Newsletter

Operations Research Society of South Africa
Operasionele Navorsingsvereniging van Suid Afrika

A MULTI-PLANT LINEAR PROGRAMME FOR STRATEGIC PLANNING

"This article describes the development of a multi-plant linear programme for strategic production planning of Sasol's petrol, diesel and related products. "

- Diki Langley

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FROM THE PRESIDENT'S DESK

By Marthi Harmse (marthi.harmse@sasol.com)
ORSSA President

Marthi Harmse

Dear ORSSA friends

In my last letter to you I wrote about us rushing towards the end of another year. Somehow the rushing never stopped for me and although I had a wonderful rest period with my family, that breathing time seemed very far away the first day I was back at work! Is it just me, or is there something happening to our country? Is everyone grabbing every opportunity Operations Research has to offer? Or is it something much bigger – maybe comet McNaught (and how beautiful it was!) spun the earth into higher revolutions on its path through the universe.

So the first month of the new year already passed by. In this second month of the year when everyone else puts little and sometimes not so little red hearts on everything they write and say and long since has forgotten any New Year resolutions they might have had, I want to write about some resolutions I have. Come to think of it, I believe I had these intentions for at least the last five years.

I want to write about the ORSSA chapters. I believe that ORSSA is its chapters. We would not have an executive committee or any national or international conferences or journals or newsletters or constitution if we had no chapters. I want to thank each current and past chapter chairperson and their committees for making ORSSA what it is. Danie Payne is chairing the Pretoria chapter, Neil Manson the Johannesburg chapter, Andy Msiza the Vaal chapter, Yvonne Fletcher the Kwazulu-Natal chapter, and Margarete Bester the Western Cape chapter.

Each ORSSA chapter may be regarded as an association of people in a specific geographical area who are drawn together by a common interest in OR. If functioning properly, these social networks can add significant value. The collective value of all these social networks and the norms of reciprocity that arise from these networks may then be referred to as social capital. ORSSA must have this social capital to be a natural professional home to all persons who are involved in a systematic way of decision support, to maintain and advance all areas of OR and to create opportunities for shared learning and networking amongst all members.

The problem is that over the past twenty five years the stock of social capital has plummeted due to changes in work, family structure, age, suburban life, television, computers, women's roles and other factors as warned by Robert Putnam in his book *Bowling alone*. At EURO 2006 Mike Trick made a presentation on *The society of OR* based on the work by Robert Putnam and Lewis Feldstein. Mike indicated that the decrease in traditional social capital activities has detrimental effects on societies such as EURO – and ORSSA as implied by our vision statement. ORSSA exists primarily to further the interests of and interact with those engaged in, or interested in, OR activities. Chapter activities provide occasions to meet and share ideas for OR practitioners, academics, young graduate members, student members, members who have progressed in their organisations and no longer actively practice OR, as well as others interested in OR and its applications. It also creates avenues for members that may lead to employment opportunities.

It might be argued that OR professionals are more dependent on social capital than many other professions. OR is about interacting with decision makers (often not OR practitioners themselves) to improve the way they make decisions in business and industry, in government and society – "the science of better". OR has furthermore an interdisciplinary nature. It involves teamwork to draw upon physical science, logic, applied mathematics, logistics, industrial engineering, social science, economics, statistics, computing, etc. to improve decision making. OR is about change and therefore practitioners search out and try to understand people's attitudes, preferences and fears towards change. It is ecumenical in nature and involves communicative competencies, resolution of conflict, generation of mutual understanding, achievement of consensus, learning, liberation of discourse and empowerment and transformation beyond the interest in problem solving or problem structuring.

At ORSSA 2006 we therefore reviewed the way we are managing our chapters. We shared lessons learnt and networks established. In learning together, we shared what goes well in our various chapters, our challenges as well as what actions we can take to improve the management of our chapters. Since then the chapter chairpersons and their committees worked very hard to review their portfolios of social capital and created opportunities for members to get even higher returns on their investments.

I know the rushing never stops for most of you, but I want to propose to each and every ORSSA member to invest just a bit of social capital in ORSSA this year as well as creating opportunities for others to share in the returns. Contact your chapter chairperson and make just one contribution this year (if you can manage, more than one!). I can highly recommend this investment – it lies very close to my heart; in fact, I think it is inside my heart. ■

FROM THE EDITOR

Basie Kok

Well, first of all I would like to introduce myself to those of you who do not know me yet, and wish you all the best for the year ahead (for most of us I'm sure it feels like the year started a long time ago!).

I am currently studying towards an MSc. in Operational Analysis at the University of Stellenbosch and have been involved in OR since 2004 when I attended the ORSSA national conference. I have now taken on the ambitious task of newsletter editor (some fairly large shoes to fill) and hope that I can maintain the excellent standard that has been set by those who went before.

This month's issue contains two excellent articles on the use of OR. The first is on linear programming from a strategic planning perspective and was submitted by Dirki Langley from Sasol, and the second is on the allocation of proportionally represented seats in a voting situation, submitted by Stephan Visagie from the University of Stellenbosch.

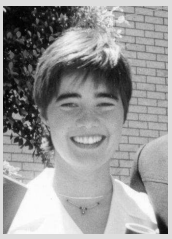
Among these excellent reads there is also a member profile of one of our organisation's leading ladies, Mrs Margarete Bester (our current Western Cape chapter chair) and a fascinating book review by Hans Ittmann on *Perspectives in Operations Research: Papers in Honor of Saul Gass' 80th Birthday.*

I hope you enjoy this issue!

Features

MEMBER PROFILE: MARGARETE BESTER

By Basie Kok (bkok@dip.sun.ac.za)



Margarete Bester

Margarete was born on the 21st of May 1979 in Bellville in the Western Cape. She matriculated from Hottentots Holland High School in 1997 and went on to obtain a BSc. degree in Mathematical Science at the University of Stellenbosch. Thereafter she specialised in the field of OR and obtained an honours degree (cum laude) in Operational Analysis.

Margarete then began working for PIC solutions in the credit risk sector which included the development of score cards whilst she completed her MSc. in Operational Analysis part time through the US. She has also had experience in data mining and data validation.

Margarete has been a member of ORSSA since 2001 and has been Chairperson of the Western Cape Chapter since February 2004. She continues to further the cause of OR on a daily basis and is passionate about bettering real world processes and utilising resources more efficiently.

How long have you been involved in OR and what attracted you to it?
I have been involved in OR since 2000 when I joined ORSSA. It attracted me as for the first time in my life I realized what a difference science could make in the world, and how the different techniques could make a difference in the lives of so many people. Personally I always want to optimize the use of resources and discovering a whole discipline focused on optimizing processes was extremely attractive.

You have lived in South Africa all your life. What are your thoughts on some of the challenges faced by our nation, such as poverty alleviation, and the role OR can play in resolving them?
I strongly believe that OR could be used in South Africa to ensure that cost effective methods are developed and implemented to channel resources and services to the poor segment of our population. As OR is the science of bettering processes it can definitely ensure economic growth in our country and in turn also ensure job creation and poverty alleviation.

What, in your opinion makes an OR project successful?
There are often so many OR projects that are started and never completed, as time as always a challenging factor. I believe that an OR project is successful when the solution is implemented in the industry. As OR is not a well known discipline in South Africa a large part of each project usually comprises the gaining the confidence of the industry.

You are involved in the consumer credit risk sector: what aspects of OR are the most useful with respect to this specific area?
Through my experience the most useful aspect of OR is the strategies OR practitioners use to solve problems in the work space. Sometimes they have to resort to (traditionally) non OR tools to solve problems, due to time constrains, but they still apply the same strategy in managing their customers in order to ensure implementation of final solutions.

