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Front Cover: Graphic photo of Korean flight OZ214's ill-fated landing at San Francisco on 6th July 2013, as discussed in Lex Clark's article titled **'Coming Up Short'**, starting on page 11 of this edition of ***New Engineer Journal.***

FORMAL PAPER REVIEWS
Leading papers published in this Journal are fully refereed. This service is available through the **New Engineer JOURNAL**. Papers which are to be fully refereed for formal publication may be submitted at any time.

The Best Edition Yet!
(Just kidding, they're all good)

Our stable of authors continues to expand. 'Old favourites' are regularly joined by invited guest authors, and this edition of the ***New Engineer Journal*** is no exception. But, as usual, first things first....

Lex Clark's Federal President's report updates us on the newly registered formal name of our institute that being: **INSTITUTE of INDUSTRIAL ENGINEERS AUSTRALIA** with new monogram **IIEA**.

Lex provides the background to this latest development and explains the advantages of such a change. The main advantage reported is further facilitating a more integrated and working arrangement with Engineers Australia (EA), and use of their ever-growing facilities that enable on-line education and other forms of continuing professional development - to be made available to all groups within EA - including of course IEEA, as one of its Technical Societies and better known within the EA as the 'Industrial Engineering Society'.

The first feature article of this edition is from Bill Ferme: *"Entrepreneurs and Start-Ups"*. An interesting and informative paper on the nature of entrepreneurship and it being a possible alternative to the more traditional but reported less available avenues of today's career development. A handy set of procedural guidelines and useful suggestions permeate the paper.

John Blakemore returns with his usual thought-provoking style in an article titled *"Australia's Need for Clear R&D Objectives"*. He reports on recent developments in measuring an economy's growth relative to its 'complexity' – the so called Economic Complexity Index (ECI). Comparison with US, UK, Germany and Japan's ECIs shows Australia lagging in this measure. John goes on to do a comparative analysis of the above countries' R&D spend and distils some interesting correlations. I leave it up to you to read John's article and draw your own conclusions...

This edition's invited paper comes from Alan Emerson – a near 30 year graduate of the original Chisholm Institute of Technology's IE program (which morphed into the IEEM degree at Monash in 1990). Alan is an expert in the bedding/mattress industry in Australia. His article is titled *"The Australian Mattress Industry"* and is a very sound presentation explaining the intricacies of that industry and how Australian manufacturers doing the "Australian Way" are able to continuously succeed against foreign imports. It is, and continues to be, a 'made in Australia' manufacturing success story.

Lex Clark returns with an article titled *"Coming Up Short"* – that relates to the very graphic Front Cover photo of this edition. It is a very current reminder to us all that we can never neglect cultural differences in human factor considerations when designing human/machine ergonomic systems within a specific operational environment.

'Radha' (Radhakrishnan) also returns to the publishing fold with his article *"Strategies for Managing an Improvement Project"*. This piece is also a current reminder to us all of the discipline required to ensure good results from projects undertaken by industrial engineering professionals.

Finally, I get to also make a return visit to the authorship team. The paper I present in this edition is titled *"On Performance Theory and the Desirability and Goodness of Utility of Resource"*. This is the latest in the series on Performance Theory and introduces some new theoretical concepts developed within the last 12 months.

In all, I wish you good reading and trust you enjoy the work of your fellow members of the new IIEA.

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Institute of Industrial Engineers Australia Federal President's Report

www.iie.com.au

The Australian Methods Engineers Association was the original official name for the organisation set up in 1953, largely by Work Study practitioners. As the roles and activities expanded across Australia, in 1959 this became the Institute of Industrial Engineers, known in Australia simply as the IIE. In 2002 the Institute became a Company still under the name Institute of Industrial Engineers.

This has not really been an issue over the years until globalisation and the internet have greatly widened the contact of Industrial Engineers around the world. In particular, the influential American Institute of Industrial Engineers formed in 1948 became simply the Institute of Industrial Engineers in 1981 in order, it was said, to reflect its international membership. In fact, I also became a Member of the then newly formed Australian Chapter of IIE Inc in 1995 (No.9406868) while remaining a Member of the Australian IIE. The Australian Chapter of IIE Inc however only operated for a few years before folding and I personally did not feel the need to renew my US membership at the time.

As you might see with this brief summary, the use in Australia of the simple acronym IIE is somewhat confusing. So we have changed the official name of the Institute to the Institute of Industrial Engineers Australia (IIEA) as it should have been right from the beginning. This is also more in keeping with our operation as the Industrial Engineering Society of the Institution of Engineers, Australia, the largest Australian Engineering organisation.

What will this change mean for you individually. Nothing really, except that you should add an "A" to your membership title i.e. if you are now MIIE, you should use the suffix MIIEA. Will it matter if your letterheads and business cards do not have the "A". No, because that is what you were designated with when you joined. New members will be issued with the amended designation, and you can change when you renew your stationary etc. The important thing to remember is that you are an Australian recognised Industrial Engineer.

Membership Numbers.

Talking of minor but important changes, as we move back to the Engineers Australia on-line membership database, those of you who still only have a Series 2000 membership number (e.g. 2014060) will be soon issued with a new Engineers Australia number which is also your Identification (ID) number that you will need to access Engineers Australia services etc. However, to go into the database, Engineers Australia needs your date of birth as this is how they identify members with the same or similar names. To do this, send an email or contact any members of the IIEA Board, including me on clarklh@clarkengineering.com.au, the Membership Chairman Scott Fairburn on scottfairburn1@gmail.com and the Federal Secretary Sam Ghaith on sam.ghaith@team.telstra.com.

If you are already an Engineers Australia member and have one of their ID numbers (e.g.1200610) you don't have to worry as you are already in the system. However, in the future you will only be contacted with through the ID number and the old IIEA number will not be utilised (even though it will still be on record, as are all the original IIE alpha-numeric numbers (e.g. C-230).

As an Australian or Overseas member of the Institute of Industrial Engineers Australia, it is important for you and Australia that you be on record for your Industrial Engineering skills and experience. Even if you are not still a member of IIEA, it is to your and Australia's benefit to be recorded in the database as an Industrial Engineer or interested in Industrial Engineering. If you need to send us your date of birth and don't, you may be missed in the system which would be a great pity.

Engineering Services and Continuing Professional Development.

IIEA used to offer a wide range of IE courses and skills training, typically run through the Institute and its State Divisions, by members who actively practiced them in the real world or operated as Consultants. Layout planning, work measurement, warehousing, production line balancing, simulation, value analysis, incentive schemes and many more were run across Australia.

It is now planned to offer these, and many more, through the resources of Engineering Education Australia (see www.eea.com.au) and Engineering On Line (www.engineeringonline.com) through Engineers Australia (www.engineersaustralia.org.au). This is a golden opportunity for IIEA members and associates to both benefit from these training resources and to participate in providing them to the wider community.

If, as good Industrial Engineers, you have ideas and suggestions for ways that you believe the Institute can be further developed and support you as Industrial Engineers in Australia and overseas, please don't hesitate to contact me or members of the Board.

Industrial Engineering – a great career and a way of life.

Lex Clark
FIEAust CPEng FIIE, FIVMA
President
Institute of Industrial Engineers Australia

Entrepreneurs and Start-Ups

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Why become an Entrepreneur?

