



Engenharia e sociedade uma visão baseada na prevenção de falhas

Paulo M. S. Tavares de Castro

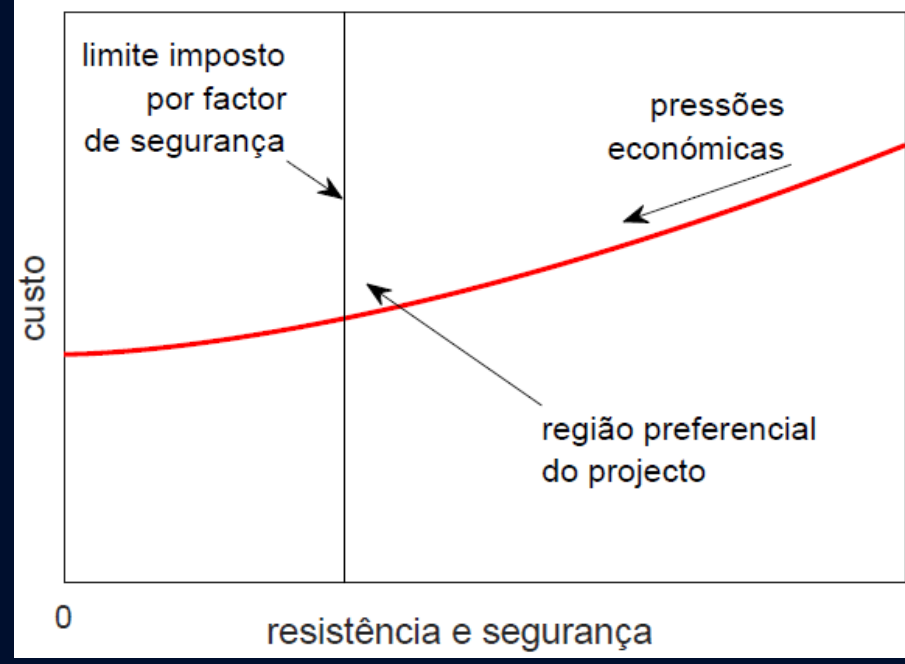
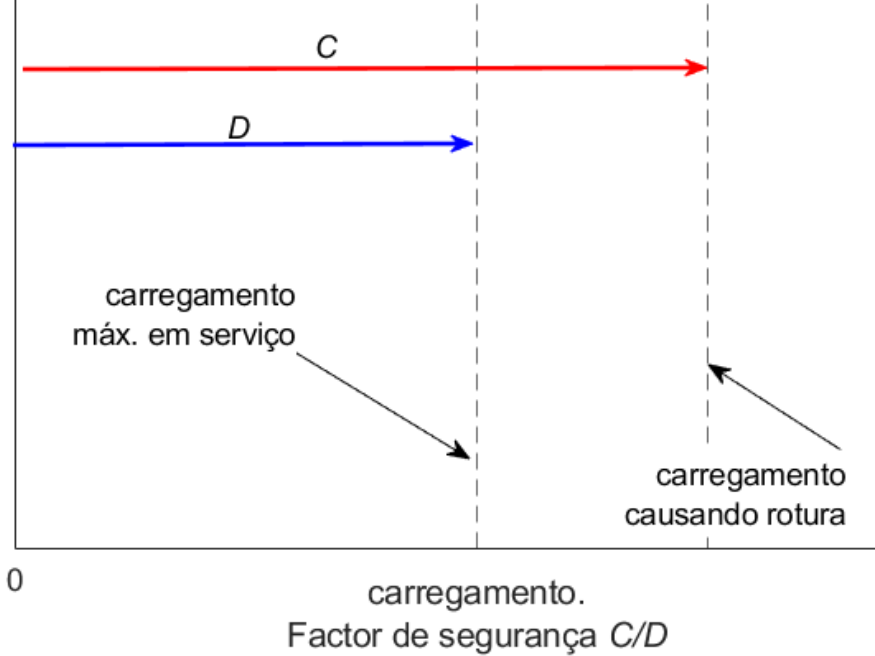
**Faculdade de Engenharia da Universidade do Porto
e
Academia das Ciências de Lisboa**

- 1 – Risco; fiabilidade**
 - 2 – Fadiga; Mecânica da Fractura**
 - 3 – Metodologia; *round robin programmes***
 - 4 – Análise e prevenção de roturas**
 - 5 – Serendipidade**
 - 6 – Aeronáutica e espaço**
 - 7 – Sustentabilidade na aeronáutica**
 - 8 – CTS, revistas**
 - 9 – alguns dados sobre i&d**
 - 10 – PIB; literacia**
- coda ou codetta*

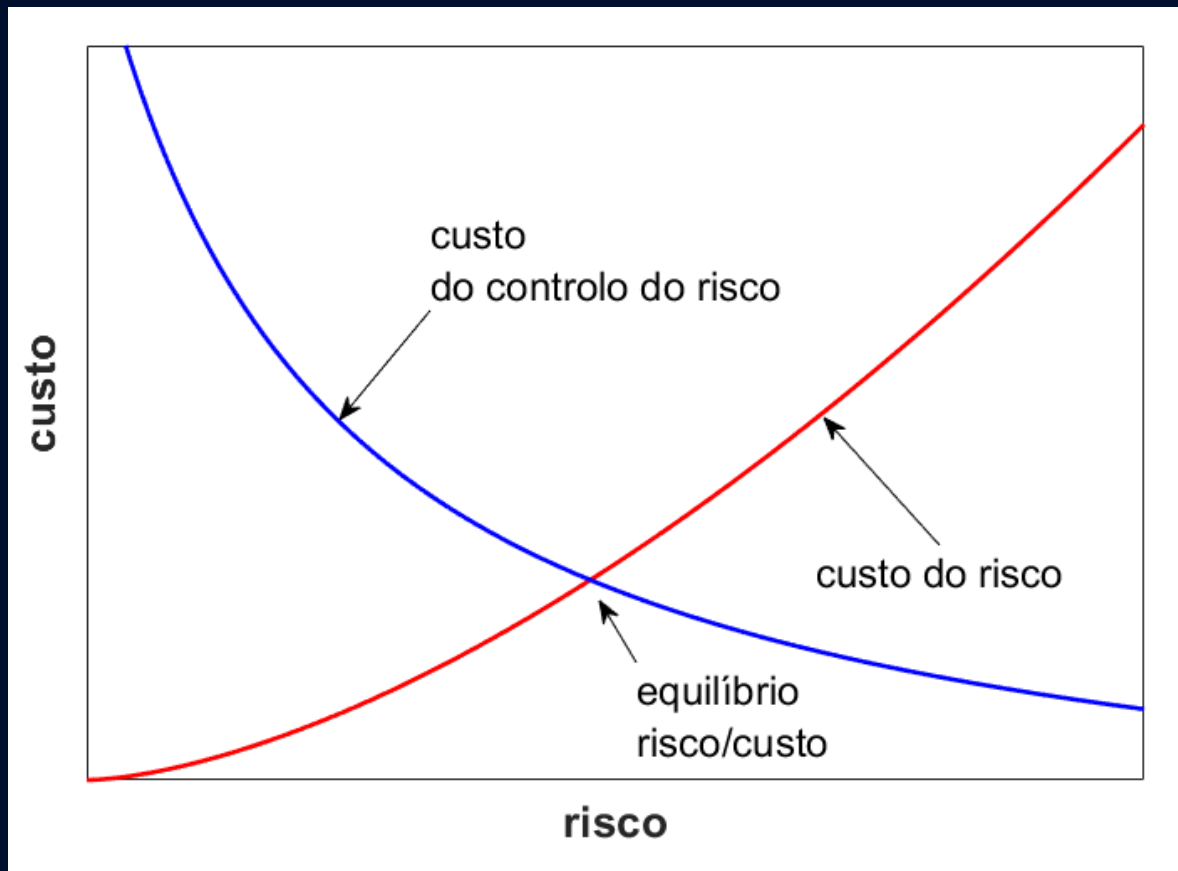
1 – Risco; fiabilidade

Hammurabi's Code:

#229 If a builder builds a house for someone, and does not construct it properly, and the house which he built falls in and kills its owner, then that builder shall be put to death.

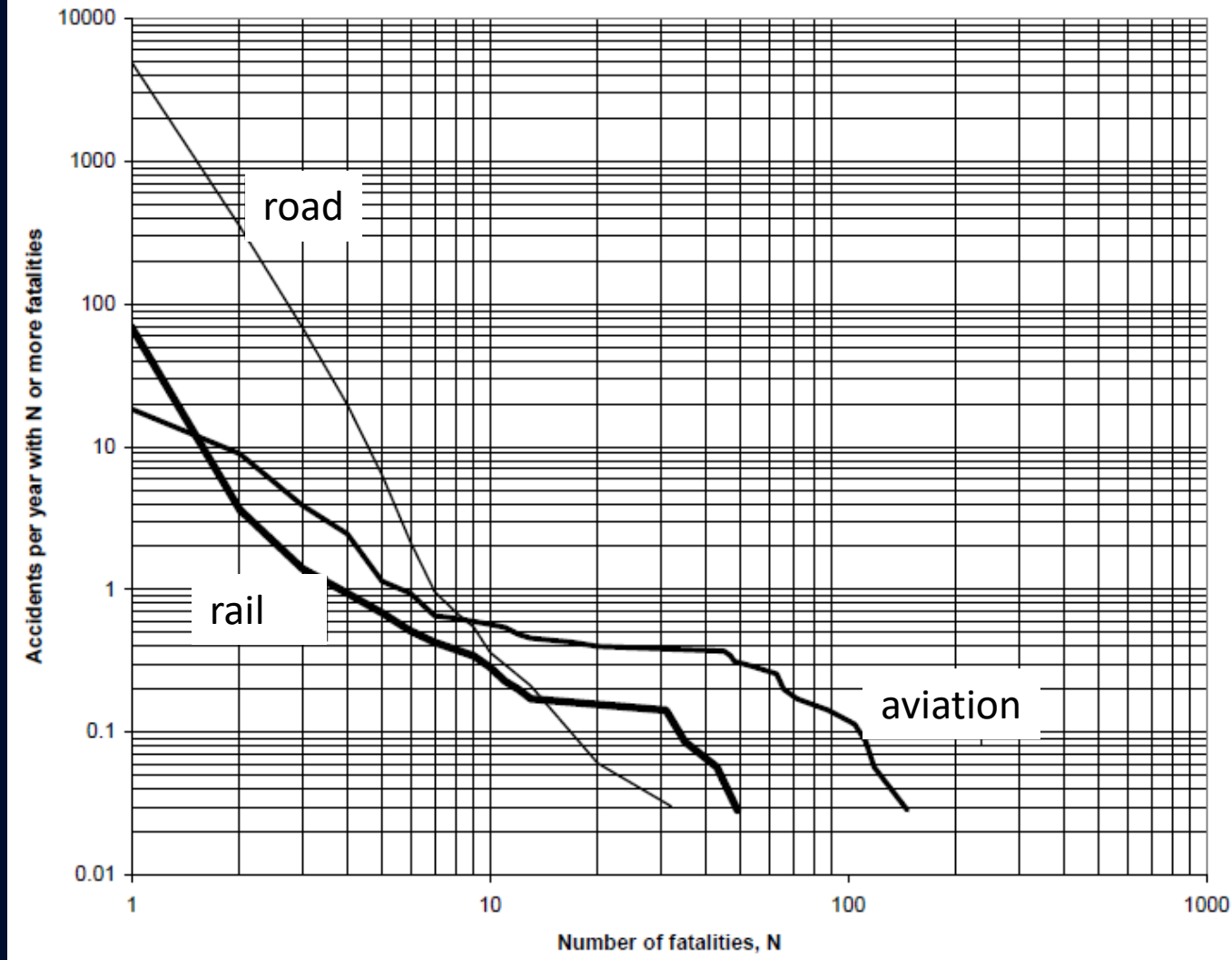


adaptado de: J. Wolfram, 'Safety and risk: models and reality',
Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering, vol.207, (1), pp.3-11, 1993



adaptado de: B. M. Ayyub, 'Risk Analysis and Management', section #207 of: R. C. Dorf, ed., 'The Engineering Handbook', 2nd ed, CRC Press, 2005

Figure 1: FN-curves for road, rail and air transport 1967-2001



W. Evans, 'Transport fatal accidents and FN-curves 1967-2001', prepared by University College London for the Health and Safety Executive - HSE, 2003
<https://www.hse.gov.uk/research/rrpdf/rr073.pdf>

dano / *harm* - resultado ou impacto adverso / *adverse outcome or impact*,

perigo / *hazard* – qualquer fonte potencial de dano / *any potential source of harm*,

risco / *risk* - probabilidade de um dano ocorrer sob circunstâncias definidas / *probability of a harm occurring under defined circumstances*,

segurança / *safety* - condição de não estar exposto - ou de estar protegido - de danos / *condition of not being exposed to or being protected from harm*.

<http://biosafety.org.za/information/know-the-basics/gmo-safety/hazard-harm-risk-and-safety>
https://www.ccohs.ca/oshanswers/hsprograms/hazard/hazard_risk.html

$$\text{risco} \left(\frac{\text{consequência}}{\text{intervalo de tempo}} \right) = \text{frequência} \left(\frac{\text{eventos}}{\text{intervalo de tempo}} \right) \times \text{impacto} \left(\frac{\text{consequências}}{\text{evento}} \right)$$

ex.: acidentes auto, EUA, 1971:

15×10^6 acidentes; 1 em 300 com uma morte. Risco societal de morte por acidente auto é:

$$15 \times 10^6 \frac{\text{acidentes}}{\text{ano}} \times \frac{1 \text{ morte}}{300 \text{ acidentes}} = 50000 \frac{\text{mortes}}{\text{ano}}$$

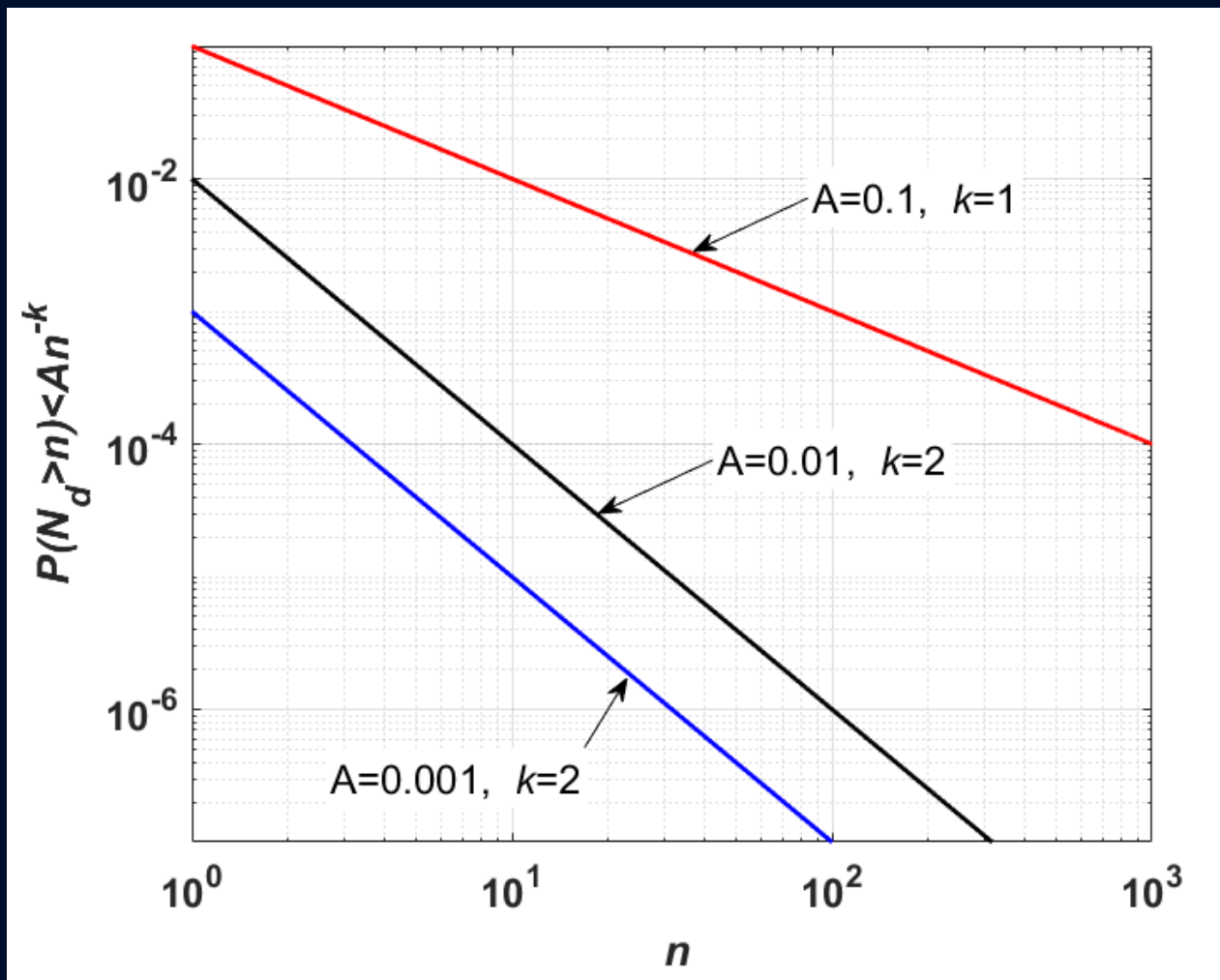
e se a população é $\approx 200 \times 10^6$, o risco individual é

$$\frac{50000 \text{ mortes/ano}}{200 \times 10^6 \text{ pessoas}} = 2.5 \times 10^{-4} \frac{\text{mortes}}{\text{pessoa} \times \text{ano}}$$

$$\text{em 2022: } 1.27 \times 10^{-4} \frac{\text{mortes}}{\text{pessoa} \times \text{ano}}$$

1971: 'Reactor safety study. An assessment of accident risks in U.S. commercial nuclear power plants', U.S. Nuclear Regulatory Commission, Report WASH- 1400 (NUREG 75/014), Oct. 1975. Page 9 of main report.

