PERCEIVED ORGANIZATIONAL EFFECTIVENESS:

DEGREE OF CONSISTENCY

IN THE PATTERN OF EXPECTATIONS

by

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Abstract

This thesis investigated the relationship between consistency and effectiveness within the context of a model of the interaction between a work unit and a functional group. The research consisted of two major areas of work: the theoretical development of the Expectation Range Model and its operationalization of interaction characteristics, and in-depth case studies for the measurement and testing of the theory. The proposed hypothesis is:

> *The more the perceived Inter-group Consistency between the expectations of a work unit and another interacting functional group, the more the perceived Linkage Effectiveness of that relationship.*

The literature has dealt with intra-group issues with role models directed at the individual. Clearly problems happen within a unit which can make them less effective, however, a work unit might also reach a high level of effectiveness with the co-operation of their supporting functions. The Expectation Range Model contributes to this literature in several ways: extending interaction concepts from the individual worker (intra-group consistency) level to groups (inter-group consistency); dealing with the reality of two way expectation communications between groups; presenting the concept of a range of acceptable responses; and applying the model to the manufacturing environment. It defined and operationalized three types of inter-group consistency as it related to the *sets of expectations* held by the Work Unit and the Functional Support Group, vis:

(1) ***Importance*** - expectations that were shared;
(2) ***Priority*** - expectations that were given primacy; and
(3) ***Acceptability*** - expectations that viewed actual behaviour in similar ways.

Two extensive case studies were conducted over a period of about three years to test the hypothesis: a high technology electronic repair unit in the U.S.A. and an automotive parts manufacturing organization in Ontario. The quantitative data collected was used for the calculation of a consistency score that was correlated with independent judgements. The results from one site strongly supported the hypothesis while the other site provided more selective support.

The results, methodology and potential directions for future research are discussed.

Acknowledgement

This journey towards the Ph.D. has crossed over several sunny summits and through a few frosty lowlands. But, like all journeys we can turn and appreciate the path for what it has made of us ... that unknown first-year Professor who took the time to reveal my abilities and start me down the road. David who gave me a name, 'Maverick.' Steve who demonstrated how shove precedes soar. Jim who allowed me to grasp reality and hone an edge on a theory. And of course, Frank ... for all your guidance, patience, wisdom, friendship and belief ... I thank you.

Dedication

To the three exemplars in my life: Jack, Beth and Giorgina ... determined, passionate and courageous love.

And to the 5-Js: Julie, Jesse, Jennifer, James and Jonathan ... may you stride hilltops resolutely, jig on warm sands and dare the path to turn.

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1 Introduction

Organizations have tried, often quite successfully, to realign their manufacturing processes by re-deploying and re-training their dedicated operations work unit members. To become more effective, however, the expectations of a work unit and their members must be consistent with the needs of the enterprise and those of the support functions in the work unit's network of task interactions. That is, organizational effectiveness is an outcome of many small but consistent interactions throughout the enterprise.

> Consider the case of an operator of a repair station on the electronic mod-line, replacing defective components. She looks with dismay at the new air activated clamping device and says, "I'm not using that, I'm doing all right without it! Just get me the parts and drawings on time." Her experience has led to conclusions about how things *should be*, what she expects from others, or "how things are done around here." Whether good or bad these experiences have set limits on how she will react to similar situations in the future.
>
> If the manager expects the operators on the repair line to update twenty circuit packs per hour and make fewer mistakes by using the new air clamp, and the operators agree, then twenty "good" packs is the output each hour. We can say that the expectations of the manager and the group are consistent. However, if the operators feel that they can modify twenty packs just as well by using a manual method then there is an inconsistency in expectations. There is conflict about what was a "good" pack and how to achieve it. This leads to conflict for both the manager and her operators, but also may lead to a reduction in productivity as energy is wasted doing the wrong actions.

Consistency happens as a conscious and sustained effort of the organization. It is built into its fabric, from the first day that an employee applies to the company through every day that he or she remains an employee of that company. Consistent expectations may lead to a sense of shared goals and norms that are the focus for continuous improvement and increased effectiveness.

This research was undertaken out of a motivation to develop a theory on how to instill a 'pattern of expectations' – a set of consistent expectations – which promotes operational effectiveness. An exploratory study of Japanese[1] manufacturing groups and the author's extensive experience with a Global Telecommunications firm have underscored the vital importance of group interaction inquiry and the need to have a way to talk about consistency. With a view to this, research into the notion that effectiveness is a function

---

[1] A study based on interviews with North American professions who have direct work experience in Japan and have observed their teams. The intention was to look at how expectations differ between Japanese and North American companies with a view to how the differences could be exploited to assist in the formation of successful work teams. The quantitative data clearly pointed to the relationship between consistency and effectiveness. However, the qualitative data did not discriminate underlying expectations of effective group interaction.

of the degree of consistency in the pattern of expectations was undertaken. It looked at the linkages of a Work Unit and its Support Functions, and their interactions. While '*interaction*' between individuals has been noted, and modeled by some researchers, it has not been modeled at the group level or applied to manufacturing situations, or has typically presented cause-effect relations rather than two-way interdependent interaction.

This thesis consists of two major areas of work: an extensive theoretical development; and in-depth case studies to test the theory. It was organized in six sections and an Appendix, as follows:

> Section 2 will summarize some of the literature on consistency and role models that have a bearing on this thesis. Most research touches on isolated aspects of interaction and intra-group issues: the situation, goals, norms and roles. For instance, the situation may set the physical and psychological context for the individual, and through interactions with other members of the group, the individual might refine their view of 'how things are done around here.'
>
> These theories have addressed small group behaviour using force, and later expectation, models. It became apparent that there was a need to define consistency and model group interactions. Kahn's Role Model, sub-section 2.4.3, was taken as a starting point to help develop the Expectation Range Model in Section 3. This detailed theoretical framework was advanced to explain, in a new way, expectations in relation to three concepts of consistency, operationalize consistency, and further the understanding of a Work Unit's linkage interaction.
>
> To provide the academic and practical depth required by a conceptual model, a case study[2] approach was undertaken to "drill-down" into the actual functioning of successful Work Unit linkages. Section 4 will provide a general description of the research methodology used to conduct the case studies to gather quantitative and qualitative data to test the Consistency formula proposed by the model. The case studies were conducted over a period of about three years and based on site observations, data from a series of group member interviews, and the results of responses to questionnaires from a Canadian auto parts manufacturer and a USA electronics repair facility.
>
> Then, Section 5 will provide in-depth analysis of a wide variety of case data, using a mix of interpretive and quantitative methods to examine the case results in relation to the theoretical framework. Section 6 provides an overview and discussion of the case findings in relation to the theory, and considers issues related to the performance of the consistency measure, methodological limitations of the study, and the generalize the results. Additionally, it identifies the primary

---

[2] Mintzberg [1979] indicates that systematic data should be supported by anecdotal data from the field, and "*the need to be on site, and to be there long enough to be able to understand what was going on.*" Unfortunately, the literature was not rich in direct observation. Cost, accessibility and the availability of appropriate situations were at the root of most problems in providing observational data.

contributions of this dissertation, examines some of the implications of the work for organizational theory and practice, and identifies areas for future research.

2 Literature Review

2.1 Overview

This research views operational effectiveness as the outcome of a network of consistent, or aligned, expectations, which arise out of numerous interactions within the task situation (e.g. structural, technological/systemic, intra and inter-group). Over the last four decades many authors have supported this view, for example: Likert (1961) writes that "the form of organization which will make the greatest use of human capacity consists of highly effective work groups linked together in an overlapping pattern by other similarly effective groups. ... they endeavor to have the values and goals of the groups which they link in harmony, one with the other." This pattern which connects is a meta-pattern, a pattern of patterns, (Bateson, 1979) intelligence is to be found in patterns of behaviour. (Weick, 1993a) Jaffe (1998) adds, "if people all had the same values with the same priorities, it would be easy for them to work together in groups."

This section is divided into three parts that review the literature, with compatible applied manufacturing examples, from the view of:

(1) ***Consistency***, topics that deal mainly with inconsistency for the individual and how a disagreeable state leads to behaviour designed to achieve a consistent and agreeable state;
(2) ***Role models***, that bring together several or all of the elements in Figure 2-1, that is, link together the actions of persons in particular positions within a social structure; and
(3) ***Models*** for consistency, manufacturing and roles are discussed in detail.

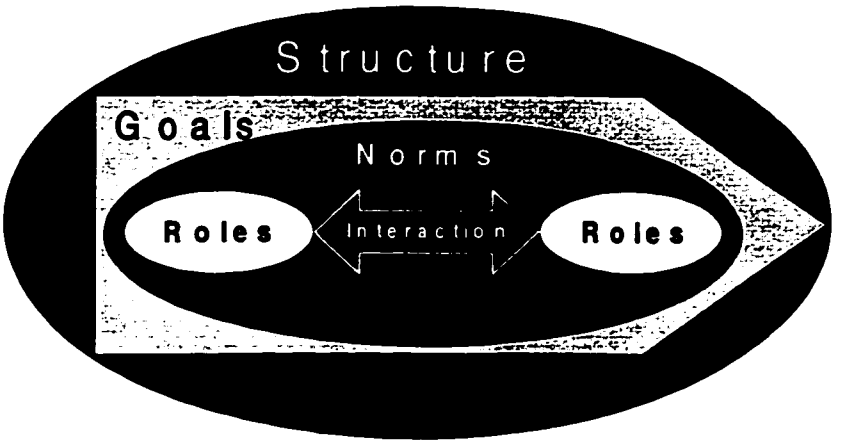


Figure 2-1: Topics in the Literature

The conclusion of this section is that there is a need for a precise understanding of consistency, to extend it to two-way inter-group linkages within manufacturing, and to operationalize it.

2.2 Consistency

Heider's (1959) Balance Model, presented in detail in sub-section 2.4.1, appears to be the first to use the concept of inconsistency. It considers the alignment of the expectations between two persons and an object, and the principle of self-other congruence suggests that inconsistency occurs less frequently and is less stable than more consistent situations. Others, like Newcomb (1965) and Festinger (1957), have extended this model, broadened the areas of application and contributed new language to the understanding of consistency. For instance, 'dissonance' may be viewed as a tension or pressure that results from a sentiment or orientation towards something and leads to behaviour to achieve 'consonance'.

These models provide a suitable backdrop for a broader discussion of consistency, using goals as an example of potentially inconsistent expectations that may result in conflict or ambiguity, and lead to stress and behaviours to reduce it. In addition, this section provides an introduction to the notion of consistency as an important aspect of role models. (See the footnote[1] for definitions of conflict and ambiguity as they are used in role models).

> Consider an operator that joins a Work Unit that has production goals that are different from their Support Group for preventative maintenance. This creates an imbalance for the worker that reduces his ability to predict the outcome of certain behaviours. Through training the worker and Work Unit learn what is expected and this results in 'consonance' of behaviour-response and allows the worker to predict how the other group will react.

For the organization, the literature on goals recognizes the unifying impact of commonly held, high level, expectations. Likert (1961) acknowledged that the productivity of a work group can be increased substantially and waste correspondingly lessened when the goals of the Work Unit shift so as to become more consistent with the objectives of the organization. Work Unit needs to have a clear direction so that they can focus their efforts and evaluate their performance. Effective organizations have consistent expectations based on a common set of "high performance goals." (Shafritz, 1978)

For an individual and the Work Unit, consistency of expectations is their common understanding. An individual is attracted to a group when they understand the group's goals, the path to achieving them and how the individual contributes. Bedeian (1980) wrote that this also applies to the connections between groups, "Organization members often have a limited appreciation of the dependencies and complicated connections existing between departments or tasks. As a consequence, individual organization member's conceptions of goals tend to be greatly influenced by the nature of their particular task assignments and their knowledge of other units ... or personal goals."

---

[1] Role Conflict: when two individuals hold equal and opposite expectations;
Role Ambiguity: when an individual does not know what is expected by another individual

When the individual's contribution deviates (becomes inconsistent) from the Work Unit's goals, the unit restores uniformity. Several authors, like Lewin (1952), Hare (1962) and Cartwright (1960) have written that pressures toward consistency can serve at least three functions: to help the group accomplish its goals, to help the group maintain itself as a group, and to help the members develop validity or 'reality' for their opinions.

However, when individual and group goals deviate from those of the organization there can be ineffectiveness. For example, the group may have a goal of making sure all members have work to do so they earn their hourly rate, 'work slowly'. On the other hand, the company gets more product orders by keeping the production costs down, 'work quickly'. The individual may be consistent with the group goals, but inconsistent with the company goals.

Conflicting and ambiguous expectations at the individual, work unit or organization levels may have stressful impacts and have been a major topic in the literature. House (1972a), whose manufacturing model is presented in sub-section 2.4.2, felt that a lack of clear performance standards or feedback and the ambiguous and frequently changing directives, are conducive to role conflict and ambiguity and reduce effectiveness. Because of this it has been suggested that astute managers should pay special attention to the factors that lead to increased levels of role conflict and role ambiguity, like the quantity and quality of communications. (Zahra, 1985) In the end, interventions aimed at reducing role strains are likely to reduce employees' propensity to leave. (Klenke-Hamel, 1990)

Several recent extensions have been made to the concepts of Conflict and Ambiguity. These extensions may improve the understanding of consistency and lead to better ways to measure it. For example, Rabinowitz (1987) split Role Conflict into four factors: "Person-role conflict; Inter-sender conflict; Intra-sender conflict; Role overload." Kahn (1994) added an overload factor to his Role Model, which is discussed in detail in sub-section 2.4.3, and demonstrated that when people are overloaded they "shut off communication from some of their satellites in the work situation, and thus reduce their own pressure, at the same time increasing the felt pressures of those who try in vain to communicate with them." Additionally, Zohar (1995) has proposed a new "justice" variable for the measurement of role stress.

Consistency is also an important aspect of each of the role model's elements: the situation, roles, norms and interactions between work units. These elements will be presented next.

2.3 Role Theory

Role theory is in the main a collection of principles about human functioning in a social context. The history of Role Theory is rooted in a theatrical *situation*, where an actor's *role* is *linked* to another 'target' role through the behaviours of the actor. This section will address these principles it turn:

(1) the ***situation***, the position in the social structure and a role associated with that position;
(2) the ***role***, and the broader norms, that are the expectations (the 'oughts') that define both the role and the possible courses of action; and
(3) the ***linkage*** to others, which includes the performance and evaluation (approval or disapproval) of the role behaviour, and may infer the strength of the relationship.

2.3.1 Situation

The situation is the stage on which the actors perform, but their performance is affected by its structure. For an organization, for example, "built structures [like a church] have both a functional and a symbolic relationship to social organization." (Baldry, 1997) When we enter one of them we know how we should act, the situation already has predefined behaviour expectations on where we should sit and when we should stand.

For an individual or work unit, understanding the situation is necessary for the formation and sustaining of consistent expectations. Hackman (1986) suggests that a performing unit structure and a supportive organizational context enable unit effectiveness. To the extent that the Work Unit and members understand and act consistently with the expectations of the situation they will be effective. A quality program, for instance, may define how the Unit should inspect their product but it will also provide them with the tools and training.

Manufacturing management may also look to *technology* to structure interactions and to 'freeze' change in place; or to use *communication and coordination* structures, like process or procedures, to link together organizational events.

- ***Technologies*** are better viewed as occasions that trigger social dynamics, changing the circumstances surrounding the task and promoting organizational change. Kahn (1974) wrote, "to change an organization means changing the pattern of recurring behaviour, and that is by definition a change in organizational structure." For example, the installation of an enterprise software package can consolidate functions or create new data management tasks. Because of the discipline required to implement a change, technology can improve the coordination among the different functions by streamlining the entire process through better communications. (Barley, 1986; Gladstein, 1990; Sims, 1992; Pouraghabagher, 1992; Huq, 1994)

- "***Communication and coordination*** are fundamentally related to organizational design. ... linkages between various organizational functions." (Purdy, 1996) The procedure changes implied by, for instance, the introduction of a new JIT process between a company and its suppliers could impact the formal and informal structures of the relationships between several functions in both organizations. This structure is found in an interrelated set of events that return upon themselves to complete and renew a cycle of activities. It is these events rather than things that are structured, so that social structure is a dynamic rather than a static concept. When situational change is stimulated, it embraces all of the interlocked areas, altering events which impact employee's performance. (Shafritz, 1978; Nora, 1986; Sims, 1992)

Further, many effectiveness problems of work units may arise from inappropriate structures created by technology or procedural coordination. (Bolman, 1991; Schultz, 1979)

2.3.2 Norms & Roles

"Norms are shared expectations about how the members of a group ought to behave. ... Roles are shared expectations about how a particular person in a group ought to behave." (Levine, 1990; Hare, 1962)

An organization's norms endeavor to distinguish behaviour that is a legitimate means for achieving organizational 'ends.' They are woven into the fabric of established power relationships to the degree that they are often unchangeable social facts. For example, at Toshiba there is a norm of always asking for help when you don't know what to do next, or to always give help to other employees before continuing with your own work. The reason for this is that if someone does not know what to do then everyone should help them get back to work so there is less wasted effort in the organization from people stand around. (Shafritz, 1978; Senge, 1991; Bolman, 1991)

Roles, on the other hand, deal with relationships. As Jaques (1951) wrote, "the quality of these relationships is governed by the extent to which the individuals concerned have each absorbed the culture of the organization so as to be able to operate within the same general code." Roles not only help to define appropriate conduct, but also how interactions should occur. Interaction requiring rapid coordination, like between persons on an assembly line, tend to be governed by roles that are relatively highly structured, and may even substitute for thinking. (Newcomb, 1965; Goffman, 1973; Sobel, 1976; Dubin, 1976; Sackman, 1991)

Attempts to explain norms and roles in terms of personality traits have been unsuccessful. Mischel's (1968) study concludes that, "behaviours which are often construed as stable personality trait indicators actually are highly specific and depend on the details of the evoking situations and the response mode employed to measure them. ... With the possible exception of intelligence, highly generalized behavioral consistencies have not been demonstrated."

2.3.3 Interaction

Several notions, like Barley's (1986) behaviour 'scripts' or Mintzberg's (1979b) 'coordination mechanisms,' have provided understanding of certain aspects of interaction in organizations but have not provided full models. Kahn's Role Model, on the other hand, deals with the interaction between individuals within a group as a one-way intra-group *expectation-response* sequence – the performance of an *expectation* (the behaviour exhibited) and the *evaluation* (approval or disapproval) towards the behaviour often characterize the interaction.

Over time the individual and group interaction gives direction and limit to their activity, and serves to differentiate them from other groups. As Barley (1986) suggests, social order is a product of negotiation that takes place as interacting individuals attempt to define situations. For example, a stamping machine operator can negotiate with a fork truck driver on where material is best dropped and picked up to satisfy both of their needs. But the management of process interactions is also very dynamic, as new channels of communication disrupt the old channels they must be made consistent with the goals of the business. (Roy, 1960; Caplow, 1964; Bannister, 1997; Thietart, 1997)

The next section will discuss three models in more detail.

2.4 Models

The following models will be discussed:

- ***Consistency*** – Heider (1959);
- ***Manufacturing application*** – House (1971a); and
- ***Role Model*** – Kahn (1996).

2.4.1 Heider's Balance Model

Heider's (1959) Balance Model considers the alignment of the expectations between two persons and an object, see Figure 2-2. The two configurations (a, b) involve attitudinal *congruence* between a P(erson) and an O(ther person) with respect to some attitude object (X). The O→ X arrow, or the attitude of O toward X, is of course his attitude as perceived by P, where '+' is a positive attitude and '-' is a negative attitude. The third diagram (c) represents a situation of *incongruence*. The principle of self-other congruence suggests that this third configuration occurs less frequently and is less stable than the two preceding.

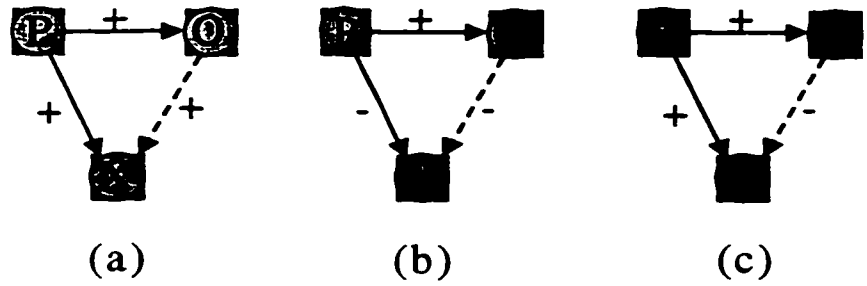


Figure 2-2: Interaction between two persons

Some of Heider's findings are:

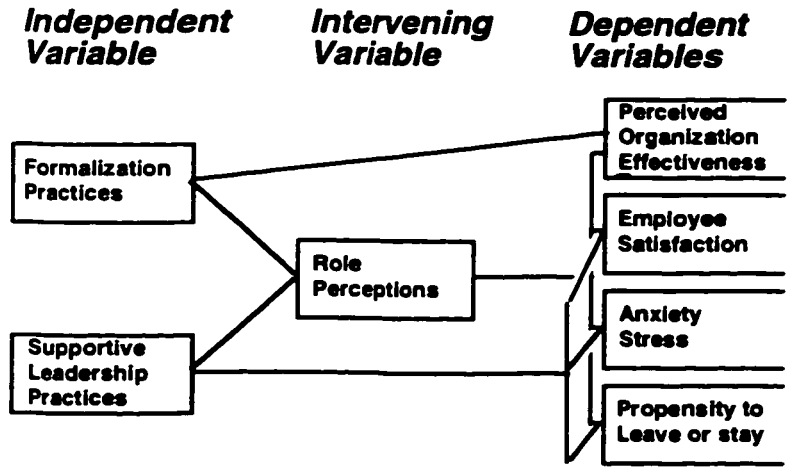
- "Familiarity usually rests upon interaction. During the course of an interaction, as P gets to know O, mutual adaptation may take place. This adaptation to environmental entities brings about harmonious interaction, they have grown upon one another." (pg. 215)
- "a person chooses or likes another person to the degree that the other's activities realize the chooser's norms and values." (pg.200)
- "if a balance state does not exist, then forces toward this state will arise. If a change is not possible, the state of imbalance will produce tension." (pg.201)

In terms of a consistency model, interaction leads to an understanding of the task situation and the opportunity during the expectation-response-evaluation cycle to choose behaviours which are consistent with the priorities of the other work units in the interaction (linkage). Unacceptable behaviours can lead to not-as-effective performance. The fact that the other holds attitudes congruent with one's own is seen as a rewarding characteristic of the other person, and this being so, such a person is likely to be perceived as rewarding-in-general (attractive).

This model lacked two-way interaction between groups, did not address consistency in perception of expectations of the object, does not include roles and norms, and does not include a task situation.

2.4.2 House's Path-Goal Model

House's (1971a) Path-Goal Model dealt with several effectiveness issues, like psychological structure and consideration from a supervisor.



House's Model is related to earlier work by Fleishman (1962) on leadership behaviour in which it was found that high consideration foremen could increase instrumental behaviour with very little increase in grievances and no increase in turnover. House (1971a) wrote, "Leader initiating structure (formalization) is used to describe the degree to which the leader initiates psychological structure for subordinates by doing such things as assigning particular tasks, specific procedures to be followed, clarifying his expectations of subordinates, and scheduling work to be done ... Leader (supportive) consideration is used to describe the degree to which the leader creates a supportive environment of psychological support, warmth, friendliness, and helpfulness by doing such things as being friendly and approachable, looking out for the personal welfare of the group, doing little things for subordinates, and giving advance notice of change."

House's model uses consideration and structure to potentially reduce inconsistency. The Supervisor presents opportunities for the group members to choose behaviours that are consistent with the priorities of the business. House's model was not selected because it was not a dynamic model and did not allow for two-way interaction between individuals or groups. Further, it lacked consistency in perception of expectations of the target employees, and did not include norms.

2.4.3 Kahn's Role Model

Kahn's (1996) work captures an insightful explanation of the relationship between individuals. It deals with individual interaction and is rich in possibility for extension to group level interaction as is proposed by the Expectation Range Model of this research. Because of this, it is presented in more detail than the previous two models.

ROLE MODEL

Kahn's model of organizational roles, Figure 2.3, is useful to thoroughly review because it represents one of the best examples of an interaction model, albeit on an individual level.

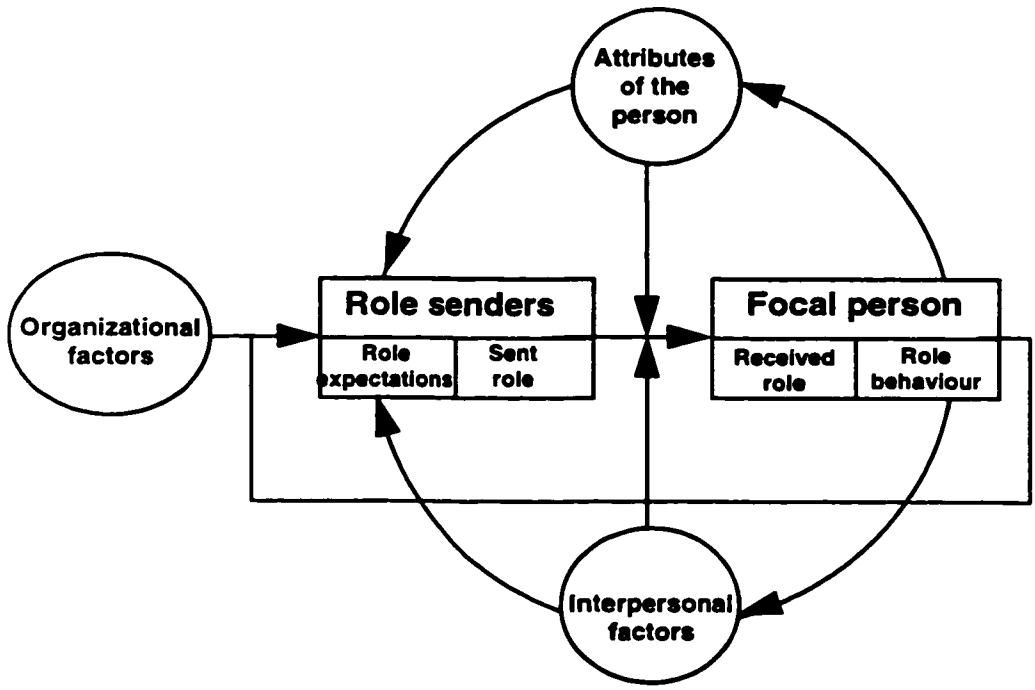


Figure 2-3: Role Model

The Model presents the significant relationship between the organizational situation and expectations. The individual's role becomes an amalgamation of the effects brought into

play by the situation, the group and the characteristics of the individual. "Roles are shared expectations about how a particular person in a group ought to behave," (Levine, 1990) the regularities of a group member's behavioral relationship to another, and the shared acceptance of the same rules prescribing appropriate behaviour. The shared rules provide structure that allows for rapid coordination. (Newcomb, 1965)

We can see from Figure 2.3 that the Role senders hold some expectations based on previous experience in the position and the pressures imposed by the environment of the organization. These expectations are 'sent' to the individual as a role that is to be complied with. The individual who is the focus of the communication attempt – the 'focal person' – receives the expectations, interprets and responds to the Role senders through their Role behaviour, and this response affects the expectations held by the Role senders. It should also be noted that the expectations from the Role sender to the focal person are affected by the personal attributes of the focal person and the relationship that the focal person has with the Role senders.

Much of Kahn's work deals with the conflicts that arise for the individual, and the health implications for them. For this research, the concern is mainly with the interactive outcomes of situation and expectations of the group for the individual. The following sub-sections explore various aspects of Kahn's model starting with the overall process and then explain in detail some of the important terms and concepts.

2.4.3.1 Role Episode:

The Role Episode is the high level process of how expectations are sent by the Role Senders to the Focal Person, and how the expectations are received and feed back to the Role Senders. That is, the Role Senders (Sent Role) apply evaluative standards (Role Expectations) in an attempt to influence the Focal Person. The ***Received Role*** is the Focal Person's perception of the sent role, and it results in the ***Role Behaviour*** which feeds back to the Role Senders the Focal Person's response. (Katz, 1978)

2.4.3.2 Role Expectations:

Role Expectations arise from systemic properties of the organization, the subsystem in which the Role-Senders are located, and the particular position occupied. They represent standards in terms of evaluating performance. The Role Senders communicate to the Focal Person an expectation in the form of an order, suggestion, request, or other kind of instruction. The compliance or noncompliance in relation to the original expectation is evaluated and communicated to the Focal Person, often with positive or negative sanctions. (Katz, 1978; McLean, 1970) Various members of the Role Set may hold quite different Role Expectations toward the Focal Person, and these role pressures give rise to role forces and psychological conflict. (Kahn, 1964b)

2.4.3.3 Sent Role:

The content of a Sent Role is expectations or preferences for specific acts, things the Focal Person should do or avoid doing. This pressure arouses a psychological force of some magnitude and direction. When the behaviour of the Focal Person is compliant then the expectations may be quite inconspicuous. But if the range of such acceptability is crossed then "there will immediately become visible the membership of the role set, the expectations which they hold, and the means of enforcement at their disposal." (Kahn, 1964b; Katz, 1978)

2.4.3.4 Received Role & Role Behaviour:

For each Sent Role there is also a Received Role and corresponding reaction or Role Behaviour. The Received Role is the Focal Person's perceptions of what was sent, and it will depend on properties of the senders, the focal person, the substantive content of the sent expectations, the clarity of the communication, etc. When "pressures are generated and 'sent,' they do not enter an otherwise empty field; the focal person is already in role, already behaving, already maintaining some kind of equilibrium among the disparate forces and motives which he experiences. Pressures to change represent new and additional forces with which he must cope; by definition they threaten an existing equilibrium. Moreover, the stronger the pressures from role senders toward changes in the behaviour of the focal person, the greater the conflict created for him." (Kahn, 1964b; Katz, 1978; McLean, 1970) The behaviour of the Focal Person feeds back to and has effects on the Role senders. If he refuses to comply with the sent role, it will change their evaluation of the Role behaviour and possibly cause an enduring change in their liking for the focal person.

2.4.3.5 Organizational Factors:

Kahn's model indicates that organizational factors affect only the Role Senders. We will expand this definition to include all situational elements – physical, policy or philosophy – which may affect all group members, including the Focal Person. In addition, we will draw upon recent Kahn (1996) models that include the "Extra-Organizational Environment," such as the socio-cultural systems in which the organization participates, demands made by external systems for organizational performance, and resources available to the organization from external systems. (McLean, 1970)

2.4.3.6 Attributes of the Person & Interpersonal Factors:

These "attributes" stem from motives or values that define inclinations of the Focal Person to behave in certain ways. Some traits of the person facilitate certain evaluations from Role-Senders; act as conditioning variables in the relationship between the role as sent and the role as received and responded to; or affect personality to the extent that "we become what we do, and in a sense we un-become what we do not do." (Katz, 1978) In addition, the quality of the interpersonal relationship between the Focal Person and the Role-senders will affect how the sent expectations are interpreted. Praise and blame have one meaning when they come from a trusted source, another when they are from an enemy.

2.4.3.7 Model Extensions

Kahn's unpublished work[2] suggests extending the Role Model to include concepts that address expectation consistency, for example, norms. "The most obvious difference between norms and roles has to do with breadth of application. Roles are position-specific; norms apply to all members of an organization, an organization subsystem, or a category of organization members." (Kahn, 1996) Norms define how the members of a group ought to behave, and it has been shown that group performance is enhanced by a group consensus around positive norms. Group norms prevent conflicts, regulate contacts with outsiders, facilitate the expression of the group's core values, and strengthen independent judgment in the face of a majority. (Levine, 1990; Weick, 1993b)

In addition, Kahn suggests the extension of the Role Model to include organizational routines: "Role sending can provide a whole sequence of appropriate actions under various possible contingencies. Learning a role involves an accumulation of these 'what to do if' routines. For the organization as a whole, that shared knowledge enables continual functioning under conditions that are always subject to some degree of change." (Kahn, 1996)

2.4.3.8 Issues with the Model

Kahn's work seeks to understand conflict, dealing with specific situations that people might experience and the health implications associated with stress. It addresses the individual who tries to accommodate a group's expectations. There are three areas of the

[2] Kahn has recently extended the role model to include: (1) further specification of the role-sending process itself, especially in the form of organizational routines; (2) fuller recognition of the role-defining activity of the focal person; (3) explanation of the linkage between roles, norms, and values; (4) acknowledgement that role structure, while a source of organizational stability, may degrade or disintegrate under certain circumstances; (5) exploration of the ways in which technology influences role structure and the limits of that influence.

Role Model that need to be addressed by the Expectation Range Model, (Section 3), before it can be applied to the Manufacturing environment, vis: (1) the Expectation Range Model needs to generalize from the group-individual case to suit expectations between groups; (2) the one-way communication of expectations must be augmented to allow for reciprocal expectations between groups; and (3) the notion of consistency/conflict needs to be expanded to allow for degrees of consistency.

First, the focus of the Role Model is on the expectations from the Role senders to the Focal Person, from the group to an individual within the group (intra-group expectations). The Role senders have the expectation and the focal person has attributes and interpersonal factors that modify how the expectation is received. In the Expectation Range Model, the expectations are between groups, (inter-group expectations), what one group expects from another group to perform their tasks. For example, a manufacturing work unit may expect Production Control to give them timely information of customer requirements so they can plan their work assignments ("No surprises!"). On the other hand, Production Control may expect the work unit to be flexible to Customer needs ("Change over runs in 4 hours!") so "Do it!" requests can be satisfied.

Second, the Role Model also indicates that the Role senders "give" the expectation and if the Focal person's behaviour is not right then the Role senders will adjust their expectation as though the Focal person didn't understand -- give the same message again or give the message in a different way. Kahn's Model does not look at what the Focal person thinks the Role senders should be doing. This may not be a problem if all the interaction is within one group, but even there the members of a group may have some reciprocation because everyone does not perform the same task; and even if they do they may do the task differently. The Expectation Range Model needs to capture the richness of the group interactions, such as, when two groups interact they both can have different sets of expectations and that this leads to reciprocal relationships. That is, a work group also communicates expectations on an ongoing basis from the point of view of that group and what is acceptable to them. There is an interaction in which two sets of expectations are involved. This means that the model must take account of the interaction in more than one direction, and with each group correcting their behaviour. For example, a work unit expects that Maintenance will "come quickly" when there is a machine problem – this is the group's expectation, not necessarily Maintenance's. On the other hand, Maintenance wants a work unit operator to "wait by the machine" to explain the problem and lend a hand – this is a Maintenance expectation, not necessarily the group's. Each group can judge the other's behaviour relative to their expectation for the other group, and re-act accordingly.

Thirdly, the Role Model indicates that when an expectation is communicated by the Role senders, that the Focal person either goes along with it (is consistent) or they run into a conflict. A lack of consistency is not conflict. In the Role Model consistency and conflict are two behaviour extremes: complete similarity, and equal-and-opposite forces respectively. The Expectation Range Model considers a behaviour range, a grayish area, or a degree of consistency. Responses or Role behaviours actually fall into a range of

acceptable behaviours. The degree of consistency is similarity of beliefs (eg: Newcomb, 1965, pg.125) and goals; the extent to which expectations about future behaviours are shared; it is a potential which is different for each work unit and its task situation. For instance, if the Maintenance group is short one person due to illness, then they can not respond as "quickly" today as the work unit would like ("get here in 2 hours"). This behaviour may be acceptable if the work unit has other tasks it can perform while it waits, or it may be unacceptable if the machine is critical to the completion of a rushed customer order. That is, there is an acceptability range that a behaviours, (from both groups), map onto to determine if the current behaviour is perceived as acceptable or not.

2.5 Conclusion

From one viewpoint, the literature has accepted the concepts of role models as a way of describing social interaction. Weick (1993), for example, goes on to extend expectations to the notion of interactions in situations of crisis. "A major contributor to this disaster was the loss of the only structure that kept these people organized, their role system. ... (that is by thrusting) people into unfamiliar roles, leave some key roles unfilled, make the task more ambiguous, discredit the role system, and make all of these changes in a context in which small events can combine into something monstrous."

On the other side, there is still a need for an intimate understanding of consistency, what it is and how it works, and to extend the available models to two-way inter-group linkages within manufacturing and operationalize it. The Expectation Range Model, presented next in Section 3, was formulated to address the understanding of consistency and these extensions. Further, it presents three concepts of consistency, which are operationalized as a mathematical model and then applied to two case studies at an automotive manufacturing site and a circuit pack repair facility.

3 Expectation Range Model

3.1 Introduction

This research looks at the association between consistency and effectiveness within the context of a model of the interaction of a work unit and another functional support group and proposes the Expectation Range Model in Figure 3-1, (see the footnote below for definitions of consistency and effectiveness).It builds on case study interviews and extends the background literature with a view to the measurement and testing of the hypothesis:

> *The more the perceived* ***Inter-group Consistency***[1]*, between the expectations of a work unit and another* ***interacting*** *functional group, the more the perceived* ***Linkage Effectiveness***[2] *of that relationship.*

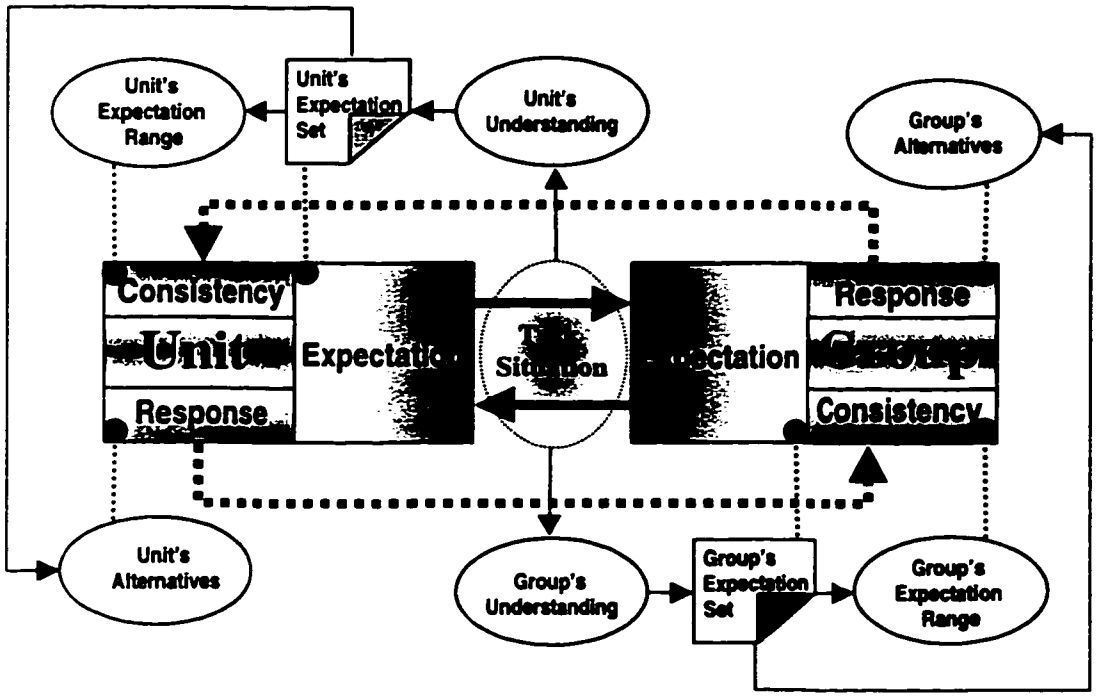


Figure 3-1: Expectation Range Model

A Functional Support Group's (**Group**) interpretation of an expectation (see Figure 3-2) from a Work Unit (**Unit**) comes out of the Group's understanding of their task situation and the alternative actions available to the Group to respond. To some extent the response of the Group will be consistent with the expectation of Unit, that is, similar but not

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[1] *Consistency* is the same or similar set of expectations shared by both parties in a linkage.

[2] *Effectiveness* of linkage relationship is from the Business or Management view.

exactly the same or exactly opposite (conflicting). The response of the Group is evaluated by the Unit against a range of acceptable responses based on the Unit's understanding of their task situation. In general, when the response falls within the Unit's *acceptable range* the relationship of the Group and the Unit may be seen as positive by the Unit and the perceived effectiveness of the relationship might stay the same or improve. However, if the Group's response is unacceptable to the Unit then the relationship may be negatively impacted and the perceived effectiveness of the relationship might stay the same or suffer. This may result in less co-operation in future interactions.

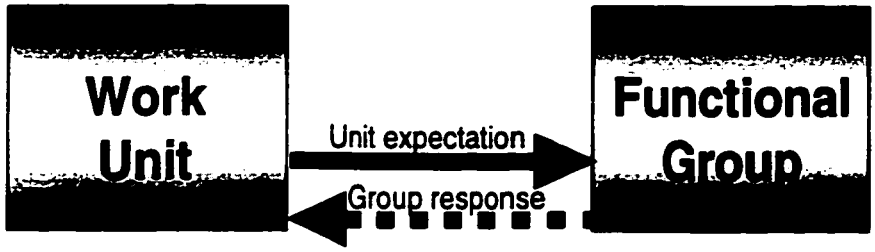

Figure 3-2: Unit Expectation

Consider a Maintenance group that receives a work order from a production work unit at 1:00pm. It is the work unit's expectation that Maintenance will come to investigate the machine fault within the usual 2 hours, by 3:00pm. Maintenance is working on the installation of a new assembly line and determines that the machine fault will not shut down the work unit and the fault can be worked on by the midnight Maintenance shift, so they do not respond until 1:00 am. An expectation of coming to fix a machine within a 'reasonable time' has been interpreted somewhat differently by the two groups.

In this example, the work unit expected a response by 3:00pm, however Maintenance did not respond until 1:00am, about 10 hours later than expected. The work unit feels that the response is 'unacceptable' and finds that the Maintenance group is a "bunch of inconsiderate, lazy, @#%!!" Interestingly, the Maintenance group feels that they did a satisfactory job, and if the work unit had an understanding of Maintenance's workload this response may have been seen as acceptable to the work unit as well.

In a similar way, a Functional Support Group has an expectation (see Figure 3-3) for a Work Unit, the Unit responds to the Group's expectation, and the Group evaluates the 'acceptability' of the Work Unit's response against the Group's *acceptable range*. For example, Maintenance expects the work unit to have a machine, that is waiting to be repaired, cleaned of all scrape material, cuttings and tools before the Maintenance group arrives to investigate the fault. When Maintenance has to wait for this to be done they anticipate an extension to their work time – about one additional hour to the work order. This looks bad for their metrics, gets Maintenance into trouble with other work units that are waiting for their help, and adds out-of-production time for the work unit. Not cleaning the machine before Maintenance arrives is unacceptable behaviour. In fact, Maintenance sees some work units as a "bunch of inconsiderate, lazy, @#%!!"

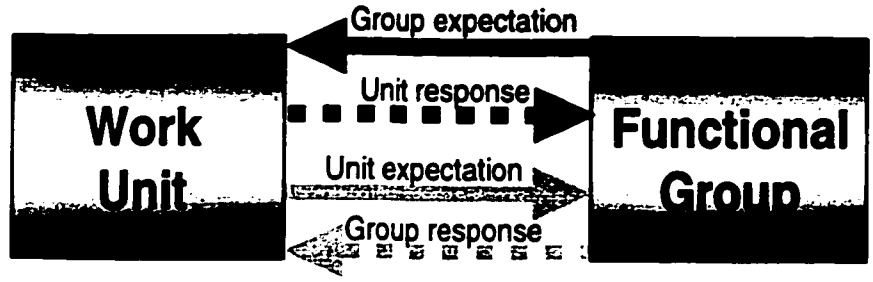

Figure 3-3: Group expectation & interaction

The Expectation Range Model extends the available models, like the Role Model, and contributes to the consistency literature in several ways: extending interaction concepts from the individual worker level to groups; dealing with the reality of two way expectation communications between groups; presenting the concept of a range of acceptable responses; and applying the model to the manufacturing environment. The succeeding sub-sections will explore the Expectation Range Model in detail. However, first some interaction, consistency and expectation notions will be presented to focus the discussion.

3.1.1 Network and Linkage Interaction

This research centers on *Linkage* interaction, not *Network* interaction. To explain the difference, consider a product that is manufactured through a network of connected tasks. That is, a series of sequential operations by Work Units, on several shifts, that are supported by numerous *staff and line* Functional Support Groups. Each Unit-Group connection is a Linkage. In Figure 3-4 the Unit[3] is the center of the network, supported by other shifts, operations and by Groups such as:

- Administration Support: groups like HR hire and train members of a Work Unit;
- Production Support: groups like Quality resolve conflicts between design and actual component specification;
- Process Support: groups like Maintenance install and repair equipment;
- Product Support: groups like Materials purchase components used by a Unit.

Although the terms **'Unit'** and **'Group'** are used to designate the two parties in an interaction, an interaction could be between two Work Units or two Functional Support Groups. For this discussion, the **Unit** will be the focus in the network, with the **Group** as

[3] This research uses the Unit as the focus, although it may be applied to the network around any Unit or Group.

the second party in the interaction. The connection among the tasks of the **Unit** and **Group** leads to interaction, and interaction leads to an exchange of expectations, responses and evaluations.

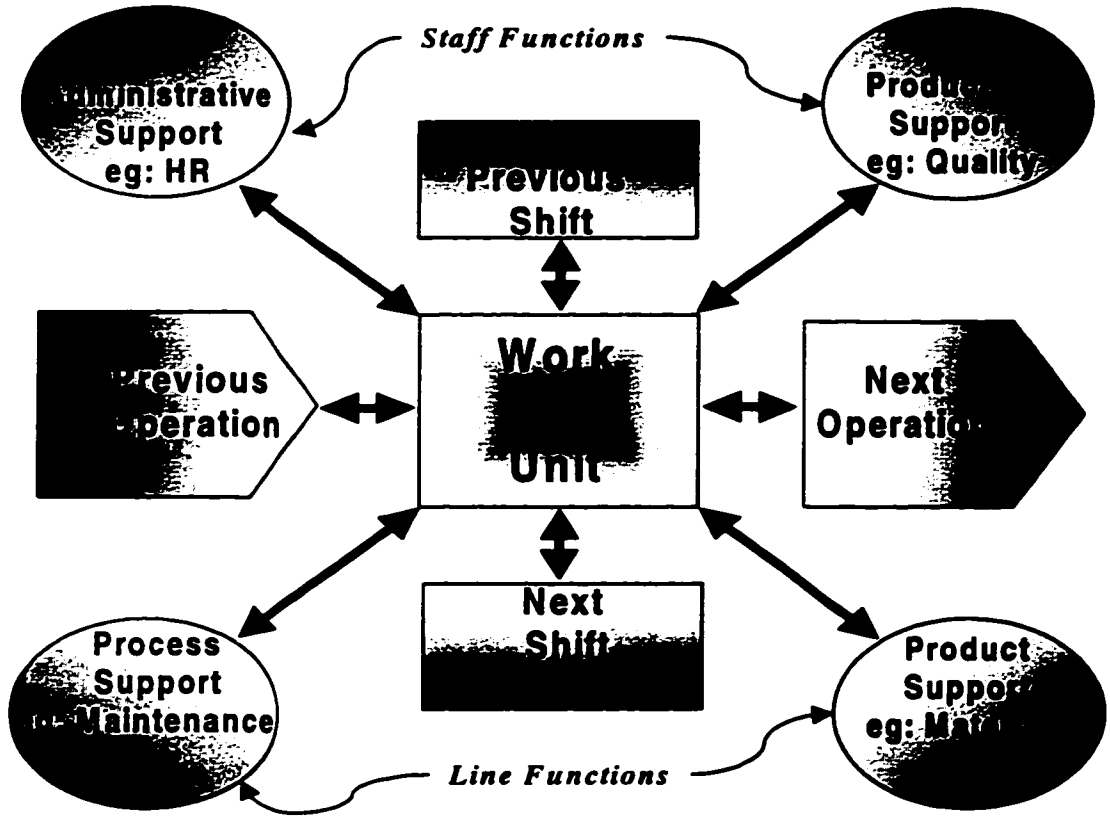

Figure 3-4: Network and Linkage Interaction

Each connection in the network, between a Work Unit and a Functional Support Group, will be called a *linkage* through which the Work Unit and the Functional Support Group communicate and place expectations on one another. However, a linkage exists only if their task situation dictates that they must interact. (Figure 3-5) For example, a Work Unit 'A' makes one product and a Work Unit 'B' makes another product. If they do not provide information or material to each other, they do not interact. Because their task situations do not directly include one another, they do not have expectations of each other... there is no linkage. On the other hand, a Maintenance Group services the equipment of both Work Units A&B and it interacts directly with Work Unit A or Work Unit B as the need arises. The Maintenance Group has expectations for both Work Unit A & B. Work Unit A or B each have their own expectations which include only the Maintenance Group, not each other. Thus, for instance, Work Unit A is only linked to the Maintenance Group.

