An earlier version of this case study appeared in the TRIZ News section of the IMechE newsletter (Institution for Mechanical Engineers, UK) http://www.imeche.org.uk/manufacturing/triz_articles.asp.

TRIZ at Bradford University
Solving a Organisational Problem using TRIZ

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It is not good starting the New Year with a sense of foreboding and I was dreading my first two TRIZ courses in 2006. These were at the engineering departments of Bradford University and Sheffield Hallam and I had my southerner's prejudice to northern cities in January. I love teaching TRIZ at universities and my experience of teaching TRIZ to academics has been almost always very enjoyable. Occasionally however there is hostility to TRIZ, as something new to them, from some awkward and vociferous individual and I have previously encountered one or two difficult engineering academics initially very opposed to it all – but who have since become enthusiasts for TRIZ (and good friends).

Academics with TRIZ can be a bit like the nursery rhyme
There was a little girl with a little curl right in the middle of her forehead
When she was good she was very, very good and when she was bad she was horrid.
To be fair, nearly all the academics I have taught have been very, very good, but one or two have been startlingly horrid and hated the idea of TRIZ supplementing formal engineering training to foster innovation and fast problem solving. There is a suspicion that somehow TRIZ is too good to be true, and anything which guides engineers to quick answers must be quite suspect.

I have also had some sticky moments at some public TRIZ lectures from furious and shocked engineers who refuse to believe that TRIZ shows how there are just 40 ways of solving most engineering problems. Most come round to TRIZ, once they look at it and try it, but it still threatens some. One training manager I know in a military establishment still actively fights to prevent TRIZ being taught again in his organization – despite their new TRIZ patents and an active and successful TRIZ group.

Most academics we have taught have taken TRIZ to their students enthusiastically because it helps them see the big picture in engineering and to approach projects systematically, and put their other engineering tools in context. When I was a Governor of Coventry University I encouraged TRIZ and for some years TRIZ has made its mark at Coventry and has been available on postgraduate courses through Dr. Peter Griffiths and others. We also taught the TRIZ Biomimetics group their first TRIZ at Bath University, under Professor Julian Vincent, and found them very receptive to it all. They are now very active in the TRIZ community with published papers, much research and fascinating results.

Problem Solving with TRIZ
Until TRIZ there have been no effective problem solving toolkits; there have been many so-called problem solving toolkits but they only help us analyse problems and to rank solutions; the actual finding of solutions is left to us to find from our own brains, often assisted by some form of brainstorming.

Also many of these traditional problem solving methods are too tedious and longwinded to be used everyday. There take many forms, under many names and have been developed in the past 50 years with many recent re-launches of these old toolkits under new names.

The benefits of TRIZ stretch far beyond its unique problem solving tools. TRIZ is largely a thinking tool and a mental approach to effective problem solving. TRIZ also has tools for fast understanding and communication of complex information about problem situations. This often leads to seeing quite obvious solutions which were eluding us and being clear about which directions to take. The power of these tools is that they are simple to learn, use and show to others.

Uniquely TRIZ has good problem solving tools particularly for solving contradictions, improving inadequacies and dealing with harm – all useful with or without brainstorming and all fast and effective for finding a good range of effective solutions.

Bradford and Sheffield of course turned out to be hugely enjoyable, challenging and very rewarding for me. Both courses were delightful, both the Cities and the Universities were a fabulous surprise, and the academics were all open-minded, enthusiastic and excited by the TRIZ tools and process. I learn something new on every course I teach but these made me think hard about the nature of engineering teaching, and what we need for our future engineers.

The Bradford group immediately wanted to apply TRIZ to their most pressing and important problem – how to get more good, mathematically able, local students to apply to Bradford University's (excellent) Engineering Department. We are now using TRIZ to look at this problem and structure our approach to tackling this problem.

TRIZ at Bradford

At Bradford we looked at how to use TRIZ to approach their problem of attracting more local students to their excellent accredited engineering courses. Bradford has a well established, good reputation for producing good engineers. Employment prospects are excellent for their graduates and they attract good students from all over the world.

This problem solving has only just begun and we hope to use TRIZ over the next two months to look for clear and detailed solution directions. I would like to show you how we have begun the process and at a later date show the progress of the problem solving with TRIZ on a very general and important problem.

The Background to the Problem

The problems facing Bradford are similar to those of all universities with good engineering departments - and to the old on-going problems have been added new ones. Changes in government policies, to ensure that more young people consider university, have created many of the new problems. The trend is towards fewer grants and more fees, together with a squeeze on university funding while student numbers rise. One solution the government is encouraging is that more students go to university in their home town – with a planned target of 40% of students living at home. This may be fine if your local university offers the course you want - otherwise are universities under pressure to meet new local demands rather than continue with their traditional strengths? Or will students be obliged to study at the local university whether or not it is appropriate to their aspirations and abilities.