2022: https://en.wikipedia.org/wiki/Motor_vehicle_fatality_rate_in_U.S._by_year



adaptado de: T. Vrouwenvelder *et al.*, 'Risk assessment and risk communication in Civil Engineering', in: Int. Conf. Safety, Risk, and Reliability - Trends in Engineering, Malta, March 22-23, 2001
 ver tb.: T. Vrouwenvelder *et al.*, eds., 'Risk assessment and risk communication in Civil Engineering', CIB Report 259, 2001 (ver sections 4.2 e 4.3)

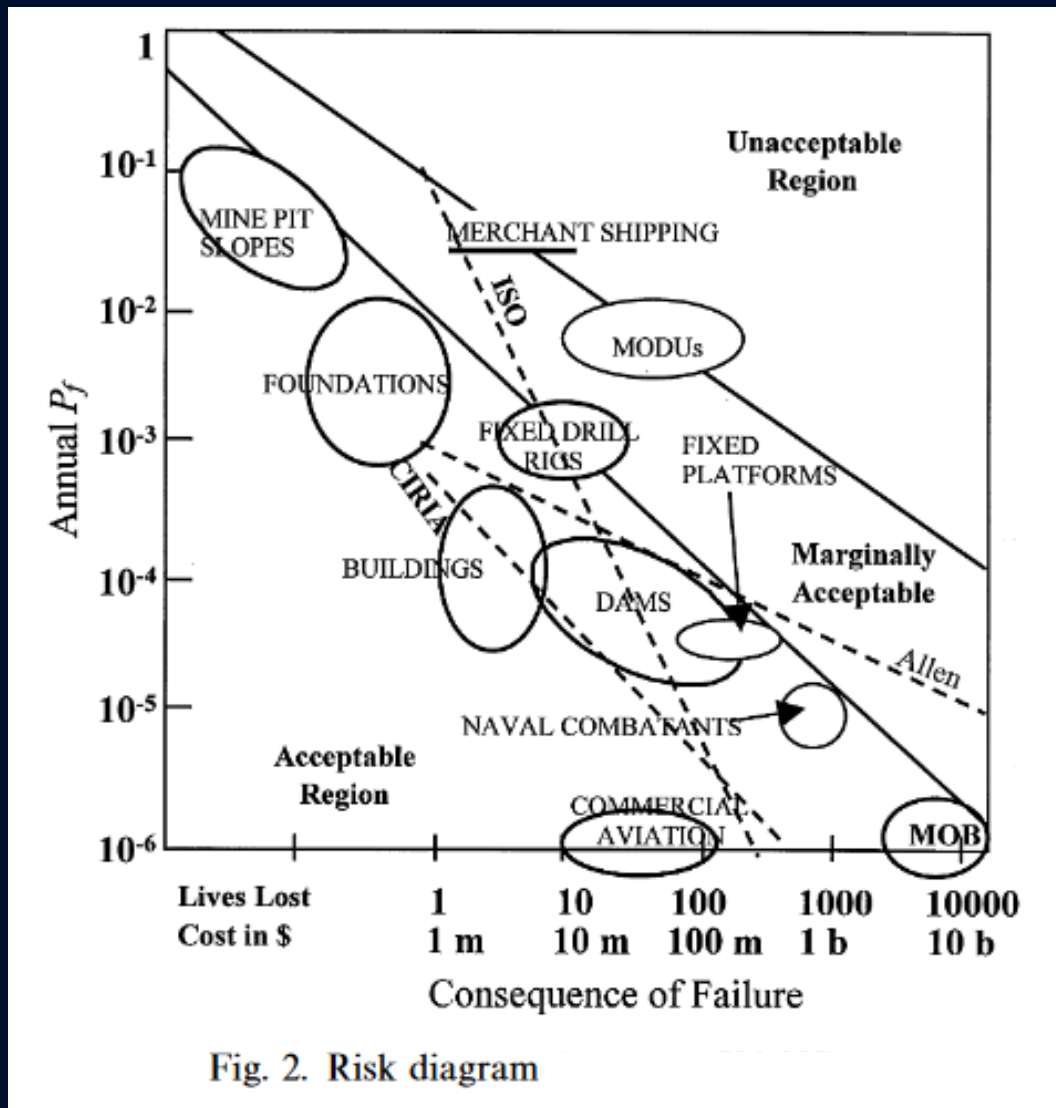
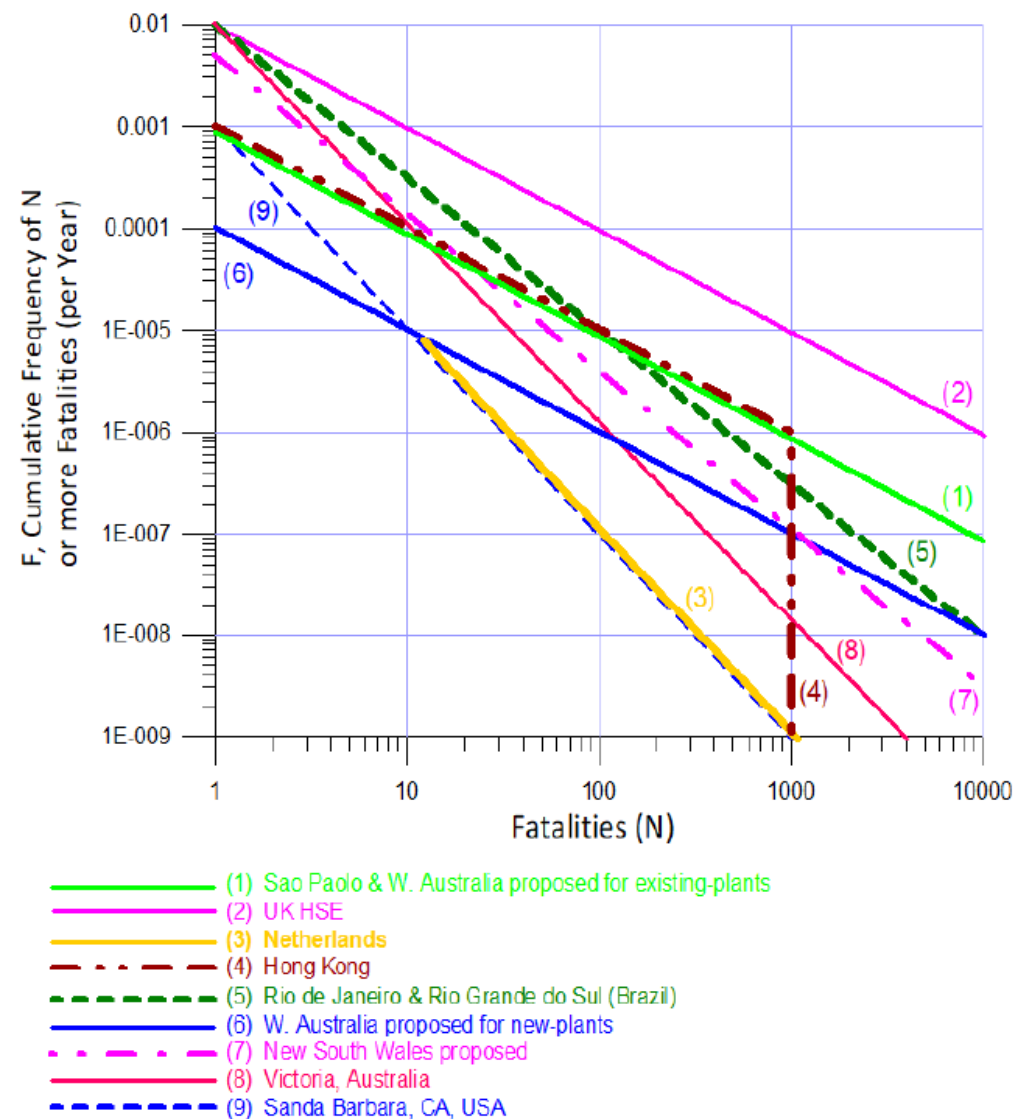


Fig. 2. Risk diagram

B. Bhattacharya, R. Basu, K. Ma, 'Developing target reliability for novel structures: the case of the Mobile Offshore Base', *Marine Structures*, vol.14, 2001, pp.37-58

Maximum Tolerable Societal RACs



Guidelines for

Developing
Quantitative
Safety Risk
Criteria

WILEY

CCPS
Center for Chemical Process Safety

Figure 6. Maximum tolerable societal RACs for the public established in various countries.

Center for Chemical Process Safety, - CCPS 'Guidelines for Developing Quantitative Safety Risk Criteria', Wiley and American Institute of Chemical Engineers, 2009

REACTOR SAFETY STUDY

AN ASSESSMENT
OF ACCIDENT RISKS
in
U.S. COMMERCIAL NUCLEAR POWER PLANTS

U.S. NUCLEAR REGULATORY COMMISSION
OCTOBER 1975

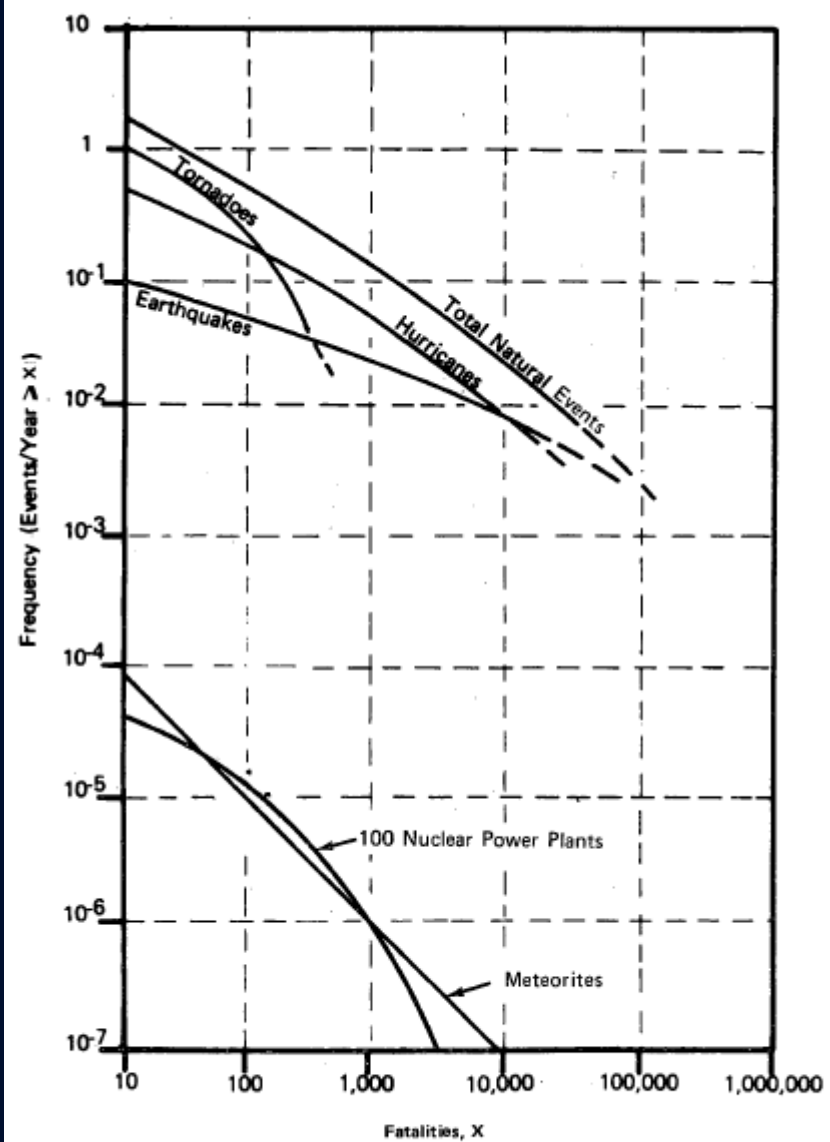


FIGURE 6-2 Frequency of Natural Events Involving Fatalities.

REACTOR SAFETY STUDY

AN ASSESSMENT
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OCTOBER 1975

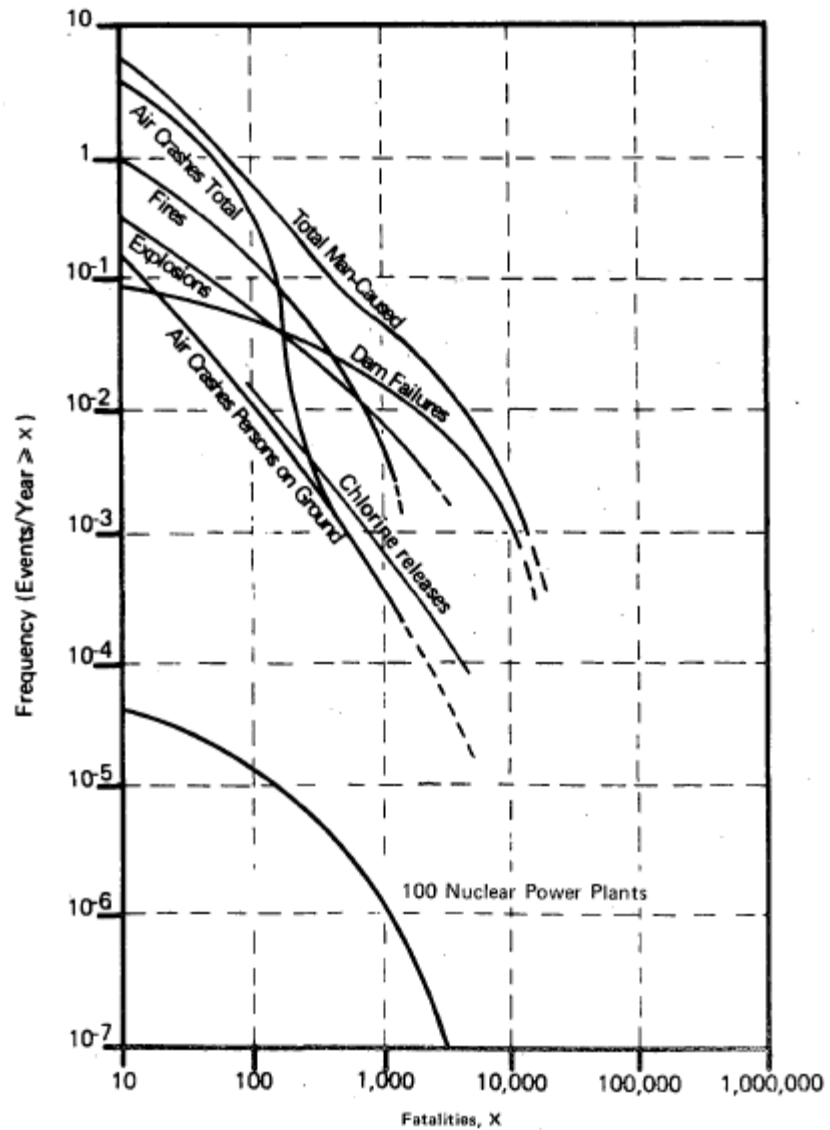


FIGURE 6-1 Frequency of Man-Caused Events Involving Fatalities.

