

**MBA
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Operational Research and
Optimization and Simulation
Modeling

Prof. Dr. Marcos dos Santos

**MBA
USP
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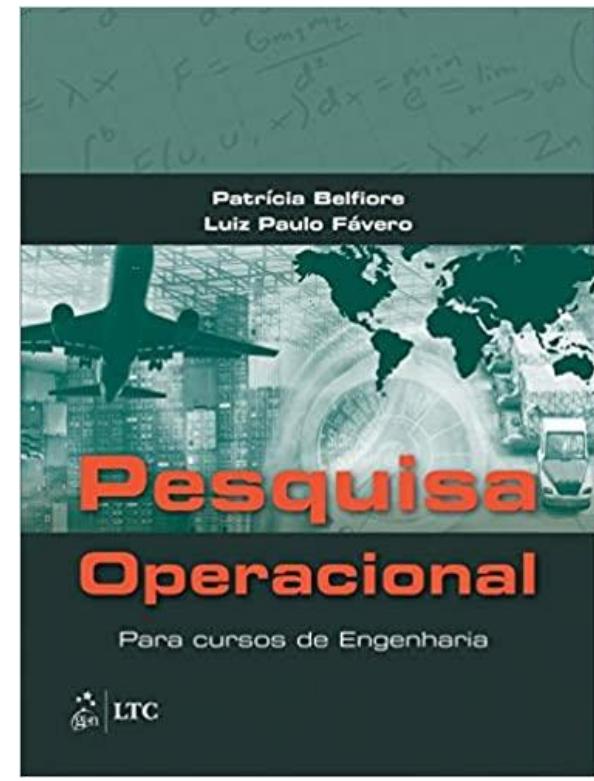
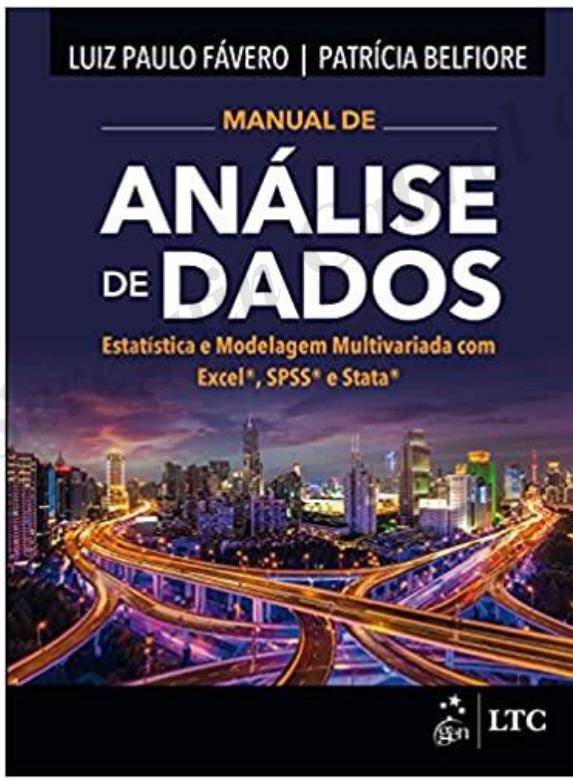
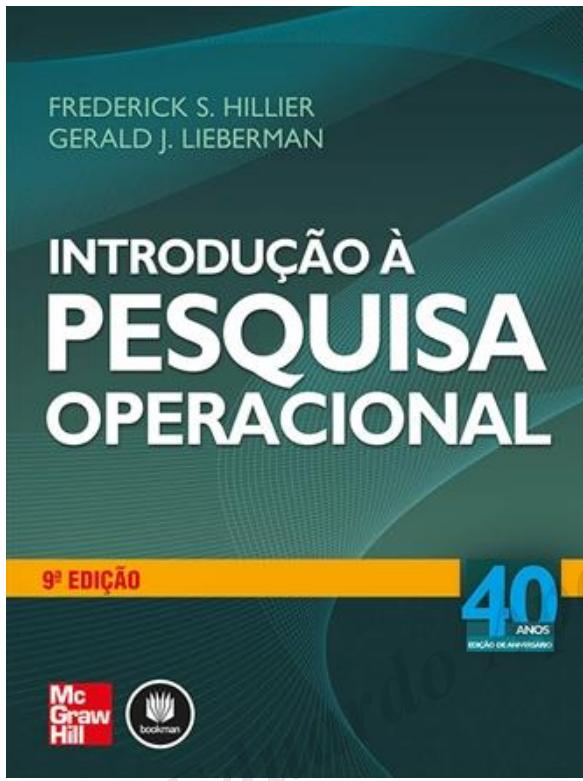
Operational Research
Prof. Dr. Marcos dos Santos

BACKGROUND

- Senior Officer, 29 years of service in the Navy of Brazil;
- Navy Academy;
- Naval School;
- Viagem de instrução de Guardas-Marinha (VIGM) in 2001;
- 10 years on board of war vessels;
- 11 years in CASNAV: Researcher and Project Manager in the Corp of Operational Research;
- Professor of P.O. of CAAML, EsAO, CIASC and ECEME;
- Specialized in Mathematical Instrumentation (UFF)
- Specialization in Mathematics (IMPA);
- IT Governance (FGV-RJ);
- Graduate Course in Production Engineering - Operational Research (COPPE/UFRJ);
- PhD and post-doctoral in Systems, Support to Decision and Logistics (UFF);
- Post-doctoral in Sciences and Spatial Technologies (ITA);
- Board of the Brazilian Society of Operational Research (SOBRAPO);
- Professor of MBA in Data Science and Analytics (USP);
- Professor of the Graduate program in Production Engineering (UFF);
- Professor of the Graduate Program in Systems and Computing (IME).



REFERENCES



THE O.R. SOCIETY



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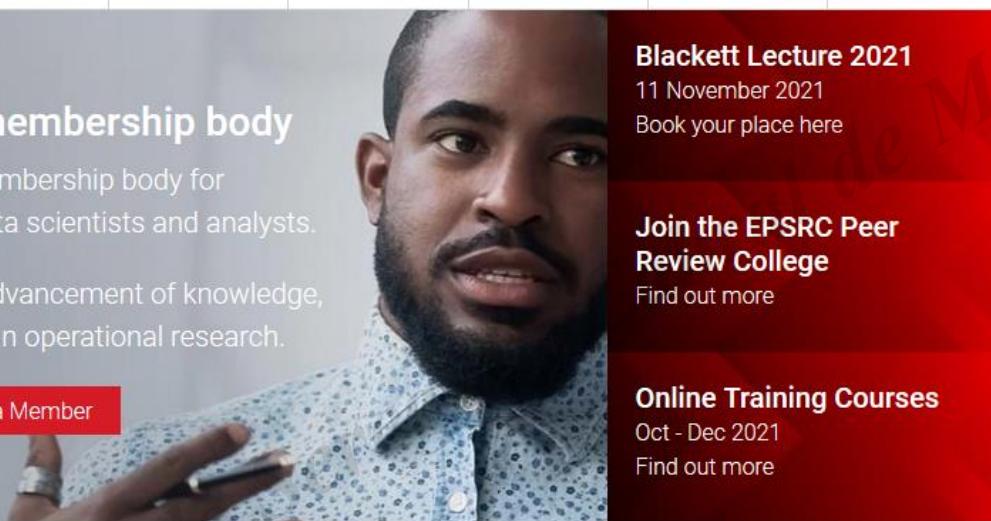
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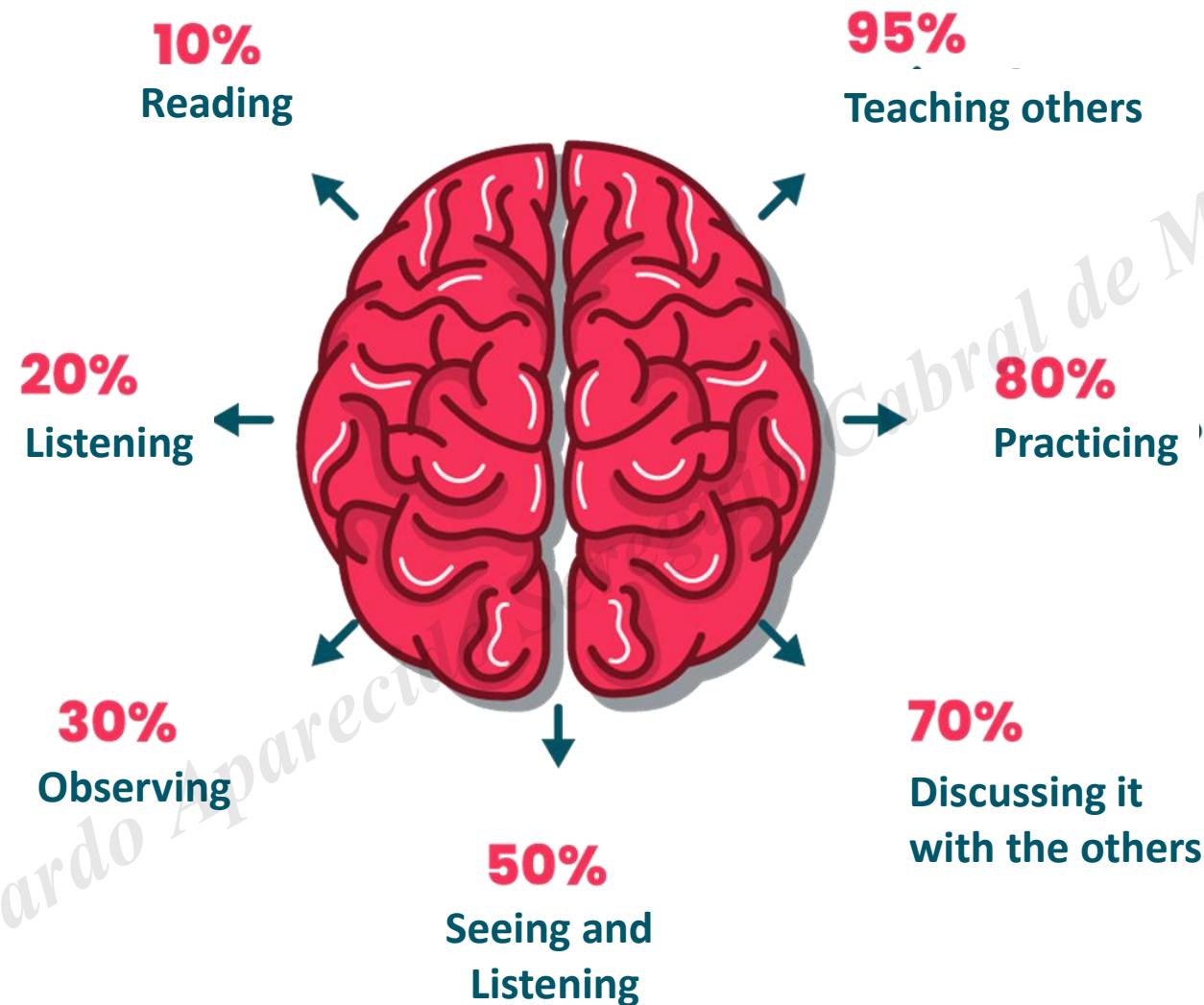
Oct - Dec 2021

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Our diverse global community of operational researchers and analysts is the gateway to a thriving career. As a member, you will access the tools you need to thrive in your profession at every stage of your career. You will enjoy distinct networking opportunities, an ever-developing library of insight and resource, and a rich programme of events and training.