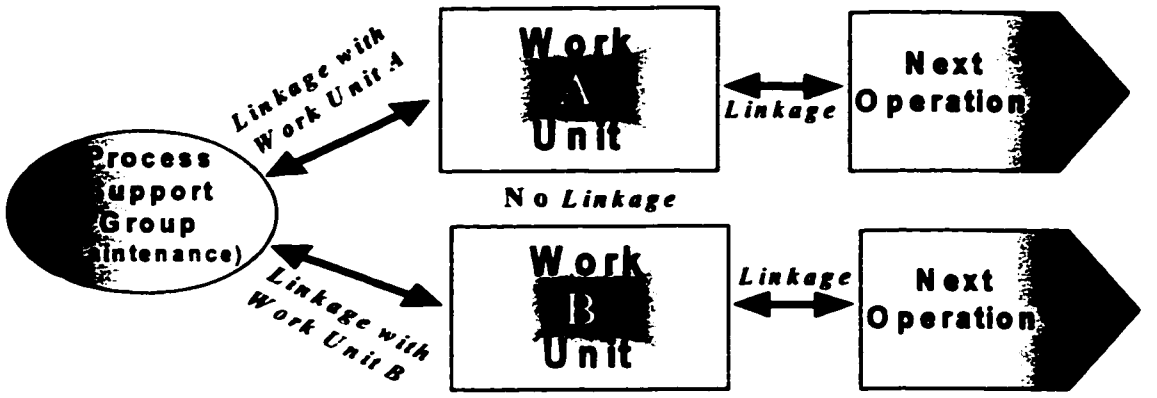

Figure 3-5: Linkage and No-Linkage

3.1.2 Intra-group and Inter-group Consistency

It is important to recognize that there are two types of consistency: intra-group consistency which is the degree of alignment of expectations *among* members of a Work Unit, or *among* members of a Functional Support Group; and inter-group consistency which is the degree of alignment of expectations *between* one Work Unit and another Functional Support Group. (Figure 3-6)

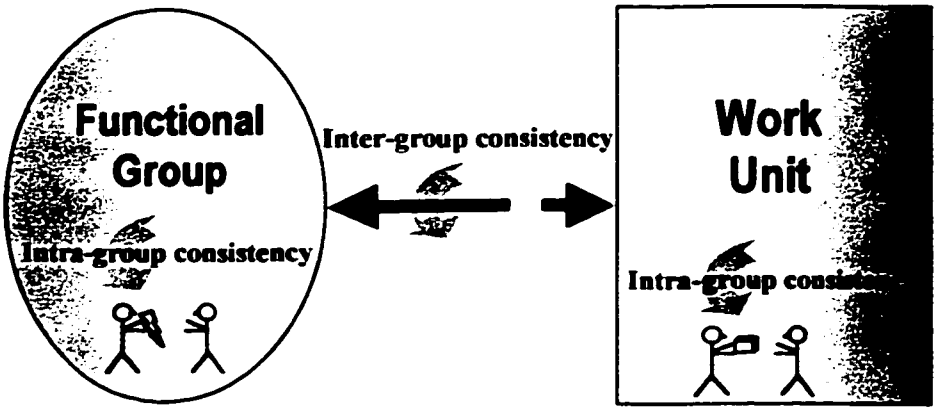

Figure 3-6: Intra-group vs Inter-group consistence

For example, with *Intra-group* consistency, one member of a **Unit** who tests circuit packs expects another member of the same **Unit**, who will repair this pack, to do exactly what is specified on the repair document and within the quality guidelines so the pack will pass the re-test verification operation. The repair operator also understands this expectation, so the test and repair operators have consistent expectations.

On the other hand, with *Inter-group* consistency, the **Unit** expects the Maintenance **Group** to train them on how to fix minor problems with their test sets so the **Unit** can be back into production quickly and without having to wait for the Maintenance **Group** to do the repair. The Maintenance **Group** also understands this expectation, so the **Unit** and **Group** have consistent expectations.

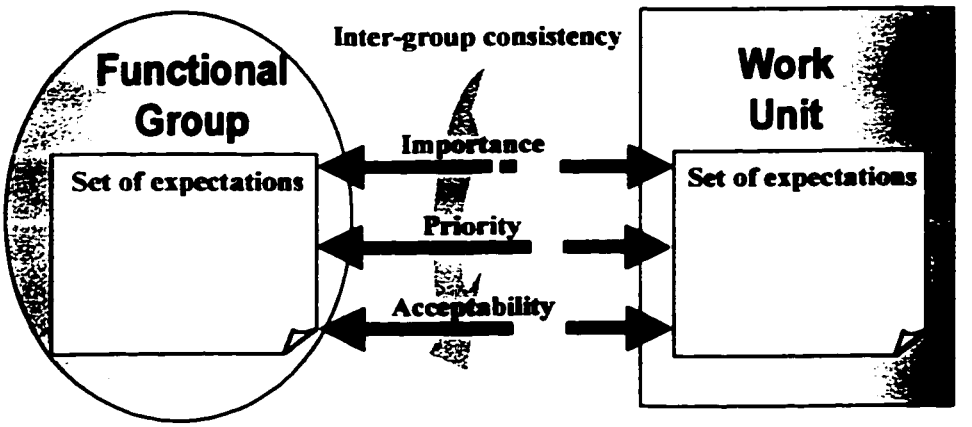

Figure 3-7: Types of Inter-group consistency

This research extends the literature on intra-group consistency and focuses on inter-group consistency. Further, it will define, in latter parts of this section, three types of inter-group consistency as it relates to the *set of expectations*[4] (represented by ▱ in Figure 3-7) held by the Work **Unit** and the *set of expectations* held by the Functional Support **Group**. The three types of inter-group consistency are:

(1) Importance - expectations that are shared by both the **Unit** and the **Group**;
(2) Priority - expectations that are given primacy by both the **Unit** and the **Group**; and
(3) Acceptability - expectations that are viewed in similar ways, compared to what actually happens, by both the **Unit** and the **Group**.

3.1.3 Network and Linkage Effectiveness

Perceived effectiveness is used in this research to rank Work Units so a correlation can be established with consistency, as was presented in the hypothesis. To this end the applicability of Network and Linkage Effectiveness will be discussed.

[4] In general, a set of expectations is all the expectations which the Unit, or Group, has which define the task situation in which the Unit and Group interact.

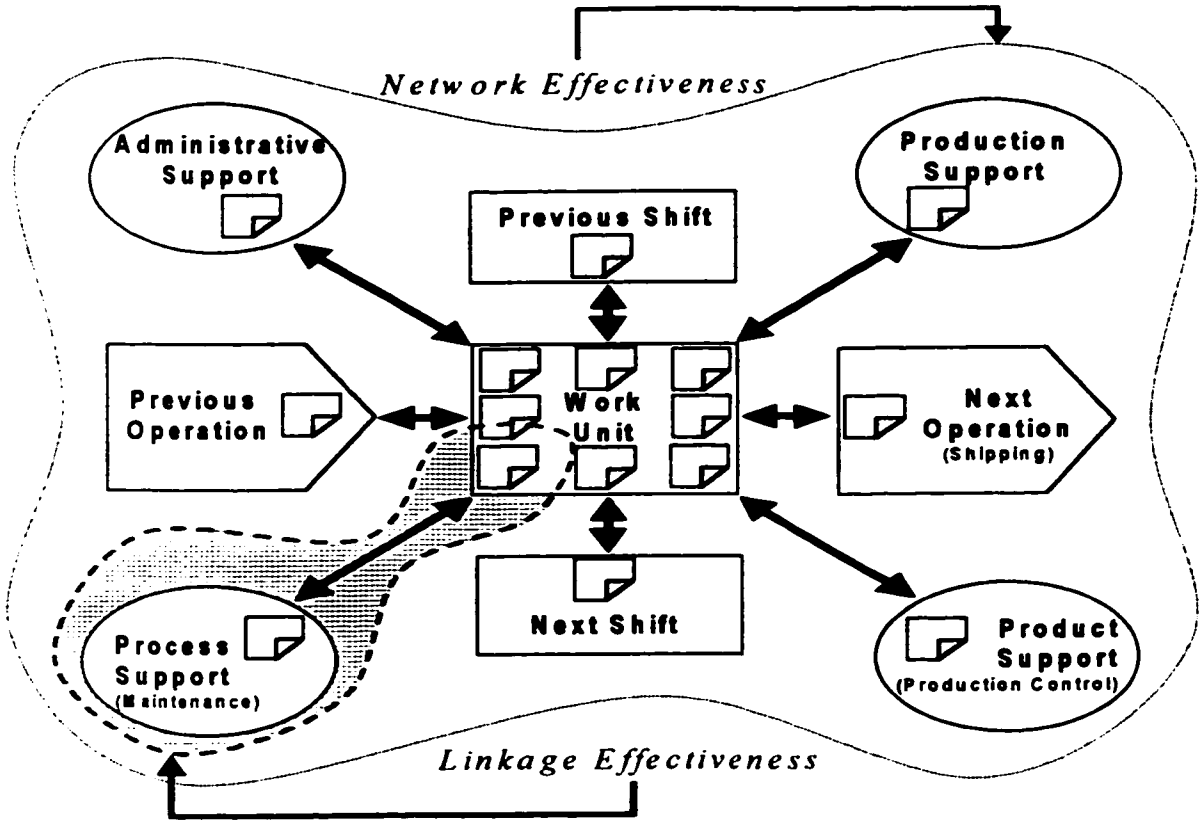

Figure 3-8: Network vs Linkage Effectiveness

Network Effectiveness is the perceived effectiveness of the Work Unit with all its network connections to Functional Groups; while *Linkage* Effectiveness is the perceived effectiveness of the Work Unit linkage with one Functional Support Group. This is illustrated in Figure 3-8 where the symbol ( )represents the set of expectations held by each Functional Support Group for the Work Unit, and the unique sets of expectations held by the Work Unit for each Functional Support Group.

Network Effectiveness: a **Unit** has task interactions with a variety of different **Groups**, such as Production Control and Shipping, to accomplish the activities required by the **Unit's** management. The **Unit**, in connection with each **Group**, has sets of expectations that define the task interactions with each **Unit-Group** pair, and these sets of expectations will, in general, be different for each **Group** because the task interactions are different for each **Group** with the **Unit**, for example:

- The **Unit** meets with the Production Control **Group**[5] scheduler to determine what sales demand the **Unit** must meet during the week. The **Unit** expects that

[5] Note: in the network example, a **Group** like Production Control has similar task interactions with several production Work Units which are not part of the **Unit's** network.

Production Control will minimize the number of rush jobs so the **Unit** can control its overtime metric. Production Control expects that the **Unit** will minimize inventory by only producing what the company has firm orders for.

- The **Unit** delivers orders to the Shipping **Group** for customer deliveries. The **Unit** expects that Shipping will package and transport the product the same day so the **Unit** can control its on-time-delivery metric. The Shipping **Group** expects that the **Unit** will complete the shipping document with piece number and count so they do not have to verify this information.

Since *Network* Effectiveness is the perceived effectiveness of the Work Unit with all its network connections to Functional Support Groups, the judgement of effectiveness needs to be made by the position in the organization that is aware of the effectiveness of the Work Unit and all the Functional Support Group connections. That is, not the manager of the Production Control Department, Shipping, or Operations but the manager of these managers – eg. the General Manager. At this level perceived effectiveness may be based on performance metrics rather than the overall effectiveness of several network connections. Thus, Network Effectiveness may not lead to a very satisfactory way of ranking Work Unit effectiveness, although a different approach is suggested, based on this research, in the section on Further Research.

Linkage Effectivness: a **Unit** has task interactions with one **Group**, such as Maintenance, to accomplish the activities required by the **Unit's** management. The **Unit**, in its linkage with this **Group**, has a set of expectations which define the task interactions with the **Group**, for example:

- The **Unit** gives the Maintenance **Group** a work order for an equipment repair. The **Unit** expects that Maintenance will come quickly to fix the damaged machine so the **Unit** can control its out-of-production metric. Maintenance expects that the **Unit** will have an operator available at the damaged machine to provide information and assistance so the repair can be rapidly diagnosed and completed.

Since *Linkage* Effectiveness is the perceived effectiveness of the Work Unit linkage with one Functional Support Group. The judgement of effectiveness needs to be made by the position in the organization that is aware of the effectiveness of the Work Unit and the Functional Support Group in the linkage, that is, the Maintenance manager (for the example above). At this level perceived effectiveness is based on the actual relationship of the Work Unit and Maintenance Group relative to other Maintenance-Work Unit

relationships (see footnote[6]). Thus, Linkage Effectiveness can lead to a reasonable way of ranking Work Unit effectiveness.

3.1.4 Linkage Interaction; Inter-group Consistency; Linkage Effectiveness

The preceding three sub-sections have covered the notions of interaction, consistency and effectiveness with a view to the measurement and testing of the hypothesis:

> *The more the perceived **Inter-group Consistency**, between the expectations of a work unit and another **interacting** functional group, the more the perceived **Linkage Effectiveness** of that relationship.*

This research looks at the association between consistency and effectiveness within the context of a model of the interaction of a work unit and another functional support group. The sub-sections that follow will address the specific concepts which define the Expectation Range Model. Then the notion of expectation sets as it relates to inter-group consistency will be presented. These will be followed by a method for aligning expectation sets of the Unit and Group, and lastly a technique for quantifying consistency.

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[6] Note: in this linkage example, the Maintenance **Group** has similar task interactions with other production Work Units which form separate linkages with the Maintenance **Group.**

3.2 Development of concept

3.2.1 Overview

The ***Expectation Range Model*** (refer to Figure 3-1) considers the response, for instance, of a Group to an expectation from a Unit[7]. Their interaction, shown in Figure 3-9 below, can be illustrated generally as follows:

- ***Task Situation:*** There is a situation that is defined, and re-defined, by the interplay of the Unit and Group during their respective pursuits of their assigned tasks;
- ***Unit Expectation:*** During the accomplishment of their tasks the Unit will interact with the Group, and the Unit will send an expectation to the Group based on what the Unit needs the Group to do;
- ***Group Response:*** The expectation will be mapped, by the Group, on to the alternatives which are available to the Group for their response;
- ***Unit Consistency Evaluation:*** The Group response is evaluated by the Unit against what they consider to be acceptable responses relative to their expectation, and the Unit may send another expectation to the Group.

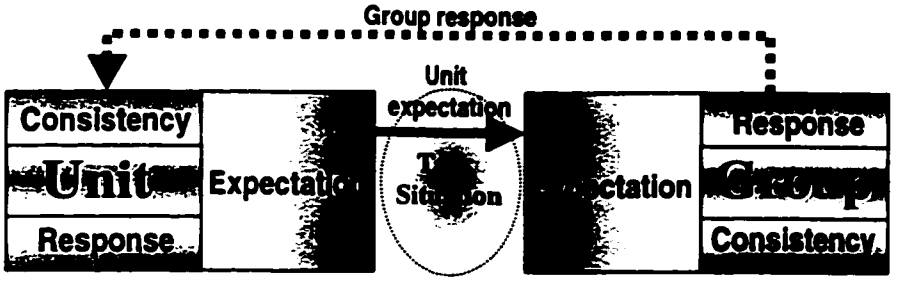

Figure 3-9: Expectation-response-evaluation (XRE) cycle

For example, a Work Unit is making high precision car parts, which are in constant demand, when an assembly press for one part breaks. The Maintenance Group has the responsibility of servicing this Work Unit's equipment. The task situation involves the repair of an out-of-production machine. The Work Unit fills out a work order and their expectation for the Maintenance Group is that they will put the Unit's repair on the priority list due to the immediate need for this part by the Customer. The Maintenance Group has one person away sick and another out of town on training. Although their response is to put the machine on the priority list they can not get to the repair as quickly as they regularly would. The Unit evaluates the response from Maintenance favorably, (the response is consistent with the expectation). In spite of the fact that they want quicker service they understand Maintenance's problem and the Unit can take other steps to minimize the impact on their metrics.

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[7] In a similar way, the reaction of this Unit to an expectation from the Group could be presented.

The next sub-sections will discuss these topics in more detail. Then the discussion will turn to the elements of interaction, the notions that underpin the expectation-response-evaluation cycle, concepts like: Understanding, Expectation Set, Expectation Range and Alternatives.

3.2.1.1 Task Situation

The ***Task Situation*** has physical, social and formal aspects that influence interactions between Units and Groups, and by their existence reduce/expand the number of options which are available, for instance:

- *Physical:* if the Unit machining car parts is in a separate building from the paint room Group, then these two will have restricted interaction around their interfacing tasks;
- *Social:* a Unit with a high mix of new employees may interact more frequently with their support Groups as they define their relationships;
- *Formal:* procedures and rules, such as safety and quality, define how Unit-Group interactions should occur.

The task situation evolves from past *expectations* that have been brought to bear on the current organizational circumstances. A 'structure' is formed in the task situation over time because things are slow to change (Bergstrom, 1995; Hare, 1976). For example, in manufacturing structuring of a task situation may reduce flexibility: (i) the route of a product through a factory is hard to change; (ii) there is a limited range of products that are made; and (iii) products are delivered from a vendor in certain size boxes.

Lastly, the task situation has a general and specific nature, vis:

- *General task situation:* a Unit interacts with several groups and they may view all specialist groups as different because they provide distinct services and interact around different tasks. The general task situation for a Unit is an amalgamation of their network of interactions - this is similar to Network Interaction as discussed in sub-section 3.1.1.
- *Specific task situation:* a Unit interacts along one of its linkages with a single group - this Functional Support Group may see all Work Units that it interacts with as the same. The specific task situation for a Unit relates to their Linkage Interaction and is the focus of this research.

Consider the specific task situation for an Assembly Unit that works with complex CNC[8] machines making high volume automotive parts, one product over-and over-again, and they often interact with a Maintenance Group which provides mechanical and electrical repair services. There is a task situation that both the Assembly Unit and Maintenance Group work within for activities like preventative maintenance and emergency repairs.

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[8] CNC is Computer Numerical Control, a piece of equipment with actions controlled by a computer.

They must communicate and understand what they want from each other to effectively complete their tasks.

3.2.1.2 Unit Expectation

When an **Expectation** is expressed it is intended to increase (or decrease) the frequency of an acceptable (unacceptable) behaviour happening. That is, when a Unit asks a Group to do something, the Unit wants the behaviour expected by the Group to take place more often.

Most of what goes on in a task situation is a negotiation – expectation and response – where a Unit has some task related need that they expect the Group to satisfy, and the Group is, to some extent, willing to be flexible at arriving at a solution (response) which is reasonable (consistent) for both parties. On the other hand, negotiation is also a willingness on the part of the Unit to adjust their range of acceptable behaviours to accommodate the response of the Group.

3.2.1.3 Group Response

A ***Response*** is the actual behaviour that occurs in an interaction as the result of an expectation and may have some of its roots in past experiences and relationships. For example, if the Assembly Unit asks the Maintenance Group to explain why a failed machine shut-down, so they might prevent a reoccurrence, and the Maintenance Group responds "no," then they might be considered by the Unit to be unreasonable. However, an explanation by the Group of their view of their issue – Units go too far in self-repairs and this can cause problems – may broaden the Unit's understanding and lead to other ways of dealing with the Maintenance response. How a Group responds affects the Unit's view of the Group and may change the task situation.

3.2.1.4 Unit Consistency Evaluation

Both parties in the Unit-Group pair evaluate the consistency of their partner's response to their own expectation – see Inter-group Consistency and Linkage Effectiveness previously introduced in sub-section 3.1.2 and 3.1.3 respectively. How a Group responds to a Unit's expectations, and how a Unit responds to a Group's expectations, influences their view of how effective their relationship is. As Heider, (1959) might have pointed out, when a (Unit) responds in a negative way relative to group expectations then a poor relationship can develop which leads to work delays and uncooperative behaviour. If the Unit's response is negative it means that the expectation of the Group may not be satisfied and an uncompromising position can lead to conflict. Agreement, on the other hand, means that both Group and Unit concur, are consistent, on what is an acceptable action to be taken by the Unit.

3.2.2 Elements of Interaction

Interaction is the two directional expectation-response-evaluation cycle between a Work Unit and a Functional Support Group relative to the task situation (see Figure 3-10). Every connection is designed for some level of coordination which results in expectations (Hare, 1976). *"The structure of the organization is the pattern of actual recurring behaviours ...."* (Kahn, 1974)

Interaction is about adjustment, the adjustment to expectations, mutual adjustment. It becomes critical, for instance, in lean organizations to know more about what is going on so the Unit-Group linkages can respond quickly to changes. This understanding helps them to modify their expectations to reflect the current task situation.

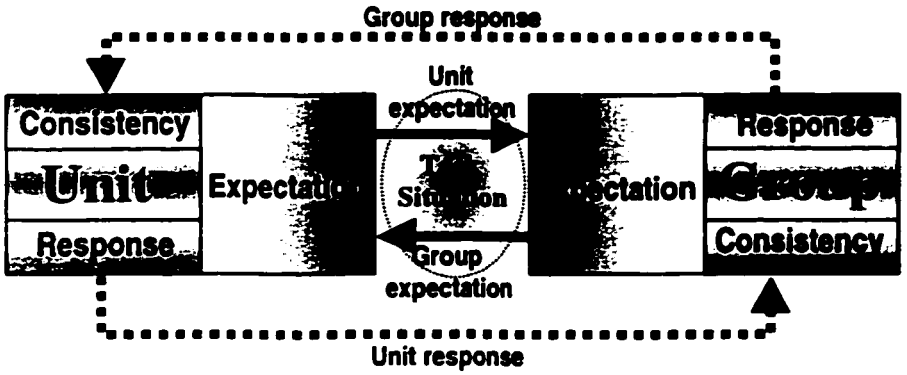

Figure 3-10: Two-way Interaction

Unit's expectations belong to themselves, not necessarily to both parties in an interaction. The Group may recognize that some issue is important to the Unit but it may not be important to them. For the Group another expectation is important, and the *Group's expectations* may not be among the Unit expectations. Each group has their own expectations for each other, independent sets of expectations, that are trying to work together. A Unit-Group linkage evolves as they interchange, and in this way they develop their own model of what is happening and how they should interact and coordinate (Mintzberg, 1979).

The next sub-sections will expand this discussion of the Expectation Range Model to consider how an understanding of the task situation leads to expectations, responses and evaluations on the part of both the Unit and Group.

3.2.2.1 Understanding

Understanding is the extent to which, for instance, the work unit is aware of the task situation they interact within (see the Figure 3-11). A Unit may understand a task

situation for several reasons, for instance: they have worked on certain tasks for some time and had interactions with a Functional Support Group in the linkage which has given the Unit experience; or the Unit may have understanding because they have worked in the group; or received skills training. As a result of 'understanding' the Unit begins to prescreen their expectations to highlight those that assist them to accomplish their tasks. They also may adjust their expectations based on their understanding about what the other group has to do. Understanding the task situation of another Group is critical to being an effective work unit (Ancona, 1990). An effective Work Unit has a cognitive good model of the whole task situation and how they should fit together with the Group in their linkage.

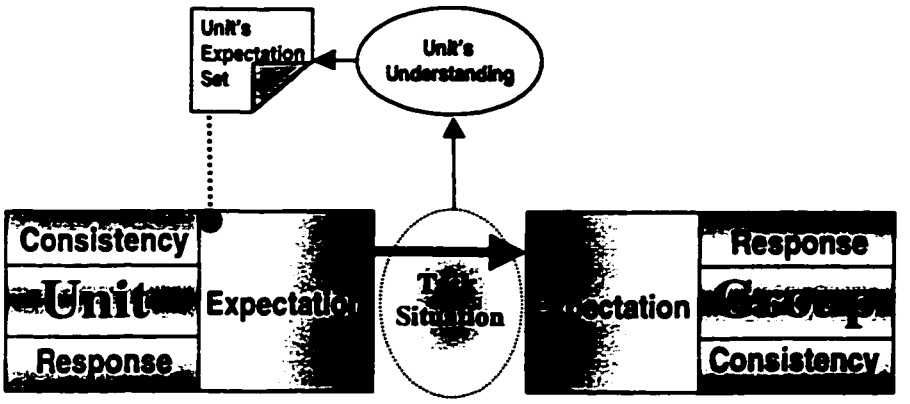

Figure 3-11: Understanding

3.2.2.2 Expectation Set

An ***Expectation Set*** is all of the expectations held by a Work Unit for the other Functional Support Group in their linkage. Both the Unit and the Group have their own set of expectations for each other based on their understanding of the task situation, and the set of expectations from the other acting on them. The Work Unit's expectation set, as will be presented later, determines whether a response to their expectation is acceptable or not, and how a new expectation from the Group is responded to by the Unit.

For example, The Maintenance Group receives an expectation from the Unit to fix a machine along with other expectations from other Work Units in the factory. The Maintenance group will respond differently if there are no other demands (takes them 1 hour to respond) or if they have several demands (it may take 5 hours to respond). If the Unit needs the machine fixed to meet a customer order which is already late and the Maintenance Group responds in 1 hour it is acceptable to the Unit (see the Figure 3-12 below, for the Work Unit Expectation Set, and the first expectation), but 5 hours is unacceptable.

- quick/fast response to the most important problem,
- put us on the priority list if we have a major problem
- fix the machine fast and efficiently, properly
- stay with us for a few cycles to make sure it is OK
- let us know now much time it will be missed when they plan to do something,

Figure 3-12: Work Unit Expectation Set

- clean machine before calling Maintenance
- exactly state the problem and stay around until we understand what is happening
- have person available if we need help like lifting
- always do TPM, oil and filter changes, minor maintenance
- when a new member comes in, teach them

Figure 3-13: Maintenance Group Expectation Set

From the case study, the boxes in Figures 3-12 & 3-13 respectively, give an expectation set of the Work Unit for the Maintenance Group; and an expectation set of the Maintenance Group for the Work Unit. Clearly, these expectation sets are not the same. However, depending on their understanding of the other's expectation set and the task situation they may share each other's expectations. The degree of overlap of their expectation sets is part of the measure of the extent of their consistency, as will be presented later.

3.2.2.3 Expectation Range

An ***Expectation Range,*** for one expectation from the Expectation Set, is the criterion for evaluating the acceptability of responses.

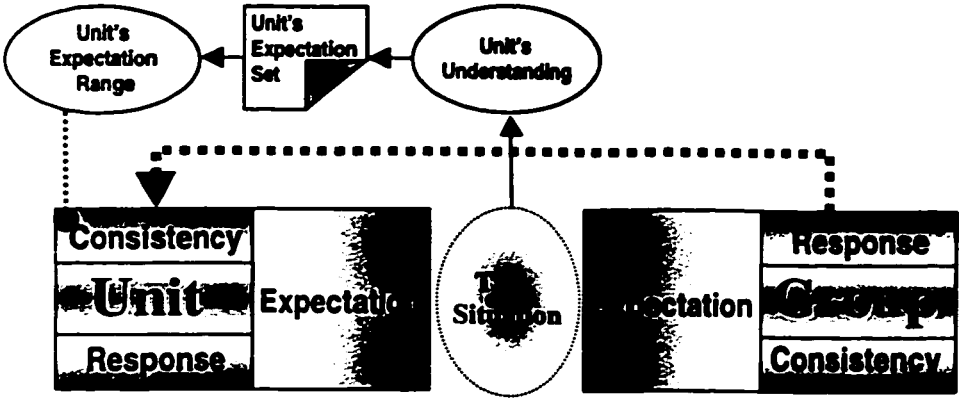

Figure 3-14: Expectation Range

For the Unit there are two regions of interest in an expectation range: (1) a span of acceptable responses or behaviours that the Unit would ideally want to happen from the Group; and (2) a span of unacceptable or minimum response that beyond which the Unit would not tolerate from the Group, Figure 3-15. Upon the expectation range is superimposed what actually happens or reality. That is, the actual response falls in the expectation range and impacts how the Group's response is viewed by the Unit. This is the evaluation aspect of the XRE cycle.

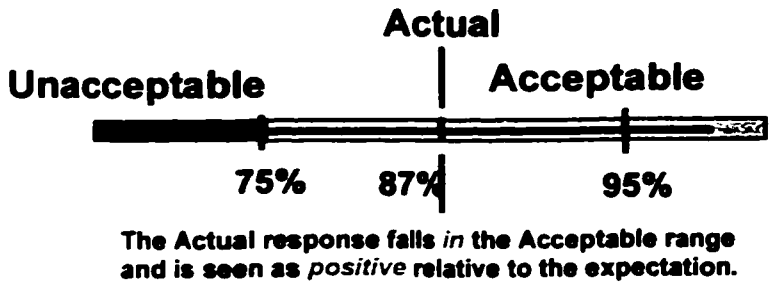

Figure 3-15: Acceptability in the Expectation Range

To recap, the *expectation-response-evaluation* (XRE) cycle, for the Unit, is:

- The Unit formulates a task need as an expectation and sends it to the Group;
- The Group responds from the alternatives available to them at that time;
- The Unit receives the actual response from the Group and evaluates it for acceptability against the Unit's expectation range, such that, an acceptable response is consistent with the Unit's sent expectation or an unacceptable response is not consistent with the Unit's sent expectation.

Consider the example of one Work Unit expectation from their Expectation Set, (see Figure 3-12), for this part of the discussion, vis:

> "After Maintenance fixes a machine they should stay until it cycles to assure that it is working correctly."

The Work Unit wants the behaviour of ***"staying for a cycle"*** to happen more often, and it would be perfect if it happened 95% of the time (see Figure 3-15). When the Maintenance groups fixes a machine and runs off, the work unit often has additional problems that could have been quickly fixed. It is not acceptable for Maintenance to stay less than 75% of the time. Actually, the maintenance group stays about 87% of the time, so the work unit sees the Maintenance group's behaviour as positive.

However, referring to Figure 3-16, during quarter end loads, the work unit can not afford to be down at all, so in this situation the work unit sees it as unacceptable for the Maintenance group to leave before a cycle test – anything less then 90% is unacceptable,

and will be viewed as negative by the work unit. In effect the work unit wants to push the actual behaviour of the Maintenance Unit away from the unacceptable area.

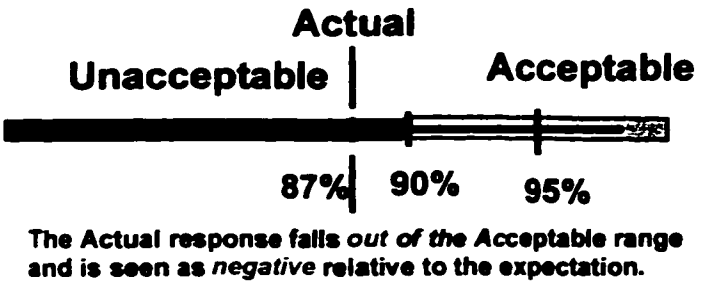

Figure 3-16: Unacceptability in the Expectation Range

When this expectation is communicated by the work unit to the maintenance group, the Maintenance group's response is evaluated against this range – the succession is: the expectation is communicated by the work unit; the Maintenance group response comes back; and the response is evaluated against the expectation range. An expectation comes from the unit's understanding of the task situation, and they feel that given their situation they are reasonable in the expression of this expectation. As new product load requirements, for example, hit the work unit this expectation range changes to address the new demands. For Maintenance, they may view that their task situation has not changed, so if they do not know the work unit's quarter-end situation they can not respond correctly. New understanding of the task situation modifies the alternative responses, as will be presented in the next sub-section, and is part of negotiation process where adjustments take place.

When the response to an expectation arrives, if it falls into an acceptable region, it will be viewed as positive, then the relationship may stay the same or improve. On the other hand, if the response to the expectation falls outside of the acceptable range, and the work unit thinks what they are asking is reasonable then their view of that action is negative, and it may push the relationship off in a negative[9] direction. As the response moves into the unacceptable area, tolerance is stretched and forces increase to move the behaviour back into the acceptable area. (Vroom, 1964; Galbraith, 1967)

3.2.2.4 Alternatives

Alternatives are the set of responses available to a Work Unit. They are the behaviours that the Unit has determined that it can, or is willing to, apply to expectations from the Group. These alternatives arise out of the Unit's understanding of the task situation, and

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[9] If, for instance, the relationship was already negative then an unacceptable response may confirm the Unit's impression that the Maintenance Group does not respond responsibly. If their relationship is positive then it is more likely to lead to flexibility in alternative responses and a willingness to deal with different expectations.

the importance and prioritygiven to the expectations in their Expectation Set, (as will be presented later).

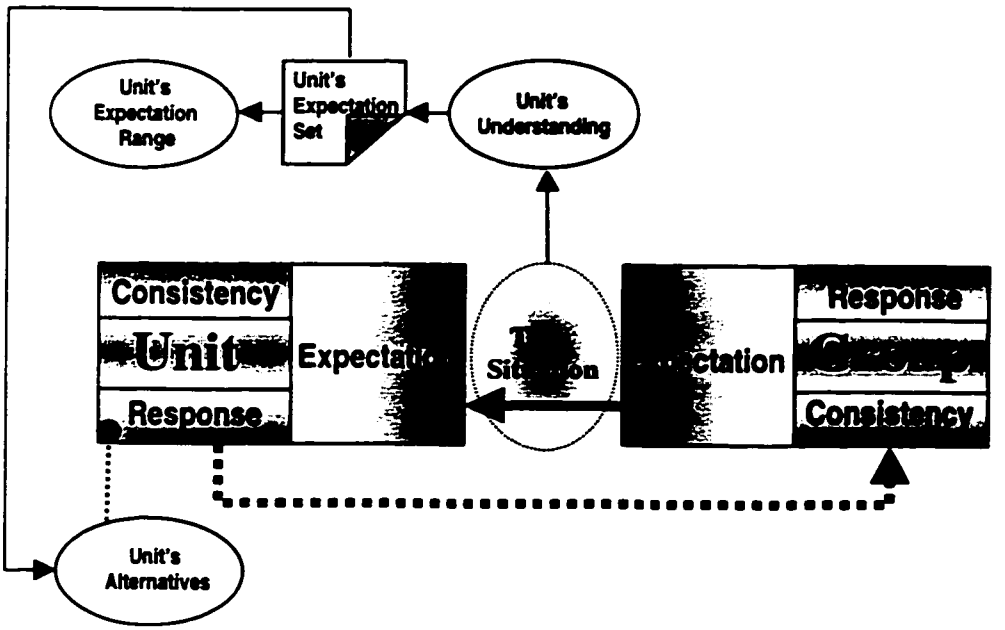

Figure 3-17: Alternative Responses

It takes time to learn all the sights, sounds and smells that define Unit-Group task situation: to experience all the issues; to define the set of alternatives that are the know-how of recovering from problems. The more a Unit works with and understands the other Group, the more the Unit may like them and consider alternatives to deal with problems they have, and the more confidence they may have in each other. Situations are dynamic and at times require extra behaviours which are beyond the immediate job situation of a Group. Heider (1956) showed that similarity of goals or working together frequently leads to more flexibility.

On the other hand, flexibility can be reduced because of the inherent structure of the task situation, relationships don't matter, (the Group has to do what they have to do anyway). Additionally, flexibility in a relationship may be reduced because it has become sufficiently negative, a Group may do enough to just cover themselves or might even do the job such that it will hurt the Unit. For example, the Maintenance Group may think: "We will drag it because we don't like the Unit due to the expectation the Unit has of us ... the Unit is never thankful of our efforts!" The Maintenance Group may come and fix the Unit's machine late, justifying it by saying "We are busy."

3.2.2.5 Evaluation of Consistency

Some authors have referred to a 'gap' between what is expected and what is received, (Porter, 1968), or, as has been presented in this research, the range or degree of consistency between the Unit's sent expectation and the Expectation Range that represents 'acceptable' behaviour on the part of the Group and the reality of the actual Group response.

Consistency for the Unit, for instance, depends on the extent to which responses from the Group, to the Unit's expectations, fall into an acceptable range. This comes from an understanding of the Task Situation which leads to an alignment of the Unit and Group's Expectation Sets. That is, a Group can make sure their response falls in the Unit's acceptable region by having a better understanding of the task situation and the Unit's Expectation Set. They make sure that they responded to the Unit in a way that will be acceptable to the Unit, and avoid the unacceptable ones. However, if the Group does not have an understanding of the Unit's Expectation Set, then a lot of times the Group will make mistakes because they just don't know. The Group does not mean to do the unacceptable, they may think it is acceptable to the Unit.

Interaction involves the two-way communication of expectation sets (see Figure 3-18). Responses to expectations fall into expectation ranges, and these ranges evaluate the acceptability of the response. As will be presented in the next sub-section, when the Unit and Group share expectations then responses may more frequently fall into each other's Expectation Ranges and be acceptable to the other linkage partner.

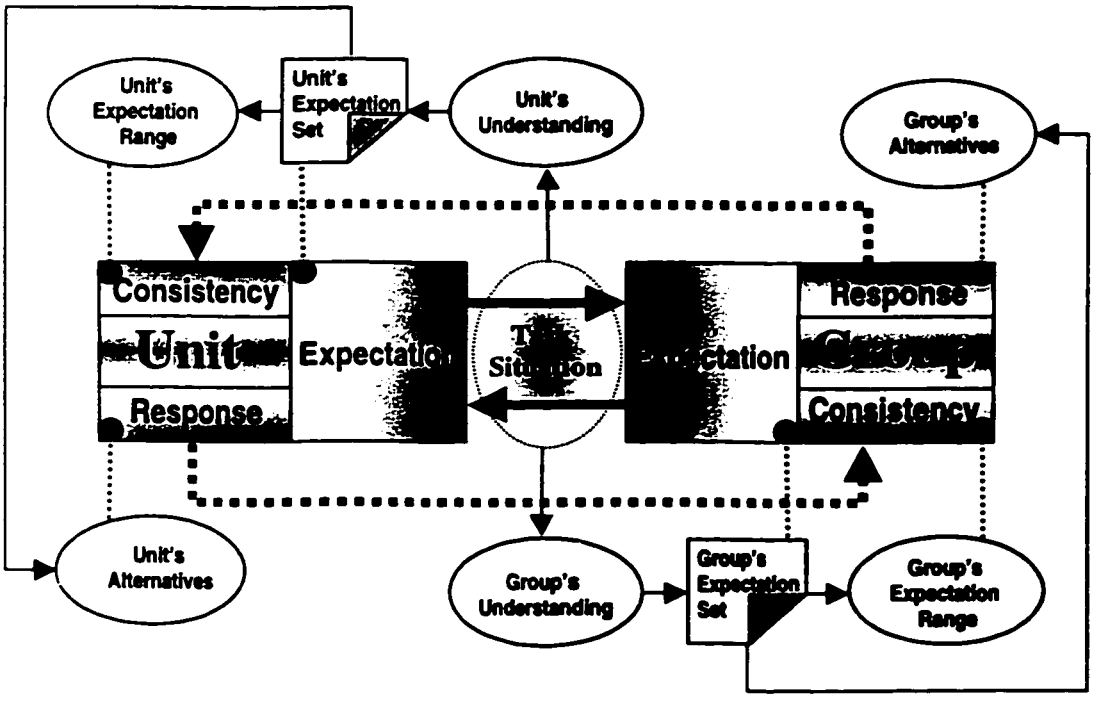

Figure 3-18: Expectation Range Model: two-way interaction

From the Unit's perspectived consistency is relative to the successful interactions with another Group - the degree of consistency with the expectations for, and of, the Group. For instance, a product manufacturing Work Unit can not be fully effective if it does not have a consistent relationship with the Maintenance group that supports its machines.

This discussion has focused on the Unit, however, the same concepts can be applied to the Group (Figure 3-18). The next sub-section will present in more detail how individual expectations, from the expectation sets of the Unit and Group, are shared.

3.3 Elements of Expectation Sets

A Unit and Group each have a set of expectations that they hold for the other they interact with. Any one expectation in an Expectation Set can initiate an *expectation-response-evaluation* cycle, where the Expectation Range is used to access the degree of consistency between the sent expectation and the response received. This sub-section will delineate the relationship between a Unit/Group Specific Expectation Set and an Expectation Range.

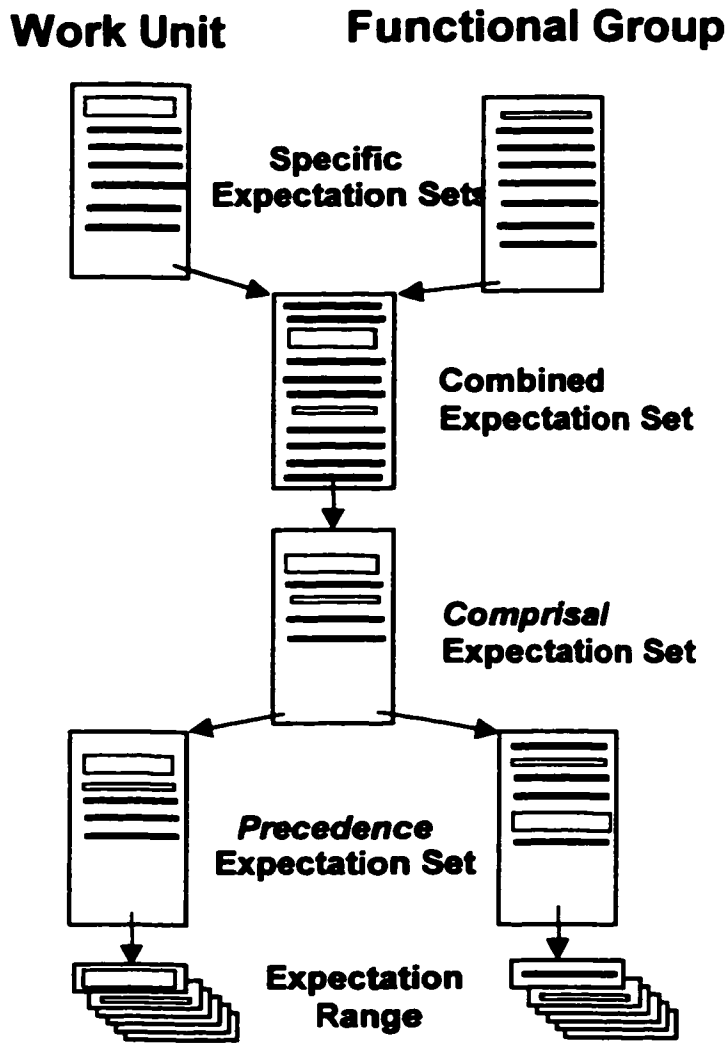

Figure 3-19: Expectation Sets & Ranges

In Figure 3-19 above the bars in the Specific Expectation Sets represent individual expectations held by the Work Unit or the Functional Support Group. The single wide

gray bar and narrow gray bar represent, for the Unit and Group respectively, a certain expectation that will be followed in this discussion. For example, the Unit's expectation might be:

> "The Group should train the Unit on how to fix minor problems with their machines."

Further, as this discussion progresses the example of a Work Unit making Circuit Packs, and a Group providing maintenance support for the Unit's insertion machines will be used for illustration of each element in the succeeding sub-sections.

3.3.1 Specific Expectation Set

A *Specific Expectation Set* is what, for instance, the Unit wants or does not want the Group to do. Put another way, the Work Unit has expectations for the Functional Support Group about what is good, or not-so-good, for the Group to do. These expectations are based on their task situation (eg. their past experiences) with the Group.

When the Group does what the Unit expects, or better, then the Unit can achieve their goals. For that particular response the relationship could be considered to be acceptable, although the response to other expectation may not be what is expected and the relationship may be regarded for that expectation to be not acceptable.

For example, in the Circuit Pack Unit's *Specific Expectation Set* there is the expectation: "The Maintenance group should train the Circuit Pack Unit on how to fix minor problems with their insertion machines." (This can be visualized as the blue bar in Figure 3-19). It is originated by the Work Unit in a effort to gain more control over the down time of their process. The more they know, the better production rate they have, and the more bonus they can earn. This is a critical item for the Work Unit. On the other hand, training might not be in the Maintenance Group's *Specific Expectation Set* because it does not directly contribute to the accomplishment of their goals.

3.3.2 Combined Expectation set

Both the Unit and Group Specific Expectation Sets together represent all of the expectations held by the two partners in the interaction and will be called the *Combined Expectation Set.* It can also be viewed as what the Work Unit and Functional Support Group should both know about each others' task situation if they had perfect understanding[10]. With it both partners in an interaction would have access to all of the expectations from both groups and they could each try to satisfy all of the other groups' expectations. Unfortunately, they do not have perfect understanding, or they may choose not to consider some of the other group's expectations to be valid or important.

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[10] The extent of interaction, for example, how often they work together, daily or monthly, as well as power positions, resources etc. dictates the extent to which 'perfect' understanding exists.

In the example, the Maintenance Group has in their Specific Expectation Set the expectation: "the Work Unit should not reset equipment fault indicators when a process goes down." (This can be visualized as the green bar in Figure 3-19). The Combined Expectation Set places this expectation with others from the Work Unit and the Maintenance group.

3.3.3 Comprisal Expectation Set: Concept of Importance

Realistically, the Work Unit and the Functional Support Group are more concerned about issues that affect their individual self interest, the welfare of their own Unit/Group and Management. However, there is a sub-set of *shared expectations* that the Unit and Group recognize are *important* to support their interaction within the task situation.

From the *Combined Expectation Set* there is a smaller *Comprisal Expectation Set* which contains expectations that both the Work Unit and the Functional Support Group share - the same expectations - ones that they see as important, expectations that are of immediate impact on the achievement of their goals.

In the example, both the Circuit Pack Unit and Maintenance share the expectation about training, they feel that it is an important expectation for the Unit to have and for the Maintenance Group to fulfill. Maintenance feels that if the Circuit Pack Unit is better informed, when they try to fix a machine without calling Maintenance, the Unit will more likely do it correctly and not "Mess thing up" so it takes longer if the Maintenance Group then needs to come and repair it.

3.3.4 Precedence Expectation Set: Concept of Priority

Although the Unit and Group agree that a certain expectation is important they may not each give it the same priority. That is, the Work Unit may feel that it is the number one issue for their success, and that even through the Maintenance Group feels that it is important they may give another expectation the number one priority. The Unit and Group give its own priority to their Comprisal Expectation Set, based on their own goals, but taking into account the needs of the other partner. They may even negotiate a balance in their priorities to optimize the Task Situation.