I studied mechanical engineering at Imperial College in the 70's where there were about 4000 students on the South Kensington campus. There are now more than three times that number of students on the same campus, and staff/ student ratios have changed dramatically but standards remain as high if not higher.

It is the same for most of our universities – facing the problems of how to attract more students and turn out many more good engineers without increasing staff numbers or facilities. Solutions such as reducing teaching time in the new 2 semester system and sending students home for reading weeks are being introduced.

The old problems include issues like:-

- How to reach and inspire mathematically able teenagers who, if not initially attracted to engineering, probably know little about it?
- Engineering (similar to subjects like music) needs ability, staying power and enthusiasm to succeed as it has great depth and the training is rigorous – how to ensure that students survive and flourish throughout such demanding courses?
- How to attract more women? (the numbers seem unchanged since my day, sadly)

To begin looking at the Bradford University Problem we have to understand the following

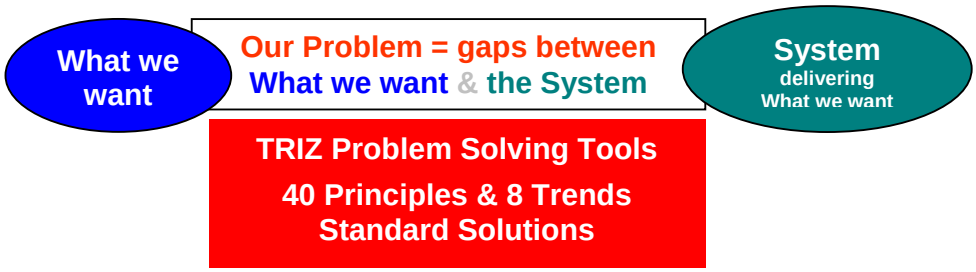
- The Problem
- What we want
- How we deliver what we want (the System)

The following is a brief guide to how TRIZ will help us.

Using TRIZ to help us solve problems

TRIZ is a set of powerful tools which help us

- Understand, list and prioritise what we want (all our requirements/ benefits)
- Understand, analyse and map the right systems (and locate the right systems) for delivering what we want
- Get the system right - Identify the problems and the causes of the problems (remove or reduce the gaps between our requirements and the system)
- Define HOW our system doesn't deliver what we want (harms, insufficiencies, excesses or contradictions) to see which problems to solve
- Solve the Problems with TRIZ to get the right system right to deliver our needs



Everything we do involves delivering WHAT WE WANT by some kind of SYSTEM. Often the **system** delivers some of **what we want** but not everything - whenever there are gaps, there are problems; whenever the system delivers more than we want there are problems like cost and complexity; therefore problem-solving is needed whenever and wherever our system does not deliver exactly what we want. This applies to all problems be they technical or management.

So to start solving the Bradford Problem we need to define

What we want - benefits
The System (we need to find the right system level)
The Problem = the gaps between benefits and the system

The Problem
In TRIZ it does not matter in which order we define each of the three – which is just as well because in real life we come at problems from many different places. At Bradford we started in the usual place with the problem.

We defined
The Problem (and its context)
What we want = outcomes we want (we being the staff of the engineering department)
The System (the engineering department of Bradford University)

Using TRIZ for Problem Understanding
Understanding the problem in context helps us subsequently to understand what we want and how the system fails us - the causes of our problem. This is a long-term problem probably with long-term solutions so we examined the context of the problem – and looked at where we are now, how this has changed in the last 5-10 years, and where we want to be in the next 5-10 years.

The TRIZ tool to understand the problem in context is the 9 Windows Tool for Problem Understanding (also known as the 9 Boxes). The first three questions below are essential to understanding what we are doing and why and are written in a simple 9-Windows chart.

What is the Problem? State overall Problem with this system
Write in PRESENT central box of 9 Boxes
Top of the head answer, don't agonise - we can re-define later if necessary

History of Problem
Write in PAST central boxes

What is the end result we want?
What are we trying to do? What Solution would we like? Write this in the FUTURE Central box.

	PAST	PRESENT	FUTURE
SUPER-SYSTEM			
SYSTEM	Engineering is less understood in schools – and not a popular choice? Qualifications harder than other courses?	**How to attract many capable engineering Students to Bradford**	Full quota of good students graduating in engineering from Bradford Many local to North East UK
SUB-SYSTEM			

We can then fill in as many of the other boxes as we have information relevant to the problem. Any big picture issues, such as government policies, university changes, cultural issues we put in the SUPERSYSTEM Windows and the details about students etc in the SUBSYSTEM Windows.