DYNAMICS OF THE CLASSES



HOW OUR
BRAIN LEARN



Eduardo Aparecido Serqueira
Carvalho de Melo

WHAT WILL WE LEARN?



GOAL

To work with optimization models and to implement them computationally.

WHAT WILL WE LEARN?

To maximize : $Z = \sum_{j=1}^n c_j x_j$

Subject to :
 $\sum_{j=1}^n a_{ij} x_j \leq b_i (i = 1, 2, \dots, m)$ 
 $x_1, x_2, \dots, x_n \geq 0$



```
RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
programacao_linear_aula_1.R* Go to file/function Addins
Source on Save Run Source
#introducao_produtos_Alegria, BabyDoll e Camiseta cada un com lucro de $3, $2 e $1 respectivamente
5 #max = 3a + 5b + 8c
6
7 # 8a + 2b + 3c <=5000 (espaço físico em m²)
8 # 2a + 8b + 3c <=8000 (tecido em m)
9 # 2a + 3b + 8c <=7000 (horas máquina)
10
11 #Chamando o help do lpSolve
12 help("lpSolve")
13
14 #Desenhando o modelo
15 funcao_objetivo <- c(3,5,8)
16 restricoes <- matrix(c(8,2,3,
17 2,8,3,
18 2,3,8), ncol = 3, byrow = T)
19 restricoes_dir <- c("<=", "<=", "<=")
20 restricoes_rhs <- c(5000,8000,7000)
21
22 #Rodando o modelo usando a LP com os argumentos Max ou Min, Objetivo, Restri., Direcao, Restri_rhs
1634 (Top Level) :
```

OBJECTIVE OF THE TODAY'S CLASS

GOAL



To Explain the basic concepts of Operational Research and of the Decision making Process.

INTRODUCTION



"Nothing is more difficult, and therefore more precious, than to be able to decide."

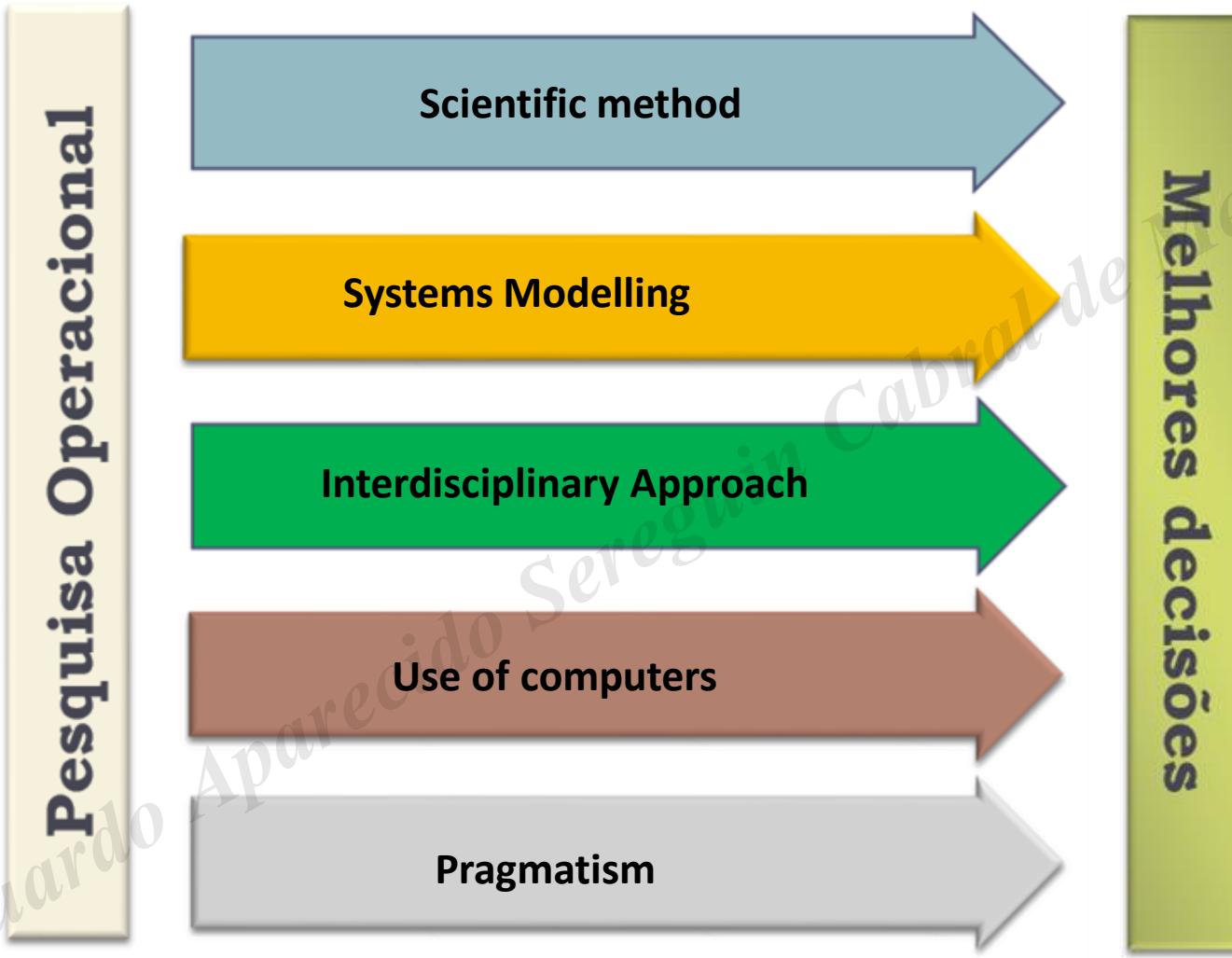
What is OPERATIONAL RESEARCH?



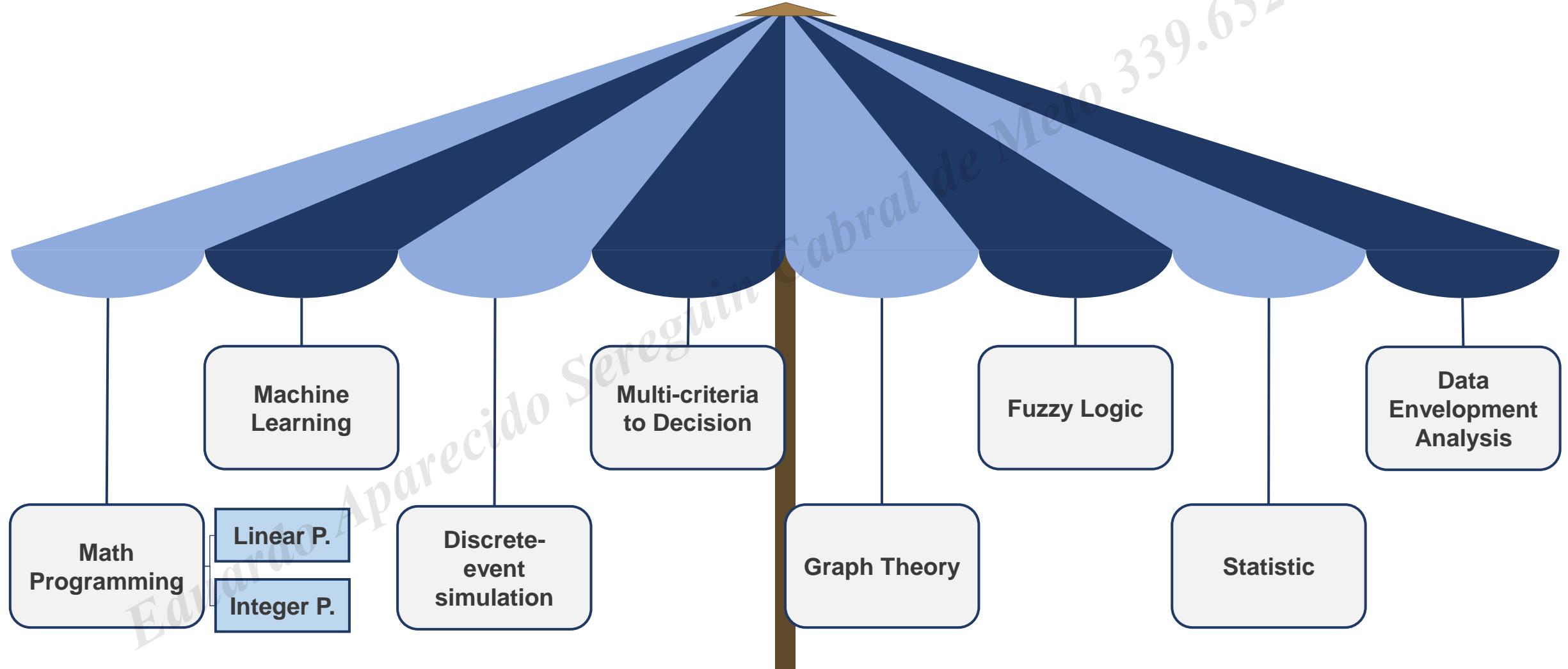
Operational research (OR) is a scientific approach to the solution of problems in the management of complex systems that enables decision makers to make better decisions.

Most of the problems OR tackles are messy and complex, often involving considerable uncertainty. OR uses advanced analytics, modelling, problem structuring, simulation, optimization and data science to determine the best solution to the problem and the best practical course of action.

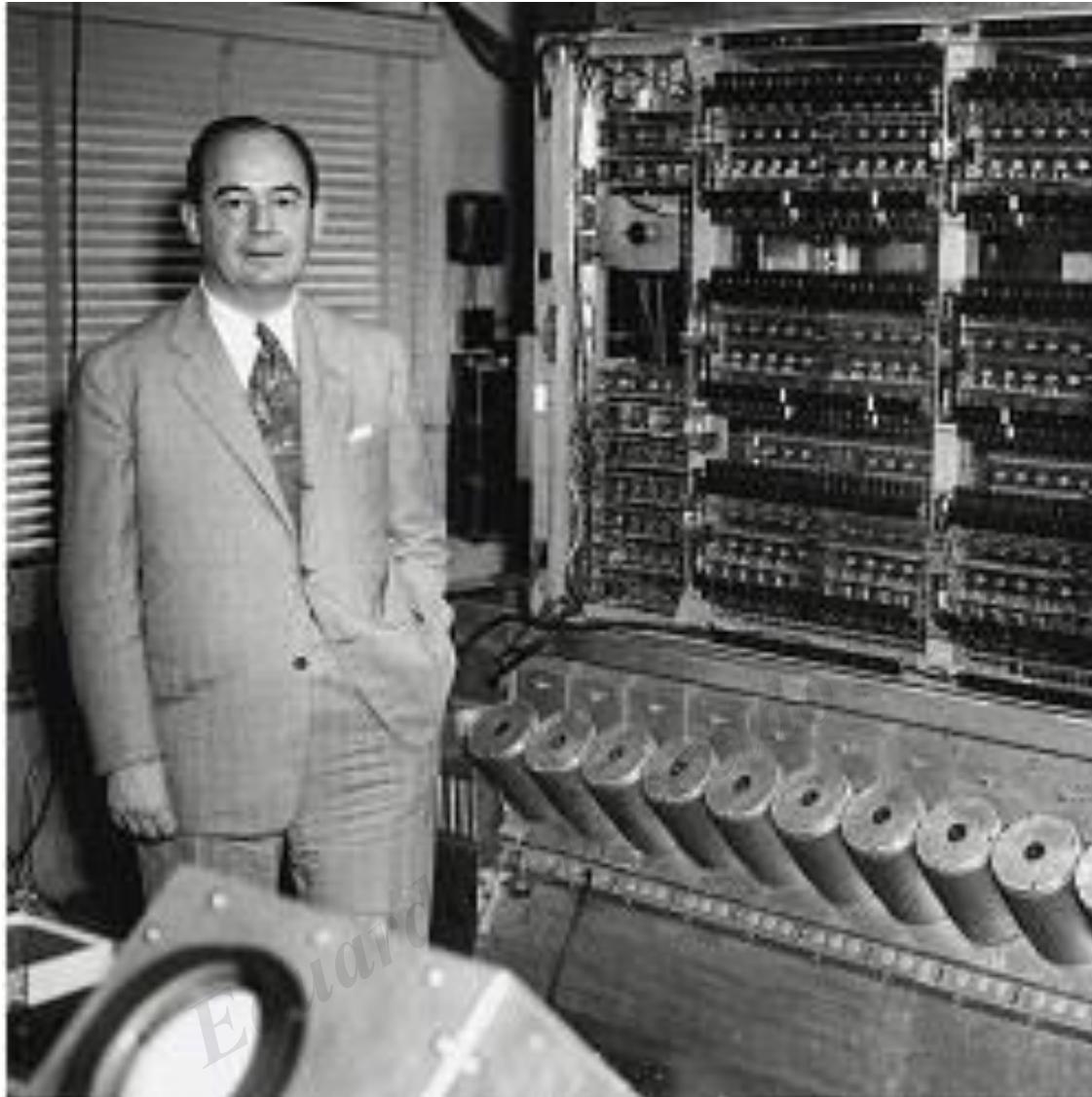
What is OPERATIONAL RESEARCH?



