Crew Health Care System (CHeCS) Design Research, Documentations, and Evaluations

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The Crew Health Care System (CHeCS) is a group within the Space Life Science Directorate (SLSD) that focuses on the overall health of astronauts by reinforcing the three divisions – the Environmental Maintenance System (EMS), the Countermeasures System (CMS), and the Health Maintenance System (HMS). This internship provided opportunity to gain knowledge, experience, and skills in CHeCS engineering and operations tasks. Various and differing tasks allowed for occasions to work independently, network to get things done, and show leadership abilities. Specific exercises included reviewing hardware certification, operations, and documentation within the ongoing Med Kit Redesign (MKR) project, and learning, writing, and working various common pieces of paperwork used in the engineering and design process. Another project focused on the distribution of various pieces of hardware to off-site research facilities with an interest in space flight health care. The main focus of this internship, though, was on a broad and encompassing understanding of the engineering process as time was spent looking at each individual step in a variety of settings and tasks.

Nomenclature

ALSP	=	Advanced Life Support Pack
AMP	=	Ambulatory Medical Pack
BME	=	Biomedical engineer
CCPK	=	Crew Contamination Protection Kit
CDR	=	Critical Design Review
CHeCS	=	Crew Health Care Systems
CMO	=	Crew Medical Officer
CMP	=	Convenience Medical Pack
CMRS	=	Crew Medical Restraint System
CDCA	=	Common Data Collection Application
EMTP	=	Emergency Medical Treatment Pack
FDA	=	Food and Drug Administration
FFQ	=	Food Frequency Questionnaire
HASP	=	HMS Ancillary Support Pack
HMS	=	Health Maintenance Systems
IFEP	=	In-Flight Examination Program
IO	=	Intraosseous
ISP	=	IV Supply Pack
ISS	=	International Space Station
IV	=	Intravenous
JSC	=	Johnson Space Center
MDP	=	Medical Diagnostics Pack
MEC	=	Medical Equipment Computer
MOB	=	Medical Operations Board
MKR	=	Medical Kit Redesign
MSP	=	Medical Supply Pack

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MTP	=	Minor Treatment Pack
NASA	=	National Aeronautics and Space Administration
OMP	=	Oral Medications Pack
PDA	=	Pre-Delivery Assessment
PDR	=	Preliminary Design Review
PEP	=	Physicians Equipment Pack
PIA	=	Pre-Installation Assessment
QAS	=	Quality Assurance Specialist
QE	=	Quality Engineer
RFID	=	Radio Frequency Identification
RSP	=	Respiratory Support Pack
SLSD	=	Space Life Science Directorate
STS	=	Shuttle Transport System
TIMP	=	Topical and Injectable Medications Pack
TPS	=	Task Performance Sheet
USC	=	University of Southern California
USRP	=	Undergraduate Student Research Program

I. Introduction

The Space Life Sciences Directorate (SLSD) is charged with the task of optimizing the crew's overall health. This directorate is broken into three systems each of which focus on certain aspects of this overall goal. (Fig. 1) The Countermeasures System (CMS) provides the equipment and protocols for the performance of daily exercise to counteract the effects of living in a microgravity environment. The Environmental Health Subsystem (EHS) monitors the atmosphere for any contamination within crew and station activities and monitors the water quality and radiation levels. The Health Maintenance System (HMS) provides in-flight preventive medicine, diagnostic and therapeutic care, and routine treatment for the majority of medical conditions expected to be encountered onboard the International Space Station (ISS). Also within the SLSD is the group termed the Crew Health Care System (CHeCS). Their task is to fulfill the overall mission of crew health care by reinforcing each of the three levels of an astronaut's care.

