Problem Solving Toolkit

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The Problem Solving Journey

Almost all problem-solving situations can be seen as a journey through four stages:

Stage 1 – Problem definition
Stage 2 – Solution Generation
Stage 3 – Evaluation: Solution screening and comparison
Stage 4 – Implementation

The description of the tools presented in this Toolkit is structured around these four stages. The examples presented with each of the tools are taken from the NTC case, which is presented at the end of the Toolkit. First, there are a few general considerations about the overall process.

Divergent versus Convergent Thought

“For every problem, there is one solution which is simple, neat and wrong. “

(H. L. Mencken)

Throughout the problem solving process it is important to recognise whether you are in a divergent or convergent thinking phase. For group problem solving it is critical that there is agreement on this issue at each stage of the process otherwise team-members will be pulling in opposite directions.

Divergent thinking generates new ideas. It broadens the scope of thinking. It requires an attitude of acceptance, trust, ‘anything goes’ and a desire to be creative. Critical evaluative statements disrupt divergent thinking.

Convergent thinking evaluates the quality of ideas and chooses between them. It narrows the scope of thinking. It requires an attitude of critical judgment, constructive criticism, objectivity and a desire to be methodical. Wooly, unfocused statements disrupt convergent thinking.

People differ in their dominant style of thinking. However, in the problem solving process it is critical that team-members recognise the value of employing both styles of thought at appropriate times throughout the process. Without divergent thought, the full extent of the problem or the full range of possibilities for solutions will most likely be missed. Without convergent thought, thinking will be unfocused and implementable solutions will not be reached.

The problem solving process is most effective when there is an ordered cyclical movement between divergent and convergent thought and all participants in the process recognise the stage that they are in. The critical thing in many groups is to appropriately balance narrowing down with broadening out. At different times in meetings, depending on how we feel, we will have a tendency to do one or the other and it is important to manage this process.

Working In Groups

Most of the tools that will be discussed in this section can be applied in either individual or group settings. If we have presented the tool as a group exercise, it would be a useful exercise for you to think of how it could be applied individually.

Some of the problems of groups arise from a lack of structure. The following simple rules should always be followed in groups:

- Always have an agenda and stick to it (→ goal setting and time management)
- Where appropriate, agree on roles such as facilitator/leader/scribe etc.
Always make time to plan the process (deciding how to decide) and check that the process is working (evaluation).

These overarching rules are obvious and we have not focused on them in detail in the tools that follow. However, just because these rules are not discussed in detail, that does not mean that they are unimportant. They should never be ignored.

If groups are working well, they have a number of advantages:

- With complex, ill-defined problems the products from groups are often better than those produced by individuals.
- The use of groups allows for the canvassing of a wide variety of perspectives on the problem situation.
- Well-structured group interactions are an efficient use of members’ time.
- Participation in groups usually increases buy in from the participants.

**The Value of Additional Information: Going Off-line**

All the techniques discussed in this manual depend upon accurate information. It is often the case that additional information is required during the problem solving process. This is particularly true in the issue identification stage where information regarding the needs and expectations of internal and external customers is frequently required. Although not explicitly discussed, there are natural opportunities for you to go ‘off-line’ and collect more information for all of the techniques listed below. If you do this, you may find it helpful to create an intermediate issue statement where the goal is to find or create the information that is needed.
Human Biases and limitations

- We tend to ‘plunge in’ to providing solutions before we have a clear idea of what the problem is. This is particularly true for groups.

- Unstructured groups are often ineffective and/or inefficient:
  - They waste time,
  - Some people don’t contribute as much as they should,
  - ‘Groupthink’ can produce bad decisions, and
  - They can be more risk seeking or conservative than the situation requires.

- Individuals are also prone to cognitive biases:
  - We tend to draw on ideas and solutions that are readily available from memory or from the external environment.
  - We are heavily influenced by the way in which a problem is framed – even when the context should have no effect on the solutions we generate.
  - We identify causes and choose solutions that appear similar to the problems, even though this similarity may be irrelevant.
  - We focus on incremental adjusting from a starting position even when the starting position is irrelevant

- We prefer to evaluate rather than generate ideas, frequently leading to narrowing down the field of ideas too early.
The Stages of Problem Solving

The four stages of problem solving serve quite different purposes and require different tools to achieve these different purposes. Some tools can be used across multiple stages but must be adapted to the purpose of each particular stage:

<table>
<thead>
<tr>
<th>Stage</th>
<th>Aim</th>
<th>Primary Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 – Problem definition</td>
<td>To generate a small set of problem statements that everyone understands and agrees upon.</td>
<td>The 5 W’s and Root Cause Analysis, Value Chain Analysis, SWOT Analysis. (Also Brainstorming)</td>
</tr>
<tr>
<td>2 – Solution Generation</td>
<td>To generate a wide range of possible solutions to core problems.</td>
<td>Brainstorming/ Brainwriting/ Mind Mapping, Fishbone Diagrams (Also Value Chain)</td>
</tr>
<tr>
<td>3a – Evaluation: Solution screening</td>
<td>To narrow down the list from stage 2 and identify only feasible solutions to evaluate in detail.</td>
<td>Elimination by Aspects, Voting and Ranking, Screening Matrix</td>
</tr>
<tr>
<td>3b – Evaluation: Solution Comparison</td>
<td>To evaluate and prioritize main solutions</td>
<td>Decision Matrices, Devil’s Advocate Role</td>
</tr>
<tr>
<td>4 – Implementation</td>
<td>To identify issues associated with implementation and build an action plan.</td>
<td>How-How diagram, Project management techniques (Also Fishbone, Brainstorming)</td>
</tr>
</tbody>
</table>

It is important to remember that at any stage you may need to go ‘off-line’ and collect or analyse additional data. This is not something we have discussed in detail below but remember that almost all complex problems cannot be addressed without assimilating data from outside the group or process. For example, in the issue identification stage, it is usually essential to gather some data regarding the needs of internal or external customers.

The following table lists the full set of tools described in this document, together with an indication when they can be used in the different stages of the problem solving process.
<table>
<thead>
<tr>
<th>Tool</th>
<th>Problem Definition</th>
<th>Solution Generation</th>
<th>Solution Screening</th>
<th>Solution Comparison</th>
<th>Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 W’s</td>
<td>+</td>
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<tr>
<td>Why-Why/Root Cause</td>
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<tr>
<td>Value-Chain Analysis</td>
<td>+</td>
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<tr>
<td>SWOT Analysis</td>
<td>+</td>
<td>+</td>
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<tr>
<td>Brainstorming</td>
<td>+</td>
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<td>Brainwriting</td>
<td>+</td>
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<tr>
<td>Mindmapping</td>
<td>+</td>
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<tr>
<td>Fishbone diagram</td>
<td>+</td>
<td>+</td>
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<td>+</td>
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<tr>
<td>Elimination by Aspects</td>
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<tr>
<td>Voting/Ranking</td>
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<tr>
<td>Screening Matrix</td>
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<tr>
<td>Decision Matrices</td>
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<td>+</td>
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<tr>
<td>Devil’s Advocate Role</td>
<td>+</td>
<td>+</td>
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<td>+</td>
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<tr>
<td>PMI technique</td>
<td>+</td>
<td>+</td>
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<td>+</td>
</tr>
<tr>
<td>Nominal Group Technique</td>
<td>+</td>
<td>+</td>
<td></td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>How-How diagram</td>
<td></td>
<td></td>
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<td></td>
<td>+</td>
</tr>
<tr>
<td>Action-planning</td>
<td></td>
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<td></td>
<td>+</td>
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<tr>
<td>Force Field Analysis</td>
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<td>+</td>
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</tbody>
</table>
Stage 1: Problem Definition

"An undefined problem has an infinite number of solutions."

(Robert A. Humphrey)

Background
Defining the problem is at least half the work of problem solving. All the tools described below rely upon a clear definition of the problem or issue. If the problem is incorrectly defined then the solutions that are generated will also be inappropriate.

In fact, problem definition is such a critical part of problem solution that you will often find yourself returning to redefine and clarify the nature of the problem throughout the problem solving process. That process frequently reveals that there is a more fundamental issue or problem that really should be the focus of your thinking.

Even when a problem appears to be clear, it is often useful to spend some time thinking about whether the assumptions underlying this problem statement are correct and/or if there is more data that is required in order to accurately define the problem.

Like much of the problem solving process, problem definition best proceeds if there is a period of divergent thinking followed by convergent thinking.