THE AREAS OF O.R.



P.O. EXPANSION



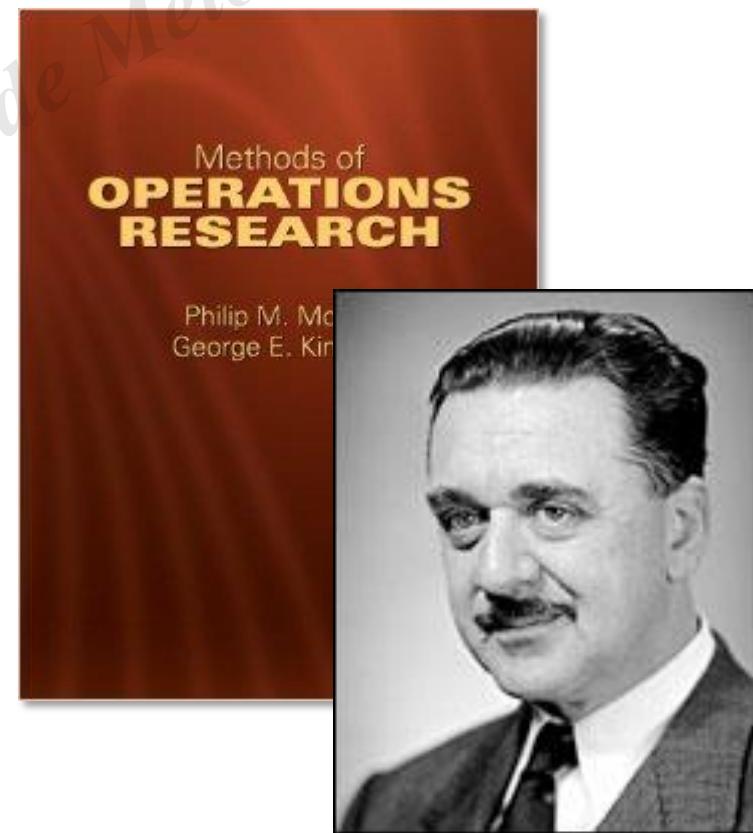
Two factors were responsible for the quick growth of P.O. in the 20th century:

- New mathematical models;
- The evolution of computers.

WHO CAN STUDY P.O.?

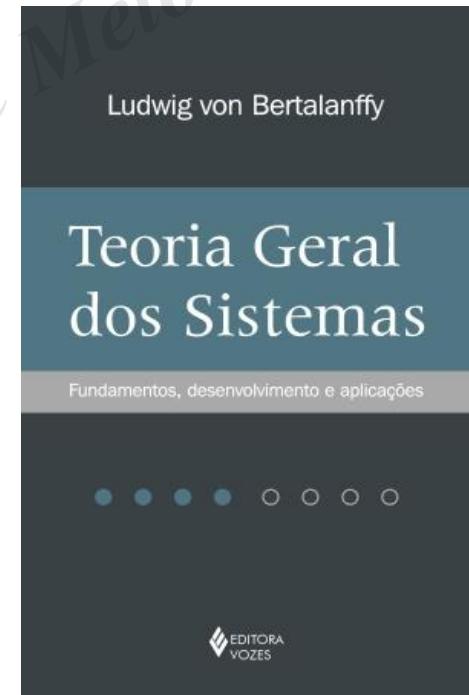
PERSONNEL AND ORGANIZATION

It should be apparent by now that the operations research worker does not need to be a specialist in any particular branch of science. He does, however, need to be a person with considerable experience in research of a scientific nature, whether he is a biologist, a physicist, a mathematician, or a worker in some other science. The important requisite is that impersonal curiosity concerning new subjects that is the very essence of research ability.



WHAT IS A SYSTEM?

It is a set of interdependent elements that interact with common goals. Normally, the result generated by the system is greater than the sum of the isolated results of the parts that make up the system.



MATH REPRESENTATION OF A SYSTEM

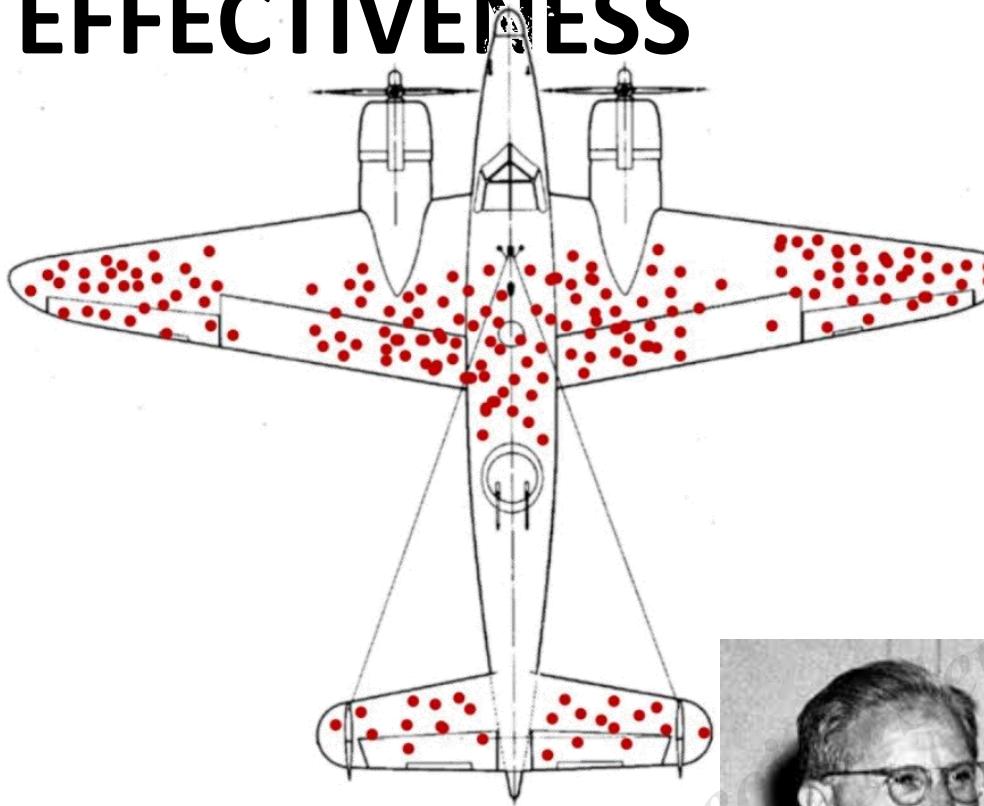
$$\left. \begin{array}{l} \frac{dQ_1}{dt} = f_1(Q_1, Q_2, \dots, Q_n) \\ \frac{dQ_2}{dt} = f_2(Q_1, Q_2, \dots, Q_n) \\ \dots \dots \dots \dots \dots \dots \\ \frac{dQ_n}{dt} = f_n(Q_1, Q_2, \dots, Q_n) \end{array} \right\}$$

MEASURE OF OPERATIONAL EFFECTIVENESS

It is a measure, quantifiable, which seeks to represent the degree which a given system, in operating conditions as real as possible, achieves its purpose. MOE allows to quantify relevant aspects to specific operational requirements.



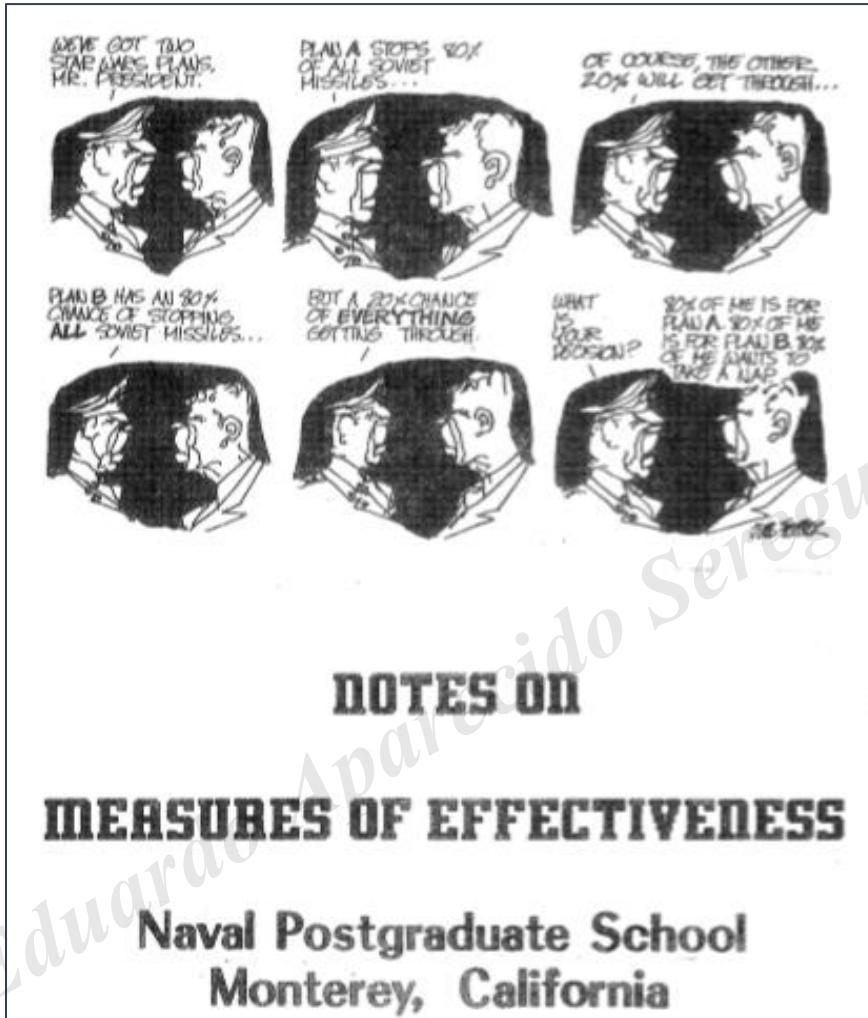
MEASURE OF OPERATIONAL EFFECTIVENESS



Abraham Wald (Romanian mathematician) concluded: the red points represented damage on planes that could return, which arrived home. The areas that really should be reinforced were the places where there were no points, because these were places where the plane would not survive when being hit.