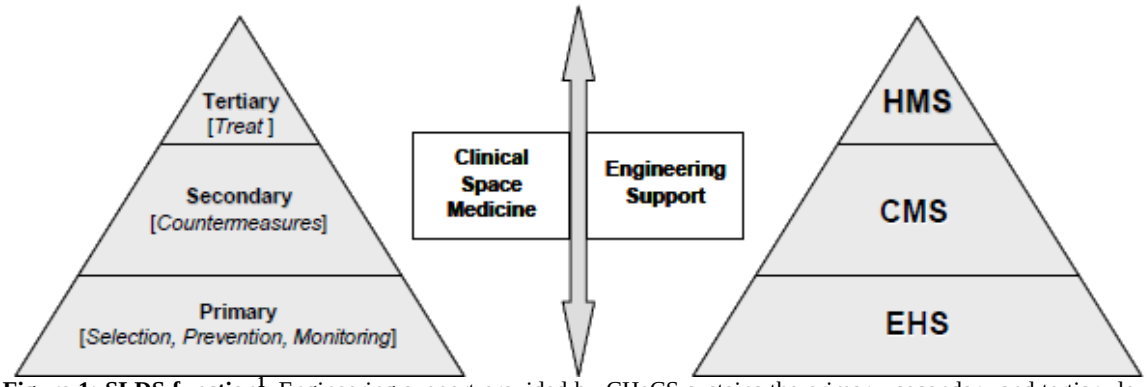


Figure 1: SLDS function[1]. Engineering support provided by CHeCS sustains the primary, secondary and tertiary levels of care in SLDS

The projects involved in this internship were mainly contained within the tertiary level of this SLSD hierarchy, the Health Maintenance System (HMS) and included assisting with the final implementations of the Medical Kit Redesign (MKR), and creating and updating various databases used within HMS and CHeCS.

II. Description of Projects

This internship fully demonstrated the agility and versatility of the SLSD directorate. Within 15 weeks, numerous projects were continued, started, completed, and ended. From supplying documentation assistance for the Medical Kit Redesign (MKR) project and helping in various hardware distributions to providing feedback on the new Common Data Collection Application and getting to work hands-on in the off-site Wyle labs, this internship has provided a continuous and extensive view of the engineering process and has shown that the SLSD is very proficient in its determination to supply the needed item or service and quickly move on to the subsequent task.

A. Medical Kit Redesign (MKR)

For over 10 years, HMS division has been maintaining crew health with the use of various packs stowed aboard the ISS housed within the CHeCS rack. (Fig. 2) Until this year, these packs included the Advanced Life Support Pack (ALSP), the Ambulatory Medical Pack (AMP), Crew Contamination Protection Kit (CCPK), Crew Medical Restraint System (CMRS), Respiratory Support Pack (RSP), the HMS Ancillary Support Pack (HASP), and a few other hardware and software items.

Figure 2: CHeCS rack aboard the ISS. Houses medical hardware and software.

The ALSP provided the necessary equipment to save the life of a crewmember with equipment for Advanced Cardiac Life Support (ACLS) and Basic Trauma Life Support (BTLS) protocols. Contents included an airway supply subpack, an emergency surgery subpack, an IV administration subpack, a drug subpack, and blood pressure cuffs.

The AMP was a non-emergency pack and could be thought of as more of a first aid kit. It had the supplies to analyze blood samples, treat minor wounds, and perform dental checks.

The CCPK provides protection for the crew from exposure to environmental contaminants with supplies such as the eyewash.

The CMRS (Fig. 3) was and continues to be used to stabilize a patient in any event where restraint is required. This makes it easier for patient transport, stabilizes the spine, and is a means of electrical isolation for defibrillation use.

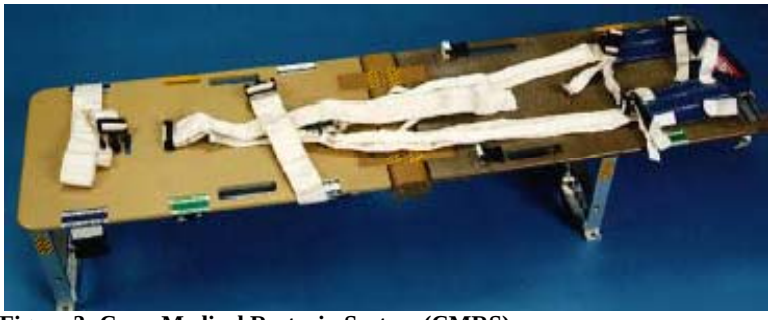


Figure 3: Crew Medical Restrain System (CMRS).

The RSP provides low flow 100% oxygen to the patient via the AMBU bag found in the ALSP.

The HASP provided resupply for the previously mentioned units. It contained items such as saline, battery packs, and ultrasound gel.