Do you think OR in general is recognized and accepted by the corporate world in South Africa, and if not what do you suggest needs to be done to in order to change this perception?
I believe that OR is certainly not as recognized as much as I would like it to be and as it should be. I think the more people realize what you can do with OR the more it would be used to optimize processes. In the corporate world it is often difficult to justify why research and development should be done on something that already has a feasible solution, even if arriving at a feasible solution is sub optimal, or the process of arriving at solutions is time consuming. I believe that OR professionals should speak up more and should really drive the redevelopment of processes and the use of OR, as it is the "science of bettering" processes.

Do you think OR practitioners, because of their often two folded academic and practical contributions have more of a responsibility to publishing their results and adding to the knowledge base for future generations, or to developing effective implementations of their work in the real world?
I think it is extremely important to be balanced between academic and practical work. As David Ryan emphasized at our recent conference, "OR is only true OR if the research is implemented", but without the research being published the wheel would have to be redeveloped every time. I believe it is extremely important to invest the knowledge gained through research into future generations, but equally important is the investment of implementing these solutions to gain economical growth.

What has been the highlight of your OR career to date?
I am extremely passionate and positive about the growth of OR, and do not want to lift out one event in my career as the highlight. Every day I am actively involved in OR is a highlight for me as I love making processes better and ensuring better utilization of resources. ■

QUERIES AND CONTRIBUTIONS

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Contributions and other forms of communication with the editor can also be conducted from the website at: **www.orssa.org.za**.

A Summary of Chapter Preferences

By Neil Manson (*neil.manson@infotech.monash.edu*)

INTRODUCTION

Marthi Harmse, the President of ORSSA, has repeatedly said that the "chapters are the lifeblood of the society". During the 36th Annual Conference held at the Sinodale Centre in Pietermaritzburg in September 2006, she arranged a very useful and stimulating workshop on managing the chapters. One of the ideas that came out of that workshop was to conduct a survey with respect to the members of a chapter to determine their preferences in relation to the following:

- the types of events the chapter should organise,
- the preferred time and day of the week that events should occur,
- the best venue for events,
- the industries in which members work,
- the types of topics which members would prefer.

An initial survey was conducted by the Johannesburg chapter, and was emailed to members of the Johannesburg, Pretoria and Vaal Triangle chapters. These three chapters are a little different from the others in that they are close enough to each other so that it is fairly easy for members of one chapter to attend events organised by another.

QUESTIONS

The email survey contained the following questions:

1) Name
2) Email address
3) Are you a member of ORSSA?
4) In which region do you live (Jhb/Pta/Vaal Triangle)?
5) In what industry do you work?
6) What kind of event would you like to attend? Please indicate which you would prefer, which you would attend if the topic was right, and which you would not attend:
   a) Afternoon Seminar (45min talk + question and discussion time)
   b) Half-day workshop (Saturday morning)
   c) Full-day workshop (Saturday)
   d) Breakfast talk
   e) Industry Visit
   f) Dinner (No technical talk)
   g) Other social (No technical talk)
7) If we hold an afternoon seminar, what is your preferred time?
8) What is your preferred day of the week?
9) Please suggest any other kind of event you would like us to arrange
10) Which of the following venues would you prefer, and which would you be prepared to travel to if the topic was right:
    a) Pretoria,
    b) Vaal triangle (Sasol),
    c) Wits University (Braamfontein), or
    d) Monash University (Roodepoort).

RESPONSES

29 responses were received from the 183 emails that were sent out. This gives a response rate of 16%, which is relatively good for an email survey. Unfortunately, information on the number of bounced emails was not recorded, so this can not be presented here. 28 of the respondents are members of ORSSA, and one is not yet a member.

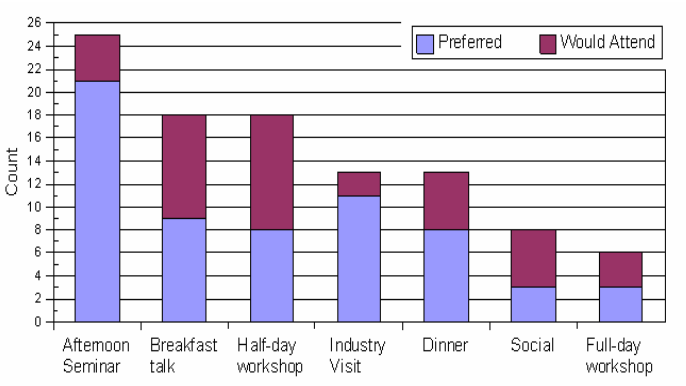

Figure 1: ***Type of Event***

Figure 1 shows the preferences for the different possible types of event. An afternoon seminar was significantly more popular than any other type. Both a Breakfast Talk and a Half-day Workshop scored well, despite the fact that neither of these types of events have been held before. Although an Industry visit did not score as well overall as a Breakfast Talk or a Half-day Workshop, more people indicated that they would prefer it to the Breakfast Talk or Half-day Workshop.

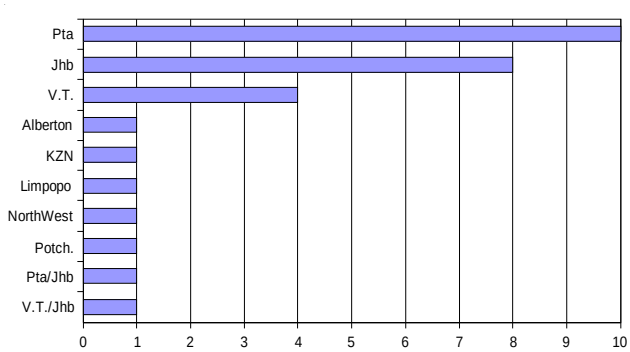

Figure 2: ***Respondent's Region***

Figure 2 shows the answers to the question "In which region do you live?" Responses from Pretoria, Johannesburg and the Vaal Triangle were the highest, as expected. However, a number of single responses were received from farther afield. Two responses were also received that indicated that the

respondent lived in one region, but worked in another.

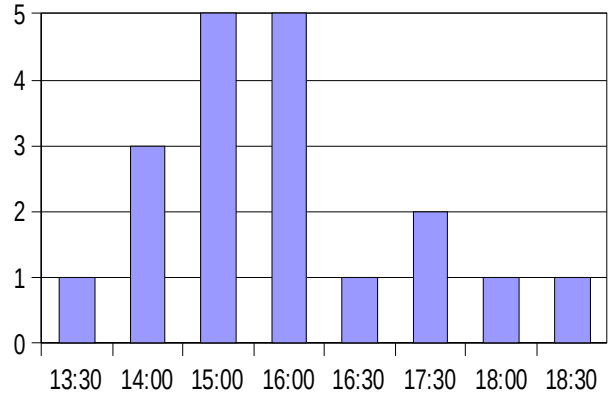

Figure 3: ***Prefered Starting Time***

Figure 3 shows the preferred starting time for an Afternoon Seminar, which was earlier than what was done in 2006.

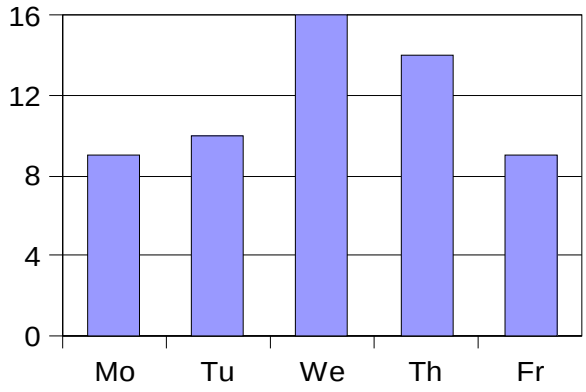

Figure 4: ***Preferred day of the week***

As shown in Figure 4, the preferred day of the week was a mid-week day with 16 (28%) preferring Wednesday, and 14 (24%) preferring Thursday. These responses do not sum to 29, as many people indicated that they equally preferred multiple days.