Aims and Tools
The aim of this stage is to generate a small set of problem statements that everyone understands and agrees upon. The tools we will consider for this stage include the 5 W’s and Root Cause Analysis, Value Chain Analysis and SWOT Analysis. Brainstorming can also be applied to this stage however we will describe that tool in the Solution Generation section.
The 5 W’s

The 5 W’s approach provides a structure for clarifying some element of the problem solving process through repeated questioning. It is most useful during the issue identification stage but it can also be used at later stages such as for identifying areas where further data collection or analysis is required.

The underlying assumption is that all problems can be defined in terms of simple attributes (the What?), location in space (the Where?) and time (the When?), and people who are affected (the Who?). Not all dimensions are relevant for all problems, however every problem will have some attributes that define the gap to be elaborated so “the What?” is always relevant and should usually be addressed first.

The fifth W is Why? Why? questions can serve two purposes. First, they can be used to gain some insight into the goals of the problem solving exercise. For example, “Why do we want to improve employee satisfaction?”

The second use for the Why? question is at a different level from the other W’s in that it requires a shift from a description of the gap to an inference about what the underlying causes or contributing factors are. Often the causes or contributing factors will be identified through answers to the other 4 W’s (or some subset of them).

The Process

1. The order of questioning has two requirements. The What? should come first and the Why? last.

   • **What**: Focus on what is. What is the problem here? This is sometimes referred to as the ‘issue attribute’. Other what questions include: What do we need to know? What would the ideal situation look like? What criteria will we use to measure our success at solving this problem?

   • **Where**: Refers to the physical or structural locations of problems. For example, Where does the problem usually arise? Where might we expect problems to arise?

   • **When**: Timing issues include: When does the problem occur? When do we have to be done? When will the solution be used?

   • **Who**: Refers to who is affected by a problem or who is the source of a problem? Who questions gather information about stakeholders including internal and/or external customers. Who is involved in the problem? Who will determine whether or not we have succeeded?

   • **Why**: Sometimes used for determining values/goals - Why do we need to solve this problem? Most useful for determining cause - Why is that happening? Why do people react in that way? Can be pursued repeatedly to determine root causes (see below). Should be used in such a way that there is no sense of interrogation.

2. While there will be frequent recycling back through questions, the general strategy is to pursue more and more specific questions at each step before moving to the next level. For example, if the issue attribute identified by a What? question points to “skills shortage” as a problem, the next question is what skills? If the answer is “technology skills”, then ask what technology skills? What internet skills? etc.

3. The stopping point will depend on the stage in the problem solving process that you are at. If time permits, it is often better to drill down to a more specific level than you need. Remember that you may have to go off-line at any point to get expert input, collect and analyse data or do some search. Going off-line breaks up the process, so some of these questions can be anticipated before group meetings.

4. Once you have generated (and preferably recorded) answers to the 5 W’s, use those responses as stimuli to generate redefinition of the problem.
5. Select from amongst those redefinitions the problem statement that should be pursued further.

**Applications**

5W's can be used to clarify and redefine issues/problems, provide cues for determining the goals in the problem situation, find out what additional data and analyses need to be conducted and better understand the causes of the problem. It can also be used to redefine solutions.

One of the reasons for using the 5W’s is to avoid leaping to thinking about solutions as you will see from the example below.

**Worked Example**

The broad issue we are going to consider is the problem of succession planning for product leaders at NTC. Here is a sequence of questions that we considered:

*What is the problem?* NTC is ill-prepared if their current product leaders leave the firm.

*What is the current succession plan for product leaders?* There is no succession plan.

*What is the effect of a lack of a succession plan?* Staff feel that they have few development opportunities. There is increasing resentment from staff that are potential product leaders that they have limited promotional opportunities.

*In what ways is the problem showing up?* There have been no new product leaders in the last three years. When acting product leaders have been tried there have been major conflicts.

*What was the nature of those conflicts?* Acting product leaders questioned the authority of marketing engineers to require changes in product design. The product development team has generally sided with the more experienced marketing engineers.

*Where is the problem most evident?* There has been a particular problem in the Circuit Design Division.

*Who are the stakeholders involved in the problem?* Existing product leaders, marketing engineers, the product development team, acting product leaders, future potential product leaders, staff working for product leaders, …

Such questioning could continue through the first 4 W's. If in a group, members of the group could brainstorm questions to consider from each of the W's. Eventually you will reach a stage where the pressure is on to start asking why?

*Why has the product development team generally supported the marketing engineers?* They believe that the marketing engineers have more experience and therefore are more likely to be right. They appear to ignore the experience of more junior staff.

And so on.

After extensive questioning a number of new problem statements emerge from the analysis such as:

- Older staff are dissatisfied with the lack of retraining opportunities.
- The product development team has not been fostering the development of new talent.
- The current working relationships between product leaders and marketing engineers are too dependent on personal friendships.
The Fifth W: Root Cause Analysis and the Why-Why Diagram

The 5 W’s should end with a sequence of ‘Why’ questions sequentially probing to greater depth. This repeated ‘drilling-down’ into the problem can provide surprising insights into the problem and is known as “Root Cause Analysis.”

Root cause analysis is very useful in the problem definition stage. It is a technique of drilling down into the problem to try to find out the essential causes of the problem rather than the symptoms. One tool that you may find useful for root cause analysis is the ‘Why-Why’ diagram.

The Why-why diagram is simply a tree diagram where causes of a problem are probed. For example, the following why-why diagram might have arisen from the redefinition “Older staff are dissatisfied with the lack of retraining opportunities”.

You can see how the why-why diagram provides a means of rapidly recording and relating a series of causes for a problem. As you move down the tree you will find that it is not possible to say why some causes arise. This may be because you need to collect additional information. Alternatively it may be because you have arrived at the root cause of the problem. If it often the case that addressing the root cause of the problem leads to the most effective and long-term solution to the problem.
Applications
The why-why technique is quite generic and can be used with the 5 W’s or on its own. The primary purpose of the why-why diagram is finding out the root causes of a problem.

A parallel to the why-why diagram is the how-how diagram. This is used after solutions have been identified for planning the implementation process. It provides a structure for identifying required resources, timelines and allocating tasks. For example, How can we improve the situation? How can we address this problem? How will we know when we have solved the problem?
Value Chain Analysis

The following tools (Value Chain Analysis and SWOT) are best used to explore the organisational context in which you work. Any issue or problem you work on has an organisational context and understanding this context will allow you to understand the issue more fully and search more widely for possible solutions. These tools are best used at the beginning of a problem solving activity to ‘set the scene’. The product of using these tools could be the input to problem identification. That is, when you have more fully understood the organisational context by doing, for example, a value chain analysis, the data generated from this analysis may be the data you use to understand your issue, or identify root causes to your problem.

The product of these tools could also be used at later stages of the problem solving process, again as data input. When searching for solutions you may use your understanding of the organisational context to identify alternatives, and when evaluating alternative solutions you may assess the feasibility of each by considering their ‘fit’ with the characteristics of the organisation.

Description
A value chain analysis is a way of understanding the different activities of the organisation, how they fit together, and it is a way of exploring how these activities and their linkages underpin competitive advantage. A value chain helps us assess the value added by each activity and identify where improvements could be made.

There are two parts to a value chain – primary activities and support activities. The primary activities chain represents the sequential stages of a system. The support activities are those activities which allow the primary activities to take place and which improve organisational effectiveness.

The original value chain framework was developed by Michael Porter and is illustrated below. Inbound logistics refers to the supply of any materials, resources or other inputs to operations. Outbound logistics refers to distribution to the customer including storage and transport. Firm infrastructure refers to systems of planning, finance, cost control, organisation design etc. Procurement refers to the acquisition of any resources, not only inbound logistics, eg the procurement of information about customer demand.
However, we can use the value chain framework to explore different organisational systems. For example, this is what a value chain analysis of an HR system might look like:

**Process**
1. Identify the system you are going to analyse, for example the production system, the HR system, the customer management system.
2. Draw a diagram similar to the above which shows clearly the activities, both primary and support, which contribute to the system. The primary activities are like steps in a process, the
outputs of one are the inputs to the next. Support activities are those activities which need to be done to ensure the system works.

3. For each activity ask ‘is value being added here?’ or more simply ‘is this a strength or weakness in the organisation?’. Identify the activities which are effective and those which are not.

4. Consider the linkages between activities. Is there a good flow between primary activities? Are the support activities sufficiently integrated with primary activities? Identify strengths and weaknesses.