The Unit or Group will have its own *Precedence Expectation Set* based on its own priorities. As an example, the Circuit Pack Unit places the training expectation very high in their Precedence Expectation Set because equipment failures is the main cause of lost production and most problems are simple to correct with proper tools and a little on-the-job training. On the other hand, the Maintenance Group agrees that the training expectation is important but does not give it a very high priority because "a little knowledge can be a dangerous thing" when the Unit tries to diagnose failures on their own. The Maintenance Group gives high priority to the expectation of "not re-setting fault indicators on machines" because when the Unit tries to fix a machine and re-sets a

fault indicator the Maintenance Group has a difficult time finding out what the original failure conditions were.

3.3.5 Expectation Range: Concept of Acceptability

For each expectation in a Precedence Expectation Set the Work Unit, or the Functional Support Group, will have their own ***Expectation Ranges.***

In the *expectation-response-evaluation* cycle, an expectation from, say, the Unit is sent to the Group which responds from the alternatives available to them. Conditions such as experience, frequency of interaction, financial pressures, or other considerations, combine together to define their understanding of the alternative responses which the Group has for their partner in the linkage. Their 'actual' response falls into an acceptable (un-acceptable) range of the *expectation sending* Unit. Expectation Range is used to judge to what extent the response is consistent or not-consistent with the sent expectation.

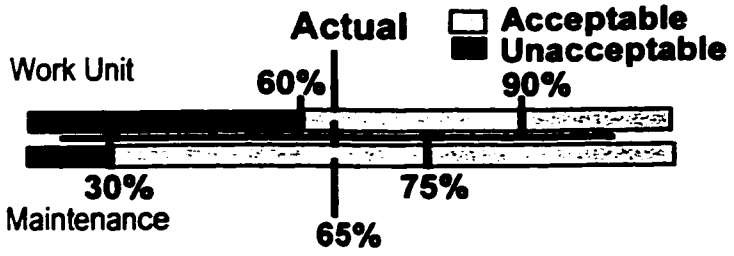

Figure 3-20: Range for Fixing a problem

For example, the Work Unit feels that it is *acceptable* (ideal) if the Maintenance Group would train them 90% of the time that they come to fix a problem. It is *unacceptable* to do it less than 60% of the time, because they can not fully utilize their preventative maintenance time allocation and will loose out on their budgeted dollars. *Actually* training is done 65% of the time. Maintenance has a different view. Training can cause problems, the Maintenance people are licensed professionals and the operators can unknowingly create a safety risk. Maintenance prefers (*acceptable* ideal behaviour) that training occur 75% of the time. However, they just don't have time, and they feel that it would only be *unacceptable* if training occurred less than 30% of the time.

3.3.6 Elements of Interaction and Expectation Sets

Figure 3-21 will pull together the notions outlined in sub-section 3.2.2 and this sub-section. That is, the Expectation Range Model has certain elements that support the interaction succession that has been referred to as the expectation-response-evaluation cycle, and these notions are presented on the right hand side of the figure. On the left hand side of the figure are the elements discussed in this section on elements of the Expectation Set. This figure, then, illustrates how the concepts of the Expectation Range

Model become operational in the sets of expectations held by the Work Unit and the Functional Support Group, vis:

1. The Task Situation is a milieu of the Combined Expectations which could be held by the Unit and Group as a result of their linkage;
2. A common Understanding comes out of their interaction and the selection of a sub-set of shared (Comprisal) Expectations;
3. Each group has an Expectation Set which is recognized as a priority for the group to accomplish their goals, the Precedence Expectation Set;
4. These expectations have ranges of acceptability for either the Unit or Group, what has been referred to as the Expectation Range.

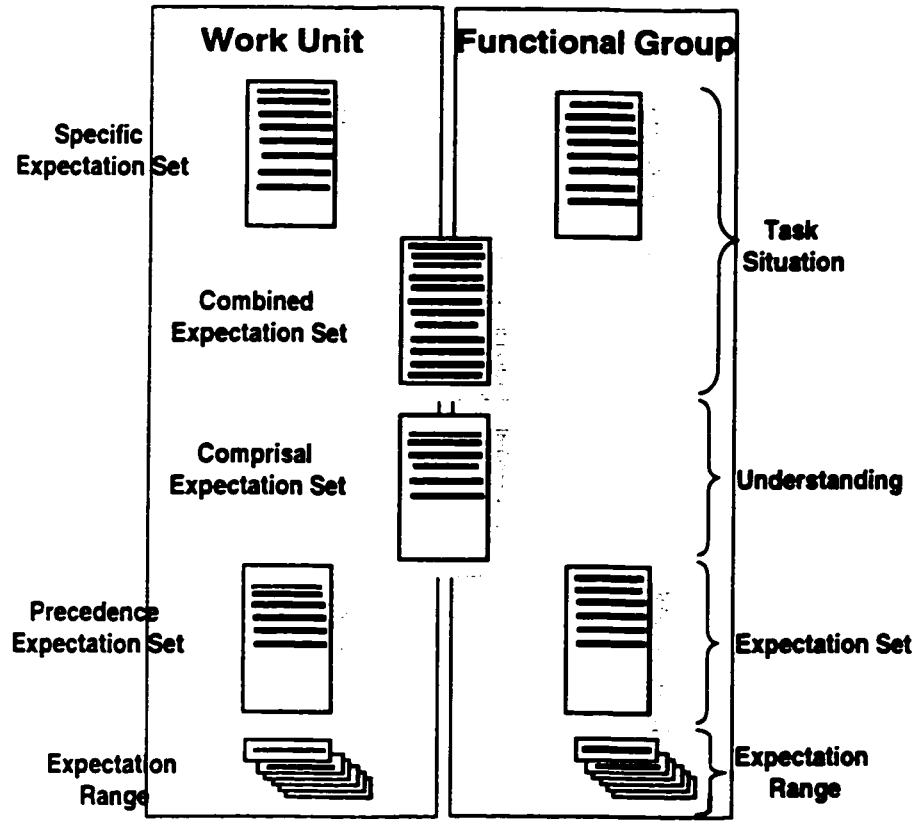

Figure 3-21: Expectation Sets in the Expectation Range Model

The next section will look deeper into the notion of the Expectation Range and how it can be used to evaluate consistency of expectations between the Unit and Group.

3.4 Overlapping Expectation Ranges

3.4.1 Expectation Range Landmarks

Both the Work Unit and the Support Function have ranges with segments termed ***Unacceptable*** and ***Acceptable*** as described in sub-section 3.3.5. However, for the same expectation they may view the task situation differently.

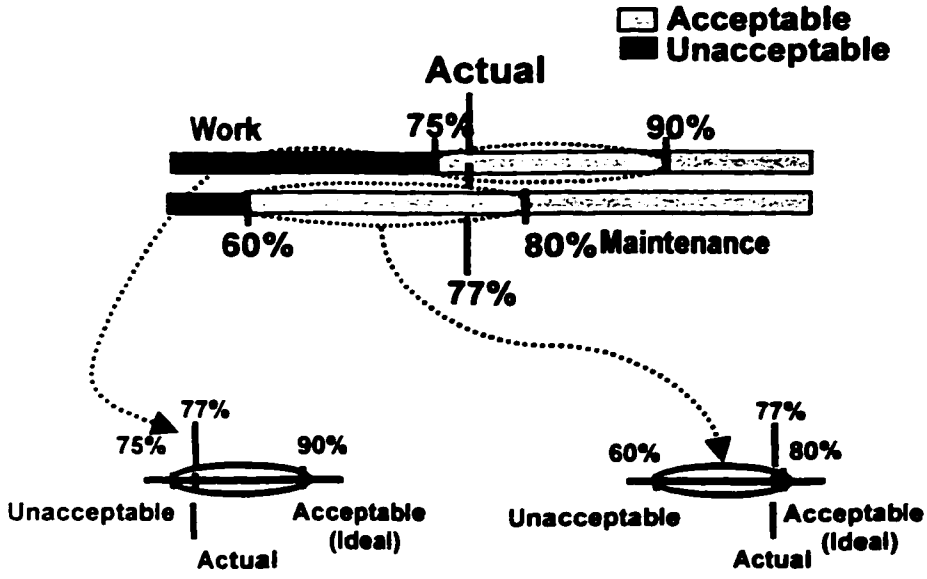

Figure 3-22: Three Range Landmarks

There are three 'landmarks' which can be considered for each Expectation Range: Actual; Acceptable (preferred ideal); and Unacceptable. For example, referring to Figure 3-22 above, if the expectation by the Work Unit is for the Maintenance Group to "come quickly to fix a broken machine," the Work unit may feel that 2 hour service would be acceptable (ideal) if it happened 90% of the time, but not always necessary; and that less than 75% is not acceptable due to month and quarter-end production loads. On the other side, Maintenance feels that there are so many new lines being installed and supported, that to respond with 2 hour service is not likely. To give 2 hours service 80% of the time is acceptable (ideal), and unacceptable if it dropped below 60%. Currently the actual percentage of the time that Maintenance responds with 2 hour service is about 77%. The Unacceptable and Acceptable landmarks bound the expected range of acceptable behaviours, illustrated in Figure 3-22 as a blue and orange oval for the Work Unit and Maintenance Support Function respectively. (Note: the 'oval' graphic will be used in this discussion to represent the Expectation Ranges.)

Actual behaviour can be measured, or is apparent to both parties, but their own interpretation of the range depends on their own view of the task situation and may not be understood by the other group. For example: (1) The Work Unit feels that 2-hour-service

understood by the other group. For example: (1) The Work Unit feels that 2-hour-service is acceptable if it falls in the frequency range of 75% to 90%. It is unacceptable for the frequency of 2-hour-service to fall below 75%. Clearly, the response of the Maintenance group will be seen as more effective as the actual behaviour falls closer to the 'high' end of the range, near 90% of the time, or happens more often. The actual response falls around 77% of the time, close to the unacceptable end of 75%. From the point of view of the Work Unit only, the relationship may be perceived as not-so-good. (2) The support function feels that 2-hour-service is acceptable if it falls in the frequency range of 60% to 80%. It is unacceptable for the frequency of 2-hour-service to fall below 60%. Clearly, the response of the Maintenance group will be seen as more effective as the actual behaviour falls closer to the 'high' end of the range, near 80% of the time, or happens more often. The actual response falls around 77% of the time, close to the acceptable end of 80%. From the point of view of the support function only, the relationship may be perceived as very good.

3.4.2 Combining Expectation ranges

The inter-group effectiveness of the relationship is not the Work Unit's view or the Support function's view only, it is a blending. Referring to Figure 3-23 below, the actual response can be used to align the expectation ranges because it is what is happening independent of the Work Unit or Support function task situations. The 'actual' is a landmark that can peg the behaviours ranges relative to one and other, that is, they each have different ranges based on how they view the task situation, but the response is something that is a shared experience.

Referring to the lower part of the figure, an overlap of the ranges can be demarcated – shaded area – to show the extent to which the expectation range of the Work Unit and Support function are the same.

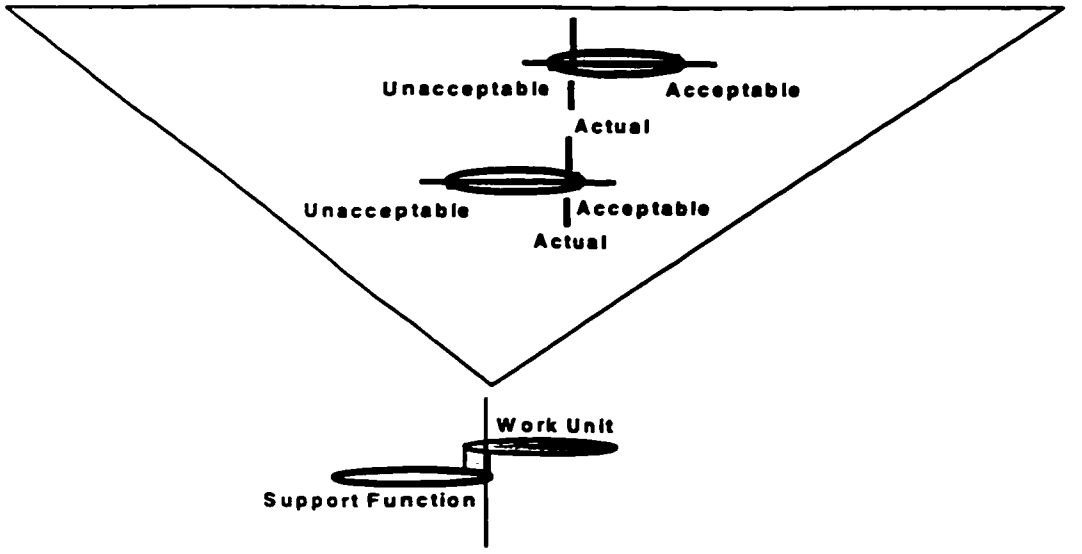

Figure 3-23: Alignment of Actual Response

3.4.3 Consistency and overlapping ranges

Overlap is indicative of the amount of consistency between the Work Unit and Support Function expectation ranges. To continue from the example on 2-hour-service: The Work Unit will fight if the service drops below 75%, and the Support function will cut-off further service above 80%. So these actions in response to the expectation have resulted in a narrow band of acceptable behaviour between 75% and 80% in which the actual behaviour falls, at 77%. There is a small area of overlap, which means potentially a lot of inconsistency. The Work Unit would like 2-hour-service to happen much more often, and the Support function feels that they are providing excellent service and if anything would like to respond with 2-hour service less often. Because the overlap is so small it is likely that the actual will frequently fall in the Work Units unacceptable area, below 75%. This will make them very angry, negative, towards the Maintenance group "They never come when they say they will!" However, service below 75% is OK for the Support function "Hay, we got to the Work Unit as soon as we could, there are other priorities besides the Work Unit!"

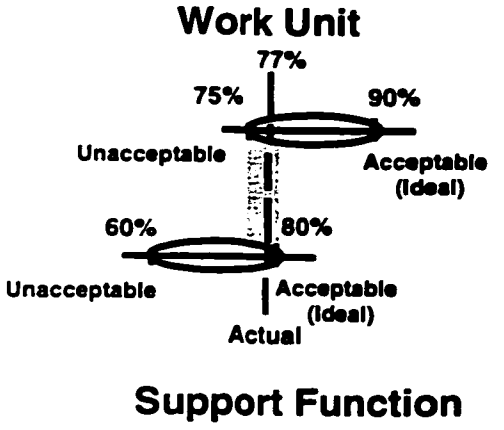

Figure 3-24: Overlapping Ranges

It is important to understand that a relatively narrow 'overlap' may have more instances of responses falling in the unacceptable area than a wider overlap. As illustrated in Figure 3-25 on the next page, a wider overlap means more perceived consistency between the two group's expectation ranges. This can come about in several ways, for instance, the Work Unit can get better information, understanding, about the service capabilities and demands on the Support function. For example, the Maintenance group has the new XJ-15 product line being installed which will take several of their staff away from service response tasks, in addition, a maintenance worker had an accident when a die fragmented and will be away for the rest of the week. Taking these changes in the task situation of the Maintenance group into account in the formation of the expectation range of the Work Unit, the Work Unit can modify their unacceptable land mark to, say, 65% and arrange to take alternative actions when a machine failure occurs. This modification of their expectation range creates more overlap, due to the understanding of the changes to their interaction with the Maintenance group, and thus a higher degree of consistency.

At this point in the discussion in should be recognized that one measure of the degree of consistency between the Unit and Support is defined as the degree of overlap of the set of expectation ranges of the interacting groups. Other measures will be presented in the next sub-section.

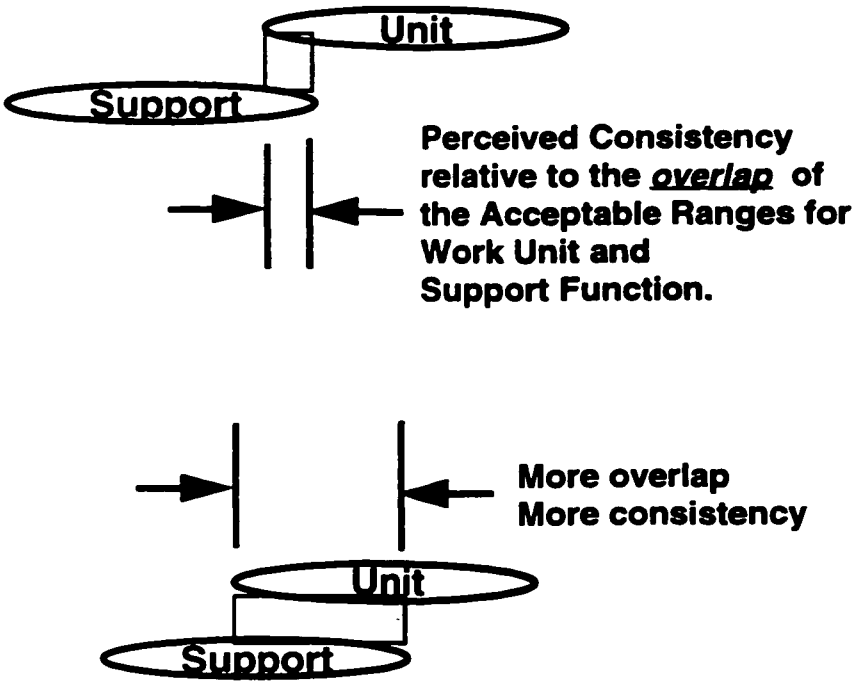

Figure 3-25: Perceived Consistency

3.5 Quantification of Consistency

3.5.1 Overview

The diagram below (Figure 3-26) shows the expectation sets and ranges for a Work Unit and a Support Group as presented in the previous sub-section 3.3, and the corresponding concepts of importance, priority and acceptability along the right hand side. To facilitate this discussion on the quantification of these concepts an example of the expectations in the expectation sets, such as presented in Figure 3-27, will be used. The blue and green ovals represent the expectations, and their ranges, of the Work Unit and Support Group respectively.

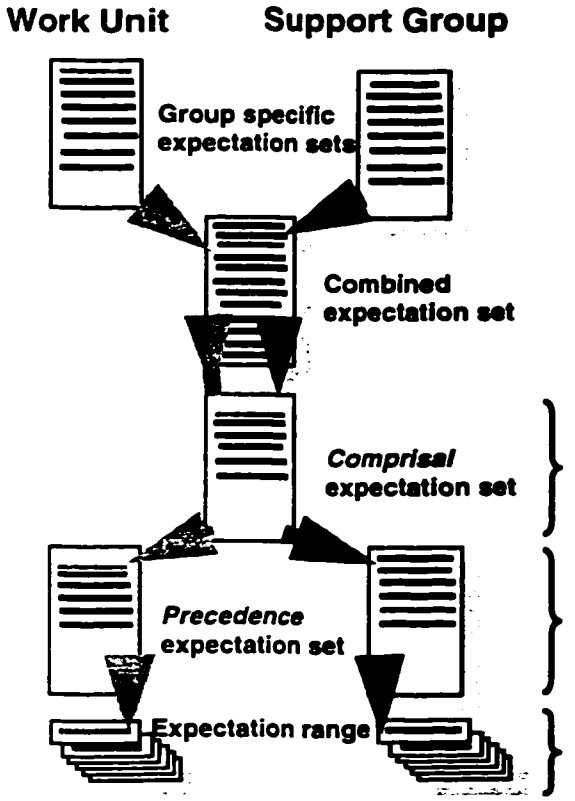

Figure 3-26: Expectation Sets and Ranges

The *Group Specific Expectation sets* for a Unit and a Group **together** represent the *Combined Expectation set.* The example in Figure 3-27 shows that the Unit holds expectations designated as (1) to (5); and the Group holds expectations (1) to (3), as well as, (6) & (7). These are their Specific Expectation sets.

All of these expectations, (1) to (7), together are their Combined Expectation set. The Unit and Group share expectations (1), (2) & (3). Only the Unit has expectations (4) & (5); while only the Group has expectations (6) & (7).

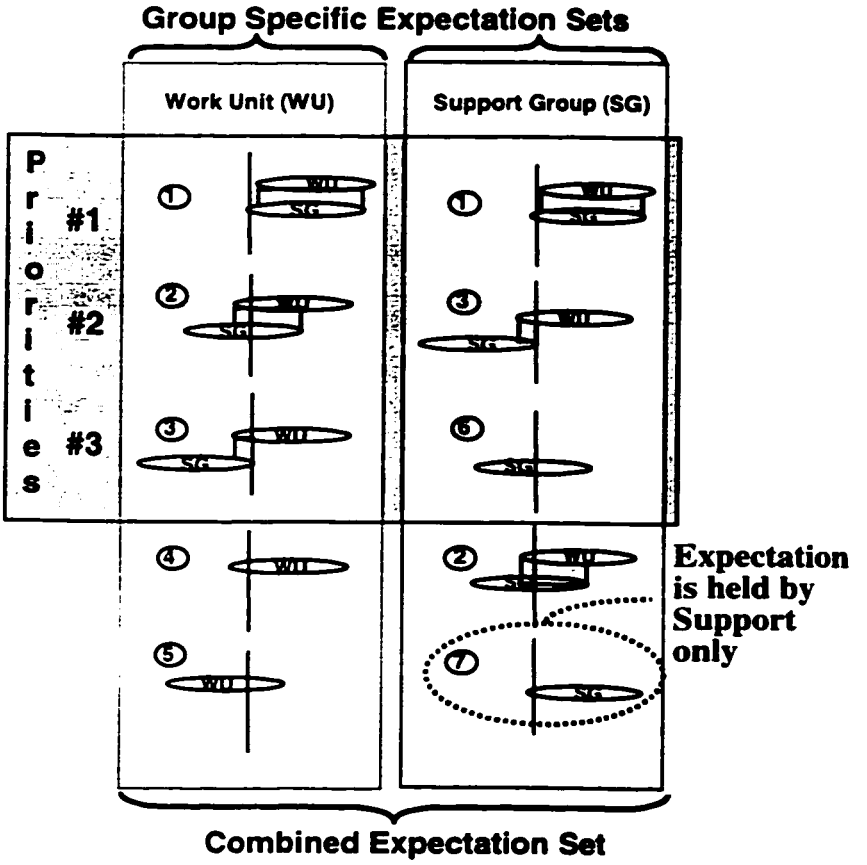

Figure 3-27: Specific & Combined Expectation Sets

In this example, there are three expectations which have been ranked by the Unit and Group – i.e.: priority #1 to #3 on the left side of the chart in Figure 3-27. The Unit has given priority to expectations (1) to (3); and the Group has given priority to expectations (1), (3) & (6). (Note: Priority is intended to mean that, in this example, they have ranked 3 out of their 5 expectations.)

The next sub-sections will continue with this example to explain and quantify the concepts of importance, priority and acceptability. But first, the notion of overall perceived consistency will be presented.

3.5.2 Perceived Consistency of the linkage

From this research the overall Perceived Consistency (**C**) of the linkage between a Work Unit and Support Group is presented in Equation #1. It is broken into three 'terms' which reflect more refined[11] views of consistency. That is,

1. Term #1 (C_1) determines the extent to which the Unit and Group share similar expectation sets (Concept of Importance);
2. Term #2 (C_2) determines, given that they share expectations, the extent to which the Unit and Group give the expectations similar priority (Concept of Priority); and
3. Term #3 (C_3) determines, given the Unit and Group share expectations, the extent to which they have the same expectation ranges (Concept of Acceptability).
4. Weight (w_i) proportions the contribution of the C_i terms and is discussed in Appendix 8.5.6.1.

$$C = \frac{\sqrt{\left[w_1 C_1\right]^2 + \left[w_2 C_2\right]^2 + \left[w_3 C_3\right]^2}}{\sqrt{\left[w_1\right]^2 + \left[w_2\right]^2 + \left[w_3\right]^2}}$$

where: w_i is a relational weight

C_i is a consistency term

$1 \geq C_i \geq 0$

$i = 1,2,3$

so: $1 \geq C \geq 0$

Equation 1 : Perceived Consistency of the Linkage

Each term can be viewed as representing a coordinate in the solution space, as illustrated in Figure 3-28 (with the assumption that the weights are all the same), such that the largest C-value would be the most consistent situation.

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[11] More 'refined' means: Term #1 requires only the agreement by the Unit and Group on the expectations that are important; Term #2 requires agreement on the priority of the important expectations; and Term #3 requires agreement on how the important expectations are view relative to the common task situation.

The intention of this research is that the Perceived Consistency be presented as a score between 0 and 1, no consistency and total consistency respectively. The terms C_1 to C_3 provide scores between 0 and 1, which are similarly interpreted as no consistency and total consistency respectively, for the considerations outlined in the sections that discuss them. The relational weights (w_1 to w_3) give preference to the terms that contribute to the performance of the Perceived Consistency (C) score.

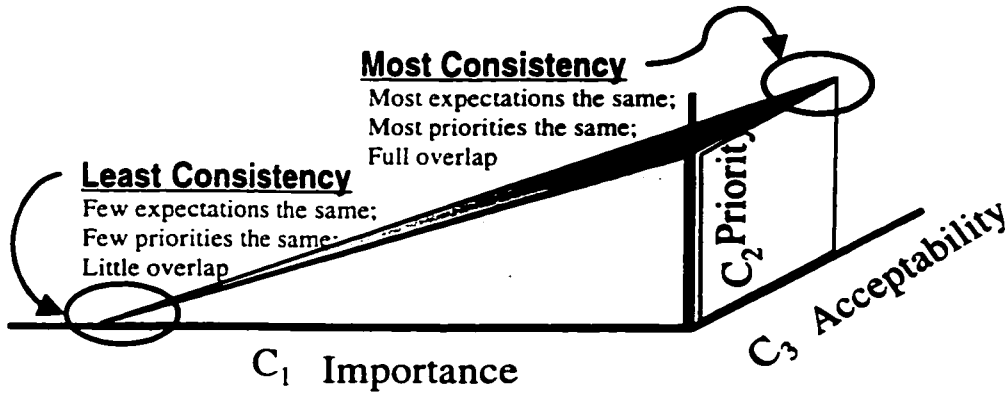


Figure 3-28: Perceived Consistency

Each of the terms (C_1 to C_3) are discussed in the succeeding three sub-sections.

3.5.3 Term #1 (C_1): Concept of Importance

Term #1, of Equation #1, measures the agreement by the Unit and Group on the expectations in the *Combined Expectation set* that are important. In the example below, Figure 3-29, only the expectations that are shared remain in the *Comprisal expectation set.* That is, the expectations (4) & (5) were only selected by the Unit so they have been eliminated for the Unit; and the expectations (6) & (7) were only selected by the Group so they have been eliminated for the Group.

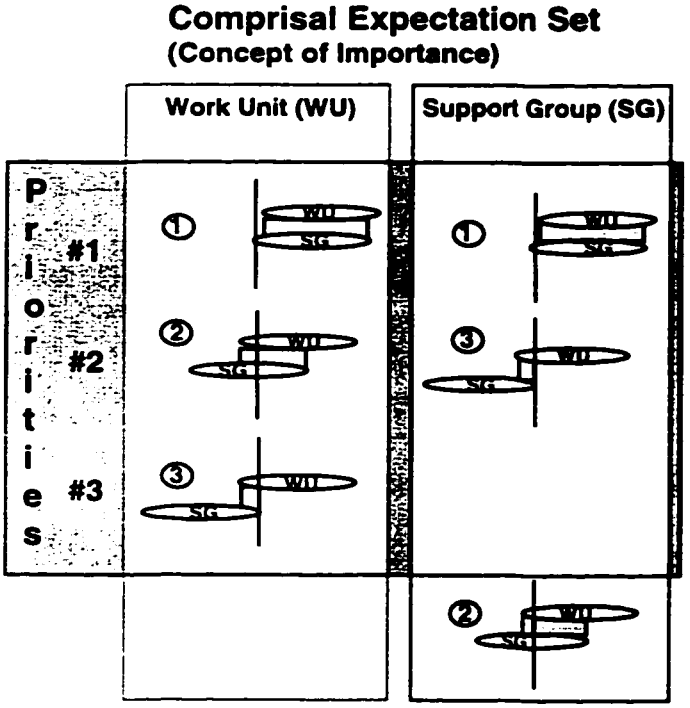
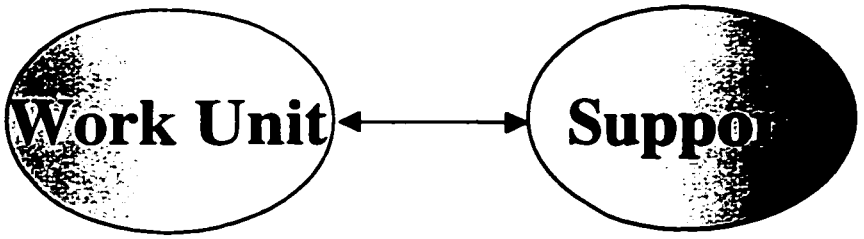
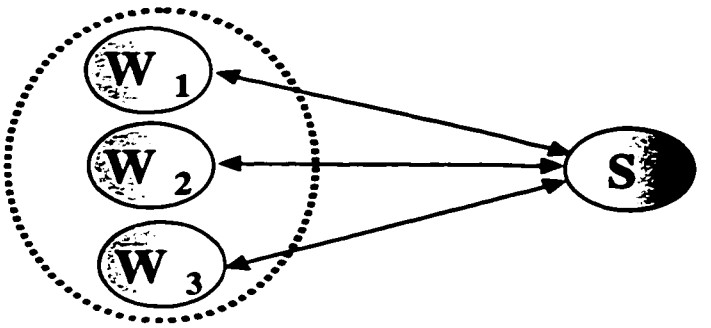


Figure 3-29: Comprisal Expectation Set example

In deriving a quantitative representation of this concept it is recognized that the Work Unit and Support Group do not have expectations of their own, they are the composite of the expectations of the persons who are members of both groups.



That is, each member of a Work Unit interacts, to some extent, with one or more members of their Support Group such that there is a paired-agreement on the expectations that are important to both the Work Unit member and the Support Group member.



As a *'**general case study**[12]'* example, assume that there are 16 expectations in the *Combined Expectation set*, and a member of the Work Unit (W_1) and the Support Group (S) select 5 expectations that they feel are the most important. The Work Unit member and the Support Group member can choose the same or different expectations. If both the Work Unit member and the Support Group member choose all different expectations then there would be 10 unique expectations and this research considers there to be no consistency in the alignment of their expectations. (Refer to the left side of Figure 3-30.) NOTE: the *Comprisal Expectation set* only contains expectations that are shared by both the Unit and Group.

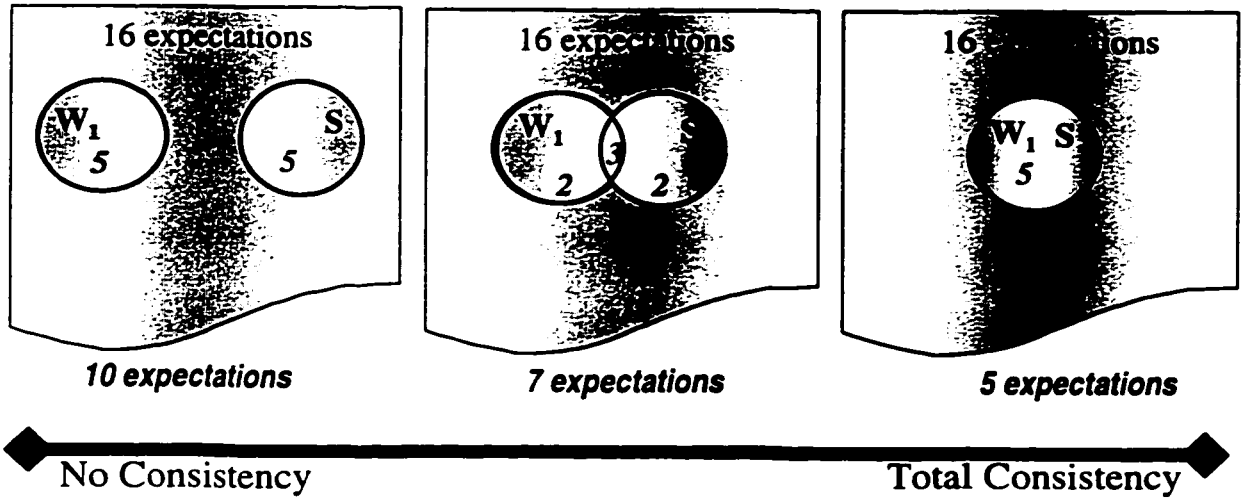


Figure 3-30: Selection of important expectations

However, if both the Work Unit member and the Support Group member choose all the same expectations then there are 5 unique expectations in the *Comprisal Expectation set* and this research considers there to be total consistency in the alignment of their expectations. Thus, a numeric score can be calculated which can represent the paired-

[12] The two case studies, presented in other sections to test this model, use a 16 expectation questionaire, 3 Work Unit participants and 1 Support Group person.

agreement for all pairs of Work Unit members with Support Group members (Figure 3-31 below presents the same three cases for 3 Work Unit members and 1 Support Group member). This research proposes that the scores for each paired-agreement be **Ave**raged, and a **Dev**iation be used to take into account the variation in cases which may have the same average score – i.e.: small variations are preferred in cases with the same average.

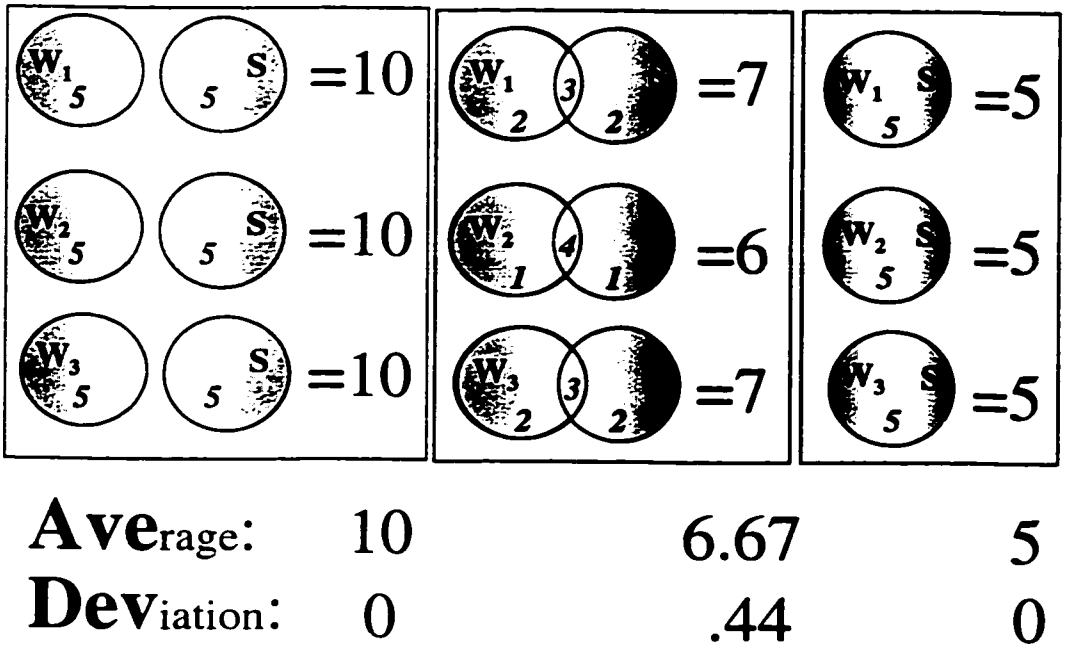


Figure 3-31: Paired agreements on importance

$$C_1 = \frac{2n - (Ave_1 + Dev_1/\delta_1)}{n}$$

where: δ = constant to size **Dev** to act as tie breaker
n = number of important expectations selected

Equation 2: Term #1 (C_1) of Equation 1

The general formula for Term #1 (C_1), above, calculates a score for the expectations that are shared between groups. There is a penalty in consistency for not understanding each other's expectations. If a Unit does not understand a Group's expectations, for instance, then they respond inconsistently because the Unit can not be as effective in the selection of their responses - they do not have alternative behaviours available to offer.
Several things should be noted about the formula:

1. Since a fewer number of expectations in the Comprisal Expectation set indicates a higher degree of alignment, and the intention of this research is to have a total score for all consistency measures (C_1 to C_3) such that a higher number represents more consistency, the factor '**2n**' is used to invert the direction of the scale.

2. The intention of this research to have all consistency measures (C_1 to C_3) present a score between 0 and 1, no consistency and total consistency respectively, is accomplished by the denominator.

3. The main determinate of consistency for C_1 is the '**Ave**' calculation presented below. The '**Dev**' term is used as a tie breaker, and the constant 'δ' is intended to assure that **Dev** does not influence the **Ave** ordering (Note: δ was set at 100 for the case studies presented in latter sections of this paper).

The formulas for **Ave** and **Dev** are presented below.

$$Ave_1 = \frac{\sum_{s=1}^{S} \sum_{w=1}^{W} \sum_{e=1}^{E} \left\{ S_{es} + W_{ew} - S_{es} W_{ew} \right\}}{s * w}$$

where:

E = total number of expectations in the Combined Expectation set

S = total number of Support Group persons providing expectation selections

W = total number of Work Unit persons providing expectation selections

$$S_{es} = \begin{cases} 1, \text{ if expectation } e \text{ is selected by Support person } s \\ 0, \text{ otherwise} \end{cases}$$

$$W_{ew} = \begin{cases} 1, \text{ if expectation } e \text{ is selected by Work Unit person } w \\ 0, \text{ otherwise} \end{cases}$$

$$Dev_1 = \frac{\sum_{s=1}^{S} \sum_{w=1}^{W} \left| Ave_1 - \sum_{e=1}^{E} \left\{ S_{es} + W_{ew} - S_{es} W_{ew} \right\} \right|}{s * w}$$

3.5.4 Term #2 (C_2): Concept of Priority

Term #2, of Equation #1, measures the Unit and Group to prioritize the expectations in the *Comprisal Expectation set.* In the example below, Figure 3-32, only the expectations which are shared and have been assigned priority by both groups remain in the *Precedence Expectation set.* That is, expectation (1) & (3) are shared by the Unit and Group, and both groups have assigned them a priority. However, expectation (2), although shared by both groups, is given priority by the Unit but not by the Group. The reason why the Precedence expectation set drops expectation (2) is that if one group does not give the expectation priority, then even though it may be shared, it does not contribute significantly to the determination of the consistency of the relationship.

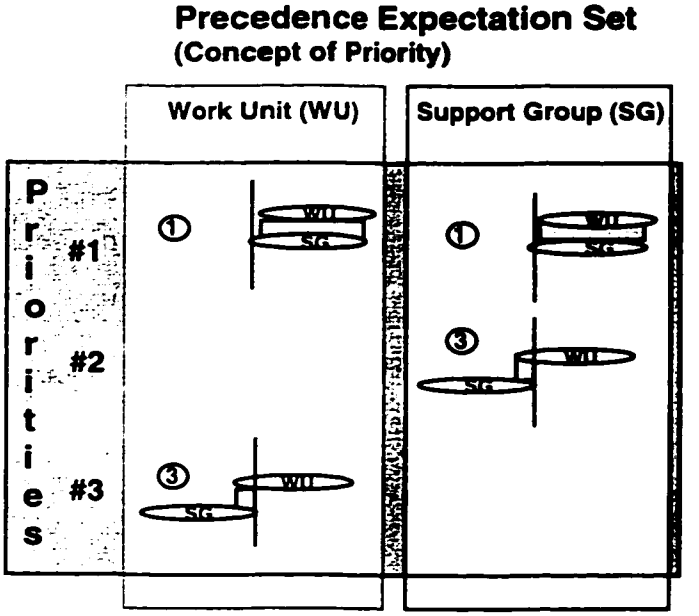
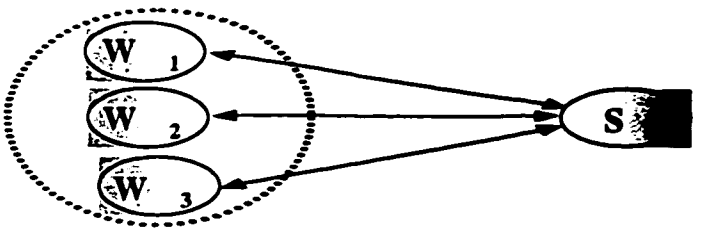


Figure 3-32: Precedence Expectation set example

In deriving a quantitative representation of this concept it is recognized, as in the previous sub-section 3.5.3, that the Work Unit and Support Group do not predetermine expectation priorities, they are the composite of the expectations of the persons who are members of both groups. That is, each member of a Work Unit interacts, to some extent, with one or more members of their Support Group such that there is a paired-agreement on the expectation priorities for both the Work Unit member and the Support Group member.



In the *'general case study'* example in subsection 3.5.3, it was assumed that there were 16 expectations in the *Combined Expectation set*, and a member of the Work Unit (W_1) and the Support Group (S) selected 5 expectations that they felt were the most important. The Work Unit member and the Support Group member could choose the same or different expectations. In this subsection, both the Work Unit member and the Support Group member assign priority-weights[13] to the 5 expectations they selected as important – the ones that are shared and given priority will become the *Precedence Expectation set*.

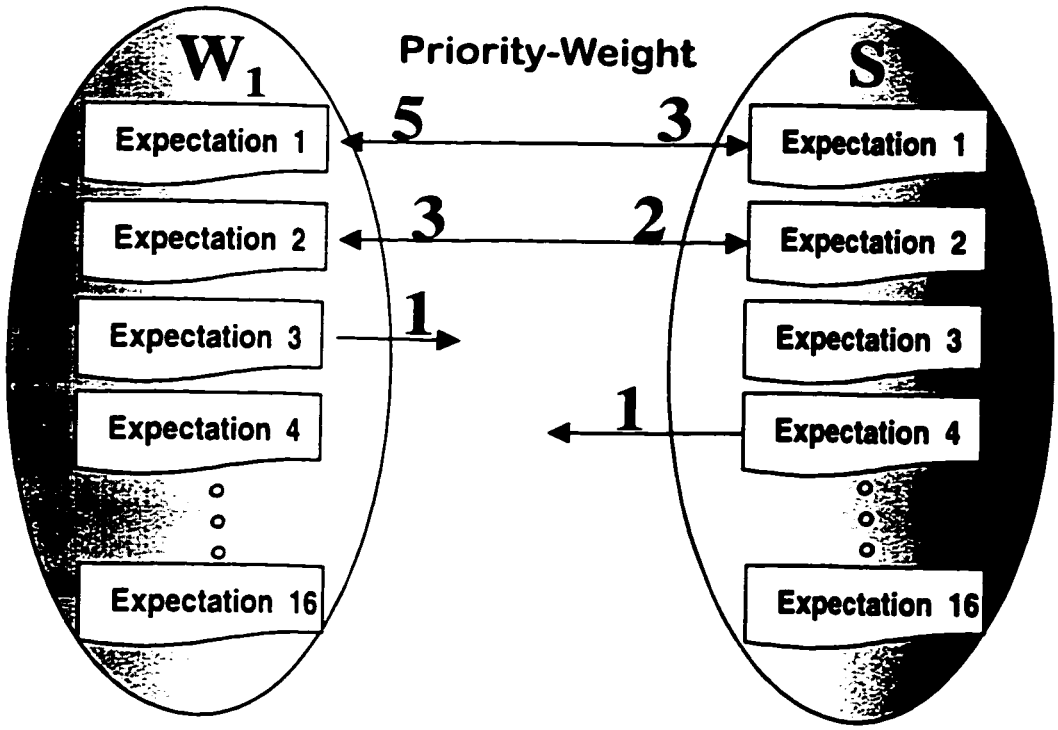


Figure 3-33: Assignment of Priority-Weight to expectations

If one Work Unit member and one Support Group member choose all the same expectations and give these expectations all the same priority-weight, then the sum of the priority-weights will be maximum[14] and this research considers there to be total consistency in the alignment of their expectations. Similarly, if all Unit-Group pairs (eg. W_1 & S; W_2 & S; and W_3 & S) choose all the same expectations and give these expectations all the same priority-weight, then the sum of all Unit-Group pairs' priority-weights will be maximum. Figure 3-34 below shows intermediate conditions, where there is *'little'* consistency through to *'more'* consistency in the Unit-Group pairs. That is:

- on the left hand side of this figure, the Support Group member (S) selects the same Expectation #1 with a Work Unit person (W_1) and they give it similar priority-weight (3 and 5 respectively). However, the Support Group member

[13] To prioritize 5 expectations: the 1st or highest priority expectation is given a weight of 5; the 2nd priority expectation is given a weight of 4; ... ; the 5th or last priority expectation is given a weight of 1.
[14] For 5 expectations: (5*5)+(4*4)+(3*3)+(2*2)+(1*1) = 55.

(S) does not share Expectation #1 with the other Work Unit persons (W_2 and W_3) ... there is little consistency in the Unit-Group pairs;

- on the right side of this figure, the Support Group member (S) selects the same Expectation #1 with all Work Unit persons (W_1, W_2 and W_3) and they give it similar priority-weight (3 or 5) ... there is more consistency in the Unit-Group pairs.

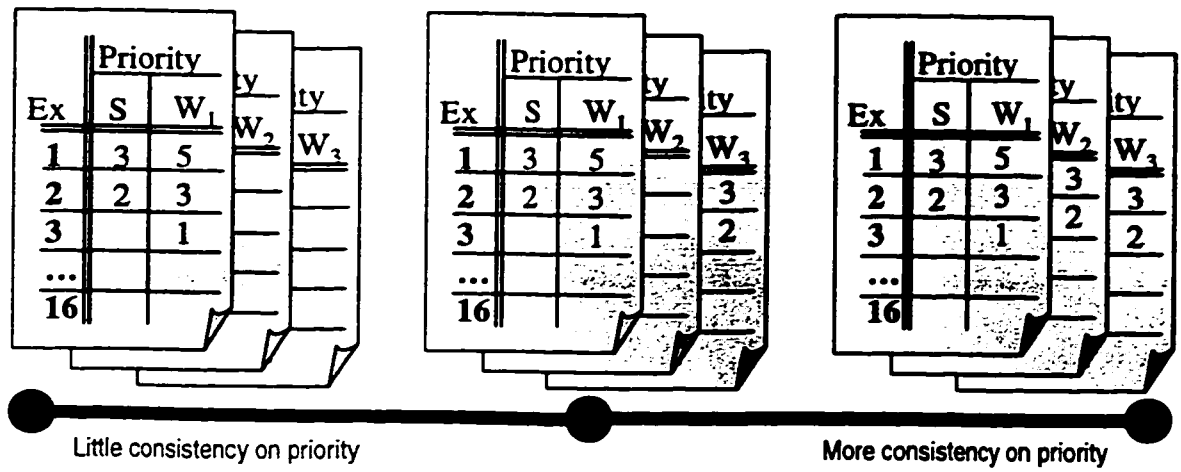


Figure 3-34: Sum of all Unit-Group priority-weights

Thus, a numeric score can be calculated which can represent the paired priority-weights for all pairs of Work Unit members with Support Group members. This research proposes that the scores for all paired priority-weights be **Ave**raged, and a **Dev**iation be used to take into account the variation in cases which may have the same average score – i.e.: small variations are preferred in cases with the same average.

$$C_2 = \frac{(Ave_2 + Dev_2/\delta_2)}{\sum_{i=1}^{n} (i)^2}$$

where: δ = constant to size **Dev** to act as tie breaker
n = number of expectations given priority

Equation 3: Term #2 (C_2) of Equation 1

The general formula for Term #2 (C_2), above, calculates a score for the expectations that are shared between groups and have been assigned priority-weights by both groups. There is a penalty in consistency for not understanding each other's priority. If a Unit does not understand a Group's expectations, for instance, then they respond

inconsistently because the Unit can not evoke the preferred behaviours as often as necessary. Several things should be noted about the formula:

1. The intention of this research to have all consistency measures (C_1 to C_3) present a score between 0 and 1, no consistency and total consistency respectively, is accomplished by the denominator.

