country. The extensive feedback led to refinements that resulted in a list of skills sought for the purpose of life-long learning. The collaborators labeled their list "Skills for Success." Its domains and items are faithfully reproduced here:

Five Skills for Success Goals

The five goals of the Maryland *Skills for Success* program are as follows:

- Learning Skills - The student will plan, monitor, and evaluate his or her own learning experiences.

- Thinking Skills - The student will think creatively, critically, and strategically to achieve goals, make effective decisions, and solve problems.

- Communication Skills - The student will plan, participate in , monitor, and evaluate communication experiences in a variety of situations.

- Technology Skills - The student will understand, apply, and evaluate technologies as labor-enhancing and problem-solving tools.

- Interpersonal Skills - The student will work effectively with others and participate responsibly in a variety of situations.

In advanced industrial countries, workplace skill may be interpreted as the ability to apply academic solutions to real-world problems. What workers must learn has come to include knowing how to apply knowledge to produce new solutions to novel challenges. The collaborators asked two more questions: "What do students need to learn to prepare themselves for careers in competitive working environments?" and "What motivates students to develop such skills?" Their conclusions dovetailed with their "Skills for Success": how to learn, how to analyze data and manage technology, and how to convey information were identified as tools necessary for success in any life endeavor. Complementary characteristics included the development of a strong work ethic, team skills, and life-long learning habits. They felt adaptability and flexibility in learning would define high school graduates who would remain gainfully employed throughout their lives.

Relationship with CSLP

CSLP has responded to the principles of Maryland's *Skills for Success* program and encourages their continued adaptation in individual CSLP programs. From its inception, CSLP has emphasized the development in students of the following career survival skills and traits:

- Ingenuity through continuous learning, project improvement, and feedback;
- Personal accountability and responsibility for projects task design and implementation;
- Team-based working and social skills associated with leadership and high quality project performance.

Chapter 4: Involved Students

CSLP program design answers to two student-engaging principles:

- Learning through hands-on involvement in live NASA science missions;
- Expectations for personal contributions to project teams and community outreach projects.

The buzz in the corporate world is "buy-in"—i.e., obtaining an investment from an employee or reluctant partner that answers to that person's agenda or other aspect of self-interest and reduces to a minimum resistance to the program at hand. Students engaged with CSLP programs experience "buy-in" through active involvement in every stage of CSLP program development, management, and review as well as through the on-stage social pressures—desire to succeed; desire for social acceptance and power; fear of embarrassment and humiliation—associated with community and school-wide outreach activities.

The freedom to participate in an area of interest certainly provides a motivator for performance. What is true for athletes on the field is no less so for the same persons engaged in one intellectual activity or another. Credits and grades also provide some reward for student effort. However, CSLP programs offer students the opportunity to be impelled by another set of learning and performance drivers:

- The experience of increasing competence and efficacy through meaningful efforts that produce change and contribute to an historical legacy;

- The experience of increasing autonomy, ironically enough, through accountable and responsible participation in team-based efforts.

CSLP Core Student Group (CSG) projects go beyond mere exercises and simulations, which draw around them the noose of time—i.e., when they're over, they're over, and nothing in the world has changed. To the contrary, CSLP programs are progressive: they set the stage for the next generation of CSLP students—and every CSG team member knows it; moreover, through their outreach aspect, they have an impact immediately visible to the CSG's that produce community-wide space science demonstrations and presentations. The press may give them coverage; local and state officials may engage them for a photo opportunity; younger siblings and others in the community may express continuing interest—or even jealousy—with regard to their work.

For individual participants, whether bound for science and technology careers or not, the CSLP model is innately rewarding on firm psychological and social grounds. In practical terms, there is an enormous difference between writing a pretend program for, say, the monitoring of spacecraft telemetry in theory, and being able to say, "My program for monitoring our project's satellite telemetry will be used here next year" or, if the task involves teaching the student's own chosen subject, "These kids are going to believe whatever I tell them about astronomy"—in either case, the pressure to get it right, whether with a telemetry program or astronomy presentation, is high, and there's very little room in such a dynamic and socially integrated educational model for merely going through the motions.

Note: Youth programs operated by the powerful, whether in government or industry, often become the butt of a later rebellious generation's vision—i.e., no one would wish to revive the children's crusades or Soviet Youth programs of medieval and modern times. Remarkably, the American space program has never lost its broad-based popularity, not even at the height of the civil rights and anti-war movements where both funding outlays and high-tech research made at best elusive targets for extreme groups; moreover, the family of continuing and healthy science fiction programs devoted to space exploration with insight into the human (and potential extraterrestrial) heart suggests that whatever Starfleet Academy is to *Star Trek* and similar program audiences, the CSLP program offers analogous practical and still "cool" preparation for similar careers and student experiences in reality and in our own time.

Hands-On Participation

From the start, CSLP found that having students directly involved and providing hands-on services during a live NASA mission enhanced learning and promoted a high level of enthusiasm on the part of Core Student Group (CSG) participants. At the risk of repeating a part of the previous section's comments on student motivation, the "hands-on" aspect of CSLP programs provides students with the following:

Efficacy—i.e., student contributions make an immediate difference in overall mission quality, feed up to CSLP program monitors and volunteers, have an impact on the community, and produce legacy objects (e.g., program presentations, data, software, etc.) for those following in their footsteps.

Autonomy and Self Reliance—by choosing their individual tasks in a team-based project environment, students accept responsibility for the quality and results of their individual contribution to the team's success; at the same time, having something to do within such a framework provides a sense of boundary as well as purpose for each team contributor.

Historical Engagement—because of the active involvement of NASA/GSFC and ATSC in linking live NASA science missions to specific CSLP programs, each student's participation in the historical science process is immediate and engaged in the present. The data is new, outcomes are uncertain, and neither students nor professionals know what may happen next with regard either to space science theory of even the physical well-being of the mission's many elements, including the satellite itself. The difference is the same as that between watching last year's Formula I race on videotape and sitting in the bleachers at the event when the starter's gun explodes.

Career Enhancement—real team-based project management; real individual contributions to problem solving; real impacts on project success: participation in CSLP programs give students real resume credits, which in turn may provide them with a real start in their college or other adult careers.

Outreach Activities

One of the best ways to learn a subject is to teach it, so why preserve the method for teachers only?

Outreach programs place students in socially hazardous but altogether responsible roles—because a subject must be well known as well as well presented to make it accessible to others, students face a variety of competence-improving challenges:

- What is the core idea in what I am going to teach?
- What do I have to know not only to teach this subject but to field questions about it?
- How can I best present this subject?
- What would make this subject as interesting to someone else as it is to me?
- What lasting impression about this subject do I want to leave?
- Who am I teaching this material to, and what will engage them?

"I could teach this to you," a teacher might say, "But it's going to be much more interesting if you have to teach it to me—and the rest of the school, your parents, a few busloads of elementary school children, the press, and possibly the governor of the state as well."

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In its own strange fashion, responsibility for one's self is inextricably linked to the ability to assume responsible positions in service to others and to perform well in them. The CSLP model provides a perfect opportunity for high school students to experience that linkage. Each Student Core Group member works on a key part of a larger project and system, accepts accountability for the performance, and obtains feedback from fellow project team members, teacher/facilitators, and the outreach audience. For the combined performance and social skills elicited from them, CSLP provides students with a strong proximate career experience.

Chapter 5: Program Elements

The CSLP program provides a model for the development of specific science and technology curricula. Each Student Core Group (SCG), teacher/facilitator, and school develops a unique program, effectively adapting CSLP program characteristics to the content development of a unique learning experience. The most critical variables driving the implementation of CSLP programs are 1) partner availability and expertise and 2) student interest—the first may affect the specific content focus, the latter the development of a dedicated or extra-curricular program format.

In addition to the two program-shaping variables noted, five program elements are generally adopted in CSLP implementations:

1. Conferences
2. Partnerships
3. Technical Programs
4. Work Environment Programs

CSLP programs are not about the delivery of fixed loads of information—they're about the learning and project development and management processes themselves. While CSLP students should, for example, know the names of the planets in our solar system, they are equally challenged to do the following:

- Develop a project concept;
- Define goals and objectives serving the project concept;
- Monitor and measure progress toward project goals and objectives;
- Manage and evaluate task efforts serving the project;
- Realizing project concepts by completing them and proposing next-step potential projects.

Learning how to learn and learning how to do are part of the same process of transformation that produces a progressive and rapidly evolving national culture. Core curriculum have long been established throughout the range of high school humanities and science courses—CSLP provides students with the opportunity to associate the learning of specific subject content (e.g., the names of the planets in our solar system) with an associated project development and management process. By taking on a project, students must develop the following skills:

- How to identify and develop new sources of information;

- How to define, segment, and solve complex problems;
- How to communicate in small groups and produce presentations for lay audiences.

It takes many types of classes and programs to create a complete educational system. CSLP programs provide a way of extending an information-providing core curriculum into a team-based problem solving learning process.

Additional CSLP Program Characteristics:

- Students do the work in CSLP programs; teachers, with wisdom, merely facilitate and guide;
- Depending on the program initiating Student Core Group, CSLP program projects may span several years or change from year-to-year—it really is up to the students to plan and prepare a technical program that produces a legacy element for the generations that follow.

Steps taken to produce a CSLP program include the following:

1. Guide students to develop a project concept and several relevant goals for the semester;
2. For each goal, guide students to develop one or two tangible and measurable objectives;
3. Guide students to define the steps required to achieve each objective;
4. Based on the project concept and plan, develop an assessment program;
5. Depending on the size of the Student Core Group, break up into teams with each team choosing to achieve a set of specific project goals;
6. Implement the project program—i.e., go to work;
7. Implement the assessment program—i.e., review work as the project effort proceeds;
8. Learn from errors and successes to modify plans while the project is under way;

9. Evaluate each of area of progress and team effort contributing to the realization of the project.

Technical Programs

CSLP technical programs have so far focused on spacecraft engineering, launches, and operations—these represent the areas of expertise owned by participating government and industry partners. However, the true objective of the technical program concept is simply to define the general discipline (e.g., astronomy, engineering, etc.) students wish to concentrate on through the development of their own overall project concept. With that frame determined, schools and their students enjoy significant freedom in determining the larger subject focus of their CSLP program.

The information objectives of each CSLP technical program may be addressed by volunteer experts, online publications, and workbooks and videos available through the CSLP office. Teachers need only present when they are expert themselves in their students' preferred area of inquiry. Even then, presenting technical information is not a CSLP teacher's primary function, which is to facilitate program activities and strongly encourage the development of autonomous and team-based habits of learning and project development.

Sample Technical Lecture: Subject Outline—

Introduction

- What is CSLP
- Overview
- Grading

Introduction to the Work Environment

- Total Quality 1
- Total Quality 2
- Planning
- Group Skills
- Team Building

Astronomy

- Origins of the Universe
- Scale of the Universe
- Contents of the Universe
- Environment of Space - Physical Characteristics:
  - Vacuum
  - Temperature
  - Magnetic and Gravitational Fields
  - Radiation
  - Spectrum

How we know what we know:

- Instrumentation: Telescopes, radio telescopes, etc.
- Spectral Analysis

Space Exploration

- Purposes of Space Exploration
  - Space Race
  - Scientific Studies: Remote Sensing, Shuttle
  - Hubble, SMEX, MTPE (EOS)
  - SETI
  - Colonization

- History of Space Exploration
  - Verne, Goddard, etc.
  - Early Satellites: Sputnik, Explorer
  - Manned Space Flights
  - Space Stations: Skylab, Mir
  - Reusable Space Vehicles: Shuttle
  - Recent unmanned space flights: Interplanetary and outerplanetary

- Discoveries from Space Exploration
  - Rocketry
  - Theory
  - Newton's Laws
  - Student Building & Launching
  - Types of Launch Vehicles: NASA, Pegasus, Scout
  - Types of Payloads

Technical Material Availability:

Teachers may build collection of technical materials through a variety of resources:

- NASA Teacher Resource Centers;
- CSLP homepage at "http://joy.gsfc.nasa.gov/CSLP/home.html";
- Jet Propulsion Laboratory at "http://www.jpl.nasa.gov/basic" (look for David Doody and George Stephan's *Basics of Space Flight Learners' Workbook*).
- World Wide Web in general.

Work Environment Program

The Work Environment Program introduces students to the concepts, methods, and tools used by business to construct and complete their various missions. As is true of the Technical Program, the availability and choice of partner has a strong impact on the actual design and implementation of the program. However, central to the Work Environment Program is the Total Quality (TQ) process, which progressively builds knowledge and skills, involves top management in the project development and management process, and helps both individuals and teams stay focused on the ultimate goal of such endeavors: customer delight.

A Few Words About Customers

CSLP program students work for themselves, other students, and the community at large. Although the concept of the customer is universal—in every dyad, family, clan, kingdom, and culture, there is always someone who must be pleased by someone else—it is worth noting in light of the CSLP program mission what customers provide to those who serve them:

- Image and reputation
- Financial support and profit
- Progressively challenging work

Ultimately, the customer is any person or group that influences the success of the vendor. Whether the customer is a school principle, a teacher, or taxpayer, students working within the CSLP program context are urged to keep in mind the needs and wishes of their customers.

External and Internal Customers

Students are well aware of the "external customer"—i.e., the buyer at the lemonade stand; they are less aware of the lemonade stand's "internal customers"—i.e., the parenting management team, the labor providing sibling, the friends who run to the store for more lemons. In fact, the internal customer is technically a part of the enterprise that provides a good or service to an external customer. For students participating in a CSLP program, the project vision includes sensitivity to the project's internal customers—e.g., the teacher/facilitators, work groups and individual work group participants, and the partnering authorities and the organizations those persons represent.

Internal customers affect the nature and quality of final project deliverables: in the so-called real world, the interplay between persons within an organization very much affects budgets, project team rosters, the selection of outside vendors, and the overall quality and pace of the project. The same may be said of projects run by high school students. The project scale may be smaller and the consequences of failure less egregious, but the management principles persist: in a powerful way, CSLP programs provide students with the opportunity to experience first-hand the organizational dynamics that contribute to virtually all of man's social undertakings.

Of course, external customers have the real power in democracies and open economies. They can hold on to their votes as well as their money or choose equally to confer political power by casting a positive vote or affirm the value of a good or service by making a purchase. For CSLP program students, feedback from the outreach audience—i.e., other students, the school community, and the community at large—may provide affirmation for their efforts, or, should those efforts come to a little less than expected, widespread disinterest. In either case, the opportunity to practice good science as well as showmanship is built into the CSLP concept, and students can only gain experience, knowledge, and skill through their participation in the CSLP project development, management, and review process.

Total Quality

- Total Quality and teams go together. By pooling diverse resources and ideas, teams accomplish the following:

- Encourage individuals to make the maximum contribution to the quality process while fostering "buy-in" or "ownership" of the project;

- With multiple knowledge and skills sets working side-by-side, they help produce superior solutions to difficult problems;

- Because participant expertise is "cross-functional," teams lend themselves to the systematic evaluation and improvement of key project processes, and that in turn encourages breakthroughs in planning and program implementation.

When they are well led or managed, teams also boost quality and productivity indirectly. Management may signal through them that the company values individual opinions, recognizes the wealth of information possessed by its workers, encourages the further development of ideas and suggestions, and that it sincerely support quality improvement efforts.