**Applications**

As a problem solving tool you can use a value chain analysis to identify key issues and to generate solutions.

*Issue identification* – Use the value chain framework to identify key issues for the business and to search for root causes of problems. Maybe a weakness in one activity, for example poor quality raw materials (inbound logistics), is at the root of customer dissatisfaction, or weak R&D is causing staff turnover because of low opportunities for innovation. Use the value chain to explore widely beyond the obvious causes of problems.

*Solution generation* – Having identified a set of key issues, use the value chain to explore where solutions might come from. Will changing suppliers improve production time? Will more research generate higher quality products? At NTC, might development lead to higher employee commitment and lower turnover? Alternatively a solution might come from another part of the value chain, like recruitment. Maybe by developing better succession plans (internal recruitment) junior employees will get the development opportunities they desire.

**Worked example**

**Value Chain Analysis of NTC’s HR function**

1. The system we are going to analyse is the HR system at NTC.

2. The diagram below shows what we know of the HR system at NTC. Since there is no HR department, HR activities are not highly developed, and often non-existent.
3. Since there is no HR department, and HR activities are not planned or resourced most of the activities do not add value. The selection system is the most significant source of value since recruiters consistently recruit for the personal initiative (PI) factor. The value this adds is that NTC employees are creative - their record in New Product Development is a measure of this. However, internal recruitment and succession planning is poor, particularly for product leaders and marketing engineers. Remuneration activities add value in that, until recently, employees had high loyalty and commitment. This could partly be attributed to high salaries and the bonus scheme. Under the bonus scheme employees are rewarded for their creativity and innovation which reinforces the value of this to the organisation.

4. There are few value adding linkages here. Selection on personal initiative is consistent with remuneration for innovation if we assume that personal initiative is a determinant of innovation (hence the dotted curved arrow in the diagram). However this is the only obvious linkage.

What would we do with the output of this value chain analysis? If, for example, we were exploring the issue of turnover, which has recently been a problem for NTC, we could use this analysis to identify root causes of the problem. The root cause suggested in the case is remuneration – the four engineers who left wanted more than was possible given limits imposed by Telecomp. Alternatively, turnover might be a result of development opportunities. If more junior employees are not being ‘groomed’ for higher positions their opportunities for development are limited.

Having identified these potential issues or root causes you may need to collect more information to test your ideas before finalising your issue identification.
SWOT

Description
A SWOT analysis is a tool commonly used to help define an organisation’s strategy. By identifying the organisation’s Strengths, Weaknesses, Opportunities and Threats the current position of the organisation is clarified and future strategic directions are identified. Identifying Strengths and Weaknesses are organisation-focussed activities and examine the current state. Identifying Opportunities and Threats are externally focussed activities, involve environmental scanning and consider potential future changes.

Examples of each are:

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong financial condition</td>
<td>Outdated practices</td>
</tr>
<tr>
<td>Brand name</td>
<td>High costs</td>
</tr>
<tr>
<td>Proprietary technology</td>
<td>Internal operating problems</td>
</tr>
<tr>
<td>Employee motivation</td>
<td>Poor R&amp;D</td>
</tr>
<tr>
<td>Good customer service</td>
<td>Weak marketing skills</td>
</tr>
<tr>
<td>Strategic alliances</td>
<td></td>
</tr>
<tr>
<td>Core competencies are also important organisational strengths</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>New markets</td>
<td>New competitors</td>
</tr>
<tr>
<td>New Alliances</td>
<td>Slow market growth</td>
</tr>
<tr>
<td>Transfer of skills to new products</td>
<td>Costly new regulations</td>
</tr>
<tr>
<td>Vertical integration</td>
<td>Vulnerability to business cycle</td>
</tr>
<tr>
<td></td>
<td>Changing patterns of demand</td>
</tr>
</tbody>
</table>

The outcome of generating a list of SWOTs is a description and familiarisation of the organisation’s position. It serves to raise general debate and encourages you to explore widely but it does not clearly identify problems or provide answers. Like the Value Chain Analysis it explores the context to the organisational issue or problem and is important input data to your problem solving.

Process
1. Identify the unit of analysis, ie the SWOTs of what? The most common unit of analysis is the organisation, but you could equally perform a SWOT analysis of an HR function.
2. Fill in each of the four boxes to identify the Strengths, Weaknesses, Opportunities and Threats of the unit you have chosen.

Applications
The information produced by a SWOT analysis could be used at various stages in the problem solving process.

Issue identification - Use your SWOT list to identify key issues by asking probing questions such as:

- Can opportunities be taken given strengths and weaknesses?
Can threats be overcome given strengths and weaknesses?
Can we continue as we are given future opportunities and threats?
Do weaknesses hinder, and strengths support, the achievement of organisational objectives?
Do opportunities need to be taken / threats need to be overcome in order to achieve organisational objectives?

You may find that current strengths won’t allow the organisation to achieve one of the opportunities identified, so an issue might be how to build organisational strengths in the future.

**Solution generation** – Given a defined problem or issue use your knowledge of the organisation’s SWOT’s to look for solutions. You could ask questions like:
- Which of our strengths can we use to solve this problem?
- Building on which of our weaknesses might solve this problem?
- If we capitalise on one of our opportunities would the problem be solved?

However, there is a danger of availability bias if we look for solutions from the current state, ie building on existing strengths to solve problems might appear easier than building new strengths. However once a set of solutions is generated you can use SWOT to evaluate which are most feasible and easy to implement as described below.

**Solution evaluation** - Your list of strengths and weaknesses can also be used to evaluate and prioritise solutions. Think about which solutions are feasible or easier given current strengths and weaknesses. You may find that it would require too great an investment in new skills or systems to implement some of your solutions. If some solutions are not possible given current organisational weaknesses then forget them. Alternatively you may find that some are more feasible given strengths. Or, it may be that one of your solutions makes a current weakness less critical if it diverts organisational activity away from it.

**Worked example**

**SWOT at NTC**
1. The unit of analysis used in the following SWOT is NTC, the organisation.
2. The following table shows the SWOTs we have identified at NTC.
<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>The NewPC product – ready for release</td>
<td>Financials – return on capital and market share</td>
</tr>
<tr>
<td>A creative workforce</td>
<td>Cost of ongoing downsizing program</td>
</tr>
<tr>
<td>Generation of new ideas</td>
<td>Victim of past excess of riches</td>
</tr>
<tr>
<td>Rapid development of prototypes</td>
<td>Bilated and bureaucratic</td>
</tr>
<tr>
<td>Design and development of core components for telecoms products</td>
<td>No clear HRM plan or processes</td>
</tr>
<tr>
<td>Good brand name in the industry</td>
<td>(eg succession planning, remuneration)</td>
</tr>
<tr>
<td>Fast moving and flexible product development and decision making process</td>
<td>Loss of brand name because past products not ready for launch</td>
</tr>
<tr>
<td></td>
<td>Poor cost controls (travel expenses and salaries)</td>
</tr>
<tr>
<td></td>
<td>Poor selling strategy</td>
</tr>
<tr>
<td></td>
<td>Poor co-ordination and integration across the organisation – silo mentality, eg no sharing of ideas in the design teams</td>
</tr>
<tr>
<td></td>
<td>Professional vs organisational clash of cultures – resulting in engineers leaving for research based companies</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market growth</td>
<td>Erosion of position by competitors</td>
</tr>
<tr>
<td></td>
<td>High cost industry</td>
</tr>
<tr>
<td></td>
<td>Audit by investment advisors</td>
</tr>
<tr>
<td></td>
<td>Staff leaving to competitors</td>
</tr>
</tbody>
</table>

**Issue identification** – If the overall problem for NTC is loss of market share to competitors and decreasing profitability, a root cause analysis using the weaknesses and threats listed above suggests these key business issues (or causes of this problem):
- How to reduce costs for profitability and to satisfy the investment auditors
- How to improve the marketing and selling of new products
- How to improve organisational loyalty to increase collaborative working for corporate gain

The quality of ideas is not a key issue since this is listed in NTC’s strengths, but turning those ideas into marketable and profitable products is.

**Solution generation** – Exploring the second of these issues, ‘How to improve marketing and selling of new products’, what solutions does the SWOT analysis suggest? A key organisational weakness is the lack of HR planning and functioning. If we improve this weakness by building an HR capability to recruit and develop marketing specialists, the problem may be solved. Another solution could be to build an HR capability around remuneration and remunerate existing staff around successful marketing of products (eg a bonus for marketability rather than innovation). Another solution to the same problem suggested by current weaknesses is the better integration of R&D and marketing via, for example, cross functional groups or a stronger matrix structure.