Throughout the years since the ALSP, AMP, and HASP were designed, medical standards have changed which constituted a change in overall design; within the Medical Kit Redesign (MKR) process, operational efficiency and easy of resupply were optimized. Of the items mentioned above, only the CCPK, CMRS, and RSP remain. The nine

redesigned kits are as follows: Convenience Medications Pack (CMP), Oral Medications Pack (OMP), Topical and Injectable Medications Pack (TIMP), Medical Diagnostics Pack (MDP), Minor Treatment Pack (MTP), Medical Supply Pack (MSP), IV Supply Pack (ISP), Physicians Equipment Pack (PEP), and Emergency Medical Treatment Pack (EMTP). (Fig. 4)

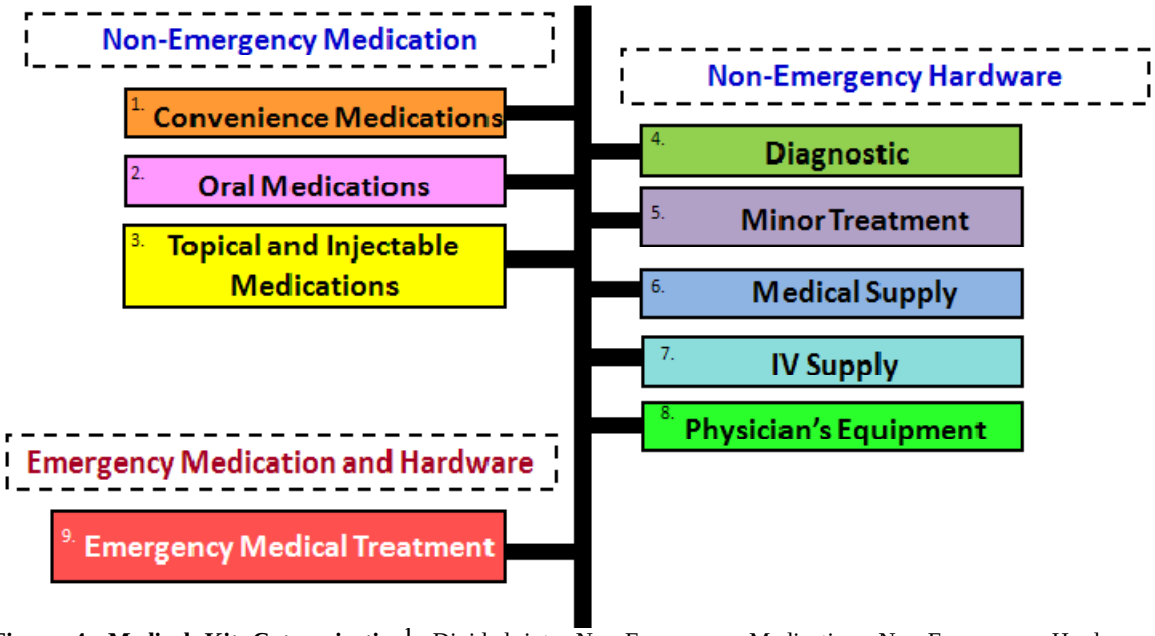


Figure 4: Medical Kit Categorization[1]. Divided into Non-Emergency Medication, Non-Emergency Hardware, and Emergency Medication and Hardware

The Non-Emergency Medication packs include the CMP, OMP, and TIMP. The CMP holds the medications that are used most frequently by the crew members. The OMP and TIMP contain pertinent medications that are used less frequently by the crew.

The MDP, MTP, MSP, ISP, and PEP are packs considered to hold Non-Emergency Hardware. This hardware is used to perform check-ups, diagnose problems, and treat minor wounds. The MDP holds electronic equipment used to diagnose the health of the crew members. Items include blood pressure cuffs, a stethoscope, a tonometer, and many other items. The MTP is easily compared to the former AMP as it contains treatments for minor wounds, catheters, and dental and surgical tools. The MSP contains items needed for medical treatment such as gauze, bandages, and syringes. The ISP contains IV fluid, pumps, catheters, and other materials needed for IV administration. The PEP is for physician Chief Medical Officer (CMO) use only. It contains several kits to aid with diagnosis that only a trained individual is capable of handling.

The EMTP is for use under emergency situations and is used to sustain life. This kit is comparable to the ALSP as it included items such as the AMBU bag, certain medications, and intraosseous (IO) infusion devices.