The reason for young Australians looking towards start-ups is because the future of work is becoming a career concern. A recent article stated that 47% of US jobs are at risk of being automated in the next 20 years (1). Jobs are not permanent, locations are not permanent and workers are returning back to what is known as a "free-agent" type of work style (2,3). These are the independent contractors, part-time employees who move in and out of the workforce, temporary employees, consultants, including engineers – that group of individuals in most of the industrialised world is already at 25 to 35% of the workforce.

Crossroads Tech Start-up Report (April 2014)

As a nation we need to affect systemic change now. Entrepreneurialism is at the heart of this retooling. The report points out that Australia has one of the lowest rates of start-up formation in the world and also one of the lowest rates of venture capital investment in the world (4). The report makes the case that as a nation we need to take immediate and far-reaching steps to address market failures that are impeding the maturation and growth of our start-up ecosystem.

Entrepreneurs

What is an entrepreneur? He/she is somebody who has a business idea and commercialises it. The success level of entrepreneurs is low as about 80% fail. World-wide research on entrepreneurs indicate that about 6.5% of them will employ up to 30 employees where only 1.6% of them will employ about 100 employees. 75% of entrepreneurs are aged between 20 and 39. The Kauffman Foundation (5) in a 2009 survey of 549 company founders came up with the following factors of success:

SUCCESSFUL ENTREPRENEURSHIP

- 1.Nearly all of the company founders surveyed – 98% - ranked prior work experience as an important factor;
- 2.40% cited lessons learned from failures as extremely important;
- 3.For 73% of the entrepreneurs, luck was important;
- 4.Professional networks were important to success ;
- 5.Only 11% received Venture Capital;
- 6.In identifying barriers to success, 98% said, the most common was lack of willingness to take risks.
- 7.Other barriers, were the time & effort required, difficulty in raising capital, business management skills,

Business Idea

A business idea can approach you the size of a dot but it leaves you the size of a bus. Business ideas come from a variety of areas:

WHERE DO IDEAS COME FROM?

- Working in an Industry/Service & seeing a Need
- People want to get into a Growth Market
- Professionals creating a new product/process
- People having a passion for something
- New Platform Technologies like the Internet/Smart Systems spawn Applications
- Creative skill becomes a Career which becomes a business
- University/Research Centres Spin-offs
- People solving personal problems turn which into a Business

As one can see they can come from any area or activity. The main thing is to have one or two. To have a business idea one does not need to be highly educated or have great skills. The community has an excess of people who have all the skills to help these entrepreneurs!

Life Readiness

What does one do next? First of all you must assess the feasibility of the idea. Do I want to start a new business with all the risks involved including failure? Can I afford to leave what I am doing where I may have a good income and what about my family, partner etc. How much do I know about the industry? How long will it take to establish the new business and when will I be able to leave my current job?

Start-Up Process

Start-Ups are all about unknowns; it is a faith-based initiative. First of all the entrepreneur has to define the product he or she is going to offer customers. If it is a product, prepare a specification: do a conceptual drawing followed by detail drawings; the business problem solved; overall function, sub-function structure; the working principle; embodiment; electronic requirements; software requirements; rough manufacturing approach.

During the above activities, the nascent entrepreneur, must research the business idea, speaking to friends and experts like business mentors.

Simultaneously, define the idea's "Value Proposition", what is the product or service giving the customer, what problem is being solved by the product?

New Business Viability

The major question, is there a business? Is there a market for the product or service? What kind of market is it? For example new products and their markets:

Product/Market Relationships	
1.	New Product into an Existing Market
2.	New Product into a New Market
3.	New Product into an Existing Market and trying to Re-Segment that market as a Low-Cost Entrant
4.	New Product into an Existing Market and trying to Re-Segment that market as a Niche Entrant
5.	Cloning a business model that's successful in another Country.

Depending on the product, if it is a new-to-the world product in a new market, this means that the market must be created and this takes time and money. If in the other categories, this means that the entrepreneur must do market research.

Is this a volume product or a small volume one, if the former, look at outsourcing to a cheaper manufacturer in Asia, if the latter, look at manufacturing in Australia where the entrepreneur either sets up a factory in his home town/city or outsources it to an Australian manufacturer. This means that economics of manufacturing will inform the entrepreneur on what path to take. What capital expenditure is required as the entrepreneur must get a prototype made and this can cost a lot of money like $1 to 3 m. There may be a need to develop a few prototypes. The next task is to find a trial user, this could be difficult, and can take some time. The trial could mean modifications and more money. Once the prototype is in reasonable shape (say about 80% suitable for the market) this is called the "minimum viable product" (MVP). The goal of the MVP is to build the smallest possible feature set.

Marketing

Detailed market research could mean finding suitable customers depending on the product. The industrial market is relatively easy as the product will have a natural market which can be found on Google. It is also important to estimate the market size for your product - as this helps to decide whether the payoff from the new venture is worth the toil, sweat and tears. To help the entrepreneur define the size of the market, if going into an existing market, the author advises using IBISWorld Market Research Studies which define the market size, major players, growth of the market, structure etc.. The above list of activities, means creating a marketing/advertising budget. The first sale is always very hard/the hardest.

Pricing is a fuzzy area for entrepreneurs. In the author's experience, most entrepreneurs price too low, so the author gets them to raise their prices. If it is a similar product to what is in the market place, the entrepreneur must follow the market-place.

All new companies should have a web-site to promote their products. Social Media is also important, as products can be marketed through Facebook, Twitter, LinkedIn and Pinterest etc.. However Business to Business (B2B) products generally use LinkedIn and You Tube for videos.

Finance

Sources of finance are wide ranging from banks to government organisations. For simpler products and services start-ups, banks like the ANZ have started an accelerator program (ANZ Innovyz START) this year already with with eight start-ups (9). The author has found that seed money could be obtained by getting a credit card from a bank.

There are other sources of money like Venture Capitalists who are only interested in "Investment Ready" companies; i.e., new products which have found a market and made sales. They are only interested in investing amounts from > $1m. They also look for a "strong management team".

Another source of finance is "Crowd Funding". There are at least three: Kickstarter, Indiegogo and Pozible (6,7,8). Pozible is the most easily accessible site for Australians and it is by far the largest Australian home-grown crowd funding platform hosting about 4,500 projects. Fees are charged by each of them at 2 different levels but generally from 4% to 9% depending on the funding arrangements.

Intellectual Property (IP)

This is an interesting area as patenting is an ideal situation for protecting a new product's design but it costs a lot of money. To patent a new product world-wide could cost an entrepreneur about $120,000. With some products it may be more suitable to register a design, however it must be new and distinctive and the design is the overall appearance of a product. Registration initially protects your design for 5 years from the date the application was filed. The cost is about $150.

Business Plans

The latest approach is from Silicon Valley and Stanford University, namely Steve Blank and Bob Dorf have recommended in their new book 'The Start-up Owner's manual' the use of Alexander Osterwalder's "business model canvas" to diagrammatically illustrate how a company intends to make money. This is a one page sheet which has nine sections: Market size; Value Proposition; Customer segments; Channels; Customer Relationships; Key Resources; Key Partners; Revenue Streams and Cost Structure. It is a great idea for a budding entrepreneur to fill in this document which will provide him/her with a great view of the nascent company and business idea.

