The Communications Requirements Evaluation & Assessment Prototype (CREAP) Project: A Case Study of a System Engineering Educational Project

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Abstract. This paper contains a case study describing the development of a software tool to prove a concept for use in design to inventory scenarios. The tool was developed by Master's students at the University of South Australia. The case study, designed as a reference for similar activities in other academic institutions, contains a list of lessons learned on the project. All the lessons learned have to do with the non-technical aspects of the project. Even though the project was small, many of the attributes of large projects were seen.

BACKGROUND

Today's requirements engineering processes do not have very effective checks to ensure that system requirements are feasible. In the main, this is because the feasibility of requirements is governed by domain knowledge (application or technology) which is lacking in the writers of the requirements. The Communications Requirements Evaluation & Assessment Prototype (CREAP) project constructed a prototype software package that provided a tool that was able to integrate military communications domain expertise and requirements engineering practice in order to ensure the feasibility of requirements imposed on communications systems.

The CREAP is an implementation of a subsection of the Frame-Based Approach to Requirements Engineering (FIBRET) initiative at the Systems Engineering and Evaluation Centre (SEEC) at the University of South Australia (Cook et al. 2001). The CREAP was developed as a student project by overseas students in the Master of Information Technology degree program.

The scope of the project was set based on experience in determining the scope of a project in the Master of Software Engineering (MSWE) Degree final project (MSWE 617) at University of Maryland University College (UMUC). In fact, the scope of work for the CREAP was significantly less than was expected of UMUC the MSWE Students.

FOCUS OF THE CREAP

Kasser and Cook (2002) describe the purpose and functionality of the CREAP, which was conceptualized as an expert system. The CREAP contains information about the capabilities of communications equipment. It also contains information about several of the links in the communications chain (Uplink terminal modem, transmitter, aerial, and downlink aerial, receiver and modem) as well as other information such as radio frequency propagation characteristics. The CREAP also designed to allow an external interface to an inventory program to be added at a future date. The CREAP prototype is designed to be used in a 'design from inventory' scenario in the following two Use Cases

- **The rapid deployment situation** in which the supply officer has to provide communications equipment for the rapid deployment force. The officer selects the desired Uplink and Downlink location co-ordinates, then selects a modem from the range of modems in stock, and the CREAP provides a list of other equipment in the communications link that can service the required service.
- **The training mode** in which the prototype teaches the supply officer which components can be used

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with which other components to establish specified communications links.

GOALS OF THE CREAP PROJECT

The goals of the CREAP Project were

1. To produce system engineering process products (documentation) educational purposes, namely for use as examples in Case Studies and other scenarios in several courses on systems and software engineering at the University. Kasser (2001) documents the lack of suitable material.
2. To document the project as an educational Case Study in system engineering that could serve as a model for subsequent similar student projects.
3. To develop a working CREAP prototype that would be useful, modifiable and upgradable.
4. To test the usefulness of Categorized Requirements in Process (CRIP) charts for measuring project progress (Kasser 1999).

ELEMENTS OF THE CREAP

The elements of the CREAP (Kasser and Cook 2002) were

- **The system** - the user interface, structure of the internal models, relationships between model elements, an external interface to an existing system, and the choice of programming language and COTS components.
- **The assessment engine** – the parameters, variables, constants, and the relationships between them. This was to be a generic engine, the two communication models were to provide instances of the engine.
- **The High Frequency (HF) communications model** – the transmitters, receivers, modems, aerials, frequencies, and times of day.
- **The Satellite communications model** – The type of satellite (Low earth orbit, synchronous, Molniya type), size of dish, or properties of other type of aerials, uplink and downlink frequency characteristics, and ground terminal output power.
- **Manuals and documentation** – the set of project documentation.

THE PROJECT SCHEDULE

The schedule was for the project to follow one iteration of the Waterfall system and software development lifecycle (SDLC) and fit within a timeline of 20 weeks. Thus the schedule was

- **Kick off meeting** – took place on February 19, 2001 and introduced the project to the students.
- **System Requirements Review** (SRR) – after 4 weeks on March 23 2001. The SRR would cover the operations concept for software, initial model information, system requirements, test plans and resources.
- **Preliminary Design Review** (PDR) – after 8 weeks on April 20, 2001. The PDR would cover the refined model information, designs, outline test procedures, build plan, and rationale for programming language.
- **Critical Design Review** (CDR) – after 12 weeks on May 18, 2001. The CDR would cover refined model information, results of prototyping, final designs, detailed test procedures, and the draft user manual.
- **Delivery Readiness Review** (DRR) - after 18 weeks on June 29, 2001. The DRR would cover the software source code, software executable, test results, user manual, and the model manual. The DRR was scheduled for two weeks before the end of the timeline to allow some time to clean up any outstanding loose ends.