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$$

$$F(x) = \Phi\left(\frac{x-\mu}{\sigma}\right) = \frac{1}{2} \left[1 + \operatorname{erf}\left(\frac{x-\mu}{\sigma\sqrt{2}}\right) \right]$$

S , R - carregamento, resistência (variáveis aleatórias)

probabilidade de sobrevivência $R_0 = P[R > S]$

probabilidade de colapso $P_f = P[R < S] = P[(R - S) < 0]$ e $R_0 = 1 - P_f$

margem de segurança, estado limite Z , $Z = R - S$

média de Z , $\bar{Z} = \bar{R} - \bar{S}$; desvio padrão, $s_Z = \sqrt{s_R^2 + s_S^2}$

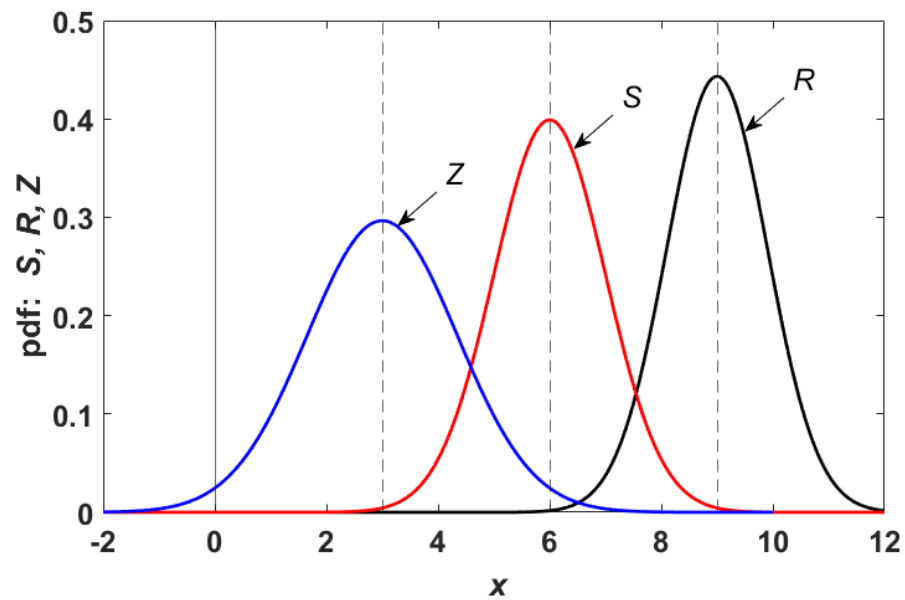
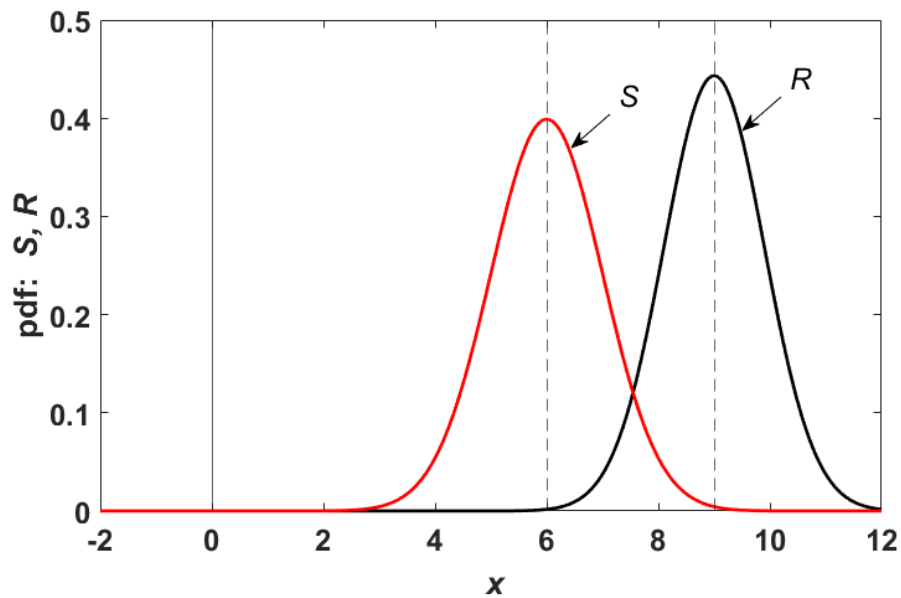
$P_f = P[Z < 0] = P[S > R]$

índice de segurança (*reliability index*) β : $\beta = \bar{Z}/s_Z = \frac{\bar{R} - \bar{S}}{\sqrt{s_R^2 + s_S^2}}$

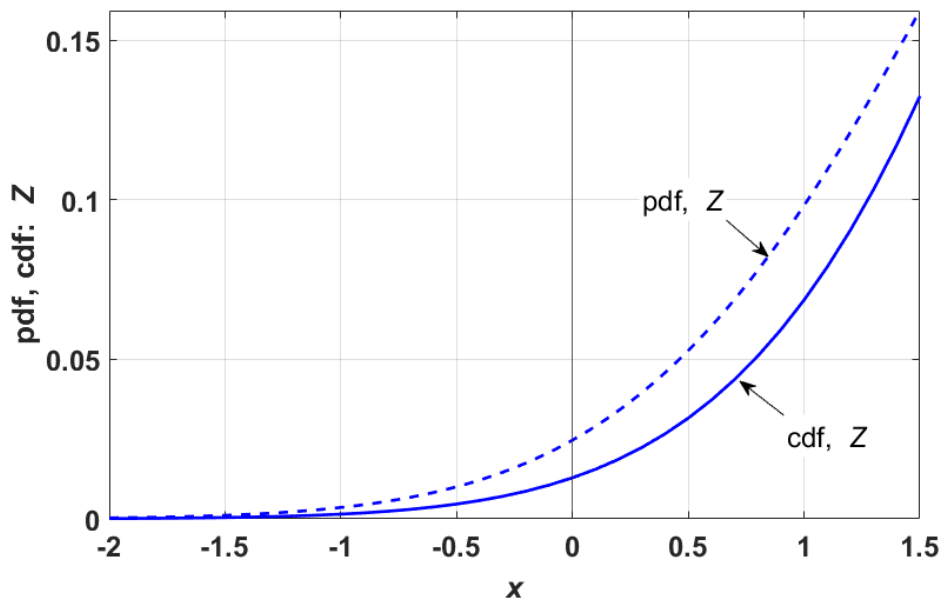
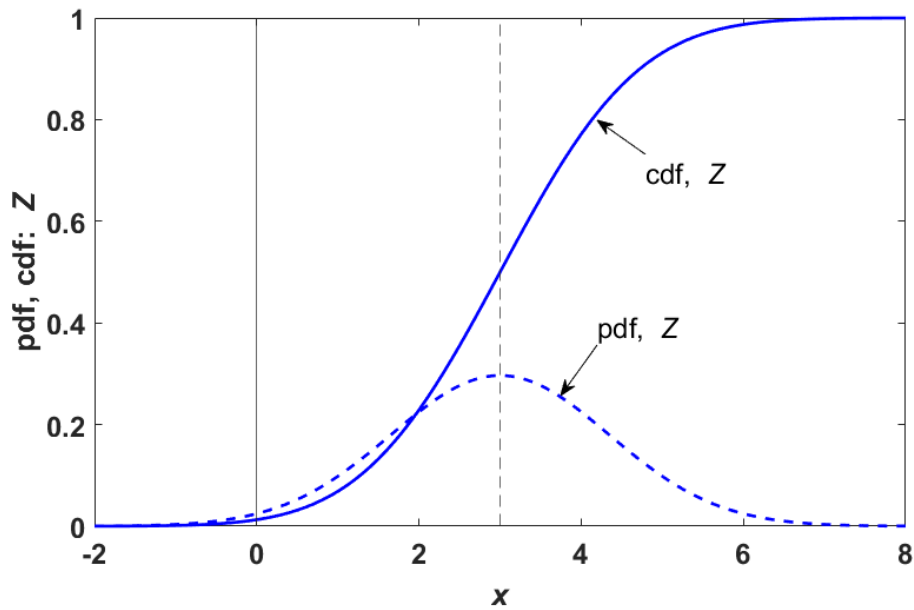
($\beta = \text{n}^\circ$ de desvios-padrão entre carga média e resistência média; aumentar $\beta \Rightarrow$ diminuir P_f)

ver e.g.:

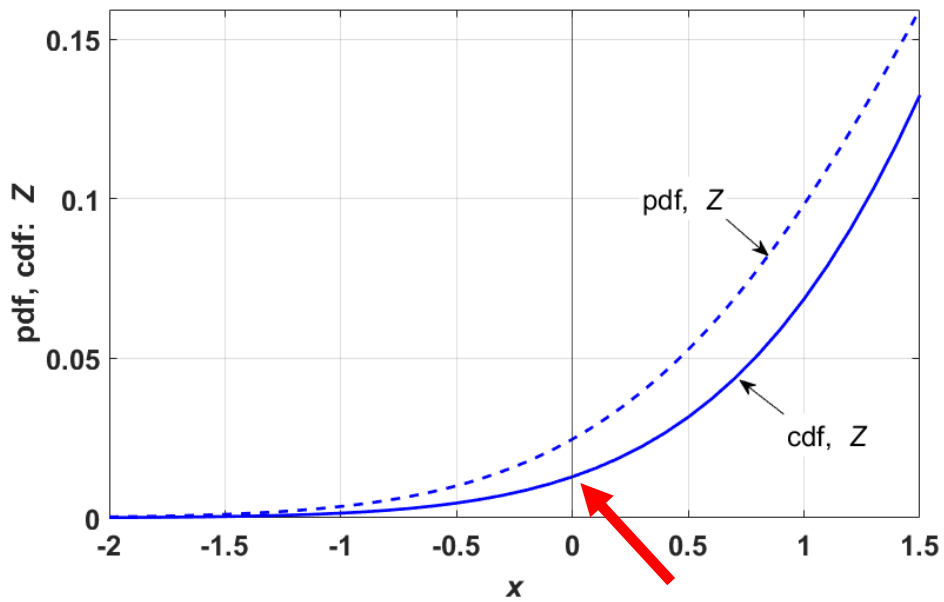
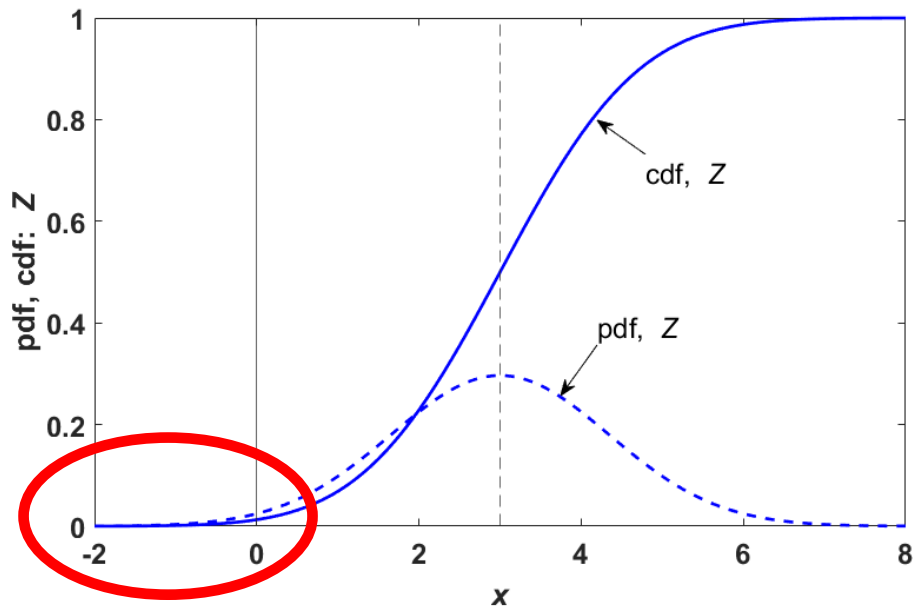
- F. Moses, C. G. Schilling, K. S. Raju, 'Fatigue evaluation procedures for steel bridges', National Cooperative Highway Research Program – NCHRP report 299, Nov. 1987
- P. Albrecht, 'S-N fatigue reliability analysis of highway bridges', ASTM 798, pp.184-204, 1983
- F. Oliveira, *et al.*, 'Avaliação da resistência à fadiga da ponte Luiz I', estudo efectuado para o Instituto da Construção, FEUP, Março de 1996



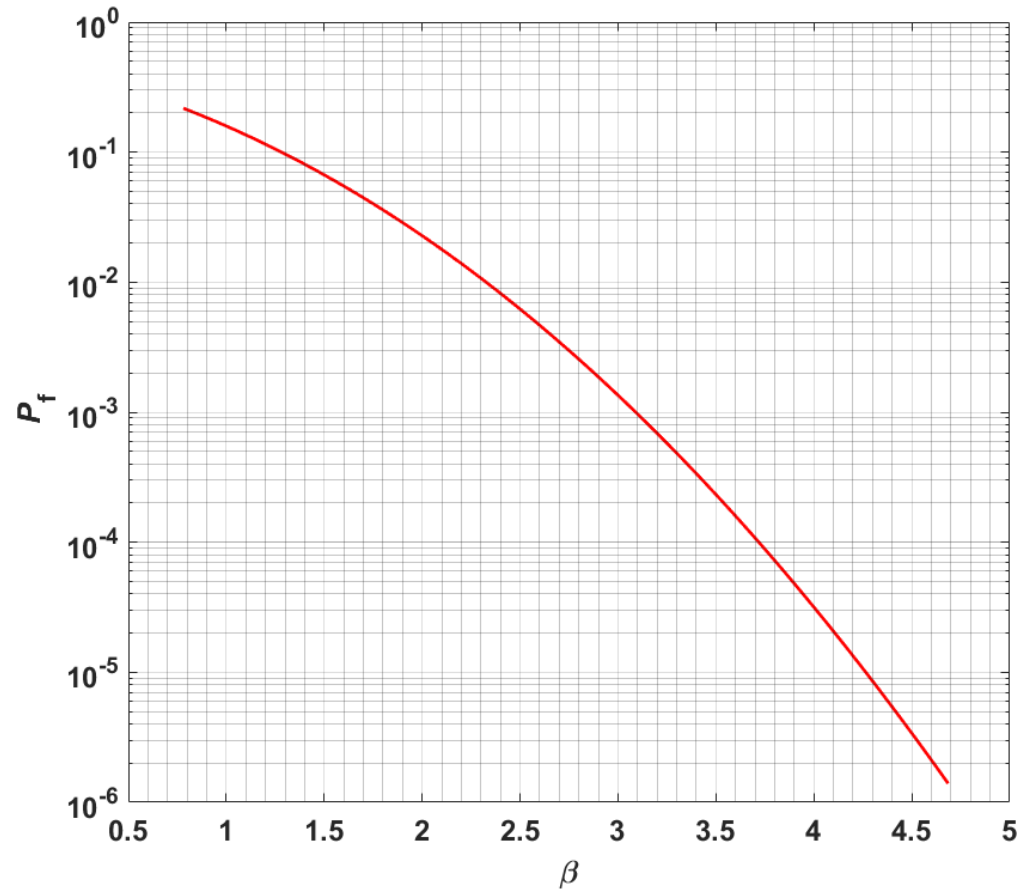
Matlab. $R = 9$; $S = 6$; $s_R = 0.9$; $s_S = 1.0$