Conclusions

Experience has shown that entrepreneurs with some corporate experience have a better chance of success. However, the failure rate is still very high for start-ups, about 80%. The business idea for a new business can come from many sources and is the basis of entrepreneurialism. Being an entrepreneur is a significant life-changing activity and must be considered seriously before becoming one. The entrepreneurial process is a complex and difficult one for all people concerned, especially for the evaluation of the new business's potential. The marketing of a new business's product or service can use the usual channels of advertising as well as the utilisation of a website and the use of social media. Obtaining finance is another difficult area. Finally, success is possible for the hard-working, persistent and lucky entrepreneur.

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Australia's Need for Clear R&D Objectives

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Introduction

Commodity trade involves large volumes of raw materials which are of low value compared with moderately transformed or highly transformed manufactured goods. The main drivers of economic growth are productivities due mainly to improvements resulting from the application of technology and the new creation of intellectual property and its application, particularly by adding value to lower value products.

Measuring Economic Growth

MIT and Harvard have come up with a new method of measuring this and forecasting economic growth. It is called Economic Complexity. (ref Hausmann, Hilgalgo et al "The Atlas of Economic Complexity" 2014.) In simple terms the Economic Complexity Index (ECI) is a measure of the productive knowledge that is implied in our export structures. It is a measure of innovation, knowledge and our use of and understanding of the economic factors that will be paramount in the future. It is a reflection of our relative adequacy in mathematics, physics and chemistry … the so called hard subjects.

This is a good indicator of the sophistication of the country and can be used as a guide to future growth. The key is Innovation.

Australia performs very badly by this measure as shown in the following Table and Chart comparing Australia, the UK, USA, Germany and Japan. The chart shows the top right-hand three points as Japan the top, then Germany and then the USA. The two outliers are the UK at the left top and of course the negative ECI country, Australia. The chart therefore shows our performance is relatively very poor.

Comparing ECI with R&D Expenditure

It is interesting to correlate this with the total expenditure on R&D in these countries, Japan at 3.67% of GDP and Australia less than 1.1%.

Some Recommendations

We must create a value adding society, focused on innovation and education using our natural comparative advantages. Some of this can be in the service industry like education, design, research, medicine, for example, but the opportunity is greater in manufacturing because some significant comparative advantages are there already.

Table:
Economic Growth % Versus ECI

	Growth 2020	ECI
Australia	1.23	-0.321
UK	1.2	1.558
Germany	2.34	1.985
USA	2.01	1.447
Japan	2.71	2.316

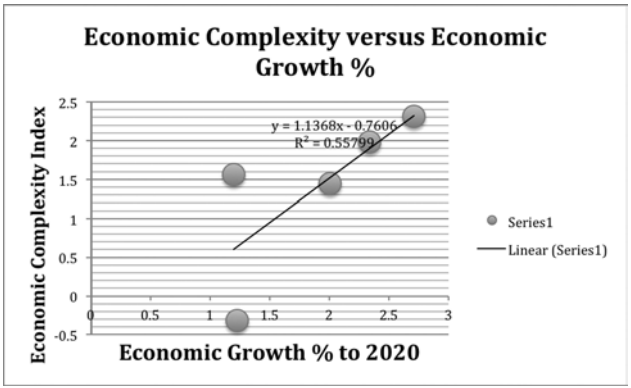

Figure: Economic Compexity and Economic Growth

It is essential in an advanced developed nation that equal opportunities are given to all talented people regardless of their profession or special skills provided that these are in the general national interest for the betterment of society. Increasing our manufacturing capability is one significant way of achieving this and broadening intellectual opportunity at the same time as improving our standard of living and balancing our trade.

We urgently need to develop an intellectual culture that values highly, skills in science and engineering that add to the wealth of society. This starts with our education system.

An innovation policy must aim to create wealth from industries and activities where, at least in the first instance, we have a comparative advantage. Later we can create such strategic advantages. Such an advantage must account for our natural resources in materials and people and position in the world aimed at competitive equilibrium but mindful of all moral sentiments.

This means we must develop an innovative system which enables small Australian owned businesses to tap in to the world's intellectual knowledge quickly and seamlessly and use the technological scientific and engineering resources available which are continuously upgraded with superior education facilities at school, colleges and universities. It is useless however to train more scientists and engineers if they have no job to go to. Barriers to business created by state bureaucracies must be removed.

Professional bodies can also play a significant role in the wider community. Scientists and engineers should no longer be invisible. A totally free market or completely unhindered free use of capital is not the answer as the current financial crisis has illustrated. A model similar to that in Denmark with a superior balance between the welfare state and Adam Smith's invisible hand and flexible security systems can improve Australian society significantly, but first we need to trade in surplus.

Conclusion

The government and Keynesian economics are the way forward. Incentives are needed in a truly cooperative system with an elevation of the need to create a new society focused on long term growth using science and engineering education and its application to innovative processes and products as a driver.

The Australian Mattress Industry

Alan Emerson
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Introduction

These days it seems to be a common occurrence to pick up a newspaper and read about another company closing down manufacturing operations in Australia or like the car industry, the whole industry being in the process of closing down manufacturing in Australia. Depending on what side of politics you are on reasons given or the blame for this are, too high wages and conditions demanded by unions, too many or too high government taxes and charges, unrealistic profit expectations from business owners / investors, or just a lack of government support for manufacturing.

Background

I sat my final university exams back in November 1984 and started work the following week as an Industrial Engineer at Yakka in the clothing industry. Back then the clothing manufacturing industry was at or was close to its peak, with many companies involved in Australian production of clothing. In general the clothing industry required relatively low capital but had high labour content, and with tariff reduction programs introduced progressively from the late 1980s, local manufacturing could not compete with imports, and over the last 30 years clothing manufacturing on any scale has now almost ceased in Australia.

With what has happened to the clothing and other related industries the general consensus seems to be that the future of Australian manufacturing is in high capital, high technology, low-labour cost industries. This is why I believe the Australian mattress industry is an interesting case study.

The Mattress Industry in Australia

The mattress industry is one which requires relatively low capital and with many manual processes appears to be labour intensive, even though direct labour costs typically only account for 10-15% of the cost of a mattress. A few hundred thousand dollars is all that is required to purchase all the machinery necessary to become a small to medium sized player in the Australian Mattress industry.

The Centre for Industrial Studies (Csil) produce an annual World Mattress Industry report. Table 1 below shows some summary data for the Australian Mattress Market taken out of the 2013 Csil World Mattress Industry Report.

From the table, mattress imports represented 11.05% in 2005 and 14.50% in 2012 as measured by wholesale dollars, and whilst they are growing, imports are still only a small part of the Australian mattress market. People who are not familiar with the Australian mattress industry are usually very surprised when I tell them this and they often ask me, why has this industry been relatively immune to imports?

Table 1: Australian Mattress Market

Year	2005	2012
Production	332*	559
Exports	2	2
Imports	41	95
Total Australian Consumption	371	653

*All numbers are in US$ millions at wholesale values.

Those that have a view believe it is most likely due to the physical bulk of mattresses and high import freight costs.