Total Quality's Nine-Step Process

Process improvement and problem solving; quality planning; group skills and team building—these concepts are at the core of the "TQ 9-Step Process":

1. Identify opportunities for improvement.
   1.1. Examine current processes and identify areas amenable to improvement;
   1.2. Produce a baseline for the process before improvement and a means for measuring the effects of the improvement effort;
   1.3. Write a problem statement listing the tasks contributing to the improvement effort.

2. Form the process improvement team and scope the project.
   2.1. Select talent to contribute to the development of a solution;
   2.2. Define the boundaries and limits of both the problem and the process improvement effort.

3. Analyze the process in depth.
   3.1. Examine process history;
   3.2. Examine process as a system;
   3.3. Define what and what doesn't work.

4. Define the outcomes desired for the improved process.
   4.1. Define the "to-be" part of the improvement vision;
   4.2. Develop and agree on a conceptual model of the improved process;
   4.3. Develop and agree on process performance measures and goals;
   4.4. Develop alternative strategies for achieving the goals defined.

5. Identify the root causes of the subject process's inferiority.
   5.1. Define what caused the process problem in the first place.
   5.2. Propose a solution that reduces the potential for further problem creation associated with the subject process.

6. Prioritize, plan and implement the solutions proposed.
   6.1. Evaluate the solutions tested.

7. Refine and implement an improved solution set.
   7.1. Improve the solutions tested;
   7.2. Obtain consensus for full-scale implementation of the proposed process improvements (i.e., solutions);
   7.3. Full-scale implementation of the agreed upon process improving solutions.

8. Measure, validate, and maintain gains.
   8.1. Determine the extent to which improvements worked.
   8.2. Take steps to ensure improvements implemented are not degraded or reversed by other influences and processes.

9. Acknowledging the team and communicate results.
   9.1. Maintain motivation for future projects and strongly encourage continuation of the improvement process successfully demonstrated throughout the project.

Planning

Choose a destination.

Plot a course.

Go.

It's that easy, even when the destination is somewhere past the end of the universe.

NASA science projects anticipate the creation of capabilities and ideas that exist as mere dreams and ideas on the day they're planned. Participation is not only an adventure in space but an exploration of the astounding human capacity for invention and the development of knowledge. CSLP programs situate students where they can experience the core creativity, discipline, and wonder that have made space exploration an achievable end, and it does so by making them a part of the mission planning and deployment process.

No less than the role of the customer (i.e., "external customer") in project development, planning is a familiar concept worthy of a second look.

Planning eliminates or reduces uncertainty while improving efficiency in operations. As a process, it also supports the clarification of objectives and provides a basis for controlling and monitoring progress in program implementation. Without a strong engagement with the planning process, projects that get off to a wildly enthusiastic start may end in chaos and disillusionment with all the attendant negative social fallout—finger pointing, tarnished reputations, the engagement of non-participants to come in and clean up the mess.

The following steps define one common management path for general project planning:

- Brainstorm;
- Define the project concept;
- Define realistic goals, objectives, and tasks;
- Develop the project personnel and teams that will do the work, including backup personnel and teams;
- Develop the information and technology resources the teams will need to do their work;
- Develop the project schedule, which includes setting "by when" dates, defining project milestones, and providing sufficient slack to speed the project along when it's humming or maintain enthusiasm for it when and if it bogs down.
- Implement the project program;
- Monitor, evaluate, and adjust the project between milestones;
- Reporting on the completed project;
- Review the completed project for potential improvements in the design and

management of other operations, projects, and programs.

To make the process easier, managers use a variety of basic planning tools, starting with the Work Breakdown Structure (WBS), which translates project requirements—i.e., the ends of multiple goals, objectives, and tasks—into small, manageable, and measurable tasks. Other commonly used tools include the Project Milestone Chart, Action Items Lists, and Performance Management Plans. The following is an example of a WBS for the task of selecting a class schedule:

[WBS Chart Fig. 1 About Here]

Figure 1. Planning Tool: Work Breakdown Structure (WBS)

Milestone charts represent project progress visually. They provide project start and end dates, important milestones, and the delivery of completed tasks (e.g., the publication of a project report). Here is an example of one:

[Milestone Chart Fig. 2a About Here]

Figure 2a. Planning Tools: Milestone Charts

Milestone charts may take advantage of bar shading to indicate project progress. In the following chart, tasks A and B are being completed simultaneously over a three week period, but task A was completed, as indicated by the arrow head, shortly into the second week, while task B at three-and-one-half weeks is only 50 percent complete. In the meantime, work on task C has been scheduled to begin in the middle of the fourth week.

[Milestone Chart Fig. 2b About Here]

Figure 2b. Planning Tools: Milestone Charts—Bar Shading

Another important feature of the milestone chart is the configuration management information in the header, which tells readers who created the chart, who approved it, when it was created, and when it was last changed.

[Milestone Chart Fig. 3 (Management Info) About Here]

Figure 3. Planning Tools: Milestone Charts—Management Tracking Information

Action Items Lists document which team members are responsible for which tasks on the Work Breakdown Structure, prioritize tasks, and note expected task completion dates, including "suspense dates" when tasks must be completed. Managers generally work with three degrees of priority—"1" is highest; "3" is lowest—and adjust priorities as task cycles move from start periods to completion.

[Action Items List Fig. 4 About Here]

Figure 4. Actions Items List

Performance Management Plans (PMP's) define and measure employee progress in terms of the achievement of four or five primary responsibilities. Such plans contribute to the determination of promotions and raises and provide baseline data for career path and performance improvements. Familiarity with the process of developing clear and measurable personal goals and objectives is a key feature of the CSLP program, and teachers are urged to adopt in their own fashion a PMP approach appropriate to their students' ambitions and desires.

Group Skills and Team Building

This program guide has frequently used the phrase "team-based project development" to emphasize the overarching nature of a continuing global corporate and industrial evolution that addresses increasingly difficult human and technical challenges in the pursuit of general industrial progress as well as progress in science and technology. While corporations through the middle decades of the 20th Century emphasized individual development and prized singular genius in their various crafts, the complexity of projects contributing to further advancements, as well as a variety of cultural factors, including the networked computing revolution, urged the development of a new appreciation for teamwork, which on the cusp of the 21st Century leads the way. CSLP programs appropriately provide students with a model working experience within that new context. The signal characteristics are three:

- An open approach to determining project and program objectives—i.e., the participants (i.e., students, teachers, and volunteers) set the course;

- A degree of challenge built into the program objectives that requires for achievement strong participant interdependence;

- A degree of accountability that flows from the business sector down through school administrators and teachers to student project teams and individual students.

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Whether involved with entertainment and film making or space technology and flight operations, the assembly of talented and highly performing teams engaged in complex tasks has set a trend for the 21st Century workplace, which CSLP programs effectively address. Perhaps of equal or greater importance is the commitment AlliedSignal Technical Services Corporation and NASA have made with regard to strengthening the linkage between the high school experience and industrial purpose, an evolving cultural integration that may influence not only the learning experience for high school students but equally and over time the project concept and development work produced by future generations of craft workers and administrative professionals across the industrial campus.

Individuals play multiple roles on teams—i.e., each member has separate administrative, craft, research, and presentation responsibilities as well as potential secondary back-up roles for others on the team. The first organizational roles are necessarily administrative and tend to follow this basic configuration:

- Team leader
- Timekeeper
- Recorder
- Scribe
- Monitor
- Observer
- Spokesperson

Team Member Roles

Team Leaders

Team leaders guide groups through activities by ensuring objectives are discussed, determined by consensus, and met. They facilitate and guide rather than direct, and to maintain group enthusiasm for group projects, strive to "make things happen" while underplaying their own stamp on the work, which properly belongs to the team. CSLP program leaders especially encourage individual participation in group projects and modulate the degrees of dominance expressed by individuals in group meetings—i.e., they quietly improve opportunities for shy members to engage the project and voice their opinions while carefully deflecting without discouraging more aggressive and vocal players. Skilled team leaders do the following:

- Clarify major points;
- Maintain their team's enthusiasm and focus;

- Promote consensus;
- Provide encouragement to team members and task subgroups.

Timekeepers

Timekeepers attend to the scheduling of tasks and the monitoring of milestones and the achievement of project goals and objectives. They participate in brainstorming, adjust project agendas when teams complete tasks early or request additional time for an item, diligently track deferred (but not to be forgotten) items, and make sure recorders register time frame changes in team and project meeting notes.

Recorders

Recorders capture the flow of decisions and ideas articulated during meetings, distributing them quickly afterwards to team members. In every sense, such minutes are the one sheet of music off of which the whole group reads: every team member needs in writing the essence of each meeting; moreover, meetings, by exploring ideas, evaluating tasks, and resolving issues in project design, management, and review, set the project course and need to be documented to provide the project with historical clarity and continuity.

Scribes

Scribes, who like recorders track decisions and ideas, provide a concurrent representation of each meeting's progress through the immediate development of flip charts, white boards, or overhead projector slides. Meeting attendees need only to refer to the scribe's work to stay focused or backtrack to an earlier point—and when the pace exceeds one scribe's ability to keep up, another scribe may be appointed to keep the meeting charging forward. Scribe duties include the following:

- Produce flip chart stands, blank pads, 3x5 notepads, overhead slides, markers, etc. for each meeting;

- Transcribe what is said with a minimum of interpretation or opinion and may use abbreviations and key words to telegraph ideas articulated by other team members;

- Request clarifications and distill ideas as meetings move along;

- Collect completed flip charts or other media and return with them for use as reference in subsequent meetings.

Monitors

Monitors keep meetings on track. They help teams adhere to the nine-step process improvement model, provide Parliamentarian guidance on meeting procedures, suggest ways of achieving objectives with the utmost efficiency, and generally shepherd the group within the bounds of the overall project management process. Monitors provide teams with the following services:

- Fend off critical or inhibiting comments during brainstorming sessions;
- Ensure that teams cover the questions developed by their members, attend to critical tasks, and generally move on to new steps in the management process in a thorough and orderly manner;
- Facilitate team problem solving.

Monitors fully participate in brainstorming, offering personal opinions and suggestions to improve the project and assure its eventual success.

Process Observers

Process Observers encourage quiet team members to speak up in order to preclude the domination of the project by a few vocal personnel. Their talents include the following:

- Asking for factual data, opinions, and suggestion from all members of the group to ensure everyone understands the issues at hand and participates in the project management process;
- Counseling to ameliorate negative behaviors, individual and group, that may be impeding progress on the project (individual discussions may take place with the team leader's participation).

Spokespersons

Spokespersons present their team's analyses and recommendations. Their skills include the ability to effectively articulate the concepts, ideas, and plans produced by their teams and to support the group in the development of presentations and reports. They participate fully in all activities, from brainstorming to task listing.

Partnerships

Partners bring to classrooms subject expertise, knowledge of how the real world works, and a model combination of neighborly good will and professional self-esteem that provides students with an exceptional opportunity to orient early to the nature of work in a significant and growing portion of the industrialized world. Although partners can be organizational in nature—i.e., government agencies, private companies, etc.—most CSLP partnership involve individual volunteers who work directly with students, a format that mirrors Maryland's Partners in Education Program, which involves business firms (through representative volunteers) in the teaching process in an effort to improve the coordination between classroom instruction and the application of various skills in the modern workplace.

Defining goals, objectives, and resources is the first step in building a partnership. Here is an example of the order of development.

Initiatives Taken by Host

- Identify needs associated with improving student competence in basic skills;
- Designate a partnership coordinator;
- Define objectives and propose an activities plan for the school year;
- Introduce partners to school staff and parents;
- Meet with CSLP program principles to evaluate program effectiveness and progress.

Government or Private Industry Response

- Designate coordinator to meet with school staff;
- Evaluate the school's specific offer or activities plan;
- Guide final development of objectives and activities plan;
- Maintain regular communications with staff to ensure the program progresses as planned;

- Recruit employees for specific projects.

Common Program Goals and Objectives

- Build the foundation for long-term partnering;
- Enable students to establish ownership of the project as well as pride in their work;
- Enhance community-wide acceptance and visibility of the CSLP program;
- Foster the development of a better educated, more skilled, and more prepared workforce for the future;
- Foster student interest in specific subject areas;
- Improve student, teacher, and volunteer motivation and morale;
- Provide a widening circle of relevant educational opportunities for all participants.

Corporate Resources

- Volunteer enthusiasm, experience, knowledge, skill, and talent;
- Administrative and facilities (e.g., conference rooms) support services;
- Surplus equipment;
- Facility tours.

School Resources

- Administrative and teaching staff dedication and knowledge as well as leadership and pedagogical skill;
- Facilities;

- Student enthusiasm and talent.

Program Design

Good program design starts with good program coordination.

Although civilian aerospace science and technology projects differ in substance from military endeavors, the military's modernized "command, control, communications, and *computers*" standard applies to the achievement of CSLP "mission success." In fact, the first job following the appearance or establishment of key government, industry, and local school system players is the selection of a program coordinator to handle the command, control, and communications required to strengthen and grow the partnership and associated CSLP program.

In the argot of management, "big picture" issues involving the project coordinator generally can be handled by phone and supported by occasional face-to-face meetings. While the real life roll-outs of CSLP programs are driven by local participants and seldom require continuous, extensive, and frequent long-distance management, central coordination ensures each program gets the institutional support needed to succeed.

Conferences

Twice a year, CSLP sponsors conferences where more than 100 students from participating schools visit the NASA Goddard Space Flight Center (GSFC) to meet other students with similar enthusiasms and learn from those who live them about careers in space science and technology. The conferences, in addition to facilities tours and the aforementioned contact with aerospace engineers and scientists, also provide a forum for each school's CSLP presentation. Once again, the CSLP focus on science and technology by no means overshadows its balanced reliance on students whose interests in the arts and humanities serve to communicate and educate with regard to CSLP program achievements.

Chapter 6: In the Class Room

One student's motivation may be another's nightmare.

The cleverness of the remark aside, the notion itself, which is true enough, has led educators and industry to produce through continuous narrowing individuals as well as businesses a thousand meters deep and a micron wide. The result of that haphazardly evolved structure, having produced English majors who can't work math problems, mathematicians who can't write, and engineers who prefer to be left alone until forced back into school for soft management science and leadership training somewhere in mid-career, has been mutual contempt and mistrust across the academic campus as well as a dysfunctional interface between educational processes and the competitive values of the world's near hegemonous capitalist business enterprise, which globally affects the political and social character of our turn-of-the-century human experience.

Academics may argue the premise—i.e., that the narrowing over time of each student's education into progressively restricted and self-serving areas of competence produced an adult tunneling effect in career path making as well as corporate vision; fortunately, the other side of a premise is an aspiration, and for that, CSLP provides a program in touch with the challenges associated with human advancement in the 21st Century: at the heart of all CSLP (Cooperative Satellite Learning Project) programs is the notion that achieving higher levels of performance in the expansion of human knowledge and skill *in all areas* will require an equally higher degree of cooperation, coordination, and organization in the projects undertaken. What that means for high school students in general and college-bound students in particular is an earlier engagement in a project development process that has as its true core requirement the development of social skills advantageous to team efforts and the concomitant mutual appreciation and coordination of wildly different interests, skills, and talents.

America's elementary and high school education system teachers provide the most critical foundation for whatever subsequent generations of adults choose to create or lend their energies to in the course of their careers. CSLP recognizes that role by encouraging teachers to act as program facilitators who expect their students to develop the independence, initiative, and responsibility required to conceive, develop, implement, manage, and review cooperative and successful space science and associated presentation projects.