Matlab. $R = 9$; $S = 6$; $s_R = 0.9$; $s_S = 1.0$



Matlab. $R = 9$; $S = 6$; $s_R = 0.9$; $s_S = 1.0$



$$P_f = P(Z < 0) = \Phi\left(\frac{0 - \bar{Z}}{s_Z}\right)$$

$$\beta = \bar{Z}/s_Z$$

$$P_f = \Phi\left(\frac{-\bar{Z}}{s_Z}\right) = \Phi(-\beta)$$

2 – Fadiga; mecânica da fractura

durabilidade, fadiga

aspectos básicos,

iniciação:

- Wöhler, curvas SN baseadas em tensões elásticas, Basquin, ...

propagação:

- lei de Paris, ...

e entre outros desenvolvimentos,

iniciação:

- estudos elasto-plásticos: Coffin-Manson, Neuber,
- multiaxialidade

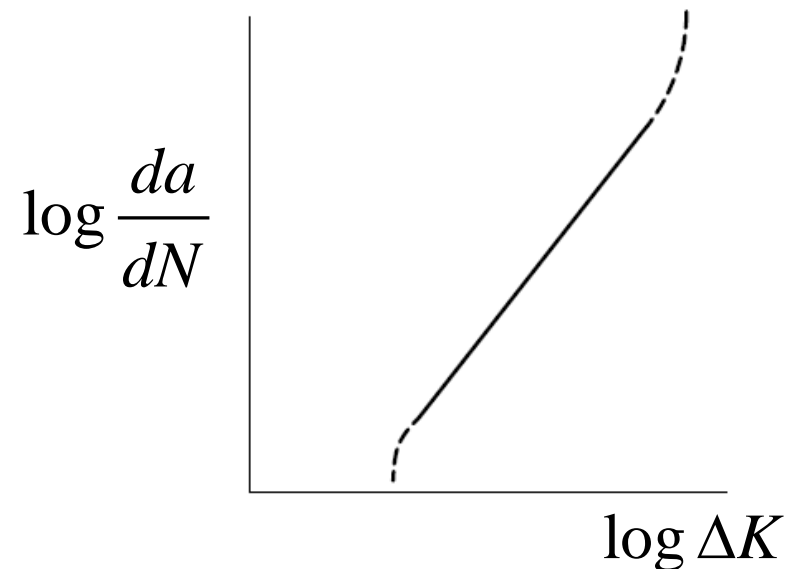
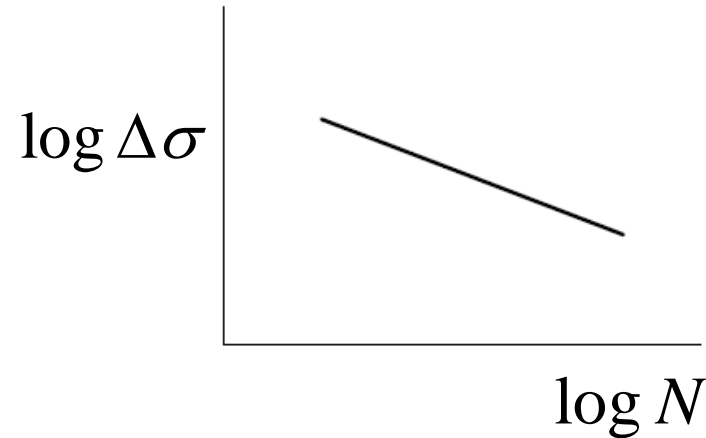
acumulação de dano:

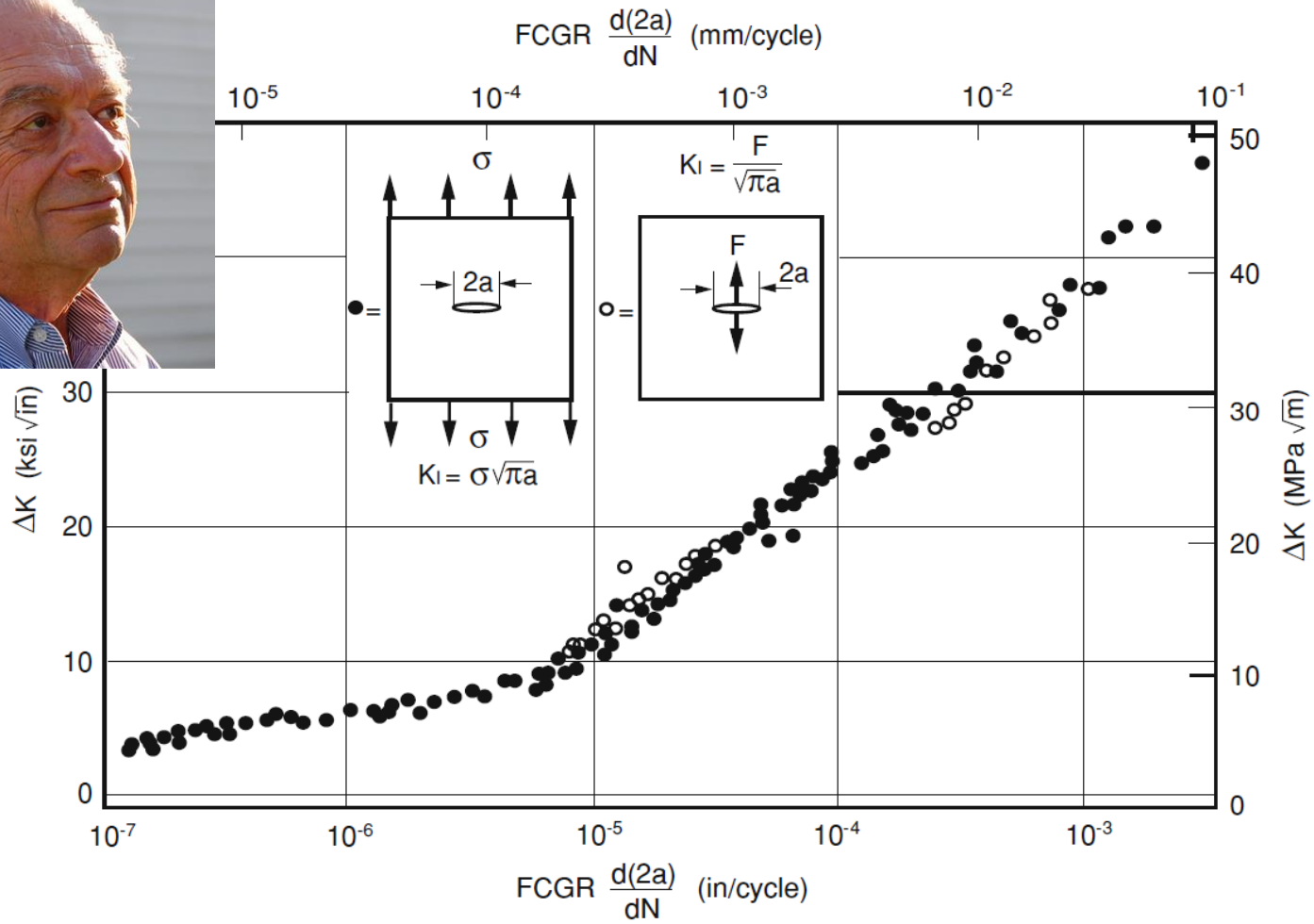
- Miner, contagem de ciclos,

propagação:

- razão de carga $R = \text{carga max.} / \text{carga min.}$,
limiar de propagação,

.....

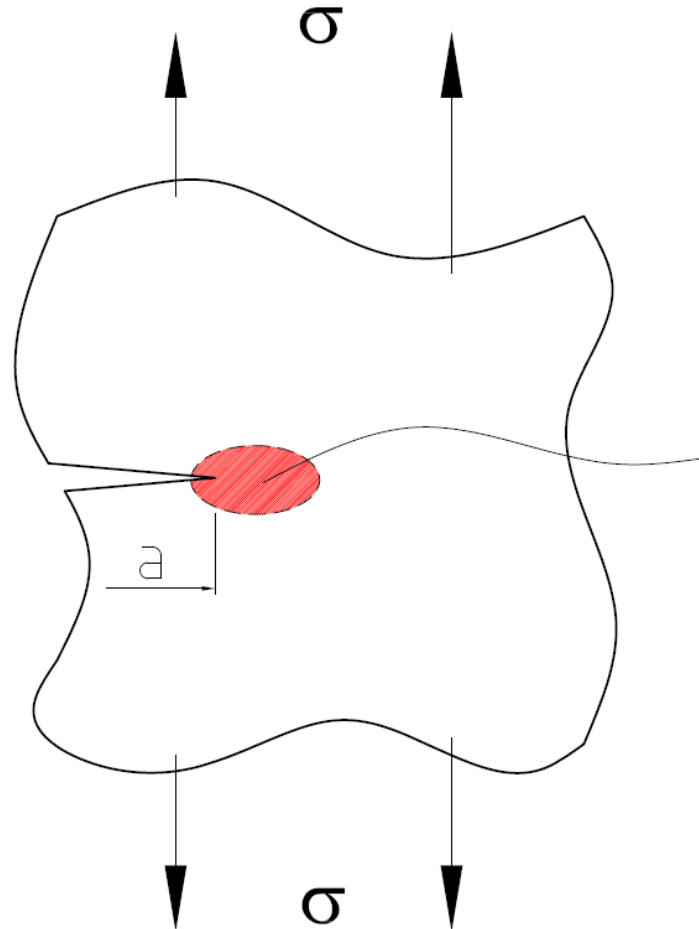




plot from: P. P. Milella, 'Fatigue and Corrosion in Metals', Springer, p.528, 2013
 P. C. Paris, 'The fracture mechanics approach to fatigue', in: Proceedings of the 10th Sagamore Conference, p. 107, Syracuse University Press, 1965
 P. C. Paris, M. P. Gomez, W. E. Anderson, 'A rational analytic theory of fatigue', *The Trend in Engineering*, vol.13, (1), pp.9-14, 1961

K – stress intensity factor

George Irwin

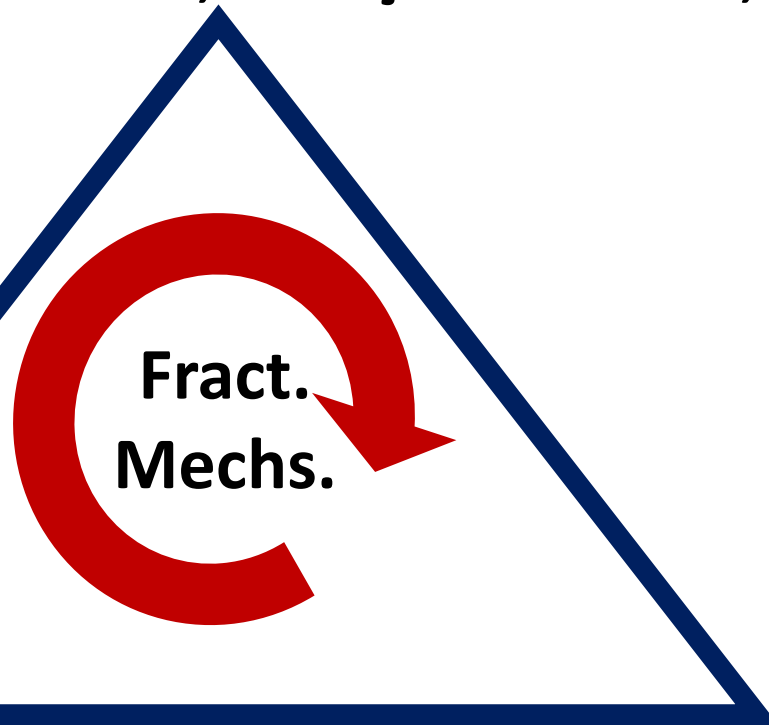


$$\sigma_{local} = f(K)$$

$$K = Y\sigma\sqrt{\pi a}$$

carregamentos:

forças, deslocamentos, condições fronteira, ...



fendas

propriedades do material

comprimento ' a ', ou geometria ...

**tensão de cedência e de rotura,
tenacidade,**



Stephen Timoshenko
1878-1972



George Irwin
1907-1998

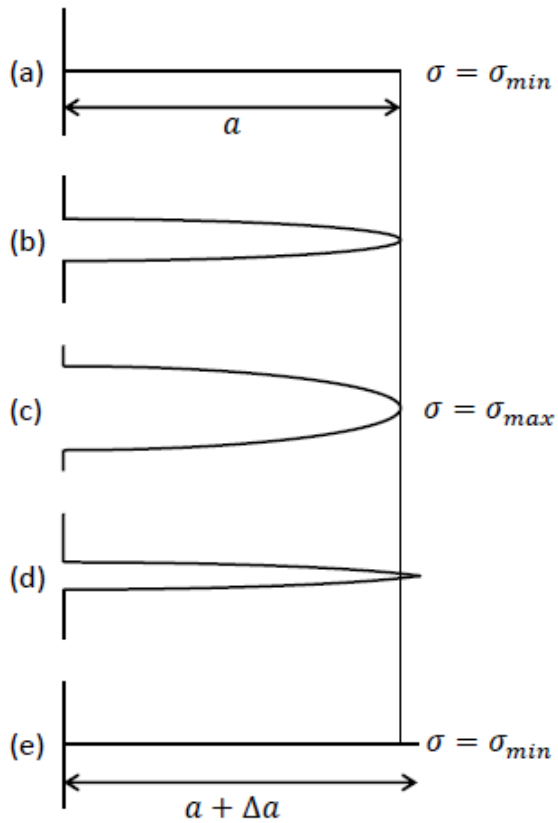


Paul Paris
1930-2017

E. H. Mansfield, D. H. Young, 'Obituary: Stephen Prokofievitch Timoshenko', *Biographical Memoirs of Fellows of the Royal Society*, vol.19, pp.679–694, 1973

A. A. Wells, 'George Rankin Irwin. 26 February 1907 — 9 October 1998', *Biographical Memoirs of Fellows of the Royal Society*, vol.46, pp.269–283, 2000

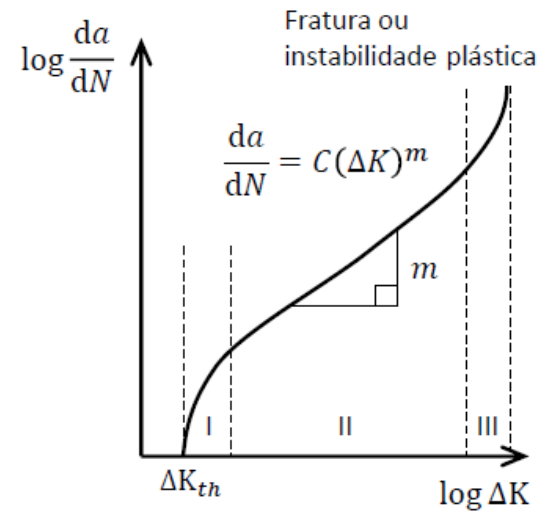
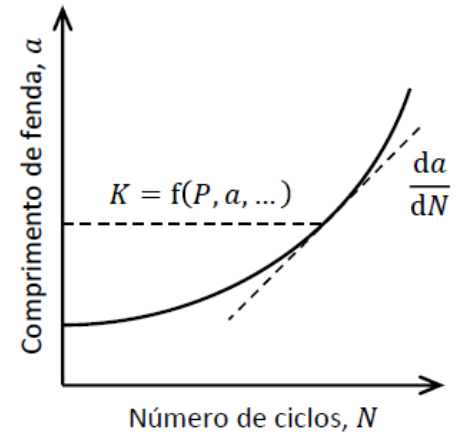
A. Ingrassia, M. Kuna, editorial, 'Dr. Paul Croce Paris. August 7, 1930 – January 15, 2017', *Engineering Fracture Mechanics*, vol.187, pp.1-10, 2018



$$K = Y \sigma \sqrt{\pi a}$$

$$\Delta K = Y \Delta \sigma \sqrt{\pi a}$$

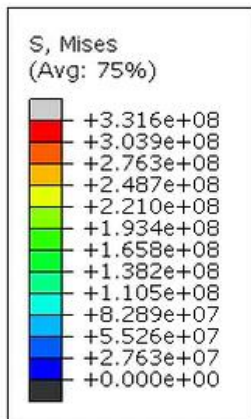
$$\frac{da}{dN} = C (\Delta K)^m$$



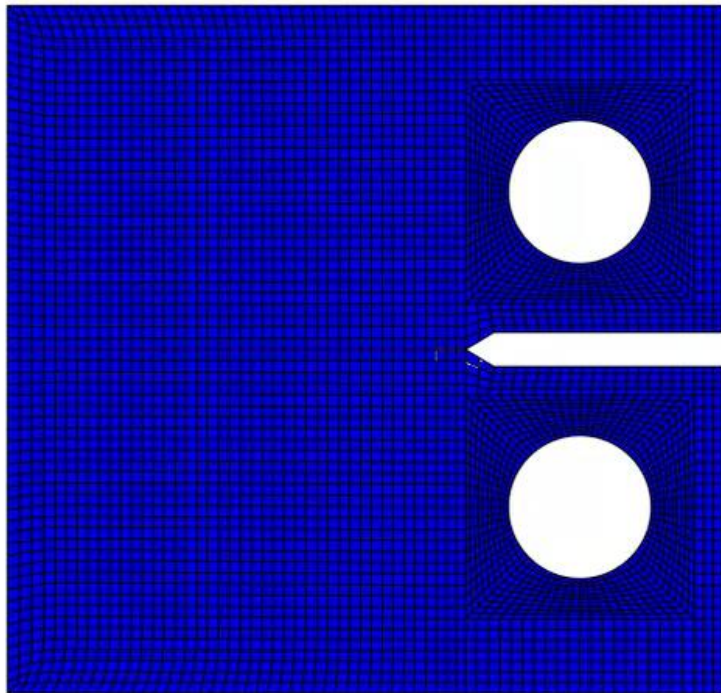
$$N = \frac{a_o^{m/2}}{C \left(\frac{m}{2} - 1 \right) \Delta K^m} \left(\frac{1}{a_o^{\frac{m}{2}-1}} - \frac{1}{a_f^{\frac{m}{2}-1}} \right)$$

$$N = \frac{a_o^{1-\frac{m}{2}} - a_f^{1-\frac{m}{2}}}{C \left(\frac{m}{2} - 1 \right) Y^m \Delta \sigma^m \pi^{m2}}$$