Weekly meetings were to take place to summarize the weeks work. These meetings represented the traditional design and periodic project status reporting meetings. There were to be two types of meetings

- **Working** – on Mondays and Wednesdays. These would allow the students to meet with the customers and faculty advisors.
- **Formal management meetings** – on Fridays. PowerPoint presentations were required (including CRIP charts). These meetings followed a standard agenda, namely
  - Work completed during current period,
  - Work planned for next period,
  - Other as appropriate.

MANAGEMENT OF THE PROJECT

The project was organized to comply with the PRINCE 2 Management methodology (Bently 2000). The organization comprised

- **The project board** – to oversee the project, represent the customer and signoff on each stage.
- **The management team** – to manage the project.
- **The design group** – to do the design and build the prototype.
- **The test group** – to perform the test and evaluation functions of the project.

The process-products were defined in accordance with the PRINCE 2 methodology but were tailored to the size for the project. For example, a written requirements document was not produced, rather the requirements were presented at the SRR in the form of presentation slides. CRIP charts were used to track the progress of the project.

The project deliverables were

- **Working software** - at the end of the 20 weeks.
- **Documentation** - at the end of the 20 weeks, to cover the design, test, maintenance and user manuals.
- **Review packages** – always due one week before each review to allow the project board and sponsor the chance to review the package before the review took place.

THE PROCESS

The project was divided into the usual SDLC phases.

The kickoff meeting took place on schedule and covered the following topics

- **The background to the project** – providing the contextual background to the students. An overview was given of the FIBRET, expert systems and communications concepts.
- **The CREAP project** – the work plan, schedule, deliverables and assignments.
- **The project goals** – as stated above.
- **Work planned, present to SRR** – To develop the operations concept for software, the initial model information, the system requirements, test plans and allocate resources

Following the Kick-off meeting, research areas were assigned to students working individually or in teams. They were to review expert systems and artificial intelligence, satellite and high frequency radio communications. During this phase of the work, two of the overseas students exhibited poor performance and there was little time and resources available to remedy the situation other than to release them from the project to allow them to seek a project that better matched their talents. A third student then also withdrew from the course, electing to take it the following year. This reduced the team from five students down to two. The scope of the project was then reduced accordingly to balance the student workload. Accordingly, the requirement to implement the HF communications model was delayed to a post project Software Build.

The SRR was held on March 30, 2001[1] to coincide with the monthly SEEC Research Group Meeting and covered the following topics

- **Background/statement of problem** – an overview for the benefit of the Research Group audience and to set the context for the rest of the SRR.
- **User scenarios** - four user scenarios were discussed.
- **A total of 32 requirements** - which were grouped as follows
- **Programmatic requirements and constraints** – inherited from the academic environment, the customer, and the PRINCE 2 methodology.
- **User requirements** – directly traced back to the scenarios. These were further subdivided into requirements for the assessment engine, the two communications models, and documentation. At this time, the Quality System Elements (QSE) (Kasser 2000) of each requirement comprised[2]
  - the identification number,
  - the imperative constructive statement incorporating the “shall”,
  - traceability to source,
  - owner, and
  - verification approach.

  The requirements were also categorized by complexity and priority for CRIP charting purposes.

- **The Management Review** – covering progress and lack thereof, the CRIP Charts and the work planned for next period. The work planned for the post-SRR and pre-PDR period covered the following areas
  - **Assessment Engine** – to look at expert systems, identify candidate languages, identify evaluation criteria for languages.
  - **Models** – to determine relationships that could be modeled.
  - **Design software** – the top-level architecture.
  - **Review Item Discrepancies (RIDs)** – where to send them, and by when.