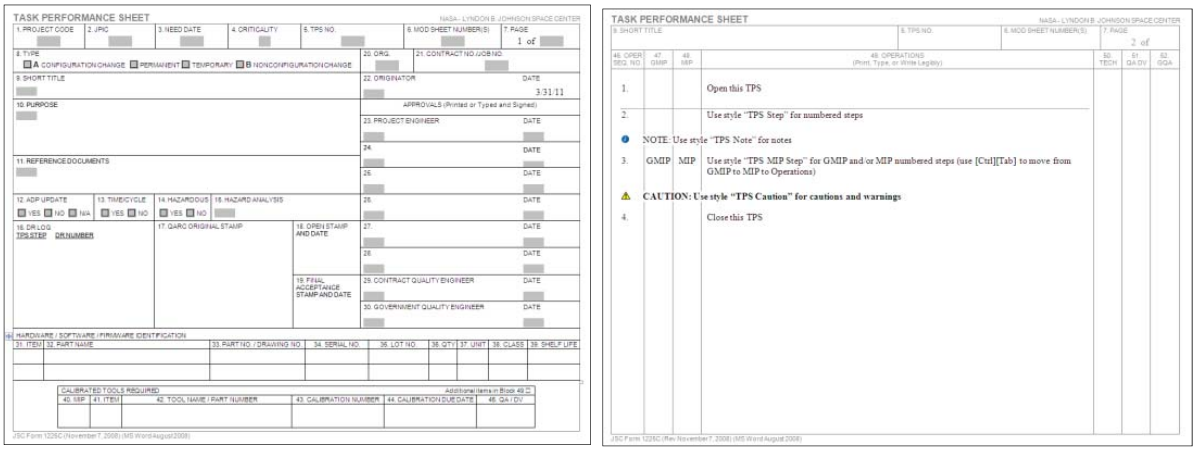
The softgoods portion of each pack is 14.25 inches wide by 16.25 inches tall by either 3 or 4 inches tall, depending on the proposed contents of each kit. Inside each kit are five horizontal strips of 1 inch wide Velcro on both the left and right sides and a vertical strip down the middle (Fig. 5). The various items in each kit are fastened inside by applying the Velcro attachment to the back of each item.

Figure 5: Inside view of the new med kit design

The portion of the project covered in this internship consisted of the final steps in the engineering process – testing, design verification, design documentation, and design review. All of the hardware devices – found primarily in the MDP – required testing and design verification in the form of functional tests, and, as a final means of quality assurances, a Pre-Delivery/Pre-Installation Assessment (PDA/PIA) review. A Quality Engineer (QE) performs these various tests along with a technician who is involved in the project. The functional tests are performed throughout the process of the project so that if changes are needed, they can be implemented early on in the progression.

Before any assessments can be performed though, these various documents have to be drawn up by the members of the project's team and opened by the QE. This step, design documentation, was also witnessed within the span of this internship. In order to carry out a needed task involving any piece of equipment relating to the Med Kits, a Task Performance Sheet (TPS) was required. (Fig. 6)

A TPS is used at NASA for a variety of purposes including (but not limited to) documentation of procedures relating to inspection, and functional testing, transfer of hardware, classification changes (downgrades), and defining the status of the hardware within the Quality Assurance Record Center (QARC)[2]. A TPS is filled out in order to explain in detail the steps each party involved must take in order to successfully and safely complete the task. Within this project, TPSs were worked for the packing process, the functional tests of the hardware within the kits, the downgrade of unused items to be used in the training kits, and in the PDA/PIA reviews.


TASK PERFORMANCE SHEET

NASA - LYNDON B. JOHNSON SPACE CENTER

1. PROJECT CODE | 2. JPIO | 3. NEED DATE | 4. CRITICALITY | 5. TPS NO. | 6. MOD SHEET NUMBER(S) | 7. PAGE 1 of

8. TYPE: A CONFIGURATION CHANGE, PERMANENT, TEMPORARY, B NONCONFIGURATION CHANGE | 20. ORG. | 21. CONTRACT NO./JOB NO.

9. SHORT TITLE | 22. ORIGINATOR | DATE 3/31/11

10. PURPOSE | APPROVALS (Printed or Typed and Signed) | 23. PROJECT ENGINEER | DATE

11. REFERENCE DOCUMENTS | 24. DATE | 25. DATE

12. ADP UPDATE: YES NO N/A | 13. TIME/CYCLE: YES NO | 14. HAZARDOUS: YES NO | 15. HAZARD ANALYSIS | 26. DATE

16. DR LOG TPS STEP DR NUMBER | 17. QARC ORIGINAL STAMP | 18. OPEN STAMP AND DATE | 27. DATE | 28. DATE

19. FINAL ACCEPTANCE STAMP AND DATE | 29. CONTRACT QUALITY ENGINEER | DATE | 30. GOVERNMENT QUALITY ENGINEER | DATE

32. HARDWARE / SOFTWARE / FIRMWARE IDENTIFICATION

31. ITEM	32. PART NAME	33. PART NO. / DRAWING NO.	34. SERIAL NO.	36. LOT NO.	35. QTY	37. UNIT	38. CLASS	39. SHELF LIFE

CALIBRATED TOOLS REQUIRED (Additional Items in Block 49)