**Solution evaluation** – Let us use the set of possible solutions to the issue of improved marketing of products identified in the value chain analysis (above). These were:
- An HR plan to recruit and select marketing specialists
- An HR plan to remunerate all staff for successful marketing of products
- Better integration of R&D and marketing via, for example, cross functional groups or a stronger matrix structure
You can evaluate each solution and decide which is most feasible given the current strengths and weaknesses of NTC. One key weakness which relates to this issue is the *culture clash between the profession (of engineering) and the organisation (NTC)*. What does this tell us about the feasibility of each of the above solutions? It alerts us to the problems of each as follows:

- We know that marketing specialists have been recruited in the past but that they were not accepted because of the strong divide (culture clash) between engineers and marketeers. The first solution is therefore a least preferred option since it has been proven to fail.
- Given the strong professional orientation of current engineering staff remuneration for successful marketing of products may meet heavy resistance. Engineers want to be engineers not marketeers. Therefore the second option may be hard to implement too.
- Increasing contact time and introducing superordinate goals which require cooperation between engineers and marketeers may reduce the cultural barrier between them at the moment. However there will most likely be an initial period of conflict.
Stage 2: Solution Generation

Brainstorming and Divergent Thinking

"If the only tool you have is a hammer, you tend to see every problem as a nail."

(Abraham Maslow)

Brainstorming is the simplest and most widely used tool for rapidly generating ideas. It is an extremely generic process that can be used to generate:

- problem statements,
- potential causes,
- ideas,
- potential solutions,
- people who are affected,
- supporting activities,
- data sources,
- criteria for measuring success, or
- any number of other products that are useful in the problem solving process.

Brainstorming is all about solution generation rather than evaluation. It is the classic divergent thinking tool. The goal is quantity rather than quality. We will show you other tools later that can be used to separate the good ideas from the bad. Brainstorming often produces ideas that later turn out to be creative and novel.

Brainstorming can be used to generate any of the problem elements mentioned above, break out of ruts in thinking or to control the contribution of members who might dominate solution generation or to encourage silent members to have their say.

The most important aspect of running a brainstorming session is to make sure everybody feels comfortable expressing even crazy ideas. It is critical that evaluation by self or others is suspended until after the brainstorming session.

Trust is usually not a problem if the group have previously brainstormed successfully together. However, if a group has not worked together before or if they have a history of being highly evaluative of one another, it is important to take some time to structure the process to produce divergent thinking.

Process for Standard Brainstorming in a Group

1. Clearly state the problem, issue or opportunity where everyone can refer to it. State the time limit. Brainstorming sessions are better if they are short (absolute maximum of 30 minutes).

2. Explain the four basic rules of brainstorming:
   a) No judgments, evaluations or comments should be made about any suggestion.
   b) All ideas, even absurd or impractical ones, are welcome – try to avoid self-criticism.
   c) The main aim is to identify as many possible solutions to the problem as possible. This will lead to quality later as the ideas are pruned.
   d) Participants are encouraged to combine ideas and to ‘piggyback’ on the ideas of others.

3. Record ideas accurately - if they must be condensed asked the contributor for a suggestion as to how to condense them.
4. After the time limit, take a break and then have a brief review stage where ideas are clarified or explained if necessary. Remember that the purpose here is not to evaluate or judge the contributions. That comes later.

Handling Tensions in Brainstorming
The biggest problem in typical brainstorming sessions is that not enough time or effort is devoted to creating a non-critical atmosphere. It is the responsibility of the group leader to ensure that all critical or evaluative statements are deferred until after the brainstorming session.

Variation 1: Allowing thinking time
The research evidence suggests that brainstorming is likely to be more effective if the team members have had some time to think about the issues privately before the more public phase of brainstorming commences. This allows people to decide what the most important issues are for them without being influenced by others. It also gives people who have not recently thought about the issue some time to ‘get their head into gear’ on the problem and often reduces anxiety levels because everyone knows that they will have something to contribute.

1. Clearly state the problem, issue or opportunity where everyone can refer to it.
2. Explain the four basic rules of brainstorming:
3. Explain that the session will start with some thinking time to allow people to generate some ideas of their own.
4. Provide group members with paper and pens so that they can write down their initial responses privately. Reassure them that nobody will see the paper so they can write anything they wish no matter how ‘far-out’ it might seem.
5. After 5-10 mins ask people to read out ideas from their page one at a time.
6. Commence brainstorming and piggybacking off ideas as before.

Variation 2: A Brainwriting Pool: Encouraging Divergent Thinking among People Who are Shy.
Brainwriting is a variant of brainstorming that places less demand on people to publicly state seemingly silly ideas. It allows people to piggyback off others ideas or continue working on their own as required.

1. The problem is identified to the group
2. A group of six to eight people, sitting around a table, write their solutions to the problem on a piece of paper.
3. After writing down at least four ideas, each person places his or her piece of paper in the center of the table.
4. When participants run out of ideas, they may choose one of the slips of paper from the center of the table and piggyback on those ideas to create new ones.
5. Eventually every participant should exchange his or her piece of paper for at least one other in the centre of the table.

Variation 3: “Mind-Mapping” - Brainstorming for Individuals
Even if you are on your own you can use the method of ‘mind-mapping’ to brainstorm ideas about a particular topic or to organise your thinking.

1. Start with a topic or issue statement in a circle in the middle of a blank page.
2. Brainstorm each major facet of the problem or issue, placing your thoughts on lines drawn outward from the central thought like roads leaving a city.

3. Add branches to the lines as necessary.

4. Add connecting lines between related or similar thoughts.

5. Use colours, pictures or shapes to organise the materials as appropriate.

6. Study the mind-map to see what insights it provides into the problem and if it suggests any solutions.

**Mind Mapping an NTC Problem**

We wanted to address the issue of how best to preserve the creative culture embodied in the concept of ‘personal initiative’. We decided to approach this problem by creating individual mind-maps. What follows is an example:

![Mind Map Example](image)

**Applications**

**Issue Identification** - Sometimes brainstorming is used in defining the problem. In that case, the problem statement for the initial brainstorming session will be something like “What is the problem that must be addressed here?”

One good use of the 5 W’s and H is to provide the focus for questions for a brainstorming session. For example, the facilitator could use the 5 W’s to form an initial list of questions to be brainstormed such as:

- What is the main problem here?
- Who is involved in this problem?
- Where in the organisation is the problem located?
- Why does that problem occur there?
- Why doesn’t the problem arise elsewhere?

This process could be organised by posting the questions on 5 sheets of butchers paper and then sequentially brainstorming answers to the questions.

Mind-mapping can also be used by individuals to record their ideas prior to participating in a group brainstorming session.

**Solution Generation** - Brainstorming is an extremely generic process that can be used throughout all stages of the problem solving process where a divergence of ideas are required including generating ideas regarding: problem statements, potential causes, ideas, potential solutions, people who are affected, supporting activities, data sources, or criteria for measuring success.

Remember, brainstorming is about generating lots of ideas. If it is working properly, not all of those ideas will be good ones.
**Fishbone Diagrams**

It is sometimes helpful to use a ‘fishbone diagram’ to help organise the output from a brainstorming or root cause analysis session. The diagram is called a fishbone because of its appearance. It has a head where the main issue or problem is recorded and as many ‘spines’ as required. Fishbone diagrams have many advantages over other recording methods. They produce a compact, readily understood representation of the generated ideas and they automatically structure the responses in broad categories of related ideas.

Once the diagram is complete it provides a basis for analysis of categories of ideas. Building the fishbone diagram does not need to occur in a single meeting. It is often very helpful to allow some time for ideas to stew. Members will often bring back new ideas after thinking about the issues for a day or two.

**Process**

1. Some sort of problem statement or question is written in the ‘head’ of the fish on the right-hand side of the page. We have found that it is most useful when this statement is written in the form of a question.

2. A straight line is then drawn to the left with branches coming from the backbone.

3. Either before or during the session, place broad category labels at the end of each of these branches. These might be generic categories where issues might typically arise (see example lists below) or they might be major issues or problems previously identified.

4. These major issues or problems are then fleshed out through adding more spines to the fish.
Worked Example: How can we increase the likelihood of getting final products to market at NTC?