The most valuable craft managers and professionals learn how to make the best use of their individual interests, skills, and talents in every situation, but neither government nor industry can encourage or even identify those abilities in the formative years. It is truly the students themselves who do that. When student interests are congruent with the general public's will or their teachers' enthusiasms and interests, they're able to step out of the shadows and serve themselves as well as their communities in positive ways. By providing opportunities for students to play pivotal roles on team projects associated with real, high value NASA space science missions, CSLP offers a broad minded and inclusive program for the demonstration and nurturing of individual student ability.

CSLP programs align with the National Science Education Standards, which have for their foundation four underlying principles:

- Science is for all students;
- Learning science is an active process;
- School science reflects the intellectual and cultural traditions that characterize the practice of contemporary science;
- Improving science education is part of systemic education reform.

Teachers as Facilitators

CSLP program instructors are guides and facilitators, not lecturers. They create program curricula, build appropriate space science learning environments, work to remove barriers impeding progress on their students' projects, and coordinate with program partners to establish, maintain, and improve the value to students of the CSLP program installed.

If not content, what do teachers involved with CSLP actually teach? The answer may be found at the nexus of three CSLP program organizing concepts:

- CSLP programs are multidisciplinary and require individuals possessing a variety of interests, skills, and talents;

- CSLP program students are challenged to put together projects drawing on abilities associated with advanced communications technologies, historical research, language (e.g., writing and presentation skills), logic, mathematics, and exemplary scientific technique.

- CLSP programs are driven by the students themselves, with the year-to-year boundaries set by the characteristics and interests of the talent and partnering resources available.

In the final analysis, CLSP programs are about the knowledge-building process—i.e., how to acquire knowledge, how to solve novel problems, how to manage projects too complex for isolated individuals, even how to deal with the inevitable human politics that most determine the true course of all projects belonging to organizations. Teachers as facilitators may provide students with problems and guidance with regard to possible methods for solving those problems, but not the solutions themselves—those prizes the students must find for themselves.

For teachers, CSLP programs offer the following benefits:

- Opportunity to engage themselves and their students in real time NASA science missions within the province of NASA's now extensive Small Explorer (SMEX) satellite program.

- Opportunity to convey through a group learning experience the nature of scientific inquiry and the experience of acquiring knowledge through a discipline revolving around the acquisition of factual data and its logical interpretation through the constant challenging of theories and their supporting hypotheses.

- Opportunity to engage all students in an endeavor lending itself to public education and fascination through adept communications and presentations, requiring as much the abilities of artists and writers as those of more scientifically or technically inclined minds.

- Opportunity to challenge students to do something more difficult and rewarding than what any of them could do as isolated individuals.

- Opportunity to provide students with a distinctive and inclusive "cool" group experience, with the exploration of space remaining a broadly popular public endeavor with a profound influence on every facet of the modern human experience, from the experience of high technology to understanding the further reaches human nature.

- Opportunity to associate with professional peers in science and, with students, to travel to participate in conferences or provide space science presentations.

School-Based Administrative Support

CSLP programs require supportive school administrations. Even the lightest of "CSLP Light" extracurricular programs may require a classroom or communications shack for success. More dedicated curriculum programs by definition require class period space, financial support for substitutes (as with any other class), encouraging senior administrative support, coordination with parents and program volunteers, and liaison with CSLP offices at AlliedSignal Technical Services Corporation.

National Science Education Standards (NSES) for Teaching

As noted, CSLP programs adhere to the National Science Education Standards (NSES), which denote what science teachers should know themselves and what they should be able to accomplish with their students. The standards are listed here verbatim:

Teaching Standard A

Teachers of science plan an inquiry-based science program for their students. In doing this, teachers:

- Develop a framework of yearlong and short-term goals for students.
- Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities and experiences of students.
- Select teaching and assessment strategies that support the development of student understanding and nurture a community of science learners
- Work together as colleagues within and across disciplines and grade levels.

Teaching Standard B

Teachers of science guide and facilitate learning. In doing this, teachers:

- Focus and support inquiries while interacting with students.
- Orchestrate discourse among students about scientific ideas.
- Challenge students to accept and share responsibility for their own learning.

- Recognize and respond to student diversity and encourage all students to participate fully in science learning.

- Encourage and model the skills of scientific inquiry, as well as the curiosity, openness to new ideas and data, and skepticism that characterize science.

Teaching Standard C

Teachers of science engage in ongoing assessment of their teaching and of student learning. In doing this, teachers:

- Use multiple methods and systematically gather data about student understanding and ability.

- Analyze assessment data to guide teaching.

- Guide student in self-assessment.

- Use student data, observations of teaching, and interactions with colleagues to reflect on and improve teaching practice.

- Use student data, observations of teaching, and interactions with colleagues to report student achievement and opportunities to learn to student, teachers, parents, policy makers, and the general public.

Teaching Standard D

Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science. In doing this, teachers:

- Structure the time available so the students are able to engage in extended investigation.

- Create a setting for student work that is flexible and supportive of science inquiry.

- Ensure a safe working environment.

- Make the available science tools, materials, media, and technological resources accessible to students.

- Identify and use resources outside the school.

- Engage students in designing the learning environment.

Teaching Standard E

Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning. In doing this, teachers:

- Display and demand respect for the diverse ideas, skills, and experiences of all students.

- Enable students to have a significant voice in decisions about the content and context of their work and require students to take responsibility for the learning of all members of the community.

- Nurture collaboration among students.

- Structure and facilitate ongoing formal and informal discussion based on a shared understanding of rules of scientific discourse.

- Model and emphasize the skills, attitudes, and values of scientific inquiry.

Teaching Standard F

Teachers of science actively participate in the ongoing planning and development of the school science program. In doing this, teachers:

- Plan and develop the school science program.

- Participate in decisions concerning the allocation of time and other resources to the science program.

- Participate fully in planning and implementing professional growth and development strategies for themselves and their colleagues.

Teaching Standards and CSLP

Teaching Standard A—The three principles of CSLP are motivation and learning through hands-on involvement, contribution, and outreach, all of which are inquiry encouraging methods. CSLP, by bringing government, business, and industry requirements into the learning process, encourages the development of culturally relevant and practical modern career skills.

Teaching Standard B—Teachers acting as facilitators are a key part of the CSLP program; spurring students to take responsibility for their learning and providing an extraordinary opportunity for their development is CSLP's core objective.

Teaching Standard C—Program monitoring and program value go together. The continuous improvement standards adopted by ATSC and NASA, hardly alone among the world's leaders in advanced industries, flow down to CSLP programs. The following questions are omnipresent:

- How can the CSLP program be improved?
- Is the current CSLP program providing all participating students with opportunities to develop their interests, skills, and talents to their fullest potential?
- Are the students living up to their own agreed upon performance standards?

Teaching Standard D—In order for programs to be effective, physical environments must be managed and made safe, and the tools and other resources required for success must be made available.

Teaching Standard E—Through their outreach aspect, CSLP programs involve the community in space science and through that portal encourage scientific literacy and the spirit of scientific inquiry in general. Moreover, CSLP programs bring together engineering, science, and teaching professionals from various economic and geographical sectors in the common mission of developing young minds. The combined coordination and diversity of the participants—administrators, students, teachers, and volunteers—sews the future for breakthrough ideas and the opening of doors heretofore unimagined.

Teaching Standard F—CSLP program planning integrates with entire educational systems. As stated but worth repeating, CSLP program projects 1) require and respond to diverse student interests, skills, and talents; 2) are process rather than content driven and designed to help students solve complex problems in concert with others and through their own initiative; and 3) offer a flexible approach to building a more adequate, efficient, responsive, and responsible interface between the community of educators and the emerging requirements of a highly developed and global industrialization built on tens of thousands of advancements annually in scientific and technological capability.

Professional Development Standards

CSLP program partners in government and industry may bring to CSLP projects significant technological and scientific know-how and resources, but they are not educators and may not be familiar, if familiar at all, with pedagogical issues evolving around everything from individual student cognitive development and style to financial accounting for classroom resources and related teaching tools (e.g., books, computers, projectors, etc.). Nonetheless, learning is a lifelong process for all of the partners involved in a CSLP program, and no less than with students, cooperation between adults should be synergistic. Government and industry may produce opportunity and wealth, but producing the people who will later create advancement for the culture remains within the province of the educator. The National Standards for Professional Development (NSES) recognize the critical role teachers play in the development of cultural and scientific literacy—i.e., the development of sufficient cognizance of scientific accomplishments, methods, and principles. NSES standards are reprinted here:

Professional Development Standard A—Professional development for teachers of science requires learning essential science content through the perspectives and methods of inquiry. Science learning experiences for teachers must:

- Involve teachers in actively investigating phenomena that can be studied scientifically, interpreting results, and making sense of findings consistent with currently accepted scientific understanding.

- Address issues, events, problems, or topics significant in science and of interest to participants.

- Introduce teachers to scientific literature, media, and technological resources that expand their science knowledge and their ability to access further knowledge.

- Build on the teacher's current science understanding, ability, and attitudes.

- Incorporate ongoing reflection on the process and outcomes of understanding science through inquiry.

- Encourages and support teachers in efforts to collaborate.

Professional Development Standard B—Professional development for teachers of science requires integrating knowledge of science, learning, pedagogy, and students; it also requires applying that knowledge to science teaching. Learning experiences for teachers of science must:

- Connect and integrate all pertinent aspects of science and science education.

- Occur in a variety of places where effective science teaching can be illustrated and modeled, permitting teachers to struggle with real situations and expand their knowledge and skills in appropriates contexts.

- Address teacher's needs as learners and build on their current knowledge of science content, teaching and learning.

- Use inquiry, reflection, interpretation of research, modeling, and guided practice to build understanding and skill in science teaching.

Professional Development Standard C—Professional development for teachers of science requires building understanding and ability for lifelong learning. Professional development activities must:

- Provide regular, frequent opportunities for individual and collegial examination and reflection on classroom and institutional practice.

- Provide opportunities for teacher to receive feedback about their teaching and to understand, analyze, and apply that feedback to improve their practice.

- Provide opportunities for teachers to learn and use various tools and techniques for self-reflection and collegial reflection such as peer coaching, portfolios, and journals.

- Support the sharing of teacher expertise by preparing and using mentors, teacher advisers, coaches, lead teachers, and resource teachers to provide professional development opportunities.

- Provide opportunities to know and have access to existing research and experiential knowledge.

- Provide opportunities to learn and use the skill of research to generate new knowledge about science and the teaching and learning of science.

Professional Development Standard D—Professional development programs for teachers of science must be coherent and integrated. Quality programs are characterized by:

- Clear goals based on a vision of science learning, teaching, and teacher development congruent with the National Science Education Standards.

- Coordination of the program components so that understanding and ability can be built over time, reinforced continuously, and practiced in a variety of situations.

- Options that recognize the developmental nature of teacher professional growth and individual and group interest, as well as the needs of teachers who have varying degrees of experience, professional expertise, and proficiency.

- Collaboration among the people involved in programs, including teachers, teacher educators, teacher unions, scientist, administrators, policy makers, member of professional and scientific organizations, parents, and business people, with clear respect for the perspectives and expertise of each.

- Continuous program assessment that captures the perspectives of all those involved, uses a variety of strategies, focused on the process and effects of the program, and feeds directly into program improvement and evaluation.

Professional Development Standards and CSLP

Professional Development Standard A—Teachers should experience the same types of activities that the students in CSLP programs experience. They need to participate and take an active role in CSLP activities but then step back and let the students go. Teachers should use partnership relations to stay in contact with the business world and use CSLP as a means to collaborate with other teachers.

Professional Development Standard B—Teachers must connect and integrate activities, partnerships and resources offered by CSLP into the education system. CSLP offers a choice of activities and projects from which teachers and students may select.

Teachers and students must decide what will fit into the curriculum and how best to implement their plans. For the program to become the best it can, teachers need to provide the CSLP national office with statistics and feedback on how CSLP can support them.

CSLP should provide teachers with opportunities to interact and work with peers and other professionals. This is done though board meeting, teleconferences, CSLP student conferences, and training seminars.

Professional Development Standard C—As part of developing a method for assessing teaching, teachers need to report on benefits realized and opportunities for improvement.

Professional Development Standard—Goals must be developed at the beginning of the program with progress monitored throughout the process. However, flexibility counts: program implementation and amended plans and goals often go together.

Assessment Standards

As with any other educational program, the assessment of pedagogical effectiveness and student performance may affect parent-teacher relationships, partner management, and program planning in general. To provide a trustworthy level of accuracy and useful scope, administrators, students, and teachers may apply multiple data development methods for individual student performance, Core Student Group and related team progress, and the success of outreach activities. As such, assessment issues—i.e., the expectations and objectives associated with individual students, the standards of success for the project—need to be defined at the start of each phase of program and project planning.

Assessment data is used to evaluate and measure student performance. Student evaluation is an agreement between the teacher and the students. It is important that the evaluation criteria be clearly set up at the start and students understand what is expected. In addition, the CSLP program itself answers to formal and informal external standards:

- Accepted and widespread business practices for evaluating employee performance;
- National Science Education Standards;
- Trends in the skill set demands of science and technology employment markets.

Below are the National Science Education Standards on assessment. They provide the criteria for assessing progress with regard to the establishment of universal scientific literacy.

Assessment Standard A—Assessments must be consistent with the decisions they are designed to inform.

- Assessments are deliberately designed.
- Assessments have explicitly stated purposes.
- The relationship between the decisions and the data is clear.
- Assessments procedures are internally consistent.

Assessment Standard B—Achievement and opportunity to learn science must be assessed.

- Achievement data collected focus on the science content that is most important for students to learn.
- Opportunity-to-learn data collected focus on the most powerful indicators.
- Equal attention must be given to the assessment of opportunity to learn and to the assessment of student achievement.

Assessment Standard C—The technical quality of the data collected is well matched to the decisions and actions taken on the basis of their interpretation.

- The feature that is claimed to be measured is actually measured.
- Assessment tasks are authentic.
- An individual student's performance is similar on two or more tasks that claim to measure the same aspect of student achievement.
- Students have adequate opportunities to demonstrate their achievements.
- Assessment tasks and methods of presenting them provide data that are sufficiently stable to lead the same decisions if used at different times.

Assessment Standard D—Assessment practices must be fair.

- Assessment tasks must be reviewed for the use of stereotypes, for assumptions that reflect the perspectives or experiences of a particular group, for language of a particular group, for language that might be offensive to a particular group, and for other features that might distract students from the intended task.
- Large-scale assessments must use statistical techniques to identify potential bias among subgroups.
- Assessment tasks must be appropriately modified to accommodate the needs of students with physical disabilities, learning disabilities, or limited English proficiency.
- Assessment tasks must be set in a variety of contexts, be engaging to students with different interests and experiences, and must not assume the perspective or experience of a particular gender, race, or ethnic group.

Assessment Standard E—The inferences made from assessments about students achievement and opportunity to learn must be sound.

- When making inferences from assessment data about student achievement and opportunity to learn science, explicit reference needs to be made to the assumptions on which the inferences are based.

Assessment Standards and CSLP

Assessment Standard A—Well thought out assessment plans should of course be consistent with the requirements of the decisions they inform. They should address goals set by students and teachers, include students as active participants in their design, be concrete and measurable, and be always clear with regard to what is expected of individuals students as well as student project teams.

Assessment Standard B—Assessments should provide data on program effectiveness, student achievement, and teaching quality. The CSLP office will use assessment data as well as project reports to produce more opportunities for students as well as program improvements.