The 9 Windows helps us sort all the many facts and different influences on the problem at the different levels. The 9 Window Tool is supposed to be a quick, rough and ready sorter of our relevant knowledge to help us understand the problem in context and communicate it to others. We shouldn't worry too much about getting exactly the right information in the right boxes. To use our brains effectively it is better that we keep moving in order to see

the whole picture and not get too lost in the details at this stage. (We can fill them in later if necessary)

PAST HISTORY	PRESENT SITUATION	FUTURE WHAT WE WANT
Government policy - more graduates Low status of engineers in UK UK Manufacturing base in decline. Less Engineering sandwich schemes and industrial sponsorship Apprenticeships disappearing New Universities offer competition Engineering compares unfavourably to big City salaries/law/accountancy Polarisation in University popularity - Chosen on clubbing and shopping facilities rather than academic?	Government required quota of engineering students at Bradford University has experienced loyal, and highly qualified engineering staff and good facilities Demand remains high from overseas students Local companies need good well-trained engineers	**What will the Government want?** **What the University willl want?** **What will Bradford want?**
Long established and good reputation for engineering at Bradford University Engineering less understood in schools - not a popular choice? Maths taught differently Other practical courses like business studies become popular Engineering courses male dominated - both students & staff	**PROBLEM** **How to attract many capable engineering students to Bradford University?**	**WHAT WE WANT** **Prime Output** **Full quota of good students graduating in engineering from Bradford University** **Many local to North East of UK**
Entry Qualifications seen as harder than other courses? Maths and Physics A level standards lower than before but still harder than most other subjects? More girls at university with better GCSE's than boys (including maths) but IT and engineering increasingly seen as geeky boy subjects	How to help ensure there is a good pool of able students available? (Good maths needed – do many at school lose maths confidence and ability before the age of 16?) How to overcome ignorance about engineering and inspire enthusiasm for engineering amongst those not previously or yet interested?	Students gain employment from local companies

The information above covers the work done so far at Bradford. The rest of the article lays out the structure of the future problem solving with TRIZ at Bradford, specifically to ensure a sufficient throughput of good students.

How to use TRIZ for the problem at Bradford University Engineering Department

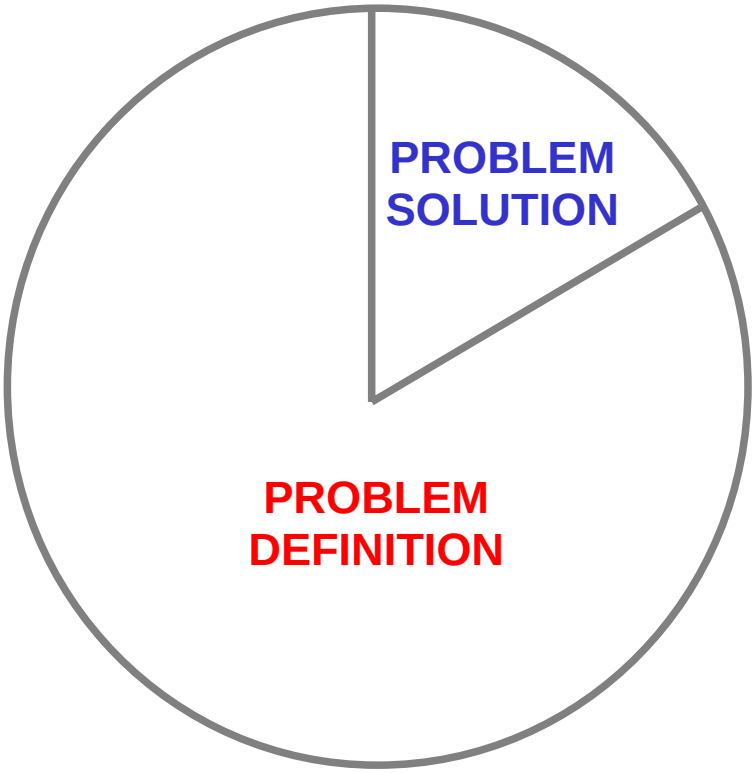
Successful Problem Solving requires the following

- define the problem (& understand why it is a problem)
- define what we want (all benefits)
- define and understand how we can deliver what we want (with the system and its resources)

and then use all of the above together with our brains to solve the problem.

The problem with problem solving is that as we start this process we think of solutions. Most of us would rather just explore those solutions than step through a problem understanding process before we get to problem solving.

There is a contradiction with many problem solving methods in that the more comprehensive they are, the more tedious they are, and we often abandon them and dive straight into solution mode. But there are advantages in fully analysing the problem and this may prove quicker in the long run.