What follows is a partially completed fishbone diagram focusing on some of the possible HR solutions to the problem of not getting products from the prototype stage to final marketing.

Classical approaches to fishbone diagramming included some pre-specified categories labels for the spines of the fishbone. Here are some ideas for ‘cue-words’ you could use:

The 4 M’s (Ishikawa/Total Quality)
Materials, Methods, Manpower (People), Machines

The 4 C’s
- Customers (What do your customers want and need? How will you satisfy those needs? What is most important to them? How much will they pay for it?)
- Competitors (What are your competitors doing? What are their strengths and weaknesses? How are they meeting the customers’ demands? What is their cost structure?)
- Capacity (What is your company’s capacity in terms of: financial, organizational, production, marketing? What are your strengths and weaknesses?)
- Costs (What is your cost structure? What are the main sources of costs?)

Other Possible Category Labels
- Communications
Applications
The fishbone diagram is a generally useful method for organising many ideas into defined categories. It allows one to see at a glance, all the issues related to the main topic. It can be used for issue identification, root cause analysis or solution generation.
Stage 3a: Solution Screening

Divergent thinking procedures like brainstorming produce numerous ideas of varying quality. There are a number of approaches to reducing the number of ideas to a more manageable quantity.

Categorising Ideas
If you have not already done so, you may wish to organise the ideas produced in the previous stages into categories. This is an area where human intuition plays a large role and there are few prescriptive methods. One approach combines some of the techniques you have already learned:

1. Generate some candidate category labels using a short brainstorming or mind-mapping session.
2. Use a fishbone diagram or mind-map to organise the ideas into a framework.
3. If ideas don’t fit easily in a category or fit into multiple categories, either redefine your categories or situate the idea in the most relevant category.
Reducing Ideas to a Manageable Number: Elimination by Aspects

When you have many ideas it is not practical to consider each one in detail. One rational approach to reducing the number of ideas is to eliminate any that do not meet essential criteria. One criterion that all ideas must eventually meet is feasibility of implementation. However, if the criterion is stated in this way, there is the risk that ideas might be discarded because they are sufficiently novel that they don’t immediately appear to be feasible. It is better to be more specific about the criteria that the ideas must meet (e.g. cost < $X, can be completed within one year, …)

Process

1. Decide on two or three essential criteria that all ideas must meet.
2. For each criterion, go through the list of ideas deleting any that do not meet the criterion.
3. Continue until you are left with a manageable number of ideas.
Using a Group to Screen Ideas: Voting and Ranking

The easiest way to screen ideas in a group is to take a vote. In some ways, this is the opposite to the elimination by aspects idea presented previously because it focuses on identifying ‘good’ rather than ‘bad’ ideas.

Process
1. Identify 2 or 3 critical criteria that group-members should consider when voting on the ideas. This could be done using some of the methods discussed previously.
2. Number all the ideas sequentially so that they can be readily identified.
3. Instruct each group-member to rank in order the five ideas that he or she thinks best meet the criteria (give a 5 for the best).
4. The facilitator then collates these votes by listing all the ideas and the rankings each received. For example:

   1. 8, 2, 1 15.
   2. 1 9. 16. 1, 1, 2, 2
   3. 5, 5, 4, 4, 3 10. 17.
   4. 11. 5, 5, 3, 2, 4 18.
   5. 4, 4 12. 19. 5
   6. 3, 3 13. 20.

5. Examine the ideas to determine which receive the most support.

In the example above, votes have been recorded for 21 ideas. Idea 3 received the most support. Note the different patterns of support for ideas 19 (where one person thought it was the best idea) and idea 16 (where all five people included it in their top 5). You should generally avoid the temptation of adding the scores together because this obscures differences in patterns of responding such as this.

Sometimes voting and ranking are enough to reduce the ideas to a single candidate which will be taken forward. At other times, a more detailed analysis is required.

An Alternative: Using a Screening Matrix to Visually Organise Ideas

Sometimes ideas might be really good on one dimension but poor on another. In this case, it may not be appropriate to rule them out altogether simply because they fail on one criterion as in elimination by aspects.

A screening matrix is an extremely useful visual representation that can be used to conduct an initial evaluation of ideas.

Process
1. Identify the two most important criteria by which you wish to evaluate your ideas.
2. If working individually, decide for each idea whether it is high, medium or low on each of the criteria.

3. If working in a group, either discuss ratings for each idea and come to consensus or take an average rating.

4. Plot the idea on the screening matrix according to the score it receives. Ideas high on both dimensions will be plotted in the top left hand corner.

This is an example of a screening matrix for ideas. Idea 4 is the most practical and creative and item 6 is the least practical and creative. Items in the top-left corner should be focused upon for further development or implementation. Items high on one dimension but not the other might be reconsidered to see if the other dimension can be improved.
Stage 3b: Solution Comparison

Evaluating Ideas in More Detail: Decision Matrices

Elimination by aspects, voting and ranking and screening matrices help us to reduce a very large number of ideas to a workable subset of ideas that can be further evaluated. A critical step in the problem solving process is to conduct a detailed and objective evaluation of the products of the earlier processes. This step is frequently overlooked as groups or individuals run out of time or fall back on traditional approaches to the problem.

A better approach is to use some of the methods mentioned previously to identify and agree upon a set of relevant criteria for judging the ideas. Once these criteria are established it is possible to systematically evaluate each idea according to the extent to which it meets the criteria using a decision matrix.

Process
1. Decide on the detailed criteria to be used in evaluating the ideas remaining after initial screening.
2. List the criteria on the left hand side of the matrix.
3. List the ideas across the top of the matrix.
4. Working across the columns, assign each idea a score out of 10 for each criterion.
5. Sum the ratings across criteria for each idea.
6. Choose ideas for progressing to next stage.

Worked NTC Example
For example, imagine that a four ideas have been generated for the problem of retaining experienced engineers: increasing remuneration, providing royalty-based bonuses, providing more transparent promotional opportunities, and increasing the level of training and development. The following decision matrix shows the criteria that were considered to be most relevant for evaluating the four options:
### Criteria Score (/10)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Solution Attractiveness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ease of Implementation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Originality</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sustainable</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>User-friendly</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Global Acceptability</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Attractiveness</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Compatibility with Firms Objectives and Resources</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Available finance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consistent with our culture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consistent with our image</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compatible with cost control measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quick to implement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Compatibility</strong></td>
<td></td>
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</tbody>
</table>

The simplest approach to analysing the matrix is to add the raw scores to get an overall measure of idea quality on the various criteria. In the case of the table above, totals were derived for two main dimensions reflecting the attractiveness of the idea and its compatibility with real world constraints and objectives. The dimensions of idea attractiveness and compatibility with the organisations objectives and resources have proved to be useful in organisational problem solving (Majaro, 1988) however the same process could obviously be applied using different summary dimensions.

### When not all criteria are equally important: Using Weights in Decision Matrices

The approach outlined above assumes that all criteria are equally important. An alternative approach is to assign weights to each of the criteria such that the most important criteria (in this case, compatibility with available finance) is assigned the highest weight. By multiplying the raw scores by the weights it is possible to obtain weighted scores which can then be added to produce weighted totals.

### Application

Screening matrices, elimination by aspects, voting and ranking and decision matrices are all useful during convergent thinking when the aim is to focus down from a large set to a smaller set of high quality ideas.

This can occur either at the end of *issue identification* where the tools can be used to decide on the most useful and critical problems statements for example. Alternatively the tools can be used at the end of the *solution generation* stage to sort the best ideas.
**Other Tools for Evaluation: Playing the “Devil’s advocate role”**

Another approach to solution evaluation in a group is to nominate a Devil’s advocate. The purpose of the Devil’s Advocate role is to provide “critical evaluation”. This step is often particularly useful if it appears that a group is converging too rapidly on time-honoured traditional solutions to the problems.

“Critical evaluation” can mean different things including:

- To challenge (not criticise) assumptions and/or judgments, including evaluations, predictions and diagnostic judgements.
- Championing an option that has been provisionally rejected, usually the second best or only available alternative (e.g. we think “A” is the best choice, let me tell you why “B” could be the best choice).
- Criticising a selected option (e.g. here are a list of reasons why I think “A” is a poor choice),
- To identify risk factors that can challenge predictions of likely future outcomes (e.g., what are the factors that could impact on the expected outcomes for “A”?)