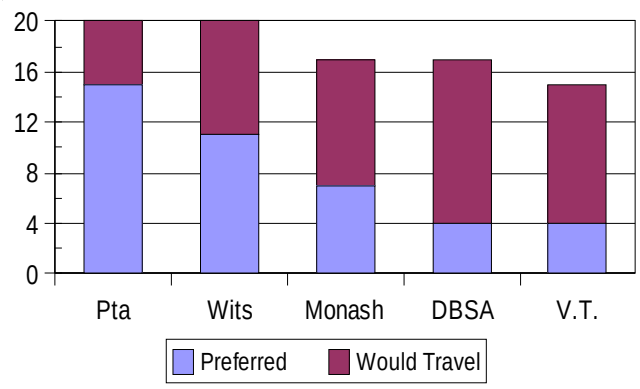

Figure 5: ***Preferred Venue***

Figure 5 presents the responses to the question "Which of the following venues would you prefer, and which would you be prepared to travel to if the topic was right?" As can be seen, Pretoria scored the highest, and Vaal Triangle the least, but one must read this graph in relation to Figure 2. There were 10 responses from Pretoria members, and only 4 from Vaal Triangle members. *(continued on page 16)*

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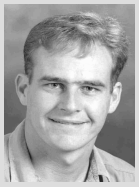

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A multi-plant linear programme for strategic planning

By Diki Langley (diki.langley@sasol.com)

Introduction

This article describes the development of a multi-plant linear programme for strategic production planning of Sasol's petrol, diesel and related products and is not technical in nature. One of the primary goals of any operations researcher is the adaptation of mathematical tools to solve real-life problems, hence the more narrative style.

Linear Programming (LP) is a common tool for planning and optimizing the operation of a petrochemical plant, particularly an oil refinery. In order to illustrate the perceived benefit of a multi-plant LP of operations within a large company such as Sasol, here is a simple example:

Suppose Farmer Brown wants to plant his land with maize and tomatoes. The production costs and selling price of these two crops differ and there are constraints set on the production of each, e.g. the growing times of the plants. How much of his land should Farmer Brown utilise for each crop in order to reap the maximum profit at the end of the year? This problem can be cast as a LP problem of which the solution will answer the question and predict the maximum profit value that Farmer Brown can aspire to.

Now suppose Farmer Brown has an enterprising wife – Mrs Brown, who wants to grow cabbages and raise chickens. Given her production costs and constraints and selling prices, how can she maximise her profits? Rather than separate planning and budgeting for Farmer Brown and Mrs Brown, it would be to their combined benefit to have one LP of their separate operations which will then optimise their overall profit, given that they have shared resources to run their operations and a common income.

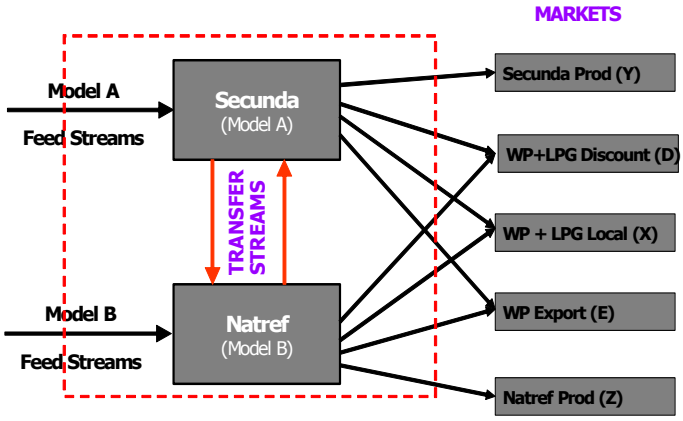
Overview of the Group Strategic LP

A multi-plant linear programme (LP) encompassing the four different Sasol sites of Natref, Sasol, Chemical Industries and Midlands Sasol Polymers in Sasolburg, and Sasol Synfuels in Secunda had been set up before, but had fallen into disuse for various reasons.

One of the reasons is that there must be a concerted effort and governance system to keep all four 'contributing' LPs updated and accurate. It was decided to compile a new LP that was smaller in scope, that focussed specifically on the main aspect of Sasol's production – its white products (petrol and diesel) slate as well as products interrelated with the production of these. Some of the objectives of this Group Strategic LP were to determine:

- The optimal diesel and petrol component transfers between the sites.
- What grades of petrol and how much each site should produce in order to comply with market requirements.
- The optimal crude selection from a Group perspective.
- How the different octane 'machines' (reactors in the separate plants that change chemicals in a stream in order to make the octane higher) in the Group should be utilised to reap the greatest benefits.
- Optimisation of liquid petroleum gas (LPG) production and supply.

There existed separate operational LPs of both the Secunda Refinery and Natref Refinery operations used for short to longer term planning of each refinery and setting up predictive budgets for each in isolation. The separate LPs were combined as shown:



Where Markets D, X and E are white product markets common to both sites, Market Y is the market for products manufactured at Secunda only and Market Z applies to products manufactured only at Natref.

Approach to building the Group Strategic LP

As mentioned previously, there existed separate LPs used for planning Secunda and Natref operations separately. The combination of the two LPs to include their transfer streams and common markets was the obvious tactic to adopt. However, the solution to 'real-life' problems is never straightforward and there were some challenges:

- The Secunda operational LP at the time was a volumetric model (based on volume flow rates). It was desired to have a mass-based Group LP since the mass flow rate of streams to a unit equals the total mass flow rate out of a unit, and these rates do not have to be balanced using factors which may require periodic updates, as in the case of volume flows.
- The Secunda Refinery operation is a unique operation not based on crude oils as are conventional refineries. The feeds to this refinery are hydrocarbon streams produced by a high temperature Fischer-Tropsch

Figure 1: ***The Sasol Secunda Plant.***

process using coal, steam and oxygen as raw materials. These streams contain a whole soup of chemicals which can be isolated or further converted to either petrol/diesel component streams or to high value chemicals. It was decided that it would be useful to track logical groups of these chemicals through all the refinery processes and streams as well as accompanying petrol and diesel qualities. This component tracking was not present in the original Secunda operational LP.

- The Secunda Refinery operation was to undergo major changes soon which would result in the reconfiguration of streams and operating units.
- The Secunda operational LP and the Natref LP were developed in different software packages: The Natref LP was developed in Haverley's GRTMPS software and the Secunda LP in Aspentech's PIMS software.
- Another softer but far more problematic issue was the recognition of and the credibility of the new Group LP company wide, but especially by the stakeholders with interest and control of the Secunda and Natref operational LPs.

In order to overcome these difficulties, the following processes were adopted:

- It was decided to transcribe the Natref GRTMPS model to PIMS, and to cast the whole Group model using Aspentech M-PIMS, which is specially designed for multi-plant LP.
- The Secunda Refinery model was re-written on a mass flow rate basis, and the tracking of chemical groups and petrol and diesel qualities through separate units was introduced. A useful feature of the software is that feed and product streams can also be expressed in volumetric flow rates, even though the LP is solved on a mass flow rate basis. Marketers of white products commonly use volumetric flow rates, so model results can be discussed on this basis.
- The model was based on the agreed design basis for the future operation. Because change in operations is a feature of any chemical plant, the essence of keeping the Group Model live is to constantly maintain the model by incorporating possible future changes which can be switched on or off, depending on which future period is required.
- Agreed sets of common data were used in both the Natref and the Secunda Refinery LPs. Validation sessions of both local models were conducted with stakeholders of the Secunda and Natref operational models. Because of the continual envisaged changes in operations, model validation is an ongoing process.
- The main user of the model has set up a procedure whereby the company as a whole is given direction based on results obtained from the use of the model. The stakeholders of the separate businesses who are using the individual operational LPs are mainly involved in this process.