I believe the physical bulk of a mattress does have an impact on the low level of imports, but not just due to the resultant high import freight costs.

The Australian Way

Australian mattress manufacturers have and are successful as they have learnt that in order to be successful they must have a deep understanding of their customer needs and provide their customers with a supply proposition that addresses these needs better than the importers are able to. Australian mattress manufacturers have recognised that their product is physically bulky and have designed a product and service package that is currently not able to be matched by imports. By product and service package I mean quick order to delivery lead-time, product innovation, product quality / performance, and after sales service.

A typical Forty Winks, Harvey Norman or Snooze retail store ranges somewhere between 50 to 60 mattress models on their floors at any given time. With 6 standard industry sizes available and both a mattress and base required to make a complete bed set or ensemble, a retailer would need to hold over 600 different skus in stock in order to just have one piece of stock of each mattress and base size they range. With the bulky size of mattresses retailers find this to be just not practical. Retailers therefore prefer to only carry a small amount of inventory of high volume selling mattress models and rely on their suppliers to supply the balance to order in short lead-times of 2-3 days.

Importers

Compression packaging technology exists today that allows an importer of mattresses to ship up to 600 queen size mattresses in a 40' container. With typical total freight costs from Asia to Australia inclusive of customs clearance being approximately $6 per queen mattress, import freight

costs are not as high as labour and overhead cost savings of producing mattresses in Asia. There is no import duty on finished mattresses imported into Australia. Through the holding of sizeable inventories, importers are also able to offer the same short physical delivery lead-times of Australian mattress manufacturers.

The first area where mattress imports have had problems is with product quality. This has typically not been with the quality of construction or workmanship, but rather with inferior quality raw materials such as polyurethane foams and spring units. Lower quality raw material components used in imported mattresses have resulted in post sale field service issues, and importers have not been set up to deal with after sales service issues. Asian mattresses are also typically much firmer than Australian mattresses and mattress importers have had a difficult time having Asian overseas manufacturing partners adjust "feel specifications" to suit the Australian consumer's desire for comfort. All of these quality issues are not insurmountable and the quality of product being offered by some importers is now considerably better than it was just 5 years ago.

The Australian Customer and Consumer

I have previously mentioned that the Australian mattress manufacturers have understood the needs of their customer, the retailer. This has been as important as understanding the needs of the end user, the Australian public which like you or I purchase a new mattress every 8-10 years.

The reason the retailer's needs need to be understood is because the purchase process for mattresses can be quite different to many other consumer durable products. At home while they are being used mattresses are covered up by sheets, mattress protectors, doonas etc when they are used, and with consumers only purchasing a new mattress every 8-10 years, consumer's product knowledge of mattresses and mattress technology is minimal. A significant number of my friends can't even tell me what brand of mattress they sleep on, or what type of technology it uses, spring, latex, memory foam etc. Greater access to the internet and internet search engines has enabled pre-purchase research to take place, but only a minority of consumers do any research before they start to visit retailers.

Consumers who go into a retailer looking to purchase a new mattress most likely do not go into a store with a specific mattress brand or mattress type in mind. The retailer, if they do their job well should come across to the consumer as a mattress / sleep expert who is there to help the consumer sort through the numerous brands and technologies that are available, and assist them in finding the right mattress for their needs.

Through this process the retailer is often able to convince the consumer to purchase a mattress the retailer is happy to sell them, and the retailer will want to sell a mattress that not only satisfies the consumer, but also makes life easy for the retailer. The retailer will try to steer consumers to mattresses they feel are easy to sell, they know they can obtain quickly, will perform well, and earns the retailer a healthy profit margin.

Competitive Advantage

In order for any business to be successful they must have a competitive advantage over their competition. Competitive advantages are typically business performance attributes such as the best quality, the highest technology product, the best service, the most well known brand or perhaps the lowest cost. Industry customers regard these business attributes to be order "qualifiers" or order "winners" and as such determine which attributes suppliers are required to do well at just to be in the game and qualify as a supplier, and which attributes will win them business and make them successful. From my experience it is usually not possible to excel at all these performance attributes as they often will conflict with each other.

Short delivery lead-times and acceptable product quality are in the main order "qualifiers" for Australian mattress retailers. Without these a retailer will not even consider to range product from a manufacturer or importer. At the very low end of market "lowest cost" can be an order winner and as such some importers are having success in this market segment. However, for most of the market it appears to me that the order winner making Australian manufacturers successful is product innovation / differentiation, and the speed of product innovation. In my opinion it is in these attributes that Australian manufacturers really lead the importers. Australian mattress manufacturers spend considerable time and effort designing their products with "a point of difference" that they claim make their products perform better from a postural support, durability or comfort perspective. As many of these "points of difference" are not able to be patented and are available to any other manufacturer, over relatively short periods of time they are copied by competitors.

It is for this reason that Australian mattress manufacturers constantly travel the world looking for new technologies, new materials and new construction methods they can quickly incorporate into new product ranges. These new product ranges are currently being developed and released to retail groups faster than they have ever been before.

Conclusion

The manufacturers that are innovative and can quickly bring new product ideas to retail faster than their competitors are the companies that are winning and growing. Companies that are slow to innovate are losing out. The local manufacturers in this category tend to also operate in the lower price market segments.

With importers having weeks of stock on hand and potentially months of inventory in import supply chains they are normally much slower to innovate and bring new products to market than local Australian manufacturers. As such imported products are mainly found in the lower price market segment where new technology and innovation are not as important.

The challenge for mattress importers is to be as innovative as the Australian manufacturers and to be able to quickly bring new product ranges to retail. If this can be done innovation and speed of innovation will become order "qualifiers" and a new order "winner" will need to emerge.

Coming Up Short

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Abstract

The following article has been reproduced from the March 2014 Australian Aviation magazine with the approval of the publisher and the author Geoffrey Thomas. While the investigation of the crash of the Korean flight OZ214 is primarily about aviation safety, the human factor and human machine interface analysis, which includes work by US Industrial and Systems Engineers, also has relevance to wider Industrial Engineering applications. In particular, the human/machine interfaces which include cultural issues can be equally relevant in many Australia environments with increasingly multi-cultural work forces, both local and imported.

Introduction

The crash of Asiana flight OZ214 at San Francisco International Airport on July 6 2013 is a sobering wake-up call for an industry where some have been lulled into a belief that cultural factors in the cockpit had been virtually eliminated.

Asiana 777-200ER HL-7742 was operating flight OZ214 from Incheon when it clipped the seawall on approach to SFO's runway 28L. The subsequent crashed killed three and injured 180 of the 307 passengers and crew on board.

Soon after a chorus of experts and commentators immediately and emphatically dismissed cultural factors as a likely cause. But the subsequent investigations have proven otherwise, raising challenging questions of the aviation industry.

Testimony by trainee captain Lee Kang-Kuk. who was pilot-flying OZ214 from the left hand seat (under the supervision of training pilot. and pilot-in-command, Captain Lee Jeong¬min in the right seat), to a US National Transportation Safety Board hearing in December raises serious concerns, despite his 9,684 hours in a variety of aircraft types.