The Devil’s Advocate role can enhance the quality of information processing in decision making in several ways, including:

- Reducing the impacts of confirmatory bias on judgements, as well as the biasing effects produced by other heuristics, such as the availability heuristic and the anchoring and adjustment heuristic.
- Increasing the depth of search and information processing so that the underlying structures, and not just the surface features, of the problem are analysed.
- As a counter to subtle group conformity pressures (sometimes called groupthink) which include the avoidance of disagreements and “Follow the leader” approaches.
- Minimizing the destructive effects of political or personally motivated critics who selectively attack ideas but resist attempts to work through the criticisms and come to some group consensus on judgements and choices.

A Devil’s Advocate forces us to consciously think about our judgements and choices, to confront the adequacy of our reasoning and to openly state disagreements. On the cost side of the ledger, if poorly managed, a Devil’s Advocate can create personal threat, interpersonal conflict and too much divergence for groups or individuals to cope with.

Performing the roles is not easy, especially in group settings. It requires analytical skills, skill in asking questions and the ability to handle the emotions or stress that can arise when challenging other peoples’ ideas. Although the role calls for “Critical evaluation” it must avoid criticism! The aim is to challenge people’s thinking and their judgements not the people or their values. Other processes (e.g. the nominal group technique discussed below) better handle conflicts or ambiguities about values. The Devil’s Advocate role works best when the goals, criteria and attributes for a decision have been agreed.

**Process**

1. Assign the role to one person in the group. The role can be rotated within or between meetings to avoid one person getting labeled as ‘the critic’. The Devil’s Advocate (DA) must have the necessary analytical and interpersonal skills.

2. The rules for the functioning of the role should be explained to everyone so that it is clear that the DA is playing a prescribed role to improve the quality of ideas.
The specific processes used by the DA will depend upon the type of critical evaluation being conducted. Championing an alternative, criticising a selected option and identifying risk factors are self-explanatory. Requirements for the challenging of assumptions and judgements include:

3. Deciding whether the interventions of the Devil’s Advocate should be part of the ongoing discussion or at selected points when judgements or decisions have been made. The choice depends upon how decision processes are structured and the skills of the individuals. Whichever approach is used, the Devil’s Advocate must learn to identify the judgements (predictive, evaluative, and diagnostic) contained within people’s statements.

4. The aim of the questioning is to push individuals to confront the quality of the assumptions and facts behind their judgements and choices. Being able to formulate and pose disconfirming questions is an important skill. Some other general types of questions include:

- “Why do you think that…?” or “What are the facts on which this is based?”
- “How can we be sure that …?”
- “Is the opposite (or some other suggested alternative) plausible? Why not?”

5. The Devil’s Advocate must not state opinions, judgements or preferences on the issues being discussed. For many people, this may be the most difficult part of the process.

**Application**

The Devil’s Advocate role is by definition critical. Therefore it is most frequently used during solution evaluation.

However, the Devil’s Advocate role can also be used to broaden thinking beyond tired old ideas by focusing on the championing of new ideas. This might occur, for example, if not enough effort is being devoted to evaluating innovative new ideas.

For groups, the actual performance of the role may take place outside group meetings. The assigned Devil’s Advocate may collect critical points from colleagues and report them to the meeting, without identifying the source of the ideas.
PMI - Plus/Minus/Interesting

PMI stands for 'Plus/Minus/Interesting'. It was developed Edward de Bono to supplement the 'pros and cons' technique used for centuries.

Process
1. Draw up a table headed up 'Plus', 'Minus', and 'Interesting'.
2. In the column underneath the 'Plus' heading, write down all the positive points of taking the action.
3. Underneath the 'Minus' heading write down all the negative effects.
4. In the 'Interesting' column write down the extended implications of taking the action, whether positive or negative.

Scoring your PMI table
You may be able to make a decision just from the table you have drawn up. Alternatively, consider each of the points you have written down and assign a positive or negative score to each appropriately. The scores you assign can be entirely subjective. Once you have done this, add up the score. A strongly positive score indicated that an action should be taken, a strongly negative score that it should be avoided.
The Nominal Group Technique: Combining Solution Generation with Solution Evaluation

The Nominal Group Technique (NGT) does not fit easily into the solution generation or evaluation stages because it is a group technique that incorporates both divergent and convergent thinking. In some ways, the NGT is a more structured form of brainstorming. It is particularly useful for groups that have not worked together before or where there are tensions in a group. In those situations, the NGT provides a structure for interaction between group members that can dramatically improve the quality of the ideas that are produced.

NGT overcomes problems like lack of participation or unequal power relationships in the group. It is very efficient, it produces substantial results, it enables strangers to work together rapidly, it can sometimes help to clarify ideas, and it is relatively easy to use and to facilitate.

Detailed Process Description

Before the meeting and Opening the meeting
1. Define the issue or question to address. Good questions are at the right level of specificity and they are simple enough that they can be held in mind by the participants throughout the process. For example, the question “How can we ensure that the culture of NTC is not swamped by the bureaucracy of Telecomp while simultaneously ensuring widespread acceptance of the need for cost controls?” really combines two different levels of analysis and is difficult to keep in mind.
2. Appoint a group leader who will facilitate the process without necessarily becoming involved in the content.
3. To open the meeting, state the importance of the task and the unique contributions each can make. Discuss the overall goal of the NGT and how results will be used. This step is very important because the process can produce many different types of statements and it is important that everyone is aligned to the task.
4. Briefly outline the four steps in the NGT. Commence the first step.

Step 1: Silent Writing
5. Distribute pieces of paper if necessary
6. Read out the question/issue aloud, if necessary say something about the level of abstraction but don’t lead the group in any particular direction.
7. Remind group that nobody is going to see the paper so it is does not matter how neatly they write.
8. Set time limit and commence writing.
9. Stop any talking immediately – it helps to demonstrate the behaviour by doing your own silent writing.

Step 2: Round Robin recording of ideas
10. Ask the group members to provide you with a phrase or brief sentence for their list without discussion or elaboration. If they have to explain their idea in a long-winded way then ask them to summarise it in a short phrase. If they cant then tell them you will return to them and go on to the next.
11. Group members can pass if they want to.
12. Encourage members to ‘hitchhike’ on ideas as they come up – they are not limited to the ideas generated in step 1. This is like brainstorming.

13. Record all items on flip-charts as rapidly as possible.

14. In a large group may need to announce in advance that will only go around 2-3 times or announce the last time and say that people should give you their best ideas that remain (the idea they most want to convey).

**Step 3: Clarification of ideas by serial discussion**

15. Announce in advance the time to be devoted to this step (2 mins per item) or number of minutes till adjournment allowing time for voting.

16. Read each item and invite questions or clarifications. There is no need to have arguments because will vote. The main point here is to get the point clear – not to get into discussion or conflict. For items that are obvious there is no need to have any discussion.

17. Note that the list is group property – the items are not owned by the person who put them there. Leader can model behaviour by saying ‘to me this item means …’

18. Some items can be added and duplicated items can be combined however the temptation to combine too many items should be resisted.

**Step 4: Voting**

19. You can use ranking or ratings but rankings are the easiest.

20. Hand out five cards to participants. Ask them to select the five ideas that they believe are most important and then write each of these on a card. They should also record the item sequence number in the top left corner.

21. When everyone is finished they lay out their cards and:

   - choose the most important and write 5 in the bottom right and underline three times. Turn this over.
   - Choose the least important and write 1 in the bottom right and underline three times. Turn this over.
   - Repeat 1 then 2 then write 3 on the remaining card.

22. Write all the sequence numbers up on the board and record votes around the group. Don’t add up the ratings as this obscures differences in patterns. Can just look at the ratings and decide if going to vote further.

**Applications**

The primary purpose of this approach is solution generation however the NGT also incorporates a simple procedure for evaluating the quality of ideas produced. One of the most appealing aspects of the NGT is the sense of closure the group experiences following completion of the process.
Stage 4: Implementation of Ideas

The final stage in the problem solving process is to implement solutions generated from the earlier phase. Although implementation is clearly a critical stage, we have chosen not to discuss it in great detail here mainly because there are many other useful sources you can access for information about project planning and implementation.

However, since we have already discussed the why-why diagram, it is worthwhile to reiterate here that this approach can also be used in the form of a how-how diagram to assist in outlining the action steps that are required.

**Process**

1. State the primary outcome that must be achieved in a circle on the left.
2. Draw branches to the right while asking ‘how’ this primary outcome is to be achieved.
3. On each branch enter a substage of the implementation.
4. Continue to ask ‘how’ for each branch, successively drilling down further into the action plan.
5. Stop when actions are at a level that can be readily assigned to one person or team. Stop before actions become so specific that the action plan is inflexible to unplanned eventualities.
Worked NTC Example

How?