The PDR was held on May 11, 2001. It covered

- **The SRR RID status** – Thirteen RIDs had been received, four had been rejected, four had been noted but no action had been taken. Four were accepted but after modifications. Two new requirements were derived from the RIDs. In addition four requirements had either been changed or had changes to their QSE.
- **The preliminary design** – a top-level concept of the frames, user interface, parametric relationships, and database designs was presented.
- **The Test Plan** – the plans, resources needed, and methodology for developing the tests and test plan matrix.

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[1] Four weeks into the project, the schedule had already slipped one week.

[2] Other QSE elements were subsequently added as the project progressed (e.g. test attributes).

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CRIP Chart for Priority

	Identified	In Produc-tion	Com-pleted	In test	Accepted
1	26-26-26	26-26-26	20-20-20	20-20-20	20-20-20
2	2-4-4	2-2-4	2-2-2	2-2-2	2-2-2
3	1-1-1	1-1-1	1-1-1	1-1-1	1-1-1
4	0-0-0	0-0-0	0-0-0	0-0-0	0-0-0
5	3-3-3	3-3-3	3-3-3	3-3-3	3-3-3
6	0-0-0	0-0-0	0-0-0	0-0-0	0-0-0
7	0-0-0	0-0-0	0-0-0	0-0-0	0-0-0
8	0-0-0	0-0-0	0-0-0	0-0-0	0-0-0
9	0-0-0	0-0-0	0-0-0	0-0-0	0-0-0
10	0-0-0	0-0-0	0-0-0	0-0-0	0-0-0

figure 1 DRR CRIP Chart showing problem in caterory 2 requirements

- **The Management Review** – covered
  - **Work completed** – design and project management. The work completed was compared with the work planned at SRR.
  - **The methodology** for evaluating the choice of programming language and choice were presented. The choices had been between C, C++, Delphi, Java and Visual Basic. After the sensitivity analysis the choice turned out to favor Java.
  - **Work planned for next period** - Refine Model information, continue working on the design, and produce outline test procedures and the software Build Plan.
  - **Planned costs** – for staff and software.
- **RIDs** – where to send them, and by when.

The CDR was held on June 1, 2001. It covered

- **PDR RIDs** - Nineteen RIDs had been received, five had been rejected, nine noted but no action taken, and five had been accepted with modifications.
- **Design** - interface design, functional decomposition, and modular decomposition of the knowledge database, user interface and assessment engine. the linkages between the scenarios and the modules were also presented.
- **Test plans** – test objectives, batch tests, conceptual test scripts for on-line system test, and test milestones.
- **Project management** – covered work completed and work planned for the next phase.
  - The work completed was reviewed. CRIP Charts provided visibility into the project progress. Other diverse items included the CDR, testing procedure (for 15 requirements), Design document completed, CDR RID status, state of the prototype, the completion of the test plan, approval of software license for 2 machines, and installation of J Builder on new machines.
  - The work planned for next phase was to cover completion of software source code and executable, document the test results, and complete the user and model manuals.
- **RIDs** – where to send them, and by when.

The DRR was held on September 27, 2001. It covered

- **CDR RIDs** – none had been received, showing that the design had indeed converged to its requirements.

- **A summary of all the tasks performed during the entire project** – this covered all elements in the Work Breakdown Structure.
- **The status of the project** – covering the completion of the satellite communications model, the failure to complete the HF model, the applicability of the frames in the satellite communications model to the future completion of the HF model.
- **The test status –** test results, summarizing that the total number of Requirements were 34 (32 Initial requirements and 2 added during the project) as shown in the CRIP Chart in Figure 1. Of the 34 requirements, the prototype had been shown to meet 26. These last 8 requirements were associated with the HF communications model, which had not been completed.
- **The deliverables** – the software and documentation were ready for delivery to the customer.

LESSONS LEARNED

Lessons learned included:

By SRR we had learnt that it took significantly more time to tell some of the overseas students what to do, than to do the job ourselves. This was very different to the UMUC experience. At UMUC the students were mature adults in the workforce. These students were overseas students from third world countries.

The selection of students for such projects has to be more rigorous. Had the students been of the caliber of those at UMUC all the project goals would have been achieved.

The multi-cultural and multi-linguistics aspects of the students need to be taken into consideration, not only at the start of the project, but also during the entire SDLC. Failure to consider these aspects results in poor communications (Kasser 1995) which leads to uncompleted work due to the failure of the students to understand what they are required to do, and communicate that fact to project management.

The students perceived members of the project board as management and customers with different requirements. It took a while for that situation to be resolved.

