SCIRA: A Risk System Management Tool

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INTRODUCTION

The System Complexity Index Risk Analysis (SCIRA)[1] evolved from risk management systems research conducted by the author and through Direct Bearing Inc., a risk management consulting firm serving the adventure, education and volunteer sectors. The index model addresses some standing issues as adventure and education based risk management moves from discrete trigger/event based prevention, control and mitigation procedures to comprehensive systems based management.

SCIRA provides an objective means of quantifying the complexity of an operation or a system. As a risk management tool, SCIRA allows:

1. a means of assessing system complexity and system failure potential;
2. comparing internal systems and prioritizing system improvements;
3. a means of targeting system improvements and modeling system change;
4. benchmarking system complexity against other programs or operations.

SCIRA is an indicator of system failure potential. It is critical to note it is not a measure of system efficacy. The more tightly coupled and complex a system is, the more vulnerable it is to system accidents or catastrophic failure.[2] SCIRA is calculated by:

$$(Cp) \times (Cx) \times fD$$

Where (Cp) is system coupling, (Cx) is system complexity, and fD is the potential for detecting failure. A multiplier can be added to each value to provide relative weighting. These concepts are explained in further detail.

Included below are the System Complexity Indexes, and a sample of values from the adventure sector for illustration and comparison purposes. Readers can skip directly to the indexes to assess their own operation, and return to the background information as needed.

SYSTEMS AND SYSTEMS THINKING

> ***System:*** *an organized and highly integrated arrangement of parts operating towards a specific goal.*

As adventure and education based risk management evolves away from safety based prevention, control and mitigation practices and turns to a macro level systems analysis approach to safety, critical incidents and program quality management; a new paradigm or way of viewing risk management is emerging.

[1] SCIRA combines and extends the ubiquitous Hazard Identification and Risk Assessment (HIRA) and the Failure Mode and Effects Analysis (FMEA) models of risk assessment (common in engineering, manufacturing, aeronautics and the health sectors), and Perrow's (1999) Normal Accident Theory.

[2] Perrow, C. (1999) *Normal Accidents, Living with high-risk technologies*. Princeton University Press, Princeton, N.J., reprint 1984 Basic Books, pp. 88-97.

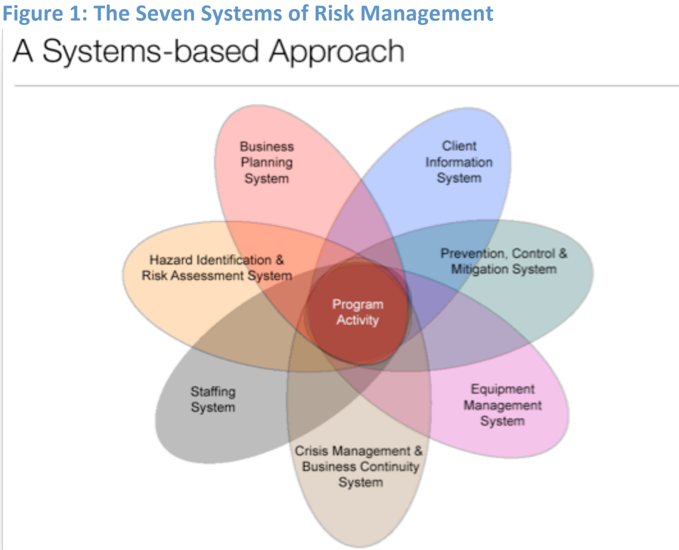
Systems thinking is a means of organizing complex processes – such as managing wilderness trips or outdoor education programs – and understanding the integrated nature of the many ingredients it takes to provide successful, quality programs.

> ***Systems thinking*** *is an approach to gain insight into a process, by considering the interactions between components.*[3]

Systems thinking is a way of seeing the world as interconnected relationships, with cause and effect crossing traditional boundaries.
A key concept for adventure risk management is understanding it as a system – an integrated arrangement of subsystems operating towards a specific goal. Risk Management is not set aside and considered separately, nor is it a checklist including waiver forms and first aid kits.

