Systems Thinking Applied to Teaming

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Abstract. The Aerospace Institute (TAI) provides the learning environment for staff at The Aerospace Corporation (a Federally Funded Research and Development Centre). The staff averages over 23 years of industry with advanced degrees. Our knowledgeable space engineering and scientific staff particularly challenges TAI when presenting concepts related to teaming.

Most people equate team-related training as applied psychology. This may make engineers and scientists uncomfortable. TAI applied systems thinking to the description of teaming and found some surprising results. It yielded a multifaceted Team Map. One facet reveals the team-based competencies, such as roles and responsibilities. Another facet conveys the team life cycle and the specific attributes for each role in the life cycle phase. The third useful facet provides the associated data of team relationships. The map has several practical applications; it provides a reference for teams, a descriptor for tool application, and a source to develop team diagnostics. The Aerospace Institute used it in curriculum evolution to differentiate among its team related course offerings.

MOTIVATION FOR THE EFFORT

Curriculum Evolution. TAI provides team related training within a "Teams and Systems Thinking" curricula segment. The segment is for space systems architects, engineers, and acquisition managers as well as corporate managers and corporate staff.

Curriculum Evolution Goals. TAI had clear goals to evolve this curriculum. To meet its distinct target population needs TAI wanted to provide a unifying team learning philosophy, clearly articulate course objectives, ensure each course covers the appropriate breadth and value as well as permiting learners to understand the course path to meet their needs.

SYSTEMS APPROACH

Approach Based on Competencies. The effort took 3 people, two hours a week, for three months. It began with agreements to look at competencies associated with teams since competencies are used as a basis for curriculum development. Needs and competency-based development are tenets of the Instructional System Design (ADTD 1999). It was agreed that each competency would have three components; knowledge, skills, and attitudes. Knowledge would address what the participants would know or understand as a result of the learning experience (course). Skills would address what the participants would be able to do. Attitudes would tackle what the participants would be willing to do.

The Need for a Comprehensive Team Competency Model. We initially believed that by describing the competencies alone, we could refine our curricula. Literature searches combined with brainstorming and several review sessions produced an exhaustive list of teaming competencies. It became evident that comprehensive lists of competencies for teaming are useful for course design, but they are unwieldy for curriculum design (definition: courses constituting an area of specialisation). Competencies were aggregated under headings. As the headings took form, discussion arose about adopting an existing team model. A unifying team model would uncover the distinctions and similarities of the teaming curricula easier than detailed competency lists.

Competency Model Alternatives. Two popular "team" models were compared to see if they were acceptable for use as a unifying reference: Team Effectiveness and the Stages of Group Development (Lacoursiere, 1980) and Forming, Storming, Norming, Performing, and Adjourning (Tuckman, 1965). Neither of the modules held up well when evaluated against Systems Thinking principles (ASTD 1997), Table 1.

1. Stating the Problem
2. Identifying Cause and Effect
3. Identifying Key Variables
4. Identifying Variable Relationships
5. Creating Loops
6. Identifying Patterns in the Outcome
7. Determining Effective Solutions
8. Evaluating the Whole Process

Table 1. Systems Thinking Steps

System Thinking relies on links, causal loops and leverage points. Process elements are defined, linked, then link relationships are characterised and leverage points are identified and controlled.

System Thinking also looks at data relationship and trends. The two team models didn't address data at all and didn't address systems thinking steps, 1, 5, 6, 7 or 8.

Lastly, we wanted a team model that had specific competencies so that we could use desired learning objectives (DLOs). Although these models had lengthy lists of component attributes, the attributes were not competencies. TAI uses DLOs to design its courses using an ISD method (ASTD 1999). The models examined didn't have DLOs and hence weren't useful to implement ISD.

Since none of the identified models were able to capture the aspects of the teaming curricula when compared to Systems Thinking principles, TAI developed its own description.

THE AEROSPACE TEAM MAP

Team Map Description. The Aerospace Institute synthesised its own solution; named the Aerospace Team Map, Figure 1. Elements of the Aerospace Team Map are further defined in Table 1.