X-FEM prediction of crack path for mode I situation



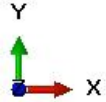
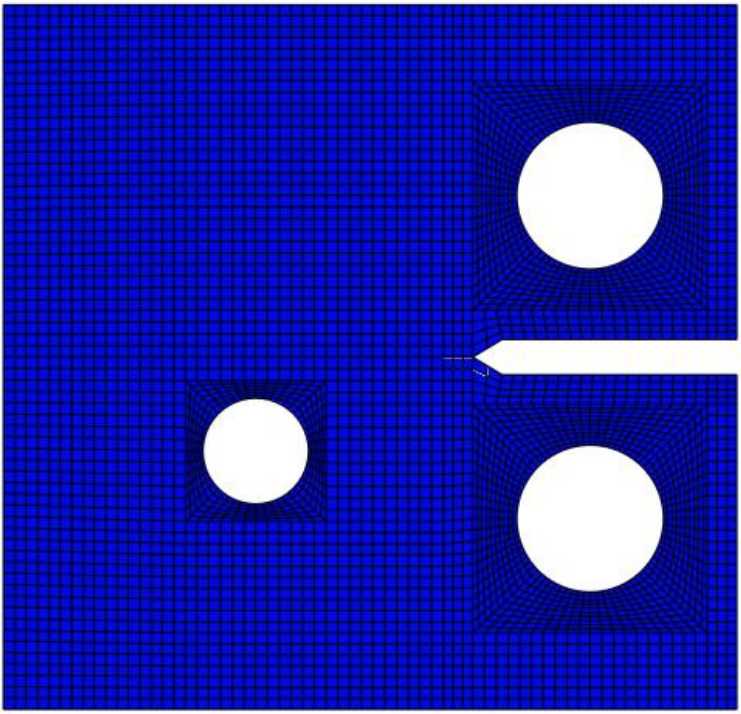
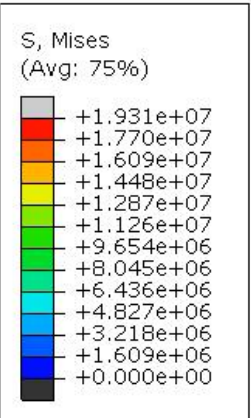
Step: Step-1 Frame: 0
Total Time: 0.000000



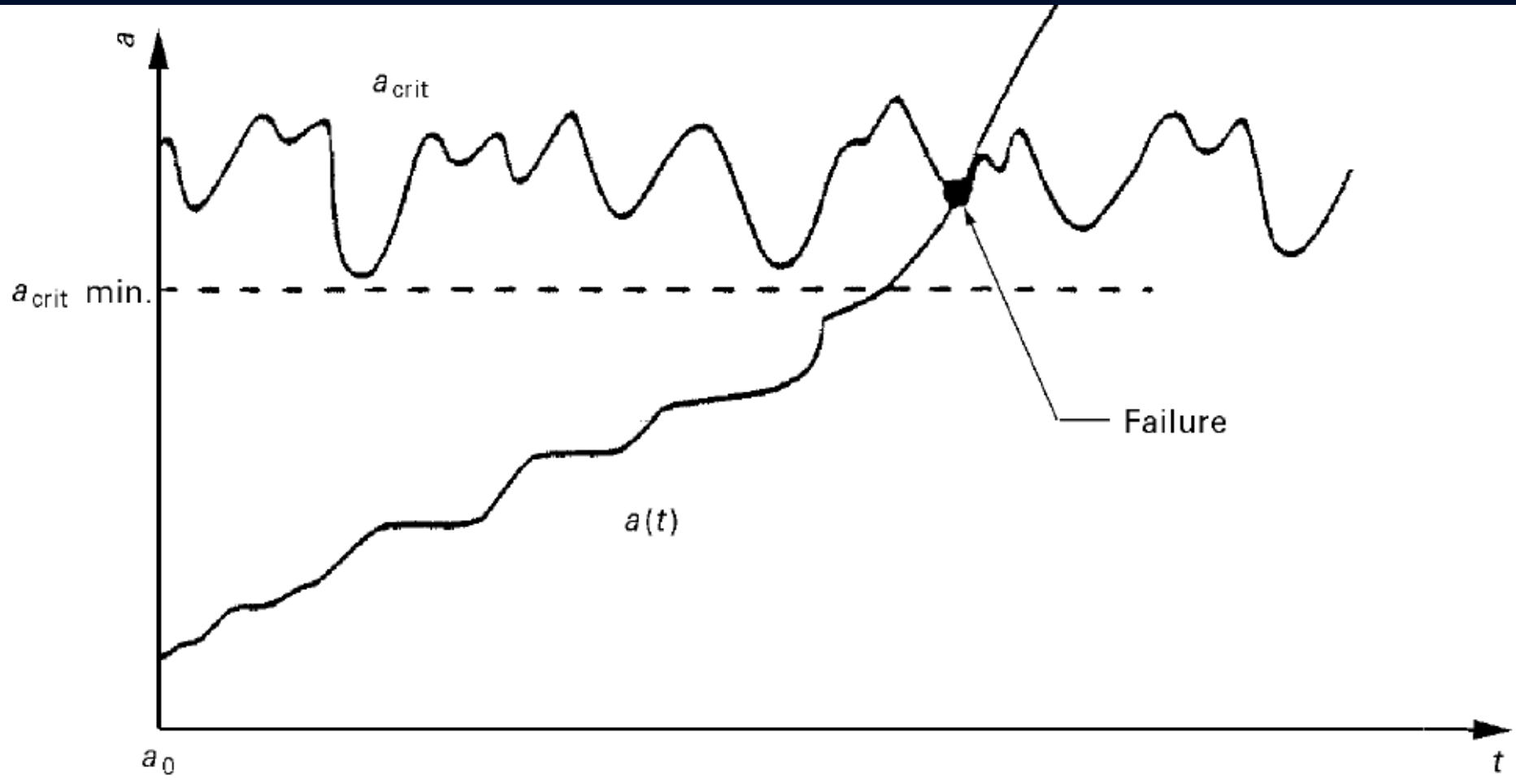
Y
↑
X →
Step: Step-1
Increment 0: Step Time = 0.000
Primary Var: S, Mises
Deformed Var: U Deformation Scale Factor: +2.827e+01

X-FEM prediction of crack path for mixed mode situations

Step: Step-1 Frame: 0
Total Time: 0.000000



Step: Step-1
Increment 0: Step Time = 0.000
Primary Var: S, Mises
Deformed Var: U Deformation Scale Factor: +1.001e+01



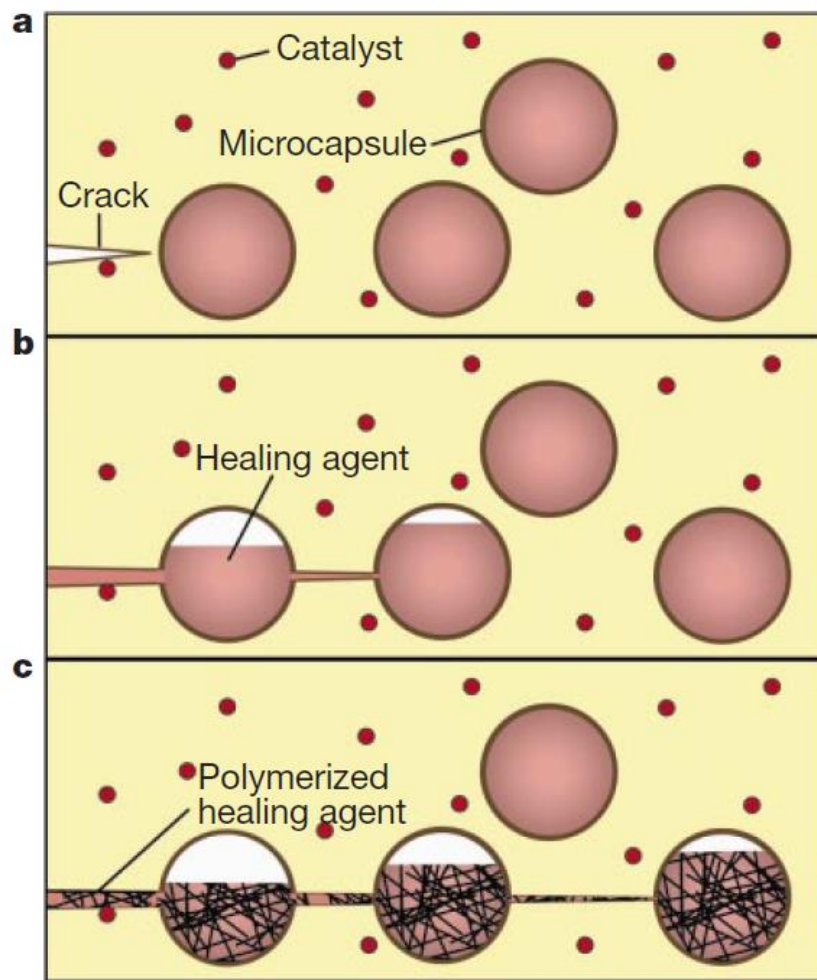


Figure 1 The autonomic healing concept. A microencapsulated healing agent is embedded in a structural composite matrix containing a catalyst capable of polymerizing the healing agent. **a**, Cracks form in the matrix wherever damage occurs; **b**, the crack ruptures the microcapsules, releasing the healing agent into the crack plane through capillary action; **c**, the healing agent contacts the catalyst, triggering polymerization that bonds the crack faces closed.

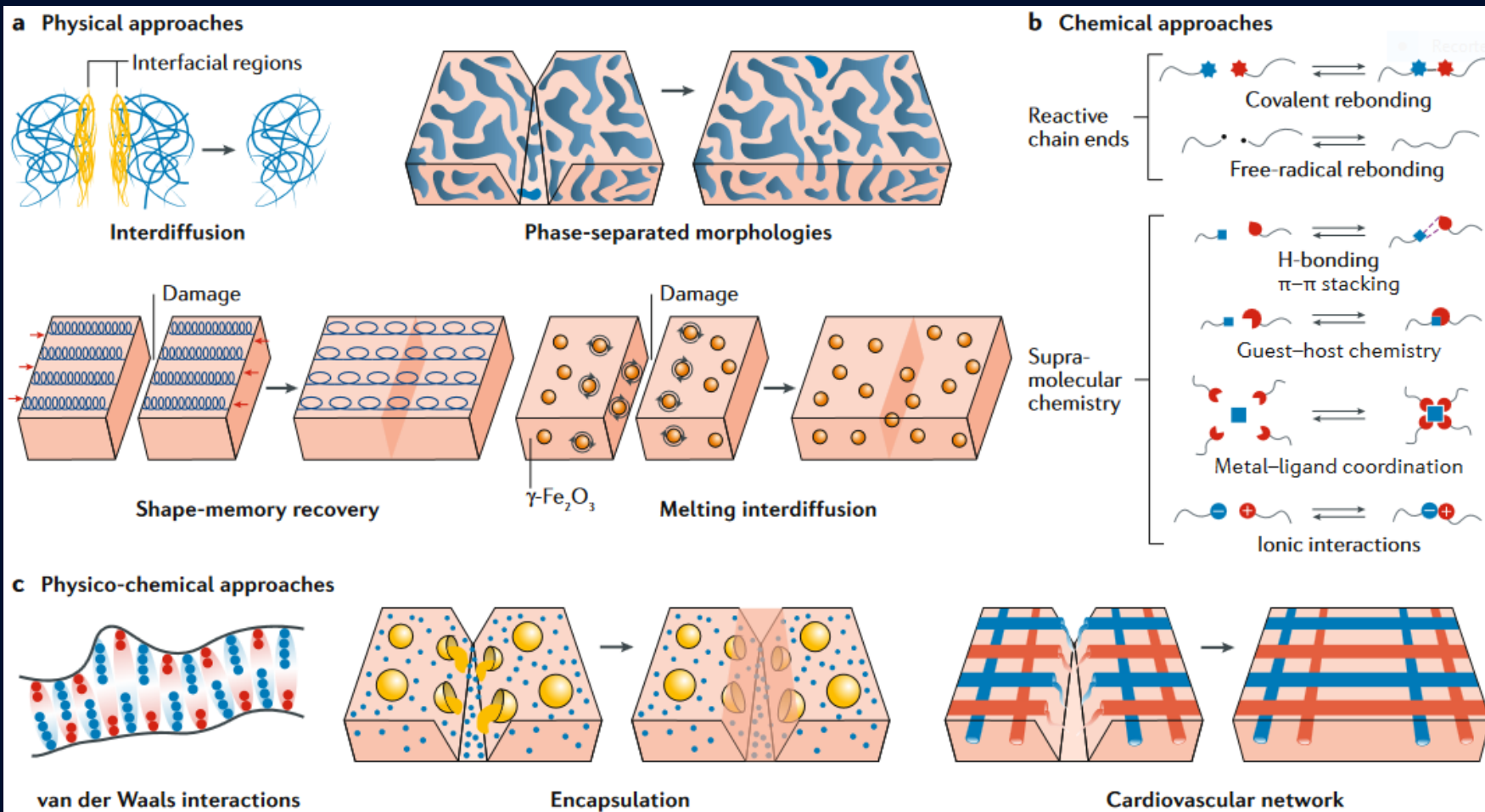


Fig. 1 | Self-healing mechanisms. **a** | Physical processes to realize self-healing include interdiffusion of polymer chains, the introduction of phase-separated morphologies, shape-memory effects and the introduction of active nanoparticles into a polymer matrix. **b** | Chemical processes to facilitate self-healing involve either introducing reactive chain ends or supramolecular chemistries. **c** | Physical and chemical processes can be combined to realize self-healing. Self-healing is achieved by incorporating enhanced van der Waals interactions, or encapsulating nanocapsules or microcapsules containing reactive liquids to heal a wound, or by mimicking cardiovascular architectures composed of hollow fibres filled with reactive chemicals to heal a polymer matrix.