> ***Risk management*** *is a systems based approach to sustainably managing uncertainty*[4] *within an operating environment.*

Figure 1: The Seven Systems of Risk Management



Equally important is an understanding that risk management is business management, and is conceptualized that way in every sector beyond the adventure field. Research by the author has identified seven systems that drive risk management – they are the same systems that run an operation, program or business in the adventure field (see Figure 1). By managing the seven systems, a business is directed towards its specific goals.[5]

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[3] Definition based on the work of Peter Senge (1990), *The Fifth Discipline: the art and practice of the learning organization,* the work that popularized systems thinking within the business community.
[4] Note the term 'uncertainty' instead of 'risk'; the economist Frank Knight differentiated between risk and uncertainty in the 1920's. Risk can be quantified absolutely with probability, while uncertainty has no calculable probability, he argues. The adventure and education field deals almost exclusively with uncertainty.
[5] For detailed reading on systems planning and implementing systems, see Jackson, Heshka, Cruchet (2010) *Managing Risk, Systems Planning for Outdoor Adventure Programs*, Direct Bearing Inc., Palmer Rapids, ON.

For the purpose of this paper, the term *system* can take on two different meanings simultaneously: it can refer to the whole of an organization or operation as 'the system'; or a particular component within an organization (i.e. the Client Information System), sometimes specifically referred to as a sub-system. SCIRA can be applied to the greater system and assess the whole of an operation, as this paper primarily considers, or it can be interpreted (and adapted) to provide an index value for the specific subsystems – the seven systems of risk management - that comprise the operation.

HOW ACCIDENTS REALLY HAPPEN

The field of error management identifies two types of errors that lead to risk events: active errors and latent errors. Additionally, coupling and complexity play a role allowing these errors types to occur.

Accident theory uses the term 'accident' differently than it is commonly understood in everyday language. For this paper, and of use in discussing risk management systems in adventure and education,

> ***System accident:*** *when a system fails to do what it is supposed to do.*[6]

In sophisticated operations there are seven systems that work together to ensure program management, quality delivery, and ultimately healthy, satisfied clients. System accidents are any event or scenario when these systems fail to do what they are supposed to. The term *system accident* opens the door to a much wider interpretation of risk events, to include logistical gaps, staffing problems, and financial exposure, for example (see sidebar on previous page). The traditional idea of personal injury may or may not be considered a system accident. It is possible, given an injury or incident, all systems work very well to control and mitigate the circumstances. In another scenario, the injury may point to a break down in one or several systems, either before or after the incident.

Active errors have been the focus of adventure risk management to date; the immediate, guide based slips, lapses, and mistakes – the "sharp end"[7] of a risk event. But Perrow cautions: "Be suspicious of operator error…" as it is often the easy target in an unclear scenario. He claims 60-80% of *system errors* are blamed

Examples of System Accidents in Adventure Operations

Client Information System:
- Participants arrive without proper forms
- Participant ability unsuited to program type
- Follow up function omitted

Staffing and Human Resources System:
- Staff with proper skill level unavailable for program dates
- Key staff certification expires
- Conflict over contract terms and conditions

Business Planning System:
- Failure to secure short term bridge loan
- Land use permits revoked
- Board of Director conflict or resignations

Crisis Management System:
- Communication chain does not function in time of crisis
- Resources unavailable during crisis to support parallel running programs
- Incident review omitted

Equipment Management System:
- Shortage of suitable program equipment
- Equipment fails during use
- Loss due to theft

[6] Based on Perrow's ***Accident:*** *damage to a system stopping its intended output* (Perrow, 1999). This definition suits less the systems approach to adventure risk management primarily in the 'stopping' aspect. Perrow's Normal Accident theory applies to high technology such as nuclear power, with systems that either works or don't. The seven systems of adventure risk management are more often process oriented, so can fail to do what they are supposed to do, yet still function. The definition used here allows the widest interpretation of measuring a system's performance.