Captain Lee told the NTSB that he was "very concerned" about landing the 777 visually at San Francisco International Airport without the aid of a glide-slope indicator (ILS). At the time of the accident the airport's ILS was not operative but its PAPIs (precision approach path indicators) were working. He added that because other pilots were doing visual approaches, "he could not say he could not do" one.

But it appears that Lee is not alone in his fear of visual approaches. In an interview with Bloomberg former Delta Airlines and Asiana Airlines (2006-11) Captain Victor Hooper said that on one approach to LAX his copilot "froze" when asked to perform a visual approach. According to the Bloomberg report Captain Hooper had to take the controls to get the aircraft back on track, and he recalled the copilot saying "I don't need to know this. We just don't do this:"

Captain Hooper was also interviewed by the NTSB and said that "while all Asiana pilots he flew with were extremely competent at executing the training they were provided, there was minimal training in how to do a visual approach." He added they had limited opportunities for stick and rudder skills training but he "was sure that, given the opportunity, they would be excellent pilots,"

He added, "they really needed to add in the syllabus more visual approaches where they just go down and fly around a local area and fly without auto throttles, because they count on the auto-throttles and assume they're going to work right."

According to the Bloomberg story, Ross Aimer, a retired United Airlines captain, who trained crews at Korean Air Lines for Boeing subsidiary Alteon Training in 2008 and 2009, and Kenneth Musser, a former Delta pilot who flew 777s for Asiana for almost four years until 2009, both said they also noticed that many Korean pilots struggled with visual approaches.

Bloomberg also spoke with David ~ Greenberg, the retired Delta Training Captain who was hired by Korean Air I in 2000 to turn around the airline's then disastrous safety record that had made it a pariah in the industry. On the deficiencies in hand-flying he said "I observed it," but added in a portent, of a much wider problem that it was not worse than with pilots elsewhere in the world.

On hand-flying, Boeing's 777 Flight Level Speed Change (FLSC) mode has come in for scrutiny. According to one 777 captain the issues revolve around the interaction between the 777's auto-flight and auto-thrust. The FLSC is not recommended for the final phases of an ILS approach but there is no guidance on a visual approach. "The FLSC allows the auto-thrust system to enter a "sleep" state if the throttles are not moved for more than 1.2 seconds," said the Captain. "The problem is that in all other auto-flight modes the auto-throttle will re-engage." The pilots of OZ214 did retard the throttles after FLSC was engaged.

The FAA became aware of this issue during the 787 certification but after consideration of all factors deemed it not a safety issue, while Boeing has noted it '!' in its training manuals for 15 years. And in the NTSB's investigation an Asiana Airlines ground school instructor who trained Captain Lee told investigators he emphasised this issue because he had "personally experienced it:"

Candid admissions

As disturbing as the fear of flying a visual approach admission was, there was more to come in the testimony from Captain Lee, who said that he was blinded while making the approach by something shiny. But when asked why he did not wear sunglasses, he said it would have been impolite for the training captain not to see his eyes. He added it was very important in their culture. Asked why he did not break off the approach as he was pilot in command he told the investigator-,: "That's very hard because normally only in our Korean culture the one step higher level the final decision people he did he decide the going around thing. It's very important thing. As a first officer or the low level people they dare to think about the go-¬around thing. It's very hard."

Responding to this answer an NTSB investigator asked: "In your mind, then, and I don't want to put words in your mouth, you tell me, did you feel that as the pilot in the left seat flying the airplane that you had the authority to do, commence a go-around yourself?"

Captain Lee responded: "Go-around thing. That is very important thing. But the instructor pilot got the authority. Even I am on the left seat, that is very, hard to explain, that is our culture." He added that it was company policy after a FO-initiated go-around - overriding the flying captain - in an A321 which resulted in a tail strike. As it happened, Captain Lee, at the time an A320 captain, was part of the investigating team that compiled the report. For him not overriding the captain or pilot monitoring was indeed - overriding.

Asked whether he had ever had to take the controls away from a captain because they were not seeing something or were confused or disoriented, Captain Lee said "no, no way." Asked if he could imagine a situation where he would ever do that, he said "no way."

However, he said that Asiana encouraged junior pilots to "speak up if they felt uncomfortable about something".

Watershed

For Najmedin Meshkati, Professor of Civil/Environmental Engineering and Industrial and Systems Engineering, who also conducts and teaches human factors in aviation safety at the University of Southern California, OZ214 is a watershed in aviation.

"We cannot change national cultures and their emitting behaviors. We have to better respect them, better understand them and try to delineate their implications on human-machine systems integration," Professor Mashkati told Australian Aviation.

He added: "In the whole context of human-systems integration paradigm, we need to try to understand and cater to cultural differences and use design for adjustability principles which we use for anthropometric (human body size) differences and use the same principles for accommodating cultural differences, if we want to be successful and get out of our denial mode."

Professor Meshkati warns that the "denial of existence and impact of cultural factors and differences in aviation systems design has been a routine practice in the past. Its time is over, thanks to the rude awakening of the Asiana 214 [accident], and has to be changed."

Professor Meshkati is one of the aviation industry's foremost experts on human factors machine interface. He has taught at the renowned 62-year old USC Aviation Safety Program since 1989 and was **its Director for seven years from** 1992 to 1997. Meshkati is also a Jefferson Science Fellow and was a Senior Science and Engineering Advisor to the US Secretary of State. He is the author of one of the original and pioneering articles on the role of cultural factors in aviation safety, which was published in the October 1996 special issue of the International Civil Aviation Organization (ICAO) journal.

On national culture, Professor Meshkati says that "*national culture, according to anthropologists, is the way of life of a people - the sum of their learned behavior patterns, attitudes, customs, and material goods. And, according to famous Dutch social psychologist, Professor Geert Hofstede, culture in this context can operationally be characterised as `collective mental programming of peoples' minds*".

He adds: "According to (late) Professor Azimi, the culture of a society consists of a set of ideas and beliefs. These ideas and beliefs should have two principal characteristics or conditions: First, they should be accepted and admitted by the majority of the population; and second, the acceptance of these beliefs and ideas should not necessarily depend upon a scientific analysis, discussion, or convincing argument."

Professor Meshkati adds that national culture affects not only the safety, but also the success and survival of any technology. "National cultures, according to Hofstede's monumental research, differ on at least four primary dimensions: Power Distance, Uncertainty Avoidance, Individualism ¬Collectivism, and Masculinity¬ Femininity. All of these play a role in safety in the cockpit."

For Professor Meshkati there are two key issues that cultural factors impact - the interaction with others in the cockpit and the human/machine interface.

"The first was very clear and played out very strongly [in relation to the Asiana 214 incident] and is a text book example of cultural factors. The latter of automation interaction is less well understood or discussed."

In 1996 the US Federal Aviation Agency (FAA) conducted a comprehensive review of human factors in aviation and identified issues with automation and cultural factors. One of its recommendations was: "The FAA should ensure that research is conducted to characterise cultural effects and provide better methods to adapt design, training, publications, and operational procedures to different

cultures. The results of the research should also be used to identify significant vulnerabilities, if any, in existing flightdeck designs, training, or operations, and how those vulnerabilities should be addressed."

Professor Meshkari questions: "What has been the response of the FAA and industry to this recommendation?" He knows of none.

The FAA report found issues across all designs from all manufacturers but did not identify specifics.