Future development

The possibility of examining the response surface generated by the Group LP using statistical experimental design techniques has arisen and will generate useful new intelligence as to the company operations represented in the LP. Conventional sensitivity analysis of LP results are usually conducted by changing one parameter at a time, which gives only limited information as to the model's response surface. By using computer experimental design techniques a far better multi-dimensional response surface can be generated which is advantageous in the generation of new ideas on improving the optimal performance of the company. To date this technique has been tested on a smaller scale on one of the local models.

Conclusions

The success of any operations research technique within a company is dependent on its continual use and this has required effort both technically and in a non-technical sense. Technically in this case there has to be an ongoing collection, conversion and update of the LP data on present and future operations to keep the model predictions accurate. This effort is part of and feeds into the non-technical effort of keeping the LP credible and accepted by the various stakeholders in the company affected by the decisions that are influenced by the model results. ■

Operations research and the allocation of seats in proportional representation

Liezl van Eck *Stephan Visagie* *Hennie de Kock*

Department of Logistics, University of Stellenbosch

Introduction

Proportional representation (PR) systems are a family of voting systems used in multiple-winner elections. The principle behind PR elections is that every vote deserves the representation in government and each political party involved should be represented in the legislature in proportion to its strength in the electorate. Essentially this means that each party should receive the same percentage of representation as the percentage of votes received. All PR systems set out to achieve this objective.

In typical PR systems there are multi-member districts. These districts may vary in size, as is the case in South Africa, where no two of the nine provinces are equal in size. Seats in these districts are allocated proportionally to the percentage of votes received in that particular district. Thus, if a party receives 30% of the votes, 3 out of 10 seats should be allocated to that party. The challenge in PR systems is to translate the electoral votes into seats in the same proportion as the actual votes received. Seat allocations are integer numbers, whilst the number of votes may be considered as continuous quantities in comparison to the number of seats. Therefore, the translation of the number of votes into the number of seats nearly always involves adjustment methods. The objective from an operations research point of view is to minimise some measure of the deviation between the actual percentage of votes received and the percentage of seats allocated to the different parties.

Short overview of existing seat allocation methods

Different methods of allocating seats after votes have been counted are in use all over the democratic world. The vast majority of these countries use some form of proportional representation. All the different PR systems used today fall into one of two categories, namely highest average (or divisor) methods or largest remainder (or quota) methods.

1. Highest average methods

A highest average method requires that the number of votes for each party is divided successively by a series of divisors. Seats are then allocated to parties with the highest resulting quotient until all the seats available are allocated. Two highest average methods, namely the d'Hondt and the Sainte-Laguë method, are the most commonly used and are considered in this study.

The d'Hondt method

Some of the countries using the d'Hondt method are Argentina, Austria, Bulgaria, Chile, Croatia, Finland, Israel, The Netherlands, Poland, Portugal, Spain and Turkey. The method works as follows. Successive quotients for each party are calculated. The formula for the quotient is given by $V_i / (s_i + 1)$, where V_i is the total number of votes received in favour of the party i and s_i is the number of seats that has been allocated to a specific party (party i) so far. Initially, s_i is set to zero for all parties. The party with the highest quotient is allocated the next seat and the quotient is recalculated with s_i increased by one. This process is repeated until all the seats have been allocated. d'Hondt's method to allocate 6 seats to 5 parties is shown in Table 1. The numbers in bold indicate where the seat has been allocated.

	Seat allocation					
	Party A	**Party B**	**Party C**	**Party D**	**Party E**	**Party F**
V_i	40,000	23,000	16,500	13,000	9,000	3,200
1st seat	**40,000**	23,000	16,500	13,000	9,000	3,200
2nd seat	20,000	**23,000**	16,500	13,000	9,000	3,200
3rd seat	**20,000**	11,500	16,500	13,000	9,000	3,200
4th seat	13,333	11,500	**16,500**	13,000	9,000	3,200
5th seat	**13,333**	11,500	8,250	13,000	9,000	3,200
6th seat	10,000	11,500	8,250	**13,000**	9,000	3,200
Total seats	3	1	1	1	0	0

Table 1: *An illustration of the d'Hondt method of allocating seats proportional to votes.*

The Sainte-Laguë method

Sainte-Laguë's method is also known as Webster's method or the divisor method with standard rounding. This method is used in New Zealand, Norway, Sweden, Denmark, Bosnia and Herzegovina, Latvia, Hamburg and Bremen. The successive quotients for each party are calculated similar to d'Hondt's method, but the formula $V_i / (2s_i + 1)$ is used instead. In this formula V_i is the total number of votes cast in favour of party i and s_i is the number of seats that has been allocated to party i so far. If no seats have been allocated, then $s_i = 0$ for all the parties. The party with the highest quotient is allocated the next seat and the quotient is recalculated for that party with the value of s_i increased by one. This process is repeated until all the seats have been allocated.

Some countries, such as Sweden and Denmark, use a modified version by replacing the first divisor with 1.4. An illustration of how the seats are allocated by means of the Sainte-Laguë method can be found in Table 2. The same

votes as in Table 1 are used. The seat allocation with the modified version of Sainte-Laguë is given in Table 3. The modified version of the Sainte-Laguë gives exactly the same seat allocation as d'Hondt's method, while the normal Sainte-Laguë method gives a different allocation of the seats.

	Seat allocation					
	Party A	**Party B**	**Party C**	**Party D**	**Party E**	**Party F**
V_i	40,000	23,000	16,500	13,000	9,000	3,200
1st seat	**40,000**	23,000	16,500	13,000	9,000	3,200
2nd seat	13,333	**23,000**	16,500	13,000	9,000	3,200
3rd seat	13,333	7,667	**16,500**	13,000	9,000	3,200
4th seat	**13,333**	7,667	5,500	13,000	9,000	3,200
5th seat	8,000	7,667	5,500	**13,000**	9,000	3,200
6th seat	8,000	7,667	5,500	4,333	**9,000**	3,200
Total seats	2	1	1	1	1	0

Table 2: *An example of the seat allocation by means of the Sainte-Laguë method.*

	Seat allocation					
	Party A	**Party B**	**Party C**	**Party D**	**Party E**	**Party F**
V_i	40,000	23,000	16,500	13,000	9,000	3,200
1st seat	**28,571**	16,429	11,786	9,286	6,429	2,286
2nd seat	13,333	**16,429**	11,786	9,286	6,429	2,286
3rd seat	**13,333**	7,667	11,786	9,286	6,429	2,286
4th seat	8,000	7,667	**11,786**	9,286	6,429	2,286
5th seat	8,000	7,667	5,500	**9,286**	6,429	2,286
6th seat	**8,000**	7,667	5,500	4,333	6,429	2,286
Total seats	3	1	1	1	0	0

Table 3: *An example of the seat allocation by means of the modified Sainte-Laguë method.*

2. Largest Remainder methods

The largest remainder methods (LR methods) are the other class of allocation methods. This method requires that each party's votes are divided by a quota, which represents the number of votes required for a seat. A notional number of seats is given to each party. This seat allocation typically includes an integer part and a remainder part. Each party receives the number of seats equal to the integer value. Generally this will leave some seats unallocated. The parties are then ranked on the basis of descending remainders. The parties with the largest remainders are allocated one additional seat until all the seats have been allocated. Several possibilities exist to determine the quota. The Hare quota and Droop quota are the most common.