[7] Reason, J. (1990), *Human Error*

on the operator.[8] System errors are considered latent errors; dormant, long term conditions that set the stage for any number of unconnected active errors. Latent errors are the "blunt end" of a risk event, and could include anything from poor equipment design, bad management decisions, poor planning, communication difficulties, or legislative or regulatory failure. Latent errors are created by the system that hosts them and are difficult to detect, since the 'active' and visible portion of the risk event usually takes the fall.
Writes James Reason (1990) in *Human Error,* "It is increasingly apparent that latent errors pose the greatest threat to the safety of a complex system."[9] Adventure guides and outdoor instructors inherit the system defects and latent errors that set them up for active errors: hiring decisions, logistics restrictions, client screening etc. Reason continues, "There is a growing awareness… [that to] discover latent failures is the best means of limiting [active] error."[10]

Systems that are tightly coupled and highly complex are more susceptible to error – both active and latent.[11]

Coupling as potential for System Accidents:
Coupling refers to the amount of 'slack' in the operating environment and/or the system that delivers the process. Slack could be considered the amount of time and possibility to correct errors. In most adventure and educational endeavors, there is a great amount of slack; there is almost always time to slow down, back track, or re-direct a path of operation that doesn't seem to be working. In fact, as most programs are not defined by articulated accuracy targets, there is almost continual operator error (or 'trial and error'), but there is so much slack it can always be corrected or never manifests itself in a major risk event. It takes the exceedingly rare and right combination of factors to turn a minor error into a major injury or system accident. Tightly coupled systems, on the other hand, do not tolerate minor errors, as by definition they do not allow correction.

For example, compare a whitewater rafting trip catering to families on a gentle class I scenic river to a high adventure class V rafting operation. The nature of a class I river allows for room to maneuver, many possible paths through a rapid, and time to correct direction. Class V allows none of that – the line is tight, difficult to achieve, and almost impossible to correct. It is easy to see how this and other tightly coupled environments have greater potential for error, which stresses the operating systems (either continually or more often) and opens the door to system accidents.

An operation itself can be tightly coupled, even if its operating environment provides plenty of slack. A fast paced, high volume, tightly managed adventure company offering multiple daily trips, for example, could be considered tightly coupled. An error in one system, such as having a vehicle break down or a trip leader who can't work, puts the whole operation at risk, since it operates with so little slack. There needs to be a balance between efficiency and slack (see Figure 2).

[8] Perrow (1999), p. 9.
[9] Reason, J. (1990), p. 173.
[10] Ibid.
[11] Perrow (1999). This is the premise of Perrow's work.

Figure 2: Comparing loosely and tightly coupled environments and systems

Loosely coupled / decoupled *systems and events*	***Tightly coupled*** *systems and events*
Slack in system – time, resources, options	No slack in system
Time between events and decisions	Events happen in rapid succession, no time to decide
Time to delay, recover or correct	No time to delay or recover, correction not possible
Many options per decision	Few options per decision, no time to assess
Sequence can be changed as needed	Sequence fixed
Safety and backup available as needed; flexible in application	Safety backup limited and designed in
Such as:	
Flatwater paddling	Continuous class V river
Skiing groomed blue run	Skiing backcountry steeps
Applying first aid: possible wrist fracture	Performing beacon search to find avalanche victims

It should be noted: any major risk event is defined by being tightly coupled. Consider coupling as a sliding scale; with slack in the system there is time to correct, until some combination of factors come together and start to limit options, and takes the slack away, until the event is so tightly coupled there are no choices left (and an injury or system accident ensues). Back country skiing is an example: the pace of travel is slow, with time to decide on a route and make corrections. However, when a group encounters unstable snow, the system starts to couple, and certain decisions can ultimately lead to an avalanche – a situation completely without slack.

Given an option, an operation should limit coupling where possible, both in its operating environment and its operating systems.

Refer to the Coupling Index below to consider the factors that contribute to system coupling, and create an index value for your operation.

<u>Complexity as potential for System Accidents:</u>
Complexity refers to the interconnectedness of the operation and seven systems that deliver the service or product, independent of operating environment (the opposite of a *complex system* is a *linear system)*.