2. The main determinate of consistency for C_2 is the '**Ave**' calculation presented below. The '**Dev**' term is used as a tie breaker, and the constant 'δ' is intended to assure that **Dev** does not influence the **Ave** ordering (Note: δ was set at 100 for the case studies presented in latter sections of this paper).

The formulas for **Ave** and **Dev** are presented below.

$$Ave_2 = \frac{\sum_{s=1}^{S} \sum_{w=1}^{W} \sum_{e=1}^{E} \{ PS_{es} * PW_{ew} \}}{s * w}$$

where: E = total number of expectations in the Combined Expectation set

S = total number of Support Group persons providing expectation priorities

W = total number of Work Unit persons providing expectation priorities

PS_{es} = Priority given to expectation e by Support person s; Otherwise = 0.

PW_{ew} = Priority given to expectation e by Work Unit person w; Otherwise = 0.

$$Dev_2 = \frac{\sum_{s=1}^{S} \sum_{w=1}^{W} \left| Ave_2 - \sum_{e=1}^{E} \{ PS_{es} * PW_{ew} \} \right|}{s * w}$$

3.5.5 Term #3 (C_3): Concept of Acceptability

Term #3, of Equation #1, requires the Work Unit and Support Group assign acceptability ranges to the expectations in the *Precedence Expectation set.* In the example below, Figure 3-35, only the expectations which are shared and have been assigned priority by both groups are attributed *Expectation Ranges.* That is, only expectation (1) & (3) are shared by the Work Unit and Support Group, and both groups have assigned them a priority – they are assumed to contribute significantly to the determination of the consistency of the relationship.

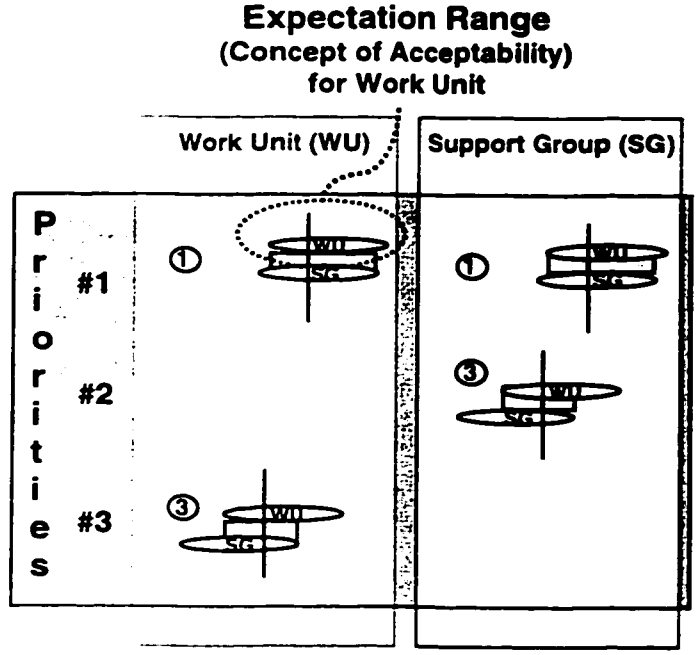
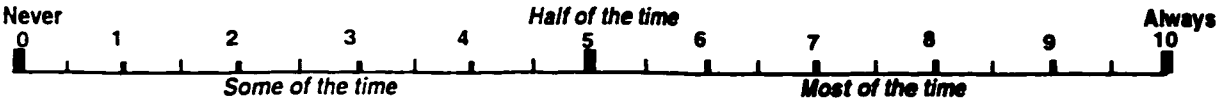


Figure 3-35: Expectation Range example

In deriving a quantitative representation of the Concept of Acceptability there are several features of the expectation range that need to be recognized, and assumptions that will be made:

(i) As in the previous sub-section 3.4 that discussed overlapping expectation ranges, the Work Unit and Support Group each evaluate an 'actual' response behaviour against their expectation range. These evaluations will be represented on a scale of how often (always = 10) or infrequently (never = 0) a response behaviour actually occurs.



(ii) The Work Unit and Support Group will also represent on this scale how often they want something to happen (refer to Figure 3-36) if the situation was better, as an

acceptable 'ideal'; and what would be an unacceptable range boundary, if the situation was worse. These together represent the extent of the expectation range. That is, the unacceptable boundary and the acceptable ideal represent the range that the actual falls within.

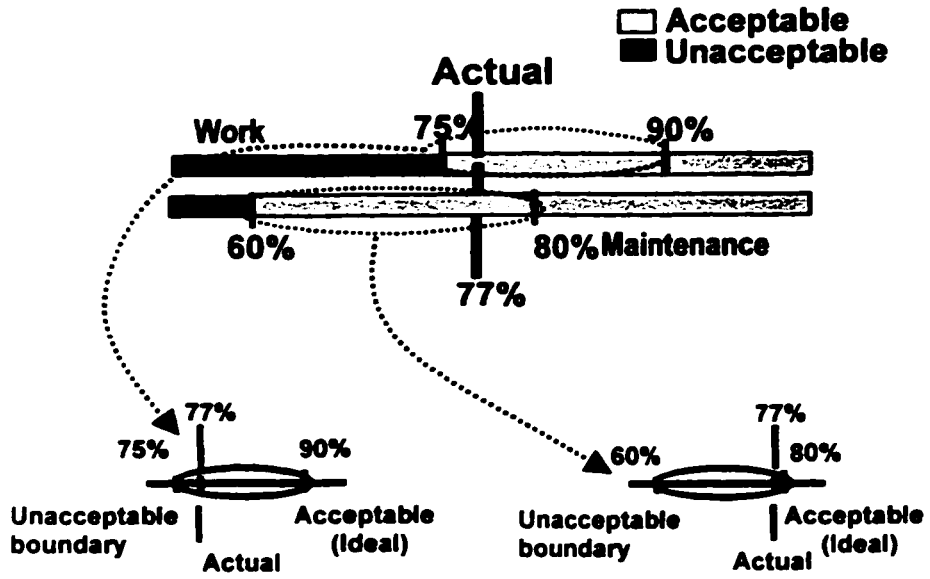


Figure 3-36: Range boundary

(iii) There are two possible orientations for an expectation: positive and negative. As examples:

(1) a positive expectation like – *"A non-emergency work order is given to Maintenance for a service call which can be planned and scheduled within the week"* – describes acceptable, preferred or better behaviour from the Maintenance Support Group's point of view and a 'force' may be applied by the Group with the intention of increasing the frequency of this response by the Unit. That is, to have the actual response frequency more towards the top of the scale (always).

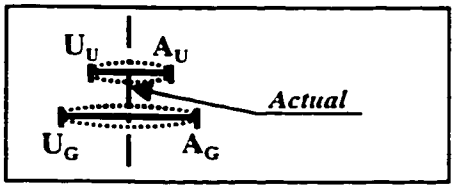
(2) On the other hand, a negative expectation like – *"A work order is given to Maintenance for a repair which should have been done by the Work Team"* – describes unacceptable, unwanted or worse behaviour from the Maintenance Support Group's point of view and a 'force' may be applied by the Group with the intention of decreasing the frequency of the response by the Unit. That is, to have the actual response frequency more towards the bottom of the scale (never).

There are also several assumptions that will be made about the nature of the relationship between the ranges of the Work Unit and the Support Group to facilitate the calculation of the range using a proportional actual (Appendix 8.5.5.1 presents a comparison of a range based on the 'actual, better & worse' landmarks and a range using a proportional

actual, and shows that the proportional actual gives similar results by using the actual only.)

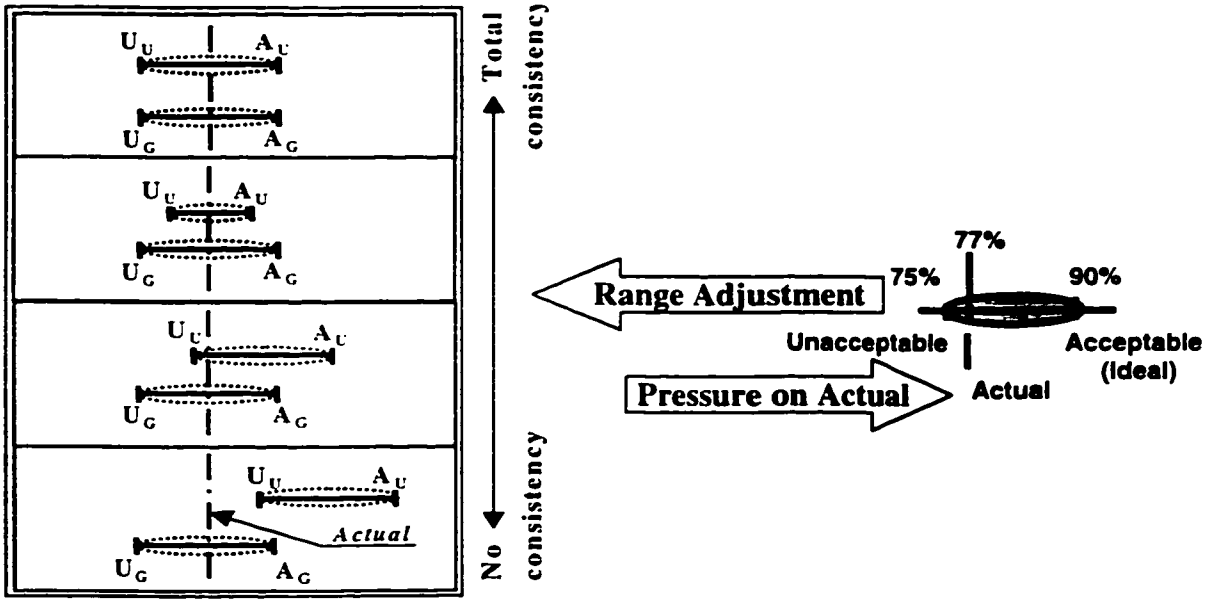
ASSUMPTION #1: Expectation Ranges are inclusive. The expectation ranges of the Work Unit and the Support Group move to a stable balance, as interaction between the Unit and Group increases or is sustained over a period time, so that the actuals are centered within the expectation ranges and one range includes the other.

Inclusion



Key: **U_U= Unacceptable for Unit**
A_U= Acceptable for Unit
U_G= Unacceptable for Group
A_G= Acceptable for Group

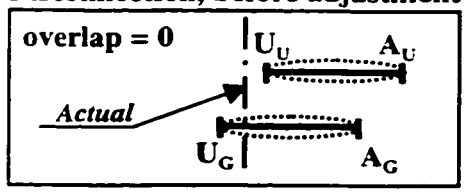
Thus, the Unit and Group's ranges are always moving towards a state where they view the task situation in the same way. In the figure below the two ranges move from 'no consistency' to the state of 'total consistency,' as will be addressed in Assumptions #2 & #3. Dissonance is assumed to cause adjustment of the actual and/or range(s) as the Unit and Group expectation ranges adjust to the realities of the task situation. (See footnote[15] for examples.)



[15] **'Pressure on Actual'**: the Work Unit, for example, may talk to management to force the Support Group to come faster to fix their machines; **'Range Adjustment'**: the Support Group, for example, may hold regular meetings with the Work Unit to inform them about what the Maintenance work load is like so the Work Unit can make alternate plans.

ASSUMPTION #2: Disconnection does not occur. The 'Actual' behaviour (response to an expectation) exits within the ranges of both the Work Unit and Functional Support Group.

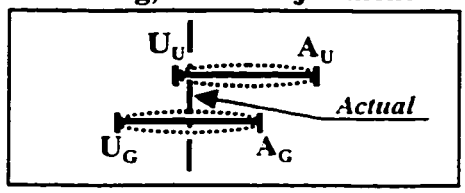
Disconnection, before adjustment



For example, the Maintenance Group expects work orders to be filled in with complete details on the nature and location of equipment faults. Several temporary workers have been assigned to the Work Unit to cover a period of peek load. They do not fill in the work orders correctly so the actual behavior of the Work Unit becomes 'unacceptable' for the Unit and marginally 'acceptable' for the Group until feedback from peers and training corrects the behaviour in line with expectations.

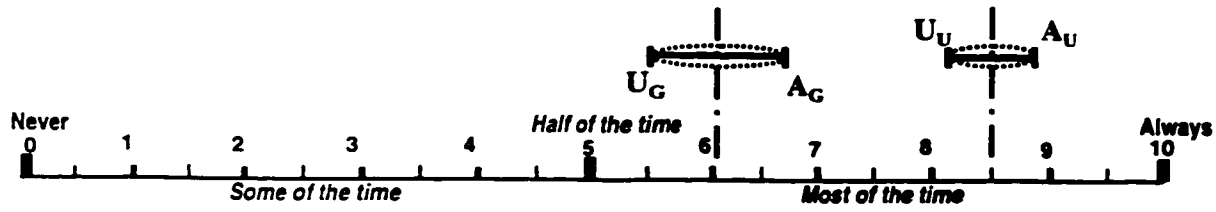
ASSUMPTION #3: Bordering does not occur. Response to an expectation at the extreme ends of a range (acceptable or unacceptable) are unstable and unsustainable, and will cause adjustment of actual and/or range(s).

Bordering, before adjustment



For instance, a policy change has been instituted that restricts the amount of overtime the Maintenance Group budget can fund. From the Work Unit's view the resulting behaviour has become unacceptable and they lobby management for more preventative maintenance training so less overtime will be required and the new service level becomes more 'normal'.

ASSUMPTION #4: An Expectation Range is proportional to the value of 'Actual' on the scale. For example, for a positive Unit expectation near the extreme of scale (Always), say 8.5 or 85%, the Unit has better information about the task situation because the actual is perceived to be happening more often and the range is tighter. Further away, say 6.1 or 61%, the Group has relatively less information about the task situation because the actual is perceived to be happening less often, 85% vs 61%, and there is more variability in the range - the range is looser. As the actual as perceived by the Unit and Group become further apart, the ranges for the Unit and the Group differ, and there is assumed to be less consistency as the overlap decreases. (Appendix 8.5.5.1 presents a comparison of a range based on the 'actual, better & worse' landmarks and a range using a proportional actual, and shows that the proportional actual gives similar results by using the actual only.)



The formula below brings together these notions, and uses the difference in perceived actual as the basis for determining a value for the consistency of the expectation range overlap.

$$C_3 = Ave_3$$

Equation 4: Term #3 (C_3) of Equation 1

$$Ave_3 = \frac{\sum_{s=1}^{S} \sum_{w=1}^{W} \sum_{e=1}^{E} S_{es} W_{ew} (1 - |AW_{ew} - AS_{es}|/10)}{S * W}$$

where:

E = total number of expectations in the Combined Expectation set

S = total number of Support Group persons providing expectation selections

W = total number of Work Unit persons providing expectation selections

$$S_{es} = \begin{cases} 1, \text{ if expectation } e \text{ is selected by Support person } s \\ 0, \text{ otherwise} \end{cases}$$

$$W_{ew} = \begin{cases} 1, \text{ if expectation } e \text{ is selected by Work Unit person } w \\ 0, \text{ otherwise} \end{cases}$$

AS_{es} = Actual for expectation e selected by Support person s

AW_{ew} = Actual for expectation e selected by Work Unit person w

for: $AS_{es} = AW_{ew}$ then $|\bullet|/10 = 0$

NOTE: the value 10 represents the magnitude of the scale.

4 Method

4.1 Overview

This research method was used to study the linkage between a WORK UNIT and a SUPPORT FUNCTION. It was conducted through two case studies: one at an automotive manufacturer in Ontario. *Company A*; and a second at an electronic repair facility in the USA, *Company B* (see the next sub-section for descriptions of the two companies). Both case studies took place over a three-year period of part time study, interspersed with several full time residencies at their facilities.

Company A, was initially contacted during the original research definition phase, then participated extensively through a four month full time study where the Expectation Range Model was developed, and once again for the final testing. Portions of this study were repeated at Company B to verify the model and test it. Company B represented a different industry that also had successful team implementations and team driven operations. It provided a low level of generality, assisted in cleaning up the methodology and refined the method of the calculation of Perceived Consistency. The testing phase was done during two-week full time residence at both of the companies' facilities.

Representatives of each Company were in constant contact with the investigator to provide feedback, arrange for the succeeding phases of the project and to receive management progress reports. The overall plan was to become familiar with each business on 24 hours basis; understand the context of operations of the work units; interview the work units; interview a selected support group impacting the work units; interview management on their expectations for teams; do informal presentations; follow-up with additional investigations as required; and then wind up with a final presentation and a written report.

The activity chart in Figure 4-1 gives an overview of the Method. It should be noted that Company A participated in all of these activities, while Company B only participated in the activities indicated as solid boxes. The activities in the 'dashed' (---) boxes were conducted with Company A during the development of the *Expectation Range Model,* which provided the structure of the Questionnaire (see the double box in the chart). The interviews with the 'focus' Work Unit and the 'focus' Support Group provided the content for the Questionnaire at both Company A & B sites

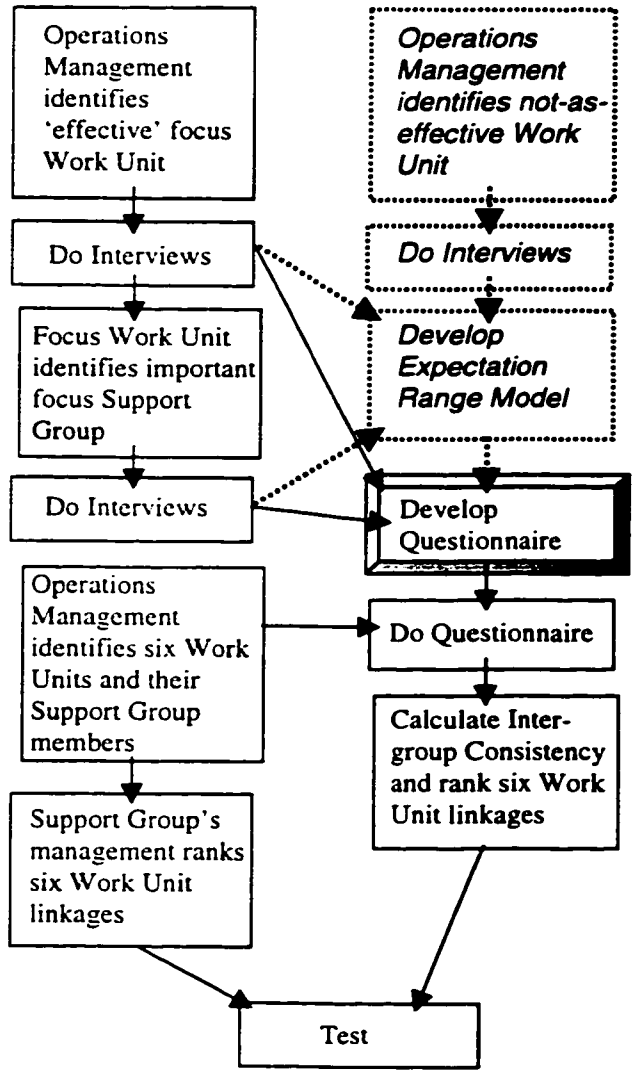


Figure 4-1: Overview of the Method

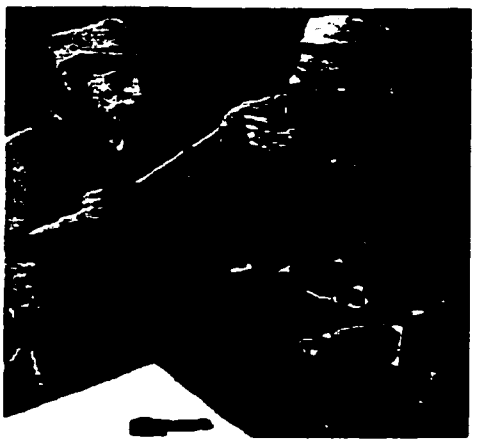
The succeeding sub-sections describe the two case study sites, the method used for the quantitative analysis of the consistency measure, and the method for qualitative collaboration of the consistency results. The Appendix 8.1 to 8.4 provide the interview guides and questionnaires used.

4.2 Case Sites

4.2.1 Company A:

Company A was an automotive division of a multi-national Corporation that provides high-technology products and services to the automotive and space, defense & information systems markets. The automotive divisions design, manufacture, and sell automotive product lines for cars, trucks, buses, and off-highway vehicles. These products are distributed directly to vehicle makers and through independent distributors.

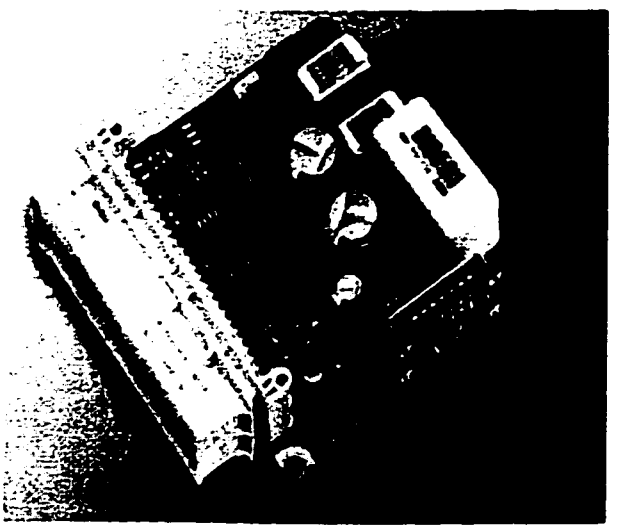
The Company A division was located in southwestern Ontario and manufactures suspension components for the Big Three auto makers and others, shipping products around the world. The operation consists of two facilities running continuously on three shifts producing 43,000 parts per day in some 20 manufacturing cells operated by 100% self-directed work teams (SDWTs) of about 440 Union/Non-Union members. In the last few years the operation has shifted from dedicated, mass production, in-line transfer operations to CNC machining centers.



Company A has received several inter-national awards for its manufacturing process, and was recognized as having excellent team practices.

4.2.2 Company B:

Company B was a repair division of a multi-national Corporation that provides high-technology telephony, wireless networking and Internet products and applications, with 1998 revenues of US$17.6 billion and employing approximately 75,000 worldwide.



The Company B division was located in Tennessee and repairs high-capacity, digital communications technology including: digital switching; wireless and multimedia communications: Internet and intranet access and security products; and wide area networking systems.

The operation consists of two facilities for repair and distribution operations in a cellular manufacturing configuration with self-directed work teams of Union members. Company B has received several corporate and regional awards for its manufacturing process, and was recognized as having excellent team practices.

4.3 Steps in the Method

4.3.1 Site Verification

Both Company A & B sites were visited to tour their facilities, meet the team members and to speak to management. The intent of this was two fold: to verify that the potential work units represented good examples of operational teams; and to broach with senior management their willingness to receive a case study research proposal presentation.

4.3.2 Research Proposal Presentation to Management

A presentation was made to the company's management team on the intent of the research, the time commitment for the initial focus work unit and support group, availability of the research results and the potential benefits to the company. Some of the benefits presented were: (1) a novel view of functional relationships; (2) recommendations based on a systematic approach to a new area of management study; and (3) potential for actions to improve team effectiveness which are congruent with the existing company culture. A commitment was secured from the senior manager and a management representative contact was assigned.

4.3.3 Identity Focus Work Unit

The operations management representative for each of the selected case study sites identified one work unit (WORK UNIT) that they considered to be very effective according to their internal measures. This was termed the *'focus'* WORK UNIT for the initial phase of the research to develop the Expectation Range Model and the Questionnaire that would be used to capture the quantitative data to test the Inter-group Consistency measure. For *Company A* only, a second not-as-effective work unit was identified to participate in the qualitative analysis, see sub-section 4.4, and to provide comparative information which was used in the development and to verify the Expectation Range Model.

4.3.4 Research Intent Presentation to Focus Work Unit

In this presentation the investigator explained to the focus WORK UNIT who he is and why the research was being conducted, that the research was about communications between work groups, that their co-operation and help was very important, and that they agree to participate. Further, an operations management contact(s) for their area, on each shift, was assigned so they knew what the researcher was doing and could make introductions to the team members.

It was agreed that the research visits would be done on three consecutive days each week - over a four month period in Company A - leaving time for subsequent analysis, so the most team activity could be observed (ie: team meetings, work station operations, team member interaction etc.)

4.3.5 Interview of Focus Work Unit members

Ten people from the focus WORK UNIT were interviewed using the questionnaire in Appendix 8-1 (see Figure 4-2 for sample). Each interview was one-half hour long and the comments were recorded by hand and then entered into a spread sheet data base for the categorical analysis to develop a questionnaire and the qualitative aspects of this research.

(1) I want to talk about your work unit's relationship with **your support functions**. Looking at all the different support groups that you have to interact with, some may be more important ... can you give me an example of one which you consider to be very important to your team's successful performance?

(2) In performing the tasks between units, what behaviours do the members of the support function consider to be GOOD for your unit to do to help them ... in other words, what do they praise members of your unit for doing and what is an example of that behaviour?

Figure 4-2: Work Unit Interview Questionnaire

4.3.6 Identify Focus Support Group

As part of the interview process, each focus WORK UNIT member identified one support function that their team works with that they consider to be an important linkage. The support function identified by the most team members was taken as the focus SUPPORT FUNCTION for the analysis.

4.3.7 Research Intent Presentation to Focus Support Group

This presentation was similar to that given to the focus WORK UNIT. The investigator explained to the focus SUPPORT GROUP who he is and why the research was being conducted, that the research was about communications between work groups, that their co-operation and help was very important, and that they agree to participate. The same operations management contact(s) was used to make introductions to the focus SUPPORT GROUP members.

The research visits were made during the same three days each week allowing observation of the group activity with the focus Work Unit (ie: team meetings, support procedures, team member interaction etc.)

4.3.8 Interview of Focus Support Group members

Interviews were done with the focus SUPPORT GROUP using the questionnaire in Appendix 8-2 (see Figure 4-3 for sample). Again, each interview was one-half hour long and the comments were recorded by hand and then entered into a spread sheet data base for analysis.

(1) I want to talk about your group's relationship with the work units that you support, in particular the _____ team.

(2) In performing the tasks between units, what behaviours do the members of the work unit consider to be GOOD for your group to do to help them ... in other words, what do they praise members of your group for doing and what is an example of that behaviour?

Figure 4-3: Support Group Interview Questionnaire

4.3.9 Categorize Interview Comments

A categorical examination of the individual interview data from Steps 4.3.5 and 4.3.8 was done for the two groups – the focus WORK UNIT and the focus SUPPORT GROUP – by the investigator.

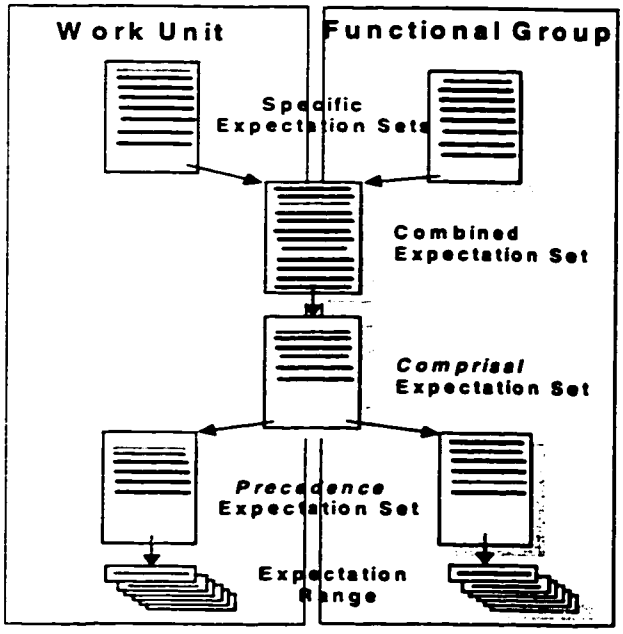


Figure 4-4: Expectation Sets

In regard to the Expectation Range Model's *Expectation Sets* presented in the previous section and above in Figure 4-4, the two categorized interview data from the focus WORK UNIT and their linked focus SUPPORT FUNCTION are their *Group Specific Expectation sets.*

4.3.10 Expert Review of Categories

The reliability of the placement of interview comments into categories was checked by an expert from the focus WORK UNIT and the focus SUPPORT GROUP. This was done by taking a 20% random sample of the comments which had been classified by the researcher and having the experts sort the comments into the researcher's categories and then checking the agreement with that of the researcher. A correspondence of 75% for the both case sites was obtained. The wording of the categories was then carefully checked by the researcher and the experts with a view to reducing any abstraction and assuring that the language was similar to that used by the organization.

4.3.11 Questionnaire Design

The behaviour items from the two *Group Specific Expectation Sets* were ranked by the number of similar instances. The most frequent expectations for the focus WORK UNIT and the most frequent expectations for the focus SUPPORT GROUP, together, become the *Combined Expectation set.* That is, sixteen expectations were chosen, the top eight from the focus WORK UNIT and the top eight from the focus SUPPORT GROUP. The *Combined Expectation set* was then used to design a questionnaire (Appendix 8-3) to collect quantitative data for the calculation of Inter-group Consistency. The example of the expectation statements from the questionnaire, given in Figure 4-5, was based on the actual interview responses.

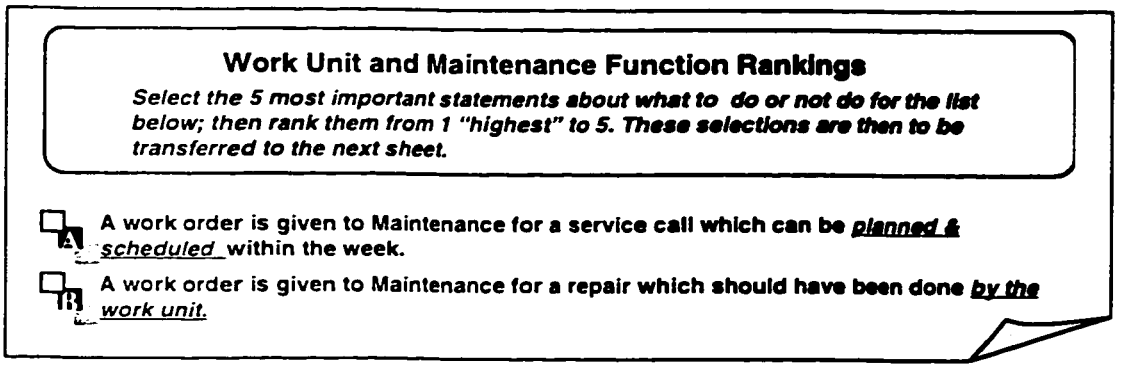


Figure 4-5: Sample Quantitative Questions

4.3.12 Expert Review of Questionnaire

The questionnaire was checked again for the reliability of the expectation questions by the experts of Step 4.3.10. That is, they confirmed that the two groups both interpret the

questions in a similar way and that they were specific enough to capture an expectation range – actual, acceptable (better) and unacceptable (worse) behaviours.

4.3.13 Identify six Work Units & their Support Group to test

The operations management representative for each of the selected case study sites identified six[1] comparable WORK UNITS for the analysis. That is, each team produced products which resemble each other (e.g. machine operations or electronic repair), using similar machines with the approximately the same number of team members. Additionally, Management chose teams that were distinguishable in terms of performance, such that there would be a discrimination between the calculated Inter-Group Consistency so it could be tested.

Since this research looks at the linkage between a WORK UNIT and its SUPPORT GROUPS, and the focus SUPPORT GROUP input was used to develop the Questionnaire, then the linkage of the six WORK UNITS to the focus SUPPORT GROUP was studied, see Figure 4-6. Thus, each of the six WORK UNITS was pre-screened to assure that there was a relationship with the SUPPORT GROUP and that the relationship was one of the more consequential for those WORK UNITS. That is, it was verified[2] that the SUPPORT GROUP was one of the linkages that the WORK UNITS felt was important. The SUPPORT GROUP member that supported each WORK UNIT was also selected to participate in the next phase of the research.

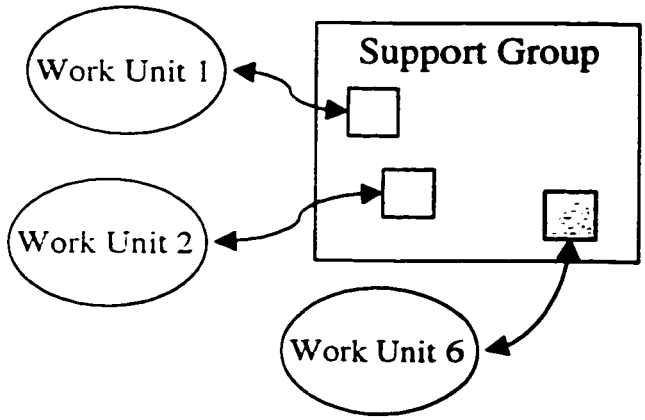


Figure 4-6: Many-to-one relationship

[1] Note: The use of 6 teams was negotiated with both site Management. There was a practical limit to how much time the site Management would allow for research, and there was a need to reduce the burden upon the Support Function in the ranking of the teams. Also, 6 observations was considered sufficient for the statistic selected to test the hypothesis.

[2] Work units that did not agree would have been eliminated and another team would have been selected by Operations Management.

4.3.14 Ranking by Support Management

The SUPPORT GROUP's Supervisor was asked to rank the six work units which where selected by Operations Management, from the most effective relationship to the least not-as-effective relationship, (i.e.: 1 to 6) on the questionnaire in Appendix 8-4. The SUPPORT GROUP's Supervision observes the SUPPORT GROUP and the WORK UNITs working together and can evaluate the differences between WORK UNIT and SUPPORT GROUP linkages. The steps are:

(i) From the 6 WORK UNITs selected, place 3 into a class called "Effective" teams, and 3 into a class called "Not-as-effective" teams.
(ii) For each class, rank the 3 teams in that category.

4.3.15 Research Intent Presentation to six Work Units & their Support Group

This presentation was similar to that given to the focus WORK UNIT. The investigator explained to the six WORK UNITS and their SUPPORT GROUP members who he is and why the research was being conducted, that the research was about communications between work groups, that their co-operation and help was very important, and that they agree to participate in doing the one hour questionnaire session.

4.3.16 Questionnaire given to six Work Units & their Support Group

The scripted introduction and guide lines for the questionnaire session is given in Appendix 8-3, along with the questionnaire, see sample in Figure 4-5. The sessions were conducted with at least three representatives from each WORK UNIT and the corresponding SUPPORT GROUP member – that was the person in the support group that provided on-going interaction within the Work Unit's task situation. In this way each of the six "work unit/support group" linkages was represented. It took about one hour to complete the following process:

(i) Explain the questionnaire format and clarify any questions on how to interpret the expectations;

(ii) the participants selected 5 expectations which they considered to be most important;

(iii) the participants ranked these 5 expectations from 1 to 5;

(iv) then the participants marked the frequency of occurrence of behaviour called "actual" (A-mark), "better" (B-mark) and worse (W-mark)," (see Figure 4-7).

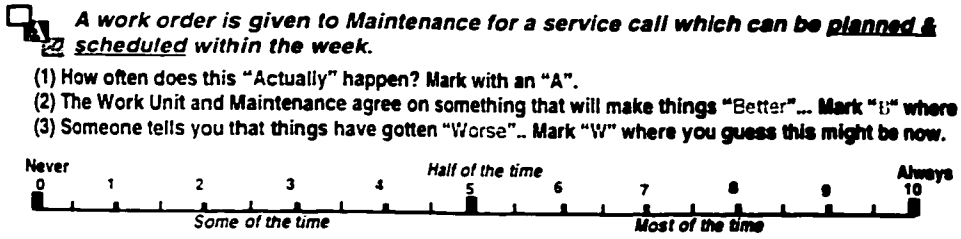


Figure 4-7: Scale for the Expectation Range

4.3.17 Compile Questionnaire Results

The outcome of the questionnarie sessions is documented in the Results sections for the two case studies. These sections provide a test of the Inter-Group Consistency measure as follows:

(i) The value for Inter-group Consistency was calculated for each Work Unit/Support Group linkage and the Work Units were ranked accordingly, (i.e.: 1 to 6).

(ii) The rankings, an ordinal measurement of Support Function Supervision and the Work Unit/Support Group calculation of Inter-group Consistency, were tested for a match to the Support Function Supervision ranking by a probability[3] measure.

(iii) The test in (ii) were done for a strict and relaxed situation:

(a) Strict situation. The rankings were tested on the outcome from the Inter-group Consistency without adjustment.

(b) Relaxed situation. The rankings were adjusted to allow for noise in the data and environment.

4.3.18 Reports to Management, Work Units & Support Groups

Progress reports and final research reports with recommendations for improvement were provided to all the participants in the study, and information sessions were conducted to present the results and clarify the conclusions reached.

4.4 Additional Analysis of Case Study Sites

For *Company A* only, a second not-as-effective work unit was identified by Operations Management to participate in a qualitative analysis and to provide comparative information which was used in the development of the Expectation Range Model and support the research results section. This method followed the same steps as outlined in 4.3.3 to 4.3.10 inclusive.

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[3] First Course in Probability, by S. Ross, Prentice Hall, pg. 35 (Proposition 4.4).

5 Results

5.1 Overview

The presentation of the results will start with three individual terms (C_1 to C_3) of the Perceived Consistency of a Linkage (**C**) formula and conclude with the combined score.

Consistency of a Linkage (**C**) {
- Concept of Importance (C_1);
  - ➥ Concept of Priority (C_2);
    - ➥ Concept of Acceptability (C_3).

That is, the expectations that define the task situation between a Work Unit and a Support Group were broken into three components of inter-group consistency, each representing a different view of consistency. These three components were aggregated so that for each Work Unit and Support Group pair the Consistency of the linkage was represented by the C-formula. A full discussion of the logic of these calculations is given in Appendix 8.5.

The result section includes three types of examination:

- First was a quantification of the number of matches between a ranking of the six Work Unit linkages by a judge, from each company, and a ranking based on the C-formula score. This was to test the ability of the formula to discern differences between linkages;

- Second was an analysis the Questionnaire results from the six Work Unit linkages in each company. They were partitioned into two groups according to the company judge rankings – the 3 Work Units ranked at the top and the 3 lower ranked Work Units. This is to provide additional understanding of the underlying reasons for the differences between highly ranked Work Unit linkages and those ranked lower; and

- Lastly, for Company A only, a comparison of one Work Unit designated as 'effective' by the Company management and one Work Unit designated as 'not-as-effective'. That is, the interview behaviour examples, used in the development of the Expectation Range Model, were categorized with the view of providing additional understanding of the underlying reasons for the differences between effective and not-as-effective Work Unit linkages.

To facilitate the presentation of the results, the next sub-section gives an overview of the test used. This is followed by the test results of the two case studies, and the additional analysis sub-sections. These are supplemented, as noted in the text, by discussions in the Appendix.

5.2 Testing the Strict and Relaxed situations

The results, which were represented by the ordinal measurement of the Work Unit/Support Group Inter-group Consistency score, were tested by an exact match to the Support Function Supervision ranking by Ross' matching probability[1] measure as shown in Figure 5-1. That is, the Work Unit/Support Group linkages were ranked by the company expert and by the Consistency score, and there were k of the N linkages matching. There was a probability ρ that k of N matches can occur from random selection. (The convention for reporting significance is given in the footnote[2].)

$$\text{Probability of exactly } k \text{ matches in a group of } N = p_{Nk}$$

$$= \frac{1 - 1 + 1/2! - 1/3! + \ldots + \dfrac{(-1)^{N-k}}{(N-k)!}}{k!}$$

for: $N = 6$ and

$k = 1$ then $p_{6,1} = .3667$
$k = 2$ then $p_{6,2} = .1875$
$k = 3$ then $p_{6,3} = .0556$
$k = 4$ then $p_{6,4} = .0208$

Figure 5-1: Ross' Matching Probability

The test was done for a match from a strict and relaxed situation, vis:

(i) Strict situation. This was the base-line case, being the most conservative or worst-case, where the rankings for the Judge and Consistency score were matched exactly as received from the company and calculated by the formula, without any adjustment. That is, the rankings of the company expert were not allowed to have ties, and there was no adjustment for ties in the Consistency score.

(ii) Relaxed situation. This was the normalized case, being a reflection of the actual situation. Although the rankings of the company expert were not allowed to have ties, the rankings from the calculated Consistency score were adjusted to allow for 'noise' in the data. Some of the possible sources of these aberrations:

(a) *Size of the data set,* for example: the Company management would only allow a small number of participants due to the time and costs

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[1] First Course in Probability, by S. Ross, Prentice Hall, pg. 35 (Proposition 4.4).

[2] The convention for describing significance is as follows: ρ = 1% or less, very significant; ρ = 5% to 1%*, significant; ρ = 10% to 5%*, moderately significant; ρ = more than 10%, not significant;

involved in the case study interviews; and in the linkages studied there may in fact only be one Support person to interact with a Work Unit.

(b) *Differences in the data,* for instance: although both Company A and B had excellent Work Units, Company A Work Units were considered to be better on average as testified by several vendor and inter-national awards; and the variance between the six Work Units selected by the two companies' management was tighter in Company A (see Appendix 8.8.1).

(c) *Situational effects,* for example: Company management may have selected another array of six Work Units to rank in a different situation; a Support Group and/or Work Unit person may have selected or ranked the expectations differently in some other Questionnaire session; or the company Judge may have ranked the expectations differently at another time.

(d) *Method improvements,* such as: The Questionnaires for Company A and B differed in two ways: the Company A questionnaire incorporated expectations from the effective and not-as-effective Work Units, while Company B only included effective Work Unit expectations; and, the Company A expectations contained 50% positively worded expectations, while Company B had 69%, see Appendix 8.8.2.

(NOTE: In the Relaxed situation the possibility of ties in the calculated scores, or 'near-ties' due to small changes in the data, were accommodated by an augmentation of Ross' matching probability. Refer to Appendix 8.8.3. for a complete discussion of ties, and to Appendix 8.8.4 for the Welch[3] addendum to Ross.)

The results for Company A & B will be presented in the next two sections 5.3 and 5.4 respectively. Each of these sections will include additional analysis of the questionnaire data to illustrate some of the fundamental differences between more and less consistent linkages.

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[3] Citation titled: Derivation of the probability distribution of the number of matching fields in random permutations of 6 objects. Appendix 8.8.4

5.3 Company A

5.3.1 Site Detail

Company A was an automotive division of a multi-national Corporation that provided high-technology products and services to the automotive and space, defense & information systems markets. The Work Units operated in a cellular manufacturing environment scheduling and maintaining their area's CNC machines by having the operators assume coordinator roles. The Work Units were assisted in their network of relationships by a management support group called Manufacturing Support Technicians.

5.3.2 Data, Analysis & Results

The next three sub-sections will present the data for the three terms of the Expectation Range Model's **C**-formula: Concept of Importance; Concept of Priority; and Concept of Acceptability. Together they comprised the Perceived Consistency of the Linkage measure, and their relative weighting was represented respectively by the **notation in brackets**: unweighted **C**(111) and weighted **C**(131). Appendix 8.6 gives complete data from the case study at Company A.

Company A had some ties or 'near-ties' due to the small variance in the calculated scores. That is, one change to the questionnaire selections could typically cause scores differences of between 5% and 20% - even more when selections had values far apart. The research took a conservative approach and only considered scores within 0.025 or ± 2.5% to be tied. The method for identifying and dealing with ties is fully explained in Appendix 8.8.3.

5.3.2.1 Concept of Importance ($\mathbf{C}_I$)

The Work Unit or Support Group person selected a set of expectations from the Questionnaire that they felt was the most important to do, or not-do, in their relationship with their linkage partner. Then the sets of expectations for all combinations of persons in the Work Unit and Support Group were compared to identify where there was agreement on the important expectations. The C_I formula captures all of these combinations and converted them into a score between 0 and 1 for each Work Unit/Support Group.

Ranked Results

The expectations selected by the Work Unit or Support Group person individually were the ones that they felt were the most strategic linkage behaviours and the ones which they felt should (not) happen. One view of this was that to the extent that both partners in the linkage could agree, were consistent, on what were the right actions to be taken, the more often these actions would be taken and the more effective the linkage would be.

The C_1 results are presented in Table 5-1. The table lists the six Work Unit/Support Group linkages across the top, with the calculated score (C1-value) and comparable 'C1-rank' for each; and the expert Support Group Management 'judge' ranking. For example, the score for Work Unit #1 (WU1) was .666 and ranked #1 of the six Work Units for consistency as interpreted from C1-values and it was like-wise ranked #1 in effectiveness of the linkage relationship by the Company A Judge.

	WU 1	WU 2	WU 3	WU 4	WU 5	WU 6
C1-value =	0.666	0.399	0.466	0.466	0.531	0.399
C1-rank =	1	5.5	3.5	3.5	2	5.5
Judge rank =	1	2	3	4	5	6

Table 5-1: C1 Results and Ranks

The table in Table 5-2 shows the number of 'Match' rankings, using a Strict and a Relaxed interpretation for the data from Table 5-1, where the designation 'yes' was a match between the ranking of C1 and the Judge. There was one match for the Strict case (although WU 3, 4 & 6 were very close) and four matches for the Relaxed case.

		WU 1	WU 2	WU 3	WU 4	WU 5	WU 6	Match
Strict	C1	yes						1
Relaxed	C1	yes		yes	yes		yes	4

Table 5-2: Strict and Relaxed Matching

The Strict case, with one match was not significant ($\rho = .3667$). Given that the C1 scores for WU3, 4 & 6 gave rankings that were very close to those of the Judge an exact match of 4 as given in the Relaxed case seems reasonable. Ross' probability of obtaining 4 exact matches out of 6 if the ranking were done randomly was significant ($\rho = .0208$). Welch's more conservative probability for 4 matches with two ties was moderately significant ($\rho = .0722$).

5.3.2.2 Concept of Priority (C_2)

The Work Unit or Support Group person assigned ranks, priority-weights, to the set of expectations selected from the Questionnaire. Then the ranked sets for all combinations of persons in the Work Unit and Support Group were compared to identify where there was agreement on the expectations' priority-weight. The C_2 formula captures all of these combinations and converted them into a score between 0 and 1 for each Work Unit/Support Group.

Ranked Results

The ranking of expectations, through priority-weights, by the Work Unit or Support Group person was an expression of their individual desire for a certain critical behaviour response to happen. One view of this was that to the extent that both partners in the linkage could agree on the most crucial actions, the more likely they were to occur.

The C_2 results are presented in Table 5-3. The table lists the six Work Unit/Support Group linkages across the top, with the calculated score (C2-value) and comparable 'C2-rank' for each; and the expert Support Group Management 'judge' ranking. For example, the score for Work Unit #1 (WU1) was .407 and ranked #2 of the six Work Units for consistency as interpreted from C2-values and it was ranked #1 in effectiveness of the linkage relationship by the Company A Judge.

	WU 1	WU 2	WU 3	WU 4	WU 5	WU 6
C2-value =	0.407	0.400	0.377	0.474	0.353	0.238
C2-rank =	2	3	4	1	5	6
Judge rank =	1	2	3	4	5	6

Table 5-3: C2 Results and Ranks

The table in Table 5-4 shows the number of 'Match' rankings, using a Strict and a Relaxed interpretation for the data from Table 5-3, where the designation 'yes' was a match between the ranking of C2 and the Judge. There were two matches for the Strict case (although WU 2 & 3 were close) and four matches for the Relaxed case.