MEASURE OF OPERATIONAL EFFECTIVENESS

(three attributes of a good MOE)



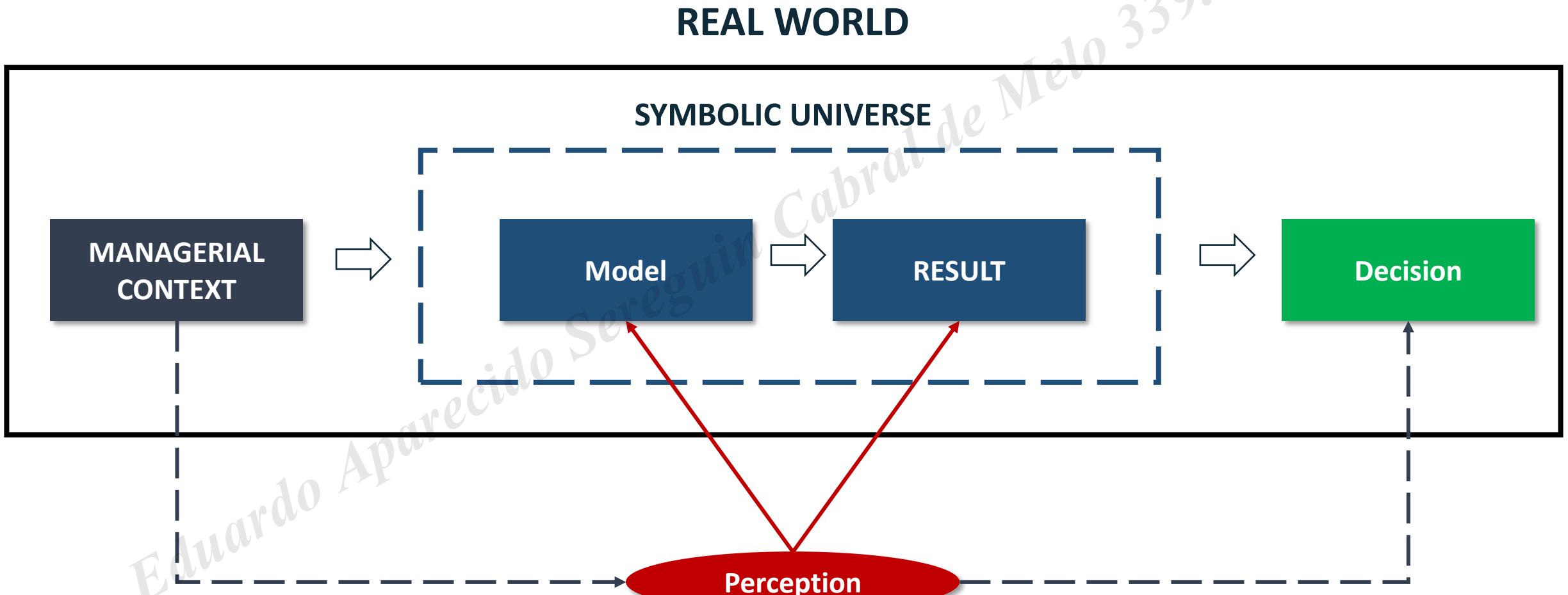
Quantifiable

Measurable

"Closely Related"

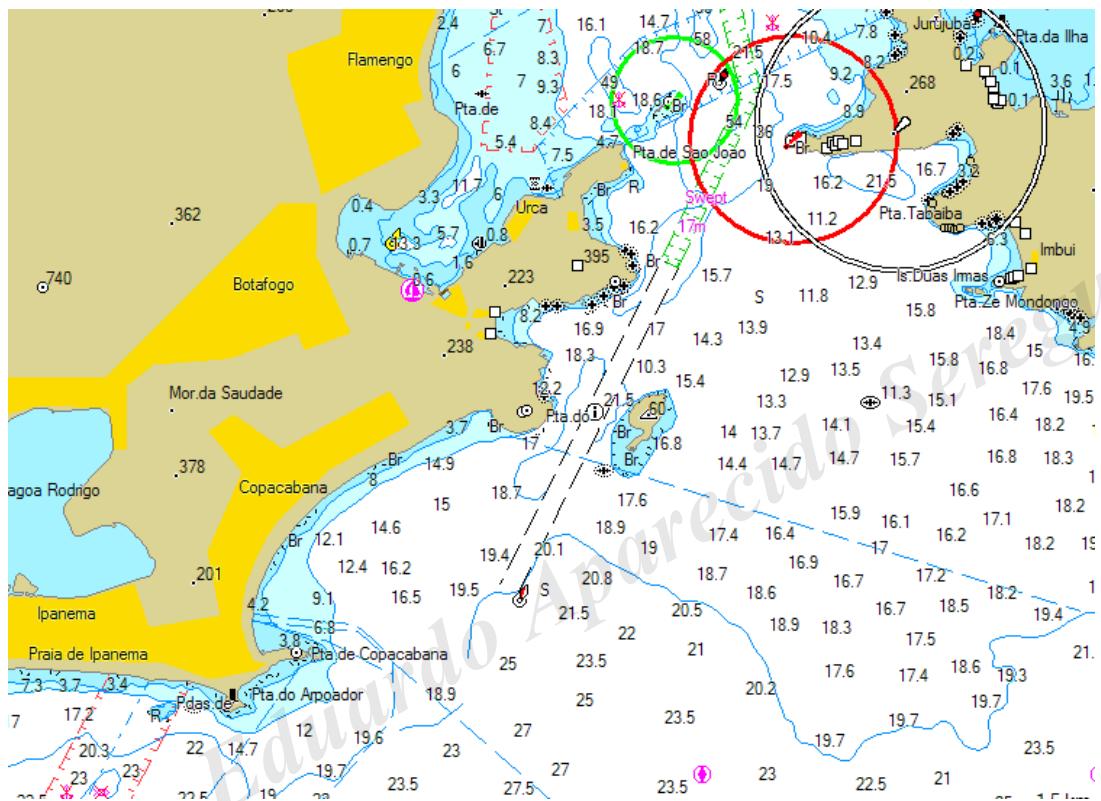
Source: Rockower (1985)

THE PROCESS OF MATHEMATICAL MODELLING



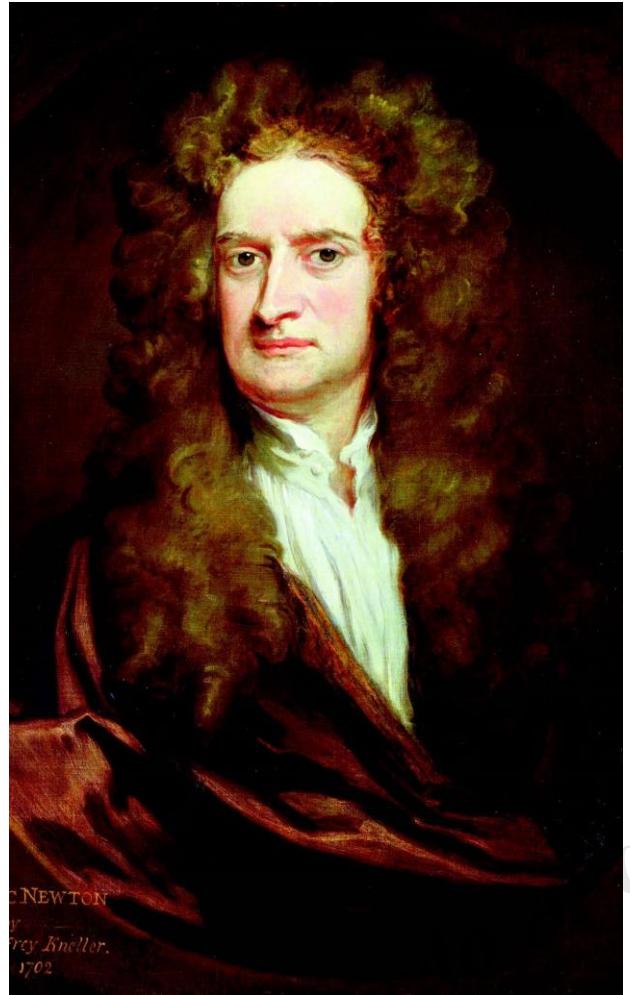
MODEL

It is a simplified representation of reality, designed to facilitate the understanding, and, consequently, the manipulation of a complex phenomenon.



$$\bar{x} = \frac{\sum x_i}{n}$$

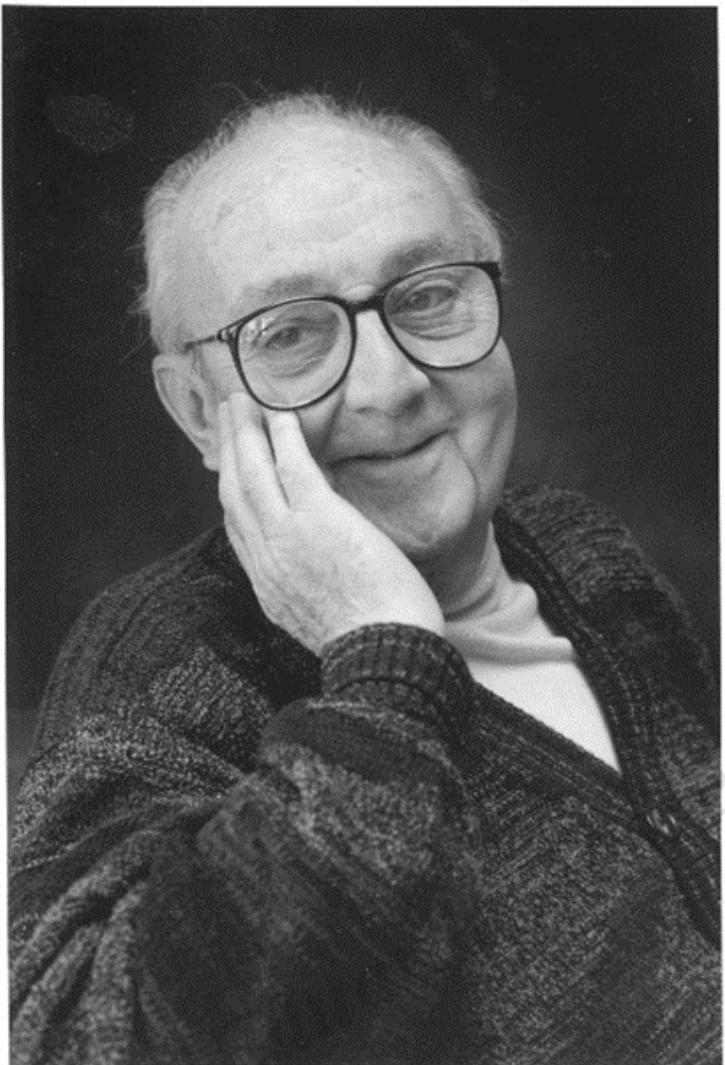
MODEL



$$\bar{F}_R = m\bar{a}$$



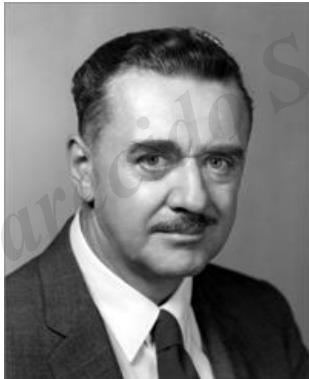
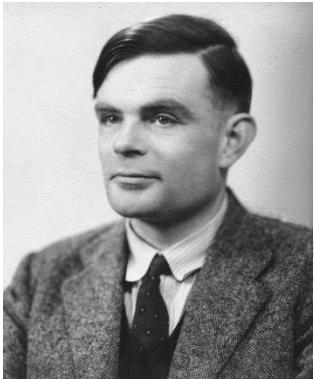
MODEL