The test for complexity, as Perrow (1999) describes it, is the predictability of the outcome of system accidents. A small scale, single purpose system, such as a science class field trip, would be considered linear, as the systems that run the field trip stand alone and the consequence of a system failure or accident can easily be anticipated. A problem on this trip does not put the whole school in jeopardy (in a direct sense). Likewise a small scale owner/operator guide service or skill instruction program would be considered relatively linear. On the other hand, a university's outdoor studies department would be considered complex: multiple offerings reliant on a complicated, multi layered management system, in which a system accident has the potential to stress other systems to failure, with unforeseen consequences on the system as a whole.[12]

For adventure and education, complexity can be created by depth or breadth. A single highly integrated and complicated program can score a high complexity index score, even though it is not particularly interconnected with outside systems: a tall ship sailing program, for example. A latent system error can have unforeseen consequences when the ship and crew are put under pressure – the test for complexity.

Consider breadth as an indicator of complexity: return to the university outdoor studies department. Even though each particular course or outing is relatively straight forward to manage, the fact that there are several thousand student field days over the semester multiplies the complexity. In this case complexity arises due to the simple greater exposure factor, plus the unforeseen and unpredictable effect a failure in one system (or for one course) has on those running concurrently or subsequently (see Figure 3).

Unlike coupling, complexity is not negative in and of itself. In some cases complex organizations exist because it will run with nothing less. Complexity often represents efficiency in manpower and resource use. Unfortunately, since most adventure operations grow from small scale, loosely coupled and linear organizations to add more trips, more staff, and more management; they ultimately become more tightly coupled, and the complexity of the management system is not recognized – the operation is interconnected but is managed as though it were linear. These companies are always under stress, as every problem (otherwise known as system accident) creates another.

[12] Perrow (1999) uses the example of a nuclear reactor as the ultimate in complex systems. To date, nuclear system accidents happen in unanticipated ways and had unpredictable effects on other operating systems. Ultimately, Perrow recommends abandoning any technology requiring such complexity that also happens to operate in a tightly coupled environment.

Figure 3: Comparing linear and complex systems

***Linear** systems*	***Complex** systems*
System easy to explain	Difficult, detailed, or cumbersome to explain
Single goal or process	Multiple goals, processes, and subsystems
Visible process and interactions	Process unclear when fails ('how did that happen?')
Expected sequences even when fails	Unanticipated interactions when sequence fails
Predictable outcome, even if unplanned	Unpredictable or unknown outcome when fails
Failure can be isolated	Failure compounding, creates unforeseen multiple failures
Direct, real time information and feedback	Indirect or inferred information and feedback
People and equipment easily substituted	Limited substitution available
Such as:	
Climbing bolted route, 5.9 difficulty	Exploratory first ascent of remote mountain range
Biology class field trip	Large university's field trip and field work program
Owner/operator canoe trip company	Large scale international adventure company

Complexity can grow inadvertently: changing key staff, adding new programs, adopting a new reservation database or communication technology will all have unforeseen interactions with existing systems. This is commonly referred to as *complexity creep*: an unrecognized and unmanaged increase in complexity.

The complexity of an organization needs to be considered within the risk tolerance and operational requirements of the product or service; but this complexity needs to be actively managed.

Refer to the Complexity Index below to consider the factors that contribute to system complexity, and create an index value for your operation. These factors also represent *leverage points*, key management areas where small changes can have great impact on the subsystem and whole system's resiliency or fragility.

Failure Detection as potential for System Accidents:
Great events have small beginnings. With almost continual active errors in loosely coupled systems, rarely does the right combination of factors turn into a major system failure. At low volumes, the right combination of factors for a major accident are exceedingly rare – or may never occur, therefore individuals don't know or understand them. Likewise, well planned systems have possibly never been tested at peak load to understand how they will react in a multiple failure environment.

Failure detection does not directly prevent accidents or injuries, it is important to note. It is a measure for index purposes only, and represents a system's (and field staff and management's) experience under stress and system failure, with the assumption being that the more often a system fails, the better able will be the staff to recognize the combination of factors that contributed to the precipitating error (active or latent), and commensurate system adaptations will be put in place to prevent, control or mitigate the resulting system accident in the future. The assumption is that an organization can learn from its mistakes; at the very least it has experience dealing with its own mistakes.