Optimise HR systems - products to market quicker

Increase productivity

- Coaching of junior staff
- Motivational strategies

Reduce delays

- Set clear company-wide deadlines
- Standard procedures for coping with errors
- Backup facilities wherever possible

How?
NTC\textsuperscript{1}

\textsuperscript{1} Prepared by Professor Robert Wood for class analysis.
The New Telecommunications Corporation (NTC) is a dynamic, high tech company that designs and develops small computing and telecommunications products. They also design and develop components for inclusion in the products of major computing and telecommunication companies. The range of products developed by NTC over the years includes software programs, printed circuit boards, LCD displays, connections and casings. These have been used in cell phones, smaller computers (notebooks, Palm pilots, personal organizers, etc) and related products (small printers and scanners, etc). In the development of new computing and telecommunications products, innovation and speed to market are critical requirements. NTC has shown a great capacity to keep coming up with new ideas and to develop prototypes for testing more rapidly than many of the bigger companies.

A recent report by Goldman Sachs described NTC as having two major sets of assets. These include a product ready for market release (the newPC, described below) and a creative workforce and related business systems with the potential to develop new innovative products that will bring high returns in the years ahead.

The product that is ready for market release is a new Personal Communicator (newPC-1) that is the size and shape of a large cell phone (dimensions: 158 x 56 x 27mm). It has a brilliant full -colour screen for enhanced viewing of digital photos and web pages as well as the capability to send and receive faxes and emails (Email up to 28.8kb per second), manage a calendar and update its counterpart on a host PC, dictate messages, play games, listen to music, and browse databases and the Internet. It can also be used as a telephone. The newPC can be linked to personal computers via a Bluetooth infrared interface. The keyboard is built into a foldout section in the back of the newPC and there is a pencil for those who find the smaller keys difficult to use. The newPC can be attached to a regular screen. It can also be used with a remote mouse and keyboard and with some printers, via Bluetooth. The newPC weighs 244 grams, has a 32-bit ARM9-based RISC CPU, runs Windows CE as its operating system and has a rechargeable battery. A focus group of potential users indicated that newPC-1 is more advanced and is easier to use than other products in the same personal communicator category. Given the many features it offers, NTC would like to price the newPC-1 at a premium to comparable products. Currently, Ericsson, Nokia and Siemens have similar products priced between $1,400 and $2,000 if they are purchased without being linked to a mobile phone plan.

The newPC is the first fully developed NTC product to reach the production and marketing stage. Over the years the company has developed a wide range of computing and telecommunications applications products that have either not passed the product testing stage or have been beaten to market by a competitor. In contrast, many NTC component designs have been sold to major companies before being fully market proven and some have ended up as components in competitor products. These include software, printed circuit designs and various other components that have been incorporated into Toshiba notebooks, Canon printers, Siemens mini-document scanners and the Siemens global positioning system (GPS) navigational aids. The company has also sold developmental work to Nokia, Sony and JVC. This has been the company’s main source of revenue. NTC has a good reputation among the leading telecommunications and computing manufacturers. The income from the sale of components is however limited as the purchaser assumes the risk associated with the testing and proving of the components in the finished product. With the introduction of newPC-1, NTC sales are expected to grow exponentially.

NTC’s annual sales are currently $150 million and, according to the Goldman Sachs report, are projected to grow to more than $600 million in the next 5 years, with the release of the newPC. The company has not reported a profit in any of the years since it was publicly listed in 1996. The annual reported losses grew from $1.3 million in 1996 to $5 million in 1999. For the years 2000 and 2001, the annual losses were between $3 and $4 million per annum. Based on projected costs of the market entry strategy for the newPC, NTC is expected to make a loss of $10m in 2002. Profit is then expected to grow to around $65 million per annum for the period 2003 to 2005. Profit projections beyond that point depend upon new products and upgrades to the newPC, some of which are already in the design phase.
Total employment at NTC is expected to double in the next 3-5 years, with the major growth in the Marketing Division. A key concern is the recruitment of staff with the skills needed to operate in competitive international markets and to achieve the integration and cooperation needed across work groups and divisions at all levels in NTC.

The Goldman Sachs report was confident in the projected sales of newPC-1 given the right sales and marketing strategies and the resources needed to support that strategy. However, the report also included a comment that, “...while NTC has been highly innovative in its output of new component designs, the management have not been able to fully capitalize on the market potential of these products by turning them into branded consumer products. The entrepreneurial spirit which pervades NTC lacks a tolerance for the routines of cost control, market development, selling and other formal management processes”.

The description of weak cost controls referred to specific problems in two areas. First, there was a lack of reporting around travel and other personal expenses. Staff spent money travelling to conventions, meeting customers and purchasing small items of equipment on the approval of their supervisors. There was often no documentation or follow up. It was difficult to establish the true cost of these expenses due to poor reporting but they were estimated to be around $5-$7 million per annum. The second area of concern identified by the analysts was the salary structure. Contracts were often written and increases awarded based on the recommendations of individual supervisors, without any considerations of consistency or control of the cost of wages. Geoff Jones and the other senior managers stated that they felt maximum flexibility in salaries enabled them to encourage personal initiative. They also resisted any attempts at formal documentation of policies, which they saw as leading to a bureaucratic structure.

**The structure**

The structure of NTC has been described as a “loose matrix” form. However, the key to the effectiveness of NTC lies more in the relationships between critical groups than in the structure. Peter Blackmore, the head of the Finance Division, drew up the attached organizational chart. None of the other senior managers have seen the chart but Peter suspects that they would disagree with it as being too simplistic and too bureaucratic.

NTC was formed in 1994 when the current CEO, Geoff Jones, acquired interests in two other companies working in new telecommunication technologies and then combined them with his own software development company to form NTC. The General Managers of the Circuit Design and Software Development divisions, Jose-Marie Urbietta and Phillipa Ong are the original owners of the companies from which the divisions were formed. The General Managers of the Component Design, Marketing and Finance Divisions were employed by NTC after the company was formed.

On a day to day basis, individual staff from the three design and development divisions report to product leaders who are responsible for the leadership of project teams that do all of the design, development and testing of a product. A staff member may be a member of several project teams at once, depending upon their role in the project and the size of the project.

Product needs and markets are identified by NTC staff (primarily marketing engineers from the Marketing Division, as described later) and referred to a central Product Development Team for approval and funding. Members of the Product Development Team (PDT) were Geoff Jones, Jose-Marie Urbietto, Phillipa Ong, George Atkin and John Boscoe. The PDT met weekly for 4 hours and reviewed all projects currently underway. Reports and proposals from marketing engineers were also discussed at the weekly meeting. In addition to
authorizing new projects, the PDT also authorizes the closing down of projects and the sale of partly developed products or components to other manufacturers.

When a market need or opportunity is identified, a product leader is appointed by the PDT. He or she then selects the staff needed for the project from those available or negotiates with other product leaders and the division heads (Jose-Marie Urbietta, Phillipa Ong and John Boscoe) to move staff off of other projects. As the project moves through the initial feasibility analyses into the design phase, more staff will usually join the project team. The selection of these staff will be through the same process of negotiation as for the original team. When needed, new staff may also be recruited to provide the skills needed for a specific project. There are currently 10 product leaders, all of whom have been with NTC since it was formed. They are the more experienced engineers and computer staff, who have demonstrated skill in design and development work.

The PDT assigns a marketing engineer to each project. Depending on the scope of the project, additional marketing engineers may be assigned to the same project team. The marketing engineers then provide market and technical information to the product leader and to the PDT regarding related developments, competing products, new research findings, etc. This information is used to make decisions about the product development process, including decisions to discontinue a project or to sell a partly completed project to another company. In this fast moving decision process, the relationship between the product leader and the marketing engineer is critical. It does not happen often, but there have been occasions when a faxed report from a marketing engineer has resulted in a product leader immediately stopping further investment in a project.

The manufacture of prototypes and finished products, when a product reaches either of these stages, is contracted out. The following is a brief outline of the divisions and their staffing.

**Circuit Design Division:** Designs and develops circuit boards. Currently has 226 staff, including electrical and electronic engineers (around 30% of the staff), technicians and laboratory assistants (together about 50%) and experts in computer assisted drafting (10%). Clerical and other support staff make up about 10% of the Division staff.