Engineers in particular are less interested in problems than solutions! Start describing a problem to engineers and after two minutes they are listening with only a part of their brain, because they have thought of answers and are thinking about their own solutions.

This is normal and often even the problem is described to them in terms of the solution (thought of by the person describing the problem) with something like “We need to do this” or “The problem is this and we could…” or “How can we achieve this?” so that even the person tasked with describing the problems can’t resist jumping into solution mode.

Engineers are trained to react to problems by thinking up solutions (unlike scientists - who are apparently better at analysing problems) and often they may not even ask for enough information about the problem because finding solutions is the way engineers almost have fun (do engineers have fun?).

BEFORE WE START WE NEED A SOLUTION PARK

A Solution Park is essential

- to capture all the good solutions we think of when faced with a problem
- to stop us thinking about those solutions while we understand the problem
- to use later because TRIZ requires us to think of solutions then use TRIZ and those solutions to either improve them or take us to better solutions

When we are first given a problem we react with great mental agility; and apply our knowledge and experience and think of good answers because problems nearly always stimulate us to produce immediate solutions in our minds.

This ability instantly to see solutions gives us access to our own valuable relevant brain power and experience and involves us in very effective creative problem solving. However when looking for all the good solutions to a problem, we want much more than everyone's first, fast reactions. We want considered thought about a problem but when we can't help jumping straight into solution mode then we need to allow that to happen, capture and park all those solutions and then return to the problem. We call this a SOLUTION PARK and it is an essential step in problem solving. We can then enjoy the experience of the initial intense burst of creativity, be excited by the solutions we first picture, and allow our instincts to think of solutions and for a short time forget about everything else.

TRIZ is here for us to locate all the solutions (not just the ones we first thought of) and therefore engineers should not try to resist this first burst of creativity, but use it, record ideas in the solution park, be acknowledged for solution finding and then move back to the problem. TRIZ needs those solutions as part of the process for later. However returning to problem understanding needs discipline as we mustn't stay in solution mode if we are to understand the essential information to find all the good solutions to a problem.

Systematic but fast Problem Solving with TRIZ

TRIZ has a number of steps for problem understanding. These are designed to be fast and simple (so we don't lose our thread of thought) and we keep using our brains – rather than plodding through detail. Once familiar with these steps they can be very fast indeed.

Understanding the Problem

The first challenge in TRIZ is to define the **Ideal Outcome**. This is a major TRIZ tool and also known in TRIZ as the **Ideal Final Result**. (This tool helps our understanding while freeing our thinking from constraints)

Defining our Ideal Outcome can take some thought but it ensures we understand what we are trying to do.

To truly understand **what we want** we must put aside from our thinking all the ways which are the **HOW** we get what we want, and the attached limitations–such as it being too expensive. We must concentrate only on benefits and forget costs and harms. It is often difficult however to forget any limitations on costs or inputs and ignore constraints and any

downsides or harms which may be associated with getting what we want. So we use a mental trick ….

We just imagine we have a magic wand which we can wave to get everything we want. **Everything we want** (without worrying about how we get it) is our **Ideal Outcome**. Achieving our Ideal Outcome would solve our problem, but even if this is not possible simply by defining and understanding the Ideal Outcome we can see which direction to move towards to seek solutions– so we define our Ideal Outcome without worrying about the **HOW** at this stage.

This is my attempt to define the Ideal Outcome for Bradford – when we do the session live next month we will ask everyone in the room to give us their definition and then define our Ideal Outcome – the result may be different from my answer below

**IDEAL OUTCOME = ** Good engineering department with long term future, providing accredited engineering courses, greatly in demand from able students (local included)

Once we have defined it we can use our **Ideal Outcome** for three steps

1. To define who **WE** are and at which **system** level we are operating and able to solve problems – although aware of separate interested parties (other stakeholders) we ignore them at this stage