An operation that boasts to have never had an accident, injury or serious risk event is the most at risk for system failure. An untested staff and crisis management system is of unknown worth. Reliance upon and interaction with associated systems is unknown. Contrast this with vehicle crash statistics: those who have been in an accident are more likely to be in another. Recall, though, the purpose of this index: to measure a system's experience under stress. By having been under stress before (or continually), it is assumed that staff and management can recognize potential problems and system accidents as or before they appear. It does not address how individuals or the system will react once under pressure or failure. Recall that this index does not measure ability to prevent accidents or injuries, only the potential to detect a system under stress.

Refer to the Failure Detection Index below to consider the factors that contribute to system failure detection, and create an index value for your operation. As with the Complexity Index, these factors also represent *leverage points*, key management areas where small changes can have great impact on the subsystem and whole system's resiliency or fragility.

SCIRA CALCULATION AND INTERPRETING INDEX VALUES
SCIRA provides an objective means of quantifying the complexity of an operation or a system and is an indicator of system failure potential. The more tightly coupled and complex a system is, the more vulnerable it is to system accidents or catastrophic failure. SCIRA is calculated by:

$$(Cp) \times (Cx) \times fD$$

Where (Cp) is system coupling, (Cx) is system complexity, and fD is the potential for detecting failure. These values are approximated from the indexes below. A multiplier is added to each value to provide relative weighting. This weighting represents relative impact of the leverage points within each index, and their ability to gauge system resiliency or system failure:

$$(Cp) \times 2(Cx) \times 0.6(fD)$$ (see footnote[13])

The numerical index value has no representation – at present there is no threshold, benchmark or 'right answer', however ongoing research by the author indicates one may exist. In general, a lower value is better; however manipulating systems to gain a low index value (for the sake of a low value) is foolhardy. Even comparing SCIRA index values to similar (or dissimilar) organizations has limited use, given the myriad of variables in any adventure or educational circumstance.

In general, coupling in the operating environment is in some ways fixed, or can only be scaled to a degree without significantly changing the scope and operating location of the organization. System coupling, on the other hand, and slack in particular, can be managed with a direct trade off between logistical and financial efficiency and operating slack. Minimizing slack in an environment with few variables (such as an assembly line) is good business, but adventure and education require some slack to account for the many vagaries in delivery. A lower value is considered better.

[13] Author's research indicates fD, the potential for detecting failure, has less impact on latent system errors than both coupling and complexity, although its presence (or a low index score) minimizes both coupling and complexity. Its leverage points are also valuable from a management perspective. Lower fD index values are often tied to organizations with higher Cx index values, necessitated by more complex organizational models.

Complexity, as detailed above, is relative to only the individual operation. Whether an operation has the appropriate level of complexity for the demands of the operation is a difficult question not addressed with this model. As complexity has many leverage points and is more easily managed than is coupling, it carries a greater weight in the formula (represented by the multiplier, as above). Research by the author indicates small changes in complexity can often have large impacts on the greater system.

Failure detection seeks the lowest value possible, and serves as a multiplier to the coupling/complexity core index value. More so than for the other two variables, the failure detection value should serve as a warning flag to management. Inexperience under peak load needs to be addressed by training, simulation and testing; information sharing needs to become institutionalized.

The index value is of most use in modeling system change. An awareness of coupling can allow for risk tolerance alignment and the purposeful implementation of slack; complexity can be managed with an understanding of the leverage points available to a manager; likewise failure detection and peak load experience can be tested. Any system adaptations can be modeled and prioritized for their value in lowering the index value.

By looking at each Index Factor in isolation (rather than the average that gets inputted into the SCIRA formula), specific change can be applied to the leverage point (each Index Factor is a leverage point). Any Index Factor that scores a ‘5’ rating, needs to be carefully considered as either necessary and fixed or open to change. Making any changes that lowers the index rating decreases coupling, complexity, or contributes to failure detection – all desirable from a systems management perspective.

SCIRA AS A RISK MANAGEMENT TOOL

> ***Risk management*** *is a systems based approach to sustainably managing uncertainty within an operating environment.*

In this case, the ‘uncertainty’ being considered is the failure potential of the management systems of an organization.