		WU 1	WU 2	WU 3	WU 4	WU 5	WU 6	Match
Strict	C2					yes	yes	2
Relaxed	C2		yes	yes		yes	yes	4

Table 5-4: Strict and Relaxed Matching

The Strict case, with two matches was not significant ($\rho = .1875$). Given that the C2 scores for WU2 & 3 give rankings that were close to those of the Judge an exact match of 4 as given in the Relaxed case seems fair. Ross' probability of obtaining 4 exact matches out of 6 if the ranking were done randomly was significant ($\rho = .0208$). Welch's more conservative probability for 4 matches with two ties was moderately significant ($\rho = .0722$).

5.3.2.3 Concept of Acceptability (C_3)

The Work Unit or Support Group person assigned an acceptability range -- defined by the actual, better and worse frequency indications -- to the set of expectations selected from the Questionnaire. Then the 'actual[4]' frequency value for all combinations of persons in the Work Unit and Support Group were converted into an overlap percentage. The C_3 formula captureed all of these combinations and converted them into a score between 0 and 1 for each Work Unit/Support Group pair.

Ranked Results

The 'range' of behaviours was what response the Work Unit or Support Group found acceptable. Beyond this range were behaviours which were considered to be unacceptable and may have impacted the performance of the linkage. That is, when response was below the standard expected the linkage relationship could deteriorate. One view of this was that to the extent that the ranges for the Work Unit/Support Group pairs overlay each other, agreeable response actions would be taken.

The C_3 results are presented in Table 5-5. The table lists the six Work Unit/Support Group linkages across the top, with the calculated score (C3-value) and comparable 'C3-rank' for each; and the expert Support Group Management 'judge' ranking. For example, the score for Work Unit #1 (WU1) was .575 and ranked #1 of the six Work Units for consistency as interpreted from C2-values and it was also ranked #1 in effectiveness of the linkage relationship by the Company A Judge.

	WU 1	WU 2	WU 3	WU 4	WU 5	WU 6
C3-value =	0.575	0.262	0.313	0.386	0.404	0.269
C3-rank =	1	6	4	3	2	5
Judge rank =	1	2	3	4	5	6

Table 5-5: C3 Results and Ranks

The table in Table 5-6 shows the number of 'Match' rankings, using a Strict and a Relaxed interpretation for the data from Table 5-5, where the designation 'yes' was a match between the ranking of C3 and the Judge. There was one matches for the Strict case (although WU 6 was close) and two matches for the Relaxed case.

		WU 1	WU 2	WU 3	WU 4	WU 5	WU 6	Match
Strict	C3	yes						1
Relaxed	C3	yes					yes	2

Table 5-6: Strict and Relaxed Matching

[4] Range issues were discussed in Appendix 8.5.5.1.

The Strict case, with one matches was not significant (ρ = .3667). Given that the C3 score WU6 gives a ranking close to that of the Judge an exact match of 2 as given in the Relaxed case seems fair. Ross' probability of obtaining 2 exact matches out of 6 if the ranking were done randomly was not significant (ρ = .1875). Welch's more conservative probability for 2 matches with one tie was not significant (ρ = .2583).

5.3.2.4 Perceived Consistency of the Linkage (C)

The consequent Work Unit and Support Group C_1, C_2 and C_3 scores were brought together in the Perceived Consistency of the Linkage (C) formula. This equation applied a 'weight[5]' to the individual scores and converted them into a final score between 0 and 1, for each Work Unit/Support Group linkage, as a point within the solution space. Higher values of C were indicative of a higher amount of inter-group consistency in the Work Unit/Support Group linkage. The results for a weight of (111) are presented first then the contrasting results with weight (131).

WEIGHT – C(111)

Ranked Results

The C(111) results are presented in Table 5-7. The table lists the six Work Unit/Support Group linkages across the top, with the calculated C1, C2 & C3 scores, the weighted C(111)-value and comparable 'C-rank' for each WU; and the expert Support Group Management 'judge' ranking. For example, the C(111)-value for Work Unit #1 (WU1) was .560 and ranked #1 of the six Work Units for consistency and it was also ranked #1 in effectiveness of the linkage relationship by the Company A Judge.

	WU 1	WU 2	WU 3	WU 4	WU 5	WU 6	Weight
C1	0.666	0.399	0.466	0.466	0.531	0.399	1
C2	0.407	0.400	0.377	0.474	0.353	0.238	1
C3	0.575	0.262	0.313	0.386	0.404	0.269	1
C(111) =	0.560	0.360	0.391	0.444	0.436	0.310	
C-rank =	1	5	4	2	3	6	
Judge =	1	2	3	4	5	6	

Table 5-7: C(111) Results and Ranks

[5] Weight issues were discussed in Appendix 8.5.6.1.

The table in Table 5-8 shows the number of 'Match' rankings, using a Strict and a Relaxed interpretation for the data from Table 5-7, where the designation 'yes' was a match between the ranking of C(111) and the Judge. There was two matches for the Strict case and the Relaxed case.

		WU 1	WU 2	WU 3	WU 4	WU 5	WU 6	Match
Strict	C(111) =	yes					yes	2
Relaxed	C(111) =	yes					yes	2

Table 5-8: Strict and Relaxed Matching

Ross' probability of obtaining 2 exact matches out of 6 if the ranking were done randomly was not significant ($\rho = .1875$).

WEIGHT – C(131)

The weights recognize the differing contribution of the C_i components. For instance, C_1 alone may differentiate the Work Units at a site when several were not-very-effective, but as the Work Units become more effective, or were clustered closer together in terms of effectiveness, then the contribution of C_2 and C_3 would be required.

The **C(131)** results represents one possible combination of the terms and is presented here to illustrate the impact of weighting. A discussion of other weights is given in Appendix 8.5.6.1.

Ranked Results

The **C(131)** results are presented in Table 5-9 represents one possible weighting of the terms. The table lists the six Work Unit/Support Group linkages across the top, with the calculated C1, C2 & C3 scores, the weighted C(131)-value and comparable 'C-rank' for each WU; and the expert Support Group Management 'judge' ranking. For example, the C(131)-value for Work Unit #1 (WU1) was .454 and ranked #2 of the six Work Units for consistency and it was ranked #1 in effectiveness of the linkage relationship by the Company A Judge.

		WU 1	WU 2	WU 3	WU 4	WU 5	WU 6	Weight
Actual	C1	0.666	0.399	0.466	0.466	0.531	0.399	1
	C2	0.407	0.400	0.377	0.474	0.353	0.238	3
	C3	0.575	0.262	0.313	0.386	0.404	0.269	1
	C(131) =	0.454	0.390	0.381	0.466	0.378	0.259	
	C-rank =	2	3	4	1	5	6	
	Judge =	1	2	3	4	5	6	

Table 5-9: C(131) Results and Ranks

The table in Table 5-10 shows the number of 'Match' rankings, using a Strict and a Relaxed interpretation for the data from Table 5-9, where the designation 'yes' was a match between the ranking of C(131) and the Judge. There was two matches for the Strict case (although WU 1 & 3 were close) and four matches for the Relaxed case.

		WU 1	WU 2	WU 3	WU 4	WU 5	WU 6	Match
Strict	**C(131) =**					yes	yes	2
Relaxed	**C(131) =**	yes		yes		yes	yes	4

Table 5-10: Strict and Relaxed Matching

The Strict case, with two matches was not significant ($\rho = .1875$). Given that the C(131) rankings for WU1 & 3 were close to those of the Judge an exact match of 4 as given in the Relaxed case seems fair. Ross' probability of obtaining 4 exact matches out of 6 if the ranking were done randomly was significant ($\rho = .0208$). Welch's more conservative probability for 4 matches with two ties was moderately significant ($\rho = .0722$).

The discussion section explains why the weighted C(131) case does much better than the un-weighted C(111) case (see sub-section 6.2.1).

5.3.3 Analysis of Expectations for Company A

These sub-sections will provide some additional analysis to show some of the underlying reasons for differences between linkage Consistency scores. First, by looking in more detail at the Questionnaire results, and then at a categorization of the behaviour examples from the interviews that contributed to the development of the Expectation Range Model.

5.3.3.1 Other Findings from the Questionnaire for the six linkages

To compare the linkages that were ranked higher to those that were ranked lower, by the company judge, the six Work Unit and Support linkages were divided into two groups.

The top three linkages (WU1, WU2 & WU3) were combined together into a group called '**Hi-group**' and the bottom three linkages (WU4, WU5 & WU6) were combined together into a group called '**Lo-group,**' and the following observations were made.

Positive Expectations

The Table 5-11 shows that the Hi-group chooses a ratio of 5.92 positive-to-negative expectations compared to 3.74 for the Lo-group, or about 58% more positive-to-negative than the Lo-group. (See footnote[6] for an explanation of the averages in the body of the table.)

Company A			
Chosen by	Positive	Negative	Ratio
Hi-group	8.56	1.44	5.92
Lo-group	7.89	2.11	3.74

Table 5-11: Ratio of Positive expectations

Positive expectations indicated exactly what behaviour was acceptable, 'good-to-do' and should happen more often, for example: "*A work order was completed and clearly describes the problem and it's location on the machine.*" On the other hand, a negative expectation was less specific and leaves open the possibility for other not-acceptable behaviour. For example, "*A work order was given to Maintenance for a repair which should have been done by the Work Team,*" was a behaviour that was 'not-good-to-do' and should happen less often.

Expectation Agreement

The Table 5-12 compares the instances of agreement on expectations selected from the Questionnaire to instance of no-agreement. That is, the table shows that the Hi-group has a ratio of 1.61 agreement to no-agreement compared to 0.93 for the Lo-group, or about 73% more agreement than the Lo-group.

[6] For the Hi-group & Lo-group, the Table 5-11 averages the 5 expectations selected by a Work Unit person and the 5 expectations selected by a Support person, across all combinations, and then calculates a ratio of Positive-to-Negative expectation choices.

Company A						
	Hi-group			Lo-group		
Agreements	Total Choices	Percentage by item	Percentage Cumulative	Total Choices	Percentage by item	Percentage Cumulative
All	16	26.7%		12	20.0%	
Partial	21	35.0%	61.7%	17	28.3%	48.3%
None	23	38.3%		31	51.7%	
TOTAL	60	100.0%		60	100.0%	
Ratio of Agreement to No-agreement =		1.61				0.93

Table 5-12: Ratio of 'All' & 'Partial' agreement

In the table, agreement of the Work Unit and the Support Group to expectations in the Questionnaire were defined as: ***'All'*** means that the Support person and the three Work Unit members agreed that a particular issues was important; ***'Partial'*** means that the Support person and one or two Work Unit members felt that a certain issue was important; ***'None'*** means that only the Support or Work Unit person indicated that an issue was important. The body of Table 5-12 (see footnote[7]) gives the percentages that each of these 'agreements' occurred as a percentage of the *'TOTAL'*, and the ratio of 'All' & 'Partial' agreement to 'None'.

Expectation Variance

Table 5-13 shows, for the linkages in the Hi-group and Lo-group, that of all[8] of the 16 expectations on the Questionnaire 31.3% were held in common by the Hi-group and Lo-group, 12.5% were unique to either the Hi-group or Lo-group, and 56.3% were not selected by either. This is further detailed in the next table.

Company A			
Expectation Selected	Number	Percent All	Percent Selected
Common	5	31.3	71.4
Unique	2	12.5	28.6
Not selected	9	56.3	
	16		

Table 5-13: Expectations selected from Questionnaire

[7] For the Hi-group & Lo-group, the Table 5-12 summarizes the 5 expectations selected by the 3 Work Unit persons and the1 Support person, across the 3 groups {5 * (3 + 1) * 3 = 60}, and then calculates a ratio of 'All' & 'Partial' agreement to 'None'.

[8] The 'Selected' column does not include the not-selected expectations, so 71.4% of the selected expectations were held in common.

For the Hi-group and Lo-group individually Table 5-14 gives the *priority-weight* or relative weighting given to the Questionnaire expectations. The top part of the table gives a breakdown of the weights in the two categories of 'common' and 'unique' used above. The priority-weight was indicative of which expectations would be acted on first, for example, for the Hi-group 94.4% of their priority was directed to expectations that were held in common with the Lo-group.

Company A					
Expectation Selected	Hi-group Weight	Percent	Expectation Selected	Lo-group Weight	Percent
Common	186	94.4	Common	145	90.1
Unique	11	5.6	Unique	16	9.9
	197			161	
Expectation Letter	Hi-group Weight	Normalized	Expectation Letter	Lo-group Weight	Normalized
P	60	32.3	P	80	55.2
I	53	28.5	I	39	26.9
F	38	20.4	J	16	11.0
J	25	13.4	F	6	4.1
H	10	5.4	H	4	2.8
	186			145	
Variance =	119.9		Variance =	478.5	

Table 5-14: Distribution of Priority-weight

In the bottom part of Table 5-14 has a break down of the specific expectations (see footnote[9] for a description of the 'expectation letters') held in the common category. The priority-weights had been normalized so a comparison could be made between the Hi-group and the Lo-group. The Lo-group had a variance of 478.5 between the five expectations compared to 119.9 for the Hi-group for the same five expectations, or almost 300% more variance. The Lo-group has 55.2% of it's priority focused on one expectation 'P', the training issue, while the Hi-group had 32.3% for the same expectation.

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9 **The expectation 'letter' was a particular question in the Questionnaire for Company A: P =** Maintenance has repaired a machine, and now explains to the operator what the problem was and what to do next time the problem happens; **I** = Maintenance repairs a machine, and stays at the machine until it is tested by a team member and successfully cycles; **F** = An emergency work order is given to Maintenance, they come, fix it, and the repair to the machine is done in less than 1 hour; **J** = A work order is completed, Maintenance arrives to repair a machine, a team member is standing by to explain and help; **E** = A work order is completed and clearly describes the problem and it's location on the machine; **H** = Maintenance arrives to repair a machine, and the machine is clean of all tools, parts, chips and oil; **M** = Maintenance completes repairing a machine, and has to wait for an operator to verify that it works.

Summary for the six Work Unit linkages

These results show that the Hi-group had a higher ratio of positive-to-negative expectations, had a higher ratio of agreement on important expectations, and differences in the priority-weights placed on expectations. These characteristics have potential for the improvement of the performance of the C-formula, as will be presented in the discussion section.

5.3.3.2 Other Findings from the interviews of Work Units

This sub-section will report some further findings that bolster the previous sub-section and illustrate some of the reasons for the differences between the Effective and not-as-effective Work Unit and Support Group linkages.

Background

As part of the development of the Expectation Range Model, the management of Company A was asked to select two Work Units that represented extremes in the performance of their operations teams and these Work Units were designated 'Effective' (called ***Effective*** in tables below) and 'Not-as-effective' (***N-effective***). Then ten members from each team were interviewed and as part of the interviews the Work Unit members were asked to identify a Support Group that was important to their team's performance. For the Support Group that was selected by the majority of both the Effective and N-effective Work Units, four members of that Support Group were also interviewed. Base on these twenty-four interviews 177 behaviour examples were collected and categorized by the researcher, then verified by an independent person. That is, using a 20% sample the independent person was asked to classify the behaviour examples using the researcher's categories, and the number of agreements was 80%.

Positive Expectations

The interviews identified behaviours that were considered by the Work Unit or Support Group as being positive or good-to-do (labeled ***DO*** in the table below), or negative or not-good-to-do (***NOT DO***) in their task situation. In Table 5-15, for the behaviour examples that were considered to be unique (see footnote[10] for a breakdown of the common and unique categories), the Effective and N-effective Work Units had ratios of 2.00 and 1.53 positive-to-negative behaviour expectations respectively – the Effective ratio was about 30.4% higher.

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[10] The 177 behaviour examples were classified into 11 categories: 5 categories were considered 'common' to both the Effective and N-effective Work Units and contained about 53.7% of the examples; 3 categories were considered 'unique' to the Effective Work Units and contained about 19.8% of the examples; and the other 3 categories were considered 'unique' to the N-effective Work Unit and contained about 26.6% of the examples. See Table 5-17 for the actual categories.

For example, in the table the DO column contains positive statements about something that should be done more often, like, *"After you fix a job, stay there until it cycles,"* (this was from the category 'After Fixing' see Table 5-17). And, *"Repair something and leaving a mess,"* was a negative statement about something that should not be done in the NOT DO column (also in the category 'After Fixing').

		Unique	Percent	Ratio
Effective	DO	18	66.7%	2.00
	Not do	9	33.3%	
		27		
N-effective	DO	23	60.5%	1.53
	Not do	15	39.5%	
		38		

Table 5-15: Positive expectation ratio

Expectation Agreement

Table 5-16 shows that the Effective Work Unit and their Support Group provided 89 behaviour expectation examples and 61 (68%) of them 'matched' while the balance were only mentioned by the Work Unit or Support Group. This was a ratio of 2.18 agreement on matching expectations vs. none-matching expectation examples. On the other hand, the N-effective Work Unit had a matching ratio of 1.51, so the Effective Work Unit ratio was 43.9% higher.

Effective	Examples	Percent	Ratio
Match =	61	68.5%	2.18
Work Unit only =	20	22.5%	
Support only =	8	9.0%	
	89		
N-effective			
Match =	53	60.2%	1.51
Work Unit only =	26	29.5%	
Support only =	9	10.2%	
	88		

Table 5-16: Matching Expectation examples

In the table the terms are:

- *'Match'* means that the behaviour example provided by the Support person and a Work Unit member were similar in intent, for example, in the After Fixing category the Support person has the example of "*stick around until we understand what was happening*" while the Work Unit has the matching example of "*stand there with them, show them the problem*";

- '***Work Unit only***' means that the behaviour example provided by the Work Unit member does not have corresponding Support person example.
- '***Support only***' means that the behaviour example provided by the Support person does not have corresponding Work Unit member example;

Expectation Dissimilarity

The 177 behaviour expectation examples were classified into the 11 categories in Table 5-17 and a ratio was taken of the number provided by the Effective Work Unit and their Support Group, to the number provided by the N-effective Work Unit and their Support Group (Eff-to-Neff ***Ratio***). In Table 5-17 a ratio of 2 or higher (highlighted at top) was considered to be mainly attributed, or unique, to the Effective Work Unit; while a ratio of 0.5 or less (highlighted at bottom) was considered to be mainly attributed, or unique, to the N-effective Work Unit. The middle five categories of the table were fairly evenly shared.

Category	Effective	N-effective	Ratio
after fixing	6		6.00
plan	9	2	4.50
work order	12	6	2.00
come to fix	11	7	1.57
attitude of unit	7	5	1.40
assist fix	16	12	1.33
attitude of support	10	9	1.11
fix quickly	9	9	1.00
training	2	13	0.15
fix by team	7	22	0.32
measurement		3	0.33

Table 5-17: Unique differences

One view of this is that these unique expectations differentiate the effective from the not-so-effective linkages. For example, the effective linkages supply accurate information and take actions that prevent and anticipate future problems that might impact productivity. This was contrasted with the not-as-effective linkages where conflict over metrics and control issues were characteristic. (See footnote[11] for examples of the 'unique' categories).

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[11] Unique to the **Effective** Work Unit: After Fixing, *"after you fix a job, stay there until it cycles"*; Plan, *"let us know how much time will be missed"*; Work Order, *"define problem, be specific."* Unique to the **N-effective** Work Unit: Measurement, *"maintenance must justify their time through work orders"*; Training, *"tell us how to fix things so we can do it our selves (TPM)"*; Fix by team, *"don't fix it themselves if they don't know the answer."*

These results are comparable to the analysis of the Hi-group in that it shows that the Effective Work Unit had a higher ratio of positive-to-negative expectations, had a higher ratio of agreement on important expectations, and differences in the priority-weights placed on expectations. These characteristics have potential for the improvement of the performance of the C-formula, as will be presented in the discussion section.

5.4 Company B

5.4.1 Site Detail

Company B was a repair division of a multi-national Corporation that provided high-technology telephony, wireless networking and Internet products and applications. The Work Units operated in a cellular manufacturing environment with test technicians and repair operators responsible for all day-to-day and planning aspects of their area. The Work Units were assisted in their network of relationships by a management support group called Business Unit Managers.

5.4.2 Data, Analysis & Results

The next three sub-sections will present the data for the three terms of the Expectation Range Model's **C**-formula: Concept of Importance; Concept of Priority; and Concept of Acceptability. Together they comprised the Perceived Consistency of the Linkage measure, and their relative weighting was represented respectively by the **notation in brackets**: unweighted **C**(111) and weighted **C**(131). Appendix 8.7 gives complete data from the case study at Company B.

5.4.2.1 Concept of Importance ($\mathbf{C_1}$)

The Work Unit or Support Group person selected a set of expectations from the Questionnaire that they felt was the most important to do, or not-do, in their relationship with their linkage partner. Then the sets of expectations for all combinations of persons in the Work Unit and Support Group were compared to identify where there was agreement on the important expectations. The C_1 formula captured all of these combinations and converted them into a score between 0 and 1 for each Work Unit/Support Group.

Ranked Results

The expectations selected by the Work Unit or Support Group person individually were the ones that they felt were the most strategic linkage behaviours and the ones which they felt should (not) happen. One view of this was that to the extent that both partners in the linkage could agree, were consistent, on what were the right actions to be taken, the more often these actions would be taken and the more effective the linkage would be.

The C_1 results are presented in Table 5-18. The table lists the six Work Unit/Support Group linkages across the top, with the calculated score (C1-value) and comparable 'C1-rank' for each; and the expert Support Group Management 'judge' ranking. For example, the score for Work Unit #1 (WU1) was .666 and ranked #1 of the six Work Units for consistency as interpreted from C1-values and it was like-wise ranked #1 in effectiveness of the linkage relationship by the Company B Judge.

	WU 1	WU 2	WU 3	WU 4	WU 5	WU 6
C1-value =	0.666	0.4	0.399	0.132	0.199	0.399
C1-rank =	1	2	3.5	6	5	3.5
Judge rank =	1	2	3	4	5	6

Table 5-18: C1 Results and Ranks

The table in Table 5-19 shows the number of 'Match' rankings, using a Strict and a Relaxed interpretation for the data from Table 5-19, where the designation 'yes' was a match between the ranking of C1 and the Judge. There were three matches for the Strict case and four matches for the Relaxed case.

		WU 1	WU 2	WU 3	WU 4	WU 5	WU 6	Match
Strict	C1	yes	yes			yes		3
Relaxed	C1	yes	yes	yes		yes		4

Table 5-19: Strict and Relaxed Matching

The Strict case, with three matches was moderately significant ($\rho = .0556$). Given that the C1 score for WU3 gives a ranking very close to those of the Judge an exact match of 4 as given in the Relaxed case seems reasonable. Ross' probability of obtaining 4 exact matches out of 6 if the ranking were done randomly was significant ($\rho = .0208$). Welch's more conservative probability for 4 matches with one tie was significant ($\rho = .0389$).

5.4.2.2 Concept of Priority (C_2)

The Work Unit or Support Group person assigned ranks, priority-weights, to the set of expectations selected from the Questionnaire. Then the ranked sets for all combinations of persons in the Work Unit and Support Group were compared to identify where there was agreement on the expectations' priority-weight. The C_2 formula captured all of these combinations and converted them into a score between 0 and 1 for each Work Unit/Support Group.

Ranked Results

The ranking of expectations, through priority-weights, by the Work Unit or Support Group person was an expression of their individual desire for a certain critical behaviour response to happen. One view of this was that to the extent that both partners in the linkage could agree on the most crucial actions, the more likely they were to occur.

The C_2 results are presented in Table 5-20. The table lists the six Work Unit/Support Group linkages across the top, with the calculated score (C2-value) and comparable 'C2-rank' for each; and the expert Support Group Management 'judge' ranking. For example,

the score for Work Unit #1 (WU1) was .686 and ranked #1 of the six Work Units for consistency as interpreted from C2-values and it was also ranked #1 in effectiveness of the linkage relationship by the Company B Judge.

	WU 1	WU 2	WU 3	WU 4	WU 5	WU 6
C2-value =	0.686	0.473	0.420	0.110	0.116	0.275
C2-rank =	1	2	3	6	5	4
Judge rank =	1	2	3	4	5	6

Table 5-20: C2 Results and Ranks

The table in Table 5-21 shows the number of 'Match' rankings, using a Strict and a Relaxed interpretation for the data from Table 5-20, where the designation 'yes' was a match between the ranking of C2 and the Judge. There were four matches for the Strict case and the Relaxed case.

		WU 1	WU 2	WU 3	WU 4	WU 5	WU 6	Match
Strict	C2	yes	yes	yes		yes		4
Relaxed	C2	yes	yes	yes		yes		4

Table 5-21: Strict and Relaxed Matching

Both C2 rankings gave an exact match of 4. Ross' probability of obtaining 4 exact matches out of 6 if the ranking were done randomly was significant ($\rho = .0208$).

5.4.2.3 Concept of Acceptability (C_3)

The Work Unit or Support Group person assigned an acceptability range -- defined by the actual, better and worse frequency indications -- to the set of expectations selected from the Questionnaire. Then the 'actual[12]' frequency value for all combinations of persons in the Work Unit and Support Group were converted into an overlap percentage. The C_3 formula captureed all of these combinations and converted them into a score between 0 and 1 for each Work Unit/Support Group pair.

Ranked Results

The 'range' of behaviours was what response the Work Unit or Support Group found acceptable. Beyond this range were behaviours which were considered to be unacceptable and may have impacted the performance of the linkage. That is, when response was below the standard expected the linkage relationship could deteriorate. One

[12] Range issues were discussed in Appendix 8.5.5.1.

view of this was that to the extent that the ranges for the Work Unit/Support Group pairs overlay each other, agreeable response actions would be taken.

The C_3 results are presented in Table 5-22. The table lists the six Work Unit/Support Group linkages across the top, with the calculated score (C3-value) and comparable 'C3-rank' for each; and the expert Support Group Management 'judge' ranking. For example, the score for Work Unit #1 (WU1) was .557 and ranked #1 of the six Work Units for consistency as interpreted from C2-values and it was also ranked #1 in effectiveness of the linkage relationship by the Company B Judge.

	WU 1	WU 2	WU 3	WU 4	WU 5	WU 6
C3-value =	0.557	0.357	0.330	0.103	0.155	0.209
C3-rank =	1	2	3	6	5	4
Judge rank =	1	2	3	4	5	6

Table 5-22: C3 Results and Ranks

The table in Table 5-23 shows the number of 'Match' rankings, using a Strict and a Relaxed interpretation for the data from Table 5-22, where the designation 'yes' was a match between the ranking of C3 and the Judge. There was four matches for both the Strict case and the Relaxed case.

		WU 1	WU 2	WU 3	WU 4	WU 5	WU 6	Match
Strict	C3	yes	yes	yes		yes		4
Relaxed	C3	yes	yes	yes		yes		4

Table 5-23: Strict and Relaxed Matching

Both C3 rankings gave an exact match of 4. Ross' probability of obtaining 4 exact matches out of 6 if the ranking were done randomly was significant ($\rho = .0208$).

5.4.2.4 Perceived Consistency of the Linkage (C)

The consequent Work Unit and Support Group C_1, C_2 and C_3 scores were brought together in the Perceived Consistency of the Linkage (C) formula. This equation applied a 'weight[13]' to the individual scores and converted them into a final score between 0 and 1, for each Work Unit/Support Group linkage, as a point within the solution space. Higher values of C were indicative of a higher amount of inter-group consistency in the Work Unit/Support Group linkage. The results for a weight of (111) are presented first then the contrasting results with weight (131).

[13] Weight issues were discussed in Appendix 8.5.6.1.

WEIGHT – C(111)

Ranked Results

The **C(111)** results are presented in Table 5-24. The table lists the six Work Unit/Support Group linkages across the top, with the calculated C1, C2 & C3 scores, the weighted C(111)-value and comparable 'C-rank' for each WU; and the expert Support Group Management 'judge' ranking. For example, the C(111)-value for Work Unit #1 (WU1) was .639 and ranked #1 of the six Work Units for consistency and it was also ranked #1 in effectiveness of the linkage relationship by the Company B Judge.

	WU 1	WU 2	WU 3	WU 4	WU 5	WU 6	Weight
C1	0.666	0.400	0.399	0.132	0.199	0.399	1
C2	0.686	0.473	0.420	0.110	0.116	0.275	1
C3	0.557	0.357	0.330	0.103	0.155	0.209	1
C(111) =	0.639	0.413	0.385	0.116	0.160	0.304	
C-rank =	1	2	3	6	5	4	
Judge =	1	2	3	4	5	6	

Table 5-24: C(111) Results and Ranks

The table in Table 5-25 shows the number of 'Match' rankings, using a Strict and a Relaxed interpretation for the data from Table 5-24, where the designation 'yes' was a match between the ranking of C(111) and the Judge. There were four matches for both the Strict case and the Relaxed case.

		WU 1	WU 2	WU 3	WU 4	WU 5	WU 6	Match
Strict	C(111) =	yes	yes	yes		yes		4
Relaxed	C(111) =	yes	yes	yes		yes		4

Table 5-25: Strict and Relaxed Matching

Both C(111) rankings gave an exact match of 4. Ross' probability of obtaining 4 exact matches out of 6 if the ranking were done randomly was significant ($\rho = .0208$).

WEIGHT – C(131)

The weights recognize the differing contribution of the C_i components. For instance, C_1 alone may differentiate the Work Units at a site when several or most were not-very-effective, but as the Work Units become more effective, or were clustered closer together in terms of effectiveness, then the contribution of C_2 and C_3 would be required.

The **C(131)** results represents one possible combination of the terms and is presented here to illustrate the impact of weighting. A discussion of other weights is given in Appendix 8.5.6.1.

Ranked Results

The **C(131)** results are presented in Table 5-26. The table lists the six Work Unit/Support Group linkages across the top, with the calculated C1, C2 & C3 scores, the weighted C(131)-value and comparable 'C-rank' for each WU; and the expert Support Group Management 'judge' ranking. For example, the C(131)-value for Work Unit #1 (WU1) was .674 and ranked #1 of the six Work Units for consistency and it was ranked #1 in effectiveness of the linkage relationship by the Company B Judge.

	WU 1	WU 2	WU 3	WU 4	WU 5	WU 6	Weight
C1	0.666	0.400	0.399	0.132	0.199	0.399	1
C2	0.686	0.473	0.420	0.110	0.116	0.275	3
C3	0.557	0.357	0.330	0.103	0.155	0.209	1
C(131) =	0.674	0.457	0.411	0.112	0.130	0.283	
C-rank =	1	2	3	6	5	4	
Judge =	1	2	3	4	5	6	

Table 5-26: C(131) Results and Ranks

The table in Table 5-27 shows the number of 'Match' rankings, using a Strict and a Relaxed interpretation for the data from Table 5-26, where the designation 'yes' was a match between the ranking of C(131) and the Judge. There were four matches for both the Strict case and the Relaxed case.

		WU 1	WU 2	WU 3	WU 4	WU 5	WU 6	Match
Strict	**C(131) =**	yes	yes	yes		yes		4
Relaxed	**C(131) =**	yes	yes	yes		yes		4

Table 5-27: Strict and Relaxed Matching

Both C(131) rankings gave an exact match of 4. Ross' probability of obtaining 4 exact matches out of 6 if the ranking were done randomly was significant ($\rho = .0208$).

5.4.3 Analysis of Expectations for Company B

These sub-sections will provide some additional analysis to show some of the underlying reasons for differences between linkage Consistency scores by looking in more detail at the Questionnaire results. (NOTE: There is no interview analysis for Company B because Expectation Range Model had been developed prior to this site study, and the method had been changed to exclude not-as-effective expectations.)

5.4.3.1 Other Findings from the Questionnaire for the six linkages

To compare the linkages that were ranked higher to those that were ranked lower, by the company judge, the six Work Unit and Support linkages were divided into two groups. The top three linkages (WU1, WU2 & WU3) were combined together into a group called '**Hi-group**' and the bottom three linkages (WU4, WU5 & WU6) were combined together into a group called '**Lo-group,**' and the following observations were made.

Positive Expectations

The Table 5-28 shows that the Hi-group chooses a ratio of 14.0 positive-to-negative expectations compared to 5.92 for the Lo-group, or about 136% more positive-to-negative than the Lo-group. (See footnote[14] for an explanation of the averages in the body of the table)

Company B			
Chosen by	Positive	Negative	Ratio
Hi-group	9.33	0.67	14.00
Lo-group	8.56	1.44	5.92

Table 5-28: Ratio of Positively worded expectations

Positive expectations indicate exactly what behaviour was acceptable, 'good-to-do' and should happen more often, for example: *"The work unit gives Production Control enough*

[14] For the Hi-group & Lo-group, the Table 5-28 averages the 5 expectations selected by a Work Unit person and the 5 expectations selected by a Support person, across all combinations, and then calculates a ratio of Positive-to-Negative expectation choices.

notice to get more work or to drop ship to the Customer." On the other hand, a negative expectation was less specific and leaves open the possibility for other not-acceptable behaviour. For example, *"The work unit goes 2 or 3 days without letting Production Control know about getting a product,"* was a behaviour that was 'not-good-to-do' and should happen less often.

Expectation Agreement

The Table 5-29 compares the instances of agreement on expectations selected from the Questionnaire to instance of no-agreement. That is, the table shows that the Hi-group has a ratio of 1.31 agreement to no-agreement compared to 0.43 for the Lo-group, or about 205% more agreement than the Lo-group.

Company B						
	Hi-group			**Lo-group**		
Agreements	Total Choices	Percentage by item	Percentage Cumulative	Total Choices	Percentage by item	Percentage Cumulative
All	16	26.7%				
Partial	18	30.0%	56.7%	18	30.0%	30.0%
None	26	43.3%		42	70.0%	
TOTAL	60	100.0%		60	100.0%	
Ratio of Agreement to No-agreement =		1.31				0.43

Table 5-29: Ratio of 'All' & 'Partial' agreement

In the table, agreement of the Work Unit and the Support Group to expectations in the Questionnaire were defined as: ***'All'*** means that the Support person and the three Work Unit members agreed that a particular issues was important; ***'Partial'*** means that the Support person and one or two Work Unit members felt that a certain issue was important; ***'None'*** means that only the Support or Work Unit person indicated that an issue was important. The body of Table 5-29 (see footnote[15]) gives the percentages that each of these 'agreements' occurred as a percentage of the *'TOTAL'*, and the ratio of 'All' & 'Partial' agreement to 'None'.

[15] For the Hi-group & Lo-group, the Table 5-29 summarizes the 5 expectations selected by the 3 Work Unit persons and the1 Support person, across the 3 groups {5 * (3 + 1) * 3 = 60}, and then calculates a ratio of 'All' & 'Partial' agreement to 'None'.

Expectation Variance

Table 5-30 shows, for the linkages in the Hi-group and Lo-group, that of all[16] of the 16 expectations on the Questionnaire 25.0% were held in common by the Hi-group and Lo-group, 43.8% were unique to either the Hi-group or Lo-group, and 31.3% were not selected by either. This was further detailed in the next table.

Company B			
Expectation Selected	Number	Percent	
		All	Selected
Common	4	25.0	36.4
Unique	7	43.8	63.6
Not selected	5	31.3	
	16		

Table 5-30: Expectations selected from Questionnaire

For the Hi-group and Lo-group individually Table 5-31 gives the *priority-weight* or relative weighting given to the Questionnaire expectations. The top part of the table gives a breakdown of the weights in the two categories of 'common' and 'unique' used above. The priority-weight was indicative of which expectations would be acted on first, for example, for the Hi-group only 51.9% of their priority was directed to expectations that were held in common with the Lo-group.

Company B					
Expectation Selected	Hi-group		Expectation Selected	Lo-group	
	Weight	Percent		Weight	Percent
Common	82	51.9	Common	70	59.3
Unique	76	48.1	Unique	48	40.7
	158			118	
Expectation Letter	Hi-group		Expectation Letter	Lo-group	
	Weight	Normalized		Weight	Normalized
C	33	40.2	H	27	38.6
G	25	30.5	G	21	30.0
H	12	14.6	L	16	22.9
L	12	14.6	C	6	8.6
	82			70	
Variance =	159.1		Variance =	161.2	

Table 5-31: Distribution of Priority-weight

[16] The 'Selected' column does not include the not-selected expectations, so 36.4% of the selected expectations were held in common.

In the bottom part of Table 5-31 was a break down of the expectations (see footnote[17] for a description of the 'expectation letters) held in the common category. The priority-weights had been normalized so a comparison could be made between the Hi-group and the Lo-group. The Lo-group has a variance of 161.2 between the four expectations compared to 159.1 for the Hi-group for the same four expectations, almost the same variance.

Although both the Lo-group and the Hi-group had a similar variance of their priorities, the expectations were in a slightly different priority order. For example, the Hi-group gave expectation 'C' a priority-weight of 33 and expectation 'H' a priority-weight of 12; while the Lo-group, in reversed order, gave expectation 'C' a priority-weight of 6 and expectation 'H' a priority-weight of 27.

What was 'unique' for each of these two groups was given almost as much priority-weight as what was 'common'. In fact the unique category receives 48.1% and 40.7% of the priority of the Hi-group and Lo-group. (NOTE: This was a different result than Company A and will be presented in the discussion section within the context of the relative strength of the two companies' teams.)

Conclusion for the six Work Unit linkages

These results support the analysis for Company A in that it shows that the Hi-group had a higher ratio of positive-to-negative expectations, had a higher ratio of agreement on important expectations, and differences in the priority-weights placed on expectations. These characteristics have potential for the improvement of the performance of the C-formula, as will be presented in the discussion section.

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17 **The expectation 'letter' was a particular question in the Questionnaire for Company B**: **J** = Production Control gives the work unit visibility on what work is coming; **C** = The work unit gives Production Control enough notice to get more work or to drop ship to the Customer; **G** = The work unit is keep up-to-date on the age-old report; **M** = The work unit replenishes EDI & reman, so there is enough stock when a drop-ship is required; **K** = The work unit is flexible enough to meet a Customer time frame of "within a day."; **H** = Production Control keeps the work unit aware of any exceptions, like large orders, so the work unit can ramp-up or be prepared; **L** = Production Control gives a timely response (few hours) when the work unit does not have any work; **N** = Production Control understands what the work unit does and how their process works; **I** = The work unit relates all information that Production Control needs for their job; **A** = The work unit is aware of what Production Control does; **O** = Production Control is in a lot of meetings and this reduces communication and response time.

5.5 Summary of the Results

The results for the six Work Unit/Support Group linkages in each of the two case studies show that the scores from the Perceived Consistency of the Linkage (**C**) formula vary with the effectiveness of individual Work Unit linkages – more effective Work Unit linkages had, in general, higher **C** values. One explanation of this might be that the Work Units and Support Groups in the more consistent linkages understand their task situation better. For instance, even though the effective and not-as-effective Work Units may have both been trained to know which expectations were important, so they had similar $\mathbf{C_1}$, the not-as-effective Work Unit may not have the experience to prioritize their expectations or know exactly how they should occur, so they could have smaller $\mathbf{C_2}$ and $\mathbf{C_3}$ values.

The additional analysis sub-sections provided some supplementary insight into the underlying reasons for the differences between the rankings of Work Unit linkages. For instance, the Hi-group (and Effective Work Unit) selected more positive expectations, were more in agreement with their Support Group on important expectations, and placed priority-weights on expectations in a manner that was different from the Lo-group (and the N-effective Work Unit). The results will be discussed fully in the next section.

6 Discussion

6.1 Overview

The discussions will start with interpretations of the Results and short comings of the Method from Company A & B, and these sub-sections will also offer criticisms and alternative explanations. Then the discussion will turn to suggestions for Future Research. A section follows these on Implications for Organizations and Practice, and wraps up with a Conclusion.

6.2 Results

The discussion of the results for Company A & B will first look at the scores from the Consistency formula and then bring into focus some of the underlying reasons for the differences between effective and not-as-effective linkages.

6.2.1 Quantitative Results

This sub-section will discuss the performance of the Perceived Consistency of the Linkage, as represented by the C-formula below. It is comprised of three terms and their associated weights: C_1, Concept of Importance; C_2, Concept of Priority; and C_3, Concept of Acceptability Range.

$$C = \frac{\sqrt{\left[w_1 C_1\right]^2 + \left[w_2 C_2\right]^2 + \left[w_3 C_3\right]^2}}{\sqrt{\left[w_1\right]^2 + \left[w_2\right]^2 + \left[w_3\right]^2}}$$

Table 6-1 summarizes the tests of the C-formula and its three C_i terms with the 'stop-light' key shown in Table 6-2. For each company the Ross test is indicated for the Strict and Relaxed situations. For example, for C_1 in Company 'A' Ross gives a red indication for the Strict situation and green for the Relaxed situation.

In general, for Company A, C_2 performs well in all tests, while C_1, C_3 and unweighted C(111) have mixed reviews. The contribution of C_2 to the C(131) score improves the number of matches from 2 to 4 over the unweighted case. Company A is the most stringent environment for the C-formula to perform because the scores are close together, compared to Company B, so it is more difficult for the C-formula to discriminate Work Unit linkages for ranking. (Appendix 8.8.1 presents a discussion of the variance of the six Work Units consistency scores in each company and shows that Company A Work Units

are similar to each other, they choose more expectations in common, and this may result in scores that are close together.)

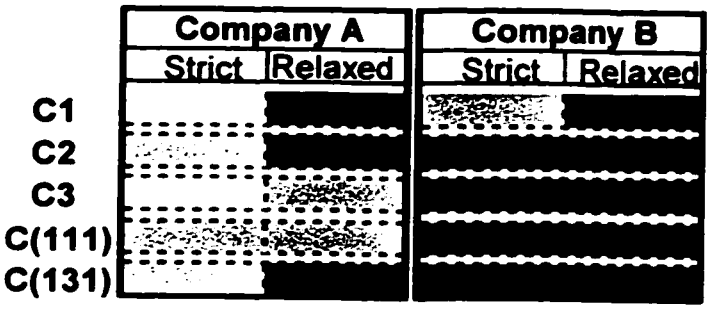


Table 6-1: Test of quantitative Consistency data

KEY:	
ROSS	Matches
	4-6
	2-3
	0-1

Table 6-2: Key for Table 6-1

Company B, on the other hand, has received across the board green indicators in almost every situation. It performs well in tests for all C_i, unweighted C(111), and weighted C(131) scores, achieving 4 matches in almost all situations. Company B has been shown to have more variance in the score values, compared to Company A, which helps the C-formula to discriminate between Work Units.

It could be argued that C_2 is the only term needed. It had the same or more matches than any other C_i term, unweighted C(111), and weighted C(131) across both companies and both situations. As a measure of consistency C_2 draws out the expectations that are consequential for both sides of the linkage – Work Unit and Support Group. That is, when a linkage is ranked highly by C_2 it means that both the Work Unit and Support Group are consistent on which expectation priorities are consequential to their linkage.

Caution should be taken to further evaluate most of the other terms before a decision is made to drop them. That is, there was data from only two case sites, and further study of their contribution is required. C_1 and C_3 provide other information that is not captured by C_2, and even if they do not demonstrate an improvement in the performance of the C-formula they may be useful in the understanding of the nature of the relationship between linkage partners. The discussion will now focus on the other terms and the consistency formula, and makes the following proposals:

a) A case for the not considering unweighted C(111); and
b) Cases for the continued consideration of weighted $C(w_1,w_2,w_3)$, C_1 and C_3.

Un-weighted Consistency formula - $C_{(111)}$:

$C_{(111)}$ performed moderately well in Company A, yellow indicator, but very well in Company B. For both companies in the relaxed situation C(111) performed no better than the individual terms. When the scores for Work Unit linkages are close together, less variance, as in Company A then the C(111) could not discriminate acceptably between Work Units.

One interpretation of this outcome is that contribution of certain terms, like C_1, may impact the final C(111) score more than the differences between the Work Unit scores. To cite an instance, in the Table below for Company A and a Work Unit (WU5) was ranked #5 by the company Judge with a C(111) score of .436. The value for C_1 is .531 while the value for C_2 is .353, so $C_1 - C_2 = .178$. The difference between the WU5 and WU2 scores for C(111) is (.436 - .360 =) .076, which is smaller than WU5's $C_1 - C_2$.

	WU 2	WU 5
C1	0.399	0.531
C2	0.400	0.353
C3	0.262	0.404
C(111) =	0.360	0.436
rank	5	3
C(131) =	**0.390**	**0.378**
rank	3	5

With the un-weighted C(111) formula WU5 gets a rank of 3. However, when the weight is changed to C(131) with a score of .378, for example, then the rank changes to 5 which is a match with the company Judge. This is compatible with the case for weighted $C(w_1,w_2,w_3)$ which is presented next.

Weighted Consistency formula - $C_{(131)}$:

As a base-line measure C(111) has shown that all terms (C_i) are not equal in their contribution to the combined C-formula score. For both the Company A & B case study results C(131) got 4 matches, which is the same as C_2 and the same or more than the other term on their own. It should be noted that the specific weights (131) were used to illustrate the benefits of weights in the C-formula and they were just one example. (Appendix 8.5.6.1 presents several weight values from Company A & B and the corresponding number of matches for the Strict and Relaxed situations, and shows that weights can improve the number of matches from the C-formula.)

The results for Company A indicate that weights help in the ranking of Work Units when the variance between Work Units is small. The weights bring forward the contribution of the terms that help to refine the differences between Work Unit rankings. For example, in the relaxed situation, the unweighted C(111) = 2 matches, while the weighted C(131) = 4

matches – due to the contribution of the C_2 term. It can be argued that C(131) should not be kept because it does no better than the C_2 term. Of course the matter of the retention of weights in the consistency formula assumes that the C_i terms, other than C_2, have a contribution to make to the performance of the consistency formula or to the understanding of the interaction between groups, and this will be presented next.

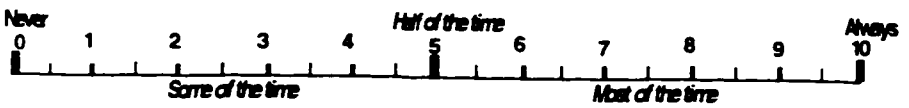
Concept of Importance - C_1:

Why did C_1 perform so well in the relaxed situation for Company A & B? C_1 has the advantage of being easy for the Work Unit and Support Group members to interpret and select from a large set of expectations, compared to C_2 and C_3. For example: "Select the x expectations out of y that you feel are the most important in your relationship with the other group," is still relatively easy for the operator to do as x and/or y are increased. However, the tasks for C_2 and C_3 become harder if the C_1 selection is not done first to narrow the number of expectations to be prioritized or have actuals determined for. That is, for C_2 the concept of 'priority' requires choices between several expectations that may be close together in rank. By first narrowing the number of expectations to be ranked, an operator is not over burdened. The same can be said for C_3, the concept of assigning an actual frequency for a behaviour on a scale requires a knowledge of how to convert an occurrence to a proportion and the task can easily over burden an operator. So as a pre-selector of important expectation for C_2 and C_3 the procedural operation required by C_1 is of value.

But C_1 also provides information about the expectations that were not selected. Because it is dealing with the entire set of y expectations, while C_2 and C_3 only deal that the x expectation that were selected, it may provide additional input into other discriminating measure like 'penalties' which might improve the contribution of C_1 to the prediction the performance of the C-formula, as will be discussed in the Further Research section.