The Hamilton method of allocation is specifically defined as using the Hare quota. It is used in Namibia and Hong Kong. The Hare quota, H_q is defined as

$$H_q = \frac{\text{total votes}}{\text{total seats}},$$

The Droop quota, D_q, is applied to elections in South Africa and is defined as

$$D_q = 1 + \left\lfloor \frac{\text{Total votes}}{1 + \text{Total seats}} \right\rfloor,$$

where $\lfloor x \rfloor$ denotes the largest integer smaller than or equal to x. Examples to illustrate the working of the LR methods (using Hare and Droop quotas respectively) are shown in Tables 4 and 5. In both cases ten seats are to be allocated to six parties.

	Seat allocation						
	Party A	**Party B**	**Party C**	**Party D**	**Party E**	**Party F**	**Total**
V_i	40,000	23,000	16,500	13,000	9,000	3,200	104,700
Votes/ quota	3.820	2.197	1.576	1.242	0.860	0.306	
Automatic seats	3	2	1	1	0	0	7
Remainder	0.820	0.197	0.576	0.242	0.860	0.306	
Largest rem. seats	1	0	1	0	1	0	3
Total seats	4	2	2	1	1	0	10

Table 4: Allocation *of seats using the Hare quota. In this table 10 seats should be allocated, which implies a Hare quota of 10 470.*

	Seat allocation						
	Party A	**Party B**	**Party C**	**Party D**	**Party E**	**Party F**	**Total**
V_i	40,000	23,000	16,500	13,000	9,000	3,200	104,700
Votes/ quota	4.202	2.416	1.733	1.366	0.945	0.336	
Automatic seats	4	2	1	1	0	0	8
Remainder	0.202	0.416	0.733	0.366	0.945	0.336	
Largest rem. seats	0	0	1	0	1	0	2
Total seats	4	2	2	1	1	0	10

Table 5: *Allocation of the seats using the Droop quota. In this table 10 seats should be allocated, which implies a Hare quota of 9 519.*

In the field of political science some work has been done on the topics of fairness and bias of these allocation methods. These topics have not been studied in great detail in the operations research literature.

Allocation of seats in South Africa

Currently, South Africa uses the LR method with the Droop quota (LRMD). Recent elections in South Africa have been dominated by one party, which logically received the majority of the seats. Another typical phenomenon in South African elections is the large number of parties participating in the elections. The majority of these parties receive almost no votes, i.e. less than 1% of the votes. Furthermore, there are almost no medium sized parties, i.e. parties with approximately 20% of the votes. It is known from other experimental studies that most of the known allocation methods tend (in various degrees) to be unfair and usually favour the larger parties. It remains a question whether this pattern of voting influences the fairness of seat allocation. Another question that is often raised in the South African media is whether the large number of small parties favours the larger party or not.

Closer investigation of LRMD revealed (and indeed can be proven) that the potential number of seats allocated from the remainders (R) increases as the number of parties increases.

A simulation was performed for 6,000 random elections to determine the probability that a certain number of seats will be unallocated for a certain number of parties. In the simulation 100 seats were allocated using LRMD. It is interesting that the probability of R taking on a certain value is not the same, i.e. $P(R=1) \neq P(R=2) \neq P(R=3)\ldots$ From the simulation it follows that R has a hypergeometric distribution. This result hints that, on average, the number of lost votes increases with an increase in the number of parties. Thus, on average, more votes will not be used to allocate seats if the number of votes is scattered over more parties.

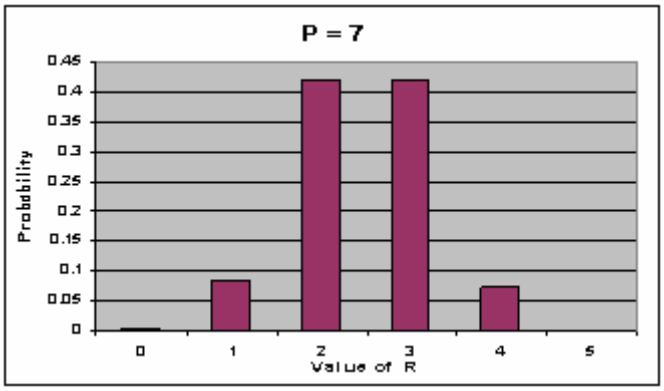


Figure 1: *The distribution of the number of seats allocated from the remainders.*

It is more convenient to express the number of lost votes, i.e. the number of votes that are not used to allocate seats, in terms of number of lost seats. The basic problem that arises when working with lost votes is that the weight (influence) of one vote differs with respect to the total number of votes counted. This gives rise to the term vote-seats. The number of vote-seats is defined as the number of lost votes divided by the quota.

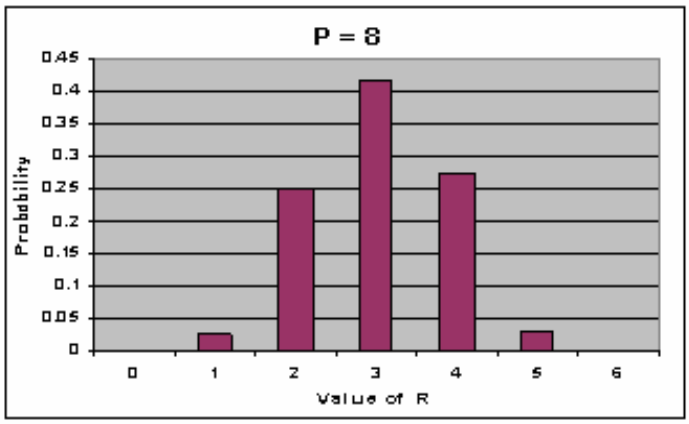


Figure 2: *The distribution of the number of seats allocated from the remainders*

It can be proven that the theoretical minimum and maximum for the number of lost votes are given by:

$$1 \leq \text{maximum number of vote - seats}$$
$$\leq \frac{(k+1)^2}{2k+1} \text{ if } P = 2k+1$$
$$\leq \frac{k+1}{2} \text{ if } P = 2k$$

for some $k \in N$. A second simulation was implemented to determine the average number of vote-seats, as well as the maximum number of vote-seats and how these values compare to the theoretical maximum. Once again 6,000 simulations runs (elections) were simulated to obtain these results.

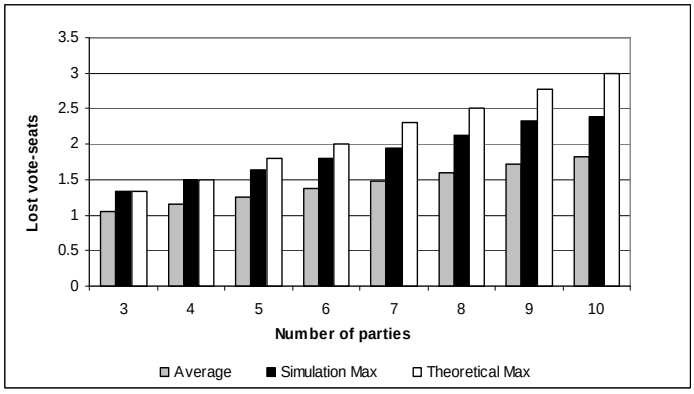


Figure 3: Average number of vote-seats versus the number of parties.

It may be seen from the data in Figure 3 that the average number of lost votes does not increase proportionately to the theoretical maximum. Where there is a small number of parties, the average number of lost votes is very near to the theoretical maximum. As the number of parties increases, the gap widens between these two variables.