Professor Meshkati highlights a 1998 study by Helmreich and Merritt of f flightdeck automation, which surveyed 5,705 pilots across 11 nations and reported that "the lack of consensus in automation attitudes, both within and between nations, is disturbing."

In the book *MacroergononaEcs: Theory, Methods, and Applications* (2005), Meshkati authored a seminal chapter "*Macroergonomics and Aviation Safety:Why your flight safety is at the mercy of cultural factors*".

He starts the chapter with a strong and relevant epigraph, a quote from (the late) Professor Stephen Jay Gould, the renowned Harvard University professor of geology, biology and the history of science, who contended that even hard sciences theories are strongly culturally-based:

"Facts are not pure and unsullied bits of information; culture also influences what we see and how we see it. Theories, moreover, are not inexorable inductions from facts. The most creative theories are often imaginative visions imposed upon facts; the source of imagination is also strongly cultural." This was written in Gould's book, *The Mismeasure of Man*.

Professor Meshkati wrote in 1996: "Research has demonstrated that technology utilisation, without the incorporation of the necessary human factors and cultural considerations, is (doomed to failure). It is incumbent upon the world's airlines and aviation industry (aircraft and equipment manufacturers, air traffic controllers, and civil aviation authorities) to systematically take into account the physical and psychological factors, as well as the cultural attributes of their user populations, in the design and operation of passenger aircraft and aviation systems. Cultural factors have a significant effect on the realities of operating a complex technology such ' as modern aviation, and the nature of ' these effects must be understood and accommodated if aviation systems are to ' operate safely'.

In a paper entitled *Design Philosophies in Flight Deck Automation,* Stephanie Chow and Meshkati quoted a study by Hutchins, Holder and Perez about culture and flightdeck operations at the University of California-San Diego, which found that there is no link between the aircraft ' manufacturer's national culture' and 'safety of the flight'.

However, the paper by Chow and Meshkati points out that the same report elaborates on how culture plays a role in the organisation of behaviour in the flightdeck. French pilots are described as `simple executants', whereas the American pilots are portrayed as pilots who like to overcorrect and take control of the aircraft.

The paper states that: "Airbus and Boeing will naturally manufacture and design flightdecks illustrating their respective culture. Even though both designs are the most advanced and safe systems in aviation history, pilots of various cultures will operate these jetliners differently. Aircraft manufacturers and airline companies need to consider national cultural influences and human factors in designing the flightdeck and in how they train pilots."

Back to the past

The admissions of Captain Lee Kang-Kuk are a disturbing flashback to a special edition of the ICAO journal of October 1996 headlined `Human Factors in Aviation'. In that edition a survey of 13,000 pilots from 25 airlines from 16 countries found agreement ranged from 15 to 93 per cent to the statement: "Crew members should not question the decisions or actions of the captain except when they threaten safety of the flight."

The same survey found a range in agreement of between 36 to 84 per cent to the statement: "If I perceive a problem with the flight I will speak up regardless of who might be affected."

The study found that pilots from Australia, New Zealand and Ireland were the most assertive and likely to speak up, while the pilots from Japan and South Korea were the least likely. It was noted in the ICAO journal that many nations had developed CRM (Crew Resource Management) training programs congruent with their own culture and these had been well accepted.

But the situation Captain Lee found himself in - of having to land for the first time at San Francisco, while under training with only 33 hours in the 777 and with the ILS inoperative - may have prompted him, when under stress to fall back on traditional values and beliefs of the Korean culture.

This is precisely what happened on July 1 2002 when a DHL 757-23APF and Bashkirian Airlines Tu-_l54M collided taking the lives of all 171 aboard both aircraft. After an ATC (Air Traffic Control) human failure due to high workload and lack of staff, the two aircraft were on a collision course and their respective TCAS systems gave opposite instructions to avoid impact. The DHL 757 was told to descend and the crew of the Tu-154 were instructed to climb. Both also received further advisories to "increase descent" and "increase climb" respectively just 8 seconds before the crash.

But in the critical last seconds the Tu-154M captain, Alexander Gross, also heard Zurich ATC, which had realised the error instructing a descent not once but twice. Captain Gross ignored TCAS in favour of the instruction given by ATC at the critical moment and descended into disaster.

His country's cultural tendency, some speculated, owed to a heritage where the command of the voice must be obeyed and in which the reliability of technology lagged well behind the West. Captain Gross at 57 would have lived through some of the worst of the Communist years where not to obey the voice of authority meant imprisonment. In an ironic tragic cultural twist, what well may have influenced the captain in the final seconds was that the human instruction was coming from Swiss ATC - known for its precision.

And cultural differences between societies are many and varied, points out Professor Meshkati. It is not just a "Korean problem". Some are major challenges for aviation.

Another cultural twist comes from a 1986 study of colour perception between populations of the US and China. Of 784 volunteers across both sexes and varied occupation groups in Kunming, China less than 50 percent associated red with stop and green with go. The ratio for the US participants was almost 100 per cent. Red is a fundamental warning colour in aviation. The pilots' saying of PAPI lights sums it up: "Red on white you're alright, Red on Red and you're dead".

Even something as fundamental as training manuals require special attention. One study found that a poor quality translation - not conceptually adjusted - resulted in performance that was 14 per cent below those using the original manuals.

Asiana Airlines says that its "training previously exceeded all Korean and international standards and we have [now] instituted even more demanding requirements across the board for basic, initial and transitional training for flightcrew and strengthened flight instructor training."

It has hired Akiyoshi Yamamura, formerly of All Nippon Airlines and the International Air Transport Association, to a new senior executive level position to oversee safety operations and it has enhanced training on automation logic and the capabilities and limitations of the auto-throttle stall protection system.

In a statement for Australian Aviation the airline says:"Asiana has a state-of-the art training program that consists of ground school, simulator training provided by Boeing Korea LLC, and operator experience training (OE). All of our training exceeds International and Korean standards.

"We also provide special training for all airports that may provide special challenges for our pilots. SFO often involves high-energy approaches, and while it is not the most difficult airport in our system, we do provide specialised training on the SFO approach".

"As the statements of Captains Jung Tai Soo and Kim Je Yeol indicate. the pilot flying was instructed on the specific effect of using FLCH (flight level change) mode on the auto throttle system in his transition training class."

On its CRM program the airline states: "Asiana Airlines has spent years studying other airline crashes, and has created training programs designed to make sure its crews work together as a team in the interests of safety. That includes making sure junior officers understand that not only are they allowed to speak up when they notice a problem in the cockpit, they are required to - even if that means challenging a more senior officer.

"Our crew resource management (CRM) program specifically takes into account the role that cultural issues have played in other aviation accidents. We train our pilots that any member of the flight crew can - and must - speak up when needed. All of our pilots understand this principle, which has long been a major focus of our training. And, importantly, no crew member is ever punished for speaking up, since we train that it's a critical safety factor. Indeed, on the accident flight, the most junior officer of the crew spoke up when he saw something wrong, according to documents released at the hearing, calling out `sink rate' - indicating that the airplane was descending too quickly."

OZ214 raises many questions but no answers-as yet!

Just as automation has given less experienced pilots a safety cocoon and the industry its best ever crash record, it has it also lulled many into thinking nothing more needs to be done in its pursuit of the holy grail of zero accidents?