Concept of Acceptability - C_3:

The Expectation Range Model presents the notions of better and worse landmarks, along with the 'actual', to define the acceptable range. In the Questionnaire the operator was asked, for an important expectation, to mark on a scale like the one below, *"How often does this Actually happen?"* Then the operator was asked, for example, *"The Work Team and Maintenance agree on something that will make things Better"*... and mark this on the scale. The intent of the second question is to capture the upper boundary on the frequency of the expectation behaviour.



Despite several revisions of the Questionnaire to ease the interpretation of the wording of the questions and the use of examples at the Questionnaire briefing session the 'better &

worse' landmarks have proven difficult for the operators to quantify. Some operators when asked to identify the frequency of occurrence of 'better' behaviour they have choose an extreme value like 'always'; or interpret the question to mean "How frequently does a better behaviour occur?" and mark 'never'.

The proposed **C**-formula uses a Proportional Actual range that does not rely on the 'better & worse' landmarks. It uses the actual only and has the advantage of being easy to quantify by the operators. One potential problem may be the responsiveness of this measure. The C_3 score was assumed to be related to the distance between two actuals – from the Work Unit and the Support Group. However, as illustrated in Appendix 8.5.5.1, the slope of the 'better & worse' lines may not be the same and an estimate of their slope may be an area for further investigation. (Appendix 8.5.5.1 presents a comparison of a range based on the 'actual, better & worse' landmarks and a range using a proportional actual, and shows that the proportional actual gives similar results by using the actual only.)

It should be noted that the C_3 term provides information about the linkage that is not available from C_1 or C_2. That is, if all work units know which expectations are important and rank them in a similar way then C_1 and C_2 are almost the same. The C_3 term may be the only way to discriminate the work units, by determining how they view reality – the 'actual' occurrence of an expectation behaviour – and whether they are in agreement with their linkage partner. The sub-section on Future Research presents the notion that the C_3 term could be revised and refined so it can discriminate between linkages with scores that are close together, less variant.

6.2.2 Analysis of Expectations

This section will discuss some of the underlying attributes that differentiate Effective and not-as-effective Work Unit linkages. These attributes: Positive expectations, Agreement and Difference are summarized in Table 6-3, and were originally presented for Company A & B in Results sub-sections 5.3.3 & 5.4.3 respectively.

Under the table heading of Company A & B are the results for the **Hi**-group and **Lo**-group and a reference to the Table where the results can be found. Additionally, for Company A similar information is tabulated for the **Eff**ective and **N-eff**ective Work Units.

Attribute	Company A				Company B	
	Hi vs Lo		Eff vs N-eff		Hi vs Lo	
	Results	Table	Results	Table	Results	Table
Pos to Neg	5.92 vs 3.74	5-11	2.00 vs 1.53	5-15	14.0 vs 5.92	5-28
Agree to Not-agree	1.61 vs 0.93	5-12	2.18 vs 1.51	5-16	1.31 vs 0.43	5-29
Different	29%	5-13	55%	5-17	64%	5-30

Table 6-3: Consistency Attributes

Looking at each 'attribute' in turn:

(i) **Ratio of Positive vs Negative Expectations:** For both Company A & B the Hi-group had a higher ratio for the selection of positive expectations to negative expectations compared to the Lo-group – in Company A, 58% higher and in Company B, 136% higher. This finding is consistent by the results from the Effective Work Unit where its ratio of positive to negative expectations is 30% higher than the N-effective Work Unit. One possible explanation for effective Work Unit linkages having higher positive-to-negative ratios is that positive behaviour expectations are more specific and tend to provide clearer communication between the groups. That is, when a linkage uses positive expectations they are precise about the behaviours that are required, and being consistent about positive expectations leads to exact behaviours happening more often in the linkage and higher perceived performance. Negative expectations may be more concerned with behaviours that should not happen or should be refrained from. Potentially, when a Work Unit and Support Group both select an expectation that is negative, like, *"Maintenance is repairing a machine, and the Maintenance person criticizes a team member or the broken machine,"* then they can stop criticizing but may still do other behaviours, like throw material around, that has the same negative effect on the relationship.

(ii) **Ratio of Agreement to Not-agreeing:** For both Company A & B the Hi-group's Work Unit and Support Group linkages were more in agreement on important expectations than the Lo-group – in Company A, 73% higher and in Company B, 205% higher. This finding is consistent with the results from the Effective Work Unit in Company A where the ratio of agreement to not-agreeing is 44% higher than the same ratio for the N-effective Work Unit. An explanation for this might be that when both linkage partners are more in agreement on the important expectations then they make consistent choices of the behaviours that influence their relationship and the *expectation-response-evaluation* cycle operates more frequently within the acceptable range. This illustrates the underlying proposition of this research that more consistent Work Unit linkages are ranked as more effective.

(iii) **Different priority-weight:**

This sub-section discusses expectations that have been given priority-weights by a Work Unit and their Support Group – consistent expectations – for Company A, then Company B. These will be supplemented by an analysis of the expectation categories for the Effective/N-effective Work Units of Company A.

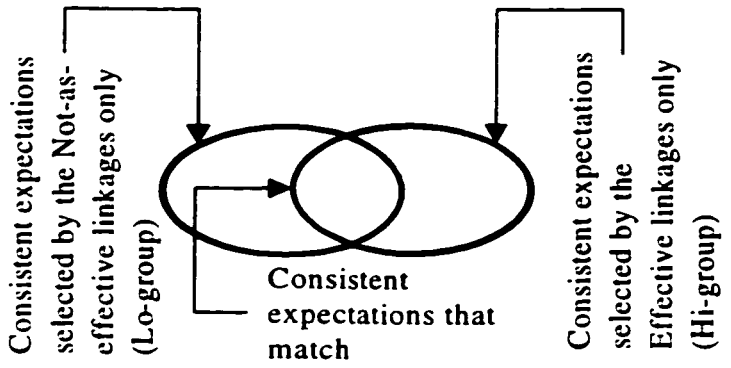


Figure 6-1: Categories for All consistent expectations

For illustration, the Venn diagram in Figure 6-1 breaks these consistent expectations into three categories: (1) Matching expectations selected by both the Hi-group and the Lo-group; (2) Effective expectations selected by the Hi-group only; and (3) Not-as-effective expectations selected by the Lo-group only. (For reference, the percentage of matching expectations for Company A & B are 71% and 36% respectively, and between the Effective and N-effective Work Units is 45%. Refer to footnote[1] for a conversion of the matching expectations from Table 6-3 held by the Hi and Lo groups.)

For **Company A**, the difference between the Hi-group and the Lo-group linkages is derived mainly from the different priority-weight they place on the common expectations (see Table 6-4). The Lo-group has placed over half of its priority-weight on 1 expectation, and they have about three times as much variance as Company A. This is supplemented by observation at the interview sessions with Effective and N-effective Work Units that showed that the expectations are viewed in a slightly different ways. For example, expectation 'P' has to do with training (see footnote[2] for descriptions of other expectations) and for the N-effective Work Unit training is necessary to keep them out of trouble, maintain control of their process, and isolate them from the Maintenance persons. On the other hand, the Effective Work Unit sees training as a way of getting to know their equipment and identify ways to improve their productivity.

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[1] Company A: (1-.29) = .71; Company B: (1-.64) = .36; Eff-N-eff

[2] **P** = Maintenance has repaired a machine, and now explains to the operator what the problem was and what to do next time the problem happens; **I** = Maintenance repairs a machine, and stays at the machine until it is tested by a team member and successfully cycles; **F** = An emergency work order is given to Maintenance, they come, fix it, and the repair to the machine is done in less than 1 hour; **J** = A work order is completed, Maintenance arrives to repair a machine, a team member is standing by to explain and help; **E** = A work order is completed and clearly describes the problem and its location on the machine; **H** = Maintenance arrives to repair a machine, and the machine is clean of all tools, parts, chips and oil; **M** = Maintenance completes repairing a machine, and has to wait for an operator to verify that it works.

Expectation Letter	Hi-group Weight	Normalized
P	60	32.3
I	53	28.5
F	38	20.4
J	25	13.4
H	10	5.4
	186	
	Variance =	119.9

Expectation Letter	Lo-group Weight	Normalized
P	80	55.2
I	39	26.9
J	16	11.0
F	6	4.1
H	4	2.8
	145	
	Variance =	478.5

Table 6-4: Variance in Company A common expectations

On the other hand, in **Company B** there are relatively fewer expectations held in common. Of the 36.4% that are common the results showed that there is very little difference in the variance between the Hi-group and the Lo-group (see Table 5-31). This suggests that the difference between them is derived mainly from the priority-weight they place on the unique expectations. This can be seen in Table 6-5 where the both Hi-group and Lo-group placed more than 40% of their priority-weight on expectations that are held as unique.

Expectation Selected	Hi-group Weight	Percent
Common	82	51.9
Unique	76	48.1
	158	

Expectation Selected	Lo-group Weight	Percent
Common	70	59.3
Unique	48	40.7
	118	

Table 6-5: Company B unique expectations receiving priority

The analysis of the expectation categories for the **Company A Effective and not-as-effective Work Units**, Table 6-6 also is congruent with this interpretation, that a more effective Work Unit chooses expectations differently or chooses different expectations than a Work Unit that is less effective.

For example, three of the eleven expectation categories in the table have a ratio of 2 or more (highlighted at top) contain behaviour examples given more often by the Effective Work Unit and were assumed to be unique to them. One possible interpretation of these particular selections is that the differentiating expectations of the Effective Work Unit are related to the preparation for or anticipation of future events that might effect productivity. This can be contrasted with the N-effective Work Unit where the unique issues (highlighted at bottom) are related to potential conflict, like metrics on downtime service. One explanation of this is that planning vs. reacting characteristic may be one of

the important attributes of relatively more consistent (more effective) linkages, and a might be an element which could possibly differentiates the good from the best.

Category	Effective	N-effective	Ratio
after fixing	6		6.00
plan	9	2	4.50
work order	12	6	2.00
come to fix	11	7	1.57
attitude of unit	7	5	1.40
assist fix	16	12	1.33
attitude of support	10	9	1.11
fix quickly	9	9	1.00
training	2	13	0.15
fix by team	7	22	0.32
measurement		3	0.33

Table 6-6: Company A unique differences

6.2.3 Summary of Results

This discussion of the results has pointed out that although there was a discrepancy between the teams in Company A & B, the contrasts have provide a broader view of the underlying causes that make Effective and N-effective Work Unit linkages different. For example, more Effective Work Units are more consistent on the expectations that they hold as important and the nature of their differentiating expectations is that they are positive-effective expectations. On the other hand, the identification of negative-not-as-effective expectations may be a way to augment the C-formula to spread the resulting scores when penalties are applied. Lastly, the weighting of the terms of the formula may bring together the right blend for accurate ranking.

These topics will be explored further in the Further Research section, after a discussion of the Method used.

6.3 Method

The next sub-sections will deal with some method issues, the calculation of the C-formula and areas for improvement. These will be followed in the next section by a discussion of some opportunities for further research.

6.3.1 Method Issues

The method involves three major steps: (1) the identification of expectations to form the questionnaire; (2) the ranking of the expectations by the Work Unit and Support Group to calculate a score; and (3) comparison with the rankings of the management judge. Each

step involves some potential for error because they depend on 'good' data from a noisy real world environment, for example:

- Step #1 requires that the 'effective' Work Unit and their Support Group provide good input and that this input can be categorized, in a way that is meaningful to the company culture, for the questionnaire. This depends to a large extent on the co-operation of the workers that are interviewed. This was addressed by being candid with them about the purpose of the research, answering their questions openly and providing access to the results, and not being too onerous in the time required for their input;

- Step #2 needs the Work Unit linkages to be ranked to provide good selections, priorities and estimates of the actual occurrence of the expectations. Again, this depends on the co-operation of the workers that answered the questionnaire. They expected to know the purpose of the research, have a clear understanding of the questions they were going to answer and how the results would be used, and not spending too much time; and

- Step #3 needs the expert judge that will independently rank the Work Unit linkages to also provide good determinations. The most serious problem was the tendency for the Judge to rank the work unit linkages quickly. If not enough thought is put into the rankings then the comparison with the C-formula will be greatly affected. One suggestion to improve the method is to have the Judge rank more than the six target teams in several rounds of paired rankings and then combine the results to identify the rankings for the six target linkages. For example, 8 teams (six target teams and two more) could be assigned randomly to pairs and the Judge would indicate which team had a more effective relationship with the Support Group.

There were other practical problems with these steps, for example;

- *Size of the data set*: the Company management only allowed a small number of participants due to the time and costs involved in the case study interviews; and in the linkages studied there was in fact only one Support person that interacted with each Work Unit;

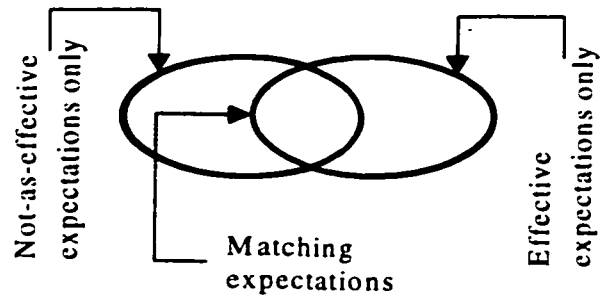
- *Situational effects*: Company management could have selected another array of six Work Units to rank if the work load of the Units had been different; the Support Group and/or Work Unit person selected to do the Questionnaire could have been different if the Questionnaire session had been scheduled for another time; or the company Judge may have ranked the expectations differently at another time.

The Questionnaires used in either Company A or B were based on interviews of work unit members at each company so they are unique to their site network, process and procedures. Company A questionnaire was developed before the Company B

questionnaire, so lessons learned from Company A could be applied to the Company B Questionnaire. However, there was two *Method improvements* that were initiated between the two case studies that may be issues for the calculation of the C-formula, vis:

- **Not-as-effective Work Unit expectations:** The Company A questionnaire incorporated expectations from the effective and not-as-effective Work Units (Step #1), while Company B only included effective Work Unit expectations. (Note: This was an issue for the Company A questionnaire and calculated ranking only).

  Site Management may designate a work unit as 'effective' when it accomplishes, and is consistent with, management's expectations for performance. That is, the effective Work Unit has expectations that are consistent with management, while the not-as-effective Work Unit may have some expectations that would not be endorsed by management. By way of illustration, the Venn diagram below shows that there can be an overlap of similar expectations provided by the effective and not-as-effective Work Units – matching. However, some expectations were unique. For example, the effective Work Unit provided expectations about planning for the prevention of future problems that were not shared by the not-as-effective Work Unit; while the not-as-effective Work Unit had expectations about the measurement of task activity that were not shared by the effective Work Unit.



The company Judge ranked Work Unit linkages based on management criteria for an effective linkage relationship. The Consistency measure ranked Work Unit linkages based on the degree of consistency in the linkage. The inclusion of not-as-effective expectations created the opportunity for a not-as-effective Work Unit linkage to be consistent on expectations that might not be endorsed by management. That is, they might choose an expectation that is unique and familiar to them rather than an effective expectation. In this case the Consistency score might be higher and this may reduce the number of matches with the company Judge.

As a method improvement the Questionnaire for Company B was based on expectations from an effective Work Unit (and their Support Group) only.

- **Positively orientated expectations:** The Company A Questionnaire had a different ratio of *positively orientated expectations* to negatively orientated expectations, 50% vs. 69% for Company B. The footnote[3] gives some examples of positive and negative expectations.

  One outcome of the Company A Questionnaire results was that more consistent Work Unit linkages select more positive expectations than less consistent Work Units. As a modification to the Company B Questionnaire the proportion of positive questions was increased. The reasoning was that by increasing the assortment of positive expectations, Work Unit linkages would choose different expectations and thereby increase dispersion of the scores between Work Units.

  However, there is a concern that including a lower portion of negative expectations in the Company B Questionnaire gave the not-as-effective Work Unit linkages the opportunity to select positive expectations and 'appear' consistent, and defeat the consistency measure. That is, if negative expectations are characteristic of not-as-effective Work Units and there are only 31% on the Questionnaire then a not-as-effective Work Unit may have no choice but to choose some positive expectations.

  This issue can not be decided from the study results. For example, Appendix 8.8.2 gives a comparison of the percentage of positive expectations on the Questionnaires and the proportion of all expectations selected that were positive, and shows that the Company A Work Units, despite having a lower ratio of positive expectations to choose from compared to Company B Work Units, selected a higher percentage of positive expectations. Negative expectations may have to be recognized and treated differently as will be discussed under Future Research.

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[3] A positive expectation is 'good-to-do', for example: "*A work order is completed and clearly describes the problem and its location on the machine.*" On the other hand, a negative expectation is a behaviour that is 'not-good-to-do', like: "*A work order is given to Maintenance for a repair which should have been done by the Work Team.*"

6.4 Future Research

6.4.1 Performance improvements

There are several opportunities for Future Research that have been addressed in the Results and previous discussion sections that will be summarized here and presented graphically in Figure 6-2. They are:

- ***Positively orientated expectations:*** One suggestion to increase dispersion of the scores is to maintain a 50% positive-to-negative expectation ratio and introduce a penalty for selecting negative expectations.
- ***Not-as-effective expectations:*** Another suggestion to increase dispersion of the scores is to identify the unique effective and not-as-effective expectations from representative effective and not-as-effective Work Units and their Support Groups and introduce a penalty for selecting not-as-effective expectations.
- ***Weighted C-formula:*** Once the model has been changed for the Ci terms to take into account positive & negative expectations and effective & not-as-effective expectations then further research might look into generalizing the weight values
- ***Increased number of expectations:*** The results for Company A indicated that when the scores for the Work Unit linkages are close together then the C-formula had difficulty in differentiating. A prospect for future research is to look at the total number of expectations to be selected from (y) and the total number of expectation to be selected (x) to determine the best values that will improve accuracy of the score without a decrement in the quality of the input from the operators due to over burdening.

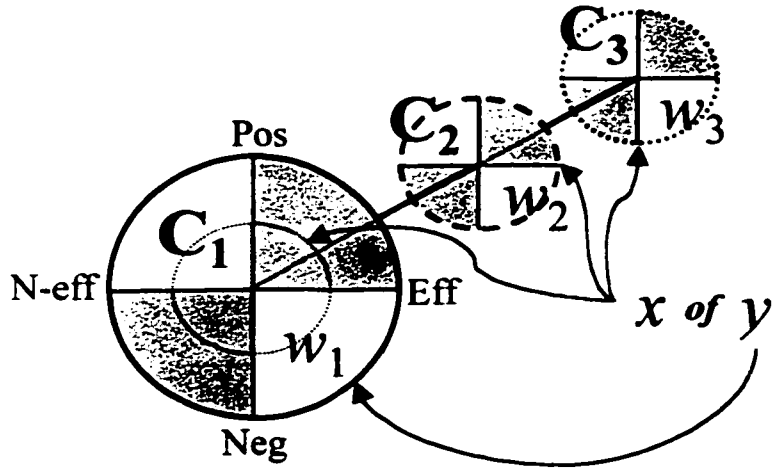

Figure 6-2: C-formula performance improvements

The graphic in Figure 6-2 as a whole represents the C-formula, and contains:

- the three C_i terms and their relative weights w_i.
- the larger C_1 circle contains the set of all expectations that a Work Unit or Support Group can select from, of size y. The two smaller circles, C_2 & C_3 (and the small circle in C_1), are the set of 'selected' expectations, of size x.
- each circle is quartered by two lines: the horizontal line is the array of expectations for the characteristic not-as-effective (**N-eff**) to effective (**Eff**); and the vertical line is the array of the same expectations for the characteristic called positive orientation (**Pos**) to negative (**Neg**).
- the green quadrants represent areas of effectiveness ... positive-effective expectations; and the red quadrants represent areas of not-as-effectiveness ... negative-not-as-effective expectations.

As has been presented in the results discussion, all the Ci terms should be re-evaluated before a decision is made to drop them – two case sites is not enough. C_1 and C_3 provide other information that is not captured by C_2, and even if they do not demonstrate an improvement in the performance of the C-formula they may be useful in the understanding of the nature of the relationship between linkage partners. For example, C_1 can provide information about expectations that are not selected, and C_3 could be refined to discriminate between close work unit scores.

Future research could be undertaken by doing the proposed changes to the model and C-formula and terms, and then applying the method of this thesis to several more sites in different industries. This would provide data to calculate best-fit weight values and evaluate the performance contribution of the C_i terms. Then these could be used in other samples to determine the improvement in performance over the unweighted C-formula and original C_i terms. This effort may be impacted by the lack of good sites to investigate or the access to these sites.

6.4.2 Method Generalization

The Work Unit linkage rankings came from the C-formula scores that were based on the Work Unit selections from the Questionnaires. The Questionnaires were based on the expectations of the highest performing Work Units in each case study company, so the expectations and results from Company A could not be compared to Company B. One prospect for a method improvement to the calculation of the C-formula might be to develop a general questionnaire that will discriminate the critical performance expectations that apply across an array of companies. This notion is presented below, after some terminology definition.

Consider the following situation: the ovals in Figure 6-1 represent three Companies that have Work Units at various levels of performance. The ovals are placed along the left hand scale to indicate the range of performance of the teams in the Companies: the dotted ('''') company has on-average lower performing teams than the dashed (---) company; and

the solid (—) company has on-average the highest performing teams. For example, Company 'A' from the case studies might be a solid oval company and Company 'B' might be a dashed oval company.

The right hand scale is an example of the team performance in the dotted oval company only, where some Work Units have lower performance and others have higher performance. For example, the 'High' performance team might be like the Effective Work Unit, while the N-effective Work Unit might be a 'Low' performance team.

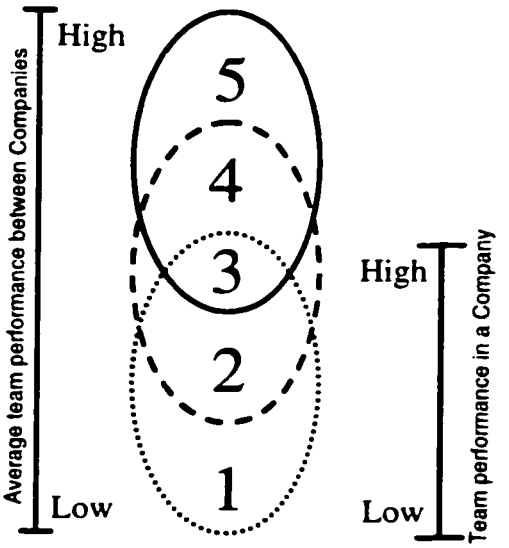

Figure 6-3: Discrimination in Ranking between Companies

The numbers 1 to 3 in Figure 6-3 represent:

(1) the expectation choices of the *lower* Work Units in the *lower* company (··· oval);
(2) the expectation choices of the *lower* Work Units in the *middle* company (--- oval), which are similar to the *mid* Work Units in the *lower* company (··· oval);
(3) the expectation choices of the *lower* Work Units in the *higher* company (— oval), which are similar to the *higher* Work Units in the *lower* company (··· oval).

Areas 1, 2 & 3: To improve ranking matches the not-as-effective expectations of the not-as-productive Work Unit and/or the not-as-productive company could be identified and incorporated into the C-formula scores as a penalty if they are selected. This would do two things: allow the not-as-productive Work Units to choose not-as-effective expectations and thereby reduce the selection of effective expectations by chance; and penalize these choices to increase the variation in scores.

The numbers 4 & 5 in Figure 6-3 represent:

(4) the expectation choices of the *mid* Work Units in the *higher* company (— oval), which are similar to the *higher* Work Units in the *middle* company (--- oval);
(5) the expectation choices of *higher* Work Units in the *higher* company (— oval).

Area 4: To generalize the scores to an array of companies it is recognized that Work Units progress in performance from Low to High during their operational life (right hand scale of figure). But, Companies also progress in performance from Low to High during their operational life (left hand scale of figure). There are expectations that may not be seen as 'important' any more to the high performance Work Units, in high performance companies. For example, Low companies or teams may see training on equipment as a way to do preventative maintenance or a way of reducing the impact of machine failure on productivity. On the other hand, High companies or teams may view training quite differently, as an element of Continuous Improvement or a way to learn how to make the process better. However, the former view of training may still be regard as necessary to the company's performance success. These expectations could be identified and incorporated into the **C**-formula scores with less weight than the high performance expectations. Again, this would generalize the questionnaire and increase the variation in scores.

Area 5: Lastly, the number of high performance expectations that are ranked by a Work Unit could be increased in number, to ten for instance. This research allowed five expectations to be selected and prioritized. There is a trade-off between ranking more expectations, and the abilities and patience of the Work Unit and Support Group members to do the ranking accurately that would need to be evaluated. Nonetheless, this would allow more data into the calculation, and may increase its reliability and increase the variance in scores that could lead to a better ranking match-rate.

General: As another enhancement, the existing behaviour example data from the case study interviews from Company A could be analyzed further to identify and then construct higher level characteristics of effective and not-as-effective linkages for a generalized questionnaire. The Table 6-6 has already provided a categorization for Company A that, when compared to a similar categorization for Company B or other companies, could be the basis for general behaviour statements in a Questionnaire that is more universal in identifying Work Unit rankings.

6.4.3 Model Future Research

The results from the case studies when applied to the Model through the Perceived Consistency of the Linkage formula (**C**) are strongly supported by Company B and more selectively supported by Company A. However, there are two areas that could be looked at to improve the performance of the formula: broadening the scope from linkage consistency to embrace network consistency; and recognizing the routine nature of

certain *expectation-response-evaluation* cycles. These will be discussed in the next sub-sections.

6.4.3.1 Scope: Linkage to Network Consistency

The model recognized that a Work Unit exists within a network of relationships with other Work Units and/or Support Groups. However, the scope of the research was restricted to look at one linkage, albeit one of the most consequential relationships, to understand Perceived Consistency (and from that Perceived Effectiveness) of the linkage. One view was that a high ranking in an important linkage might be indicative of high ranking in other linkages and high ranking in general.

Clearly, a Work Unit must sustain several linkages successfully to be effective overall. It is speculated that if a Work Unit knows how to deal with one linkage consistently, then it would understanding their other linkages and would tend to be among the higher ranked Work Units – practice is transferable. On the other hand, a high ranking in one linkage does not guarantee a high ranking in every linkages since each Work Unit has its own strengths and weaknesses. Further research might broaden the scope to Network consistency. For example, by combining the scores of several linkages together – only the top three linkages may be needed – and weighting (ω_m) the linkages to reflect their significance, an overall Network Consistency could be calculated. That is,

$$\Sigma\{\omega_m * \text{Linkage Consistency}_m\} \equiv \text{Network Consistency}$$
where: m = meaningful linkages.

6.4.3.2 The XRE cycle and Consistency

Two notions have be proposed by the model:

(i) Interaction in a linkage is characterized by what has been called the *'expectation-response-evaluation'* cycle (**XRE**); and
(ii) The three components ($\mathbf{C_i}$) to consistency: importance, priority and acceptability.

One way to view these two concepts together is to recognize that an expectation's importance is its potential to occur vs. unimportant expectations. Given that a expectation is important, the priority of an expectation is related to the (action) initiation of the XRE cycle, while the response (reaction) is related to evaluation of its acceptability. Refer to Figure 6-4.

Consider this from the view of one group in the XRE cycle: the model presents that a certain expectation is held, for example, by the Work Unit and it must be recognized by the Support Group for there to be consistency. *"To arrive to fix a machine in 2 hours or less"* is an important expectation originated by the Work Unit, and shared by the Maintenance Group. Since the Work Unit originates this expectation they give it priority. And, since the Work Unit originates this expectation they also give it an acceptability

range. The Maintenance Group responds to the expectation and the response is evaluated by the Work Unit against this range. The Maintenance Group, being consistent, will also give this expectation priority and match, to some extent, the acceptable range by their response. Clearly, a similar description could have been made for the point of view of the Support Group.

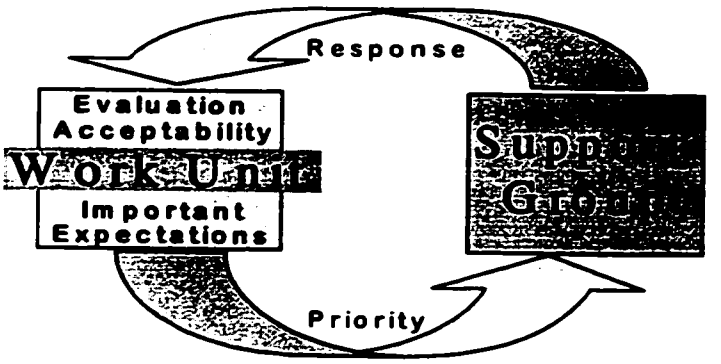

Figure 6-4: XRE cycle

It can be seen that the XRE cycle is the thread that ties both views of a certain expectation together, Work Unit as the holder of the expectation and Maintenance as the respondent to the expectation – a cycle with two consistent views.

One avenue for further research could look into these cycles as intact routines that reoccur. More consistent Work Unit linkages might have routines that relate several expectations together or represent a complex XRE cycle. Routines could facilitate the interactions between linkage partners by assisting them to operate more frequently within the acceptable range. The Perceived Consistency of the Linkage formula could be refined to recognize routines as well as individual expectations.

Lastly, the XRE cycle could be augmented to recognize a ***reflection*** dwell time. This is, a regular time in-between successive XRE cycles where the Work Unit and/or Support Group reflect on the outcome of the last cycle, or history of cycles, and perhaps take action to change some aspect. The reflection could be part of informal interactions between linkage members or a procedural requirement like a Continuous Improvement Program. How effective vs. not-as-effective linkages deal with 'reflection' may provide further insight into how work units differ and may augment the C-formula terms.

6.5 Implications for Organizations and Practice

Jackson's (1985) meta-analysis of the consistency literature recommends, "a useful direction for further research would be the development of good diagnostic tools for pinpointing specific aspects about one's job that are ambiguous or conflicting." The proposed Expectation Range Model not only has contributed to understanding the notion

of consistency and operationalizing it, but it has also provided the elements for a diagnostic tool. That is, the Questionnaire that contains the expectations from effective and not-as-effective Work Units and Support Groups, that forms the basis for differentiating between linkages, could also provide feedback to the groups on which expectations they might have selected differently – e.g. effective expectations that are not preferred, or not-as-effective expectations that are picked.

The discussion of the results has pointed out that more Effective Work Units are more consistent on the expectations that they hold as important and the nature of their differentiating expectations is that they are positive-effective expectations. For example, "Maintenance completes repairing a machine and an operator verifies that it works," is a positive effective expectation originated by the Maintenance group to prevent future problems. If a linkage did not select this 'effective' expectation then remedial training could be done with the Work Unit and their linkage partner to instill this behaviour, so it becomes consistent with their task situation.

For the most part, the planning vs. reacting behaviour expectations, that are characteristic of effective and not-as-effective linkages respectively, may not only be one of the important ways to differentiate and diagnose problems, they have 'proactive' implications without using a diagnostic Questionnaire. That is, rather than waiting to find out which not-as-effective expectations are held by the not-as-effective linkages, the operators could be trained directly on what the practices of effective Work Unit linkages are.

Alternatively, the operators could be trained on how to have good communications. They could be made aware that effective linkages are consistent on expectations and a process could be put in place to facilitate the exchange of expectations sets with their linkage partners: what is important, what are the priority behaviours and how should they 'actually' happen.

Lastly, this research could also address a large body of applications: from two departments linked together, to the linkage between two enterprises. On the one hand, an avenue for organizations might be to generalize the findings of this research to study Network Effectiveness of departments. That is, to investigate unique ways of ranking overall department effectiveness, such as, taking the scores of several linkages and weighting them together to reflect their importance for the linkage's performance. This might result in an understanding of overall consistency elements and lead to a network based diagnostic tool. On the other side, Supply Chain management is an example where the exchange of information and expectations between functions in independent companies may be improved by an understanding of their consistency elements. More case study analysis, or lab study, might identify the corresponding effective and not-as-effective expectations between linked organizations.

6.6 Conclusion

The research consisted of two major areas of work: the extensive theoretical development of the Expectation Range Model and its operationalization of interaction characteristics, and in-depth case studies with a view to the measurement and testing of the theory:

> *The more the perceived Inter-group Consistency, between the expectations of a work unit and another interacting functional group, the more the perceived Linkage Effectiveness of that relationship.*

The Expectation Range Model is promising and captures consistency in several original ways: extending interaction concepts from intra-group to inter-group consistency; dealing with two way expectation communications between groups; presenting the concept of a range of acceptable responses; and applying the model to the manufacturing environment.

Having access to companies that were recognized for 'excellent' work units challenged the researcher and stimulated the thoughtful discussion that is reflected in the development of the Expectation Range Model and its operationalization. The test results show strong and reasonable support for the hypothesis and the proposed calculation of a consistency score. By having a variety of case study examples that provided divergent results, this thesis could achieve some generalization and lead to several improvements of the method.

The future of the model lies, to a certain extent, in improvements to the formula's performance. To this end the treatment of positive & negative expectations, effective & not-as-effective expectations, and weights have all been identified. However, the model could be generalized in at least two directions: to include more linkages – network consistency; and to identify key consistency factors independent of a particular department and its linkages. A useful direction for further research would be the development of good diagnostic tools for pinpointing specific aspects about one's network that are consistent and effective, and sharing that understanding with the entire enterprise.

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8 APPENDIX

8.1 Interview Guide for Work Units

INTRODUCTION

The intention of this Guide is to direct the general flow of questions. It is not meant to be restrictive. That is, the interviewer is to explore the topics within the time limits and the overall interview process. Additional time will be through agreement with the interviewee. The progression is from general considerations to more specific information through open ended questions. If the interviewee does not answer a question, then ask for the three most important aspects. If the interviewee can still not answer, then indicate that you will return to the question at the end of the questionnaire and move on through the balance of the questions.

The interviewer will introduce themselves and the scope of the interview. The underlined and uppercase words are to be emphasized. If the interviewee does not know your name then provide it and start the interview.

"__(Interviewee's name)__ , as you are aware, I am doing this research in conjunction with the Department of Management Sciences at the University of Waterloo. The information that I get from these interviews, along with other sources of information, will be used as the basis for my Doctoral thesis on manufacturing communications.

The purpose of the questions that I am going to ask you is to collect examples of the things that happen in the work place between your work unit and others -- your experiences. I want to reemphasize that I am interested in your observations so there are really NO correct answers. OK?

QUESTIONS

(1) I want to talk about your work unit's relationship with **your support groups**. Looking at all the different support groups you interact with, some may be more important to interact with ... can you give me an example of one which you consider to be very important to your team's successful performance?

ANSWER:

(1.1) How do you co-ordinate with this support group ... can you give me an example of how you co-ordinate?

ANSWER:

(1.2) In performing the tasks between units, what behaviours do the members of the support group consider to be GOOD for your work unit to do to help them ... in other words, what do they praise members of your work unit for doing and what is an example of that behaviour?

ANSWER:

(1.2.1) Again, looking at the same support group, what behaviours do the members of the Support group consider to be NOT good for your work unit to do to help them ... in other words, what do they discouraged members of your work unit from doing and can you give me an example?

ANSWER:

(1.3) In performing the tasks between units, what behaviours do the members of YOUR work unit consider to be GOOD for the support group to do to help you ... in other words, what do you praise members of the support group for doing and what is an example of that behaviour?

ANSWER:

(1.3.1) Again, looking at the same support group, what behaviours do the members of YOUR work unit consider to be NOT good for the support group to do to help you ... in other words, what do you discouraged members of the support group from doing and can you give me an example?

ANSWER:

(1.4) Looking at your work group and the support group, how would they know that they were being really effective ... and, how often would they say that they were being really effective?

ANSWER:

8.2 Interview Guide for Support Groups

INTRODUCTION

The intention of this Guide is to direct the general flow of questions. It is not meant to be restrictive. That is, the interviewer is to explore the topics within the time limits and the overall interview process. Additional time will be through agreement with the interviewee. The progression is from general considerations to more specific information through open ended questions. If the interviewee does not answer a question, then ask for the three most important aspects. If the interviewee can still not answer, then indicate that you will return to the question at the end of the questionnaire and move on through the balance of the questions.

The interviewer will introduce themselves and the scope of the interview. The underlined and uppercase words are to be emphasized. If the interviewee does not know your name then provide it and start the interview.

"__(Interviewee's name)__ , as you are aware, I am doing this research in conjunction with the Department of Management Sciences at the University of Waterloo. The information that I get from these interviews, along with other sources of information, will be used as the basis for my Doctoral thesis on manufacturing communications.

The purpose of the questions that I am going to ask you is to collect examples of the things that happen in the work place between your group and others -- your experiences. I want to reemphasize that I am interested in your observations so there are really NO correct answers. OK?

QUESTIONS

(1) I want to talk about your group's relationship with the **work units** that you support, in paticular the _____ team.

(1.1) How do you co-ordinate with this work unit ... can you give me an example of how you co-ordinate?

ANSWER:

(1.2) In performing the tasks between units, what behaviours do the members of the work unit consider to be GOOD for your group to do to help them .... in other words, what do they praise members of your group for doing and what is an example of that behaviour?

ANSWER:

(1.2.1) Again, looking at the same work unit, what behaviours do the members of the work unit consider to be NOT good for your group to do to help them ... in other words, what do they discouraged members of your group from doing and can you give me an example?

ANSWER:

(1.3) In performing the tasks between units, what behaviours do the members of YOUR group consider to be GOOD for the work unit to do to help you ... in other words, what do you praise members of the work unit for doing and what is an example of that behaviour?

ANSWER:

(1.3.1) Again, looking at the same work unit, what behaviours do the members of YOUR group consider to be NOT good for the work unit to do to help you ... in other words, what do you discouraged members of the work unit from doing and can you give me an example?

ANSWER:

(1.4) Looking at your work group and the work unit, how would they know that they were being really effective ... and, how often would they say that they were being really effective?

ANSWER:

8.3 Questionnaire for Work Units and Support Groups

Script: To explain Questionnaire

I would like to thank you for coming this morning (afternoon). What I am looking at is the continuation of some research I did last year with some teams here, and I am on the final part of this research toward a Ph.D. at the University of Waterloo looking at how teams communicate. What I have is a questionnaire that I need your help to answer, relative to the relationship between your Work Team and the Maintenance group. I selected this particular relationship because it is an important one for the successful performance of your team. Any questions so far about what I am doing? {show overhead of the first page of the Questionnaire}

What I have outlined on the first page is 16 expectations which were mentioned by team members and Maintenance people that I interviewed. So, what I want you to do as a first step is to identify the expectations that you feel are the most important ... in fact I only want the five that you feel are the most important. {Quickly read the 16 statements} Remember, there is no correct answer, only what is important from your experience. So if you could do that now, read though each of the statements and then indicate by a check mark which are the 5 most important. {Put a check mark on the overhead.}

Now, what I would like you to do for the 5 that you checked off, I would like you to rank them from the most important -- being number 1 -- to the fifth most important being number 5. {Put a '1' beside the check mark on the overhead.} Please do that now.

Now, please turn over to the next page. {Show overhead of second page of Questionnaire.} At the top of the page you will see a box that has the numbers 1,2,3,4,5. If you can transcribe the letters from the previous sheet on to this ... for example, the one you chose as number 1, put the letter in that box. {Put a letter in box on overhead.} And the one you chose as number 2, put that letter in the box on the top of the second page. Please do that now for your 5 selections.

The next step is: I would like you to take those numbers ... so for number 1, say you chose 'C', I would like you to put the number 1 in box 'C' below {Put a '1' in box 'C' on overhead.} ... and number 2 being your second choice ... and number 3 etc. Please do that now.

For each of the statements that you have selected, I want you to go through an exercise of indicating where the actual behaviour would fall on this scale. Lets look at letter 'A'. It says: "**A non-emergency work order is given to Maintenance for a service call which can be planned and scheduled within the week.**" There are three questions below this statement. {Point to questions.} I want you to read each one and mark a letter onto the scale ... don't worry, I am going to give you an example, but basically the three questions are: "(1) How often does this actually happen?" and you would mark a letter '**A**' on the scale ... the second question is "The Work Team and Maintenance agree on something that will make things better ... mark a '**B**' [on the scale] where this might be."

And the third question is "Someone tells you that things have gotten worse ... mark a 'W' where you guess this might be now." And on the scale -- {Point to the scale.} -- it gives the numbers one to ten, zero being "never" and ten being "always" ... and then in between the words "some of the time" ... "half the time" ... and "most of the time."

So, let's go through an example which I made up ... I call it the Donut shop example. {Show overhead of Donut Example.} I will go through how I did this example. Now the reason that I am spending so much time going through this is that I need to get a fairly accurate measurement so I need you to be very careful when you put the letters on to the scale, so that I can capture the information as accurately as possible.

Lets look at the donut shop example. This is any donut shop you might happen to go into, and as you can see we have similar kinds of expectation statements about how successful donut shops operate. Two of the choices are shown here ... the number 1 choice was 'B' and the number 2 choice was 'A', etc. {Point to box at top right of overhead.} So we will go through 'A' and it says: "When I arrive at any donut shop for coffee, my order is taken within 2 minutes." And it asks, "(1) how often does this actually happen" and to mark an 'A'. Now I am saying that when I go into a donut shop this actually happens most of the time, so I give it a score of '8' and I put a letter 'A' there. {Point to 'A' on scale.} And then the second question says: "the servers and management agree on something that makes things better" so mark a 'B' where this might be. So I am saying that things have gotten better on my order being taken within 2 minutes, so I am saying it is happening more often, probably at a '9'... so I have marked a 'B' there. {Point to 'B' on scale.}. And then the last one, question three is, "someone tells you that things have gotten worse, mark a 'W' where you guess this might be now." So, I am use to a certain level of service, and now things are worse, so I feel my order will be taken within 2 minutes ... some of the time, around a 3, I mark a 'W'. {Point to 'W' on scale.}. So that is the statement 'A'.

So that's what I want to do for the ones that you have marked. If you can go through each of the 5 that you indicated as being important in the relationship between your team and the Maintenance group. Just those 5, ignore the other ones. And go through each of the three questions, and if you have any problems, let me know. Do you have any questions before you start? OK, please start.

Work Team and Maintenance Function Rankings

Select the 5 most important statements about what to do or not do for the list below; then rank them from 1 "highest" to 5. These selections are then to be transferred to the next sheet.

☐ A. A non-emergency work order is given to Maintenance for a service call which can be ***planned & scheduled*** within the week.

☐ B. A work order is given to Maintenance for a repair which should have been done ***by the Work Team.***

☐ C. A work order which should have been done by this Maintenance shift, but passed on to the ***next shift's*** Maintenance.

☐ D. An emergency work order is completed and given to Maintenance to repair a machine. Maintenance arrives in ***1/2*** hour.

☐ E. A work order is completed and ***clearly describes*** the problem and it's location on the machine.

☐ F. An emergency work order is given to Maintenance, they come, fix it, and the repair to the machine is done in ***less than*** 1 hour.

☐ G. A work order is given to Maintenance, they fix the machine, and they leave a ***mess behind*** when they are finished.

☐ H. Maintenance arrives to repair a machine, and the machine is ***clean*** of all tools, parts, chips and oil.

☐ I. Maintenance repairs a machine, and stays at the machine ***until*** it is tested by a team member and successfully cycles.

☐ J. A work order is completed, Maintenance arrives to repair a machine, a team member is ***standing by*** to explain and help.

☐ K. Maintenance is repairing a machine, and stops ***before completion*** to get a coffee, or talk, or go for a break.

☐ L. Maintenance arrives to repair a machine, and the fault indicators have been ***reset*** by the Work Team.

☐ M. Maintenance completes repairing a machine, and has to wait for an operator to verifie that it works.

☐ N. Maintenance is repairing a machine, and a team member ***criticizes*** the Maintenance person or work being done.

☐ O. Maintenance is repairing a machine, and the Maintenance person ***criticizes*** a team member or the broken machine.

☐ P. Maintenance has repaired a machine, and now explains to the operator what the problem was and ***what to do next time*** the problem happens.

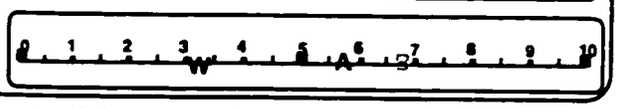
Exhibit 8-1: Example of first page of Questionnaire

Work Team and Maintenance Function Details

For the 5 statements that you ranked on the previous page, put the corresponding letters in this box. Then, place the numbers 1 to 5 in the corresponding boxes below.

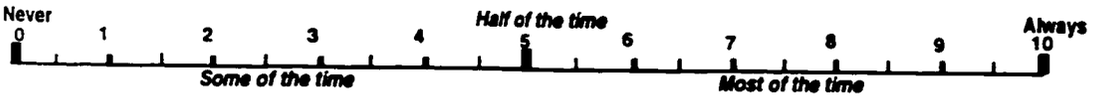
1	2	3	4	5

Then read the three questions for each statement you ranked and mark the scales as shown here.



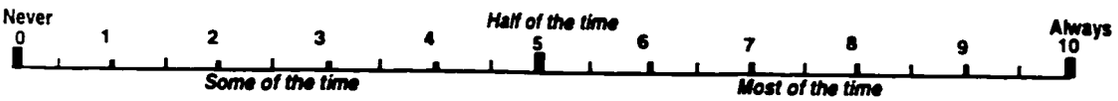
A ***A non-emergency work order is given to Maintenance for a service call which can be planned & scheduled within the week.***

(1) How often does this "Actually" happen? Mark with an "A".
(2) The Work Team and Maintenance agree on something that will make things "Better"... Mark "B" where this might be.
(3) Someone tells you that things have gotten "Worse".. Mark "W" where you guess this might be now.



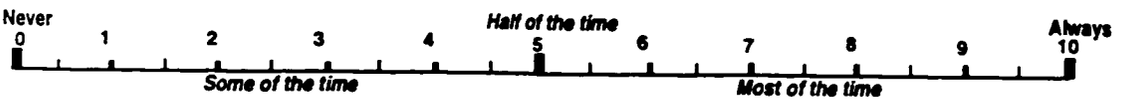
B ***A work order is given to Maintenance for a repair which should have been done by the Work Team.***

(1) How often does this "Actually" happen? Mark with an "A".
(2) The Work Team and Maintenance agree on something that will make things "Better"... Mark "B" where this might be.
(3) Someone tells you that things have gotten "Worse".. Mark "W" where you guess this might be now.



C ***A work order which should have been done by this Maintenance shift, is passed on to the next shift's Maintenance.***

(1) How often does this "Actually" happen? Mark with an "A".
(2) The Work Team and Maintenance agree on something that will make things "Better"... Mark "B" where this might be.
(3) Someone tells you that things have gotten "Worse".. Mark "W" where you guess this might be now.



D ***A work order is completed and given to Maintenance to repair a machine. Maintenance arrives in 1/2 hour.***

(1) How often does this "Actually" happen? Mark with an "A".
(2) The Work Team and Maintenance agree on something that will make things "Better"... Mark "B" where this might be.
(3) Someone tells you that things have gotten "Worse".. Mark "W" where you guess this might be now.