2. To help us understand **what we want** – the Benefits

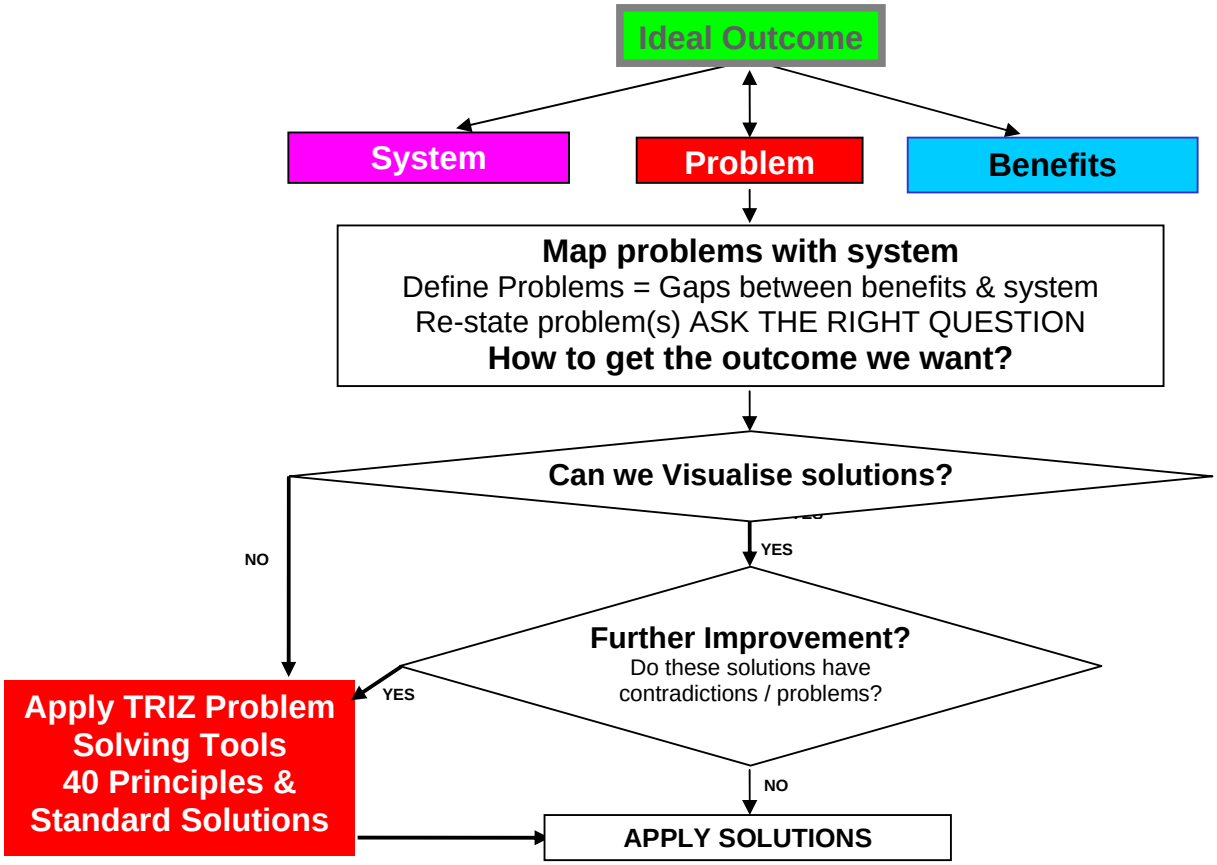
3. To help us understand and visualise solutions to our **problem**

We now have to define the following:-
The System
The Prime Output of the System
The main Benefits we want
The Problem (already defined in our 9 Windows above)

Problem = How to get an on-going full quota of good students graduating in engineering from Bradford including many local to North East of UK

This is so we can use the TRIZ flowchart below to get to problem solving

TRIZ Flow Chart

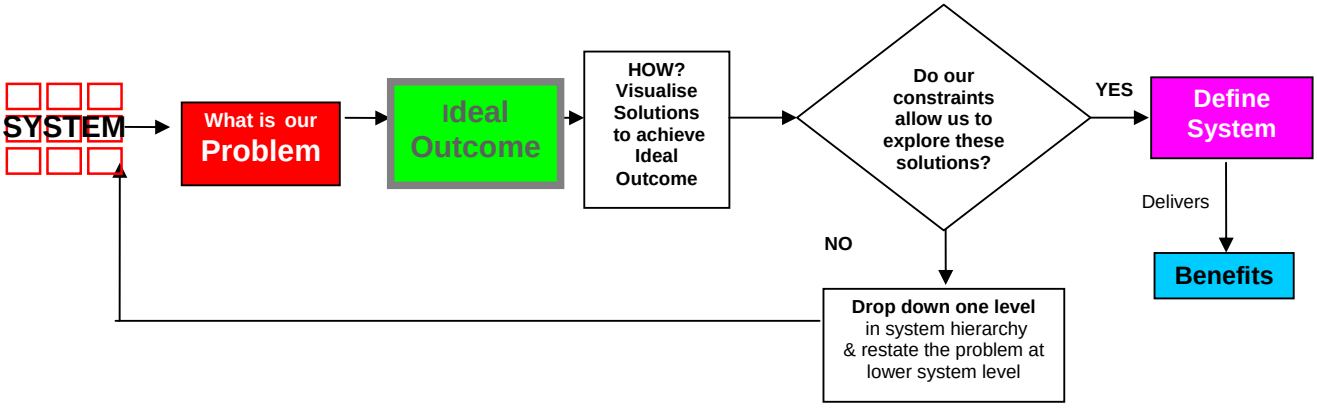


1. IDEAL OUTCOME for which system level?
What are the different system levels we could consider?
Where must we/can we operate to be able to tackle the problems?
At which system level can we influence inputs/ constraints?