**Software Design Division:** Designs and develops new software applications. These include programs that are imprinted into the circuit boards developed in the Circuit Design Division. Currently has 196 staff, including computing and design engineers (around 20% of the staff), computer programmers (70%) and clerical support staff (10%). Contract programmers often supplement the large contingent of programmers when there is a large project with tight deadlines.

**Components Design Division:** Currently has 38 staff and includes a range of design engineers (about 80%) who work on component design and clerical support staff. Staff in this division are often referred to as the “fashion experts”. Most of their work deals with the aesthetic and functional aspects of the packaging. Their contributions also include the design of internal components to fit into small spaces with unusual shapes.

**Marketing Division:** Currently has 52 staff, 20 of whom are marketing engineers with extensive experience in the design and development phases of telecommunication products. The remaining 32 are clerical and support staff for the marketing engineers. The marketing engineers are the main source of ideas and proposals for the PDT. Their role is to stay abreast of new products and to identify market niches and products needs. To do this, they constantly travel to conventions, visit colleagues in other companies, commission research from academics and other groups, read widely, and analyze competitor products.
It was research by staff of the Marketing Division that identified the opportunities for NTC to get a lead in the
development of the newPC. The information from the Marketing division is also used to make decisions to shut
projects down or to sell off partly completed products (even ideas) to the major companies. The Marketing
Division staff currently spends around $5 million per annum on travel and other personal expenses, including the
purchase of competitors products in order “to stay in touch with the market frontier”.

**Finance Division:** Handles all of the accounting, financial and personnel records. Currently has 12 staff, which
include accountants and clerical staff.

**Human Resources Management at NTC**
NTC has no HRM function. Issues like training, development, promotions and other human resource activities
are left to the initiative of individuals and their supervisors. The Finance Department manages salaries,
employment contracts and personnel records.

When the company was first listed as a public company in 1996, all 200 NTC employees at the time each
received an allocation of shares worth $23,000. Staff employed since the 1996 listing have been given the
opportunity to join the share ownership scheme and to purchase shares worth $30,000 at 75% of their market
value. The company offered low interest loans to assist in the purchase. Ninety seven percent of the current 524
NTC employees are members of the share ownership scheme. Geoff Jones, Jose-Marie Urbietta and Phillipa
Ong, respectively, hold 10%, 3% and 2.6% of the NTC stock.

In addition to the share ownership scheme, staff at NTC, who were mainly engineers and computer experts and
other forms of technical support staff, were well paid. The average annual total employment cost per employee
was $216,000. This total employment cost included salary, superannuation, annual bonuses (see below), cars
and all other forms of benefits. NTC paid in the top 25% of the established market for staff positions at all
levels. A major component of all NTC employees’ salaries was paid in a lump sum “performance bonus” at the
end of each year. The available bonus pool was based on an “innovation index”, which included assessments of
how well the company performed in the development of new products and sources of revenues. Profits are not
included in the calculation. The size of the bonus (which had ranged between 20% and 30% from 1994 to 2000)
was decided by the Board, which included Geoff Jones, Jose-Marie Urbietto and Phillipa Ong, at the end of each
year. Except for a few minor variations, all staff received the same percentage of their salary as their bonus
payment.

NTC does have an informal HRM strategy built around the idea of personal initiative, which is referred to as the
“PI factor” by staff at all levels in NTC. Everyone is aware of the PI factor because it is a major criterion in the
selection of new staff at all levels and is often referred to in talks by the three senior managers. Geoff Jones has
described the five elements of PI as follows.

- Self-starting, high energy, proactive behavior

- A willingness to think differently about problems

- Goal setting supported by action planning

- Persistence in the face of barriers, setbacks & obstacles
- Individual and team goals linked the big picture and longer-term goals

When new staff are recruited for any position in NTC, the selection committee considers three criteria; past experiences, qualifications and PI. The first two criteria are checked out before an individual is considered for an interview. At the interview, the applicant is tested for PI through their responses to a series of challenges and questions that are related to the job that for which the applicant is being considered. The five pages of documentation describing the selection process and the annual bonus scheme are the only formalized human resource management policies at NTC.

A popular story told at NTC is about a marketing engineer who flew to Tokyo to purchase a newly released product of a competitor, which had been kept secret up until released. According to the story, he took the product apart in his hotel room and based on his analysis of the components immediately prepared a proposal for the PDT in which he recommended the discontinuation of one existing project and the modification of another. This story, which some people questioned, was often told by Geoff Gordon, Jose-Marie Urbietto and George Atkin to illustrate the importance of personal initiative in a fast moving market. Peter Blackmore of Finance comments that, after hearing the story many times over 3 years, he is still waiting for the marketing engineer to submit the report on his expenses.

Current issues
The Goldman Sachs report also mentioned some issues and problems that the analysts felt “…were potential indicators of growing misalignments in the NTC architecture”.

The marketing engineers were complaining about the increasing administrative work that they felt was becoming part of their job. Many of them still refused to fill in expense reports and referred to them as “the bureaucratic burden”. Peter Blackmore had prepared guidelines about travel and hotel accommodation for the marketing engineers but these had been largely ignored. Geoff Gordon, Jose-Marie Urbietto and Phillipa Ong had supported the guidelines “in principle” but when there was conflict tended to back the marketing engineers who, along with the product leaders, they believed were critical to their business.

A previous attempt to bring in 3 marketing experts who had considerable experience in the telecommunications and computing industries, but did not have engineering backgrounds, had been a disaster. The product leaders had simply refused to take their advice on projects. The new hires had felt unaccepted by the marketing engineers and eventually resigned. All three had mentioned a lack of support from the division heads as a contributing factor in their decision to resign. The Goldman Sachs report identified the lack of acceptance of non-engineers as a contributing factor in the poor conversion of projects into marketable products. The lack of appreciation for marketing was also mentioned as a potential problem in the development of an effective marketing team for the newPC.

Staff in the Circuit Design Division frequently complained about the lack of service from staff in the other two design and development divisions. In particular, they felt that their efforts to obtain innovative programs from the Software Development Division for the development of circuit boards were inhibited by the attitudes of the computer engineers. It was generally felt that the computing engineers were fiercely loyal to their own division and to Phillipa Ong, rather than to NTC. The majority (70%) of staff in the Software Development Division had worked for Phillipa since before NTC was formed and tended to prefer projects where the majority of the team came from within their own division. Jose-Marie, whose division had tripled in size since joining NTC, had suggested to Phillipa that she hire computing engineers who were less pre-occupied with technical excellence.
and who understood what customer service meant. The marketing engineers also complained about what they felt was a lack of responsiveness from the Software Development Division engineers.

Questions had also been raised about staff management, including the process of assembling project teams, development of staff and salaries. The product leaders controlled the process of appointing engineering staff to project teams, based on advice from the marketing engineers and the PDT. Individual staff members, particularly the newer and younger engineers, complained that their own interests and opportunities for development were never taken into account. Because of the pressures associated with the product design and development cycle, staff had little opportunity for personal development and it was more common for new staff to be hired, often at short notice, when new skills were needed. Older staff complained that the newer, less experienced engineers were being paid higher salaries as a result of the urgent need for their skills rather than some measure of their longer-term value to the organization.

Another issue identified in the evaluations of NTC was the heavy dependence on the skills of the current product leaders and their relationships with the marketing engineers. There had been no new product leaders appointed in the last three years. The current set were all highly competent engineers (6 from the Circuit Design division and 4 from the Software Division) who also happened to be good team leaders who could schedule and manage projects. They all worked well with the marketing engineers, whose input was often disruptive to their projects but critical to their commercial success.

Concerns had been expressed about the lack of succession planning for the roles and relationships of the product leaders and marketing engineers. On the few occasions that other engineers had been given an acting role as product leader, major conflicts had arisen over the authority of the marketing engineers to require changes in product design or the scheduling of a project. These issues were routinely resolved in negotiations between the product leader and the marketing engineer. However, when conflicts arose between acting product leaders and marketing engineers they were resolved by the PDT, who always backed the more experienced marketing engineers. On two occasions, the engineers who were acting as product leaders had left NTC because of what they described as “a lack of support from senior management”. There were many engineers in the Circuit and Software Divisions with the technical expertise and project experience to act as product leaders but it was unknown if they could handle the teams or the negotiations with the marketing engineers.
ORGANISATIONAL STRUCTURE OF NTC

CEO

Product Leader

Circuit Design

Software Development

Component Design

Finance

Product

Stockist