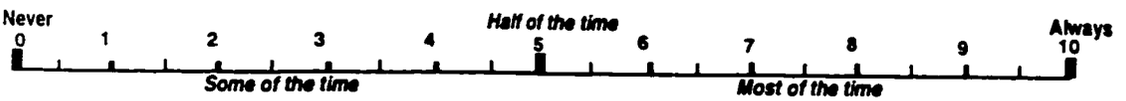
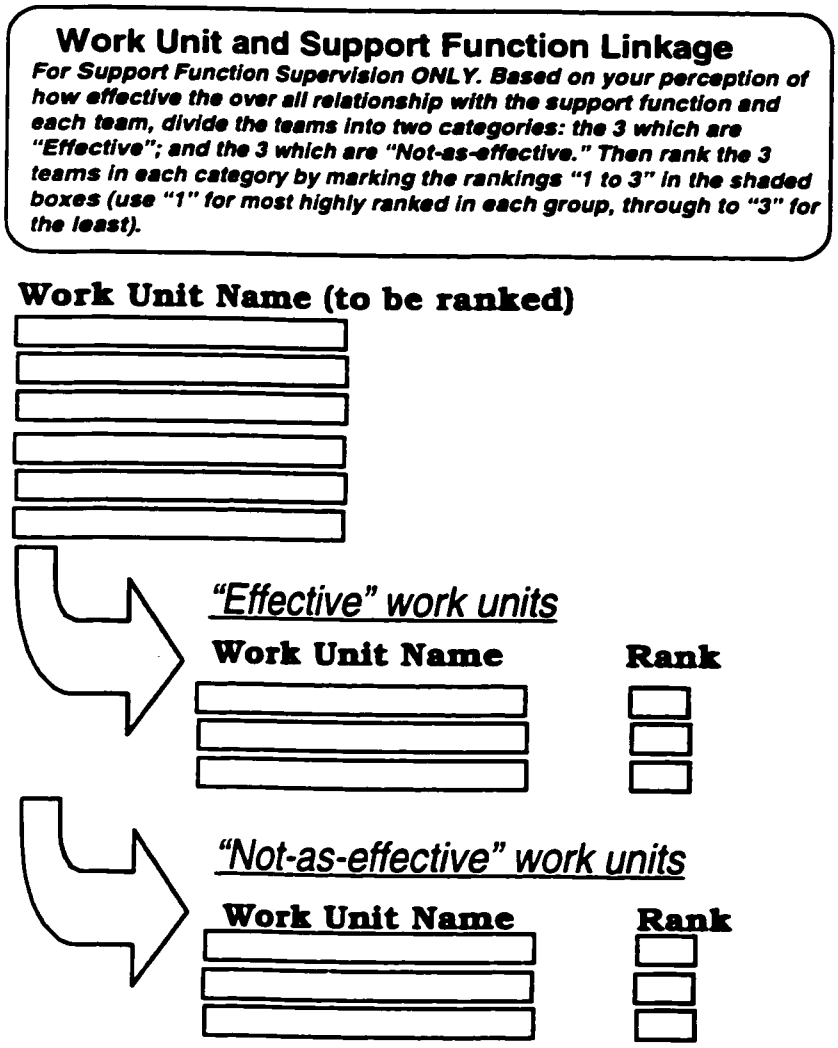


Exhibit 8-2: Example of second page of Questionnaire

8.4 Questionnaire for Support Management



8.5 Logic of Calculation

8.5.1 Overview of the Consistency of the Linkage Formula

The Perceived Consistency of a Linkage (**C**) formula provided a score based on the expectations that define the relationship, the task situation, between a Work Unit and a Support Group. It was broken into three components or 'levels' of inter-group consistency, each level representing a more refined view. These three components were aggregated so that for each Work Unit and Support Group pair the Consistency of the linkage was represented by the **C-formula.**

Consistency of a Linkage (**C**) { Concept of Importance ($\mathbf{C_1}$); ➥ Concept of Priority ($\mathbf{C_2}$); ➥ Concept of Acceptability ($\mathbf{C_3}$).

That is, for $\mathbf{C_1}$ the Work Unit and Support Group were each selecting from the Questionnaire the expectations, from their point-of-view, that they consider important in their linkage. That is, the expectations about what were 'good' or 'not-so-good' behaviours for the Work Unit or Support Group to do. Together these selections point to their agreement on which behaviours should (not) be done. The extent to which the Work Unit and Support Group agree, were consistent, they will do the same actions more often and the linkage will be more effective.

➥ C_2 requires more than mere selection of a set of expectations, it requires that the Work Unit and Support Group place a valuation on the expectations -- which expectations do they place higher worth? The priority that they assign to an expectation was indicative of how often it will (not[1]) occur. Together these selections indicate their agreement on which of the alternative behaviour responses will be drawn upon first. The extent to which they were consistent they will do the appropriate response and the effectiveness of the linkage will be better.

➥ C_3 looks at the selected expectations in a different way. It asks the Work Unit and Support Group how often does the behaviour actually occur, with a view to their account of the 'reality' of the task situation. Together these selections indicate their agreement on the expectation-response cycle and a range of behaviours that were (not) acceptable. That is, they will do the expected actions more exactly and the effectiveness of the linkage will be better.

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[1] For instance, Positive expectations were desired to happen more often: "An emergency work order was completed and given to Maintenance to repair a machine. Maintenance arrives in 1/2 hour."; Negative expectations were desired to happen less often: "A work order was given to Maintenance, they fix the machine, and they leave a mess behind when they were finished."

8.5.2 Introduction to the Logic of the Consistency of the Linkage Formula

All of the results presented in the case study sections 5.3 and 5.4 were based on responses by the persons[2] in the six Work Units and their mutual Support Group (see Figure 8-1) to a Questionnaire that contained a set of linkage specific expectations. The expectations came from interviews in which members from an effective Work Unit and their Support Group identified expectations that reflected good or not-so-good behaviours to do in their linkage.

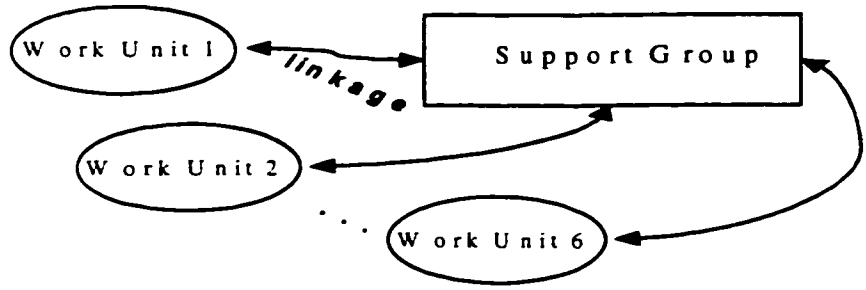

Figure 8-1: Linkages between Work Units and their Support Group

Each of the components (C_1, C_2 and C_3) of the Perceived Consistency of the Linkage (C) involved an 'average' over the combinations of Work Unit and Support Group persons that made up a linkage[3] (see Figure 8-2). That is, in deriving a quantitative representation it was recognized that the Work Unit and Support Group did not have expectations of their own, they are the composite of the expectations of the persons who were members of both groups. Each member of a Work Unit interacted, to some extent, with one or more members of their Support Group such that there was a paired-agreement on the expectations.

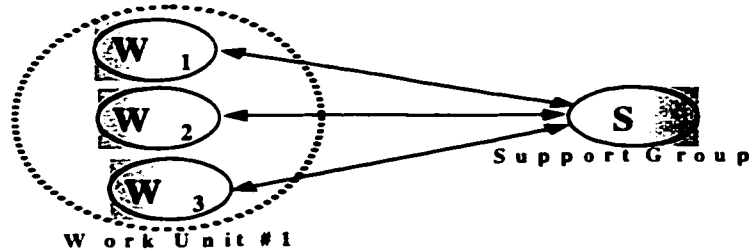

Figure 8-2: Combinations of Work Unit and Support Group persons

Each of the sub-sections that follow builds on this understanding and presents the course of thought for the calculations (complete details on the derivations are available in the

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[2] Participants were selected by the site management.

[3] In this research the case study data was collected for three members in each of the six Work Units and one Support Group person. This was all of the employee involvement that would be allowed by the site management.

Model section). That is, they show the method for the calculation of the Perceived Consistency of a Linkage (C), starting with the computation of each of the three terms (C_1 to C_3) using actual data. The complete data sets and calculations for Company A and B are given in Appendix 8.6 and 8.7 respectively.

8.5.3 Concept of Importance (C_1)

$$C_1 = \frac{2n - (Ave_1 + Dev_1/\delta_1)}{n}$$

$$Dev_1 = \frac{\sum_{s=1}^{S}\sum_{w=1}^{W}\left|Ave_1 - \sum_{e=1}^{E}\{S_{es}+W_{ew}-S_{es}W_{ew}\}\right|}{s * w}$$

Ranked data for one Work Unit is presented in Table 8-1. The left column gives the 16 expectations from the Questionnaire, the next columns are the rankings (1 being the highest rank) of these expectations by the Support Group member and the three Work Unit persons.

Work Unit 1 Expectation Number	Data			
	Support	Work Unit		
	1	1	2	3
A				
B				
C				
D		3		
E		2	1	2
F	4		4	1
G				
H				
I	2	4	2	4
J	1	5	5	
K				5
L	3			
M				
N				
O				
P	5	1	3	3

Table 8-1: Ranked Expectations for Support Group and Work Unit

The corresponding Importance matrix in shown at the left of Table 8-2, with the Average (Ave_1) calculation shown at the right. The Importance matrix cells are populated with a '1' if the expectation has been given a rank by the Support Group or Work Unit, 0 otherwise. For example, expectation 'F' was ranked 4 by the Support Group; 4 by Work Unit person 2; and 1 by Work Unit person 3.

Importance	Support	Work Unit			Ave		S-W1	S-W2	S-W3	
	1	1	2	3						
A						A				
B						B				
C						C				
D		1				D	1			
E		1	1	1		E	1	1	1	
F	1		1	1		F	1	1	1	
G						G				
H						H				
I	1	1	1	1		I	1	1	1	
J	1	1	1			J	1	1	1	
K				1		K			1	
L	1					L	1	1	1	
M						M				
N						N				
O						O				
P	1	1	1	1		P	1	1	1	6.667

Table 8-2: Importance Matrix and Average Matrix

In this example, there are three combinations of the Support Group member and the three Work Unit persons -- called S-W1, S-W2 and S-W3. The cells in the Average matrix are populated using the $\{S_{es} + W_{ew} - S_{es}\, W_{ew}\}$ portion of the $\mathbf{Ave_I}$ formula, such that, expectation 'F' was selected by at least one person from the Support Group and/or Work Unit so all expectation 'F' cells have a value of '1'. The value of $\mathbf{Ave_I}$ is given as 6.667. Table 8-3 gives the deviation calculation ($\mathbf{Dev_I}$) and the value for this example of $\mathbf{C_I}$. The deviation is used as a tie breaker and is the scatter of the three combinations of the Support Group member and the three Work Unit persons -- S-W1, S-W2 and S-W3 -- from the average $\mathbf{Ave_I}$. In this example, the combination S-W1 deviates .333 from the average, and the 'average' deviation for all three combinations is $\mathbf{Dev_I}$ which has a value of .444.

Dev		S-W1	S-W2	S-W3	
		0.333	0.667	0.333	0.444
C_I	0.666				

Table 8-3: Deviation and Concept of Importance

Putting the values of $\mathbf{Ave_I} = 6.667$ and $\mathbf{Dev_I} = .444$ into the formula for *Concept of Importance* gives a value of $\mathbf{C_I} = .666$ (note that $\delta = 100$ was used for the case studies).

8.5.4 Concept of Priority (C2)

$$C_2 = \frac{(Ave_2 + Dev_2/\delta_2)}{\sum_{(i)^2}^{n}}$$

$$Ave_2 = \frac{\sum_{s=1}^{S}\sum_{w=1}^{W}\sum_{e=1}^{E}\{PS_{es} * PW_{ew}\}}{s * w}$$

$$Dev_2 = \frac{\sum_{s=1}^{S}\sum_{w=1}^{W}\left|Ave_2 - \sum_{e=1}^{E}\{PS_{es} * PW_{ew}\}\right|}{s * w}$$

Ranked data from Table 8-1 for the Work Unit has been converted into priorities and is presented in Table 8-4. The left column gives the 16 expectations from the Questionnaire, the next columns are the priorities of these expectations by the Support Group member and the three Work Unit persons. The rank of '1' has been given a priority-weight of 5, ... , the rank of '5' has been given a priority-weight of 1. For example, expectation 'F' was ranked 4 by the Support Group and is given a priority-weight of 2; ranked 4 by Work Unit person 2 and is given a priority-weight of 2; and 1 by Work Unit person 3 and is given a priority-weight of 5.

Work Unit 1	Data			
Expectation	Support	Work Unit		
Number	1	1	2	3
A				
B				
C				
D		3		
E		4	5	4
F	2		2	5
G				
H				
I	4	2	4	2
J	5	1	1	
K				1
L	3			
M				
N				
O				
P	1	5	3	3

Table 8-4: Ranked Expectations converted to Priority-weights

The corresponding Priority matrix is shown in Table 8-5, with the calculated Average ($\mathbf{Ave_2}$) shown in the bottom right box. In this example, there are three combinations of the Support Group member and the three Work Unit persons -- called S-W1, S-W2 and S-W3. The cells in the Priority matrix are populated using the $\{\mathbf{PS_{es}} * \mathbf{PW_{ew}}\}$ portion of the $\mathbf{Ave_2}$ formula, such that, an expectation must be selected by both the Support Group and one or more of the Work Units. In this example, expectation 'F' was selected by both the Support Group and Work Unit persons 2 & 3. That is, expectation 'F' was prioritized (ranked) so the 'S-W2' and 'S-W3' cells have values of (2 * 2 =) 4 and (2 * 5 =) 10 respectively. The value of $\mathbf{Ave_2}$ is given as 22.33.

AVERAGE

	S-W1	S-W2	S-W3	
A				
B				
C				
D				
E				
F		4.00	10.00	
G				
H				
I	8.00	16.00	8.00	
J	5.00	5.00		
K				
L				
M				
N				
O				
P	5.00	3.00	3.00	22.33

Table 8-5: Priority Matrix Average

Table 8-6 gives the deviation value ($\mathbf{Dev_2}$) in the upper box and the valuation for this example of $\mathbf{C_2}$. The deviation is used as a tie breaker and is the scatter of the three combinations of the Support Group member and the three Work Unit persons -- S-W1, S-W2 and S-W3 -- from the average $\mathbf{Ave_2}$. In this example, the combination S-W1 deviates 4.33 from the average, and the 'average' deviation for all three combinations is $\mathbf{Dev_2}$ which has a value of 3.78.

	S-W1	S-W2	S-W3	
DEVIATION	4.33	5.67	1.33	3.78
$\mathbf{C_2}$	0.407			

Table 8-6: Deviation and Concept of Priority

Putting the values of $\mathbf{Ave_2} = 22.33$ and $\mathbf{Dev_2} = 3.78$ into the formula for *Concept of Priority* gives a value of $\mathbf{C_2} = .407$ (note that $\delta = 100$ was used for the case studies).

8.5.5 Concept of Acceptability (C3)

$$C_3 = \frac{\sum_{s=1}^{S} \sum_{w=1}^{W} \sum_{e=1}^{E} S_{es} W_{ew} (1 - |AW_{ew} - AS_{es}|/10)}{S * W}$$

The expectation range data for the Support Group and the three Work Units is presented in Table 8-7. The left column gives the 16 expectations from the Questionnaire; the next sets of columns give the range data for the Support Group (S1) and the three Work Unit persons (W1 to W3). The 'Range' is defined by the landmarks called 'Actual, Better & Worse' which were marked on a ten-point scale in the Questionnaire, see Figure 8-3, by the participants. For example, the expectation 'F' was given an actual value of (AS_{F1} =) 6 by the Support Group member; an actual value of (AW_{F2} =) 7 by the Work Unit 2 person; and an actual value of (AW_{F3} =) 6.4 by the Work Unit 3 person.

Work Unit 1 Expectation Number	Data											
	Range (S1)			Range (WU1)			Range (WU2)			Range (WU3)		
	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse
A												
B												
C												
D				5	6.9	2						
E				7	8.9	4	7.5	9.1	5	7.4	5.2	4.2
F	6	5.4	2.5				7	9	4.1	6.4	4.2	5.2
G												
H												
I	9.5	7.5	1	9	9.9	5	8	9.1	5.5	9.4	5.2	1.4
J	8	6	2	5	7.9	3	7.1	9.1	5			
K										3.4	2.7	4.7
L	6	5	1									
M												
N												
O												
P	8	4	1	3	6.8	1	7	9.1	4.5	7.7	5.7	4.2

Table 8-7: Expectation Ranges for Support Group and Work Unit

Note: Referring to Figure 8-3, the ten-point scale has the two extreme key words of 'never & always' and the intermediate designations 'some of the time, half the time, & most of the time.' The 'landmarks' are plotted based on the questions: (1) How often does this actually happen?"; (2) "The Work Team and Maintenance agree on something that will make things better ... mark a '**B**' [on the scale] where this might be."; and (3) "Someone tells you that things have gotten worse ... mark a '**W**' where you guess this might be now."

An emergency work order is given to Maintenance, they come, fix it, and the repair to the machine is done in less than 1 hour.

(1) How often does this "Actually" happen? Mark with an "A".
(2) The Work Team and Maintenance agree on something that will make things "Better"... Mark "B" where this might be.
(3) Someone tells you that things have gotten "Worse".. Mark "W" where you guess this might be now.

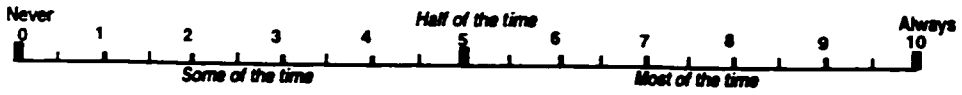


Figure 8-3: Expectation 'F' scale and landmarks

The corresponding Overlap matrix is shown in Table 8-8, with the calculated *Concept of Acceptability* ($\mathbf{C_3}$) shown in the bottom box. In this example, there are three combinations of the Support Group member and the three Work Unit persons -- called S-W1, S-W2 and S-W3. The cells in the Overlap matrix are populated using the $\{\mathbf{1 - | AW_{ew} - AS_{es} | /10}\}$ portion of the $\mathbf{C_3}$ formula, such that, an expectation must be selected by both the Support Group and one or more of the Work Units. Expectation 'F' was selected by both the Support Group and Work Unit persons 2, for instance, so with $\mathbf{AW_{F2}} = 7$ and $\mathbf{AS_{F1}} =$ 6 the value of the S-W2 cell is (1 - | 7 - 6 | /10 =) .90.

Work Unit 1 Expectation Number	Overlap Area		
	S-W1	S-W2	S-W3
A			
B			
C			
D			
E			
F		0.90	0.96
G			
H			
I	0.95	0.85	0.99
J	0.70	0.91	
K			
L			
M			
N			
O			
P	0.50	0.90	0.97
	0.43	0.71	0.58

C3= 0.575

Table 8-8: Overlap Matrix and Concept of Acceptability

Putting the cell values, for this example, from the Overlap Matrix into the formula for the *Concept of Acceptability* gives a value of $\mathbf{C_3} = .575$.

8.5.5.1 Range: Better-Worse vs. Proportional Actual

Better-Worse Range

The model section introduces the concept of a range of acceptable responses and landmarks *'better, worse & actual'* that define the range. As is presented in the discussion section, there were interpretation problems by the operators that answered the questionnaire. That is, the Work Unit and Support Group employees had no problem in determining the Actual frequency of occurrence of the expectations they selected. However, the workers did have some interpretation problems when it came to the Better and Worse frequencies. One view of this is that the operators did not have the training or experience in dealing with complex context relationships, for example the Actual compared to Better frequency, and the concept of ratios in general.

Relative Actual Range

This research uses a proportional or what will be called a Relative Actual Range for this discussion, as expressed in the formula through the variables $\mathbf{AW_{ew}}$ - $\mathbf{AS_{es}}$, rather than a Better-Worse Range. This is because a Relative Actual Range is a similar estimate, as will be shown below, but it also may provide more reliability. For instance, the Work Unit and Support Group employees had no problem in determining the Actual frequency of occurrence of the expectations they selected, which was not always the case for the other 'landmarks'.

From the range data collected at the two sites from the Questionnaires there was 240 range samples[4] available. The Questionnaire contained positive and negative expectations, and the outcome from the two sites was 201 positive (84%) and 39 negative range samples selected by the participants. Of the positive range samples, 176 (88%) are in 'natural' order and 25 are in 'reverse' order, see Figures 7-4 and 7-5 respectively, where 'A' is the actual, 'W' is the worse landmark, and 'B' is the better landmark as described in the model section.

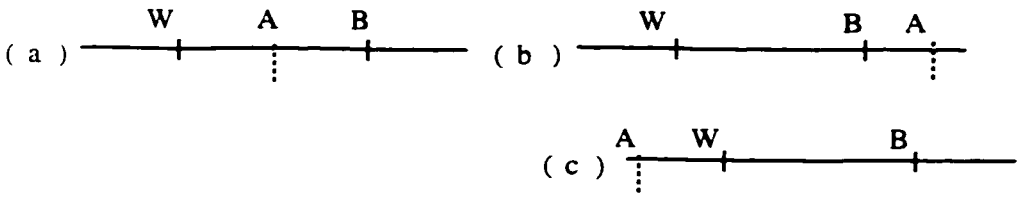


Figure 8-4: Natural order positive ranges

[4] ((one Support person + three Work Unit persons) * five expectations selected by each person) * six teams at each site * two sites = ((1 + 3) * 5) * 6 * 2 = 240.

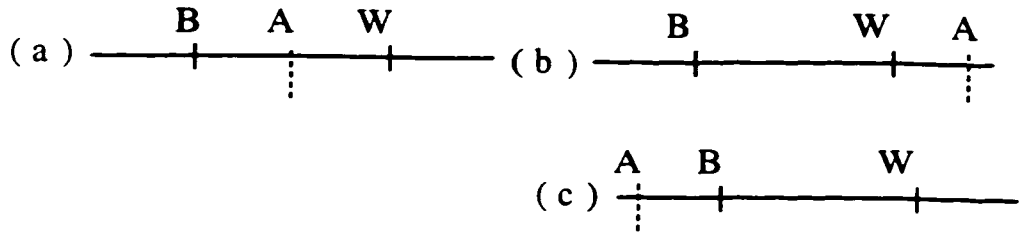


Figure 8-5: Reverse order positive ranges

This research assumes the two characteristics below for a 'range', for example, for **positive** expectations:

(i) Natural Order. The Better landmark is higher on the scale than the Worse landmark. That is, 'better' indicates that an expectation will happen more often.

(ii) In-range Actual. The Actual is between the Better and Worse landmarks. That is, 'better' indicates that an expectation will happen more often than the in-range Actual. Referring to Figure 8-4, (a) is in-range, while (b) & (c) have the Actual outside the range.

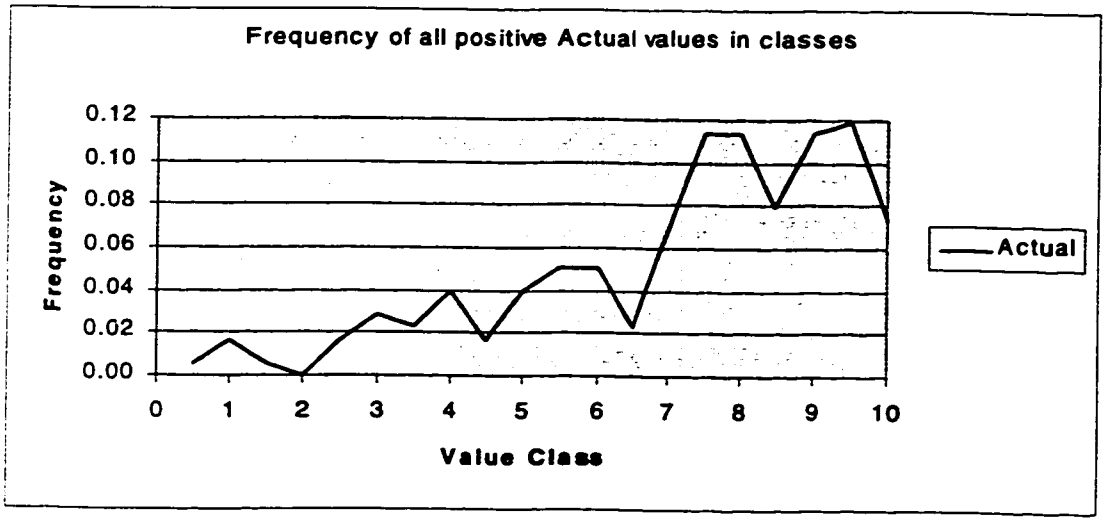


Figure 8-6: All Natural Order Actual values

It is proposed that the 176 'natural order Actual' samples can be reasonably represented by 96 (55%) '***in-range*** natural order Actual' samples.

The chart in Figure 8-6 shows the number of occurrences of 'natural order Actual' values in 0.5 classes from the Questionnaire scale. For instance, for the class 4 (values

from 3.51 to 4.00) there were 7 positive natural order Actual samples, or about 4% of all 176 positive natural order Actual samples. From the chart in Figure 8-7, about 50% of the values fall into value classes of 7.5 or more.

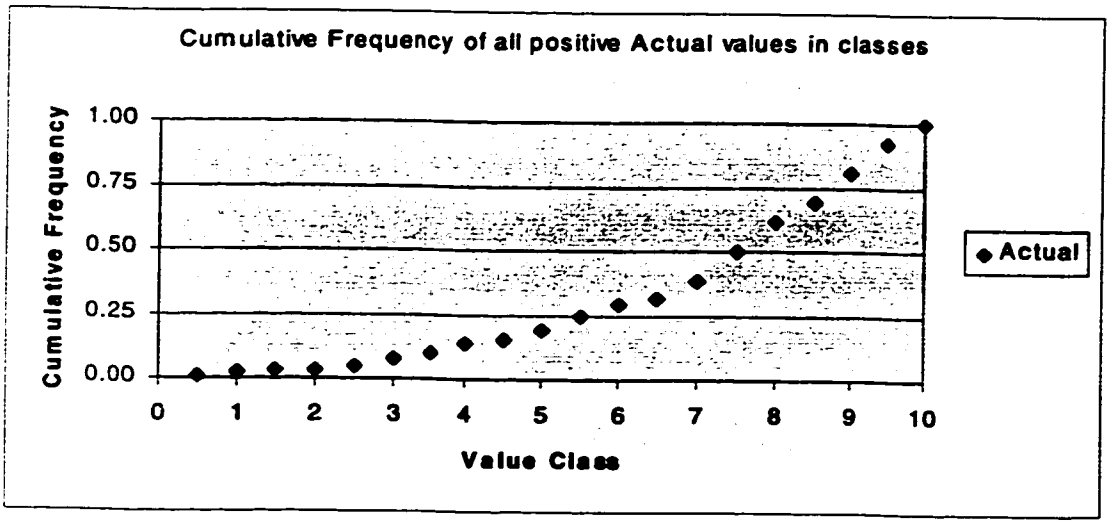


Figure 8-7: Frequencies for All positive natural order Actual values

In a similar way, the chart in Figure 8-8 shows the number of occurrences of 'in-range natural order Actual' values in 0.5 classes from the Questionnaire scale. For instance, for the class 4 (values from 3.51 to 4.00) there were 4 positive in-range natural order Actual samples, or about 4% of the 96 positive in-range natural order Actual samples. From the chart in Figure 8-9, about 50% of the values fall into value classes of 7.5 or more.

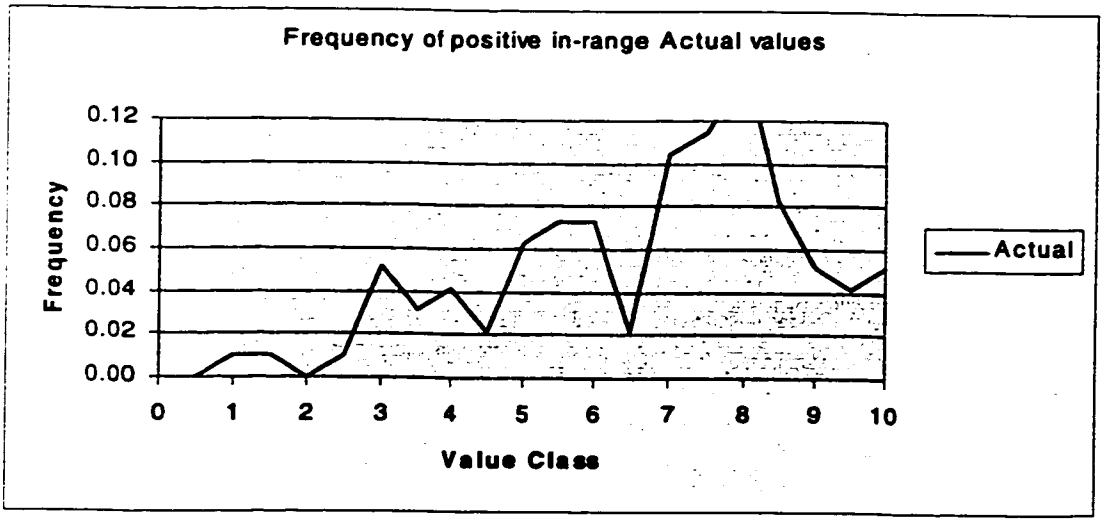


Figure 8-8: In-range Natural Order Actual values

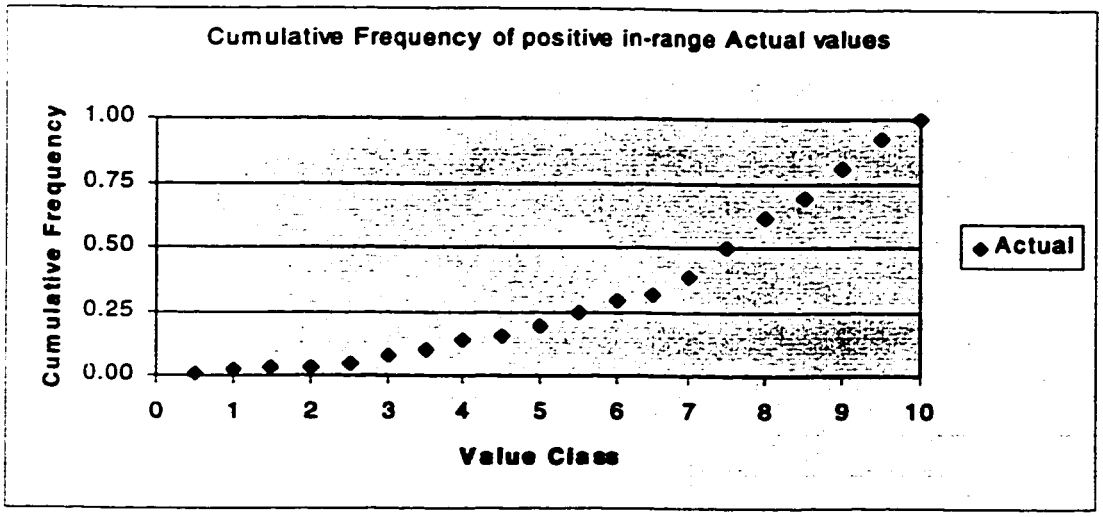


Figure 8-9: Frequencies for positive in-range natural order Actual values

Using the CORREL[5] Excel spreadsheet function, the correlation coefficient for both of the frequency arrays from Figures 7-6 & 7-8 is 75.6%, and for the cumulative arrays from Figures 7-7 & 7-9 is 98.9%. It is assumed, for this discussion, that the range samples from the sub-set of *positive in-range natural order Actual* samples can be used to represent all *positive natural order Actual samples.*

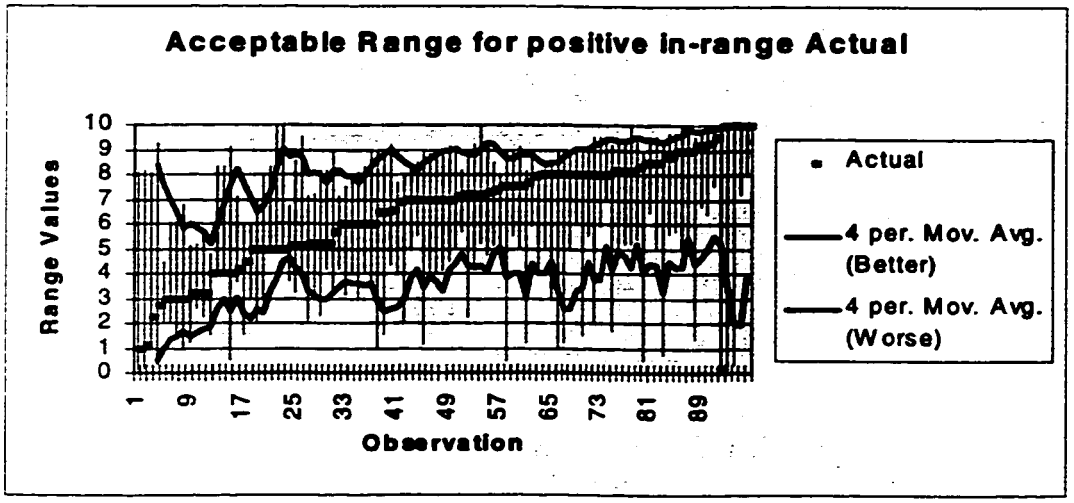


Figure 8-10: Acceptable Ranges for positive in-range Actuals

The charts in Figure 8-10 shows the 96 *positive in-range natural order Actual* samples along the X-axis. The Y-axis gives the range values for a certain expectation in 'stock market' format: Actual, Better and Worse. The range values come from the Questionnaire

[5] Returns the correlation coefficient of the array1 and array2 cell ranges to determine the relationship between two properties.

scale as selected by a Support or Work Unit person. For instance, expectation #9 has Actual = 3.2; Better = 5.1; and Worse = 1.2. The top chart shows a 4-sample moving average for the Better points (green line) and the Worse points (red line). It can be seen that as the Actual (blackened points) approaches the end of the scale at '10' (0) the range value for Better (Worse) gets closer to the Actual, and the range value for Worse (Better) gets further away.

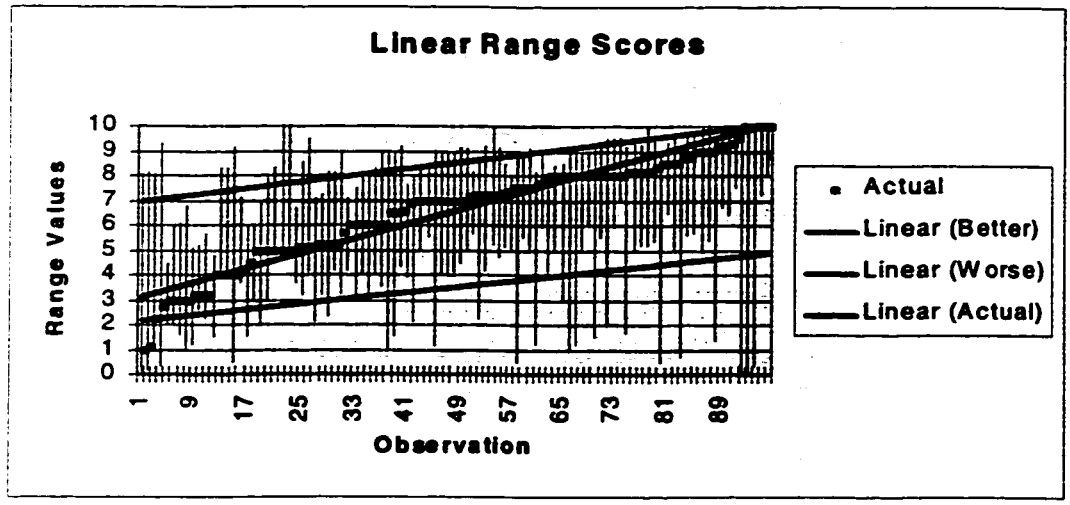


Figure 8-11: Acceptable Ranges linear trend representation

This is also represented in the Figure 8-11 chart by the linear trend lines. Thus, as the Actual value approaches the extreme end of the Questionnaire scale there is more or less opportunity to place the other landmarks on the scale.

To illustrate the calculation of the range overlap using the Better and Worse values see Figure 8-12. There are three cases selected from the bottom chart of Figure 8-11, with the corresponding Better and Worse values, vis:

(Case #1) Actual = 3; Better = 7; and Worse = 2.2;
(Case #2) Actual = 4; Better = 7.2; and Worse = 2.6;
(Case #3) Actual = 7; Better = 8.8; and Worse = 3.6.

Each case is normalized so that the Actual = 0 and the Better and Worse values assume their relative values. There are two examples of the overlap calculation using the Better and Worse, the first being of two Actuals close together (A=3, A=4); and the second of two Actuals far apart (A=4, A=7). The overlap area is shown in gray.

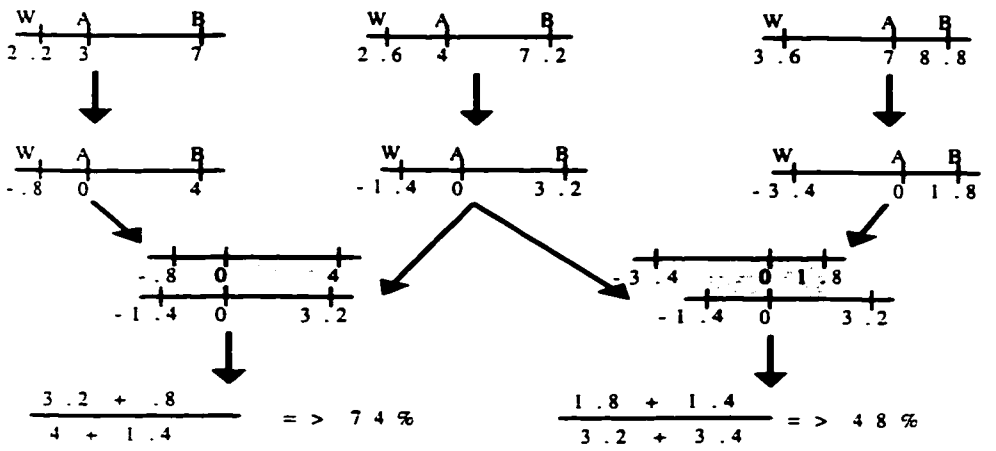


Figure 8-12: Overlap calculation using Better and Worse

In can be seen that when Actuals are close together (A=3, A=4) there is a large percentage of overlap; and then Actuals are far apart (A=4, A=7) there is a smaller percentage of overlap. This proportionate nature of the ranges is what the Relative Actual Range aspect of the C_3 formula is capturing.

8.5.6 Perceived Consistency of the Linkage (C)

$$C = \frac{\sqrt{[w_1 C_1]^2 + [w_2 C_2]^2 + [w_3 C_3]^2}}{\sqrt{[w_1]^2 + [w_2]^2 + [w_3]^2}}$$

The consistency of the linkage data, between the Support Group and the six Work Units, is presented in Table 8-9. Note that this matrix is based on the use of the 'actual' only for the range calculation of C_3 as presented in the previous sub-section. The six Work Units are indicated as WU1 to WU 6 across the top. The left column gives:

- C_1 → the Concept of Importance
- C_2 → the Concept of Priority
- C_3 → the Concept of Acceptability
- **C(111)** → Consistency of the Linkage, using weights $w_1=1$; $w_2=1$; and $w_3=1$
- **C(131)** → Consistency of the Linkage, using weights $w_1=1$; $w_2=3$; and $w_3=1$

		WU 1	WU 2	WU 3	WU 4	WU 5	WU 6	Weight
Actual	C1	0.666	0.399	0.466	0.466	0.531	0.399	1
	C2	0.407	0.400	0.377	0.474	0.353	0.238	3
	C3	0.575	0.262	0.313	0.386	0.404	0.269	1
	C(111) =	0.560	0.623	0.676	0.769	0.755	0.537	
	C(131) =	0.454	0.390	0.381	0.466	0.378	0.259	

Table 8-9: Six Work Units' *Consistency of the Linkage*

In the example for Work Unit 1 (WU1) the cell values of C_1 = .666, C_2 = .407, C_3 = .575 and the corresponding weights are put, from the Table 8-9 Matrix, into the formula for the *Consistency of the Linkage* and gives a value of **C(111)** = .560 and **C(131)** = .454.

8.5.6.1 Weights and Matches

This sub-section provides an explanation of the weights C(131) selected for the Perceived Consistency of the Linkage formula $C(w_1; w_2; w_3)$ and reported on in the Results section.

Various weight values, as presented in Table 8-10, were selected to cover an array of possibilities (w_i = 1, ..., 4). The corresponding C-formula scores were calculated for Company A, using the Strict and Relaxed situations to access matches.

	Company A		Company B	
	Strict	Relaxed	Strict	Relaxed
C(111) =				
C(211) =	2	4	4	4
C(311) =	2	4	4	4
C(411) =	2	4	4	4
C(121) =	2	3	4	4
C(131) =	2	5	4	4
C(141) =	2	5	4	4
C(112) =	2	4	4	4
C(113) =	1	4	4	4
C(114) =	1	4	4	4
C(221) =	2	3	4	4
C(331) =	2	3	4	4
C(441) =	2	3	4	4
C(212) =	2	4	4	4
C(313) =	2	4	4	4
C(414) =	2	4	4	4
C(122) =	2	3	4	4
C(133) =	2	3	4	4
C(144) =	2	3	4	4

Table 8-10: Weights and Matches

This was done because Company A had Work Unit scores closer together on average than Company B, with the consequence that Company A had $\mathbf{C_i}$ values with less variance (see Appendix 8.8.1 which show that Company A has less score variance). By varying the weights from $\mathbf{C}(w_1=1; w_2=1; w_3=1)$ to $\mathbf{C}(w_1=1; w_2=3; w_3=1)$ a better match rate was achieved for Company A, from 2 matches to 5 when the near-tie criteria was removed. However, the performance for Company B did not improve, for the same weights, beyond 4 matches in the Relaxed situation.

There was not enough data to fully explore their values and significance. However, one explanation of the results can be offered. When Work Units are very close together in performance, as was the case for Company A, there is a need for more discrimination in the formula to rank the linkages. On the other hand, the weights have less merit when the Work Units are already very different, as was the case for Company B.