Professor Meshkati warns much more needs to be done. He cites the late Nobel physicist Richard Feynman (1986) in reference to the Space Shuttle *Challenger* explosion: "For a successful technology, reality must take precedence over public relations, for nature cannot be fooled."

He stresses "when it comes to vexing and serious issues of cockpit automation, cultural factors, and their complex and mostly unknown interactions, we need a paradigm shift in our thinking and should diligently be addressing their paramount influence on aviation safety."

Perhaps Albert Einstein sums up the problems best in this quote: "We cannot solve our problems with the same thinking we used when we created them."

Strategies for Managing an Improvement Project

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Introduction

The Project Management Process focus has traditionally been that of completing a defined set of work requirements within given time constraints and established cost levels, and delivering a final output to the customer that meets required quality-conformance levels.

Formal Definition

Project management involves the co-ordination of resources to complete a project within a set of planned time and resource constraints and to meet pre determined quality levels. It includes planning and allocation of resources and may make use of other management techniques for planning and control purposes.

Action plan for Project Implementation

The following action plan outlines the process methods in project Management, provides a framework of procedures for the Project Manager undertaking a project, and offers a general synthesis of current practice, incorporating elements from the various approaches to managing a project.

1. Define the objectives

Understanding of an agreement on certain factors by both project owner and the project manager are essential to the successful management of any project. The strategies are:

- What is to be achieved?
- The required outcome or result to be delivered
- Completion dates and financial budgets for completion of the project.

2. Appoint the Project Manager

The project manager must be someone who has a proven track record , can command the respect of a mix of multi discipline professionals and can get action from them. He or she should be able to:

- Plan and communicate all aspects of the project
- Motivate the project team
- Gain productivity and trust through delegation and participatory decision making.
- Lead the team
- Monitor costs, efficiency and quality without excessive bureaucracy.
- Get things done right the first time
- Use both technical and general management skills to control the project.
- See clear-sightedly through tangled issues.

3. Establish the terms of reference.

This should specify the objectives, scope, time limits, limitations, risks involved, project costs and specialist professionals required for the Project. As per good Industrial Engineering practice it is important to establish a level of contingency prior to commencement of the project.

4. Determine key processes for successful operation of the project.

Having established the terms of reference, consideration should be given as how to achieve project objectives.

The main activities should be flow charted so that they can be constructed into the final output of the project. By identifying the resources required to achieve each process a project schedule can be drafted showing how this can be satisfied against the time schedule, taking into account inevitable resource constraints.

The final project plan then becomes the basis for implementation. While making project progress plans, the following techniques can be used for successful operation/ execution of the project.

a. Critical path analysis
b. Gantt charts

5. Quality planning

Planning for quality requires both paying attention to detail and ensuring that the project outcome will conform to the acceptable quality conformance levels.

Use of ISO guidance documents can help to establish standards, monitor product/process quality performance and suggest preventive and corrective actions. The above process enables you to get output right first time.

6. Project costing

This is the major component in which project managers often make mistakes. Frequent errors occur in the various project stages in the underestimation of costs. The following cost aspects have to be controlled to achieve the project objectives.

- Personnel time and remuneration

- Overheads
- Materials and supplies
- Equipment and machinery- decisions on leasing or purchasing and the depreciation factor.
- Administration- purchasing & supply, accounting and information processing.

When considering costs, a workable budget has to be established in order to monitor costs while the project is in progress; and also to set an appropriate level of contingencies while designing a cost structure for the project.

7. Scheduling and control

By applying critical path analysis, we can calculate shortest time necessary to complete the project.

Using Industrial Engineering techniques we can calculate the following:

a. The earliest time a process can commence
b. the duration for each stage
c. the latest time by which a process can be completed.

8. Project monitoring and progress control

Monitoring project budgets, time schedules and quality conformance are all important factors and can be used to help avoid any deviations against planned strategies.

Early identification of risks and issues can also provide the basis for mitigation and where required, for contingency planning and help ensure the achievement of success.

9. Deliver the output

Preceding the delivery of the project result may include the compilation of standard operating procedures and also training programs. The approval by the project owner is important. All project proposals have to be accepted by the senior management and other personnel to be involved in the implementation process.

10. Project Evaluation

The evaluation consists of the process of measuring project success according to predetermined levels and see what lessons can be learned. The key area for review would be the cost benefit analysis which includes the following:

1. Identification of skills gained through this project
2. Right at first time. No mistakes to be repeated
3. Tools and techniques used and their benefits
4. What process should be given special priority?

Conclusion

Leadership of the project is of great importance, not the project consultant but the steering committee that the project reports to. This committee sets the standards for the project, finds the resources and should monitor all stages and final delivery. The steering committee should also decide each project milestone, decide if the project remains valid or if the situation has changed and a new direction is needed.

On Performance Theory and the Desirability and Goodness of Utility of Resource

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Abstract

This paper complements the paper titled '*On Performance Theory and the Desirability and Goodness of Productivity of Process*' by the same author, published in the May 2013 edition of ***New Engineer*** (1). That is, this paper is a 'natural' progression given that the central formulation of performance theory is the utility-productivity performance equation of form $P_p = \mu\eta$ - where the *productivity of process* term 'η' was the focus of the 2013 paper and where the *utility of resource* 'μ' is the focus of this paper.

This paper discusses the desirability and goodness of the utility of resource. It introduces the concept of 'potential' of resource that enables any input resource to be processed (hopefully) into a desirable and good output resource.

Input, output (i,o) diagrams are also introduced to better illustrate the connectivity and relativity of the inputs {i} to and of a process and the outputs {o} of the same process.

Finally, the concept of *potency of resource potential* is introduced in the discussion.

Keywords

Utility, Desirable utility, Good utility, Undesirable utility, Bad utility, Potential of resource, i-o diagrams, Potency of potentials of resource.

Introduction

The set of input resources to any productive system includes not only the variable input resources (labour, materials, etc.) but also the 'house' resources that constitute the physical productive system itself (plant, equipment, etc.). Each resource (i) within the total set of input resources {i} is defined to have "utility" (symbol μ).

Definition of Utility

Utility (in performance theory) is defined to be 'the amount of input resource required to generate a unit of output resource'. That is, utility is a ratio measure of input to output and has the generalised form:-

$$\{\mu_{resource}\} = \frac{\{input\}}{\{output\}} \qquad (1)$$

- where $\{\mu_{resource}\}$ is the set of utilities of a single input resource, $\{input\}$ is the set of inputs (variable and house) available to the process and $\{output\}$ is the set of outputs generated by the process.

Not So Good and Undesirable Outputs

As noted in the complementary paper (1), not all outputs of a productive system are both desirable $\{o\}_1$ and/or good $\{o_1\}$. That is, some members of the desirable set are not good (i.e. poor quality) $\overline{\{o_1\}}$. Other undesirable outputs include land pollution sets $\{o\}_2$ and air pollution sets $\{o\}_3$.