Mathematical programming models for seat allocation

Three mathematical programming models, based on mixed

integer programming, were used in a comparative case study using the actual results of the 1999 and 2004 national elections in South Africa. For each election there was one national and nine provincial sets of votes, producing a total of 20 data sets. The objective of the mathematical programming models was to minimise the deviation caused by the discrete nature of the seats to be allocated. Thus, the objective is to ensure that the percentage of the seats allocated is as close as possible to the actual percentage of votes received. In the comparative case study the seat allocations resulting from mathematical programming methods are compared to the LRMD, currently used by South Africa, as well as to the other popular methods used to allocate seats in other countries. In general the absolute deviation D_i for party *i* is given by

$$D_i = \left| \frac{v_i}{V} - \frac{s_i}{S} \right|,$$

where v_i is the number of votes cast for party *i*, V is the total number of votes cast, s_i is the number of seats allocated to party *i* and S is the total number of seats.

Results of the comparative case study for South Africa

The performances of the mathematical programming models (MPM) were tested for all the sets of data against that of LRMD and the other popular allocation methods. All three mathematical models gave exactly the same seat allocation results for all the data sets. The total absolute deviation was used as a measure to compare the mathematical models against the other methods. A method with a lower total absolute deviation is thus considered to yield a better seat allocation than a method with a higher total absolute deviation. The total absolute deviations for the seat allocations resulting from the different allocation methods for all the voting districts participating in the 1999 and 2004 national elections are summarised in Tables 6 and 7.

District	MM	LRM D	H	SL	MSL	LRM H
National	1.078	1.078	2.546	1.078	1.419	1.078
Eastern Cape	3.498	3.498	7.732	3.498	5.507	3.498
Free State	11.444	12.686	19.535	12.686	16.196	11.444
Gauteng	4.551	4.551	12.384	4.689	4.689	4.551
Kwazulu-Natal	3.894	3.894	7.53	7.53	5.03	3.894
Mpumalanga	11.984	11.984	22.818	14.796	14.796	11.984
Northern Cape	10.371	11.423	19.543	11.423	14.652	10.371
Limpopo	7.498	8.098	19.342	8.098	10.302	7.498
North West	10.342	10.342	20.767	13.183	13.183	10.342
Western Cape	6.662	6.662	17.643	8.119	8.119	6.662

Table 6: *The total absolute deviations for the allocation of seats for the different allocation methods using the results of the South African election in 1999.*

District	MM	LRM D	H	SL	MSL	LRM H
National	1.531	1.533	3.008	2.464	1.964	1.531
Eastern Cape	5.406	7.092	10.855	5.406	9.052	5.406
Free State	11.4	14.04	18.17	14.04	18.17	11.4
Gauteng	4.069	5.05	11.11	4.07	6.68	4.069
Kwazulu-Natal	4.781	4.781	10.327	5.949	9.113	4.781
Mpumalanga	9.801	11.87	13.99	13.99	13.99	9.801
Northern Cape	8.805	8.805	15.672	11.91	13.521	8.805
Limpopo	5.256	7.16	12.933	7.16	9.614	5.256
North West	8.835	11	13.271	13.271	13.271	8.835
Western Cape	8.164	9.181	15.68	9.181	9.181	8.164

Table 7: *The total absolute deviations for the allocation of seats for the different allocation methods using the results of the South African election in 2004.*

The following abbreviations are used: MPM for mathematical programming models, LRMD for Largest remainder method using

		MPM		LRMD		H		SL		MSL		LRMH	
Party	% votes	Seats	AD	Seats	AD	Seats	AD	Seats	AD	Seats	AD	Seats	AD
A	82.05	25	1.28	26	4.62	27	7.95	26	4.62	27	7.95	25	1.28
B	8.87	3	1.13	3	1.13	3	1.13	3	1.13	3	1.13	3	1.13
C	2.07	1	1.27	1	1.27	0	2.07	1	1.27	0	2.07	1	1.27
D	1.32	1	2.01	0	1.32	0	1.32	0	1.32	0	1.32	1	2.01
E	1.30	0	1.30	0	1.30	0	1.30	0	1.30	0	1.30	0	1.30
F	0.96	0	0.96	0	0.96	0	0.96	0	0.96	0	0.96	0	0.96
G	0.82	0	0.82	0	0.82	0	0.82	0	0.82	0	0.82	0	0.82
H	0.66	0	0.66	0	0.66	0	0.66	0	0.66	0	0.66	0	0.66
I	0.61	0	0.61	0	0.61	0	0.61	0	0.61	0	0.61	0	0.61
J	0.43	0	0.43	0	0.43	0	0.43	0	0.43	0	0.43	0	0.43
K	0.34	0	0.34	0	0.34	0	0.34	0	0.34	0	0.34	0	0.34
L	0.11	0	0.11	0	0.11	0	0.11	0	0.11	0	0.11	0	0.11
M	0.10	0	0.10	0	0.10	0	0.10	0	0.10	0	0.10	0	0.10
N	0.07	0	0.07	0	0.07	0	0.07	0	0.07	0	0.07	0	0.07
O	0.07	0	0.07	0	0.07	0	0.07	0	0.07	0	0.07	0	0.07
P	0.07	0	0.07	0	0.07	0	0.07	0	0.07	0	0.07	0	0.07
Q	0.06	0	0.06	0	0.06	0	0.06	0	0.06	0	0.06	0	0.06
R	0.04	0	0.04	0	0.04	0	0.04	0	0.04	0	0.04	0	0.04
S	0.03	0	0.03	0	0.03	0	0.03	0	0.03	0	0.03	0	0.03
T	0.02	0	0.02	0	0.02	0	0.02	0	0.02	0	0.02	0	0.02
U	0.02	0	0.02	0	0.02	0	0.02	0	0.02	0	0.02	0	0.02
Total	100	30	11.40	30	14.04	30	18.17	30	14.04	30	18.17	30	11.40

Table 8: *A comparison of the seat allocation for the 2004 election results in the Free State province. AD denotes absolute deviation. The other abbreviations is the same as for tables 6 and 7.*

a Droop quota, H for d'Hondt's method, SL for Sainte-Laguë's method, MSL for modified Sainte-Laguë's method and LRMH for Largest remainder method using a Hare quota.

In all the cases the total absolute deviation of the mathematical models was less than or equal to the LRMD. Additionally, the mathematical programming models yield a smaller total absolute deviation than all of the other allocations methods mentioned in this article, with one exception (namely the largest remainder method using the Hare quota), where they give the same deviation. It is worth mentioning that the LR method using the Hare quota yielded the exact same seat allocation as the mathematical models for both the 1999 and 2004 national elections in all the 9 provinces as well as for the national seating.

In Table 8 a summary is provided where all the allocations methods were applied to the votes cast in the Free State province during the 2004 elections. It may be seen that some methods favour the more popular parties and some favour the less popular parties. These figures tend to support the theory that d'Hondt and Modified Sainte-Laguë methods are more biased towards the larger parties.

Seat allocations based on the Sainte-Laguë and LRMD yield better proportional representation, but it is the LR method using the Hare quota and the mathematical programming methods that give the lowest overall total absolute deviation. Hence, these last two models are the fairest for this example.

This pattern repeats itself in all the other provinces as well. These results are in line with the findings of similar experimental studies done elsewhere in the world. Another interesting pattern that arises from this data set is that the total absolute deviation increases as the number of seats increases.

The results of the comparative case study indicate that relatively simple OR methods may be used to determine more fair allocations than the current methods used around the world. This study also indicated that the largest remainder method using the Hare quota yields the best seat allocations in the South African context and does outperform the LRMD that is currently in use.

Acknowledgement

The information and results presented in this article are based on the following paper by the same authors:

Van Eck L, Visagie SE, De Kock HC, 2005, *Fairness of seat allocation methods in proportional representation*, ORiON, **21(2)**, pp. 93–110.

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BOOK REVIEW

By Hans Ittmann (hittmann@csir.co.za)

Perspectives in Operations Research: Papers in Honor of Saul Gass' 80th Birthday, Edited by Frank B. Alt, Michael C. Fu and Bruce L. Golden, 2006. Springer Science+Business Media, LLC, 233 Spring Street, New York, USA. pp. 431. ISBN 10: 0-387-39933-X(HB), 99.95 Euro.