"All models are wrong, some models are quite useful"
(George P. Box)

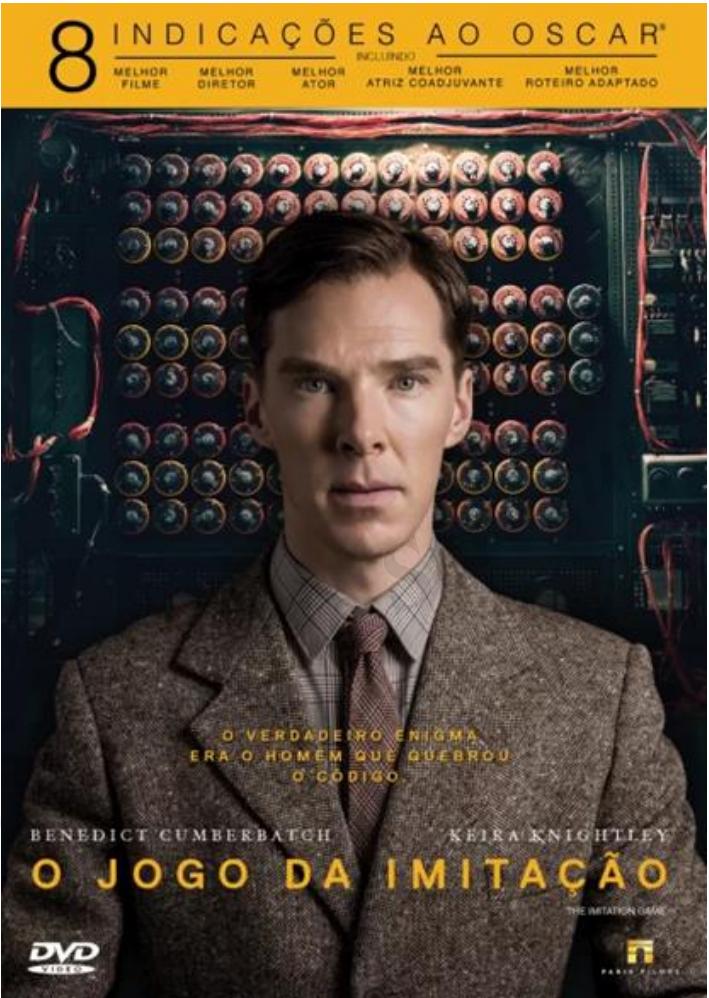
THE O.R. IN THE WORLD WAR II

Many practical applications of optimization were developed during
the Second World War (1939 – 1945).



THE O.R. IN THE WORLD WAR II

(movie suggestion)



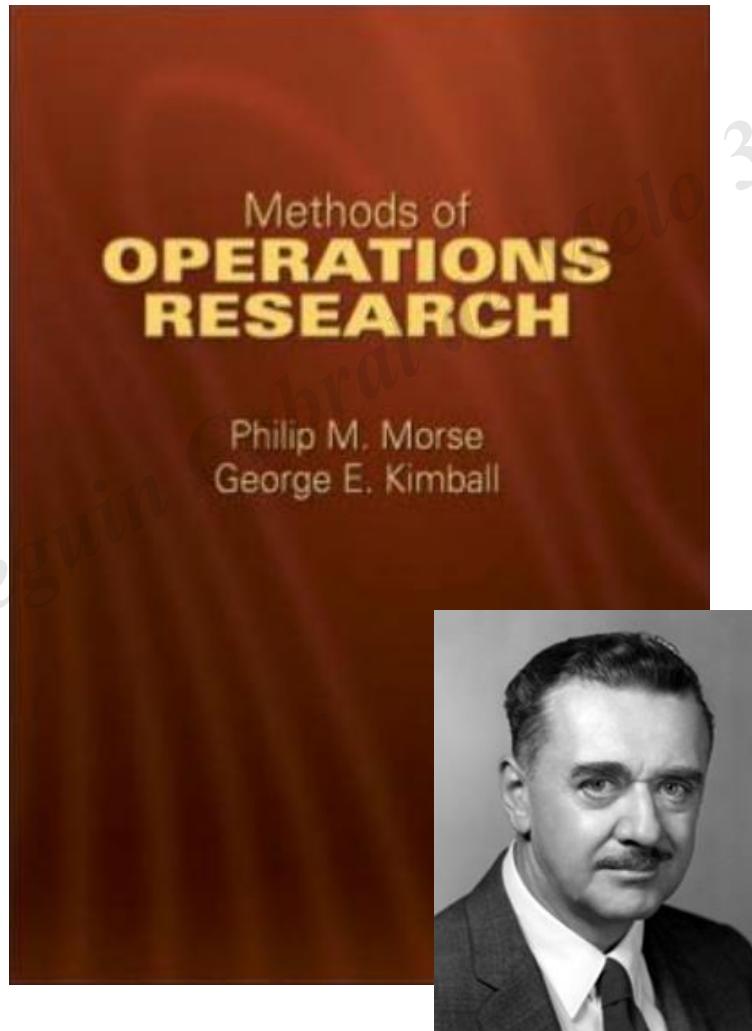
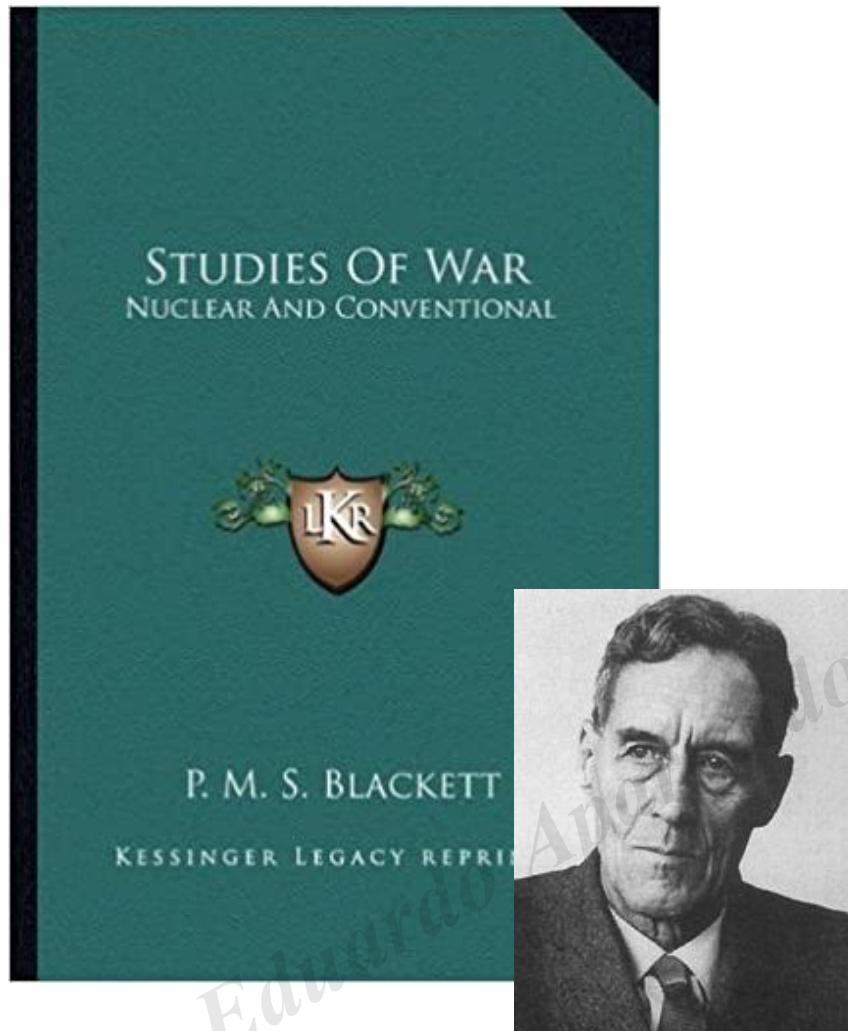
THE O.R. IN THE WORLD WAR II

During the Second World War, the original groups of O.R. used the imaginative thinking to solve problems that involved human being, machines, materials, and money. Some examples of high complexity problems:

- How to make efficient use of the recent radar technology.
- How to reduce the number of ships sank by German submarines.
- How to maximize the use of squadrons.
- How to maximize the accuracy of bombers.



FIRST REFERENCES



THE O.R. WAS TRANSFERED TO OTHER AREAS



STAGES FOR PROBLEM SOLUTION

1. Understand the system (objective); → PSM

2. Define MOE;

3. Build the Model;

4. Obtain big data;

5. Improve the model;

6. Validate the model;

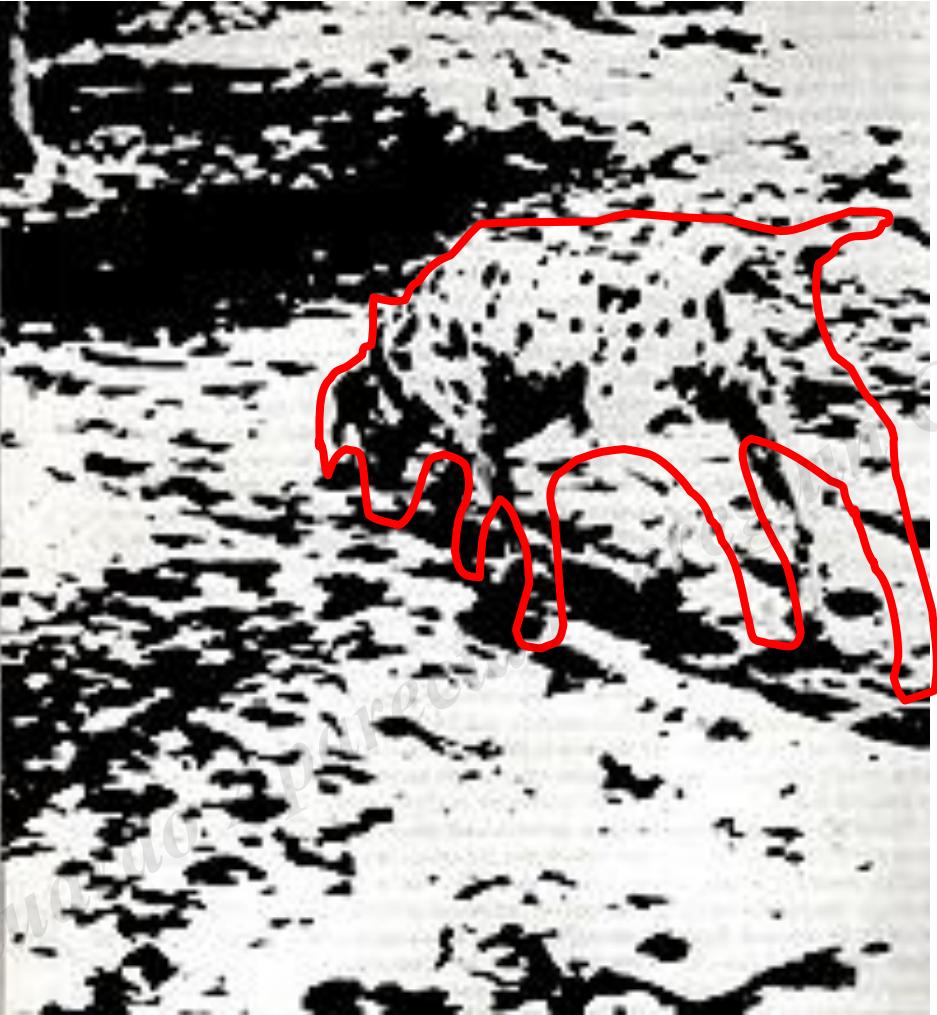
7. Report, explain, communicate and help the implementation of the model. → Storytelling

O.R.
D.S.