Assessment Standard C—Assessments should be consistent over time and sensitive with regard to the seriousness of the decisions to which they may contribute. Assessments provide the CSLP director's office with a critical window on program implementation at the local level.

Extracurricular CSLP programs generally refrain from evaluating student performance. Nonetheless, program administrators should still receive assessments conveying data on program effectiveness and opportunities for improvement.

Assessment Standard D—The measurement of tasks associated with assessments should be fair, multidimensional, and realistic. Data developing instruments should be sensitive to the variety of interests and strengths represented by participants in Student Core Groups, and they should allow students to demonstrate achievement and growth in more than one way—i.e., the evaluation of student progress should not be restricted to any single benchmark, favored corporate point-of-view, or type of test. Data gathering tools include but are by no means limited to the following:

- Engineering Puzzles
- Essays
- Level of Effort or Participation Observations for Individuals and Teams
- Management Puzzles
- Math Puzzles
- Multiple Choice Knowledge Surveys in the Project Subject Area

During the project development phase, Student Core Groups and teachers may enjoy establishing together a set of pre- and post-program measurement tools to help them observe the effects of the program in terms of individuals knowledge, skills, and abilities as well as improvements in the quality of team functioning.

Student Evaluations

In CSLP programs, students contract with teachers with regard to their own goals, time frames for achievement, and appropriate assessment. A very few but overarching steps define the process:

- Establish individual student missions and goals;
- Determine how much credit or weight to give to each method used to assess progress toward those goals;
- Develop calendar or timeline for evaluating student progress and recording individual milestones.

As implied earlier, each student should be able to demonstrate accomplishment—i.e., new knowledge, skills, and abilities—in several ways to ensure against the bias produced by one dimensional tests.

The development of student mission statements mirrors the purpose defining processes of business enterprise. Such missions are results oriented—i.e., they provide a vision that focuses corporate and individual effort toward some concrete and measurable end. Specific goals and objectives subsequently orient toward that vision and provide a basis for evaluating individual and team performance in service to it.

Here is Laurel High School's (Laurel, Maryland) mission statement and its goals:

Our Mission is to

- Study Small Explorer (SMEX) and other current satellite projects while becoming knowledgeable with satellite subsystems;
- Observe the application of advancing technology in space science missions;
- Inform others through a space awareness outreach program;
- Stay updated on current space-related matters.

We will accomplish this through

- Direct hands-on involvement with the space industry;
- Using computers and telecommunications;
- Applying Total Quality Techniques.

Laurel High School's CSLP Goals:

1. Establish a working, mutually beneficial relationship with business, government agencies, and the local community.

2. Become technically aware of satellites and knowledgeable of satellite missions.

3. Outreach to the K-12 community in order to create enthusiasm for space science within all students.

4. Become skilled and knowledgeable on telecommunications and computer software.

5. Visit local air and space operations sites in order to support our learning about satellites and careers.

6. Populate and operate the Space Awareness Center with current satellite information and displays such that it becomes a useful outreach tool.

7. Use Total Quality management methods in team activities.

8. Become knowledgeable in astronomy.

The development of individual and project assessment plans and evaluation timelines necessarily follows the establishment of the project mission and supporting goals.

Assessment Data

Traditional Exams and Quizzes

While CSLP programs focus on developing high value learning and project management skills, a process orientation, subject content nonetheless counts. For one thing, content (facts and their interpretation) provides a basis for assessing program effectiveness with regard to the development of knowledge building skills. As such, CSLP programs are not without quizzes and exams. How many of each there will be, how they will be graded, and how missed quizzes and exams will be addressed should be made part of CSLP program assessment planning.

Authentic Observations

Authentic observation evaluates students while engaged in project tasks, which are essentially learning activities. The degree to which students engage their work, their sustained levels of effort, and the outcomes they produce are measurable and lend themselves to individual and overall program assessment. "Holistic," "outcome," and "performance" based assessments define the most common program evaluation options. The National Science Education Standards (NSES) recommends the following steps for the development of authentic assessments:

1. Select the object you wish to evaluate
2. Choose a key skill outcome
3. Select the content area
4. Write a behavioral objective
5. List materials needed

6. Determine any necessary safety precautions
7. Develop question for each task
8. Write directions that are clear and concise
9. Use graphics to illustrate the setup
10. Check the reading level of the directions
11. Develop scoring procedures using a complete, concise rubric
12. Conduct a trial of the assessment

Performance indicators may include the following:

- Following directions
- Measuring and recording data
- Planning
- Elegance of approach
- Evidence of reflection
- Quality of observation
- Behavior in the face of adversity
- Skills for success behaviors

Portfolios

Portfolios log activities and accomplishments, present projects on which students have been working, contribute to the development of career social skills, and by providing the student's own representation of work accomplished, provide feedback on individual strong points. Because each phase of portfolio development provides a snapshot look at the quality of each student's work, students and teachers should agree on the desired content during CSLP program development, which goals will suggest what things will represent associated achievements worthy of inclusion in the program book. Issues to be resolved during the specification of the portfolio include the following:

- What is required?
- How will items be selected?
- Will the portfolio contain the best work or all work in progress?
- Where will the portfolio be stored?
- How much material will be kept in the portfolio?
- How often will the data be gathered?
- When will the portfolio be reviewed?
- Who will review the portfolio?

Portfolios can contain a wide range of information. Concept writings, drawings, diagrams, summary reports, or self-evaluations.

Reports

It is an old standard frequently attacked as culturally biased, potentially individually devastating, and altogether inaccurate with regard to indicating either levels of achievement or capability associated with any given individual or team; however, well written reports remain a standard for classroom and professional career evaluation as well as the wholesale evaluation of projects and programs of all kinds. For the purposes of CSLP program assessment, formal student reports may contain achievement logs, descriptions of activities and their purposes, program statistics, progress summaries, and project diagrams and illustrations. The assessment plan for reports may include the following:

- What is required?
- What will the report look like?
- How many pages?
- What material will be in the report?
- When will the report be submitted?
- Will there be opportunities for review and re-submittal?
- Who will grade the report?

Peer Review

Every business is show business. For schools, CSLP programs provide an extraordinary opportunity to develop presentations for peer education and review as well as community outreach. CSLP presentations developed for peer review cover student projects, highlight milestones, and bring to light project issues and implemented or potential solutions. They may also use multimedia techniques and technologies to captivate audiences, thereby providing another avenue for the further development of high tech student skills. Issues covered in the assessment plan for peer reviewed presentations may include the following:

- What is required?
- What will the review cover?
- How long will the review be?
- What types of multi-media equipment will be available?
- When and where will the review be held?
- Who will attend?

- Will there be an opportunity for a dry run?

Measurements

The big picture of how individual adjustment, education, and career mesh over a lifetime may ultimately not be a quantifiable; such personal factors lend themselves in their totality much more to the work of entertainers, politicians, and pundits; however, small parts of that picture, including knowledge and skills picked up through participation in CSLP programs may well be measurable and useful for the purposes of program assessment. Key issues to address during a CSLP project development phase include the following:

- What measurements will be taken?
- How often will the measurements be taken?
- How will data be represented or displayed?
- What is the criteria for successful accomplishment levels?

Teacher Evaluations

CSLP program teacher-facilitators encourage the spirit of student inquiry and the development of individual interests, skills, and talents. As such, assessment criteria should be keyed to further developing instructional techniques that inspire student initiative, individual and team project responsibility, and the appreciation of processes associated with scientific study and the development of new technologies.

Suggestions for teacher evaluations are:

- Log "lessons learned" during project review periods;

- Maintain open communications with parents, partners, peers, and school leaders for comments, insights, and constructive suggestions;

- Study successfully completed student tasks for keys that may be applied to the inception and development of other project objectives and tasks;

- Survey students for their impressions and TQ feedback with regard to opportunities for improvement.

Standard evaluative criteria for contracting may well apply to the art of the CSLP program instructor: "responsive" and "responsible" program management geared toward achieving overall CSLP goals ought ultimately provide the yardstick for the instructor's efforts.

CSLP Program Evaluations

Levels of funding, the character of volunteer support, contributions of technology, the demands made on students and teachers, and the character of the community outreach portion of the program are all influenced by CSLP program evaluations. Certain numbers, including the number of participating students, volunteer hours expended, outreach presentations completed, and so on, will tell part of the story. Other measurements, such as the match between a CSLP program timeline and the actual achievement of program milestones, will tell another part, as will data associated with individual student achievement. Survey and testimonial data—e.g., what school peers and principles have to say about the installation of a specific CSLP program—will also contribute to an accurate image of the program effectiveness as a teaching element and its impact with regard to building community-wide science literacy.

Learning Plan

As noted (and at risk of repeating it ad nauseam), teacher-facilitators encourage initiative and responsibility on the part of participating students throughout the CSLP program development, management, and review process. Toward that end, the student-owned space science projects respond directly to individual student proclivities—students essentially create for themselves, individually and as teams, their own path for growth. What responsive teacher-facilitators must have at hand are forms of activities into which those interests may be specifically channeled within the context of the overarching CSLP program vision. Activity options already established in existing CSLP program include the following:

- Data collection and analysis associated with the progress of live NASA Small Explorer (SMEX) satellite missions;
- Historical research focused on specific NASA missions and programs;
- Newsletter development;
- Web site development;
- Spacecraft model building.

The frames noted are merely examples. There are no limits to the focus of CSLP mission statements and the resulting configuration of program personnel and technical resources students, teachers, and volunteers.

Develop a Framework of Yearlong and Short Term Goals:

An objective is an end; a goal is an accomplishment in service to an objective; a strategy represents a set of actions that taken together will accomplish a goal; and a task is an action undertaken in service to a strategy: In descending order of their contribution to the achievement of a vision—as defined by a mission statement—they may be listed as follows:

- Objectives
- Goals
- Strategies
- Tasks

CSLP project blueprints start with the development of a mission statement supported by several mission goals in turn supported by strategies that define in concrete terms the tasks that when accomplished will achieve the goals and contribute to the fulfillment of the mission. The process of defining goals, establishing strategies, and setting schedules for the accomplishment of tasks may consume a significant amount of time. Nonetheless, good work in planning improves everyone's chances for getting what they most want out of the program—a successful mission and the attendant improvements in personal knowledge, skills, and abilities that accompany it.

Note: a new trend in industry is to produce the "visual workplace," where goals, strategies, tasks, and progress reports are posted and can be seen daily by all employees.

Class Design

Teacher-facilitators control the apportionment of time for planning, project task fulfilling activities, team meetings, volunteer visits, and outreach presentations. In Laurel, Maryland, Laurel High School's CSLP project includes visits from volunteers (to brief students on spacecraft operations) on Tuesdays and Thursdays with students working on their tasks on Mondays, Wednesdays, and Fridays. When the volunteers are not available, either the students or the CSLP teacher provide a demonstration, presentation, or talk on a related topic.

Select Projects and Content

Individual student attributes determine the characteristics of specific CSLP program installations. Affective development, inclinations, maturity, and motivation contribute to the degree of complexity and difficulty to be posed by each project's mission statement; whatever is lacking in the way of individual student ability will be lacking as well when those students are part of a team. With luck, teacher-facilitators and the key students who produce enthusiasm for the kind of opportunity CSLP represents will gather a well-rounded group possessing separately traits that tend to balance and complement one another.

CSLP projects need not by limited by the length of a semester or even the time available in a school year—the adult notion of building a platform for succeeding generations applies, and student projects may be undertaken with the knowledge that they will soon become a part of a legacy available to unknown others. However, the perception of accomplishment and resulting good feelings and good will depend on being able to develop something concrete for the limited engagement each participant—student, teacher, or volunteer—has with the program. For that, students and teachers may want to establish project milestones for each month or semester of work.

The World Wide Web

The world's library—i.e., the World Wide Web—provides an outstanding resource for CSLP program curriculum development. CSLP's own site, in fact, provides links to available scholarships, participating partners, CSLP projects, and enough associated education industry and space science sites to consume a career. Teacher-facilitators will appreciate the web for the stimulation of ideas and improved awareness of available resources; students will come to appreciate it for the development of research and critical thinking skills as well as the compilation, winnowing, and presenting of information in *meaningful ways* requiring just such skills.

Note: as with all adult libraries, opportunities for play abound on the "'Net"; however, that characteristic provides students with an opportunity to 1) set their own standards for appropriate use of the web while engaged in project activities, and 2) link those standards to productivity goals—e.g., visits to and reports on each of the national laboratories, space flight centers, key university departments, etc.

Resources

The life of the mind is not engaged solely with mind itself but with all things external to it. With the exception of departments of philosophy, and these days, they may not even meet the "bed and bowl" standards of medieval monasticism, modern education requires sophisticated accouterment, information, and instrumentation—to list but a few items:

- Administrative support
- Classroom space
- Communications and computing equipment and space
- Publishing and presentation technology
- Teacher-facilitators and volunteers
- Textbooks, Internet access, and other electronic and traditional library resources
- Transportation (for community outreach presentations)

Access to advanced knowledge, computer communications, and exotic engineering equipment may contribute to the appeal of CSLP programs. While wireless communications may be on its way and satellite television a part of the rural den from Appalachia to Alaska, few students on the planet will ever have a direct tie-in with a NASA satellite program and first-hand knowledge of space technologies and scientific breakthroughs.

Teachers interested in developing for students a first class space science library enjoy a wealth of government and industry sponsored information sources. NASA education offices may provide lists of potential classroom activities for students, documents on NASA programs and space science projects, and educational CD-ROM's, videos, and software. CSLP's own web site provides updates to its advice on curriculum development. Other resources:

- Businesses in the community, especially computer-driven ones that keep current with new technology and junk, sell, or surplus their old machines;
- Computer museums, museums of science and technology, science centers;
- Contractor laboratories contributing to NASA science and technology missions;
- University departments in the school's locale.

Chapter 7. Program Development In Depth

Program Planning

CSLP started as a volunteer program when NASA and ATSC employees visited their hometown high schools and established afternoon space science clubs. As the clubs took hold, integration into the school's curriculum became possible, and dedicated classroom programs were created. Today, as a funded national program, "full up" installations are possible from the start and both schools and the CSLP office are becoming experienced with establishment plans.

To establish curricula, many CSLP programs have worked through a three month planning stage followed by a proof-of-concept period. The pace of development is really set by the students, their level of commitment and enthusiasm, their availability in numbers, and, inescapably, the direction of their interests and talents. It remains perfectly fine to incorporate CSLP program resources into a "CSLP Light" or related extracurricular club-type program. Regardless of the final form of CSLP program adoption, the following steps provide the backbone structure for getting started:

A. Planning Period

1. Produce approach to developing a CSLP program
2. Produce initial set of projects and activities
3. Develop a facilities plan
4. Develop training plan

B. Proof of Concept

1. Demonstrate feasibility
2. Discover unknown challenges
3. Discover ways to improve the original plan

Program and Content Standards

Science Education Science Standards (NSES) should be kept in mind throughout the program development period. They are reprinted here for guidance:

Program Standard A—All elements of the K-12 science program must be consistent with the other National Science Education Standards and with one another and development within and across grade levels to meet a clearly stated set of goals.

- In an effective science program a set of clear goals and expectations for students must be used to guide the design, implementation, and assessment of all elements of the science program.
- Curriculum frameworks should be used to guide the selection and development of units and courses of study.
- Teaching practices need to be consistent with the goals and curriculum frameworks.
- Assessment policies and practices should be aligned with the goals, student expectations, and curriculum frameworks.
- Support systems and formal and informal expectations of teachers must be aligned with the goals, student expectations and curriculum frameworks.
- Responsibility needs to be clearly defined for determining, supporting, maintaining, and upgrading all elements of the science program.