40. SEP	41. ITEM	42. TOOL NAME / PART NUMBER	43. CALIBRATION NUMBER	44. CALIBRATION DUE DATE	45. QA / DV

JSC Form 1225C (November 7, 2008) (MS Word August 2008)

TASK PERFORMANCE SHEET

NASA - LYNDON B. JOHNSON SPACE CENTER

5. SHORT TITLE | 6. TPS NO. | 6. MOD SHEET NUMBER(S) | 7. PAGE 2 of

46. OPER SEQ. NO.	47. GMIP	48. MIP	49. OPERATIONS (Print, Type, or Write Legibly)	50. TECH	51. QA DV	52. QQA
1.			Open this TPS			
2.			Use style "TPS Step" for numbered steps			
			NOTE: Use style "TPS Note" for notes			
3.	GMIP	MIP	Use style "TPS MIP Step" for GMIP and/or MIP numbered steps (use [Ctrl][Tab] to move from GMIP to MIP to Operations)			
			CAUTION: Use style "TPS Caution" for cautions and warnings			
4.			Close this TPS			

JSC Form 1225C (Rev November 7, 2008) (MS Word August 2008)

Figure 6: Task Performance Sheet (TPS)

Another form of documentation within this project was photographs. (Fig. 7) Photos were taken to keep a record of the packing process, each individual packed and labeled item, the labeled softgood containers as well as the configuration of the items within each kit. These photos were compiled, labeled, sorted and stored on the CHHIPS share drive so as to be viewable to the various team members.

Figure 7: Examples of photo documentation of the Med Kits

These photos, along with all of the Med Kit certification documentation needed to be reviewed by Russian customs so that the Med Kits could be shipped. In order for non-JSC employees to view these documents, they had to be export controlled. This required the completion of form JSC1724 or the JSC Export Control Request and Approval Worksheet.

The addition of Radio Frequency Identification (RFID) tags was another task involved in this project. After determining the feasibility of implementation, tags were designed and then fabricated by the decal lab. (Fig. 8)

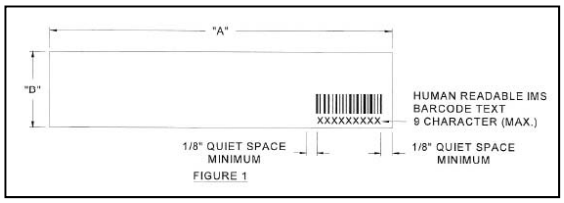


Figure 8: RFID tag drawing

The tags were placed on certain items within the Med Kits. (Fig 9) These items were decided based on medical privacy, and the importance of the need of inventory. Items with the RFID tags are now able to be inventoried by an RFID reading machine by a simple procedure of allowing the device to scan the area – in this case, the appropriate Med Kit.

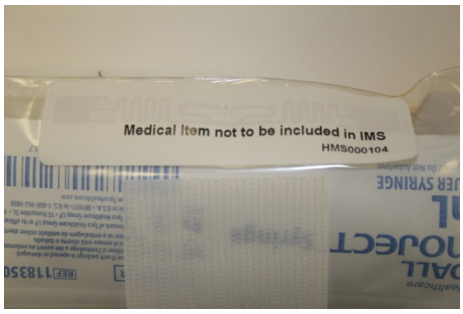


Figure 9: Example of RFID tag in Med Kit

In order to review the work, a PDA/PIA is performed when all drawings and documents have been released. This assessment verifies the basic functions of the equipment as well as the functional requirements. This process is also used to verify that the equipment is built in line with the released drawings and packing document. A crew review is also performed to ensure that the products are in line with what crew members are expecting and with what they are comfortable with. (Fig. 10)

Figure 10: Crew review of the Med Kits

For any type of hardware to fly, it must be certified which involves flight-readiness testing and paperwork to document the analysis. Certification of the med kits was completed on March 23, 2011. Once that was complete, the kits were shipped to Russia. They arrived in Moscow on March 30th and were then shipped to Baikonur in order to be loaded on the Progress vehicle where they were launched on April 27th as a part of 42P. In June, the kits will be unpacked and the crew will do a medical contingency drill so that the new kits can be considered operational. The old kits (AMP, ALSP, and HASP) will be discarded in a trash burn over the Indian Ocean sometime during the summer of 2011.