Problem understanding

What do you see in the figure?



*Now that you have seen, try
to not see the dog...*



Understanding the problem is
a question of **PERCEPTION**

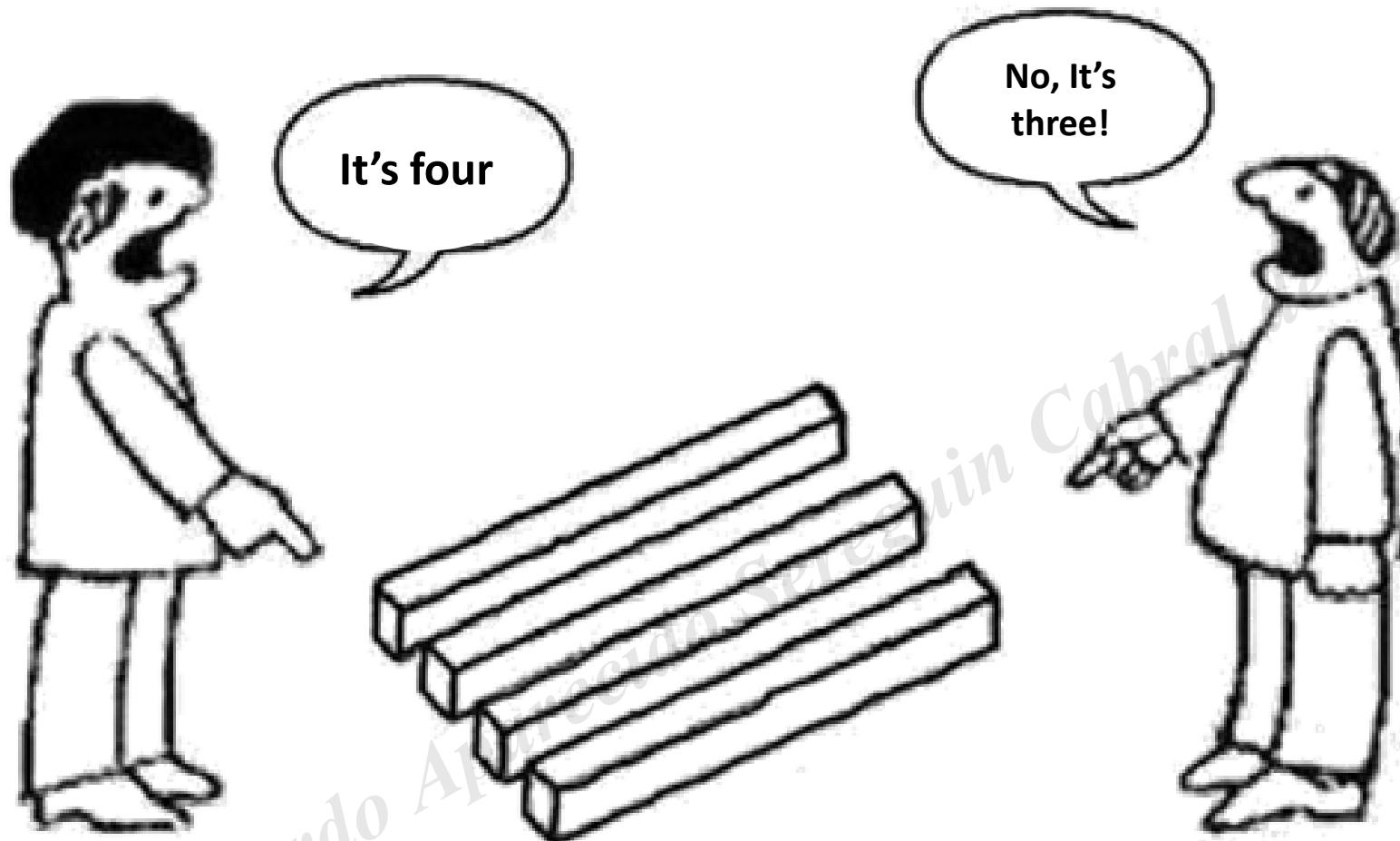
Problem understanding

Which animal do you find in the drawing below?



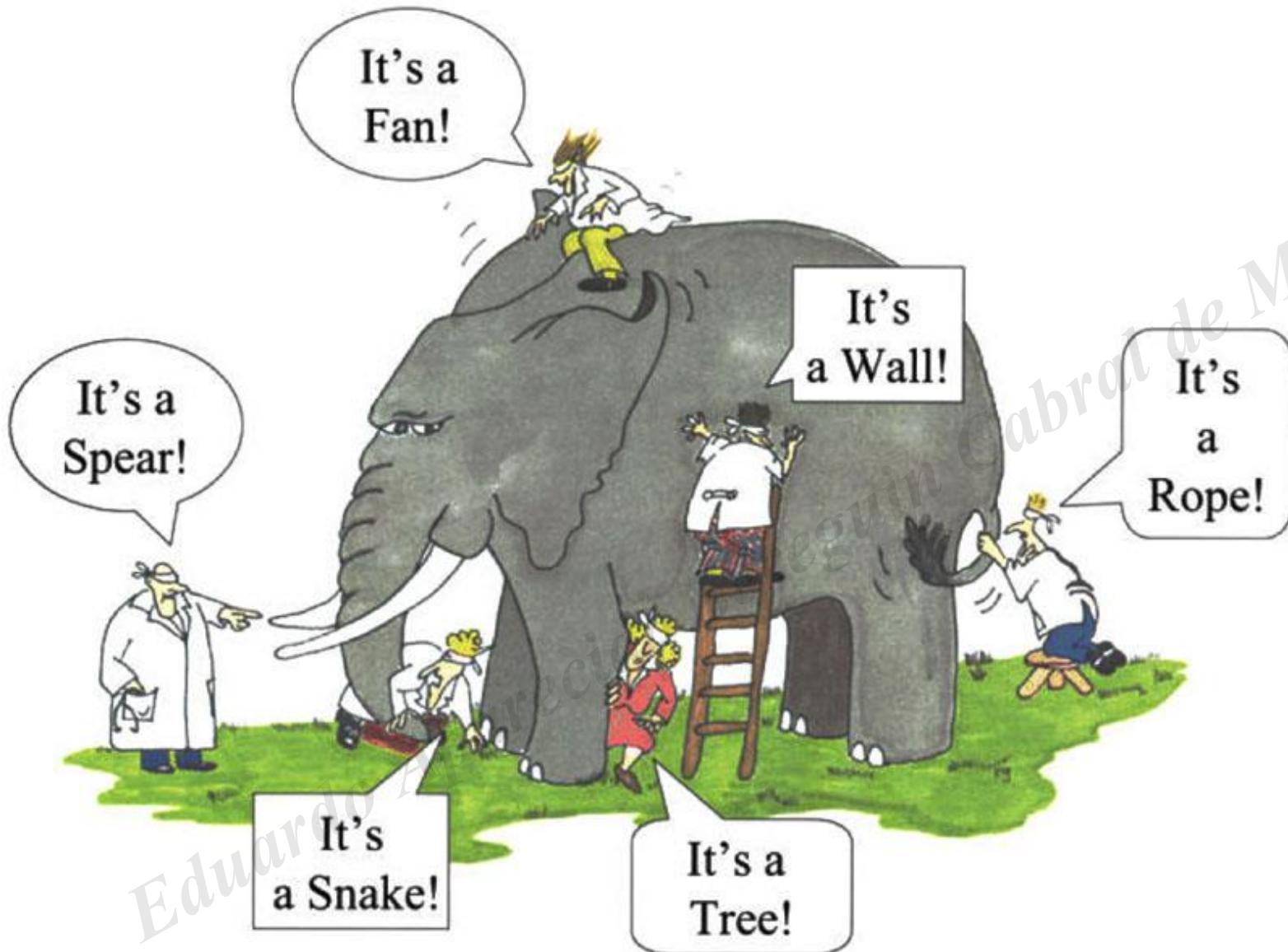
Understanding the problem is
a question of **PERCEPTION**

Problem understanding



Understanding the problem is
a question of **PERCEPTION**

Problem understanding



Often, each individual has a different **perception** regarding the same problem. What results in a wrong mathematical modeling of the problem.

Problem understanding

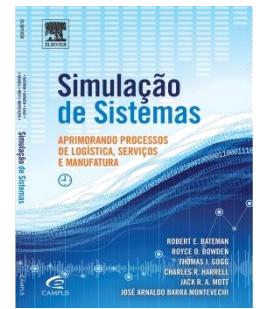
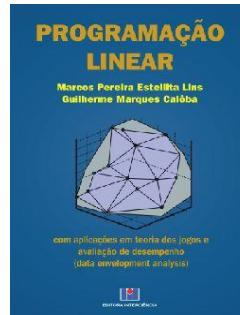
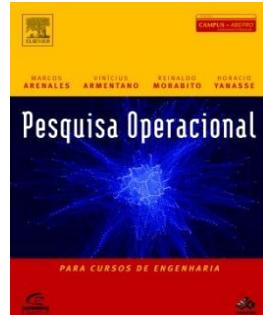
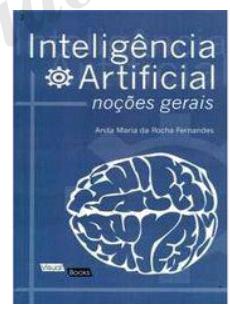
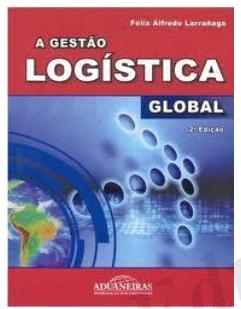
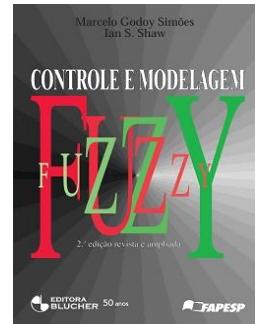
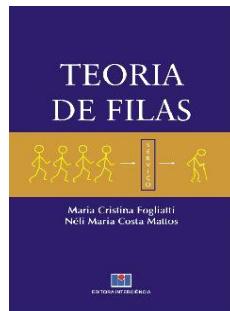
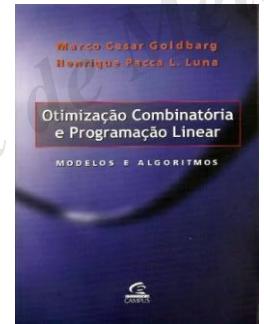
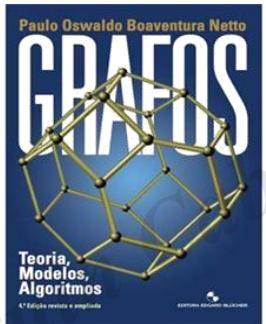
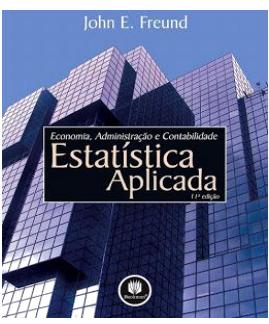
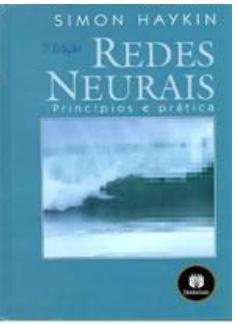
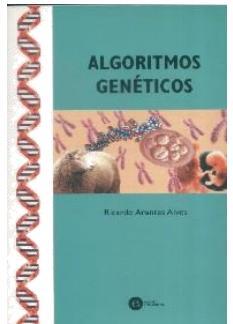