<https://phys.org/news/2023-01-secrets-self-healing-roman-concrete.html>

L. M. Seymour, 'Hot mixing: Mechanistic insights into the durability of ancient Roman concrete', *Science Advances*. 6 Jan. 2023, vol. 9, issue 1, DOI: 10.1126/sciadv.add1602

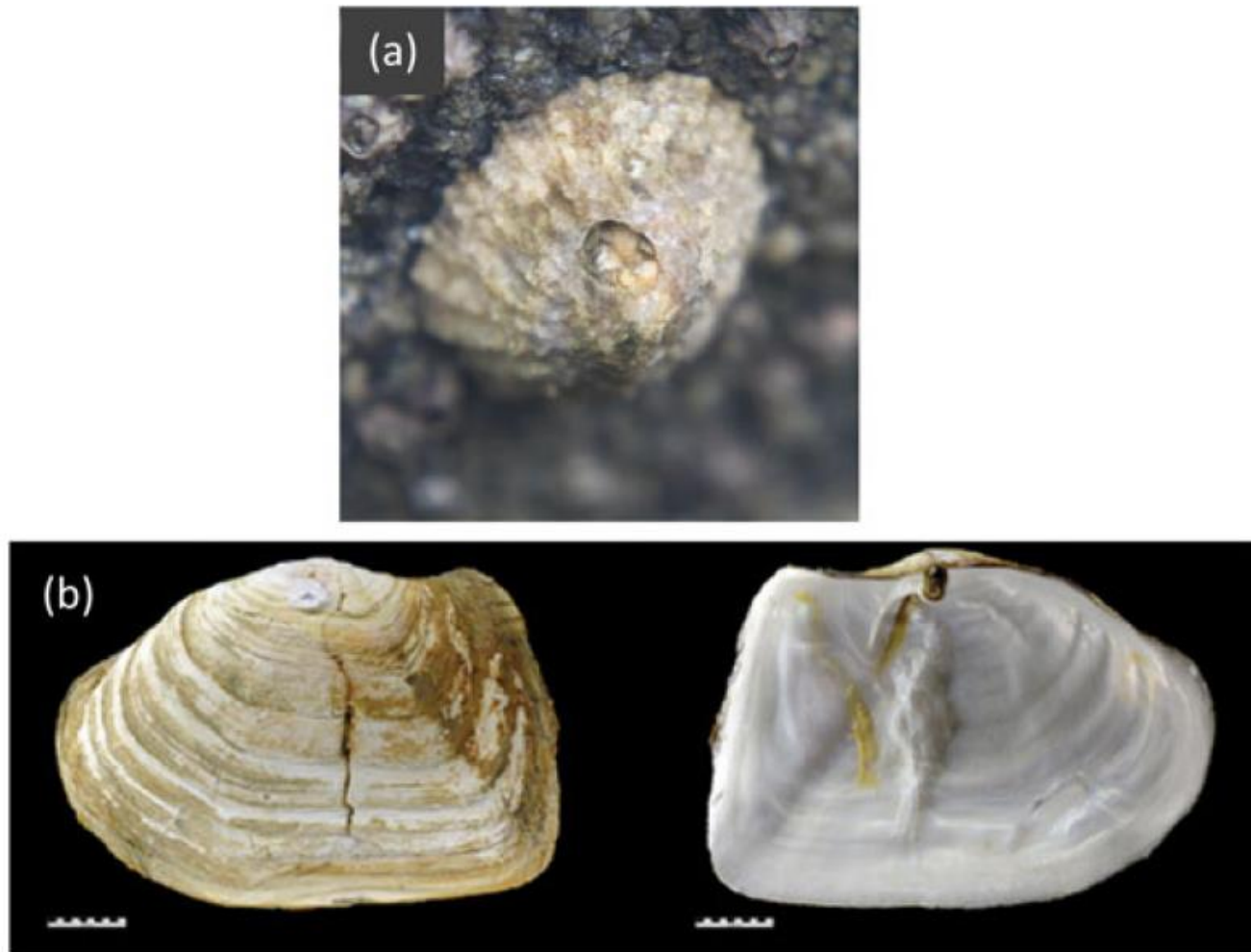
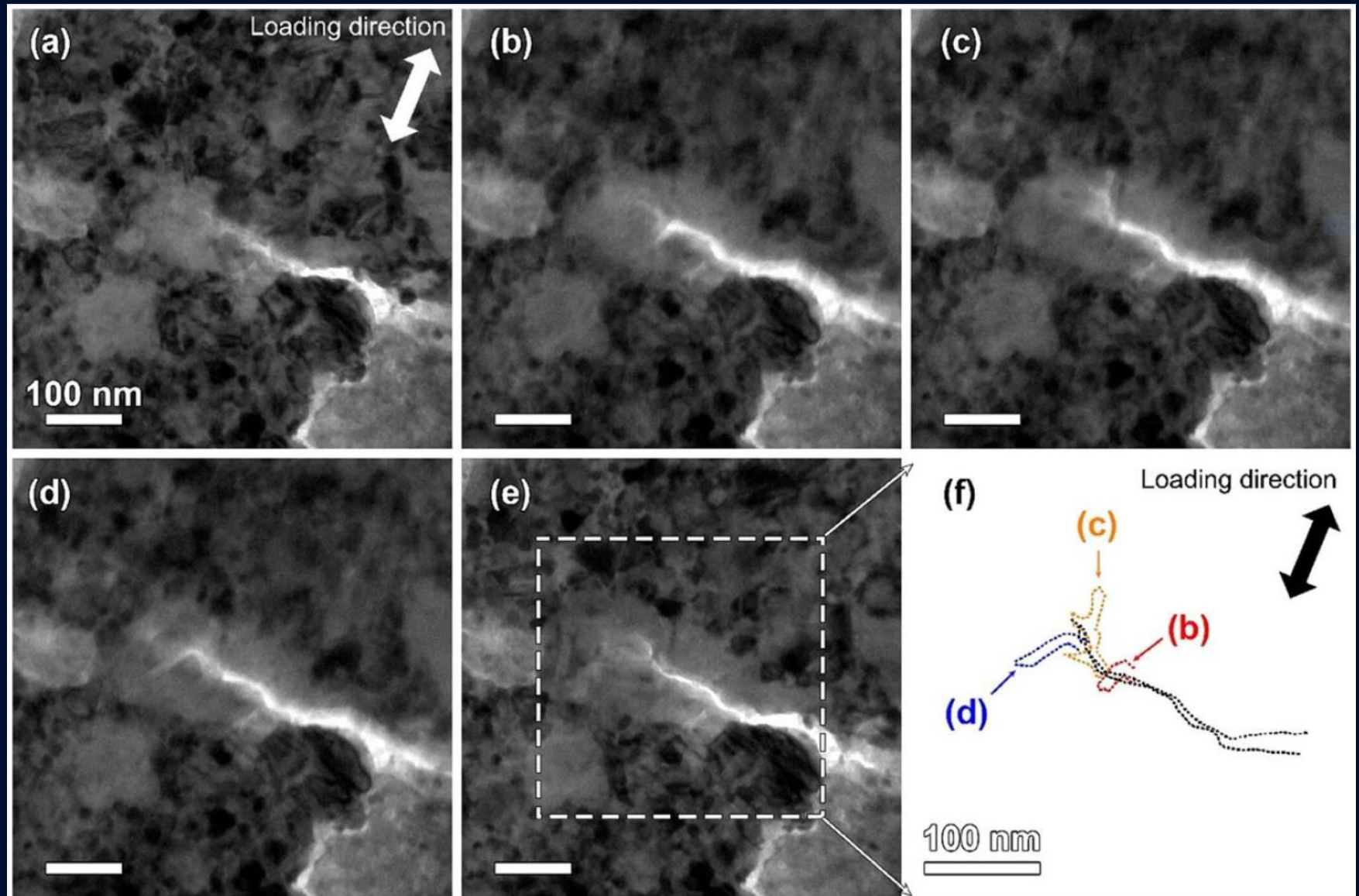


Fig. 2 Examples of damage and repair in molluscs. (a) Impact damage created a hole in the shell of this limpet, which has been repaired by patch formation (previously unpublished photograph). (b) Repair of a crack in the shell of a bivalve (photographed from both sides), showing how the new patch material formed underneath the cracked area.¹⁵ [Colour figure can be viewed at wileyonlinelibrary.com]





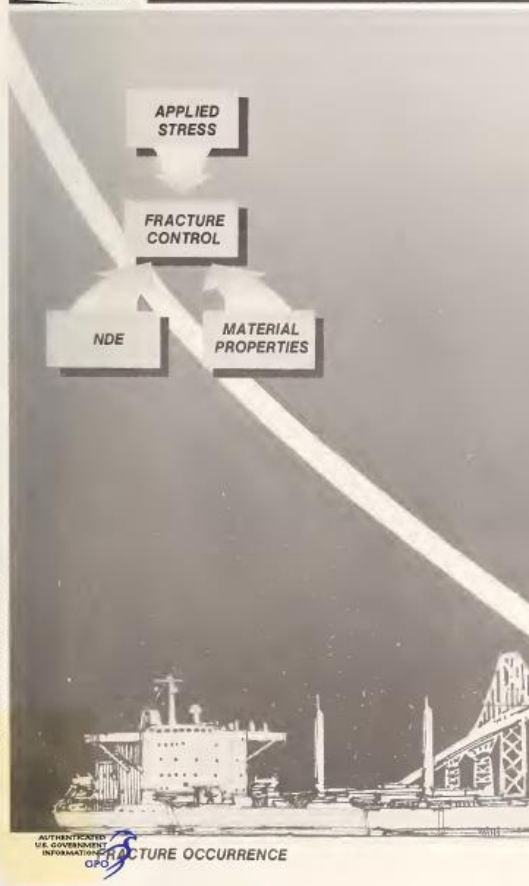
111107 198147 MERCE
National Bureau of Standards

SPECIAL PUBLICATION 647-1

The Economic Effects of Fracture in the United States

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FRACTURE PREVENTION



AUTHENTICATED
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INFORMATION
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The Economic Effects of Fracture in the United States

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FRACTURE PREVENTION



FRACTURE OCCURRENCE

A11103 066607



NBS SPECIAL PUBLICATION 511-1

U.S. DEPARTMENT OF COMMERCE / National Bureau of Standards

ECONOMIC EFFECTS OF METALLIC CORROSION IN THE UNITED STATES

511-1
B

SPECIAL PUBLICATION 511-2

U.S. DEPARTMENT OF COMMERCE / National Bureau of Standards

ECONOMIC EFFECTS OF METALLIC CORROSION IN THE UNITED STATES—

Appendix B)

Report to NBS
by
Columbus Laboratories

PROGRAMME
AND CALL FOR REGISTRATION

Symposium on

**“Risk and Economic Evaluation
on Failure and
Malfunction of Systems”**

Workshop on

**“Cost and Insurance Assessment
of Failures”**

To be held in Lisbon

30, 31 October and 1 November 1995

An ISTLI (International Society For Technology,
Law and Insurance) Symposium

Organised by SPM (Portuguese Society of Materials)

SYMPOSIUM

**"RISK AND ECONOMIC
EVALUATION ON FAILURE AND
MALFUNCTION OF SYSTEMS"**

WORKSHOP

**"COST AND INSURANCE
ASSESSMENT OF FAILURES"**

LISBON-30, 31 OCTOBER/1 NOVEMBER 1995

AN ISTLI
(INTERNATIONAL SOCIETY FOR TECHNOLOGY,
LAW AND INSURANCE)
SYMPOSIUM

ORGANISED BY SPM
(PORTUGUESE SOCIETY OF MATERIALS)

Vol.1

Vol.2

Vol.3

PROCEEDINGS PREPRINTS

PROCEEDINGS PREPRINTS

PROCEEDINGS PREPRINTS

THE ECONOMIC EFFECTS
OF FRACTURE IN EUROPE

Final Report

STUDY CONTRACT No. 320105

between

THE EUROPEAN ATOMIC ENERGY COMMUNITY

and

THE STICHTING VOOR TOEPASSING VAN MATERIALEN
(DELFT-NEDERLAND)

PROJECT LEADER AND RAPPORTEUR

PROF. LUCIANO FARIA

(CEMUL - Centro de Mecânica e Materiais da Universidade Técnica de Lisboa)

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CONFIDENCIAL

3 – Metodologia; *round robin programmes*



Development of the Euro fracture toughness dataset

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Institute of Materials Research, GKSS Research Centre Geesthacht, Max-Planck-Street, D-21502 Geesthacht, Germany

Received 7 February 2000; received in revised form 12 January 2001; accepted 26 January 2001

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J. Heerens, D. Hellmann / Engineering Fracture Mechanics 69 (2002) 421–449

Table 1 (continued)

Laboratory number	Test laboratories	<i>T</i> (°C)	Size	Number of tests	Steel block indication
9	SCK CEN, Boeretang 200, B2400 Mol, Belgium	0	1/2T	22	SX8
		0	1T	11	SX10,8
		−10	1T	5	SX6
10	VTT, Metals Laboratory, Kemistintie 3, 02150 Espoo, Finland	−20	1T	20	SX16
		−20	1TSG	20	SX14
		0	1T	20	SX18

Consulting partners

- 11 Magnox Electric, Berkeley Centre, Glou. GL139PB, United Kingdom
- 12 AEA Technology, Risely Lab. RD3/122, Warrington WA3 6AT, United Kingdom
- 13 Univ. do Porto, Dep. de Engen. IDMEC, Rua dos Bragas, 4099 Porto, Portugal
- 14 Imperial College, Dep. of Mech. Engineering, Exhibition Road, London SW7 2BX, United Kingdom
- 15 Fraunhofer Institut für Werkstoffmechanik, Wöhlerstrasse 11, D79108 Freiburg, Germany

**Statistical and Geometrical Analysis
of Fracture Toughness Data**

Carla Costa e Silva*, Elza M Fonseca*,
José Laiginha Leal*, Paulo M S T de Castro⁺

Departamento de Engenharia Mecânica e Gestão Industrial
Faculdade de Engenharia da Universidade do Porto
Rua dos Bragas, 4099 Porto
Portugal

*Contribution of the Universidade do Porto to phase I of the EC
M&T Project no. MAT CT940080, 'Fracture Toughness of Steel in
the Ductile to Brittle Transition Regime'.
Porto, 23rd July 1996*

C. C. e Silva, E. M. Fonseca, J. L. Leal, P. M. S. T. de Castro, 'Statistical and geometrical analysis of fracture toughness data', EC M&T project no. MAT CT940080 - 'Fracture Toughness of Steel in the Ductile to Brittle Transition Regime', 23rd July 1996



Measurement and Testing Programme
Contract MAT1-CT-940080

FINAL REPORT

**Fracture Toughness of Steel in the Ductile
to Brittle Transition Regime**

J. Heerens
D. Hellmann
GKSS Forschungszentrum Geesthacht

February 1999

EC M&T project MAT CT940080 - 'Fracture Toughness of Steel in the Ductile to Brittle Transition Regime'. *Project leader:* GKSS; partners: AEA, BAM, CISE, CEA, Imperial College, FhG, IRSID, Nuclear Electric, Siemens, TWI, IEHK-Aachen, SCK-CEN, VTT, Universidade do Porto-IDMEC. *Concerted action* aprovada em Nov. 1994. **1995 - 1998.**

Statistical and Geometrical Analysis
of Fracture Toughness Data

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José Laiginha Leal*, Paulo M S T de Castro†