If we ask the membership cadre of ORSSA whether they know Saul Gass it would be surprising if more than twenty percent answered in the affirmative. The twenty percent is just a guess but it would, most probably, not be far off the actual number. Nevertheless, Saul Gass, who hails from the United States, has been a leading contributor to operations research for more than 50 years and **Perspectives in Operations Research** gives one a glimpse of what Gass has contributed to the field over all these years. For many of us who call ourselves operations researchers, one of the outstanding aspects of this profession is the fact that one is exposed to so many different problems, so many different domain areas, that the extent of this is sometimes overwhelming. Nevertheless, this is what makes OR such an exhilarating profession. Saul Gass is an outstanding example of this. His achievements and all the things he has been involved in during his lifetime are captured in this Festschrift companion to the Symposium, held on 25 February 2006 in his honour.

The book is divided into three sections. The first section comprises eight articles that are of a historic or professional nature. Some of these are in fact presentations that were presented at the function commemorating Gass' 80th birthday. The second section, titled o*ptimization and heuristic search*, contains nine articles while section three includes six articles focusing on the general area of *modelling and decision-making*. The articles in the first section are very interesting from an OR historical perspective; although they focus on the initiatives Gass was involved in, they also highlight many of the early OR activities in the USA that have not been captured elsewhere. The articles in sections two and three are fairly varied, but pay tribute to the areas that Gass was interested in, in the field of operations research. Most of these articles are by friends, colleagues and several of Gass' former students.

The title of the book indicates that there is a range of different perspectives on OR in the form of a series of unrelated articles. This is in a sense true of especially sections two and three, with an element of this in section one as well. This makes the review of the book difficult, because the reviewer tends to highlight those articles of interest to him/her, while a different reader/reviewer may find other articles more interesting and worth mentioning. Nevertheless, one tries to give a view of the book and it can only be subjective!

One of Gass' colleagues, Arjang Assad, in his article "Portrait of an OR Professional" presents the "OR life history" of Saul Gass. This is fascinating reading since it illustrates exactly the nature of the life of an operations researcher. Only selected aspects will be highlighted here. Gass started his career in the US Air Force when he joined the Aberdeen Bombing Mission. They performed ballistics analysis for bombs in this group. He then joined project SCOOP (Scientific Computation of Optimal Programs) at the Pentagon in Washington D.C. This was "*the first linear-programming shoppe*" as Gass called it, with huge historical significance: "*All of us in OR are indebted to project SCOOP. The linear-programming model, the simplex method, the first computer-based solution of LP problems, much of the theory of linear and mathematical programming, the basic computational theory of linear programming, and the extensions of LP to industry and business all stemmed, wholly or in part, from the research and development of SCOOP*." The main objective of SCOOP was to plan the requirements for air force programs and the chief scientist of this program was George Dantzig! Many others on this program also became well known names in OR. Gass had the privilege to work with these top people.

The next very interesting project Gass became involved in was Project Mercury, the Man-in-Space Program, where he was the manager of the Simulation Group. They developed computer programs that computed the orbits with simulated data. On 20 February 1962, Gass was at Cape Canaveral watching John Glenn's lift-off – the first US manned orbit flight. In 1963 Gass decided to do a PhD and he did this with George Dantzig, developing a novel decomposition scheme and an algorithm to solve large-scale LPs. He returned to OR practice after this and was pulled into a Task Force looking at crime in the USA, where his role was to investigate how science and technology could best serve police operations. A whole range of consulting projects followed. There was, however, always the inclination to go into the academic world. Gass joined the University of Maryland in September 1975 as chairman of the Faculty of Management Science and Statistics. He remained there for the rest of his life and in June 2001 was appointed professor emeritus. Not only did he publish during this time but he also continued with consulting work, most notably OR in the public sector.

The main areas of research that Gass contributed to were linear programming as well as multiple criteria decision-making, especially the Analytical Hierarchy Process (AHP). He published the first text book on *Linear Programming* in 1958, which was followed by a number of subsequent editions, the last being in 2003. Additional books included *An Illustrated Guide to Linear Programming* as well as *Decision Making, Models and Algorithms*, while Gass was one of the co-editors of both *Encyclopaedia of Operations Research* and *An Annotated Timeline of OR*. In addition to these books, Gass authored many journal articles on modelling, the OR profession, ethics, the history of OR, etc- indeed a rich, rewarding and full career!

Another article that caught my fancy was that by Tom Magnanti titled "Learning from the Master". It provides a different angle to the article of Assad. Most notable is the reference to a series of papers Gass published in *Interfaces.* Called Model World, the first paper in the series was published in 1989, followed by many others in subsequent years. The first four were titled *Model World: A Model is a Model is a*

Model is a Model; Model World: Have Model, Will Travel; Model World: Danger, Beware the User as Modeler; and *Model World: In the Beginning.* All very insightful and thoughtful, it would be useful to read them again today! Larson provides some insight into the OR profession, looking backwards and forwards, while Golden argues that Benjamin Franklin was the first operations researcher! The final article in the first section is devoted to the OR profession in its entirety and links clearly to the international drive around branding and the Science of Better.

The articles in the last two sections are very varied – some theoretical, others more practical. The first article "Choosing a Combinatorial Auction Design: An Illustrated Example" the question is asked: "Why do people sell or buy goods via an auction mechanism?" It then endeavours to answer this by developing the required theory and by the ample use of illustrations. There are articles on "Label Correcting Algorithms", "Farkas Lemma", "Parametric Cardinality Probing in Set Partitioning", etc, all different topics Gass was interested in. "The Close Enough Travelling Salesman Problem: A Discussion of Several Heuristics" describes an interesting variation on the TSP. Here one is using RFID technology to read meters but since it is wireless, you can read the meters from a distance and therefore CETSP!

Three articles stand out for me in section three. The first is one on EOQ (Economic Order Quantity); the second, an employee scheduling problem for Fedex; and, finally one on sport where the AHP is used to answer the question "Why the New York Yankees signed Johnny Damon?" All three are more practically orientated and maybe that's where the preference comes from.

Personally, I enjoyed **Perspectives in Operations Research** immensely, not just because of the historical content but also to get to know more about Saul Gass as an individual. Something else that should be mentioned is the 10km race that many delegates to ORSA and then INFORMS, and even IFORS, conferences got to know as part of the conference activities – the man behind these, Saul Gass! It shows the variety of the man – he has indeed had a very long career in OR and made a huge contribution in all kinds of ways. Enjoy this! ▪

PRELIMINARY ANNOUNCEMENT

2ND CONFERENCE ON OPERATIONAL RESEARCH PRACTICE IN AFRICA
NATIONAL CONFERENCE OF THE OR SOCIETY OF SOUTH AFRICA

incorporating
The ORPA/INFORMS Workshop on OR Education

University of Cape Town
10–14 September 2007

We are pleased to give notice of the above important OR activities scheduled for Cape Town in September 2007. The 2nd OR Practice in Africa (ORPA) conference follows on from the original meeting which took place in Ouagadougou, Burkina Faso in April 2005. This year the meeting is being run jointly with the annual national conference of the OR Society of South Africa (ORSSA). In collaboration with INFORMS, the workshop on OR education will take place during 10–11 September, based on the recent successful ALIO/INFORMS Workshop on OR Education held in Latin-America.

Full details of the meeting will shortly be available on the conference web site, a link to which will be provided from the ORSSA web page (www.orssa.org.za). However, provisional key dates are the following:

Fri 6 July 2007:	Deadline for submission of abstracts
Fri 13 July 2007:	Latest Notification of acceptance
Tue 31 July 2007:	Deadline for early-bird registration
Wed 5 Sept 2007:	Deadline for conference registration

Make a note of these important dates right now!