"I believe that this Nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to earth"

ATTENTION WHEN CHOOSING THE MODEL

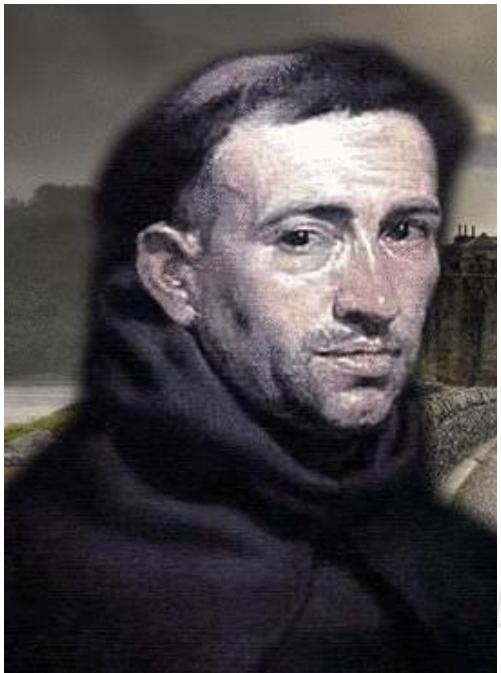


LITERATURE ABOUT THE THEME



OCCAM'S RAZOR

"All things being equal, the simplest solution tends to be the best one"



1) Achieving what you want with the least effort and expenditure of resources;
or

2) To obtain the maximum return from what you have.

Guilherme of Occam 14th century.

O.R. IN PRACTICE

The O.R. can be applied in several knowledge areas.

And this is one of its main characteristics. **The O.R. is a
INTERDISCIPLINARY science.**

Manufacture

Civil Construction

Logistics

Finance

Education

AGRICULTURE

Health

...

O.R. IN PRACTICE

Manufacture

It allows the reduction of production time when optimizing the production processes, then, increasing productivity:



Universidade Regional do Cariri – URCA
Caderno de Cultura e Ciência, Ano XI, v.15, n.1, Out, 2016
ISSN 1980-5861

REDIMENSIONAMENTO DA LINHA DE PRODUÇÃO DE UMA FÁBRICA DE SACOS DE LIXO EMPREGANDO SIMULAÇÃO DE EVENTOS DISCRETOS

Marcos dos Santos¹, Leonardo da Costa Martha², Renato Santiago Quintal³, Ernesto Rademaker Martins⁴

Resumo

No Brasil, grande parte das empresas, especialmente as de pequeno e médio porte, passa por dificuldades no que diz respeito ao processo decisório. As decisões se tornam ainda mais difíceis quando envolvem grandes investimentos de tempo e capital. Levando em consideração estas dificuldades, o emprego de *softwares* para simulação de cenários tem se tornado cada vez mais difundido no meio corporativo como potencial auxiliador na tomada de decisões. O objetivo deste artigo é apresentar estratégias de planejamento a partir da simulação de processos fabris utilizando uma plataforma informatizada, por meio do *software* Arena, versão estudante, uma ferramenta gratuita e de qualidade.

O.R. IN PRACTICE

Logistics

When choosing the best transport model, getting the most out of the strengths of each modal:

Chapter 6

- Scripting of vehicles;
- Optimization of the urban bus schedule;
- Programming of urban bus's crews.

APPLYING THE TRAVELLING SALESMAN PROBLEM
IN SCRIPTING OF NAVY VEHICLES FROM BRAZIL:
THE GRAPH THEORY APPROACH

Luiz Rodrigues Junior

SENAI - Engenharia de Produção

Rio de Janeiro - RJ

Marcos dos Santos

SENAI - Engenharia de Produção/ Instituto Militar

de Engenharia - IME

Rio de Janeiro - RJ

custos de transporte, por meio da clusterização das OM que estejam dentro de um raio de proximidade, além da roteirização por meio da solução do Problema do Caixeiro Viajante (PCV). O estudo ora apresentado, indica que pode haver uma significativa economia dos recursos da Força, os quais poderiam ser

O.R. IN PRACTICE

Education

To make use of the availability of each resource, as professor/student, classrooms, equipment, etc.:

- Programming the Schools' Schedule;
- Placement of Classrooms;
- Construction of scenarios.



Identificação das variáveis que influenciam as universidades federais do Brasil: uma etapa do método Momento de construção de cenários prospectivos

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IME

O.R. IN PRACTICE

Health

Sizing of health services, both outpatient and emergency;

- Programming of nurses' schedules;
- Programming of the doctors' schedules;
- Simulation of emergency service.

The image shows a rectangular publication card with the following details:

- ELSEVIER** logo (a tree)
- CrossMark** logo
- Available online at www.sciencedirect.com
- ScienceDirect**
- Procedia Computer Science 55 (2015) 931 – 938
- Information Technology and Quantitative Management (ITQM 2015)
- Simulation of Operation of An Integrated Information for Emergency Pre-Hospital Care In Rio de Janeiro Municipality**
- Marcos dos Santos ^{1a}, Renato Santiago Quintal ^b, Alexandre Camacho da Paixão ^c, Carlos Francisco Simões Gomes ^d
- ^aMaster of Science in Production Engineering (UFRJ) ^b Master of Science in Accounting (UERJ) ^c Master in Civil Engineering (UFF) ^d PhD in Production Engineering (UFRJ)

O.R. IN PRACTICE

Civil Construction

With the optimization of resources and risk management:

- Optimization of metal structures;
- Distribution of the use of equipment;
- Distribution of the workload balance;
- Risk Management.



GERENCIAMENTO DE RISCOS
NO PLANEJAMENTO DE EMPREENDIMENTOS:
UMA ABORDAGEM A PARTIR
DA SIMULAÇÃO DE MONTE CARLO

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Finance

Modeling the financial market to search better investment portfolio:

- Risk analysis;
- Investment traceability;
- Investment portfolio.



Pesquisa Operacional para o Desenvolvimento
Vol. 13, e13004, p. 1-17, ANO 2021

ISSN 1984-3534

FINANÇAS EM PERÍODOS DE CRISE: APLICAÇÃO DO MÉTODO SAPEVO-M PARA COMPOSIÇÃO DE PORTFÓLIOS DE INVESTIMENTOS

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Recebido 15/07/2021, aceito 02/10/2020

RESUMO

A pandemia do novo coronavírus ocasionou diversas perdas e dúvidas para os investidores por todo o mundo. Neste cenário econômico de riscos e incertezas, este artigo tem por objetivo apresentar uma nova ferramenta de apoio à decisão para a confecção de um portfólio de investimentos. Com esse intuito, foi aplicado o método multicritério SAPEVO-M a fim de obter a distribuição de recursos em um portfólio composto por investimentos de renda fixa e variável presentes no mercado brasileiro, levando em consideração a liquidez, risco, volatilidade e rentabilidade apresentados pelas alternativas nos últimos doze meses. Para a estruturação do problema, foram consultados três decisores com diversos perfis de investimento e analisados diversos cenários. O método SAPEVO-M mostrou-se muito eficiente ao ser aplicado, tanto na classificação das alternativas, quanto na otimização do portfólio de investimentos, apresentando uma carteira diversificada e segura, levando em consideração a opinião de múltiplos decisores de diferentes perfis.

O.R. IN PRACTICE

AGRICULTURE

Planning of agricultural processes from the planning of planting, through harvest, storage and distribution:

- Planning of agricultural production;
- Planning of storage;
- Planning of distribution.



XIX SÍMPOSIÓ DE PESQUISA OPERACIONAL E LOGÍSTICA DA MARINHA
RIO DE JANEIRO, RJ, BRASIL - 06 A 08 DE NOVEMBRO DE 2019

AUXILIANDO O PROCESSO DECISÓRIO NA AGRICULTURA 4.0: REVISANDO OS MÉTODOS ORDINAIS NA SELEÇÃO DE DRONES

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O.R. IN PRACTICE



Optimization of mix of production of a plastic products Corporation from the Branch and Bound method

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O.R. IN PRACTICE



Anais do XLVIII SBPO
Simpósio Brasileiro de Pesquisa Operacional
Vitória, ES, 27 a 30 de setembro de 2016.

MULTI CRITERIA APPROACH FOR SELECTING A MIDSIZE WARSHIP TO BE BUILT IN BRAZIL

Marcos dos Santos (Brazilian Navy & UFF)

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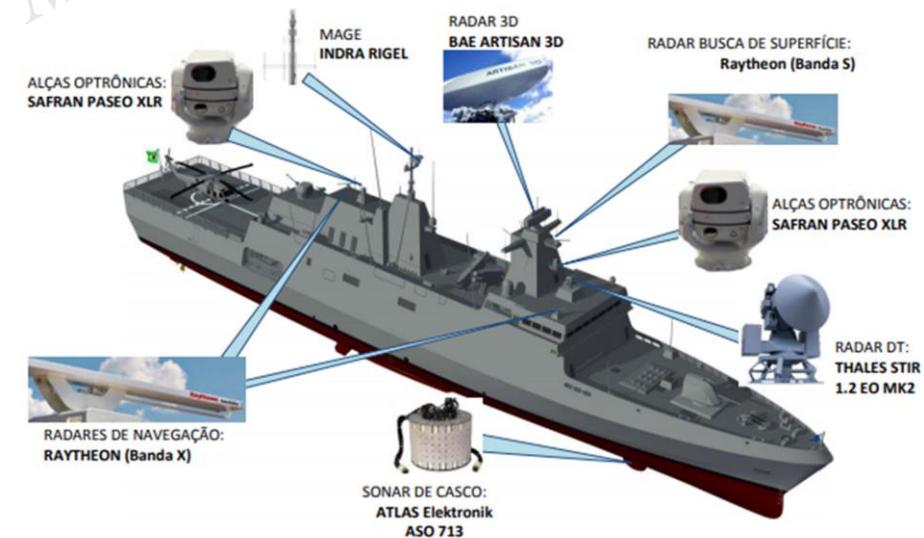
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RESUMO

O objetivo desse artigo é fundamentar a escolha de um navio de médio porte, no caso, 2.000 a 3.000 toneladas, a ser construído no Brasil, apresentando as opções de maneira hierarquizada. Dentre as inúmeras ferramentas do Apoio Multicritério à Decisão (AMD), será utilizado o



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G1

VALE DO PARAÍBA E REGIÃO

VAN
GUAR
DA

**Consortium with Embraer is
choose to build ships for Navy
for US\$ 1,6 billions.**

Serão fornecidas quatro embarcações do tipo corveta entre 2024 e 2028. Empresa de São José é responsável pelo aparato tecnológico dos navios.