Program Standard B—The program of study in science for all students should be developmentally appropriate, interesting, and relevant to students' lives; emphasize student understanding through inquiry; and be connected with other school subjects.

- The program of study should include all of the content standards.
- Science content must be embedded in a variety of curriculum patterns that are developmentally appropriate, interesting, and relevant to students' lives.
- The program of study must emphasize student understanding through inquiry.
- The program of study in science should connect to other school subjects.

Program Standard C—The science program should be coordinated with the mathematics program to enhance student use and understanding of mathematics in the study of science and to improve student understanding of mathematics.

Program Standard D—The K-12 science program must give students access to appropriate and sufficient resources, including quality teachers, time, materials and equipment, adequate and safe space, and the community.

- The most important resource is professional teachers.
- Time is a major resource in a science program.
- Conducting scientific inquiry requires that students have easy, equitable, and frequent opportunities to use a wide range of equipment, materials, supplies, and other resources for experimentation in direct investigation of phenomena.
- Collaborative inquiry requires adequate and safe space.
- Good science program require access to the world beyond the classroom.

Program Standard E—All students in the K-12 science program must have equitable access to opportunities to achieve the National Science Education Standards.

Program Standard F—Schools must work as communities that encourage, support, and sustain teachers as they implement an effective science program.

- Schools must explicitly support reform efforts in an atmosphere of openness and trust that encourages collegiality.
- Regular time needs to be provided and teachers encouraged to discuss, reflect, and conduct research around science education reform.
- An effective leadership structure that includes teachers must be in place.

Program Content Example

Sample Course Description

This year long course builds the skills for success required for individuals to be successful in their future careers. This program uses hands-on activities, professional partnerships, out-reach programs and direct involvement with government and industry to motivate students to develop learning, thinking, communication, technical, and workplace social skills. This course helps students interested in space science and satellite design and generally encourages students to work on a variety of projects even though they may be interested in other career channels. This program is especially of value to students who plan on pursuing careers in the computer, mathematical, and physical sciences and or engineering. Students will use engineering methods, materials and team-building skills; they will deal with mechanical, structural, power, telemetry, tracking, command and communication, attitude control, and thermal satellite subsystems. Students will also work with computer software and the Internet.

In this program, students will not be instructed specifically on how to complete particular project tasks. They are required to take responsibility for their own educational experience and develop their projects themselves. The course will take the students through the thought and development process of planning, researching, coordinating, implementing, problem solving, evaluating, adjusting and completing an advanced objective. Students will be provided the flexibility to select projects that best match their capabilities and interests. They will be required to demonstrate their accomplishments throughout the course as scheduled in a contract between the teacher and student.

A simple build-out of the course description might include the following:

- Mission statement
- Class goals and educational outcomes
- Units of Instruction
- Curriculum abstract

While CSLP programs focus on the grooming of advantageous skill sets that go hand-in-hand with the development of knowledge, programs must nonetheless remain consistent with National Science Education Standards for levels 9 through 12, as listed below:

Content Standard A—Science as Inquiry: As a result of activities in grades 9-12, all students should develop:

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

Content Standard B—Physical Science: As a result of their activities in grades 9-12, all students should develop an understanding of:

- Structure of atoms
- Structure and properties of matter
- Chemical reactions
- Motions and forces
- Conservation of energy and increase in disorder

- Interactions of energy and matter

Content Standard C—Life Science: As a result of their activities in grades 9-12, all students should develop understanding of:

- The cell
- Molecular basis of heredity
- Biological evolution
- Interdependence of organism
- Matter, energy, and organization in living systems
- Behavior of organisms

Content Standard D—Earth and Space Science: As a result of their activities in grades 9-12, all students should develop an understanding of:

- Energy in the Earth system
- Geochemical cycles
- Origin and evolution of the Earth system
- Origin and evolution of the Universe

Content Standard E—Science and Technology: As a result of their activities in grades 9-12, all students should develop:

- Abilities of technological design
- Understandings about science and technology

Content Standard F—Science in Personal and Social Perspectives: As a result of their activities in grades 9-12, all students should develop understanding of:

- Personal and community health

- Population growth
- Natural resources
- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

Content Standard G—History and Nature of Science: As a result of their activities in grades 9-12, all students should develop understanding of:

- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

Science Education Systems

Below are the National Science Education Standards for Science Education Systems. They provide criteria for judging the performance of the components of the science education system responsible for providing schools with necessary financial and intellectual resources.

System Standard A: Policies that influence the practice of science education must be congruent with the program, teaching, professional development, assessment, and content standards while allowing for adaptation to local circumstances.

System Standard B: Policies that influence science education should be coordinated within and across agencies, institutions, and organizations.

System Standard C: Policies need to be sustained over sufficient time to provide the continuity necessary to bring about the changes required by the Standards.

System Standard D: Policies must be supported with resources

System Standard E: Science education policies must be equitable.

System Standard F: All policy instruments must be reviewed for possible unintended effects on the classroom practice of science education.

System Standard G: Responsible individuals must take the opportunity afforded by the standards-based reform movement to achieve the new vision of science education portrayed in the Standards.

Chapter 8: Facilities

In addition to classroom or meeting space, some participating schools have developed dedicated CSLP facilities. The two most typical models are the Mission Monitoring System (MMS), and the Space Awareness Center (SAC).

In MMS control centers, students use computers and telecommunications equipment to receive and process satellite data as well as observe their chosen satellite in orbit. MMS computers have also functioned as interactive tutors, teaching students about satellite and ground system and related space science topics. The computers have also supported desktop publishing projects (e.g., newsletters, web site development, outreach presentations, etc.).

SAC combined display, library, and museum-type spaces provide students with space-related books, mounted images, and models that promote awareness of space industry history and current missions. SAC's have been used to host CSLP outreach events, including press briefings for spacecraft launches.

Suggested Specifications for School-Based Mission Monitoring Systems

Mission Monitoring Systems (MMS) in schools may contain the following elements:

A. Computer Equipment

1. Apple Macintosh Series computers (II, Iix, SI, LC, Power Mac) or better (2 minimum)

- 15" to 21" color monitors
- 16M RAM (minimum) each
- 270M Hard Drive (minimum) each
- 3.5" external disk drive
- Access to World Wide Web
- CD-ROM
- Color Printer (HP DeskJet recommended) (1 networked)
- Networking cables

2. PC: (Required for STK software only)

- Memory. & Disk Space: 16MB RAM; 50 MB Hard Disk; Win 95; or
- 32 MB RAM; 75 MB Hard Disk; Win NT

- Screen Resolution: 1024x768 min, 1280x1024 recommended

- Platforms: Windows 95, Windows NT, or X-Windows
- CPU: Pentium 100 Class

- Media: CD-ROM

For X-Windows:
Memory. & Disk Space: 32MB RAM, 50MB Hard disk or 32 MB RAM, 100MB Hard Disk for all products

Screen Resolution: 1024x768 min, 1280x1024 recommended

Platforms: SUN Sparc 2 or above, SGI Indy or above
DEC Alpha AXP, HP 9000/700, IBM RS/6000 Processor

Media: CD-ROM

B. Software

- Communications (Internet, FTP, Gopher)
- Data base, system management and administration
- Newsletter development
- Plotting and trending of spacecraft engineering data
- Presentation development
- Satellite design
- Training
- Video editing and playback

C. Office Products

- 5 boxes 3.5" diskettes (to start)
- Answering machine
- Bookshelves
- Chairs
- Diskette holder
- Dry eraser and cork Bulletin boards

- Phone line for modem connection
- Tables

Suggested Specifications for School-Based Space Awareness Center

Part conference center, display case, library, and presentation facility, Space Awareness Centers support student outreach projects, individual study, and general project development activities. Below are a few of the elements that have been built into such centers:

A. Weather Station

Automated Weather Source:

http://www.awa.com/

Two options: Option one includes access to a school station. Option two is to use Automated Weather Source software to access sophisticated weather sites on the World Wide Web.

B. Library

- Books, CD's, journals, videos
- Bookshelves
- Tables and chairs

C. NASA Select TV

Direct connection with narrowcast of major NASA events and space programs.

D. Display Space

E. Video Room

A Note from a CSLP Volunteer

The following note from Ken Griffin, a CSLP volunteer, provides insight into why space engineering and science professionals lend their valuable time to high school students involved in CSLP programs.

> "I guess the real question is why do so many people work so hard to create and maintain a program such as CSLP. There are obviously as many reasons as there are volunteers, but I will give you one: the ATSC and NASA volunteers who come to your schools are what you might call the second generation of space pioneers. The first generation put humans into space and eventually on the Moon. My generation concentrated on exploring Earth and near space, but also on building the aerospace infrastructure. But I think its going to be the third generation, your generation, which is going to have all the real fun.
>
> "I believe you will put humans back on the Moon, permanently. You will complete and operate the first permanently occupied space station. You will exploit the emerging technology to clean the air and water, to feed 10 people where one can be fed now, and to create medical breakthroughs which can only be dreamed of today. You will also be the first generation which will routinely travel on transcontinental shuttles above the Earth's atmosphere. And you will go to Mars, and to Europa, and perhaps even beyond. You CSLP students have the unique opportunity to be the leaders in the inevitable technical and cultural evolution which will take shape over the next four decades. So, perhaps a little selfishly, we do what we do because we understand how vital your leadership will be to the successful continuation of our own life's work. So welcome, please take full advantage of the opportunities, and, above all, have fun!"
>
> Ken Griffin

APPENDICES

APPENDIX A: Abbreviations

Abbreviation Description

ATSC—AlliedSignal Technical Services Corporation
CSLP—Cooperative Satellite Learning Project
GSFC—Goddard Space Flight Center
NASA—National Aeronautics and Space Administration
MMS—Mission Monitoring System
NSES—National Science Education Standards
SAC—Space Awareness Center
SAMPEX—Solar Anomalous Magnetosphere Particle Explorer
SMEX—Small Explorer Satellite
TBS—To Be Supplied

APPENDIX B: References

Kinlaw, Dennis C . (1992) Continuous Improvement and Measurement for Total Quality: A Team-Based Approach. Pfeiffer and Company, pg. 27, 98.

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APPENDIX C: SAMPLE PROGRAM IMPLEMENTATION

Program guides such as this one shape but do not represent curriculum—every school has a unique set of resources; every teacher has a unique teaching style; and the Core Student Groups for whom CSLP programs work will bring to their chosen projects their own set of individual and group abilities, skills, and talents. Consequently, our program guide provides principles rather than prescriptions for the development of CSLP programs. Insight into the application of CSLP principles may be obtained by studying an example of a CSLP program implementation. What follows is a course curriculum developed and submitted by Dr. Carol Miglin for the Old Bridge Township Public Schools in Old Bridge, New Jersey.

Dr. Carol Miglin's Cooperative Satellite Learning Project

Philosophy

The Cooperative Satellite Learning Project (CSLP) is an elective science course for students who have an interest in space science and satellite deign. It is of value to students who plan on pursuing careers in the computer/mathematical and physical sciences and/or engineering fields. It is also of value to students who are interested in other careers and want to learn in a real world setting. The course is project driven.

The CSLP curriculum is designed to provide students with a learning atmosphere that is a step beyond science as a process in which students learn skills such as observing, inferring, and experimenting. It also involves the science of inquiry including asking questions, planning and conducting an investigation, using appropriate tools and techniques, thinking critically and logically about the relationships between evidence and explanations, and communicating scientific arguments.

This learning atmosphere also involves a partnership with business, government, education, and the community.

UNIT I Introduction

A. what is CSLP
B. History of CSLP
C. Overview of program

D. History of the Space Program

UNIT II Introduction To Work Environment

A. Total Quality Control
B. Group Skills
C. Team Building

1. Small, class groups
2. Large groups

UNIT III The Environment of Space

A. The Solar System

1. The Sun
2. The interplanetary Space
3. The Terrestrial Planets
4. The Jovian Planets
5. Inferior and Superior Planets
6. Asteroids, Comet and Meteorites

B. Earth and its Reference System

1. Terrestrial Coordinates
2. Rotation of Earth and Precession of the Earth Axis
3. The Celestial System
4. Right Ascension, Declination, and Related Terms
5. Time Conventions

C. Earth System Science Related to Space System Science.

1. Electromagnetic Phenomena
   a. Ultraviolet and infrared light - effects on matter
   b. Doppler Effect
2. Relationship between heat, light and color
3. Contour maps and physical relief maps
4. Remotely sensed images - match earth locations

D. Gravitation and Mechanics

1. Ellipses
2. Newton’s Principles of Mechanics
3. Acceleration in Orbit
4. Kepler’s Laws
5. Gravity Gradients and Tidal Forces

E. Interplanetary Trajectories

1. Hohmann Transfer Orbits
2. Gravity Assist Trajectories

F. Planetary Orbits

1. Orbital Parameters and Elements
2. Types of Orbits

UNIT IV Space Flight Projects

A. Overview of mission inception

1. Conceptual Study
2. Phase A: Preliminary Analysis
3. Phase B: Definition
4. Phase C/D: Design and Development
5. Operations Phase
6. Design Considerations - budget, Tracking, etc.

B. Experiments

1. Gathering Scientific Data
2. Science and Engineering Data
3. Radio Science
4. Gravity Field Surveys
5. Dissemination of Results

C. Spaceship Classification

1. Flyby Spacecraft, Orbiter Spacecraft

2. Atmospheric Probe Spacecraft
3. Atmospheric Balloon Packages
4. Landing Spacecraft
5. Surface Penetrating Spacecraft
6. Surface Rover Spacecraft
7. current Flight Projects and Flight Projects being studied

D. Student Project Groups Begin to Design a Mission and do all other assigned projects

UNIT V Space Flight Projects

A. Telecommunications

1. Signal Power
2. Uplink and Down link
3. Modulation and Demodulation
4. Multiplexing and Coherence

B. Subsystems

1. Data Handling Subsystems

   a. Spacecraft Clock
   b. Telemetry Packaging and Coding
   c. Data Storage
   d. Fault Protection

2. Attitude and Articulation Control Subsystems
3. Telecommunication Subsystems

   a. High-Gain, Low-Gain, and medium-Gain antennas
   b. Spacecraft Transmitters and Receivers

4. Power Supply and Distribution Subsystem

   a. Photovoltaics
   b. Electrical Power Distribution and Power Storage

5. Environmental Subsystems

   a. Passive Cooling, Active Heating
   b. Micro-meteoroid Protection
   c. Jovian Radiation

6. Propulsion Subsystems
7. Pyrotechnic Subsystems

C. Typical Science Instruments

1. Science Payload
2. Direct and Remote Sensing Instruments
3. Active Sensing Science Instruments

D. Spacecraft Navigation

1. Data Types
2. Spacecraft Velocity, Distance and Angular Measurements
3. Optical Navigation
4. Orbit Determination
5. Trajectory Correction Maneuvers

E. Student Project Groups continue to design their mission and do all other assigned projects

UNIT VI Space Flight Operations

A. Launch Phase

1. Launch Vehicles
2. Launch Sites
3. Launch Windows

B. Cruise Phase

1. Spacecraft Checkout and Characterization
2. Real-time Commanding
3. Typical Daily Operations
4. Preparation for Encounter

C. Encounter Phase

1. Flyby Phase
2. Planetary Orbit Insertion
3. System Exploration and Planetary Mapping
4. Occultation
5. Gravity Field Surveying

6. Atmospheric Entry and Aeobraking
7. Landing
8. Balloon Tracking

D. Extended Operations Phase

1. Completion of Primary Objectives
2. Additional Science Data

E. Students Continue to Design Mission and do all other assigned projects.

UNIT VII Astrobiology and Student Projects

A. Student Projects

1. Completion of Mission Design
2. Building a small scale model of spacecraft for mission
3. Newsletter Project - Monthly Basis
4. Space Science - Current science data - bimonthly
5. Space Awareness - current space news—bimonthly report
6. Flight Operations - Daily Flight Operations Report
7. MAP Satellite - construction, mission, instruments, et
8. Model Rocket Group - learn and demonstrate basic rocket design.
9. Outreach - All students participate - other schools, community etc.