8.6 Company A data

8.6.1 Company A Data: C_1

WU 1

Data

Expectation Number	Support	Work Unit 1	Work Unit 2	Work Unit 3
	1			
A				
B				
C				
D		3		
E		2	1	2
F	4		4	1
G				
H				
I	2	4	2	4
J	1	5	5	
K				5
L	3			
M				
N				
O				
P	5	1	3	3

Importance

	Support 1	Work Unit 1	Work Unit 2	Work Unit 3
A				
B				
C				
D		1		
E		1	1	1
F	1		1	1
G				
H				
I	1	1	1	1
J	1	1	1	
K				1
L	1			
M				
N				
O				
P	1	1	1	1

Ave

	S-W1	S-W2	S-W3
A			
B			
C			
D	1		
E	1	1	1
F	1	1	1
G			
H			
I	1	1	1
J	1	1	1
K			1
L	1	1	1
M			
N			
O			
P	1	1	1 [6.67]

Dev

S-W1	S-W2	S-W3	
0.333	0.667	0.333	[0.44]

Importance 0.666

WU 2

Data

Expectation Number	Support 1	Work Unit 1	Work Unit 2	Work Unit 3
A	3			
B				
C		1		
D			1	1
E		4		
F	2			
G				5
H				
I	1	2	2	3
J		5	4	
K				
L		3		
M	4			4
N				
O			5	
P	5		3	2

Importance

	Support 1	Work Unit 1	Work Unit 2	Work Unit 3
A		1		
B				
C			1	
D				1 1
E			1	
F	1			
G				1
H				
I	1	1	1	1
J		1	1	
K				
L			1	
M	1			1
N				
O			1	
P	1		1	1

Ave

	S-W1	S-W2	S-W3
A	1	1	1
B			
C	1		
D		1	1
E	1		
F	1	1	1
G			1
H			
I	1	1	1
J	1	1	
K			
L	1		
M	1	1	1
N			
O		1	
P	1	1	1 [8]

Dev

S-W1	S-W2	S-W3	
1		1	[0.667]

Importance 0.399

WU 3

Data

Expectation Number	Support	Work Unit		
	1	1	2	3
A	3			
B				
C			4	3
D				
E		4	1	
F			2	
G				
H	1			4
I	2	1	5	2
J		5		
K		3		5
L	4			
M				
N				
O				
P	5	2	3	1

Importance

	Support	Work Unit		
	1	1	2	3
A	1			
B				
C			1	1
D				
E		1	1	
F			1	
G				
H	1			1
I	1	1	1	1
J		1		
K		1		1
L	1			
M				
N				
O				
P	1	1	1	1

Ave

	S-W1	S-W2	S-W3	
A	1	1	1	
B				
C		1	1	
D				
E	1	1		
F		1		
G				
H	1	1	1	
I	1	1	1	
J	1			
K	1		1	
L	1	1	1	
M				
N				
O				
P	1	1	1	7.6667

Dev

S-W1	S-W2	S-W3	
0.333	0.333	0.667	0.4444

Importance 0.466

WU 4

Data

Expectation Number	Support	Work Unit		
	1	1	2	3
A		5		
B				
C			4	
D	2			
E	4		2	
F		4		4
G			1	
H	5			2
I	1	3	5	1
J	3	2		3
K				
L			3	
M				
N				
O				
P		1		5

Importance

	Support	Work Unit		
	1	1	2	3
A		1		
B				
C			1	
D	1			
E	1		1	
F		1		1
G			1	
H	1			1
I	1	1	1	1
J	1	1		1
K				
L			1	
M				
N				
O				
P		1		1

Ave

	S-W1	S-W2	S-W3	
A	1			
B				
C		1		
D	1	1	1	
E	1	1	1	
F	1		1	
G		1		
H	1	1	1	
I	1	1	1	
J	1	1	1	
K				
L		1		
M				
N				
O				
P	1		1	7.6667

Dev

S-W1	S-W2	S-W3	
0.333	0.333	0.667	0.4444

Importance 0.466

WU 5

Data

Expectation Number	Support	Work Unit		
	1	1	2	3
A				
B				5
C		3		
D			2	
E	1		3	
F	3		5	1
G		4		
H				
I	4		4	2
J	2			
K		5		
L				
M				
N				
O		2		4
P	5	1	1	3

Importance

	Support	Work Unit		
	1	1	2	3
A				
B				1
C		1		
D			1	
E	1		1	
F	1		1	1
G		1		
H				
I	1		1	1
J	1			
K		1		
L				
M				
N				
O		1		1
P	1	1	1	1

Ave

	S-W1	S-W2	S-W3	
A				
B			1	
C	1			
D		1		
E	1	1	1	
F	1	1	1	
G	1			
H				
I	1	1	1	
J	1	1	1	
K	1			
L				
M				
N				
O	1		1	
P	1	1	1	7.333

Dev

S-W1	S-W2	S-W3	
1.667	1.333	0.333	1.111

Importance 0.531

WU 6

Data

Expectation Number	Support	Work Unit		
	1	1	2	3
A				
B				
C				
D		1	1	
E		3	4	2
F	3		2	
G		5		
H	1			
I	4			4
J	2		5	3
K				5
L				
M		2	3	
N				
O				
P	5	4		1

Importance

	Support	Work Unit		
	1	1	2	3
A				
B				
C				
D		1	1	
E		1	1	1
F	1		1	
G		1		
H	1			
I	1			1
J	1		1	1
K				1
L				
M		1	1	
N				
O				
P	1	1		1

Ave

	S-W1	S-W2	S-W3	
A				
B				
C				
D	1	1		
E	1	1	1	
F	1	1	1	
G	1			
H	1	1	1	
I	1	1	1	
J	1	1	1	
K			1	
L				
M	1	1		
N				
O				
P	1	1	1	8

Dev

S-W1	S-W2	S-W3	
1		1	0.667

Importance 0.399

8.6.2 Company A Data: C_2

with RANKS converted to PRIORITIES-Weights

WU 1

Expectation Number

	Data			
	Support	Work Unit		
	1	1	2	3
A				
B				
C				
D		3		
E		4	5	4
F	2		2	5
G				
H				
I	4	2	4	2
J	5	1	1	
K				1
L	3			
M				
N				
O				
P	1	5	3	3

AVERAGE

	S-W1	S-W2	S-W3	
A				
B				
C				
D				
E				
F		4.00	10.00	
G				
H				
I	8.00	16.00	8.00	
J	5.00	5.00		
K				
L				
M				
N				
O				
P	5.00	3.00	3.00	22.33

DEVIATION	S-W1	S-W2	S-W3	
	4.33	5.67	1.33	3.78

PRIORITY 0.407

WU 2

Expectation Number

	Data			
	Support	Work Unit		
	1	1	2	3
A	3			
B				
C		5		
D			5	5
E		2		
F	4			
G				1
H				
I	5	4	4	3
J		1	2	
K				
L		3		
M	2			2
N				
O			1	
P	1		3	4

AVERAGE

	S-W1	S-W2	S-W3	
A				
B				
C				
D				
E				
F				
G				
H				
I	20.00	20.00	15.00	
J				
K				
L				
M			4.00	
N				
O				
P		3.00	4.00	22.00

DEVIATION	S-W1	S-W2	S-W3	
	2.00	1.00	1.00	1.33

PRIORITY 0.400

with RANKS converted to PRIORITIES-Weights

WU 3

Expectation Number	Data: Support	Work Unit 1	Work Unit 2	Work Unit 3
	1	1	2	3
A	3			
B				
C			2	3
D				
E		2	5	
F			4	
G				
H	5			2
I	4	5	1	4
J		1		
K		3		1
L	2			
M				
N				
O				
P	1	4	3	5

AVERAGE	S-W1	S-W2	S-W3	
A				
B				
C				
D				
E				
F				
G				
H			10.00	
I	20.00	4.00	16.00	
J				
K				
L				
M				
N				
O				
P	4.00	3.00	5.00	20.67

DEVIATION	S-W1	S-W2	S-W3	
	3.33	13.67	10.33	9.11

PRIORITY 0.377

WU 4

Expectation Number	Data: Support	Work Unit 1	Work Unit 2	Work Unit 3
	1	1	2	3
A		1		
B				
C			2	
D	4			
E	2		4	
F		2		2
G			5	
H	1			4
I	5	3	1	5
J	3	4		3
K				
L			3	
M				
N				
O				
P		5		1

AVERAGE	S-W1	S-W2	S-W3	
A				
B				
C				
D				
E		8.00		
F				
G				
H			4.00	
I	15.00	5.00	25.00	
J	12.00		9.00	
K				
L				
M				
N				
O				
P				26.00

DEVIATION	S-W1	S-W2	S-W3	
	1.00	13.00	12.00	8.67

PRIORITY 0.474

with RANKS converted to PRIORITIES-Weights

WU 5

Expectation Number	Data: Support	Work Unit 1	Work Unit 2	Work Unit 3
	1	1	2	3
A				
B				1
C		3		
D			4	
E	5		3	
F	3		1	5
G		2		
H				
I	2		2	4
J	4			
K		1		
L				
M				
N				
O		4		2
P	1	5	5	3

AVERAGE	S-W1	S-W2	S-W3	
A				
B				
C				
D				
E		15.00		
F		3.00	15.00	
G				
H				
I		4.00	8.00	
J				
K				
L				
M				
N				
O				
P	5.00	5.00	3.00	19.33

DEVIATION	S-W1	S-W2	S-W3	
	14.33	7.67	6.67	9.56

PRIORITY 0.353

WU 6

Expectation Number	Data: Support	Work Unit 1	Work Unit 2	Work Unit 3
	1	1	2	3
A				
B				
C				
D		5	5	
E		3	2	4
F	3		4	
G		1		
H	5			
I	2			2
J	4		1	3
K				1
L				
M		4	3	
N				
O				
P	1	2		5

AVERAGE	S-W1	S-W2	S-W3	
A				
B				
C				
D				
E				
F		12.00		
G				
H				
I			4.00	
J		4.00	12.00	
K				
L				
M				
N				
O				
P	2.00		5.00	13.00

DEVIATION	S-W1	S-W2	S-W3	
	11.00	3.00	8.00	7.33

PRIORITY 0.238

8.6.3 Company A Data: C_3

Using Proportional Actual Range

WU 1

Expectation Number	Range (S1)			Range (WU1)			Range (WU2)			Range (WU3)		
	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse
A												
B												
C												
D				5	6.9	2						
E				7	8.9	4	7.5	9.1	5	7.4	5.2	4.2
F	6	5.4	2.5				7	9	4.1	6.4	4.2	5.2
G												
H												
I	9.5	7.5	1	9	9.9	5	8	9.1	5.5	9.4	5.2	1.4
J	8	6	2	5	7.9	3	7.1	9.1	5			
K										3.4	2.7	4.7
L	6	5	1									
M												
N												
O												
P	8	4	1	3	6.8	1	7	9.1	4.5	7.7	5.7	4.2

Overlap Area

S1 & WU1	S1 & WU2	S1 &WU3
	0.9	1.0
1.0	0.9	1.0
0.7	0.9	
50.0%	90.0%	97.0%
43.0%	71.2%	58.4%

C3= 0.575

WU 2

Expectation Number	Range (S1)			Range (WU1)			Range (WU2)			Range (WU3)		
	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse
A	9.2	1.2	2.2									
B												
C				3.7	5.2	2.7						
D							4.2	7	5	5.7	5.2	4.7
E				1.1	3.6	5.7						
F	7.2	2.2	0.3									
G										3.2	3.7	2.7
H												
I	2.2	1.7	0.7	7.7	8.2	1.2	4	6	5.5	8.2	7.7	1.2
J				8.6	7.6	1.2	3	4.5	5.5			
K												
L				7.2	4.3	5.2						
M	7.2	2.2	1.2							1.1	1.6	1.3
N												
O							6	5.5	6.5			
P	3.2	1.7	1.2				4	6	4.5	3.7	1.2	1.7

Overlap Area

S1 & WU1	S1 & WU2	S1 &WU3
0.5	0.8	0.4
		0.4
	92.0%	96.0%
9.0%	34.8%	34.8%

C3= 0.262

WU 3

Expectation Number	Range (S1)			Range (WU1)			Range (WU2)			Range (WU3)		
	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse
A	4	4.8	1.5									
B												
C							2.7	4.2	0.7	4.6	2.4	6.6
D												
E				6	7.5	3.1	6.7	4.6	3.2			
F							7.1	4.8	2.7			
G												
H	1.7	0.7	3.3							3	6.1	1.6
I	9.2	5.2	0.3	8	9.1	1.5	6.7	2.2	3.7	3.2	5.1	1.2
J				5.1	9.5	4.1						
K				5.1	4.1	2.6				6.1	3.6	8.7
L	3.3	2.2	0.7									
M												
N												
O												
P	8.7	1.7	1.2	9.1	5.1	2.1	0.7	2.7	2.2	5.1	8.6	3.2

Overlap Area

S1 & WU1	S1 & WU2	S1 &WU3
		0.9
0.9	0.8	0.4
96.0%	20.0%	64.0%
36.8%	19.0%	38.2%

C3= 0.313

Using Proportional Actual Range

WU 4

Expectation Number	Range (S1)			Range (WU1)			Range (WU2)			Range (WU3)			Overlap Area		
	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse	S1 & WU1	S1 & WU2	S1 &WU3
A				5.1	6.7	3.7									
B							2.2	0.6	4.1						
C															
D	7	4	1				8.7	9.7	5.6					0.9	
E	8	4.5	6												
F				7.1	5.1	3.2	2.3	0.6	3.7	2	2	5			
G															1.0
H	3	4.5	2							3	6	2			
I	9	2	1	9.1	5.1	2.2	9.2	9.8	6.7	1	7	2	1.0	1.0	0.2
J	9	8	1	9.1	5.1	2.2				6	4	5	1.0		0.7
K															
L							5.1	1.1	7.2						
M															
N															
O															
P				5.1	4.1	2.1				2	2.3	2.5			
													39.6%	38.2%	38.0%
													C3=	0.386	

WU 5

Expectation Number	Range (S1)			Range (WU1)			Range (WU2)			Range (WU3)			Overlap Area		
	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse	S1 & WU1	S1 & WU2	S1 &WU3
A															
B										3.2	5.7	1.7			
C				4.5	6.2	3.5									
D							5.2	8.2	4.2					0.9	
E	8.1	3.1	2.1				7.2	8.2	5.7					0.9	1.0
F	6.2	3.2	2.2				5.2	7.2	3.2	6.2	2.6	4.7			
G				5	6.8	3.9								0.4	0.9
H															
I	9.2	3.2	2.1				3.2	5.2	2.6	7.7	5.2	4.7			
J	8.4	2.1	1.7												
K				4	7.5	2.5									
L															
M															
N															
O				4	3	6.5				4.7	1.6	7.2			
P	9.1	4.2	1.2	7.4	8.5	5.1	4.2	7.1	3.7	5.7	2.3	3.3			
													83.0%	51.0%	66.0%
													16.6%	54.4%	50.2%
													C3=	0.404	

WU 6

Expectation Number	Range (S1)			Range (WU1)			Range (WU2)			Range (WU3)			Overlap Area		
	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse	S1 & WU1	S1 & WU2	S1 &WU3
A															
B															
C															
D				4.7	6.7	5.3	8.2	0.7	4.7				1.0	0.7	
E				4.3	4.7	5.8	9.2	8.2	1.2	6	3.5	6.5	1.0	0.5	0.8
F	6.5	2.8	1.1				9.7	5.3	1.2						
G				5.7	4.3	6.7							1.0		
H	6.9	7.7	3.9												
I	9.7	5.9	3.1							8	9	1			
J	7.1	4	2.9				9.7	5.3	0.7	9	8	2			
K										9	0.5	9.5			
L															
M				7.8	1.7	7.2	9.7	8.3	0.2				1.0	0.8	
N															
O															
P	8.2	3.2	3.4	2.2	3.7	4.7				4	3	5			
													100.0%		82.0%
													100.0%	39.4%	33.0%
													C3=	0.575	

8.6.4 Examples of expectations from the Questionnaire

P = Maintenance has repaired a machine, and now explains to the operator what the problem was and what to do next time the problem happens.

I = Maintenance repairs a machine, and stays at the machine until it is tested by a team member and successfully cycles.

F = An emergency work order is given to Maintenance, they come, fix it, and the repair to the machine is done in less than 1 hour.

J = A work order is completed, Maintenance arrives to repair a machine, a team member is standing by to explain and help.

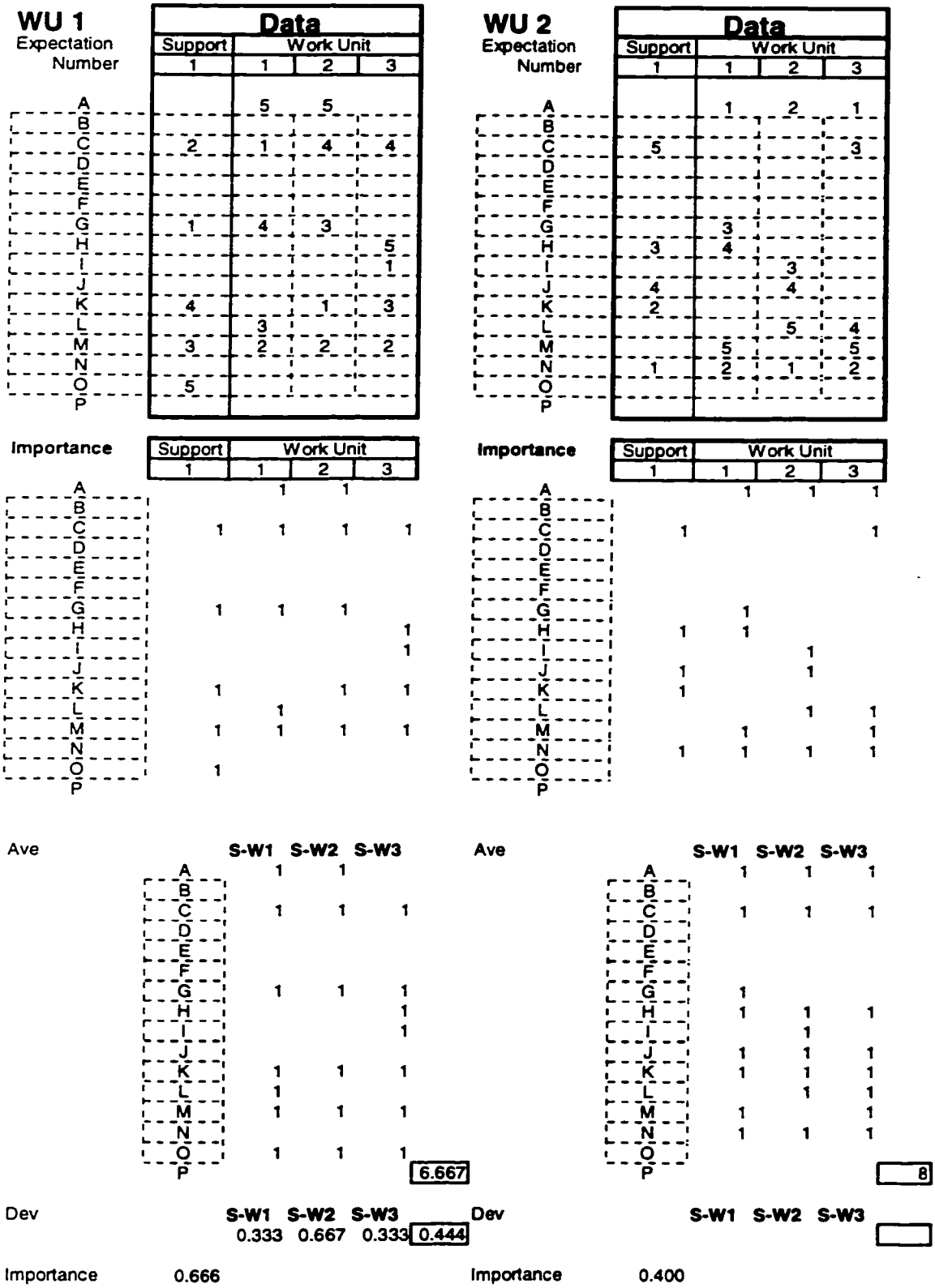
E = A work order is completed and clearly describes the problem and it's location on the machine.

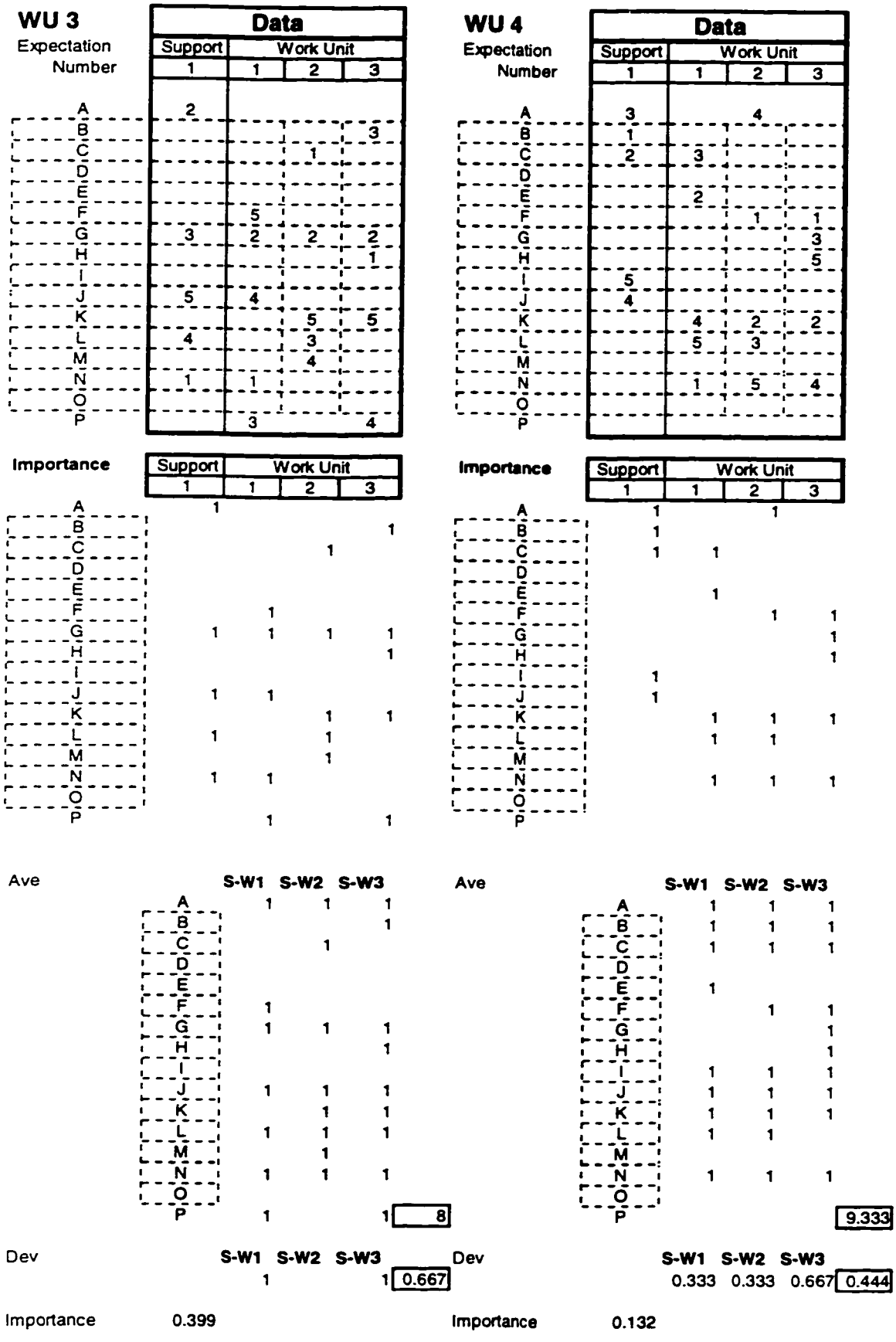
H = Maintenance arrives to repair a machine, and the machine is clean of all tools, parts, chips and oil.

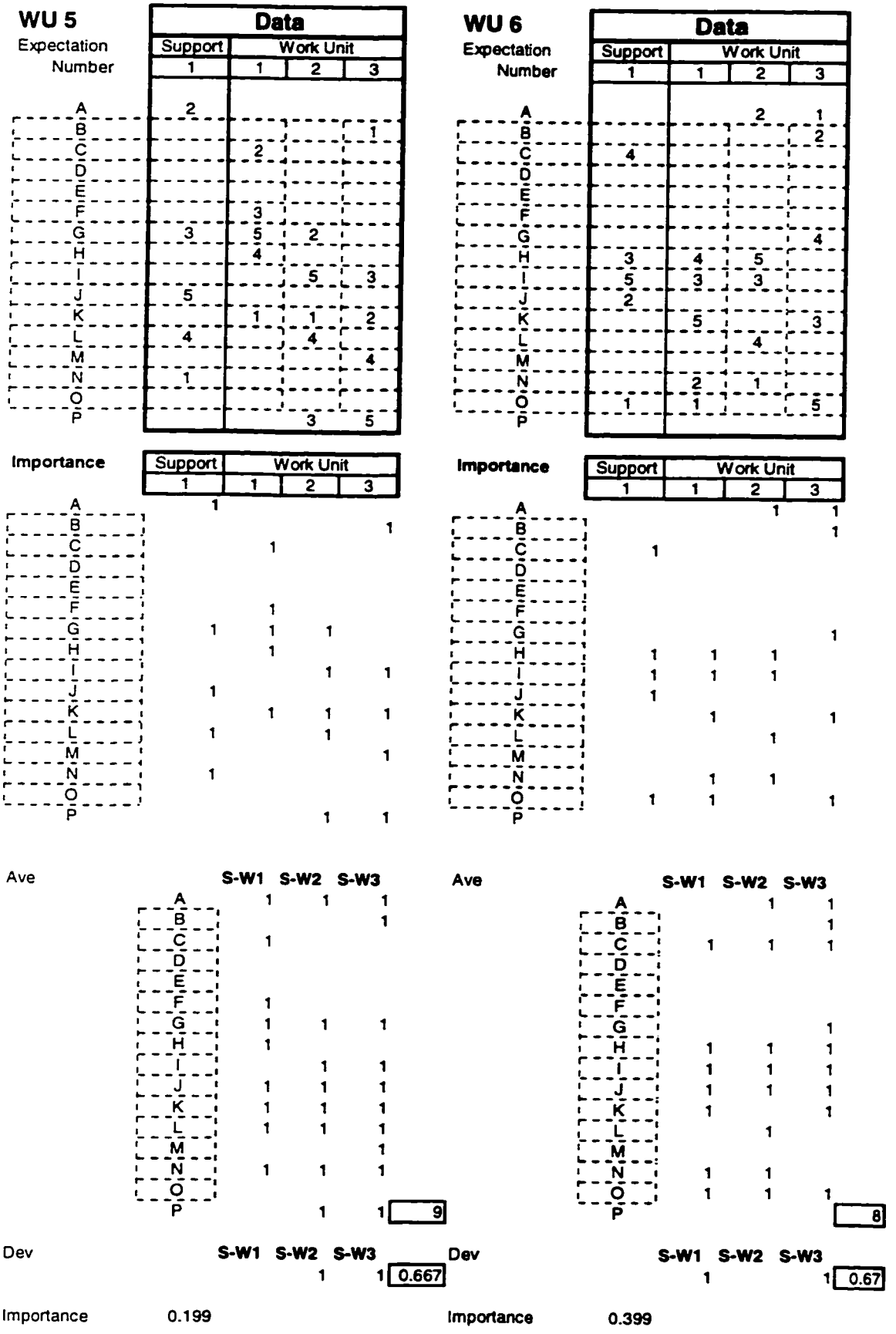
M = Maintenance completes repairing a machine, and has to wait for an operator to verify that it works.

8.7 Company B data

8.7.1 Company B Data: C_1




WU 3
Expectation Number
Data
Support
Work Unit
WU 4
Expectation Number
Data
Support
Work Unit
Importance
Importance
Ave
S-W1 S-W2 S-W3
Ave
S-W1 S-W2 S-W3
9.333
Dev
S-W1 S-W2 S-W3
0.667
Dev
S-W1 S-W2 S-W3
0.333 0.333 0.667 0.444
Importance 0.399
Importance 0.132


WU 5
Expectation Number
Data
Support
Work Unit
1
1
2
3
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Importance
Support
Work Unit
1
1
2
3
Ave
S-W1
S-W2
S-W3
9
Dev
S-W1
S-W2
S-W3
0.667
Importance
0.199
WU 6
Expectation Number
Data
Support
Work Unit
1
1
2
3
Importance
Support
Work Unit
1
1
2
3
Ave
S-W1
S-W2
S-W3
8
Dev
S-W1
S-W2
S-W3
0.67
Importance
0.399

8.7.2 Company B Data: C_2

with RANKS converted to PRIORITIES-Weights

WU 1

Expectation Number	Support	Work Unit 1	Work Unit 2	Work Unit 3
	1	1	2	3
A		1	1	
B				
C	4	5	2	2
D				
E				
F				
G	5	2	3	
H				1
I				5
J				
K	2		5	3
L		3		
M	3	4	4	4
N				
O	1			
P				

AVERAGE	S-W1	S-W2	S-W3	
A				
B				
C	20.00	8.00	8.00	
D				
E				
F				
G	10.00	15.00		
H				
I				
J				
K		10.00	6.00	
L				
M	12.00	12.00	12.00	
N				
O				
P				37.67

DEVIATION	S-W1	S-W2	S-W3	
	4.33	7.33	11.67	7.78

PRIORITY 0.686

WU 2

Expectation Number	Support	Work Unit 1	Work Unit 2	Work Unit 3
	1	1	2	3
A		5	4	5
B				
C	1			3
D				
E				
F				
G		3		
H	3	2		
I			3	
J	2		2	
K	4			
L			1	2
M		1		1
N	5	4	5	4
O				
P				

AVERAGE	S-W1	S-W2	S-W3	
A				
B				
C			3.00	
D				
E				
F				
G				
H	6.00			
I				
J		4.00		
K				
L				
M				
N	20.00	25.00	20.00	
O				
P				26.00

DEVIATION	S-W1	S-W2	S-W3	
	3.00	3.00	2.00	

PRIORITY 0.473

with RANKS converted to PRIORITIES-Weights

WU 3

Expectation Number	Data: Support 1	Work Unit 1	Work Unit 2	Work Unit 3
A	4			
B				3
C			5	
D				
E				
F		1		
G	3	4	4	4
H				5
I				
J	1	2		
K			1	1
L	2		3	
M			2	
N	5	5		
O				
P		3		2

AVERAGE	S-W1	S-W2	S-W3	
A				
B				
C				
D				
E				
F				
G	12.00	12.00	12.00	
H				
I				
J	2.00			
K				
L		6.00		
M				
N	25.00			
O				
P				23.00

DEVIATION	S-W1	S-W2	S-W3	
	16.00	5.00	11.00	10.67

PRIORITY 0.420

WU 4

Expectation Number	Data: Support 1	Work Unit 1	Work Unit 2	Work Unit 3
A	3	2		
B	5			
C	4	3		
D				
E		4		
F			5	5
G				3
H				1
I	1			
J	2			
K		2	4	4
L		1	3	
M				
N		5	1	2
O				
P				

AVERAGE	S-W1	S-W2	S-W3	
A		6.00		
B				
C	12.00			
D				
E				
F				
G				
H				
I				
J				
K				
L				
M				
N				
O				
P				6.00

DEVIATION	S-W1	S-W2	S-W3	
	6.00		6.00	4.00

PRIORITY 0.110

with RANKS converted to PRIORITIES-Weights

WU 5

Expectation Number	Data: Support 1	Work Unit 1	Work Unit 2	Work Unit 3
A	4			
B				5
C		4		
D				
E				
F		3		
G	3	1	4	
H		2		
I			1	3
J	1			
K		5	5	4
L	2		2	
M				2
N	5			
O				
P			3	1

AVERAGE	S-W1	S-W2	S-W3	
A				
B				
C				
D				
E				
F				
G	3.00	12.00		
H				
I				
J				
K				
L		4.00		
M				
N				
O				
P				6.33

	S-W1	S-W2	S-W3	
DEVIATION	3.33	9.67	6.33	6.44

PRIORITY 0.116

WU 6

Expectation Number	Data: Support 1	Work Unit 1	Work Unit 2	Work Unit 3
A			4	5
B				4
C	2			
D				
E				
F				
G				2
H	3	2	1	
I	1	3	3	
J	4			
K		1		3
L			2	
M				
N		4	5	
O	5	5		1
P				

AVERAGE	S-W1	S-W2	S-W3	
A				
B				
C				
D				
E				
F				
G				
H	6.00	3.00		
I	3.00	3.00		
J				
K				
L				
M				
N				
O	25.00		5.00	
P				15.00

	S-W1	S-W2	S-W3	
DEVIATION	19.00	9.00	10.00	12.67

PRIORITY 0.275

8.7.3 Company B Data: C3

Using Proportional Actual Range

WU 1

Expectation Number	Range (S1)			Range (WU1)			Range (WU2)			Range (WU3)		
	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse
A				5.2	4.8	0.3	6	9	3.5			
B												
C	8.2	10	5.2	10	10	0.1	6	7.1	4.2	7	8.9	1.1
D												
E												
F												
G	8.2	9.3	5.2	10	10	0.3	9	9.7	5.7			
H										8	7	2
I										8	9	1.2
J												
K	7.2	9.2	4.2				5.7	9	3.2	9	7	1.2
L				8.3	7.8	0.4						
M	7.2	10	5.2	2.7	9.3	0.3	6.6	9.2	4.3	7	8	2.1
N												
O	5.2	2.2	8.3									
P												

Overlap Area

S1 & WU1	S1 & WU2	S1 &WU3
0.8	0.8	0.9
0.8	0.9	
	0.9	0.8
0.6	0.9	1.0
43.8%	69.8%	53.6%

C3= 0.557

WU 2

Expectation Number	Range (S1)			Range (WU1)			Range (WU2)			Range (WU3)		
	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse
A				7.5	8	5	7.5	6.4	1.8	6.5	9	1.5
B												
C	4	9.1	0.5							7.5	9	0.5
D												
E												
F												
G				10	10	8						
H	8.2	9.2	1.7	8	8	4						
I							8.7	5.7	2.7			
J	9.2	9.5	1.4				8.7	6.2	2.2			
K	10	10	0.1									
L							7.2	8.7	2.2	9	7	1
M				8	8.5	3				6.5	9	1
N	8.5	9	0.5	8	8.4	5	7.2	5.2	3.3	8	9.5	2
O												
P												

Overlap Area

S1 & WU1	S1 & WU2	S1 &WU3
		0.7
1.0		
	1.0	
1.0	0.9	1.0
38.6%	36.4%	32.0%

C3= 0.357

WU 3

Expectation Number	Range (S1)			Range (WU1)			Range (WU2)			Range (WU3)		
	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse	Actual	Better	Worse
A	4.5	6	1.5									
B										1.1	3.2	2.1
C							8.7	6.7	2.3			
D												
E												
F				9.3	10	6.4						
G	7	9	4	9.5	10	7.5	9.7	7.7	2.2	7.2	4.1	2.6
H										7.2	3.6	2.2
I												
J	6	8.1	3	8.3	9.4	5.4						
K							7.7	5.7	2.2	2.2	6.6	5.2
L	7.5	9	5.5				9.8	7.7	2.3			
M							9.7	7.6	2.2			
N	8	9.5	5.9	8.5	9.5	5						
O												
P				1.3	0.1	5				6.6	6.2	3.3

Overlap Area

S1 & WU1	S1 & WU2	S1 &WU3
0.8	0.7	1.0
0.8		
	0.8	
1.0		
49.4%	30.0%	19.6%

C3= 0.330

Using Proportional Actual Range

WU 4

Expectation Number	DATA: Range (S1) Actual	Range (S1) Better	Range (S1) Worse	Range (WU1) Actual	Range (WU1) Better	Range (WU1) Worse	Range (WU2) Actual	Range (WU2) Better	Range (WU2) Worse	Range (WU3) Actual	Range (WU3) Better	Range (WU3) Worse	Overlap Area: S1 & WU1	S1 & WU2	S1 &WU3
A	4	7	6				5.2	8.2	2.3					88.0%	
B	0.5	6	4												
C	5	6	3	8.3	7.7	1.4							0.7		
D															
E				8.3	1.3	0.8									
F							9.2	8.2	0.3	5	10	5			
G										4	8.3	4			
H										5	8.3	5			
I	7	8.5	5.5												
J	9.5	9	6												
K				8.7	9.2	0.7	9.3	8.3	2.3	4	8.3	4			
L				8.8	7.8	0.8	9.3	8.3	1.3						
M															
N				8.8	8.3	0.8	9.3	8.2	0.7	5	10	5			
O															
P															
													13.4%	17.6%	

C3= 0.103

WU 5

Expectation Number	DATA: Range (S1) Actual	Range (S1) Better	Range (S1) Worse	Range (WU1) Actual	Range (WU1) Better	Range (WU1) Worse	Range (WU2) Actual	Range (WU2) Better	Range (WU2) Worse	Range (WU3) Actual	Range (WU3) Better	Range (WU3) Worse	Overlap Area: S1 & WU1	S1 & WU2	S1 &WU3
A	8	9.5	7												
B										1	8.5	0.5			
C				9.5	9.3	1									
D															
E															
F				9.5	9	1									
G	8.5	9.4	6.5	10	9.5	0.5	10	10	7.2				0.9	0.9	
H				9.5	8.9	0.5									
I							5.2	7.1	2.1	8.5	7.5	0.9			
J	7.9	9	5.9												
K				10	9.5	0.4	7.3	9.1	4.7	9	8	1			
L	7	8.4	5				3.2	5.7	2.2					0.6	
M										9	5.2	0.5			
N	8	9	6												
O															
P							8.6	5.2	1.6	4	5.5	2.5			
													17.0%	29.4%	

C3= 0.155

WU 6

Expectation Number	DATA: Range (S1) Actual	Range (S1) Better	Range (S1) Worse	Range (WU1) Actual	Range (WU1) Better	Range (WU1) Worse	Range (WU2) Actual	Range (WU2) Better	Range (WU2) Worse	Range (WU3) Actual	Range (WU3) Better	Range (WU3) Worse	Overlap Area: S1 & WU1	S1 & WU2	S1 &WU3
A							6	8	4	6	6	6			
B										2.7	2.7	2.7			
C	3	1	8												
D															
E															
F															
G										8.6	8.6	8.6			
H	1	8.1	0.1	5	4	5.5	6	8.3	4				0.6	0.5	
I	2.2	8.1	1.2	7	6	5	8.2	9.3	5				0.5	0.4	
J	1.1	8.2	0.2												
K				2	5	5				7.5	7.5	7.5			
L							0.1	4.2	2						
M															
N				8	9	5	9	10	5.4						
O	4.2	8.2	2.2	9	5	5				0.1	0.1	0.1	0.5		0.6
P															
													32.8%	18.0%	11.8%

C3= 0.209

8.7.4 Examples of expectations from the Questionnaire

J = Production Control gives the work unit visibility on what work is comming.
C = The work unit gives Production Control enough notice to get more work or to drop ship to the Customer.
G = The work unit is keep up-to-date on the age-old report.
M = The work unit replenishes EDI & reman, so there is enough stock when a drop-ship is required.
K = The work unit is flexible enough to meet a Customer time frame of "within a day."
H = Production Control keeps the work unit aware of any exceptions, like large orders, so the work unit can ramp-up or be prepared.
L = Production Control gives a timely response (few hours) when the work unit does not have any work.
N = Production Control understands what the work unit does and how their process works.
I = The work unit relates all information that Production Control needs for their job.
A = The work unit is aware of what Production Control does.
O = Production Control is in a lot of meetings and this reduces communication and response time.

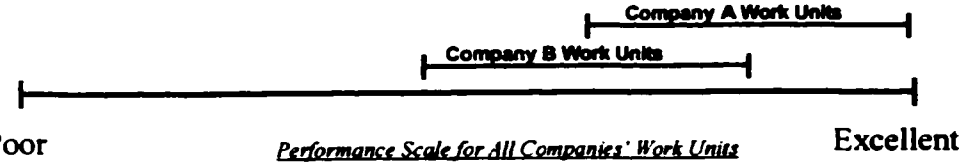
8.8 Research Issues

8.8.1 Variance between company's scores

This discussion suggests an explanation for the differences between Company A& B matching performance. That is, although both Companies A & B had excellent work units, Company A results were expected to be somewhat different from Company B because, as will be discussed further below, the Company A Work Units:

- were recognized as being better;
- choose a greater percentage of expectations in common; and
- had less variance in their consistency scores.

This means that the performance of the C-formula for Company A may not be as good because the Work Units, being better, might be similar to each other so they may choose more expectations in common and this could result in scores that are closer together and make it harder for the C-formula to discriminate between them. These opinions are presented below in turn.



Company A's international recognition through an industry competition as one of the ten best plants in North America (1998), their receipt of numerous customer awards, and observations at the site of their efficient team meetings and the cleanliness of the physical plant all testified to their superior performance.

Company A			
Expectation Selected	Number	Percent	
		All	Selected
Common	[redacted]	31.3	71.4
Unique	[redacted]	12.5	28.6
Not	9	56.3	
	16		

Company B			
Expectation Selected	Number	Percent	
		All	Selected
Common	[redacted]	25.0	36.4
Unique	[redacted]	43.8	63.6
Not	5	31.3	
	16		

Table 8-11: Selections held in common

Table 8-11 summarizes the results from Tables 5-13 and 5-30 as diagrams. Of the 16 expectations on the Questionnaire 43.8% were selected by the Hi-group and/or the Lo-group (green & yellow shading compared to red) of Company A, and 68.8% for Company B. Company A selected 36.3% less expectations than Company B. For the expectations that were selected by any of the six Work Unit linkages, the Company A Work Units were focused on a smaller set of expectations.

For the set of expectations selected 71.4% were selected by both the Hi-group and the Lo-group (green shading compared to yellow) of Company A, and 36.4% for Company B. The proportion of Company A expectations held in common was 96.1% more than Company B. So the Company A Work Units had more focus on expectations held in common between the Hi-group and Lo-group.

Company A

	MIN	MAX	Interval	AVE	AVEDEV
C1-value =	0.399	0.666	0.267	0.488	0.074
C2-value =	0.238	0.474	0.236	0.375	0.053
C3-value =	0.262	0.575	0.313	0.368	0.087
C(111) =	0.310	0.560	0.250	0.417	0.063
C(131) =	0.259	0.466	0.207	0.388	0.049

Company B

	MIN	MAX	Interval	AVE	AVEDEV
C1-value =	0.132	0.666	0.534	0.366	0.134
C2-value =	0.110	0.686	0.576	0.347	0.180
C3-value =	0.103	0.557	0.454	0.285	0.130
C(111) =	0.116	0.639	0.523	0.336	0.143
C(131) =	0.112	0.674	0.562	0.344	0.170

Table 8-12: Variation in the six Work Unit values

Table 8-12 presents some of the differences in the score data and shows that the variance between the six Work Units selected by the two companies' management was tighter in Company A. The chart compares, under several headings, the Company A & B C_i and C-formula calculated values (unweighted and weighted) for the six Work Units (WU1 to WU6), vis:

- MIN: Lowest score between the six Work Units;
- MAX: Highest score between the six Work Units;
- Interval: (MAX – MIN) scores;
- AVE: Average of the scores for the six Work Units;
- AVEDEV: Average Deviation of the scores for the six Work Units from AVE;

It can be seen that in each case the Company A values are within the bounds of the Company B values. That is, the Company B **MIN** are all lower than the Company A **MIN**; the Company B **MAX** for each C_i or C-formula value are all higher than the corresponding Company A **MAX**; the Company B **Interval** are all larger than the Company A **Interval**; and the Company B **AVEDEV** are all larger than the Company A **AVEDEV**. Thus, Company A has less variation in it's scores than Company B, so the ranking of Company A Work Units might be seen as a more stringent condition because it is harder for the C-formula to discriminate between Work Units.

Again, one interpretation from this section is that the performance of the C-formula for Company A, compared to Company B, is not as good because the Company A Work Units, being better, are similar to each other so they choose more expectations in common and this results in scores that are closer together and this makes it harder for the C-formula to discriminate between Work Units.

8.8.2 Positively orientated expectations

Both Company A & B Work Units selected a high number of positive expectations, 78% and 89% respectively in Table 8-13. It appears at first look that Company B is more 'positive'. However, due to a *method improvement* on the ratio of positive to negatively orientated expectations the Questionnaires for Company A and B were different. That is, the Company A expectations contained 50% positively worded expectations, while Company B had 69%. This brings into question whether Company B is more positive if it had more opportunity to choose positive expectations. Normalized results show that Company A is in fact more positive than Company B.

	Positive vs. Negative		
	Selected	Questionnaire	Normalized
Company A	78.3%	50.0%	78.3%
Company B	89.2%	68.8%	64.8%

Table 8-13: Positive vs Negative expectations on Questionnaire

As is discussed in the Results section, one alternative for future research is to keep the ratio of positive-to-negative expectations at 50% and have a penalty for the selection of negative expectations. This should allow not-as-effective Work Units to be consistent with the negative expectations, allow a greater spread in the consistency scores and ease of ranking.

8.8.3 Ties and Near-ties in consistency scores

When two scores are the same they are considered to be 'ties' and their rankings will be added and divided by 2. The Work Units associated with the tie can take on either ranking. For example, if the 3rd and 4th Work Units have the same score, then they both receive the rank of 3.5, and they can assume the ranking of 3 or 4 for the purpose of accessing matches in the relaxed situation.

The calculations of the consistency scores are subject to noise as outlined in section 5.2. To estimate the impact, the researcher did small changes to the actual data to determine the range of scores that would result. For example, a Work Unit member's selects a certain expectation as important, assigned it a priority and an acceptability range. These choices are reflected in the scores for C_1, C_2 and C_3. Then these values are put into the unweighted and weighted C-formula (**C(111)** and **C(131)**). These scores are called 'Actual' in Table 8-14.

	Consistency in Company A scores						
	WU1			WU6			
	More	Actual	Less	More	Actual	Less	Weight
C1	0.732	0.666	0.599	0.466	0.399	0.331	1
	10.0%		10.1%	16.8%		16.9%	
	0.067		0.067	0.067		0.068	
C2	0.455	0.407	0.359	0.268	0.238	0.226	3
	11.9%		11.8%	12.6%		5.0%	
	0.048		0.048	0.030		0.012	
C3	0.633	0.575	0.509	0.322	0.269	0.215	1
	10.0%		11.5%	19.6%		20.0%	
	0.057		0.066	0.053		0.054	
C(111) =	0.617	0.560	0.499	0.362	0.310	0.263	
	10.3%		10.9%	16.7%		15.2%	
	0.058		0.061	0.052		0.047	
C(131) =	0.505	0.454	0.402	0.296	0.259	0.236	
	11.2%		11.4%	14.2%		8.9%	
	0.051		0.052	0.037		0.023	

This table shows the scores when one 'more' or 'less' expectation is consistent for a Work Unit

Table 8-14: Variation in consistency scores

This table also shows the two extreme examples of actuals for Company A, Work Unit #1 and Work Unit #6. That is, WU1 was the highest ranked by the Company A judge, and WU6 was the lowest ranked.

Lastly, the table shows the scores called 'More' and 'Less' consistency. That is, the actual data for one expectation was changed, by the researcher as an experiment, to allow for ***one more*** instance of consistency between one Work Unit member and the Support Group person, and the scores were recalculated. For example, for WU1 the actual score for C1 is .666, and when one further instance of consistency is created then the 'more' consistency score is .732 which is .067 higher than the actual, or 10.0%. On the other hand, when the actual data for one expectation was changed to allow for ***one less*** instance of consistency and the scores were recalculated the 'less' consistency score is .599 which is .067 lower than the actual, or 10.1%.

From the analysis above it can be seen that a very small change in the selections by one person alone might have an impact on the resulting scores of more than ∓ 5%, or a 10% range. This research takes a more conservative approach and assumes that in the case of scores within ∓ 2.5%, or a 5% range, that the ranked values will be considered to be a 'near-tie', and will be treated the same as a tie in scores.

8.8.4 Welch amendment to Ross for ties

Citation:
Dr. Patricia (Newcombe) Welch
Statistical Consulting Service
Department of Statistics and Actuarial Science
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DERIVATION OF THE PROBABILITY DISTRIBUTION OF THE NUMBER OF MATCHING FIELDS IN RANDOM PERMUTATIONS OF 6 OBJECTS

Consider a permutation of a finite number of objects. Each of the sequential positions of the objects in this permutation will be described as a "field". The term "completely non-matching permutation" (CNMP) is defined here to describe a permutation of these objects which differs in all fields from the original permutation. The term "tie" indicates that two objects are considered to be indistinguishable.

If two permutations of the same x objects have matching objects in exactly k corresponding fields, they are said to have k matches. The problem at hand is to derive the probability distribution of the number of matching fields of random permutations of 6 objects which may consist of the following :

Case 1: 6 unique objects
Case 2: 4 unique objects and one tied pair
Case 3: 2 unique objects and two distinct tied pairs
Case 4: 3 distinct tied pairs

If 2 permutations of x objects have one matching field only (k=1), then the remaining (x-1) fields must comprise CNMP's of the remaining (x-1) objects. Similarly, if k=2 then the remaining (x-2) fields must comprise CNMP's of the remaining (x-2) objects, and so on. We note that if 2 permutations of the same x objects match on (x-1) fields, then the remaining field must also match and thus it is impossible to have k=(x-1).

Let CNMP(x;y,z) represent the number of completely non-matching permutations (CNMP's) of x objects, of which y are unique and the remainder consist of z tied pairs which are unique from each other. Elementary counting rules can be used to derive the results in Table 1 below, which may then be used to derive the required probability distribution.

Table 1:

x	Number of CNMP's of x unique objects	Number of CNMP's of x objects, consisting of (x-2) unique object s and exactly 1 tied pair	Number of CNMP's of x objects, consisting of (x-4) unique objects and 2 distinct tied pairs
2	CNMP(2;2,0) = 1	CNMP(2;0,1) = 0	
3	CNMP(3;3,0) = 2	CNMP(3;1,1) = 2	
4	CNMP(4;4,0) = 9	CNMP(4;2,1) = 2	CNMP(4;0,2) = 1
5	CNMP(5;5,0) = 44	CNMP(5;3,1) = 12	CNMP(5;1,2) = 4
6	CNMP(6;6,0) = 265		

Let k represent the number of matching fields in two permutations of 6 objects.

Case 1: Permutations of 6 Unique Objects

If all six objects are unique, the required probability distribution is simple to derive, since the (6-k) non-matching objects in a permutation must constitute CNMP's of the objects in the corresponding fields of the permutation to which it is being compared. The probability that k=j is thus given by

Prob(k=j) = { [6!/((j!)x(6-j)!)] x CNMP((6-j);(6-j),0) }/ 6! for j=0,1,2,3,4.

and Prob(k=6)=1/6!

where the values of CNMP((6-j);(6-j),0) for j=0,1,2,3,4 are obtained from Table 1.

Cases 2, 3 and 4: Permutations of 6 objects, which include Tied Pairs

These cases are more difficult to deal with since the number of CNMP's of the non-matching objects in a permutation will depend on whether or not the non-matching objects themselves include tied pairs. Thus it is necessary, for each possible value of k, to determine the number of distinct ways in which k fields can be selected from 6 fields, and then for each of these, to determine the number of CNMP's of the remaining non-matching objects using the results in Table 1 above.

The probability distributions for the number of matching fields are presented in table 2 for cases 1,2,3 and 4. A sample calculation follows table 2 to illustrate the procedure.

Table 2: Probability Distributions of the Number of Matches (k) for Cases 1 - 4

k	No Ties (Case 1)	One Tie (Case 2)	Two Ties (Case 3)	Three Ties (Case 4)
0	0.3681	0.2333	0.2167	0.1111
1	0.3667	0.3778	0.3111	0.2667
2	0.1875	0.2583	0.2611	0.3000
3	0.0556	0.0889	0.1333	0.1778
4	0.0208	0.0389	0.0722	0.1333
6	0.0014	0.0028	0.0056	0.0111

Example Calculation: Find Prob[k=1] for Case 2 (4 unique objects and 1 tied pair)

If the matched field contains one of the tied objects, then the objects in the remaining 5 non-matching fields will be unique. We know that the number of CNMP's of 5 unique objects is given by CNMP(5,5,0)=44 from table 1. Thus we have 2 distinct choices of matching fields multiplied by 44 CNMP's of the remaining 5 unique objects to yield a total of 2x44=88 distinct permutations of this type.

However, if the matched field contains one of the 4 unique objects, then the remaining 5 non-matching fields will consist of 3 unique objects and one tied pair, for which CNMP(5,3,1)=12 is obtained from table 1. Thus we have 4 distinct choices of matching fields containing a non-tied object multiplied by 12 CNMP's of the remaining 5 objects to yield a total of 4x12=48 distinct permutations of this type.

We note that there are 6!/2!=360 distinct permutations of 6 objects which consist of 4 unique and 2 tied objects. Since we have 88+48=136 distinct permutations which will match on one field only, the probability that k=1 for Case 2 is 136/360=0.3778 .