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"Proposal for a model of demand prediction of spare parts for war ships of the Brazilian Navy"





ISSN: 1983 7402

ITA, 24 a 26 SET de 2019

Choice of a Debarking Ship of Troop for Army from Argentina through SAPEVO Method with Multiple Decision Makers (SAPEVO M)

Tomás Greco¹, Marcos dos Santos², Carlos F. S. Gomes³, Angélica R. Lima³

¹ARA – Armada da República Argentina, ²CASNAV – Rio de Janeiro/RJ, ³UFF – Niterói/RJ

Resumo – A Marinha Argentina tem como principal tarefa cuidar dos interesses vitais da Nação ante as novas ameaças existentes. Essas novas ameaças são compostas principalmente pelas potências extra regionais que desejam as riquezas dos mares do sul. A defesa desses interesses requer uma Marinha oceânica orientada para o controle do mar, incluindo a projeção do poder naval sobre a terra. O objetivo do estudo é selecionar um tipo de embarcação de desembarque capaz de transportar uma força do Corpo de Fuzileiros Navais que possa cumprir sua função principal de contribuir para os interesses nacionais. O

cento maior do que se sabia. No total, seriam 6.816 quilômetros de extensão, que colocam o país em terceiro lugar na América do Sul e entre os primeiros trinta países do mundo neste critério. Um território muito grande para controlar e defender, sem contar as Ilhas Malvinas, tarefa difícil sem a possibilidade de transferir, de maneira consistente, o poder naval para a terra.

Como já mencionado, com a perda da ARA Cabo San Antonio (O-42) as capacidades de projeção marítima e

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Strategy for Purchase of opportunity of a frigata for the Brazilian Navy through the Multi Criteria THOR Method

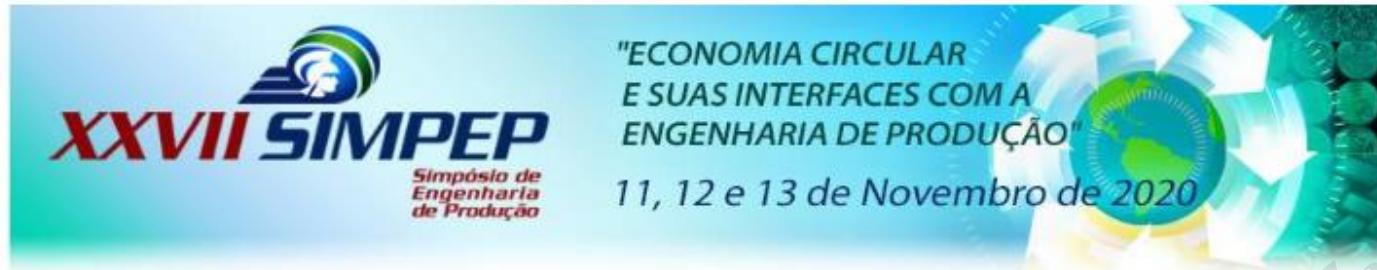
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DYNAMIC MODELLING FOR CHOOSING A PREDICTIVE MODEL OF CHURN THROUGH SAPEVO-M AND VIKOR METHODS

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II Simpósio Brasileiro de Pesquisa Operacional
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SIMPLEX: o método de Dantzig numa feira livre

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Thematic Section - Advances in Analytic Hierarchy Process

PRO
DUÇÃO
PRODUÇÃO

Multi-criteria analysis applied to aircraft selection by Brazilian Navy

Sérgio Mitihiro do Nascimento Maeda^a ,
Igor Pinheiro de Araújo Costa^{a*} , Marcos Alexandre Pinto de Castro Junior^b ,
Luiz Paulo Fávero^c , Arthur Pinheiro de Araújo Costa^d , José Victor de Pina Corriça^d ,
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Authors [M. Santos](#), T. Silva, C. Gomes, J. Vieira, R. Walker

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The 8th Information Technology and Quantitative Management
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Sensitivity Analysis by the PROMETHEE-GAIA method:
Algorithms evaluation for COVID-19 prediction

Miguel Ângelo Lellis Moreira^{a,b*}, Carlos Francisco Simões Gomes^a,
Marcos dos Santos^b, Antonio Carlos da Silva Júnior^c, Igor Pinheiro de Araújo Costa^a



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Strategic Study for Managing the Portfolio of IT Courses Offered by a Corporate Training Company: An Approach in the Light of the ELECTRE-MOr Multicriteria Hybrid Method

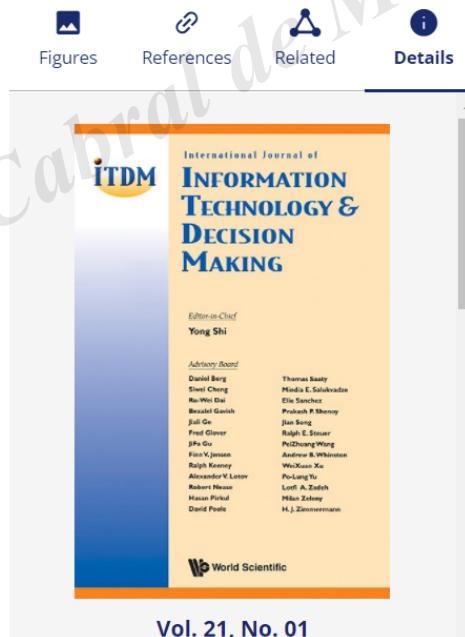
Igor Pinheiro de Araújo Costa✉, Miguel Ângelo Lellis Moreira, Arthur Pinheiro de Araújo Costa,

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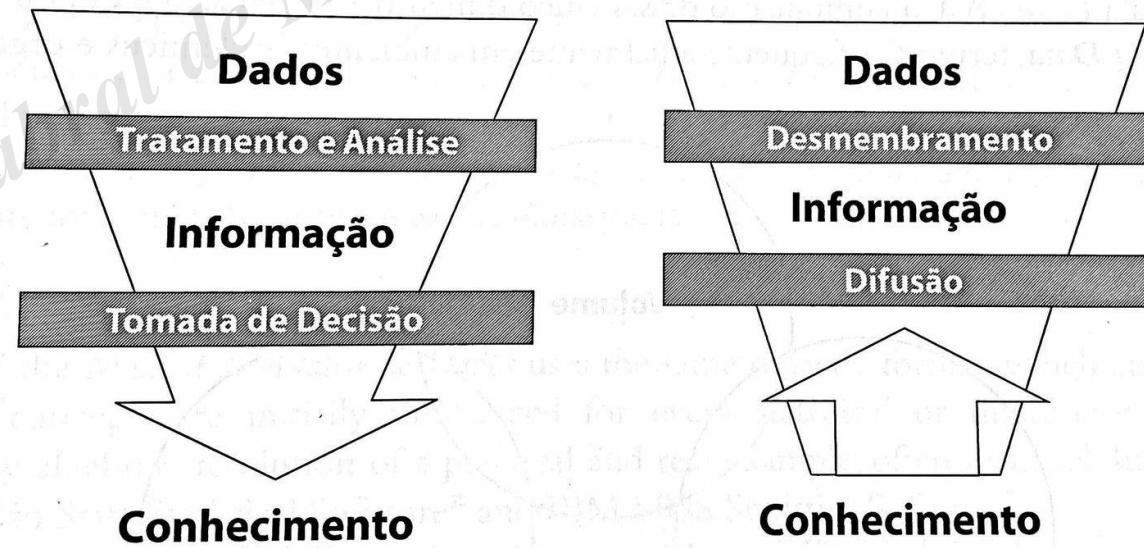


Did you observe the amount of different methods that were used in the work presented?

The researcher who works with O.R. cannot "fall in love" with this or that method.

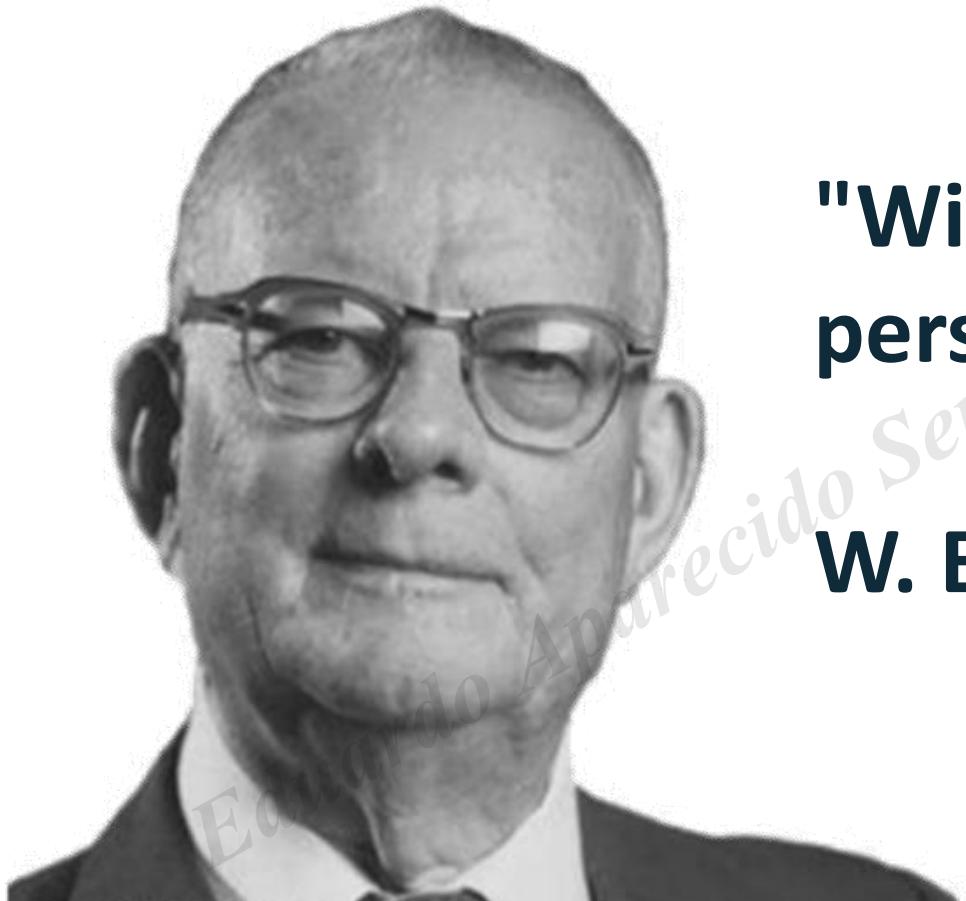
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Operational Research and Data Science are closely related. The models of the O.R. need the data so that they can be processed and can generate a useful result for the decision maker. Otherwise, there's no point having a dataset, in quantity and in quality, if there is not a math model that can form these data to adequately support the decision-making process.



Source: Fávero and Belfiore
(2017)

CLOSING OUR TODAY MEETING



"Without data you are just another person with an opinion".

W. Edwards Deming

FOR THE NEXT CLASS



GOAL



To Explain the basic concepts of Operational Research and of the Decision making Process.