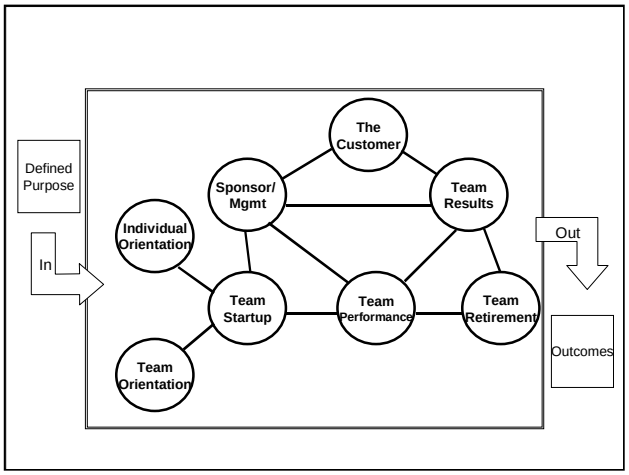

Figure 1. Aerospace Team Map

TAI specifically chose to identify its solution as a "map" rather than as a "model."A model conveys the structure or workings of a concept whereas a map shows the correspondence between the elements of one set and those of another. The Aerospace team map was able to establish a correspondence between the team elements of one set and those of another. TAI felt that the initial presentation of the map would provide a simple expression of the concepts. Eventhough annotated representations do help to clarify individual competencies, member viewpoints, information exchange, and translation to project schedules for resource assignments.

Black Box. From the highest level of abstraction, the team map is a black box system. It is a transfer function where it accepts inputs and produces outputs. The inputs are the defined purpose and the outputs are potential outcomes. The defined purpose includes such diverse items as running a process or solving a specific problem. The recommended outcomes range among bounding a problem, identifying alternative solutions with various values weighting, to recommending specific data or courses of action.

Element	Description
Individual Orientation	How a person *individually* applies his or her professional expertise, work styles, personal styles, strengths and limitations to the team activities.
Team Orientation	How the team members *collectively* apply their professional expertise, work styles, personal styles, strengths and limitations to the team activities.
Sponsor/ Management	The person (usually a member of management) who assumes the role of advocate/supporter for the team, and who is accountable for and owns the team's resource allocations.
Team Start Up	The initial phase in the team life cycle, in which team members develop a team charter and organize the team functionality.
The Customer	The customer organization which has requested the team and/or will benefit from the team's product or solution.
Team Performance	How the team operates, including: task completion, problem solving, decision-making and communication within/outside the team.
Team Results	The team's work output, including: product, solution, or opportunity generated from a defined purpose, decision, or problem statement
Team Retirement	The last stage in the team life cycle, when the team's purpose has been fulfilled or conditions have changed which impact the team's longevity

Table 2. Aerospace Team Map Element Definitions

Team Map Discoveries. The Aerospace Team Map addressed areas that are often missed in other team models. Aerospace staff cited these areas as:

understanding customer direction and constraints, effective management of the effort, ensuring team results met customer (and sponsor) expectations and requirements, recognising individual contributions and keeping management apprised of issues. Most team models usually ignore the customer element. Specifically identifying the customer as a key element in the team map uncovered competencies necessary for the customer to clearly commission work and evaluates the results.

Another area that is routinely ignored is the team retirement. There are several reasons why the retirement of a team must be acknowledged and recognised. Defining when a team has completed its work (exit criteria) is necessary to reallocate them to other work. Retirement also permits customer and management the opportunity to provide feedback to the team members for celebration and reward.

Element Composition. Within the team map, functional elements are represented by circles: Individual Orientation, Team Orientation, etc.. The elements are connected to identify relationships/interfaces between elements.

Each element has a set of competencies as attributes. These competencies form the performance benchmark. If a significant portion of competencies is performed well, a person can be viewed as highly competent. Conversely, if a lessor portion of the competencies are performed or are performed less well, a person can be viewed as less competent.

Each element requires resources to perform. Team progress cannot be made unless resources are available and are allocated. As such, having all the elements is useful in defining all the resources needed. How often has a team come to the end of a task and not allowed time or budget to celebrate?