As a risk management tool, SCIRA allows:

1. a means of assessing system complexity and system failure potential;
2. comparing internal systems and prioritizing system improvements;
3. a means of targeting system improvements and modeling system change;
4. benchmarking system complexity against other programs or operations.

CONCLUSION

As presented here, the index values approximate an operation’s overall system resistance to failure. With some adaptation, it could be used to compare subsystems within an organization, as a means of prioritizing development. As it evolves further and more comparison values are generated (and tested), a benchmarking value may emerge for operation types.

As an awareness tool this index has value in articulating coupling and complexity, and highlights their role in active and latent errors. The leverage points the indexes measure present the management tools to improve system reliance and organizational performance. Ultimately, as risk management becomes more systems focused, system management tools must emerge to support adventure and educational operations.

REFERENCES

Jackson, Heshka, Cruchet (2010) *Managing Risk, Systems Planning for Outdoor Adventure Programs*, Direct Bearing Inc., Palmer Rapids, ON.

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COUPLING INDEX (Cp)	Loosely coupled (1)	Moderately coupled (3)	Tightly coupled (5)	Approximate INDEX RATING (1-5)
Possible model operations	The Nature Guiding Company	The Skill Instruction Program	"Extreme" Adventure Guiding	N/A
Cp1: Typical activities	Soft adventure, low speed activities: snowshoeing, flatwater canoeing; international travel	Activities in need of management to limit exposure: open water sea kayaking; mountain biking; rock climbing; groomed skiing; off trail travel	High exposure activities: high grade whitewater rafting; scuba diving; mountaineering; adventure racing; motor sports	
Cp2: Time restraints	Flexibility in itinerary or timeline	Itinerary actively managed; can be adjusted by altering plan	Itinerary dictated by environment: difficulty of terrain, weather window, access options; delays create additional exposure	
Cp3: Client focus	Program designed around known client needs, and is adaptable to changing client needs	Clients matched to appropriate program demands; responsive to needs given base level skill and ability	Little to no adaptation possible, environment dictates needs	
Cp4: Human resources: Field staff	Qualified staff readily available (based on technical skill)	Experienced staff with specific skill set	Specialty staff with intimate knowledge of environment, few in number	
Cp5: Volume / delivery pressure	Low volume operation; program logistically independent	Concurrent programs with minimal overlap or logistical link	High volume operation or tightly linked logistics	
Cp6: Equipment and technology	Little reliance on equipment or technology	Specific equipment and technology expected but can be improvised	Specific, critical equipment and technology vital to safety	
			TOTAL COLUMN; Divide by 6 for COUPLING RATING (Cp)	

COMPLEXITY INDEX (Cx)	Linear operation (1)	Hybrid operation (3)	Complex operation (5)	Approximate INDEX RATING (1-5)
Possible model operations	Ski school; canoe tripping company	Adventure resort; high school outdoor education semester; summer camp	International adventure travel company; university outdoor degree program; large scale expedition company	N/A
Cx1: Ease of understanding operation/ Cognitive complexity	Simple, visible program, easy to explain to potential participants	Program with multiple options or offerings, explanation raises questions requiring detailed answers	Multiple logistically complex programs with different goals and performance requirements; defies simple explanation	
Cx2: Operational consistency	Standard trip or program repeated exclusively	Variety of offerings or variations available within standard offering	Programs or services continually added, removed, modified or customized	
Cx3: System age / latency period	Operation has had little need for evolution from inception	Operation experienced growth and development from original concept, but stabilized at a working model	Operation experienced significant growth and development from original concept, continuing developmental process	
Cx4: Human Resources: Supervisory and management	Owner/operator directly involved in delivery of program or service	Top management have been involved for significant portion of operation's history; management removed from daily operations; hand full of managers oversee whole operation	Notable turnover among middle and top management; removed from daily operations; possible multiple levels of management oversee different aspects of operation	
Cx5: Capacity utilization (average)	Consistently operates at less than 60% capacity	Consistently operates at 60-90% of capacity	Consistently operates above 90% capacity	
			TOTAL COLUMN; Divide by 5 for COMPLEXITY RATING (Cx)	