Bradford?

The University?

The Engineering Department?



The System level has to be decided and for this we have to understand our constraints

We have not defined the constraints with the Bradford group and so we cannot exactly determine our system level yet but we will assume until that work is done at Bradford that the **System** is the **Engineering Department.**

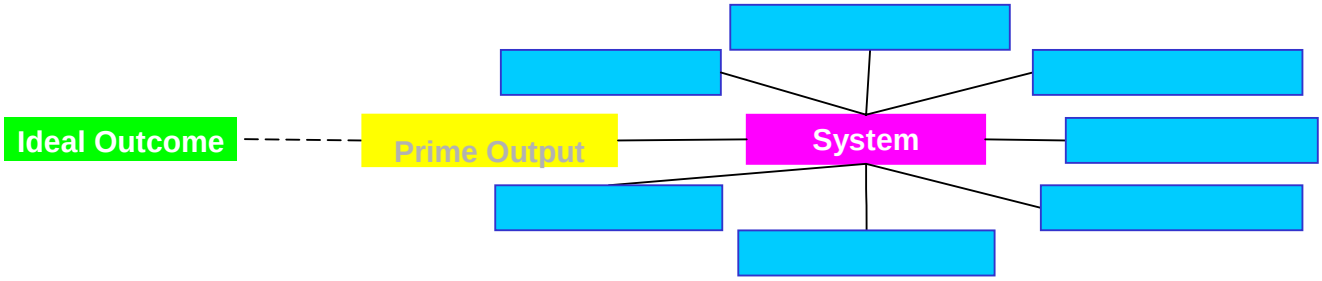
We now use the **Ideal Outcome** to help us understand **what we want -** for this we need the following definitions:-

Problem	= How to get an on-going full quota of good students graduating in engineering from Bradford including many local to North East of UK
System	= Engineering Department of Bradford University
Ideal Outcome	= Good engineering department with long term future, providing accredited engineering courses, greatly in demand from able students (local included)
Prime Output	This is the main function the system delivers = Good, accredited engineering courses delivered to able students (for this exercise we are ignoring other important outputs such as engineering research)
Benefits	Everything we want the system to deliver
Features	How we deliver the benefits
Resources	Everything we need to provide to deliver the features

Once we have defined our Ideal Outcome and Prime Output and system level then we begin to have choices, especially if we are able to change our system or if we don't already have one. We simply ask 'What will deliver our Prime Output?" *For example if the Prime Output I want is transport to work, there may be several systems to choose between - bike, bus, car motorbike etc. Each of these systems offers different benefits at different costs, and when choosing a system I need to be clear about all of these.*

How we can get our Ideal Outcome is largely defined by the system which is defined by all the benefits must deliver, so our next task is to define benefits and the inputs we need to get these benefits – the resources we must mobilise.

We must now identify the main Benefits we want which would help the System (*the Bradford Engineering Department)* deliver its Prime Output and ultimately its Ideal Outcome.



High level benefits may include….

1. A steady and high throughput of able students
2. Good Engineering teaching which is much in demand by students
3. Effective Engineering Research
4. Good facilities
5. Clear, stable, long term targets
6. Secure future for the department
7. Successful, confident and competent engineering department
8. Meet all requirements of the University, the IMechE, the Government

Defining these benefits may give us an understanding of:-

The gaps between what we want and what we've got (our general problems)