B. Astrobiology

1. Formation and evolution of habitable worlds
2. Emergence of living systems
3. Recognition of other biospheres
4. The relationship between biological evolution and the development of planetary environments
5. The response of ecosystems to environmental changes on time scales relevant to human

civilization
6. The potential for survival, adaptation, and biological evolution beyond the home planet.

I. COURSE DESCRIPTION

Grades 11 and 12
Elective

This year-long course is for students who have an interest in space science and satellite design. It is of value to students who plan on pursuing careers in the computer/mathematical and physical sciences and/or engineering fields. It is also of value to students who are interested in other career choices and wish to learn in a real world setting.

This course involves a partnership with business, government and education. Students will listen to lectures, and have the opportunity to speak with scientists, engineers, accountants, astronomers, astronauts, etc. There will be a conference in the fall every year. Students come from high schools in surrounding areas. Students will be involved in collecting real data from a flying satellite and helping to interpret this data. Students will be grouped in project teams and work on many projects. They will set their own goals and timetables and operate as project teams do in the real world.

Students will use engineering methods, materials and information to study a specific NASA satellite mission. Instructional, problem-solving and team building experiences will deal with satellite subsystems - power, telemetry, tracking, command and communications, attitude control and thermal.

II. PROFICIENCIES

The students should be able to gain and demonstrate practical knowledge, awareness and understanding of:

1. Significant past and present contributions of individuals and cultures to the accumulations and advancement of scientific theory, principles and technology in the space program.

2. Significant past and present contributions of individuals to the accumulations of knowledge about the CSLP program

3. The skills used in cooperative learning and working in project groups and working with the Total Quality program to help prepare students for the future work force.

4. The skills used in supporting students learning through outreach projects.

5. The environment of space including the solar system, Earth and its reference system and how Earth system science relates to space systems science, gravitation and mechanics,, interplanetary trajectories and planetary orbits.

6. An overview of mission inception including conceptual study, preliminary analysis, design and development, operations phase and design considerations.

7. Experiments including scientific data, science and engineering data, and radio science.

8. Spaceship classification including flyby spacecraft, orbiter spacecraft, atmosphere probe spacecraft, atmospheric balloon packages, landing spacecraft, surface penetrating spacecraft, etc.

9. Telecommunications including signal power, uplink and downlink, etc.

10. Subsystems on a spacecraft including data handling, attitude and articulation control telecommunication, electrical power supply and distribution, environmental, propulsion and pyrotechnic.

11. Payload on a spacecraft including direct and remote sensing instruments and active sensing science instruments.

12. Space flight operations including launch phase, cruise phase, encounter phase and extended operations phase.

13. Skills used in their various projects including model building, newsletter, MAP satellite, flight operations on ACE, etc.

Actual CSLP program implementations do not lend themselves to generalizations. Each is in its own way as ambitious, comprehensive, and stimulating as its participating students, teachers, and volunteers.

APPENDIX D: Group Projects Menu

Inspire your students. This appendix provides a collection of projects on which CSLP students have already worked. None of those listed contain sufficient detail for immediate implementation—whatever the mission, the students themselves will have to plan it. Project divisions include the following:

- Communications
- Hands-on Activities
- Outreach

Note: workbooks, where specified, may be downloaded off of the CSLP homepage at the following address:

http://joy.gsfc.nasa.gov/CSLP/home.html

Communication Projects

Through communication projects, students develop the writing and Information Technology (IT) skills associated with a variety of information and presentation formats. A few of the formats and technologies in current production or use by CSLP participants include the following:

- CU-See Me Live Information Exchange
- Homepages
- Newsletters
- Video Productions

Cooperative Satellite Learning Project
Program Guide

Activity Name: Newsletters

Objective: Newsletters inform the school body, local businesses, and the community at large about CSLP program projects. Students who produce newsletters obtain the following benefits:

- Enhanced creativity and problem solving abilities;
- Improved computer and information technology skills;
- Improved discipline under deadline and within group monitored projects;
- Improved organization and team participation skills;
- Strengthened editing and writing skills.

Time Requirement: The time spent by newsletter teams on each issue depends on the size of the newsletter and number of issues planned.

Prerequisite Skills: Fundamental writing skills plus basic competency with graphics and word processing software.

Materials: Access to a word processing and graphics program (e.g., MSWord, PageMaker, Claris Draw, etc.) plus some means for printing and distributing the newsletters.

Preparation: Students need to form a team and assign the following positions:

- "Ads" person—when advertising is part of the newsletter, the ads person—i.e., advertising account executive—develops sponsors and shepherds each advertisement through the sales and publications process.

- Distribution Team—this team distributes the newsletter by handing it out, putting it in the mail, dropping it at a popular school location, posting it to a web site, or circulating it via e-mail.

- Editor—the editor assigns and reviews articles and is responsible for the make-up or layout of the newsletter.

- Graphic Artist—the graphic artist supports newsletter design and illustration needs, often using a combination of computer and hand tools to do so.

- Printing Team—this team manages the newsletter's press run, which includes meeting all printing, folding, and sorting requirements.

- Readership Team—the readership team gathers and maintains the newsletter's circulation lists, adding new records as they acquire them and retiring old one as they become outdated.

- Writers—writers investigate stories and produce the copy for news items and feature articles.

Procedure:

1. Schedule and hold group discussions. The team needs to work out details, including the format of the newsletter, its page count, the kind of articles it will contain, the length of news announcements, reports, and feature articles, the overall design and look of the publication, its potential advertisers and sponsors, its target readership, the tools to be applied to its production and distribution, etc.

2. Develop the production timeline. Given some decisions about the length of the newsletter and the frequency of its distribution, how much time should each take from the assignment of articles to the print run and subsequent distribution? From the business perspective, how many advertisers or sponsor dollars should be obtained over the term of the project at each stage of growth or production?

3. Determine how to build the readership. While the readership team is responsible for the work, the entire newsletter team should contribute to policies affecting the makeup and size of the target audience. How will the newsletter be advertised or promoted to those readers? Will the readers themselves have an opportunity to provide the newsletter with feedback (e.g., letters to the editor)? How will volunteers or interested parties outside of the community obtain the newsletter? Will newsletter reportage be coupled with press releases to community newspapers? Will their be a charge for the newsletter? An old NASA saying is, "If you look at a picture and think you've seen it, you haven't looked long enough." The same may be said of simple newsletter management questions. The mission is only deceptively simple, and issues pertaining to newsletter development and distribution will affect the quality of the newsletter activity as well as processes somewhere else in the CSLP program.

4. Assign tasks. Look at the list of jobs. Is your newsletter going to require all of them, and are there any tasks which should be added. Assign tasks to individuals. Make sure everybody knows their assignment and the deadline for meeting their responsibilities.

5. Implement the program—i.e., go to work; modify the newsletter development plan as needed.

Conclusion:

Producing a newsletter means confronting a range of human and technical production issues and obstacles, which makes it a very good exercise for developing skills relevant to the modern work place.

Cooperative Satellite Learning Project
Program Guide
Activity Name: Homepages

CSLP students at Woodlawn High School in Baltimore are building a web site around a satellite and its subsystems: the top web page is a picture of the spacecraft with imbedded links to each of its parts. The concept is simple but challenging, and it requires, if it is going to be done well, a combination of good computing, graphic design, and writing skills.

Posting pages on the World Wide Web has already become one of the 21st Century's common skills. Academic, business, and personal sites have come to number in the millions as the global village transforms itself into an electric commons. CSLP programs that include web site development projects provide an excellent platform for the development of HTML (HyperText Markup Language), computer graphics, photography, and solid writing and presentation skills. Such web sites may be developed along "intranet" lines, enabling team members to stay on top of projects by checking progress reports posted at the site, or designed for community outreach, providing public information on CSLP accomplishments, upcoming events, and personnel.

Objective: Develop web site publishing skills using HTML, graphic design software, good writing skills, and associated presentation development abilities.

Time Requirement: Webs sites are living magazines with open-ended life spans.

Prerequisite Skills: Ability to learn about HTML and discipline to adhere to HTML scripting protocols.

Materials: Computer, ASCII text editor (minimum), HTML editing software, Internet access.

Preparation: Basic knowledge of HTML and basic web site design options.

Procedure:

1. Decide what you would like the page to look like.

- What content do you wish to develop for the web site?
- What kinds of graphics will you include?
- Will you make the page interactive?
- How many levels deep will the site be?

2. Surf the web for ideas as well as HTML specifications (they're posted) and web site development shareware or beta releases (i.e., free) of emerging web site editing software. Also collect books on web site development.

3. Pull the content elements together (texts, graphic arts elements, photographs and other illustrations, even audio content), script a few pages, invite CSLP program participants to review the effort on the resident computer, make changes responsive to the collection of comments, and transfer the files to the Internet server.

4. Over time, improve and update the content, file organization, and page design.

Conclusion: An intranet portion of a web site may be password protected, providing information to those who share the password, and while security techniques in business and government have become appropriately sophisticated, a simple key code for a web site directory may be sufficient to provide Student Core Groups with a similar "in-group" experience in information management; of course, the other side of Internet use is widespread publication: for that, working on a CSLP web site provides an unmatched opportunity to rapidly develop responsible journalism, public relations, and general publishing skills.

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Program Guide

Activity Name: E-Communications

Objective: Students, using e-mail to communicate with businesses, community partners, and other schools, evaluate e-mail client software, develop information organizing methods for developing and tracking "threads" and filing messages.

Time Requirement: Legacy producing process.

Prerequisite Skills: Information organizing and typing skills

Materials: E-mail accounts

Preparation: Assign e-mail accounts.

Procedure: Log on and send your e-mail.

Would the procedure were that simple. In fact, because of the volume criss-crossing the Internet, software selection and the development of adequate e-mail response and management routines has become part of the hidden infrastructure supporting complex project efforts. As with the web site publishing activity, trial software may be downloaded from the World Wide Web and worked with and reported on with the intent of developing a set of good choices or a recommendation for long-term use of the Internet's e-mail capability. E-mail filing and automated filtering, in-line presentation capability, panel presentation, thread-tracking (an e-mail "thread" is an exchange between parties on a single topic or theme), organizational and personal account security, and other issues will confront students as they become familiar with the Internet as a common communications carrier.

Conclusion: E-Communications can be vital to keeping CSLP program participants within and across schools in touch with one another. The exploration of e-mail as a mode of communication provides a unique opportunity for discovering issues and producing evaluations and judgments about software and e-mailing protocols and responsibilities that will affect how those coming into an ongoing CSLP program will communicate.

Activity Name: Video Production

We're living in what some have called the "media age," and, appropriately, several CSLP programs have access to video cameras and editing and playback equipment.

Objective: To produce or contribute to an educational video that may reach a large audience outside of the CSLP program and providing information on both specific CSLP program activities as well as CSLP goals and objectives.

Time Requirement: One semester pre-planning and pre-production (minimum); open shooting schedule spanning months.

Prerequisite Skills: Need to learn about how to work the equipment.

Materials: The equipment varies depending on the school's video lab.

Preparation: Acquire access to video recording and editing gear; produce budget for video supplies—i.e., recording tape, editing software, cleaning supplies, etc.—and secure budget through the standard funding channels or the development of sponsors.

Procedure:

1. Define the specific purpose of the video, its target audience, possible content sources (events, people, technology, etc.), and the aesthetic rules or style (i.e., "the look") to which the producers will adhere in the production and post-production phases of the project. Some of the questions that need to be answered up front include the following:

- Brain-stormed shooting list (including dramatizations, interviews, events coverage, existing footage from multiple sources, etc.)
- Content focus
- Narrator
- Presentation length
- Sub-content sources for the inclusion of animation (if any), music, the presentation of credits, the development of special effects, etc.

2. Pre-Production: script out the video and develop a story board.

The more planning you do, the less energy, money, and time will be wasted across the term of the production process. From the total list of images possible, develop the shooting script—decide specifically what existing footage needs to be obtained, what events need to be recorded, what stories need to be dramatized, what animations or special effects need to be developed, and then decide in what order each of the elements will be produce (the essence of the "shooting script") and where each produced element will be inserted in the final video product (the model provided by the "story board," which is really an assembly of panels representing in comic book form the forward movement of the video). Keep in mind how the final assembly of the video content will work with such background elements as music and editing styles (cross-fades, visual effects for fade-in and fade-out techniques, etc.), the voice-over narrative, and the linear flow of ideas.

3. Assign Production Responsibilities.

Director(s) for scene compilation;
Photography units—camera operators, lighting technicians, audio producers;
Producers—business persons to obtain and manage sponsorships, clear all production issues (site permissions, script approvals, etc.) and plan distribution or presentation events and tactics; artistic or communications persons to oversee the assembly and editing of the final product;
Production Assistants—responsible for completing every specific small task required by the production;
Talent—narrators, actors, and extras;
Theatrical technicians—costume makers, make-up artists, set designers and dressers;

4. Pre-Production: Arrange to Shoot Video

- Obtain permissions for on-location shooting;
- Track and respond to challenges posed by weather;
- For each shot or sequence, arrange for the presence of all on-camera and supporting elements.

5. Production

Obtain in sequence as available, or as developable, all of the audio and visual elements specified by the shooting script and supportive of the story board and overarching stylistic elements contributing to the completed video production.

6. Post-Production: Edit the Production or Production Partial

Depending on the producer's concept and CSLP program objective, a video may consume a few weeks of effort, or several years; however, as with all projects, the process lends itself to the achievement of project milestones. In fact, just getting to production (having funding, tape, shooting script, and the first event at hand) may be considered a significant achievement. In the world of professional documentary and film making, most projects die in pre-production. In any case, the pacing of development is up to the CSLP program team and the availability of content (e.g., launch coverage, CSLP student gatherings at Goddard Space Flight Center, etc.) over time.

Post-production activities include off- and on-line editing, the finalization of video distribution or presentation plans, the review of the total project ("lessons learned") in terms of costs and benefits as well as the dissection of production disasters, if any, and the noting of production triumphs as well as recognition for outstanding contributions and teamwork. Finally, completed projects often lead to the conception of new ones, especially when the development of a project has produced substantial improvements in available technology and skill as well as funding and other social relationships—it only makes sense to "do it again—and do it better."

7. Whatever the milestone, including production completion, schedule the "wrap party"!

Conclusion: The benefits of working on a video project are varied enough to suit a variety of latent student interests. From the project management perspective, few human endeavors require the kind of cooperation, planning, and teamwork that media projects do. The mix of opportunities for classroom "creatives," "techies," "suits," "managers," "sales types," etc. is seldom matched by more narrowly focused activities, and, with the link through CSLP to NASA space science missions, the invitation for all to become involved in the process of science from many satisfying perspectives is unique in American education.

