5th Asia-Pacific Conference on Systems Engineering (APCOSE 2011)
Seoul, Korea. October 19-21, 2011

An application of Checkland's soft systems methodology in the context of systems thinking

Joseph Kasser
Visiting Associate Professor
Temasek Defence Systems Institute
National University of Singapore
Block E1, #05-05, 1 Engineering Drive 2 Singapore 117576
etmkj@nus.edu.sg; joseph.kasser@incose.org

Copyright © 2011 by the Author. Published and used by APCOSE with permission.

ABSTRACT

This paper provides a case study on how Checkland's Soft Systems Methodology (SSM) [1, 2] was applied to investigate an organisational problem in a government organisation. The intervention investigation used Hitchins' systems engineering problem-solving approach to identifying and tackling the problem [3]. The last part of the paper compares SSM with the systems thinking perspectives approach [4].

KEY WORDS: soft systems methodology, problem solving, systems engineering, systems thinking.

BACKGROUND

In early 2000, the Defence Systems and Technology Department (DSTD) within the government of Engaporia[1] performed a variety of research tasks that was aimed at upgrading the national defence systems, and the acquisition and implementation of appropriate technology in the Engaporean defence environment. DSTD worked in close cooperation with the Engaporean Defence Materiél Acquisition Organization (DMAO) and the Engaporean Defence Forces (EDF). At that time, the members of the Command, Control, Communications, and Intelligence (C3I) group within the DSTD were concerned about the effect an impending reorganization would have on their jobs. This was because they had the impression that they were underperforming because DSTD wanted them to do more research than they were doing and the group's Research Leader was not spending any time with group. The members of the group were so concerned about these issues that their morale had suffered and key members of the group were seriously considering leaving the DSTD for other employment. The group's Research Leader and the DSTD Big Chief were so concerned about the situation that they asked the Systems Engineering Centre at Hypothetical University to investigate the situation as a task under an existing research contract. This paper discusses the case providing analysis and comments in the form of footnotes.

After receiving the task and analysing the situation, the plan[2] for the intervention investigation in the form of Hitchins' systems engineering problem-solving approach to tackling a problem [3] became:

Task 1: Define the problem.
Task 2: Conceive alternative solution options.
Task 3: Identify ideal solution evaluation criteria.
Task 4: Perform trade off to find the optimum solution
Task 5: Select the preferred option
Task 6: Formulate strategies and plans to implement the preferred option.

Consider the relevant steps in this description of an application of SSM, namely Tasks 1, 5 and 6.

TASK 1: DEFINE THE PROBLEM

This task began with a review of the relevant documentation[3]. The documentation provided was sparse and mostly useless. However, what was gleaned was that:

1. The situation had persisted for some time.
2. The DSTD Big Chief was concerned about the situation.

[1] A fictitious third world country, ex British Colony used to provide a context for case studies in classes in systems engineering.

[2] This paper focuses on the activities and products elements of the task. Cost, schedule and other resource information is omitted.

[3] This is not an unusual first step.

3. A consultant had been called in some months previously to make recommendations with little apparent effect.
4. This investigation would be the same type of task as the C3I group performed on other groups with the EDF.

Once the information had been harvested from the documentation, preliminary discussions were held with the Research Leader to clarify points that were obscure in the documentation and receive an update on the situation. Then, after some consideration it was agreed that systems engineering was an appropriate approach to resolving the situation since the task statement provided the clear, singular objective and the concept of operations (CONOPS) for the solution system that would describe the activities performed by the C3I group would be part of the final report [5].

This was a people intensive situation; the solution system would probably be a rearrangement of the work performed by the existing (and possibly) additional personnel. Consequently the intervention approach was based on Checkland's SSM [1] pages 224-225). The CATWOE elements of SSM in this instance were:

Customers. The C3I group had two distinct groups of customers.

1. *External customers* in the form of the EDF where a client element within the EDF perceived a problem which was reported to DSTD who tasked the C3I group to examine the situation and recommend improvements in a timely manner[4].
2. *Internal customers* in the form of DSTD management and other groups within DSTD.

Actors. The actors were the members of the C3I group, the Research Leader and the Big Chief within DSTD management.