The general directions we would like to move in

The contradictions between the benefits

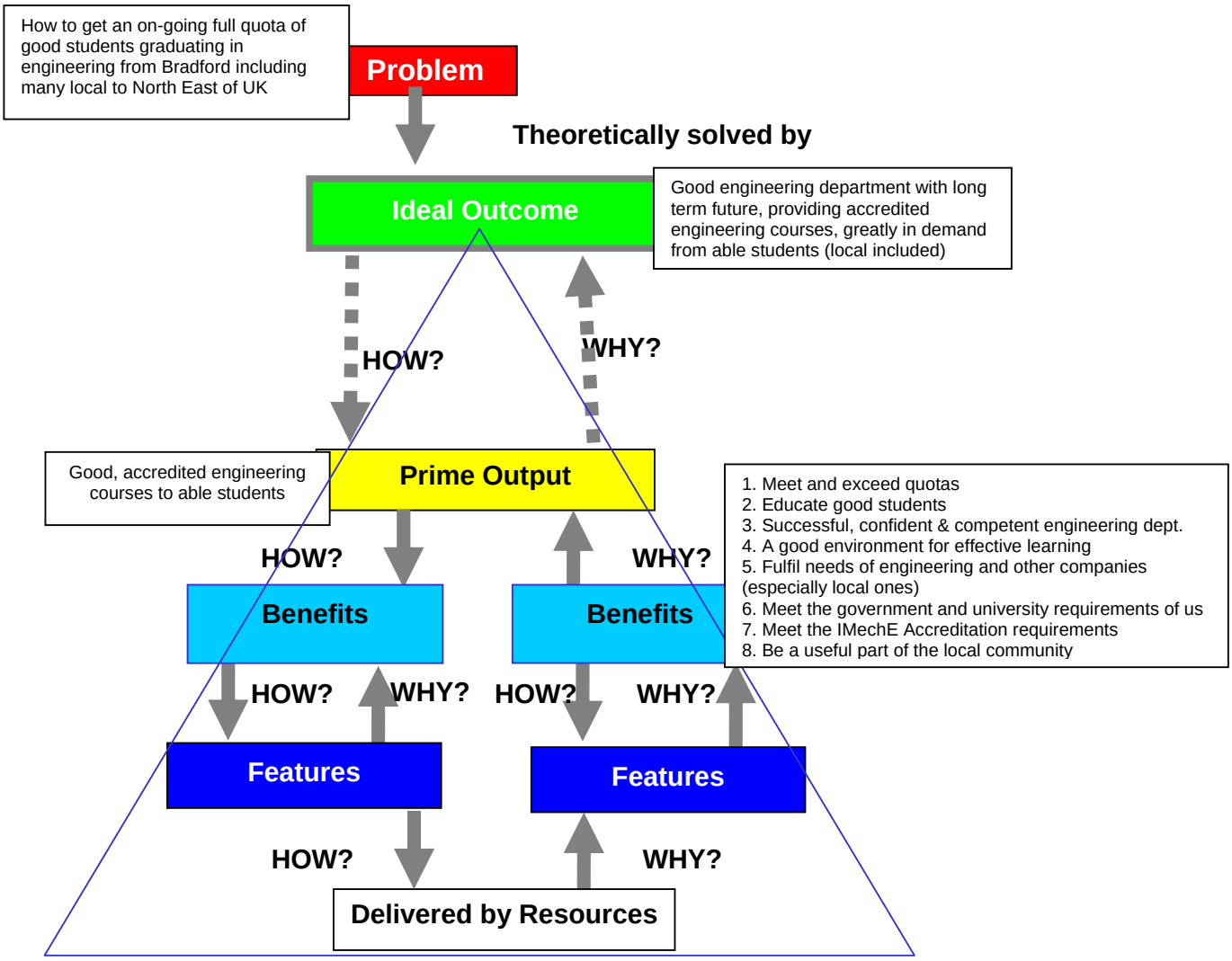
We are not however trying to solve all our problems - we are focusing on solving our specific problem. Coming down from our ideal we can now probably define on a very practical level (a lower level) what we want. We now need to list the realistic benefits we want to deliver, and to define the ways we deliver those benefits (the Features) and what resources we need.

Benefits we want to deliver - These might simply be…..

1. Meet and exceed quotas
2. Educate good students
3. Successful, confident and competent engineering department
4. A good environment for effective learning
5. Fulfil needs of engineering and other companies (especially local ones)
6. Meet the government and university requirements of us
7. Meet the IMechE Accreditation requirements
8. Be a useful part of the local community

In the long term solving our defined problem depends on achieving most, if not all, of the above benefits. So we will look at each of these benefits in turn and see HOW they can be delivered and what resources are available. An important part of TRIZ thinking is finding and using resources intelligently. The chart below shows how to move from Ideal Outcome to this hunt for resources.

In this problem essential Resources may include: - An effective, settled teaching team, well equipped engineering department to meet teaching needs, a university managerial support system to provide everything from marketing to students to human resources etc.



How does the chosen tentative Ideal outcome get us closer to the benefits we want?
Our Bradford problem relates to how we achieve our benefits with our current system and what are the best means of doing so. In choosing /accepting our system we have to make sure that most of the outcomes it will give us are directly or indirectly connected to the benefits we want.
Benefits are delivered by **features** which are delivered by **resources**.
(For example – a benefit Bradford may want is that many students choose Bradford; one feature that may deliver this is that Bradford is seen as an attractive option for students as

it offers safe, reasonably priced places to live. Resources which might deliver this would include good, inexpensive student accommodation near and on the Campus)

We now search for the resources to ensure we can deliver the benefits we want
Clever problem solving means finding the right inputs at the minimum costs. In TRIZ we need to do a resource hunt to define the resources / inputs we've got and which could be used more effectively. We need to look at each benefit and see HOW we might achieve them with features, and which resources could deliver the features for maximum benefit and minimum cost.