B. Updating databases

A database is simply a system intended to organize, store, and retrieve large amounts of data easily. Within any project the use of these are very practical and constructive. In order to ensure the most accurate data at all times, databases must be updated periodically. Throughout the course of this internship, several different databases needed to be revised. The databases included records of open and closed paperwork within the HMS project code, medicines being supplied in the Med Kits, and supplies in the astronaut's personal IMAKs.

In a government job, paperwork is used at all times to track and keep record of all actions taken with hardware or software. Open paperwork means that the task described has not been completed or documented as completed. If paperwork gets forgotten or lost, it can only cause more work and cost in the future so the desired end result for each piece of paperwork is ultimately closure. In order to keep track of each document that is open within HMS, a database was created. Now, information such as the document name, number, description, initiation date, and point of contact (POC) are held within this database making it ready for any search that comes its way.

These databases are useful for not just for inventory but for cross-checking against other databases. For instance, after updating the database of Med Kit medicines and the IMAK supply list, they were compared against one another for redundancies. Any superfluous items could be removed from one of the two packs, therefore reducing the weight and size of the packs.

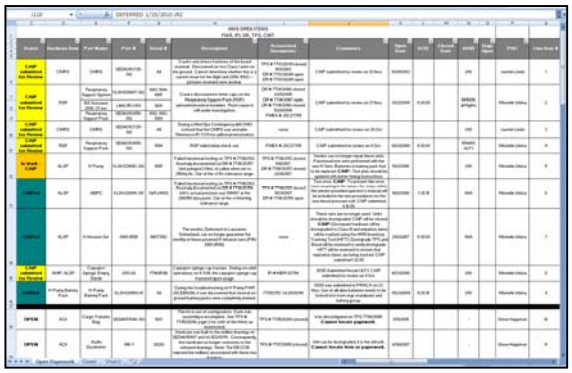


Figure 11: Example of an HMS database

C. Hardware Disbursement

Research for NASA is not limited to the JSC campus or the NASA community. Collaboration has developed with other research facilities. During the course of this internship, the established connection between JSC and the University of Southern California (USC) Department of Aeronautical Engineering was carried on. Hardware was requested by this organization to support planetary surface exploration. After the loan agreement was written and signed, an IV pump, extra tubing, and a saline bag were shipped to USC by on-site shipping. They will be using the IV pump to conduct research evaluating through-the-suit IV administration.

Ties have also been established with the Food and Drug Administration (FDA) to have some hardware loaned. The hardware they are requesting would serve as educational tools and would demonstrate how ground based medicine influenced the technological development of space hardware. The loan agreement for this transfer of property was written and sent to the appropriate people where we await the signatures before the hardware can be sent. This medical hardware that has flown in space will be exhibited at the FDA White Oaks Maryland location to showcase how hardware used by astronauts in orbit is regulated by the FDA. The hardware delivered them includes an IV Infusion Pump, a Portable Clinical Blood Analyzer (PCBA), an Automated External Defibrillator (AED), and a Zoll Defibrillator.

III. Conclusion

The central focus of this internship was the overall comprehension and implementation of the engineering process. Throughout the internship, a great variety of tasks were assigned and completed which gave the student a broad overview of the design process.

Allowed to sit in on budget meetings, and System Requirements Reviews (SRR), the student got to see the managerial perspective of an engineering process. Asked to complete paperwork, run errands, and assist in various tasks within the engineering team, the student was allowed to view the same process from the perspective of the contractors and engineers within a project.

This internship also allowed the student to learn skills that will prove useful in future careers. Time management, organization, working efficiently, teamwork, the ability and willingness to ask for needed help – these are all skills that the student will be able to take with her from this internship experience as she moves on in life.

Acknowledgments

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References

[1]Reyna, B., Urbina, M., "ISS Medical Kit Critical Design Review (CDR) and Summary Presentation" NASA, 2010
[2]Altemus, S., "Task Performance Sheet (TPS)" NT-CWI-001, NASA, 2011
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