Potentials of Resources

The ***source*** of the sub-set of not good desirable outputs $\overline{\{o_1\}}$ and the pollution sets $\{o\}_2$ and $\{o\}_3$ are undesirable potential(s) of process and undesirable potential(s) of input resource respectively. This can be seen by consideration of the basic calculus expression:-

$$\Delta o = \frac{\partial o}{\partial \vee_i} \Delta \vee_i \qquad (2)$$

where $\Delta o = \frac{\partial o}{\partial \vee_i} \Delta \vee_i$ says that to generate any change in output from a productive system, the input resource consumed has had to have at least an amount of *potential* within it of value $\Delta \vee_i$ in order to generate output Δo. That is, the potential of the input resource V_i has to be greater than zero. This potential is then converted through the action $\frac{\partial o}{\partial \vee_i}$ to generate Δo.

This *potential of the input resource* is inherited by virtue of its initial creation. It is then in the eventual consuming of this resource, a new output resource is created that defines the *real meaning of potential*:

That is, ***the potentials*** $\vee_i$ ***of an (input) resource*** *i* ***lay in their realisation via*** $\frac{\partial o}{\partial \vee_i}$ ***to be transformed into other (output) resources*** Δo .– be the results *desirable* (good or bad) or *undesirable.*

Finally, it can be noted that the differential operator in Equation 2 $(\frac{\partial o}{\partial \vee_i})$ is effectively the productivity of the conversion process.

Example

For example, if all the house input resources (i.e. the productive system itself) have NO potential to produce poor quality desirable outputs, then there can simply be no $\Delta V_{i\,house}$ and all desirable outputs $\{o\}_1$ will be good (i.e. $\{o\}_1 = \{o_1\} + \overline{\{o_1\}} = \{o_1\} + 0 = \{o_1\}$). Further, if all variable input resources have no potential to produce undesirable outputs $\{o\}_2$ and $\{o\}_3$, then these outputs will also simply not be produced.

Thus, it is only when input resources have the potential to produce either poor quality desirable outputs or undesirable outputs, can such outputs be produced. Needless to say, therefore, in a perfect world all resources should only have the potential to produce good, desirable, un-polluting products and services. (One hopes!).

i,o Diagrams

To better explain the concept of *potential of resource*, one can make use of "i,o" diagrams. Such diagrams show the relativity among inputs to a productive system and the outputs from the same productive system. The 'relativity' of set

{i} to set {o} is based on a vectorial representation of the basic utility – productivity performance equation.

For example, (from ref. 2, equation 9, pg 21) consider the basic utility-productivity performance equation;-

$$P_{p=\mu_{desirable}} = \frac{\mu_{g_{desirable}}}{\mu_{a\ desirable}} \qquad (3)$$

$$= \mu_{g_{desirable}} \eta_{a_{desirable}}$$

Here, the emphasis is being placed on desirable utility (hence, the performance parameter *p* of interest is desirable utility).

In basic i-o form, equation (3) can be re-written:-

$$P_{p=\mu_{desirable}} = \frac{i_g}{o_{Gi}} . \frac{o_a}{i_a} \qquad (4)$$

(all i, o being *desirable*)

In vectorial form, $i_g = |i_g| . \hat{i}$, $o_{Gi} = |o_{Gi}| . \hat{o}$, $o_a = |o_a| . \hat{o}$ and $i_a = |i_a| . \hat{i}$ where $\hat{i}$ and $\hat{o}$ are input and output resource unit vectors respectively.

The relativities of a productive system's input and output resources (in i-o diagrammatic form) are shown in Figure 1.

Figure 1 shows the input vector representing $\{i_a\}$ having potentials $\vee_1$ to produce output $\{o\}_1$, $\vee_2$ to produce output $\{o\}_2$ and $\vee_3$ to produce output $\{o\}_3$. As a result of processing, Figure 1 also shows outputs $\{o\}_1$ consisting of good units $\{o_1\}$ and not good units of $\overline{\{o_1\}}$ being produced, along with undesirable outputs of $\{o\}_2$ and $\{o\}_3$ also being produced.

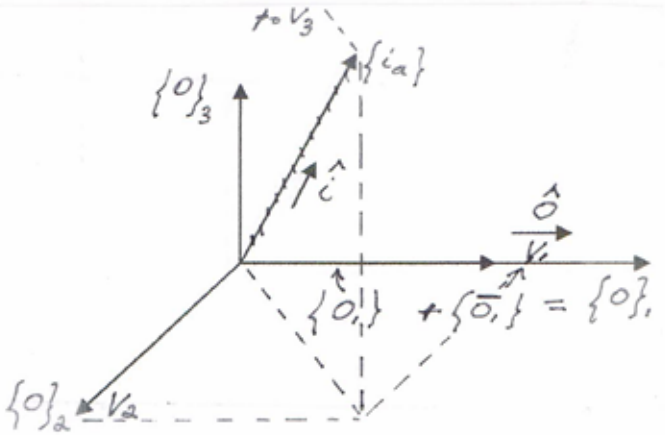

Figure 1

By first refining the variable input resource components of $\{i_a\}$ to only having $\vee_1 = \vee_1$ $(\vee_2 = \vee_3 = 0)$, Figure 1 collapses to that of Figure 2:-

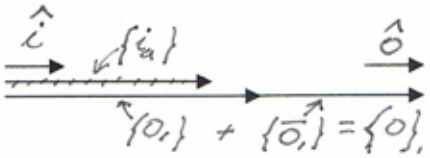

Figure 2

Here, only outputs $\{o\}_1$ consisting of good units $\{o_1\}$ and not good units of $\overline{\{o_1\}}$ are now being produced.

Note that the input and output unit vectors are now aligned. This is a necessary and sufficient vectorial condition for the realisation of a highly efficient but not yet effective productive system.

Further refinement of the house resources will eliminate non-conforming $\overline{\{o_1\}}$ units resulting in all of $\{o\}_1$ now being of good quality as shown in Figure 3:-

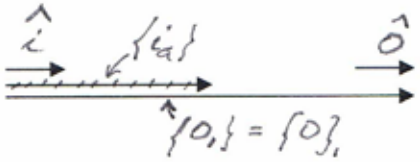

Figure 3

The productive system at this stage is now both highly efficient AND highly effective.

Potencies of Potentials

Finally, by now 'supercharging' the input resources $\{i_a\}$ to only having $\vee_i = \vee_1$ but in highly concentrated form (i.e. the ***potencies*** of the input resources' potentials are greatly boosted), Figure 3 further collapses to that of Figure 4:-

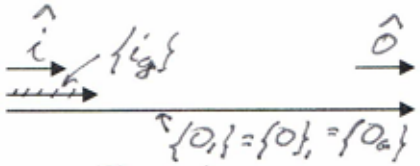

Figure 4

Here, the ultimate goal of $\eta_a = \eta_{Ci} = \dfrac{\{o_{Ci}\}}{\{i_g\}}$

is reached!

Conclusion

This paper has shown the power of concepts of utility of resource, productivity of process and the underlying concepts of potential of resources and their potencies. At a higher level, the usefulness of the utility-productivity performance equation has again been demonstrated.

Reference

1.Kennedy, R.D. "On Performance Theory and the Desirability and Goodness of Productivity of Process", ***New Engineer Journal***, Vol. 16, No. 1, May 2013.

2. Kennedy, R.D. "On the Desirable and Undesirable Utility of Resource and Productivity of Process", ***New Engineer Journal***, Vol. 12, No. 2, October 2009.