Transformation process. The then existing transformation process was based on scenarios describing the work performed by members of the C3I group (CONOPS) gleaned from the documentation and the preliminary discussions. The C3I group performed an organisational analysis intervention (process) on elements of the EDF as and when needed. This was the purposeful action or 'root definition' shown in Figure 2. The analysis subprocess was further broken out as shown in Figure 1. The transformation process was a 'standard' process in which the C3I group collected relevant data about the specific situation they were investigating, performed a comparison with a reference model and acquired insight as a result of the analysis. The group then produced a timely report. At the same time the group reported the insight to DSTD and was expected to publish research papers in their field of expertise[5].

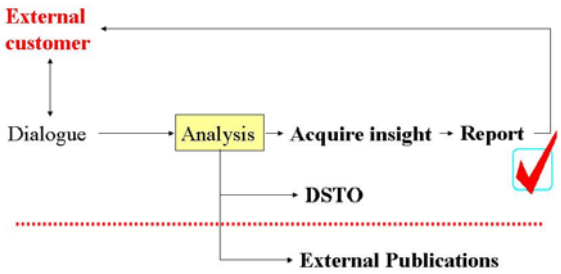

Figure 2 The transformation process

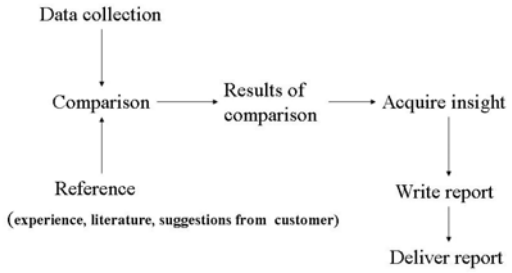

Figure 1 The Analysis Process

Weltanschauung (worldview or paradigm). The differences in the world view of the situation as seen by the C3I group and the Big Chief was the root problem. The C3I group existed in a task-ordered environment. The group's goal was the improvement of effectiveness of the EDF by performing organizational analysis tasks on elements of the EDF and then providing timely reports and recommendations to those elements (customers). At the same time, the group had to make the knowledge gained in each task available to the DSTD which constituted a research environment. The Big Chief had a different perspective on what the group was to do as described below.

Ownership. The ownership resided in the DSTD.

Environmental constraints. The environmental constraints were external and internal.

1. *External.* Military activities were changing, there was a Revolution in Military Affairs under way and military organizations were changing,

[4] Within two weeks or less.

[5] This study performed the same organizational analysis on the C3I group that the C3I group performed on their customers.

and consequently, their external customers were changing. The reports of the group's investigations needed to be made in a timely manner in this changing environment.

2. *Internal.* Within DSTD there was (1) a pending reorganization, and (2) a perceived need to do more "research" as resources permitted.

The SSM perspective together with the domain knowledge pertinent to such situations provided sufficient information to formulate the hypothesis that the underlying problem lay in the different worldviews exacerbated by a communications breakdown between the Big Chief, the Research Leader and the members of the C3I group.

Supporting or refuting the hypothesis

The investigator had to study the C3I group with minimal interference to their ongoing activities. This translated to planning and carrying out short interviews with selected people and a sample of the remainder.

The algorithm for determining which members of the C3I group would be interviewed was as follows:

1. Identify specific key persons to interview. These turned out to be the Research Leader and the Big Chief.
2. Sample the members of the C3I group. The sampling algorithm was simply to telephone each person for an appointment. If the phone was answered an appointment for an interview was made, if the phone was not answered the next person was telephoned.

Interview starter questions for C3I group members. After thanking the person for taking the time for the interview, and explaining the sampling algorithm[6], each interview began with the following five open-ended questions:

1. What does the individual like?[7]
2. What does the individual dislike?
3. What does the group do?[8]
4. What does the person feels group should be doing but isn't?[9]
5. What does the person feel the Big Chief wants the group to be doing?[10]

The answers to the starter questions by the various members of the group are summarized below.

1. What are individual likes

- The range of activities.
- Contributing to improvement of defence.
- Learning new things.
- Research.
- Interacting with co-workers.
- Making a difference.
- Being a change agent.

2. What are individual dislikes[11]

- Uncertainty of the future.
- Work overload.
- Changing directions.
- Political agendas.
- Nugatory work.
- Rushing through the process.
- Interfacing with customer[12].
- Working in a new area without an adequate foundation in the subject matter.
- Not being sure of what the Research Leader wants them to do.
- Conflicting instructions.
- Each task is different.
- Unsure how group fits into DSTD structure.
- Complexity.
- The shifting of the task from tactical to strategic.
- Research without a purpose.