Element Ordering. The elements can be arranged in a temporal fashion from start to finish (not shown). The elements are roughly arranged from left to right in order of occurrence: Customer, management/sponsor, team leader, team individuals, team startup, performance, results, and retirement. This type of ordering is helpful in defining a project management schedule.

The map can be annotated to form a process diagram with direction information flow arrows. Element information transfer is recursive; there is more than one path through the elements. The process view can also be translated into a project schedule.

The elements can also be viewed hierarchically. For example, the customer element, at the top of the map, initiates the work with management. Management commissions the team and may name individuals to populate the team. The team is made up of individuals performing the work.

Element Relationships. To transform the map into a process, arrows on the connections would impart the information flow between elements.

Comparing Map Elements to System Thinking. Briefly comparing TAI's effort to system thinking steps, we find a positive correlation. One conclusion that can be drawn is that the TAI Team Map is a process description that uses Systems Thinking steps, Table 3.

Systems Thinking Step	TAI Team Map
Stating the Problem	Understand the team's defined purpose. Stating the problem is an input to the team map "Black Box."
Identifying Cause and Effect	Connecting elements of the team map. Recognising temporal, character, and data relationships among elements.
Identifying Key Variables	Identifying team map elements, input and output
Identifying Variable Relationships	Understanding the recursive nature of data development, flow and co-ordination.
Creating Loops	Presenting the map in temporal or hierarchical order.
Identifying Patterns in the Outcome	Understanding alternative team viewpoints; customer, manager/sponsor, team leader, team member, team.
Determining Effective Solutions	Understanding alternative uses of the map based on situation; learning and operations.
Evaluating the Whole Process	Describing a comprehensive team map with many attributes and many views.

Table 3. Systems Thinking Steps and the TAI Team Map

MAP USED TO REFINE CURRICULUM

Comparing Courses to the Map. TAI had four courses on teaming in its curriculum and were considering two others. Several of the courses were externally provided while the others were developed in-house. The courses were open to all employees; technical staff, leadership (management) and business (administrative).

The desire was to have course offerings that were (a) tailored to the population, (b) meeting the

staff needs and (c) based on valuable, consistent, instruction. TAI wanted to ensure that the courses enabled staff to do something they couldn't do or couldn't do as well prior to the learning experience.

TAI found that the criteria (a through c) above were useful. It eliminated two teams courses by focusing on the following populations; technical staff, managers, leaders without direct authority, and business staff.

Some Surprising Results. TAI found some surprising results since not all courses covered all of the Team Map elements. In particular, we found that our teams courses, and most teams courses we've been exposed to, don't focus on the customer relationship to management or the products. We also found no references where customers should have minimal competencies! Imagine where customers actually performed their competencies as their overall contributions to the team.

Another set of surprising results related to the team tools. Prior to our group forming to improve the curriculum we had tools for teaming that were not applied across the curriculum. We decided to leverage this in the other courses as a technique and a reference document.

De-conflicting Courses. Targeting the populations was key to curriculum and course change. TAI established evaluation criteria and a short procedure to examine course value (Table 4).

Evaluating course materials helped to minimise course conflicts and ensure that the material was both valuable and consistent. Consistency provided a means to select vendor or organic instructors, instructional materials and methods. Reviewing the course materials and methods against the map provided a breakthrough since each of the courses had strengths and weaknesses. The concept of building on the strengths and leveraging those across the other courses was powerful. For example, TAI eliminated duplicate means for self-inventory and found that once a participant has a self-inventory experience, it wasn't necessary to repeat it. This led to another breakthrough, modularising the classes.

Team Course Design Alternatives. Given our investigation to improve our teams curriculum and the discoveries made, we decided to examine alternative curriculum designs. Our current design is stove-piped -- we have separate courses for the three corporate communities; technical, leadership, and business. This has pros and cons. The pro is that we permit each community to have a focused offering. The cons are that its difficult to leverage lessons learned with different instructor pools, with some taught by organic resources and others taught by vendors. It also didn't lend itself to sharing tools. Lastly, it prevented populations from mixing.