Special attention needs to be paid to improve the written skills of overseas students for whom English may be a second language. This is of critical importance to finding useful employment in the English speaking world.

SUMMARY

The goals of the project had been partially met. The goal of developing a working usable CREAP prototype had been partially achieved. The concept had been proven, but the lack of the second model meant that the degree of reusability of the assessment engine for a general-purpose tool was unknown.

The goal of producing system engineering process products (documentation) for educational purposes had been achieved.

The goal of documenting the project as an educational Case Study in system engineering has been achieved with the publication of this paper.

The goal of testing the usefulness of CRIP charts had been achieved. They were simple to use and provided a high degree of visibility into the progress of the project.

CONCLUSIONS

The delays in the schedule on even this small project conformed to Augustine's (1986) rules for project delays. The confusion experienced by the students at the start of the project is the norm for projects. The real world had been modeled well!

The CREAP concept has been demonstrated as a useful addition to Requirements Management Tools and will be subject to further research.

REFERENCES

Augustine, N.R., Augustine's Laws, Viking Penguin Inc., 1986.

Bently, C., *PRINCE 2 A Practical Handbook*, Butterworth Heinemann, 2000.

Cook, S.C., Kasser, J.E., Asenstorfer, J., "A Frame-Based Approach to Requirements Engineering", *11th International Symposium of the INCOSE*, Melbourne, Australia, 2001.

Kasser, J.E., *Applying TQM to Systems Engineering*, Artech House, 1995.

Kasser, J.E., "Using Organizational Engineering to Build Defect Free Systems, On Schedule and Within Budget", *PICMET*, 1999.

Kasser, J.E., "A Framework for Requirements Engineering in a Digital Integrated Environment", *SETE* 2000.

Kasser, J.E., "Leveraging Student Projects into Case Studies for Educational Purposes", *Australasian Conference of the Engineering Management Educators*, Wollongong, 2001.

Kasser, J.E., Cook, S.C., "The Communications Requirements Evaluation & Assessment Prototype (CREAP) Project", *12th International Symposium of the INCOSE*, Las Vegas, 2002.

MSWE 617, Software Engineering Project, http://www.umuc.edu/grad/mswecat.html#MSWE617, last accessed November 23, 2001.

AUTHOR'S BIOGRAPHY

Joseph Kasser has been a practising systems engineer for 30 years. He is the author of "*Applying Total Quality Management to Systems Engineering*" published by Artech House. Dr. Kasser is a DSTO Associate Research Professor at the University of South Australia (UniSA). He performs research into improving the acquisition process. Prior to taking up his position at UniSA, he was a Director of Information and Technical Studies at the Graduate School of Management and Technology at University of Maryland University College. There, he developed and was responsible for the Master of Software Engineering degree and the Software Development Management track of the Master of Science in Computer Systems Management (CSMN) degree. He is a recipient of NASA's Manned Space Flight Awareness Award for quality and technical excellence (Silver Snoopy), for performing and directing systems engineering. Dr. Kasser also teaches systems and software engineering in the classroom and via distance education.

Professor Stephen Cook. After graduating in Electronics Engineering from the South Australian Institute of Technology in 1977, Prof Cook commenced work as a telecommunications equipment design engineer in the UK where he also completed an MSc in Computer Science at the University of Kent. On his return to Australia, he worked in the defence electronics industry until 1988 when he joined the Defence Science and Technology Organisation (DSTO). He completed a PhD in 1990 in Measurement Science and Systems Engineering at the City University London. Prof Cook joined the University of South Australia as the Foundation Professor of Systems Engineering in 1997. He has contributed to three books and has published over fifty refereed journal and conference papers. Prof Cook is a Fellow of the Institution of Electrical Engineers (UK), a Fellow of the Institution of Engineers, Australia and Past President of the Systems Engineering Society of Australia.

Anthony Pilgrim is an Associate Lecturer at the System Engineering and Evaluation Centre (SEEC), which is located at the University of South Australia. He currently liaises with the Ministry of Defence (MoD) graduate program from the UK and is investigating the extension of the Communications Requirement Evaluation Assessment Prototype (CREAP) Project. He was Project Manager of the initial CREAP Project (2001) and obtained a Bachelor of Engineering in Electronic Engineering, 1998. Anthony has an extensive trade background with multiple trade qualifications and years of experience.