3. What the group does

- Responds to client's demands.
- Goes into organizations and evaluates them.
- Analyze structures and processes.

[6] The interview began with common courtesy, and explained the sampling algorithm to avoid upsetting members of the C3I group.

[7] This was an interview about the nature of the person's work. Like and dislike of work has an effect on morale. The first two questions were posed to determine if the nature of the work could have been a cause of poor morale and were also an ice breaker to start the conversation moving.

[8] This question was posed to determine if (1) there was a common vision of the purpose of the group, and (2) to confirm the transformation process shown in Figures 1 and 2.

[9] This question was posed to obtain ideas for improving the work and obtain buy-in to the results of the intervention.

[10] This question was posed to determine of there was a communications gap within the hierarchy of the DSTD.

[11] Responses to this question confirm the presence of a communications gap between the members of the group and the Research Leader.

[12] This was from an individual whose job required meeting with customers!

- Analysis not necessarily compared with a reference model.
- Research into group's own methodologies.
- Research into organizations.
- Assess impact of technology on capabilities.
- Gets additional work through satisfied customers.
- Considers aspects of:
  - C3.
  - Organizational analysis.
- Supposed to be in research context but is in evaluation context.
- Emphasis on current or short term.

4. What the person feels group should be doing but isn't

- Continue task to help implement recommendations (enterprise improvement).
- What ... if – simulations.
- Research.
- Removing uncertainty.
- Being more proactive in developing customers.
- Transition planning into new tasks.

5. What the person feels the Big Chief wants the group to be doing

- More or less the same.
- Apply more academic rigor.
- Quote "sources used" as basis for recommendations.
- Implement own research program.
- Continue to satisfy external client's needs.
- Publish more.
- Promulgate credibility by referencing underlying principles for recommendations.
- More research.
- "No idea, I only hear things second and third hand"[13].

Research Leader and Chief's perspective

The Research Leader and Big Chief were identified as key personnel that had to be interviewed. The open-ended starter questions and findings are listed below.

Questions to the Research Leader

1. What should the C3I group be doing?
2. How well are they doing it?

[13] A definite communications gap.

The answers to the starter questions are summarized below.

1. What should the C3I group be doing?

- Ultimate goal is to provide information to determine if the investment should be in command, control and communications (C3) or in weapons systems.
- Need to work on these to show importance.
- Determine if C3 makes a difference.
- Operational and organizational analysis, synthesis and evaluation.
- Determine if people understand doctrine and equipment.
- Form Measures of Effectiveness (MOE) for C3.

2. How well are they doing it?

- Strengths:
  - Work together well as teams.
  - GLOWING REPORTS from external customers.
- Weakness:
  - The way in which the job is done.
- Is Management satisfied?
  - Yes and no.

Research Leader's additional comments

- Not unhappy with rate of change.
- Does not want to interfere with a good group.
- Group needs to evolve faster than customers and add new skills.
- Research Leader is not spending time with group because there are more urgent problems elsewhere[14].
- Reduction of budget will have an effect.

Big Chief's perspective

The Big Chief was asked to:

1. Comment on group.
2. Define "research".
3. Provide metrics for successful "research".

The answers to the questions are summarized below.

Comments on group

- Group performed a useful role.
- She recognized the strengths of the group.

[14] The Research Leader seems to be applying Management by Exception. However, the C3I group perceived it in a negative manner. There is a communication issue here.

- Group had credibility with customers.
- Group was evolving too slowly.
- Issues that gave rise to the need for the previous consultant's seminars hadn't improved rapidly enough.
- Good use of empirical techniques in the group coupled with a lack of "scientific" theoretical background.
- Analyses seemed shallow.
- Needed to use a stronger research based methodology on what they did.
- Needed to add researchers to the group.
- Failed to communicate items of importance.

Definition of "research"

- Was NOT publish - publish – publish.
- Was - document in a manner consistent with scientific method.
- Was - use the scientific method in their work.

Metrics for successful "research"

- Needed to be convinced on authority of conclusions[15].
- Needed to quote from the literature to reinforce conclusions and justify methodology.

The interview responses were analyzed with the following conclusions.