- Targets all Customers: Technical, Leadership, and Business
- Addresses complete competency: knowledge, skills, and attitude
- Individualizes / tailors customer assignment
- Enables customers to do something right away
- Permits interchangeable staff instruction
- Increases TAI cooperation
- Minimizes TAI expenditure
- Is achievable
- Is based on solid information
- Uses a mix of learning methods: simulation, case study, role play, report out, etc..

Table 4. TAI Course De-Conflicting Criteria

We are currently examining an alternative (Figure 2). This alternative provides the purpose for a generic introductory team course; Collaboration for problem solving and decision making. It counters many of the cons from the stove-pipe design. Where the stove-pipe design is a day for each class, this would be a single day. Notice that we intend to retain domain specific instruction to provide experience in handling domain specific language, situations, etc.. We are considering tackling this by having specific sessions for each population.

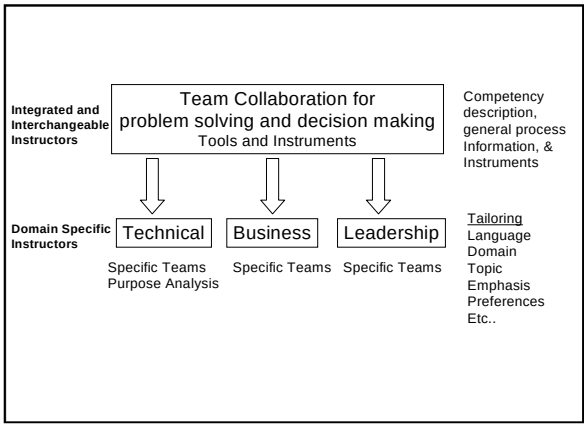

Figure 2. Alternative to a stove-piped teams curriculum

Advertising Courses. The team map also provides a comprehensive picture for advertising how the courses relate to one another. For example, we have different teams courses for technical staff, leadership and management, and for business staff. The maps can be used to explain specific elements that are more important than others in the learning experience.

When training leaders and managers they

typically fulfill the "manager/sponsor" role. So focusing on those duties helps to explain what managers/sponsors need to do and the competencies involved. Similarly, managers/sponsors can be customers and have to be familiar with that role. Lastly, managers/sponsors work with customers to get a job done and understanding that role and interaction is vital to success. Table 5. Lists top-level manager/sponsor competencies that are the focus of our High Performance Management Teams course.

Setting project/program constraints; performance, budget, schedule, risk, resources
Negotiating/setting priorities with other Sponsors/managers
Addressing issues with other stakeholders
Requesting resources/monitor the utilisation of resources
Acting as an advocate for the team with other teams/groups
Ensuring customer satisfaction
Reviewing team and individual performance
Providing recognition to team members

Table 5. Manager/Sponsor Competencies

MAP USED OPERATIONALLY

Views and Viewpoints. The map is used to understand views and viewpoints. A viewpoint is a role; customer, manager, team leader, or individual. A view is how the person in a role understands the environment; what is important, how processes work, etc.. A view is made up of beliefs and assumptions. Individuals, the team, the customer and management each have their perspective of the work, team, and performance.

A view/viewpoint is helpful since it allows us to walk in someone else's shoes and understand what is important to them and what they see.

Individual and Team Viewpoint. Individuals gain a viewpoint from self-inventory and understanding where they fit in. Looking at the Team Map (Figure 3) they may be concerned with understanding their capabilities, their role on the team, how to dialog with their management about the task, performing and getting results from their unique contributions, and when the team and their participation will end.

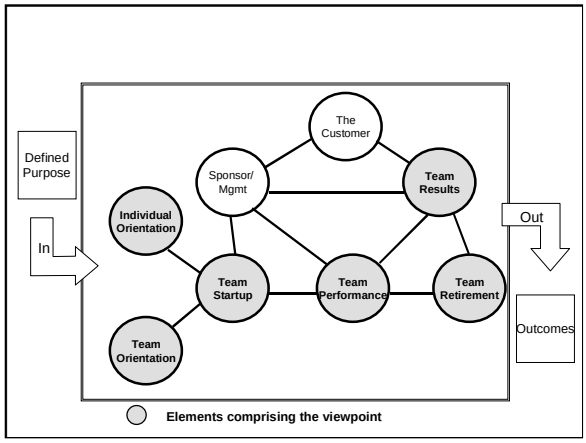

Figure 3. Individual View

Customer Viewpoint. Although we are all concerned about our customers, how many of us really have thought through what attributes a good customer should have? Have we considered how to help them become good customers? A customer competency description may be a key to answering both of these questions (Table 6).