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Activity Name: CU-See-Me

Cornell University's (CU) demonstration of its version of the digital picture phone has become a commonplace if experimental novelty in many settings, including schools exploring the possibilities for video conference via the Internet. CSLP programs adopting CU-See-Me may work with distant volunteers using the same technology.

Objective: Establish a relationship with an industry partner or other CSLP program school who can assign a point-of-contact for face-to-face Internet-based long-distance communications.

Time Requirement: Continuous.

Prerequisite Skills: Because CU-See-Me is in continuous development at the university level, patience will help when in installing and testing the system's hardware and software.

Materials: Requirements: A "Connect cam" (a small camera, usually mounted on a computer monitor), and access to the World Wide Web.

Preparation: Install Connect cam and software.

Procedure: CU-See-Me technology, no less than e-mail, is a common carrier method for personal communications. Creating standards for its use, and, for the purposes of project development, keeping track of CU-See-Me conversations and their outcomes will provide students with a number of challenging issues in information and Information Technology (IT) management.

Conclusion: CU-See Me can be an effective way to communicate with program participants in government, industry, and at other schools. It is expected that CU-See Me in some commercial form will be a common computer utility early in the 21st Century.

Direct Involvement ("Hands On") Projects

CSLP found that having students directly involved in NASA space science missions through such hands-on activities as processing satellite data, building satellite mock-ups, and interacting with government and industry partners enhanced their learning experience and produced a high level of enthusiasm and motivation for academic work. Hands-on activities, defined as such because they require real-time cooperation between NASA program managers, industry volunteers, and the students themselves, include the following:

- Anomalies Activities
- Rocket Program
- Satellite Design
- TRACE Video
- Tracking Video

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Activity Name: Anomalies Activities

The jump from Edgar Allan Poe to Rod Serling to Chris Carter (creator of *The X-Files*) to the CSLP "Anomalies Activities" program is a dot on the line of reality shadowing the work of mystery and science fiction writers. CSLP participants first worked a version of this exercise at the May 1996 student conference, and it proved so popular it could not but be included in this curriculum guide.

Objective: Using a model based on observations of real spacecraft and space missions, students confront a spacecraft anomaly and use their investigative powers to understand the problem and propose corrective solutions. There are no incorrect answers—only good ideas and new paths for exploration.

Time Requirement: Leaders need about a week to prepare the problem; the activity itself requires one or two team hours.

Prerequisite Skills: Good decision making instincts coupled with imagination, knowledge, and logical reasoning.

Materials: Anomalies Activities workbook (available at the CSLP web site).

Preparation: See workbook

Procedure: See workbook

Conclusion: Mystery making, space engineering, and science have become the stuff of many television documentaries and dramas—CSLP puts those elements in the classroom, turns students and volunteers into voyaging detectives and engineers, and by doing so engages each student's natural knowledge-building and problem-solving abilities.

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Activity Name: Rocket Program

Manufacturing, math, poetry, and physics all come together in the CSLP rocket building program. More than propellant-packed tubes, model rockets provide students with an opportunity to apply quality producing craft skills (especially as regards the application of patience to lacquer and sandpaper) side-by-side with the exploration of telemetry and weather, aerodynamic design and propellants, command, communications, and control systems, and the development of new social relationships (siting a model's launch pad involves many factors, including finding ample space, designating a recovery area, producing favorable community relationships, and acting in an environmentally sound manner that NASA site development professionals have faced on a much more complex scale).

Objective: Produce a CSLP launch program involving the 1) design, manufacture, and launch of a rocket, 2) the co-development of a body of knowledge about the rocket, its design parameters and capabilities as well as external weather-related or other physical influences, and 3) the administrative development of a launch site, launch and tracking team, observation unit, and linkage to a community relations or publicity unit.

Time Requirement: Weeks to design and build at minimum two rockets—one for display, reference, and study; the other for launch and recovery.

Prerequisite Skills: exemplary craft skills, including an eye for aesthetically pleasing constructions, patience in assembly and finishing activities, good sense in the selection of propellant and recovery system components, and fair administrative and political skills applicable to obtaining permissions for craft construction, the possession of propellant materials, and the right to launch from a property large enough to support the project.

Materials:

Commercial Off-the-Shelf (COTS) model rocket kits or access to appropriate component elements and materials;

Launching kit, including recovery assistance elements as specified by the launch project team.

Preparation: For basic out-of-the-package commercial rocket building, conduct the following:

- "Reverse engineer" the component systems and obtain reports on what they are and why they were built the way they were—e.g., determine propellant tube circumference, volume, and strength; the basis for propellant chemistry; the history of the skin's decals and coatings; the relationship between tube length and nose and wing design;

- Build a base of knowledge and report on weather, weather systems, environmental hazards, and, from a purely operational perspective, preferred launch conditions;

- Build a predictive model of the rocket's flight path and probable destination under different launch conditions;

- Develop a baseline rocket recovery plan—i.e., determine the equipment needs, number of spotters, and stations that should be assembled for each model rocket launch to make loss of the vehicle improbable—and customize for the actual launch site and launch conditions.

- Following the launch and recovery episode, develop suggestions for improvement in all facets of the model's design, range, and recoverability functions.

Conclusion: As rural hobbies go, model rocket building has long been one of the healthy fresh air escapes available to simultaneously industrious and destructive boys (primarily), and in its marketing as pure and approved as post World War II camping, fishing, and hunting. However, the tradition belies a much more complex political and social reality for urban and suburban high school students—today, even students in rural areas may not have immediate access to land for a rocket launching demonstrations. Moreover, for students interested in all of the variables, social and physical, bearing down on the design, launch, and recovery of true space vehicles, and for volunteers and teachers who have a legitimate purpose in introducing students to adhesives, lacquers, and propellants, the combined administrative, engineering, and scientific challenges may be motivation enough for getting started.

Activity Name: Satellite Design

Several CSLP programs have led to students designing in rudimentary but sensible fashions their own satellites.

Objective: Design a satellite with subsystems responsive to flight and function requirements as understood through the study of current NASA Small Explorer (SMEX) missions.

Time Requirement: Months

Prerequisite Skills: Ability to apply a systems perspective to the study and reverse engineering of existing satellite systems.

Materials: Computer Assisted Design (CAD) software may prove helpful.

Preparation: Select a satellite for study, explore its mission requirements, and study its flight attributes and observation making characteristics.

Procedure:

1. Define your spacecraft's mission:

- Will it observe weather?
- Will it study astronomy? What kind? (i.e. star formation, quasars, planets, nebula)
- Will it study the Sun or Earth?
- Is it a communications Satellite?
- Is it a GPS Satellite?

2. Select an orbiting protocol congruent with the satellite's mission:

- Geostationary orbit?
- Low Earth orbit?
- Circular or elliptical orbit?
- Will the satellite require escape velocity?

3. Develop the requirements document—i.e., the list of things the satellite will have to be able to do:

- How will it receive power (sun, batteries, nuclear fusion)?
- Does it need to point at anything? How accurately? How will you point it?
- How will you control the spacecraft's movement?
- What kind of structure will your spacecraft have?
- What kind of electrical system?
- How will commands be sent to each sub-system?
- Will it require fuel, and how will that be stored?
- Will you need to deploy anything? (solar cells, booms, antennas?)
- Will the spacecraft spin?
- What are the thermal considerations?
- How much can it weigh?
- How much can it cost?

4. Finalize the requirements document and list system and subsystem specifications.

5. Propose a satellite design responsive to all of the requirements and specifications developed.

Conclusion: All sophisticated industrial manufacturing follows the satellite design model—the definition of needs or requirements leads to a set of component specifications, which when assembled should support the final mission objectives. The process, apart from its politics, requires imagination and systematic thinking skills using engineering, math, and physics to produce a physical capability for remote observation. In some ways, satellite design has more to do with photography—i.e., capturing images across the wavelength spectrum using remote, space-based lenses or other radiation-detecting instruments—than with any other human art. The end is an extension of the simple human act of looking at things and testing the interpretation of what we see. As such, CSLP satellite design programs open a window into the limitations and mysteries involved in the art of remote observation, a glimpse at the volumes of intuitive and scientific techniques our species has developed to test the truth of our own perceptions, and a potentially astounding introduction to the extensibility of knowledge through the combined power of conjecture, data receipt, and logic that underlay all empirical processes.

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Activity Name: View the TRACE Video

In the summer of 1997, CSLP program students from two high schools (Laurel in Laurel, Maryland; DuVal in Lanham, Maryland) collaborated on a video about the development of the TRACE satellite. Students interviewed the engineers responsible for the design of the spacecraft and its subsystems as well as many non-engineering professionals whose labors were required to move the project from the drawing board to the launch platform.

Objective: To learn about spacecraft subsystems, and the people who build them.

Time Requirement: 2 sections each about 30 minutes long. Classroom discussion should double the time requirement.

Prerequisite Skills: None

Materials: Video and player

Preparation: None

Procedure: Obtain a copy of the video (see the CSLP homepage for instructions).

Conclusion: The TRACE video provides a good introduction to both project team and satellite design processes by offering a rare glimpse of the people whose day to day efforts transform dreams into solid space science programs and corresponding spacecraft systems.

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Activity Name: Satellite Tracking Video

Subject specialist and CSLP volunteer Dan Junker created with the help of several CSLP program schools a workbook and video covering processes mission managers use every day to track satellites, predict their course, and, when appropriate, apply course correcting strategies. In this exercise, the object of interest is a simple helium filled balloon for which students will learn to predict flight path, elevating rates, position determination, and other aspects of the balloon's airborne sailing mission. In fact, the historical connection between naval, air, and space operations has never been stronger, and the similarities between sailing, flying, balloon tracking, and satellite control may fascinate students for whom objects sailing through space might seem far removed from their earthbound analogs floating in the air or on water.

Objective: To grasp fundamental navigational principles common to air, sea, and space borne objects through the study of balloon behavior and satellite positioning.

Time Requirement: One week of class periods

Prerequisite Skills: Simple algebra.

Materials:

1. CSLP Spacecraft tracking video and workbook (on CSLP homepage);
2. Helium balloons;
3. Tracking equipment (see workbook);
4. Timers;
5. Stop watches;
6. Log Sheets (see workbook).

Preparation:

1. Obtain a copy of the video by either copying it at the Teachers Resource Center at the Goddard Space Flight Center or ordering through the CSLP webs site.

2. Obtain and pass out copies of the workbook to each student.

3. Watch the video. You can stop the video at any time to practice the exercises.

4. Discuss the video and go over each concept again. If you need to, continue reviewing key parts of the video.

5. Practice working the math by doing all calculations on the data in the workbook.

Procedure:

1. Move to a football field and set up the viewing stations (see video).

2. Practice recording data before ever releasing a balloon.

3. Release a balloon and record all the data suggested in the video and workbook.

4. Do the suggested calculations, and plots.

Conclusion: Ship captains of old kept their navigational secrets--and their ship's position--to themselves, a method of ensuring their preservation whatever the mutinous desires of their sailors; certainly, navigation is one of man's oldest, most cherished, and most practical of arts, and this activity, which draws on student talents for observing, plotting, recording, and calculating quickly may produce new enthusiasm for math and physics as well as stimulate the unfettered romance with travel and all things that sail across large open spaces.

Outreach Projects

To learn something well enough to teach it requires equal measures of attention, courage, creativity, curiosity, empathy, insight and plain old fashioned verbal communicating skills. For CSLP outreach team participants, the opportunities to apply those traits in concert with one another and with the additional support of modern presentation technologies—e.g., computer-driven graphic arts, slide shows, and other presentation software—are outstanding. Project kernels CSLP student may wish to build around include the following:

- Build a Satellite Model
- Community Days
- Design a Board Game
- Design Reviews
- Develop a CSLP Activity
- Education Programs
- Orbital Ideas
- Present Hubble Solar System Astronomy
- Press Briefings
- Solar System in an Auditorium
- Write an Activity Workbook

Activity Name: Build a Satellite Model

Many CSLP program participants have already studied specific satellite programs, developed accurate models of the mission spacecraft, and used them in conjunction with more extensive outreach presentation activities.

Objective: Build a satellite model and integrate it into an outreach program presentation.

Time Requirement: Models, when they're well done in every detail, require weeks, months, or years to complete depending on the concept driving the development (some models may be full scale facsimile's of the orbiting counterpart), the kind of building materials required, and the finishing specifications of the project.

Prerequisite Skills: Strong craft and handicraft values, an interest in base materials, adhesives, coatings, and electronics and, especially for models that are part of an outreach presentation program, good foresight and problem solving skills for resolving display, packing, and transport issues.

Materials: Per CSLP student design team specifications, materials and supplies may include everything from balsa wood to scrap metal, from hobby fiber optic cable to small servo motors that operate outboard engines or inboard observation equipment. Budgets, imagination, and project time lines are the only constraints.

Preparation: Select a satellite program for study, build up a library of information about it, and obtain images and any other information that will help reconstruct it as a model.

Procedure:

1. Produce the model development plan, which would include the following:

- Construction budget;
- Construction requirements and specifications for the model as well as associated display and packaging elements;
- Materials list;
- Plans for the model: blueprint and wiring schematics;
- Plans for protective case: blueprint;
- Security plan for protection of the project while under construction;
- Work site designation.

2. Assemble materials and supplies, assign component task teams, if necessary, establish project time line and milestones.

3. Build the model, continuously improving modeling techniques and working through unforeseen problems.

Conclusion: Children, lacking the necessary attention spans, unwilling to return again and again to constructive tasks that are similar to one another, and taking more pride in their efforts than in their results, make poor model builders. However, for high school students, model building, depending on the subject, may become a passion, no less than any other art. Building a satellite in the classroom for later public presentation produces a number of social and technical challenges that many students will naturally engage—model making is an arm of show business, after all—and it will require cooperative concept developing skills, project managing abilities, and interdependent team work for accomplishment.

Activity Name: Community Days

Objective: In a live presentation, have students inform the public about the CSLP program, NASA Small Explorer (SMEX) science missions, and the state of space exploration and technology-producing capability in general.

Time Requirement: Several months.

Prerequisite Skills: Ability to grow every facet of project management and presentation developing skill.

Materials:

- Event site
- Presentation materials
- Supporting audio-visual presentation equipment

Preparation: The project requires substantial lead time and pre-project planning that resolves the following questions:

- When will the event be held?
- Where will the event be held?
- What will the agenda be like?
- Who will be invited? (i.e. parents, partners, local businesses, school board, individuals from a local college or University, etc.)
- Are you going to invite additional speakers?
- What are the costs associated, and how will those funds be raised?
- What teams are required? (i.e. speaker coordinators, fund-raisers, news brief release team, video production, advertisement, linguistics, refreshments team, etc.)
- What were the lessons learned from other CSLP classes?

Procedure: Develop the presentation project plan, its time line and milestones, and related individual and team evaluation criteria; work the plan and produce the presentation event.

Conclusion: A CSLP "community days" program is a little like a cross between the annual show and local science fair—it requires a high level of student involvement and participation; it comes freighted with social expectations involving peers, teachers, volunteers, and parents; and it leaves a lasting impression on students as well as the community, such is the nature of all public displays. For CSLP program participants, the emotional, intellectual, and spiritual rewards are accordingly high. Every student steps out of the shadows to contribute measurably to the success of the day, a powerful quasi-cool thing for all involved.

Activity Name: Design a Board Game

Objective: Develop a board game which teaches younger students about what is in the solar system or any additional subject you choose.