1. The fundamental problem was indeed a communications issue, or rather a lack of communications between the Big Chief, the Research Leader and the members of the C3I group. As a consequence, the group were uncertain about their future and how the Research Leader perceived their work, as well as perceiving a conflict between performing their organizational analysis tasks for their customers and performing research.

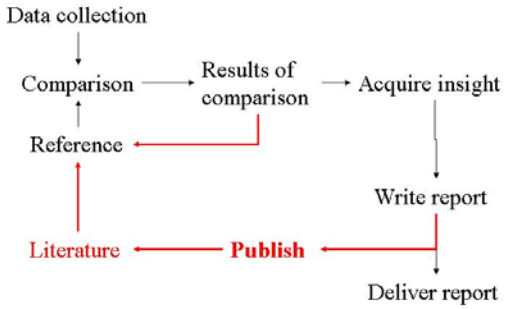

Figure 3 C3I group reference model

2. There was an emphasis on short term or current problems.
3. The group needed to consider the enterprise architectural framework in which the customer organization operated both in the present and future.
4. The work straddled the boundary between soft systems and hard systems which meant they were pushing the envelope but had an excellent 'name making' and publishing opportunity.

TASK 5: SELECT THE PREFERRED OPTION

After considering several solutions[16], it was felt that the perceived conflict felt by the group between performing their organizational analysis tasks and publishing in the research literature could best be overcome by modifying the transformation model shown in Figure 2 into the CONOPS (for what they should be doing) shown in Figure 3. The extra step in the modified process would be to take the same information in the report to the customer and reformat it for publication in a conference proceedings or journal.

TASK 6: FORMULATE STRATEGIES AND PLANS TO IMPLEMENT THE PREFERRED OPTION

The strategies and plans to implement the preferred option took the form of a final report containing an overview of the findings[17], a description of the study methodology, the recommendations and an Action Plan presented in the form of a PowerPoint presentation.

Recommendations to DSTD

The recommendations to DSTD were to open communications channels between the Big Chief, the Research Leader and the C3I group. Specifically the recommendations were for:

- DSTD Management to remove the fear of "research" and uncertainty about future.
- For the C3I group to:
  - Take courses[18] on how to do "research", C4ISR Architecture Frameworks and Soft

[15] By citing references to the literature that support the conclusions.

[16] Not described in this paper since this paper focuses on describing an application of SSM.

[17] Presented first and then amplified later in the presentation.

[18] The intervention was performed by academics from Hypothetical University.

Table 1 Apparent relationship between SSM's CATWOE and the Systems Thinking Perspectives

CATWOE	Systems Thinking Perspective
Client/customer	Big picture
Actor	Operational
Transformation	Functional and Quantitative
Weltanschauung	Big Picture
Owner	Big Picture
Environment	Big Picture

Systems Methodologies as applied to Information Systems.

- Develop personal career plans.
- Modify their methodology by adding architecture issues to customer dialogue and considering medium and long term impacts.
- Develop conceptual models based on the literature for appropriate customer organizations which would speed task completion, provide an objective basis for work and allow structured analysis of impact of technology to units and force structure.
- Reorganize to match current and expanded functions to personal skills/likes dislikes.
- Team within the group for publication in Journals and at the Engaporean Systems Engineering Conference the following year.
- Acquire mentors within DSTD on research methods, Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance Architecture Frameworks (C4ISRAF), and systems methodologies.

The Action Plan

The Action Plan contained the following four elements:

1. DSTD Management to remove uncertainty about the performance and future of group within 30 days.
2. Members of the group to attend courses, starting within two months.
3. Members of the group to acquire mentors within DSTD within 3 months.
4. Create a target for acceptance for publication of at least three manuscripts within 12 months[19].

Preparation and Delivery of the Final Report

With the agreement of the DSTD customer, the report was delivered in the form of a PowerPoint presentation[20]. The presentation was discussed with the Big Chief and then made to the Research Leader and members of the C3I group. The format of the presentation also provided an example of how to implement some of the recommendations and included:

- Explaining the sampling algorithm, stating that there was not a 100% sample, and that not being sampled does not equate to unimportance.
- References to the literature for the methodology and conceptual models providing some academic rigour.