General chair:	Theo Stewart (theodor.stewart@uct.ac.za)
Programme chair:	Jan van Vuuren (vuuren@sun.ac.za)
Education Workshop chair:	Jim Cochran (jcochran@cab.latech.edu)

(continued from page 5)

I was surprised that Monash scored so low, as it seems to me that Monash is easier to get to than Wits if you are coming from either Pretoria or the Vaal Triangle. This is probably due to the fact that many people do not (yet) know where Monash is, and perhaps I am biased.

When the survey was sent out, the Development Bank of South Africa (DBSA) was not included as a possible venue, so the values shown in Figure 5 are inferred. If a respondent said they preferred Pretoria and preferred either of the Johannesburg venues, they were recorded as preferring DBSA as well. If they said they preferred either Johannesburg or Pretoria, and would travel to the other, then they were recorded as being prepared to travel to DBSA.

SUGGESTIONS

The penultimate question on the survey asked members to suggest other types of events. Some of these suggestions included combining a technical talk with a dinner; holding a formal seminar with more than one speaker; trying to make the talks more practical than theoretical; holding a workshop for students including some skills development and opportunities to meet prospective employers; and some suggestions for specific topics.

A theme that arose from the suggestions, that has been felt by the executive for a while, is the need to market the society to those outside of the society. Some chapters currently run events to market the society and the O.R. to scholars and students, but more work needs to be done in this area, as well as marketing to professionals.

CONCLUSIONS

In conclusion, the Johannesburg Chapter has decided to focus on running Afternoon Seminars, on the first Wednesday of each month from March to October, starting at 16:00. These will be held at the Wits Club. The main objective of these will be to establish consistency, so that anyone interested will know that there will be an ORSSA seminar on the first Wednesday of each month. We will also hold a social dinner in February, our regular Schools Day in April, and our AGM, combined with a technical talk in November. No event will be held in September, to make space for the annual conference. If this process goes well, we will also try holding a breakfast talk, and perhaps an industry visit next year.

If anyone has any ideas how we could market more effectively to students and professionals who are not members of the society, please contact me. ■

CHAPTER NEWS AND EVENTS

For up to date information regarding provincial chapter events and news, please visit our website at:

http://www.orssa.org.za

and then click on Chapters (in the navigation bar). The relevant province can then be selected.

Post Doctoral Position in Operations Research

Applications are awaited for a post doctoral position in operations research (specializing in graph and network theory) at the Department of Mathematical Sciences of Stellenbosch University.

Duties: A successful candidate is expected to fit in with the already established research group in graph and network theoretic applications of operations research within the department by making a full-time contribution towards the research output of the group.

Requirements: Candidates should have obtained a PhD in operations research or in a mathematical discipline (on a topic related to graph or network theory) within the last 5 years, should already have demonstrated their ability and interest in conducting independent research (by means of publications / conference papers) and will be expected to take up residence in Stellenbosch for a period of two years.

Contract period: 24 months, starting no later than July 1st, 2007. A scholarship of R90 000 per annum is attached to this position. The money will be paid out as a bursary and is therefore not taxable.

Closing date for applications: May 31st, 2007

Enquiries : Prof JH van Vuuren (Host)
Division of Applied Mathematics
Department of Mathematical Sciences
University of Stellenbosch
Private Bag X1
7602 Matieland

Tel: (021) 808 4213
Fax: (021) 808 3778
Email: vuuren@sun.ac.za

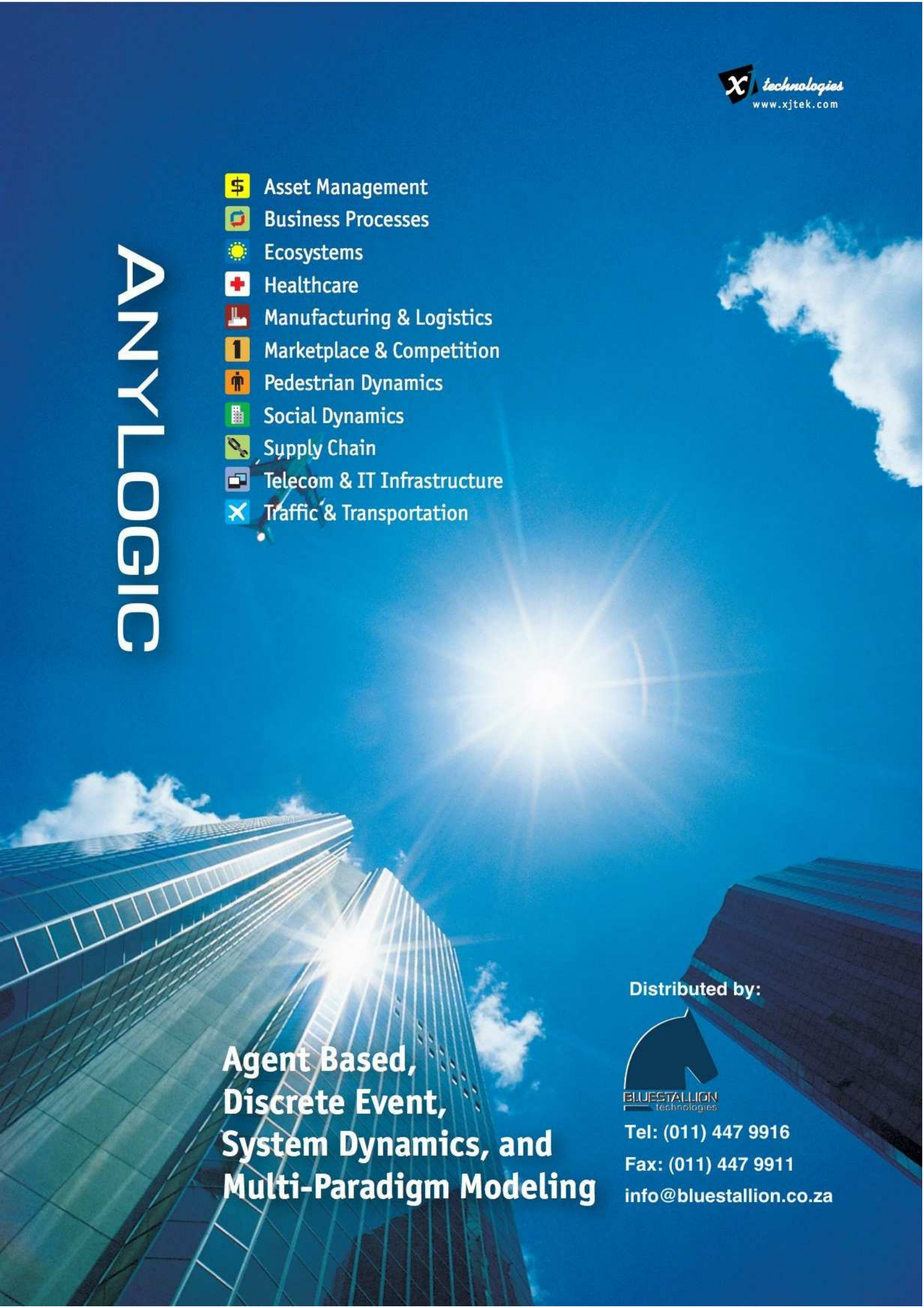
Stellenbosch University reserves the right not to award this scholarship.

PHD WORKSHOP FOR OR IN DEVELOPMENT

Prague, Czech Republic, University of Economics - July 7, 2007

Queries: Leroy White (leroy.white@bris.ac.uk)
Department of Management
University of Bristol

http://www2.ing.puc.cl/~fcrespo/eurofdv/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