Departamento de Engenharia Mecânica e Gestão Industrial
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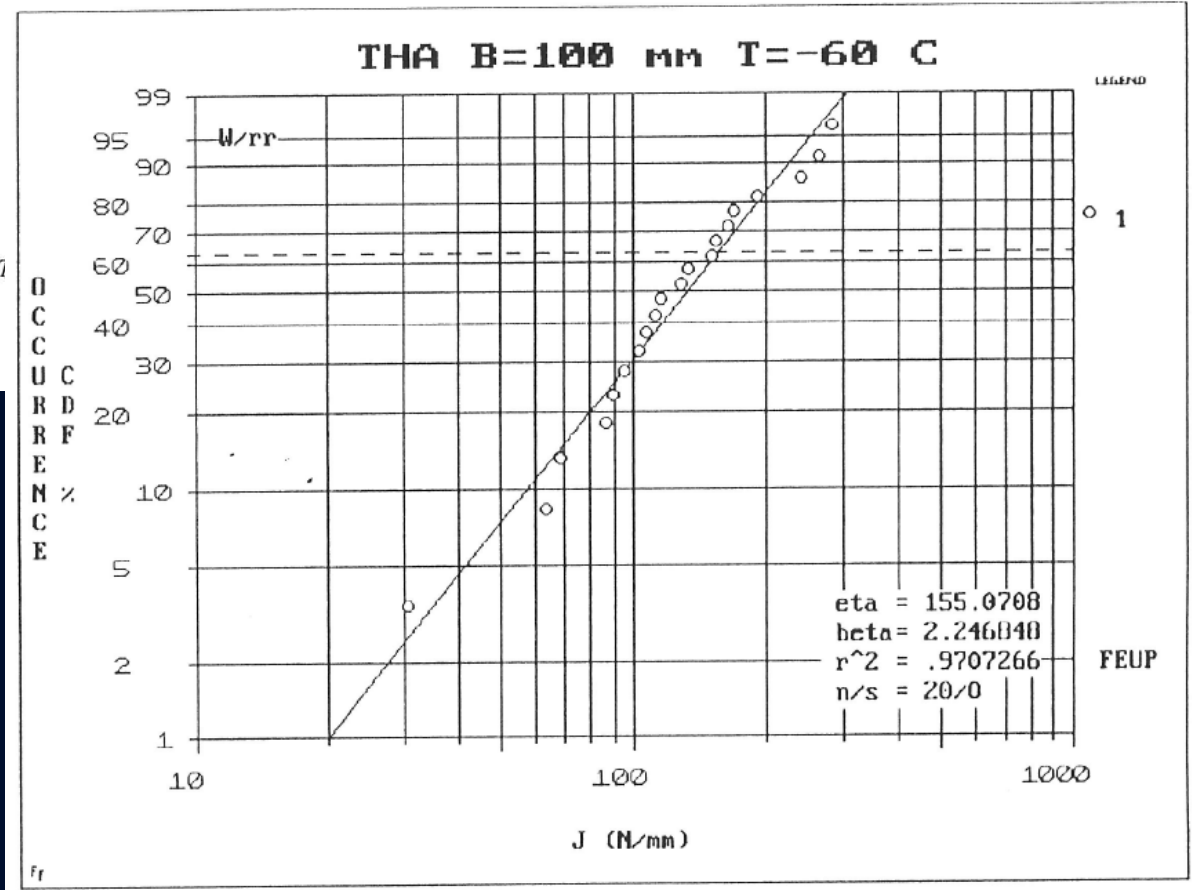
Contribution of the Universidade do Porto to
M&T Project no. MAT CT940080, 'Fracture in
the Ductile to Brittle Transition Regime'.
Porto, 23rd July 1996

$$J_c = \frac{(1-\nu^2) K_{Ic}^2}{E}$$

$$P(J) = 1 - e^{-\left(\frac{J}{\eta}\right)^\beta}$$

1

C. C. e Silva, E. M. Fonseca, J. L. Leal, P. M. S. T. de Castro, 'Statistical and geometrical analysis of fracture toughness data', EC M&T project no. MAT CT940080 - 'Fracture Toughness of Steel in the Ductile to Brittle Transition Regime', 23rd July 1996



VALIDATION OF THE FRACTURE MECHANICS TEST METHOD EGF P1-87D (ESIS P1-90/ESIS P1-92)

Twenty-one laboratories participated in the study; these are listed below:

Admiralty Research Establishment, Holton Heath, UK.

BAM, Berlin, FRG.

CEGB, UK.

CENIM, Madrid, Spain.

CISE spa, Milan, Italy.

Creusot-Loire Industrie, Le Creusot, France.

David Taylor Naval Ship R&D Center, Annapolis, USA.

ECN, Petten, The Netherlands.

EDF, Moret-sur-Loing, France.

Fraunhofer IWM, FRG.

GKSS, Geesthacht, FRG.

MPA, Stuttgart, FRG.

NII (HSE), UK.

Universidade do Porto, Portugal.

SCK/CEN, Belgium.

Statens Provningsanstalt, Boras, Sweden.

Sulzer, Winterthur, Switzerland.

Technische Universiteit Delft, The Netherlands.

TWI, Cambridge, UK.

UKAEA, Harwell, UK.

UKAEA, Risley, UK.

³The Welding

AN EGF EXERCISE IN PREDICTING DUCTILE INSTABILITY: PHASE 1, COMPACT TENSION SPECIMENS

Central Electricity

APPENDIX 2

List of Participants

Ainsworth R. A.	CEGB BNL (U.K.)
Baudendistel E.	IWM Freiburg (Germany)
Bradford R.	CEGB SWR SSD (U.K.)
Chell G. G.	CEGB CERL (U.K.)
Dormagen D.	LEHK Aachen (Germany)
Duarte J. A. O. F.	University of Porto (Portugal)
Ewing D. J. F.	CEGB CERL (U.K.)
Garwood S. J.	Welding Institute (U.K.)
Harrison R. P.	CEGB GDGD (U.K.)
Hellmann D.	GKSS (Germany)
Hodulak L.	IWM Freiburg (Germany)
Nyilas A.	ITP Karlsruhe (Germany)
Packeiser R.	BAM Berlin (Germany)
Steenkamp P. A. J. M.	University of Delft (Holland)
Williams D.	CEGB SWR SSD (U.K.)

Ductile Instability round-robin, European Group on Fracture EGF (actualmente ESIS), organizado por I. Milne:

- I Milne, 'An EGF exercise in predicting ductile instability: phase 1, compact tension specimens', *Fatigue and Fracture of Engineering Materials and Structures*, vol. 9, (2), pp.79-94, 1986
- I Milne, 'An EGF exercise in predicting ductile instability: phase 2, cracked pressure vessel', *Fatigue and Fracture of Engineering Materials and Structures*, vol. 9, (4), pp.231-257, 1986

AN EGF EXERCISE IN PREDICTING DUCTILE INSTABILITY: PHASE 2, CRACKED PRESSURE VESSEL

Technolog
Electricity

List of Participants

Ainsworth R. A.	CEGB BNL (U.K.)
Bradford R.	CEGB SWR SSD (U.K.)
Cairns H.	Rolls Royce & Ass. Ltd (U.K.)
Chell G. G.	CEGB CERL (U.K.)
Cornec A.	GKSS Geesthacht (W. Germany)
Curr R. M.	Imperial College (U.K.)
Dormagen D.	Aachen (W. Germany)
Duarte J. A. O. F.	Porto (Portugal)
Etemad M. R.	Imperial College (U.K.)
Ewing D. J. F.	CEGB CERL (U.K.)
Garwood S. J.	The Welding Institute (U.K.)
Hodulak L.	IWM Freiburg (W. Germany)
Marchini F.	Imperial College (U.K.)
Packeiser R.	BAM Berlin (W. Germany)
Slatcher S.	Det Norske Veritas (Norway)
Turner C. E.	Imperial College (U.K.)
Witts N.	NNC (U.K.)
Anonymous	

Ductile Instability round-robin, European Group on Fracture EGF (actualmente ESIS), organizado por I. Milne:

- I. Milne, 'An EGF exercise in predicting ductile instability: phase 1, compact tension specimens', *Fatigue and Fracture of Engineering Materials and Structures*, vol. 9, (2), pp.79-94, 1986
- I. Milne, N. Knee, 'An EGF exercise in predicting ductile instability: phase 2, cracked pressure vessel', *Fatigue and Fracture of Engineering Materials and Structures*, vol. 9, (4), pp.231-257, 1986

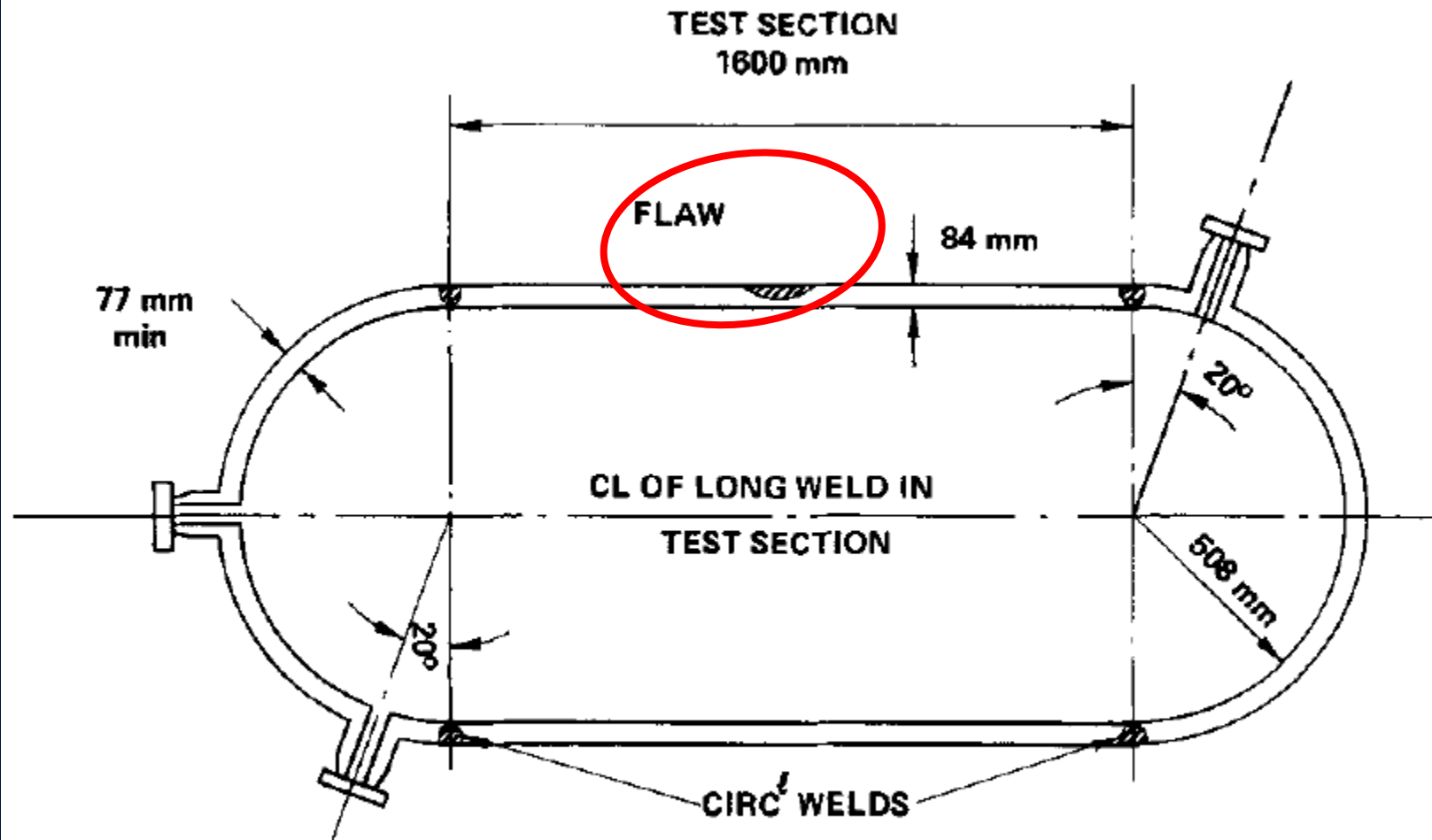


Fig. 6. Geometry of vessel.

I. Milne, 'An EGF exercise in predicting ductile instability: phase 2, cracked pressure vessel', *Fatigue and Fracture of Engineering Materials and Structures*, vol. 9, (4), pp.231-257, 1986

4 – Análise e prevenção de roturas

Technology, Law and Insurance, 1996 1, 143–150

Failure analysis: a methodology

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Methodologies for failure analysis: a critical survey

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Received 16 June 2003; accepted 23 September 2003

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CASE STUDIES IN ENGINEERING MECHANICS AND MATERIALS

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11th November 1981

Dr. P.M.S.T. Castro
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Mecanica
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Rua dos Bragas
4099 Porto
Portugal.

Dear Dr. Castro,

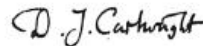
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We expect to set a high standard for the first issues and we would like to invite you to contribute a Case Study of about 8-10 pages length (4000-5000 words). We are in the process of inviting a distinguished international Editorial Board which will represent a wide subject base and reflect the strong interdisciplinary nature of the journal.

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D.J. CARTWRIGHT

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Custos de falha incluem (Milne, 1994):

- custo directo de reparação ou substituição;
- perda de receita enquanto indisponível;
- custos de serviços/itens de substituição durante indisponibilidade;
- custos de danos consequentes;
- custos para evitar falhas em itens semelhantes;
- outras implicações (segurança, perda de confiança, imagem e comércio).

Questões para o(s) perito(s) incluem (Rossmanith, 1995):

- o que aconteceu?
- onde aconteceu?
- como aconteceu?
- o que causou?
- quem é o responsável pelo que aconteceu?
- quais são os custos para reparar ou substituir?
- quais são os danos sofridos pelas diversas partes envolvidas?

I. Milne, 'The importance of the management of structural integrity', *Engineering Failure Analysis*, vol.1, (3), pp.171–81, 1994

H. P. Rossmanith, 'Structural failures – liability, learning from failures, technical insurance and legal consequences'. Invited lecture 5th special chair AIB-Vinçotte 1995, Vrije Universiteit Brussel, 21 February 1995

Por ex. em estruturas de Eng. Civil, causas de falhas incluem, (Carper, 1989)

- erros de selecção e desenvolvimento de localizações
- deficiências de programação
- erros de projecto (incluindo falha em considerar alguma combinação de cargas, falta de redundância, detalhes de ligações, ...)
- erros de construção
- deficiências de materiais
- erros operacionais (incluindo mudança de uso, manutenção inadequada, ...)

Petroski (1992) inclui duas 'listas' de causas,

- a primeira sendo abrangente: ignorância; economia; lapsos ou descuidos; ocorrências incomuns (terremotos, tempestades extremas, incêndios, ...)
- a segunda não pretendendo ser exaustiva: estados limites (sobrecarga, resistência insuficiente, movimentos, deterioração). Perigos aleatórios (incêndios, inundações, explosões, terremotos, impactos de veículos). Erros de base humana (erros de projecto, erros de construção).

K. L. Carper, 'Learning from failures', in: K. L. Carper KL, ed., 'Forensic Engineering', Elsevier, pp. 14–31. 1989

H. Petroski, 'To engineer is human: the role of failure in successful design.', Vintage Books, 1992.

Prolongamento da vida útil dos equipamentos ou instalações existentes.

elementos de uma abordagem sistemática para este problema incluem:
(Rossmanith, 1995):

- avaliação das condições materiais;
- tipo de dano (fadiga, fluência, ambiental, etc.);
- local do dano (superfície, volume, interface);
- extensão do dano (localizado, global);
- nível de dano (insignificante, comprometendo a funcionalidade, causando perigo);
- condições de carregamento;
- temperatura.

Os itens de uma metodologia de análise de falhas são normalmente (Robinson e Cox, 1983; Wulpi, 1985):

- definição do problema;
- obter informações básicas;
- investigar e recolher informações;
- examinar evidências (exames macroscópico e microscópico como SEM ...);
- avaliar mecanismo, sequência e causas da falha;
- realizar testes exemplares;
- análises e cálculos, incluindo método dos elementos finitos (MEF) e análises de mecânica da fractura;
- avaliar o risco;
- tirar conclusões com base em todas as evidências e fazer recomendações.