FAILURE DETECTION INDEX (fD)	Detection Likely: (1) History of system failure/system accident	Detection Potential: (3) Experience at peak capacity/peak load	Detection Difficult: (5) No history in recognizing system failure	Approximate INDEX RATING (1-5)
fD1: System failure or critical incident experience	Operation has experienced several different types and scales or failures or critical incidents	Operation has experience with a particular type or scale of failure or incident	Operation has never had to deal with system failure or critical incident	
fD2: Capacity utilization (peak load experience)	100% or greater on a regular basis (i.e. every weekend)	100% on specific occasions; predictable and planned (i.e. key holiday weekends)	Rarely exceeds 80%; have not had to operate under peak load	
fD3: Product quality control	Every program or product is measured for *accuracy* against strict and objective standards	Product sample or average measured for *reliability/consistency* within wide parameters of quality	Quality not defined or is based on client satisfaction; *reliability/consistency* not measured	
fD4: Incident reporting; Information sharing	Rigorous multi-level reporting system in place, information pushed to all levels of organization	Field based reporting system; information deemed relevant passed to certain organization levels	No formal reporting system, relies on word of mouth information sharing	
fD5: Contracted service reliance	Isolated use of contracted service providers, typically on non-delivery related functions (or no use = 0)	Limited use of contracted service providers for delivery and non-delivery functions	Extensive use of contracted service providers to deliver core program or service; variety of providers	
fD6: Cost control	Operational costs are tracked per program or monthly and compared program-over-program and year-over-year	Operational costs are tracked but viewed independent from operations and risk control	Costs not tracked	
			TOTAL COLUMN; Divide by 6 for FAILURE DETECTION RATING (fD)	

INTERPRETATION OF INDEX FACTORS

INDEX FACTOR	Interpretation of factor	Management notes
Cp1: Typical activities	A focused program or single activity organization scores according to that activity's rating. Any program that offers a span of activities scores to the highest activity rating applicable i.e. if both nature hikes and open water sea kayaking are offered, score 3 for sea kayaking.	For multiple activity programs, the management system must be built around the highest index activity or the activity with the least slack. It is possible to have two separate management systems, one each for the lower and higher, but care must be taken to manage the overlap and control of each. The two system option may work when 90% of 'normal' operation is the lower activity, while the higher index activity represents only 10% of the operation (and can therefore be specifically managed due to its smaller size). If the ratio between activities is more balanced, build one robust system to cover both.
Cp2: Time restraints	This is the time restraints placed on the active management of the trip, program or activity. It does not apply to prior planning or to time available in an 'emergency' situation, as that is by definition a situation with minimal slack.	Slack can be purposefully implemented by changing the route, allowing more time for the same route, allowing flexible logistics (pick up times etc.), more training and competency for demands of activity or route.
Cp3: Client focus	As a spectrum, programs that are based around and are adaptable to client needs and abilities score the lowest, while those activities with environments that dictate the skill demands score the highest. Heli skiing, high grade whitewater, and mountaineering dictate the skill demands and are less adaptable, even for clients with the requisite skill. These score the highest rating.	Even activities and environments that dictate the demands can still accommodate varied individuals, but other coupling factors need to be eased off: time restraints eliminated, higher skilled staff and lower client ratios, or lower volume. Programs that attempt to match clients to appropriate activity demands need to invest in their Client Information System i.e. help 'intermediate' climbers select between a 5.5 or a 5.8 guided climb.
Cp4: Human resources: Field staff	This refers to front line and activity staff. Camp counselors and canoe trip instructors likely score 1, while licensed mountain guides or technical specialists score 5. Middle scores apply to positions requiring experienced guides, but not technically limiting. It does not refer to specialty support positions like camp doctor etc.	Consider long term in-house training and mentor programs to develop specialty human resources.
Cp5: Volume / delivery pressure	The index score applies to the link between volume and logistical overlap. High volume operations with little overlap score down a level (i.e. Girl Guides: high volume, but participants operate in independent troops; score 3). Medium sized operations with tight logistical links score up one level.	