Time Requirement: Several weeks to develop the board game, only a few minutes to play.

Prerequisite Skills: Access to information about the solar system or your particular subject.

Materials: Cardboard and other art construction materials as well as creativity and imagination.

Preparation:

1. Develop information about what is contained in the solar system—remember there is a lot more out there then just the planets.

2. Design a board and game pieces which will make learning about the solar system fun. This can be as simple as just moving from object to object by rolling dice or as challenging as answering questions for points. I have a game which is a lot like monopoly where players can buy planets or moons they land on, build property, and charge for fuel—but if they run out of fuel before getting to their next property, they lose.

3. Develop rules that respond to the intended players' age bracket and educational level.

4. Obtain the materials and develop the game.

5. Develop instructions for playing the game.

6. Test the game by playing it and having other students play it as well. If needed, go back and make improvements.

Procedure: Follow the rules and play the game.

Conclusion: Developing a new board game can inspire young minds and put some fun into learning about science.

Activity Name: Design Review

"Program design, development, and review"—the term of art applies to all CSLP program activities. Participants produce concepts, next-step project management plans, implementation activities, project monitoring methods, and, as "tickers" (task lists) go from the "to do" stage to "done" and objectives are reached, the total process is subject to review for potential improvement and spin-offs. This activity suggests making a final review session a formal group activity.

Objective: Participants look back on the CSLP achievement, present its highlights and weak points, and report on what they learned and, perhaps, what was not learned and needs to be a part of subsequent similar projects.

Time Requirement: Most reviews are internal and the time required will be in proportion to the complexity of the project, its development period, and the number of participants involved—the more players, the more issues and performance variables in need of comment. Among the challenges students will face is the one revolving around recognizing and defining issues and apportioning to each the degree of importance merited.

Prerequisite Skills: All of the skills required to manage organizations and projects come to bear on the review process—data development and recording methods, diplomacy, insight, language, leadership smarts, presentation techniques and technologies are all required. Presumably, CSLP teachers and volunteers are sufficiently conversant in all of the above to guide student efforts through the final project or program review process.

Materials:

- Facility to host the event
- Audio/Visual equipment
- Presentation Material

Preparation: The systems-minded engineering community generally parses reviews to subsystem and subcommittee levels, and the review is given over the reports of subsystem team leaders or subcommittee chairs. Again, the complexity in breadth and depth influences the structure of the total review presentation package.

Procedure: The following steps, many of which were developed in the program or project planning stage, should lead to an ample and useful concluded review:

- Determine issues or topics to be covered on the review day;

- Determine presentation formats and resources;
- Determine the budget for the event;
- Assign issue or topic reports to specific Core Student Group members—
  - Assemble data
  - Reflect on the import or meaning of the data;
  - Articulate the key points to be covered in the presentation;
  - Determine the physical form of the presentation (e.g., PowerPoint slide show? VueGraphs? Standard bound report? etc.);
  - Write the report, assembling all charts and graphics along the way.

- Plan the review day event;
  - Facilities: set place, time, chairs, tables, A/V support, etc.;
  - Hospitality: order beverages and snacks, if any are to be provided out of the review day budget;
  - People: list presenters, volunteers, teachers, administrators, and others expected to be in attendance;
  - Script: Who speaks about what and when?
  - Event Day Management: appoint, whichever is most appropriate, the chair for the review meeting or the floor director for a larger event, and the principal speaker who will introduce other speakers as they come up to address the assembly;
- Hold the event.

Conclusion: CSLP programs require some significant effort on the part of participating students, who are rewarded not merely by grades but by public acknowledgment, starting with peer-to-peer recognition, of their contribution to the success of the projects in which each student actively participated. In full up CSLP programs, the review day has in some instances been effectively substituted for the final exam.

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Activity Name: Education Programs

The title of this exercise is a catch-all for outreach activities not explicitly suggested in this appendix. What follows is the suggested form for developing an outreach activity concept from a blank slate.

Objective: The activity leads to students teaching others subject matter and techniques that they themselves had to develop during their participation in the CSLP program.

Time Requirement: Open.

Prerequisite Skills: Student interest in project development, management, and review.

Materials: Open.

Preparation: Open.

Procedure:

Inspirations lead to ideas, ideas to concepts, concepts to operational programs. The question of where ideas come from is one of the larger and more profound of human puzzles, but for practical purposes, the invention of ideas in industrial processes comes from people with aspirations, ideals, visions, and needs (practical and otherwise) who are in a position to say what they want and powerful enough to alter the behavior of others to achieve their ends. With CSLP, the students themselves are positioned to invent the program they want and, with corporate and institutional support, achieve their own ends.

Management program planning processes commonly include the following consensus-building steps:

1. Establish an Inventory of Ideas

- Brainstorm—i.e., survey program participants for what they think is attractive, desirable (the "fun factor"), and possible in terms of the work to be done, probable costs, and the availability of administrative, financial, and political support for the ends desired;

- Organize ideas into super- and sub-categories—what ideas are overarching (e.g., having in place a CSLP program on principal), and which ones (e.g., adopting a specific NASA science mission) would contribute to the larger vision?

- Rank ideas for desirability and feasibility.

2. Select an idea or two for further development

- Imagine the participants—will "doer" students really wants to develop the concept?
- Determine the level of commitment *desirable* and the one *available* to develop each idea and actually implement a project plan;
- Develop the concept—this goes back to the program planning process covered in the body of this curriculum guide; nonetheless, imagination, intuition, and knowledge of in-place social relationships (i.e., the inevitable politics) can be used to evaluate the feasibility of the concept prior to committing a group of students to fleshing it out into a program plan.

Concepts need to respond to the key requirements of the CSLP program philosophy. Program teachers and volunteers need to evaluate whether further development of the concept will lend itself to the following:

- Student ownership or stewardship of the project;
- Improved science literacy;
- Cognizance of NASA space science missions and their importance;
- Favorable introduction to the application of communicating, engineering, math, and science skills in the industrial world;
- Intellectual growth and *motivation for growth*;
- Improved craft and other quality producing values;
- Improved skills in areas associated with or related to communicating, engineering, math, project and systems management, and technology.

3. Immediate Concept Development Prospects

If an idea has vaulted over the bars suggested—i.e., it's feasible; student interest is good; the rewards for students are identifiable and measurable; and the probable impact on students as adults and on the community in general is favorable in light of long-standing educational ideals as well as the aspirations suggested by the National Science Education Standards—the next step is to take it out of the idea inventory and put it in the hands of a student-populated program development team.

Conclusion: For the purposes of industry and science, progress refers to the intellectual and material transformation of human cultures through the further development of knowledge and technological prowess. Because of the extraordinary complexity posed by advanced scientific projects and the organizational management and leadership issues associated with them, CSLP programs provide a unique preparatory link to young adults streaming into the course established for 21st Century industrial cultures.

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Activity Name: Orbital Ideas

Objective: Introduce elementary school children to the mysteries of orbital mechanics and associated principles of physics.

Time Requirement: Students need to rehearse their demonstration weeks before the event. It take one class period to present the ideas.

Prerequisite Skills: This activity requires reading, public speaking skills, and, of rouse, some interest in orbital dynamics.

Materials:

- Orbital Ideas Handbook (On CSLP web site)
- Demonstration 1: two Styrofoam cones, and stiff paper.
- Demonstration 2: yo-yo, and a Used Thread Spool
- Demonstration 3: drop cord, Styrofoam ball, and pencil
- Demonstration 4: three or more elementary students
- Demonstration 5: orbital shape sheets (in workbook), stiff paper, small round balloons, 1 small poster sheet, and some paper clips

Preparation: See Orbital ideas handbook.

Procedure: See Orbital ideas handbook.

Conclusion: See Orbital ideas handbook.

Activity Name: Press Briefings

Objective: A press briefing is a specific type of community day, only it is focused on the presentation of a single significant event such as a spacecraft launch, planetary probe milestone, opening of a NASA facility, or dedication of a large spacecraft model or program inception.

Time Requirement: This event may require weeks or months of planning and coordination between volunteers, students, schools, the press, and the public at large.

Prerequisite Skills: Journalism and showmanship are the talents required, and the slant is on communicating about science for the lay audience.

Materials:

- Facility to host the event
- Audio/Visual equipment
- Presentation Material

Preparation: The preparation for this event is the same as community days with the following additions:

- Research, write and prepare press packets. (information, pictures or flyers related to the event);
- Prepare specific presentations designed for the event;
- Set up interviews with key personnel.

Procedure: Develop a plan to prepare for the event. Include a timeline of deadlines, methods of tracking progress, and then implement that plan and monitor and evaluate the status. After the program, have participants complete a survey measuring knowledge obtained and satisfaction.

Conclusion: Press briefings provide students with the challenge of planning and implementing a public presentation program; it will also provide them with insight into the making of the news.

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Activity Name: Solar System in an Auditorium

CSLP students at Old Bridge High School, Old Bridge, New Jersey developed this activity for teaching elementary school students about solar system dynamics. Where physicists would have panicked, the less daunted (or, perhaps, just less inhibited) high school students faced the challenge with creativity and elan. The concept: have each elementary school student pretend to be a spacecraft journeying from earth to the end of our solar system.

Escape velocity, gravity assists, solar winds—all were demonstrated physically by the older students' nudging, pushing, pulling, and spinning (what better way to communicate the power of centrifugal force in achieving escape velocity?), which made not only great fun for the younger ones but also an unforgettable lesson in the many influences bearing down on the course of an object careering through space.

Objective: Get elementary students excited about orbital dynamics and space sciences.

Time Requirement: This activity requires several weeks for planning, development, and rehearsal. The presentation itself takes a class period.

Prerequisite Skills: A little showmanship and a feel for orbital dynamics will be helpful.

Materials: A large room such as a cafeteria.

Preparation: CSLP students will have to develop a strong general understanding of orbital dynamics.

Procedure:

1. Get all CSLP program participants grounded in orbital dynamics.

2a. Start the administrative legwork (e.g., develop points-of-contact for target schools; set aside potential demonstration dates; pursue the contacts) required to involve a local elementary school in the activity demonstration.

2b. Plan the activity's "who, what, when, where, and how"—i.e. profile the specific audience, determine the length of the presentation, list the orbital dynamics to be demonstrated by CSLP students, and work out strategies for producing a method for demonstrating each space flight influence. The following provide a few key questions about the orbital mechanics of space flight and may be incorporated into this activity:

Escaping From the Earth:

- How will the students experience escaping from the Earth's gravity? What will happen if they do not achieve sufficient escape velocity?
- What will happen if they achieve the escape velocity to soon? (spin off in the wrong direction)
- How will they avoid crashing into the Moon? (Remember if they get too close to the Moon, the Moon's gravity will pull them in)

Forces Encountered on Their Journey:

- What is a gravity swing by and how can the elementary students achieve it? (Grab their hands and swing them by)
- What about pressure from the Sun's light. (Light pressure actually will effect the path of a spacecraft)
- How will their own rockets effect their paths?
- What other forces are there?

3. Develop the solar system obstacle course, fitting it to the specific demonstration site.

4. Rehearse the demonstration at the CSLP site (class room or other space before taking it to the host elementary school). If there are young children in the vicinity, use them.

5. Take the show on the road: go to an elementary school and do the demonstration.

6. In keeping with the Total Quality aspect of CSLP programs, learn from the experience—is there anything the program participants would like to see done differently in subsequent orbital science demonstrations, and are there any elements that if added would improve the demonstration, e.g., static space science displays, an orbital dynamics PowerPoint-type slide show, etc.?

Conclusion: While CSLP programs provide an orientation to the fledged world of industrial professionals, they are not meant to suffocate childhood or youth with an overbearing emphasis on the development of conformed (a sharp child might read that word as "intimidated") adult corporate behavior. The "fun factors" will change naturally enough with age—in the meantime, this activity especially preserves the exuberant and altogether good spirit of teen hijinks within a meaningful educational context.

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Activity Name: Present Hubble Solar System Astronomy

One of the Hubble Space Telescope program's key contributors, Dr. Robert Chapman, developed this CSLP outreach program, which includes a workbook and several sets of slides containing images from the Hubble Space Telescope, with elementary school children in mind as the target audience.

The workbook and accompanying material guide students through the solar system using a variety of resources including charts, slides, hands-on exercises, and classroom discussions. In particular, the materials present the simple characteristics of each planet as well as the minor bodies of the system, especially comets, and encourage examination for the potential for life on other planets.

Objective: To inspire and teach younger students about our solar system and space science with support from information and slides derived from the Hubble Space Telescope program.

Time Requirement: Several weeks to practice and develop the presentation and one period to present.

Prerequisite Skills: Outreach activities and showmanship—specifically, research, presentation production, and public speaking skills—are inseparable; the CSLP program itself provides the learning platform for students to develop such abilities. The desire to develop or impart such skills is the only prerequisite for CSLP program participants, including volunteers and teachers.

Materials:

- The Hubble Space Telescope package. This package is available on the CSLP homepage, curriculum guide sub-page;

- Three sets of slides which can be ordered from Finley Holiday Films for $8.00 each plus postage and handling. Call Finley Holiday Films at 1 (800) 345-6707 and ask for the slide sets listed below.

  - HST20-8 Deep Space & Planets 94-95
  - HST20-9 Deep Space & Planets 95
  - HST20-10 Deep Space & Planets 95-96

- Slide projector

Preparation: Read the package, and practice giving the presentation. You may wish to do extra research on the solar system to be prepared for additional questions students may ask.

Procedure:

Give the presentation

Conclusion: This activity is an example of how professionals in the industry can team up with the students to create valuable science programs for youngsters.

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Activity Name: Write an Activity Workbook

Anyone can write a curriculum guide—even high school students. That at least is what students in the CSLP program at Laurel High School (Laurel, Maryland) did for surrounding local elementary school students. The product was an astronomy activity workbook.

Objective: Develop a set of activities younger students may use to improve their interest in and facility for asking questions and testing answers in a scientific manner.

Time Requirement: This activity may take weeks or months to develop but will be probably be presented to younger students in one class room period.

Prerequisite Skills: Knowledge of astronomy or other science is useful. This activity will build artistic, creative, critical, and logical thinking skills.

Materials: Writing/Drawing programs.

Preparation: Choose a topic and develop a body of knowledge about it. Also determine the scope of the workbook—how many activities may it cover? As with sonnets and sonatas, it helps to have in hand the physical form of the work far ahead of its content. With the limitations established, greater freedom may be obtained in the actual design and development of the work.

Procedure: The procedures are simple but the work involved in creating each page may be extensive. In many ways, the challenge for CSLP program students is to develop brain teasers for elementary level minds.

1. Develop an activity page for each proposed item or topic. Here are some examples of activities.

- Origami—cutting, folding, and taping paper leads to the construction of a launch vehicle, voyaging spacecraft, or orbiting satellite
- Color in the numbers
- Crossword puzzles
- Hidden words within tables of letters
- Matching common items
- Mathematical calculations to connect the dots (Instead of connecting dots in numerical order, students do small calculations to figure out which numbered dots

to connect)

- mazes
- One of these things is not like the others
- Paper dolls
- Pictures to color
- Questions and answers

2. Make copies of the completed workbook.

3. Present the activity book to younger students and explain how to work the problems posed.

4. Conduct a presentation review: watch how the students react to the book. Is it too easy, is it too hard. What types of activities do they like the best. How can you improve the activities?

Conclusion: Creating an activity book is challenging and a wonderful way to learn about how to present information in a form others find enjoyable and challenging to use.