Be able to clearly articulate needs and objectives; technical, cost, schedule and political.
Be able to articulate the priorities of the needs and objectives as well as the impacts and consequences if they are not met.
Be able to build appropriate customer teams to consolidate the needs and objectives.
Negotiate as necessary to consolidate the customer needs and objectives.
Provide a customer representative to dialog with the team management/sponsor and potentially dialog with the team.
Provide adequate resources.
Setting project/program constraints; performance, budget, schedule, risk, resources
Reviewing team outcomes
Providing feedback to Management or Sponsor
Provide feedback/evaluation of team results

Table 6. Customer Competencies

Manager/Sponsor Viewpoint. Another view to consider is the Manager/Sponsor View. How might this be illustrated with the help of the Team Map? This exercise will be left for the reader to think about and construct.

Team Leader Viewpoint. The Team Leader View is a difficult one. It encompasses almost all of the team map elements. Surely a team leader must have a global understanding of the team concept in order to get the job done. This creates interesting bridges among competency development, teams learning, project management, and systems thinking. A team leader must understand the team viewpoints, must be able to think systematically, then derive project plans and perform project management systematically.

A team leader builds the team with management/sponsor assistance. The team leader coaches team members and builds the team through start up and performance. In order to perform, the team leader has to set systematic performance goals. These are sometimes referred to technical performance measures (TPMs). The TPMs are goals that can be measured by collecting data (e.g., metrics). The derivation of setting team goals, plans, TPMs and metrics is a logical part of systems thinking. There is also a rich set of project and management theory that is systems based; concurrence engineering, total quality management, etc.. The team leader must decide on what techniques to use, why, and then go do it. These are not easy tasks.

SUMMARY

This paper discussed how The Aerospace Institute applied Systems Thinking to Teaming with the intent of improving the Teams and Systems Thinking curriculum. In doing so we:

- Derived a Team Map that was useful for de-conflicting courses,
- Examined alternative Teams and Systems Thinking curriculum designs,
- Used the map to assist us in advertising the courses to customers needing the competencies,
- Improved the course coverage and provided helpful tools that can be used operationally.

CONCLUSIONS

Summary of Results. The Aerospace Institute and the Aerospace Corporate staff greatly benefited from the effort to describe teams in a systematic way. Below are the conclusions, benefits and discoveries:

Conclusion: The Aerospace Team Map provides a systems construct that connects with engineers and scientists in a way far more powerful than traditional team related learning materials.

Summary of Benefits.

- The Aerospace Team Map is useful in applying Instructional Systems Design to a Team Curriculum.
- The Team Map competencies and tools are powerful components to building team member character.
- The Team Map is useful as a field guide for team members.

Summary of Discoveries.

- Describing customer competencies helps to understand the customer capabilities and is a practical tool for improved support by taking on additional responsibilities and tailoring tasks.
- Team Leaders have a tremendous responsibility and may require additional coaching.

Building on Success. The Aerospace Institute (TAI) is now in the process of leveraging off the success of the effort. We are continuing our efforts to broaden our Teams and Systems Thinking curriculum by building up the Systems Thinking side.

TAI is considering putting as many of the Teams course materials onto the corporate intranet to permit staff to access the materials whenever needed. This potential benefit needs to be further evaluated, if implemented, since there is a possibility that staff won't be able to adequately use some of the tools appropriately (such as the personal inventory systems).

Lastly, we are postulating that practical team diagnostic material would be useful. Much like home appliances have tables for problem trouble-shooting, we postulated that diagnostic materials could be developed for each element of the team map. This could be very powerful to the operational use of the model. We could equip course graduates with diagnostic tools and couple them with potential remedies.

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BIOGRAPHIES

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