Cp6: Equipment and technology	A scale from little reliance on equipment or technology to critical reliance upon equipment or technology. Backpacking and canoe tripping scores 1; ropes course and top rope climbing scores 3; reliance upon satellite tracking, constant communication technology, or complex mechanical support (helicopters or hydraulic snow groomers for example) score 5.	The more specific and critical equipment is to safety and program operation, the more effort need be dedicated to managing that equipment.
	SCORE each item 1 through 5	TOTAL COLUMN; Divide by 6 for COUPLING RATING (Cp)

INDEX FACTOR	Interpretation of factor	Management notes
Cx1: Ease of understanding operation/ Cognitive complexity	The first glance and relative simplicity of an operation is telling of its complexity. If the average person has a hard time understanding what the operation is about or does, then there is inherent complexity built into the operation.	Since most adventure operations grow from small scale, loosely coupled and linear organizations to add more trips, more staff, and more management; they ultimately become more tightly coupled, and the complexity of the management system is not recognized – the operation is interconnected but is managed as though it were linear. This complexity creep need be recognized and managed.
Cx2: Operational consistency	Continual change leaves gaps and loose ends. Good system planning should account for this, however many organizations' systems do not keep up with the scale and nature of the changes.	Program change need be managed from the top down via systems that ensure development happens within risk tolerance and operational parameters. Changing programs from the bottom up leaves management reacting rather than planning.
Cx3: System age / latency period	Staying small and simple means a predictable operation. Older systems, though, risk complacency.	Steady growth and development means more potential for loose ends and management diligence is required to keep the organization on track.
Cx4: Human Resources: Supervisory and management	Self explanatory.	Turnover is in some cases difficult to avoid, but practices can be implemented to capture organizational learning. This avoids every new employee starting at the bottom of the learning cycle, which stunts organizational capacity.
Cx5: Capacity utilization (average)	Higher capacity utilization implies a higher interconnectedness, higher coupling, and more complexity to manage it.	Returning to the coupling index, the purposeful implementation of slack in the system acts as a margin of error for the operation at peak capacities.
	SCORE each item 1 through 5	TOTAL COLUMN; Divide by 5 for COMPLEXITY RATING (Cx)

INDEX FACTOR	Interpretation of factor	Management notes
fD1: System failure or critical incident experience	The low score for operations that have experienced several different types and scales or failures or critical incidents is based on the assumption that this experience will help them recognize these situations again in the future (as opposed to an operation which has never seen a critical incident, and is assumed would be slower to recognize it and its implications).	Testing, training and simulations are a means of building experience with critical incidents.
fD2: Capacity utilization (peak load experience)	As for the factor above, this assumes a busy operation is regularly (or has been) tested. The systems are regularly under stress, so it is assumed bugs have been identified and worked out of them.	Thorough systems planning and implementation can negate this effect; in particular establishing system control mechanism and having accuracy targets.
fD3: Product quality control	Measuring for *accuracy* against objective standards provides direct and immediate feedback when systems aren't working properly.	Accuracy in adventure and service industries is rare for lack of clearly defined performance standards. Most organizations are satisfied with consistency and reliability, and are reluctant to imagine what 'perfect' looks like.
fD4: Incident reporting; Information sharing	Information sharing assumes learning is happening at all levels of an organization, and performance improves with it.	This is relatively easy to improve in any organization, through reporting, briefings, newsletters or any structured means of distributing important learning and/or information.
fD5: Contracted service reliance	Contracted service providers create a net loss in organizational learning: expertise is temporary, and any learning they pick up on behalf of the organization goes away with them.	Managing contracted service providers is time consuming and expensive. Establishing accuracy standards as in fD3 allows for measuring contractor performance but also learning from their performance can be re-invested in the organization.
fD6: Cost control	Cost control is a means of managing profit/loss exposure, but also is an indirect early warning system. If costs are going up per course, there may be minor failures in supporting systems which cash is being used to cover.	Compare costs on a trip per trip or course per course basis, or a month over month analysis.
	SCORE each item 1 through 5	TOTAL COLUMN; Divide by 6 for FAILURE DETECTION RATING (fD)