SSM AND SYSTEMS THINKING

SSM came out of Operations Research. Its "root definition" describes the purpose of the system under consideration. The CATWOE template seems to align with some of the systems thinking perspectives (STP) [4] as shown in Table 1[21]. The quantitative, structural, generic, and continuum perspectives are not implicitly invoked in SSM and the scientific perspective is implied by the findings of the study using SSM. While this case focused on the application of SSM the remaining STPS were invoked. For example,

- The structural perspective was used to develop the DSTD organisation chart to match the people into the hierarchy and indentify which people had to be interviewed and who could be sampled.
- The 'to be' or reference model came from prior experience, namely the generic and temporal perspectives.
- The temporal perspective showed that an earlier intervention had not been successful which is why this intervention was invoked.

[19] Acceptance is an output measurement. Specifying submissions for publications was useless because it did not require any academic standards and rigor to be applied to the manuscript.

[20] The intervention was performed within 40 man-hours. Creating a written report would have doubled the time and cost of the study. It was felt that a presentation would serve the purpose of distributing the findings of the intervention to the necessary personnel in the C3I group.

[21] The boundaries do not align directly because the decomposition of systems thinking is different.

- The analysis of the initial observations produced the hypothesis (scientific perspective) that the situation was the result of a failure in the hierarchical communications path between DSDT management and the C3I group. The interview questions were then phrased to determine if the hypothesis was supported.
- The continuum perspective points out that the different SSM actors may have different Weltanschauungs which may need to be considered.

LESSONS LEARNED

The lessons learned from the case included:

1. When dealing with people, perceptions are more important than the reality. It was the perception that the Research Leader was unhappy with the C3I group that drove their morale down.
2. Communications is the key to success. The failure in communications between the C3I group and DSDT upper management was a major contributor to the situation.
3. SSM needs to be tailored to the situation, like all methodologies.
4. The STPs were useful in scoping the intervention and determining the key interview questions.
5. Hypotheses can be made based on a small data sample by experts who compare the situation at hand with similar situations that have been observed in the past. However, the analyst performing the intervention has to make sure that if additional data does not fit the hypothesis, the data is not discarded but rather the hypothesis is modified to fit the data.

SUMMARY

This paper provided a case study on how Checkland's SSM was applied to investigate an organisational problem in a government organisation. The intervention investigation used Hitchins' systems engineering problem-solving approach as the approach to identifying and tackling the problem. The last part of the paper showed that SSM is a useful tool for gaining an understanding of certain aspects of situations but is incomplete when compared to the STPs.

AUTHOR'S BIOGRAPHY

Joseph Kasser has been a practicing systems engineer for 40+ years and an academic for about 10 years. He is a Fellow of the Institution of Engineering and Technology (IET), an INCOSE Fellow, the author of "*A Framework for Understanding Systems Engineering*" and "*Applying Total Quality Management to Systems Engineering*" and many APCOSE and INCOSE symposia papers. He is a recipient of NASA's Manned Space Flight Awareness Award (Silver Snoopy) for quality and technical excellence for performing and directing systems engineering and other awards. He holds a Doctor of Science in Engineering Management from The George Washington University. He is a Certified Manager and holds a Certified Membership of the Association for Learning Technology. He has also served as the inaugural president of INCOSE Australia and as Region VI Representative to the INCOSE Member Board. He gave up his positions as a Deputy Director and DSTO Associate Research Professor at the Systems Engineering and Evaluation Centre at the University of South Australia in early 2007 to move to the UK to develop the world's first immersion course in systems engineering as a Leverhulme Visiting Professor at Cranfield University. He is currently a Visiting Associate Professor at the National University of Singapore.

REFERENCES

[1] P. Checkland, *Systems Thinking, Systems Practice*, vol. Chichester: John Wiley & Sons, 1993.

[2] P. Checkland and J. Scholes, *Soft Systems Methodology in Action*: John Wiley & Sons, 1990.

[3] D. K. Hitchins, *Systems Engineering. A 21st Century Systems Methodology*. Chichester, England: John Wiley & Sons Ltd., 2007.

[4] J. E. Kasser and T. Mackley, "Applying systems thinking and aligning it to systems engineering," presented at the 18th INCOSE International Symposium, Utrecht, Holland, 2008.

[5] J. E. Kasser and D. K. Hitchins, "Unifying systems engineering: Seven principles for systems engineered solution systems," presented at the 20th International Symposium of the INCOSE, Denver, 2011.