Benefits - Features – Resources - See how we can use these to give us best results

1. Meet and exceed quotas
2. Educate good students
3. Successful, confident and competent engineering department
4. A good environment for effective learning
5. Fulfil needs of engineering and other companies (especially local ones)
6. Meet the government and university requirements of us
7. Meet the IMechE Accreditation requirements
8. Be a useful part of the local community

How can we achieve these benefits with the resources we've got?

1. **Meet and exceed quotas**

HOW?
With Features = Demand to join the engineering department from capable, motivated, mathematically able, hard working **Students** with enough resources to fund their training who finish the course and get good jobs in engineering
HOW?
Use our Resources = The engineering department creates this **demand** with their good reputation (well publicised?) A local environment which satisfies student needs socially (clubbing and shopping?) and appropriate student facilities for accommodation, student union, social and cultural needs. These need to include good sports facilities, good sports opportunities for able students, good cultural activities (choirs, orchestras, religious needs, etc.)

Students are provided with help from our schools, the education system, families, local companies, government education policy, the University etc. If local school children have any shortfalls in maths these could be addressed by the University itself. Resources would need to be found to encourage local school children to learn and enjoy maths to a higher standard with the University through maths clubs etc.

2. **Educate good students**

HOW?

With Features = Good courses delivered (well) by competent and enthusiastic staff with the right engineering abilities and teaching skills.

HOW?

Use our Resources = The engineering department with good staff, facilities and many decades of relevant experience and success to choose and retain the best people.

but we will need to later explore how this may need some changes to meet new criteria and markets.

3. **Successful, confident and competent engineering department**

HOW?

With Features = The right staff with appropriate workloads, rewards and experience etc., teaching the right students in good facilities. Good courses (well delivered) by experienced and successful staff. High on-going demand for good teaching, good results etc. Meet the university's quotas and obtain good feedback from university and industry. Achieve success in the League Tables and have no abuse from the local and national press.

HOW?

Use our Resources = The right salaries, made possible by a supportive university structure for the staff which minimises our problems and unnecessary administration, meetings etc., gives support when needed, responds appropriately to necessary and desirable changes. Staff training is made available when appropriate. Good leadership, good management and good systems, appropriately applied. Good PR and marketing from the University and the department itself.

4. **Good environment for effective learning**

HOW?

With Features The engineering department with good staff, and facilities - available when needed, attractive buildings and rooms which are well maintained, have good lighting and heating, appropriate technologies and equipment (projectors etc.)

HOW?

Use our Resources = Sufficient and flexible funding at the right times, supportive University, efficiently run teaching facilities, offices etc. available when needed. Secure environment with few security issues.

5. **Fulfil needs of engineering companies (especially local ones)**

HOW?

With Features = The right students learning the relevant skills and subjects (may sometimes conflict with (3) above). Good staff relationships with local companies for research and project needs.

HOW?

Use our Resources = Knowledge and good relationships with local companies, understanding and response to their needs. For example Bradford Engineering department has identified that there will be many complex construction projects on Brown Field Sites in and around Bradford as old heavy industrial manufacturing sites are converted to other uses. What skills should the engineering department be offering for these types of problem – should they consider supplementing present courses and move towards design and architecture?

6. **Meet the government and university requirements of us**

HOW?

With Features = Appropriate response to quotas, rules, directives etc.

HOW?

Use our Resources = Staff available to monitor what is needed, good leadership. Stable government university policy which provides guidelines which hopefully don't constantly change – providing trust, resources and recognition in return for reasonable annual targets on research and personal achievements.

7. **Meet the IMechE Accreditation requirements**

HOW?

With Features = The right subjects, in the right proportions, taught to the right level with students passing the courses.

HOW?

Use our Resources = The engineering department and its staff motivated by a desire to deliver accredited courses.

8. **Be a useful part of the local community**

HOW?

With Features = Respond to local company needs, provide a sufficiently attractive environment to build a high quality student population to bring disposable income to Bradford, control student excesses,

HOW?

Use our Resources = Knowledge of local industry trends**,** a culture which fosters pride in Bradford and in engineering and academic achievement, regulation and monitoring of students. HOST A TRIZ WORKSHOP

To be continued…….after further problem solving sessions

Bradford University is hosting a one-day TRIZ workshop for the Institution of Mechanical Engineers for everyone in the local community, local IMechE members, local businesses and from the university this includes students, academics, administrators, management etc.

This is to help deliver some of the benefits listed above.

The Workshop is on 30th March 2006 in the Engineering Department - more details on the outcomes in future instalments of this case study.