J. N. Robinson, D. O. Cox, 'Failure analysis methodology'. ASME paper 83-PVP-33, 1983

D. J. Wulpi, 'Understanding how components fail', American Society for Metals, 1985

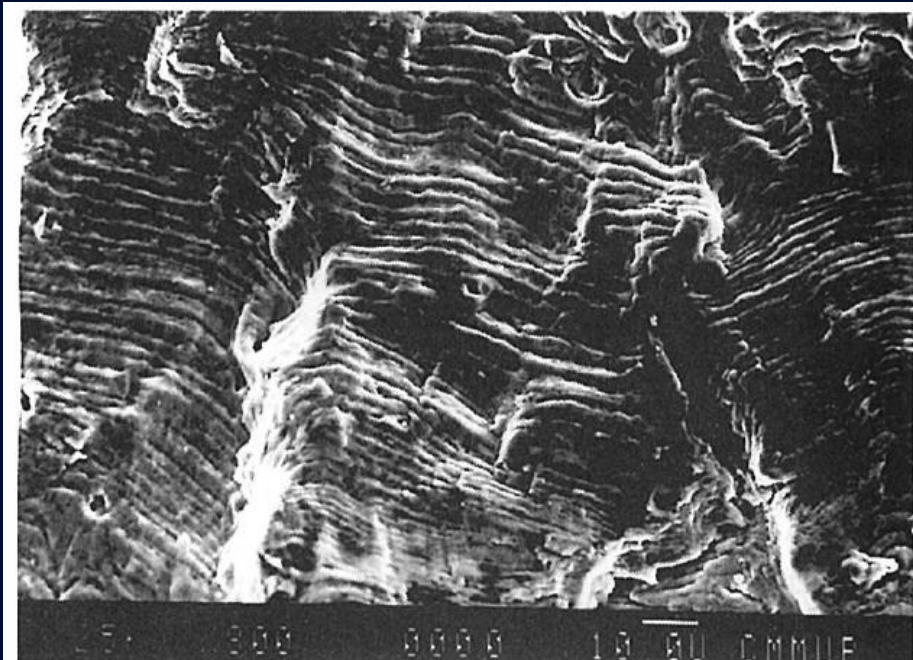


Figure 2 SEM fractograph of failed bolt (Antunes and de Castro, 1985)

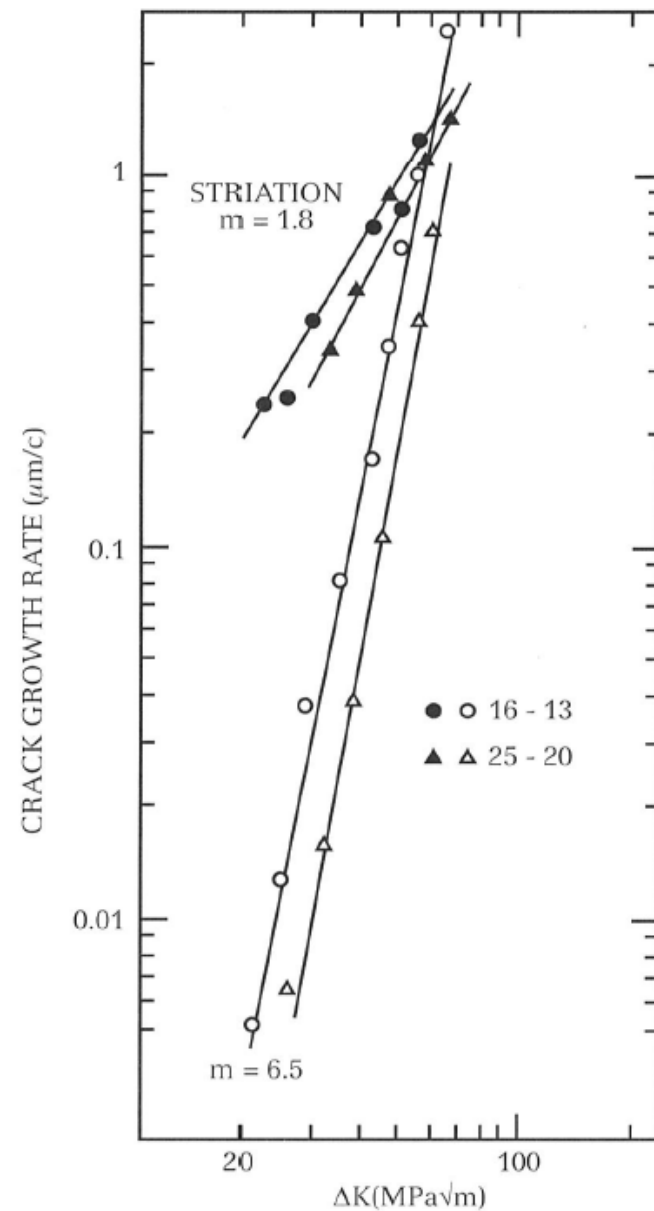


Figure 3 Macro and micro fatigue crack growth data, austenitic steels. Adapted from Bathias (1980). (m – Paris law exponent. m = 6.5, macro data; m = 1.8, micro data)

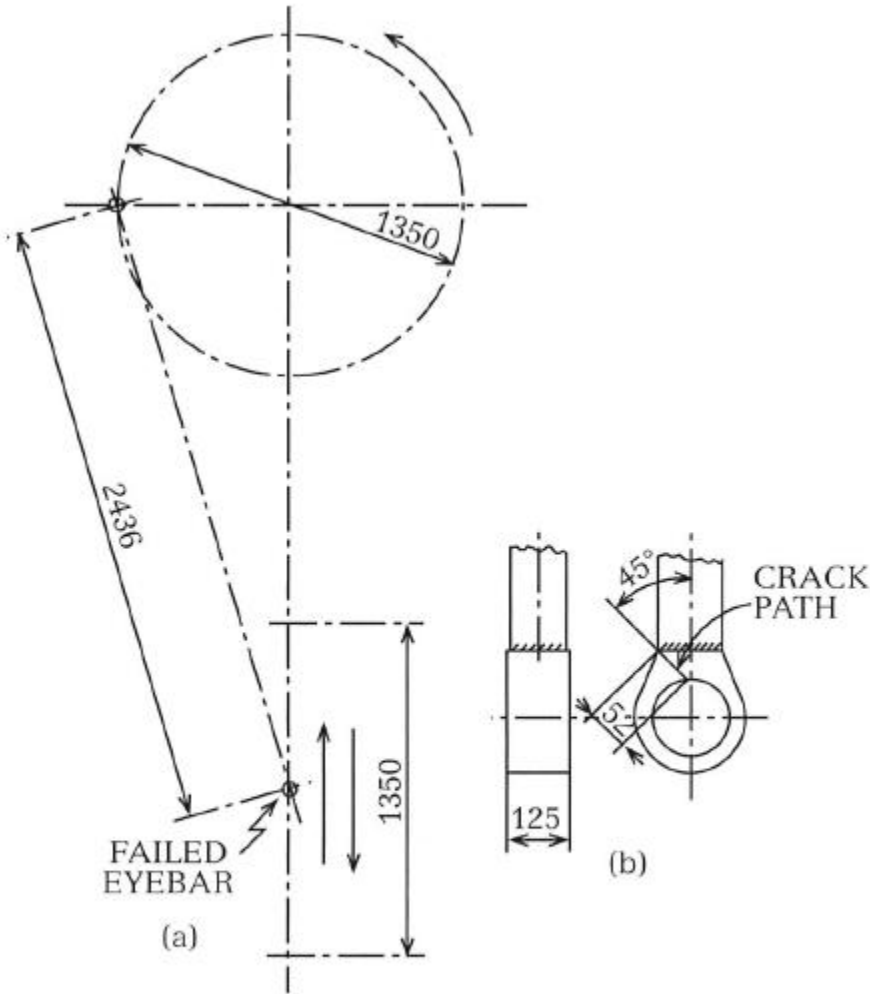


Figure 5 Machine to cut thin wood slices from logs: failed eyebar and movement of the blade (1350 mm) (Duarte *et al.*, 1985)

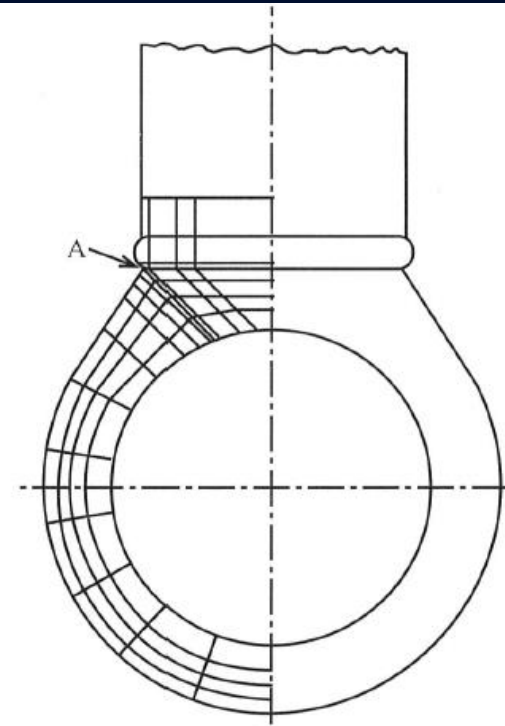


Figure 6 FEM mesh for the analysis of failed eyebar (Duarte *et al.*, 1985). A, crack initiation site

P. M. S. T. de Castro, F. M. F. Oliveira, A. A. Fernandes, 'Failure analysis: a methodology', *Technology, Law and Insurance*, vol.1, pp.143-150, 1996

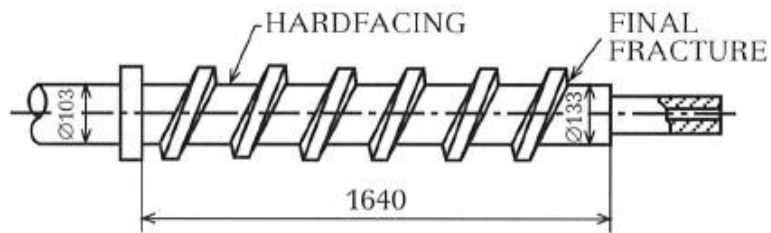
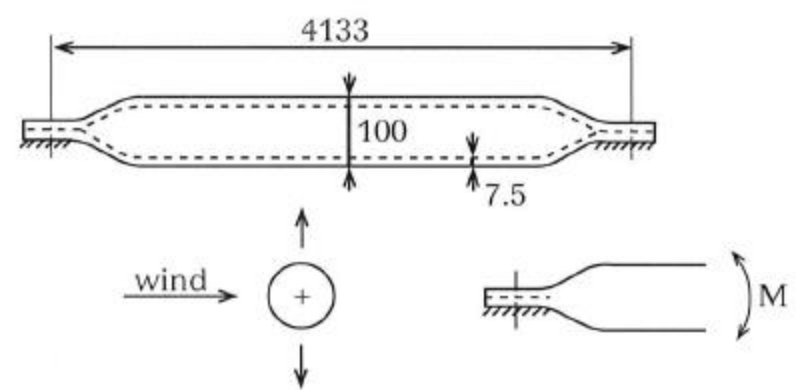
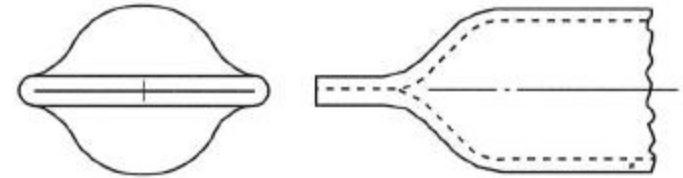


Figure 4 Failed cobalt hardfaced steel shaft (Fernandes et al., 1985)



ORIGINAL
MANUFACTURING
SOLUTION



MODIFIED SOLUTION



Figure 7 Tubular electric conductor of commercially pure Al (Fernandes and de Castro, 1990). Original (failed) design, and modified solution

FCGR and Striation Marks

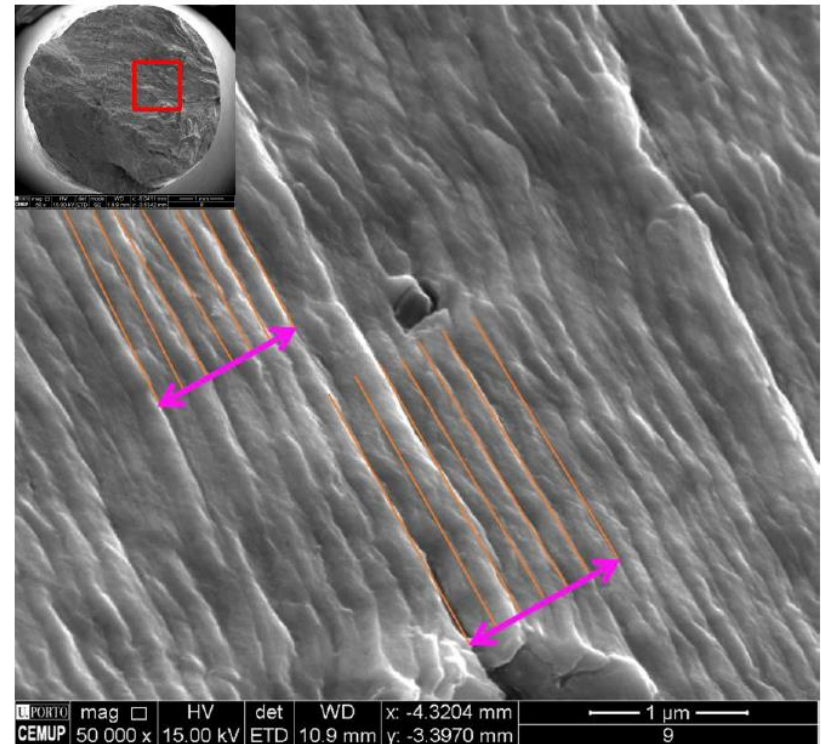
Striation Spacing and ΔK Measurements

- SEM images were used to identify and measure striation spacing.
- Several measurements were performed and an average value of striation spacing was computed for each location.
- Along with the striation spacing, it is necessary to know the position where the image was taken (distance between crack nucleation and crack front, a , at a given "time").
- This crack length will be used to estimate the SIF at that "time" (crack front position).

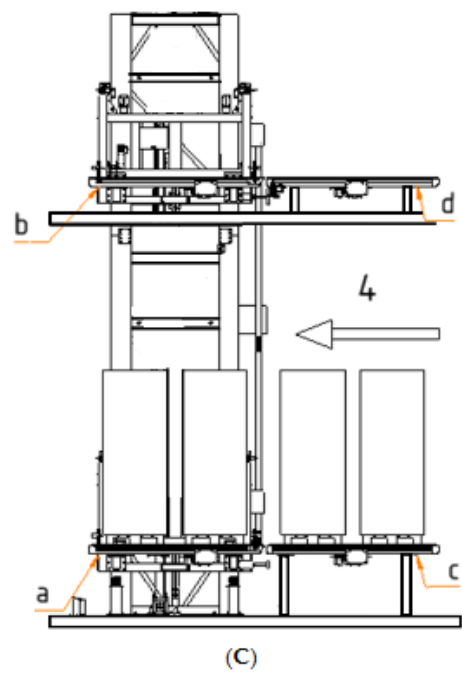
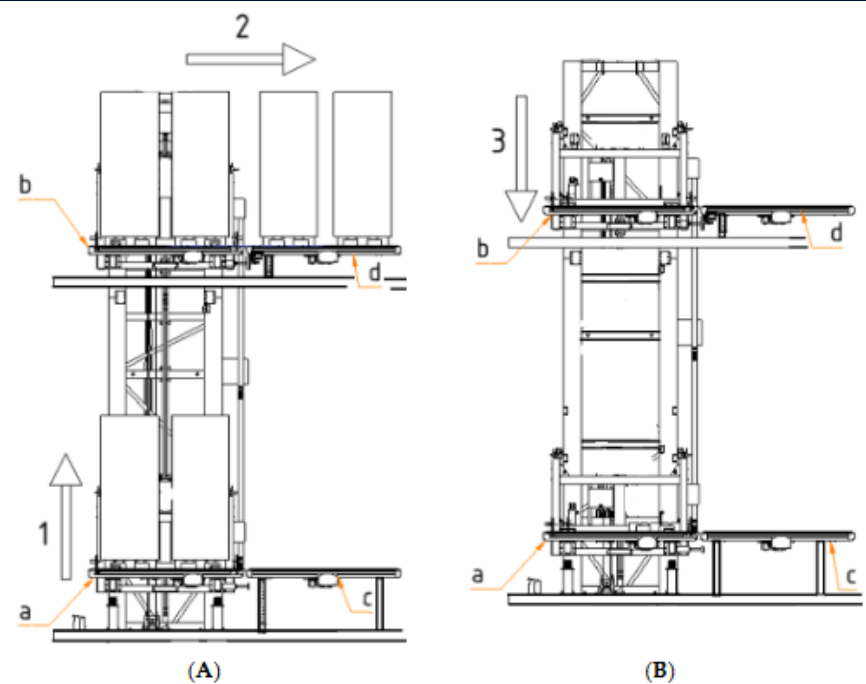
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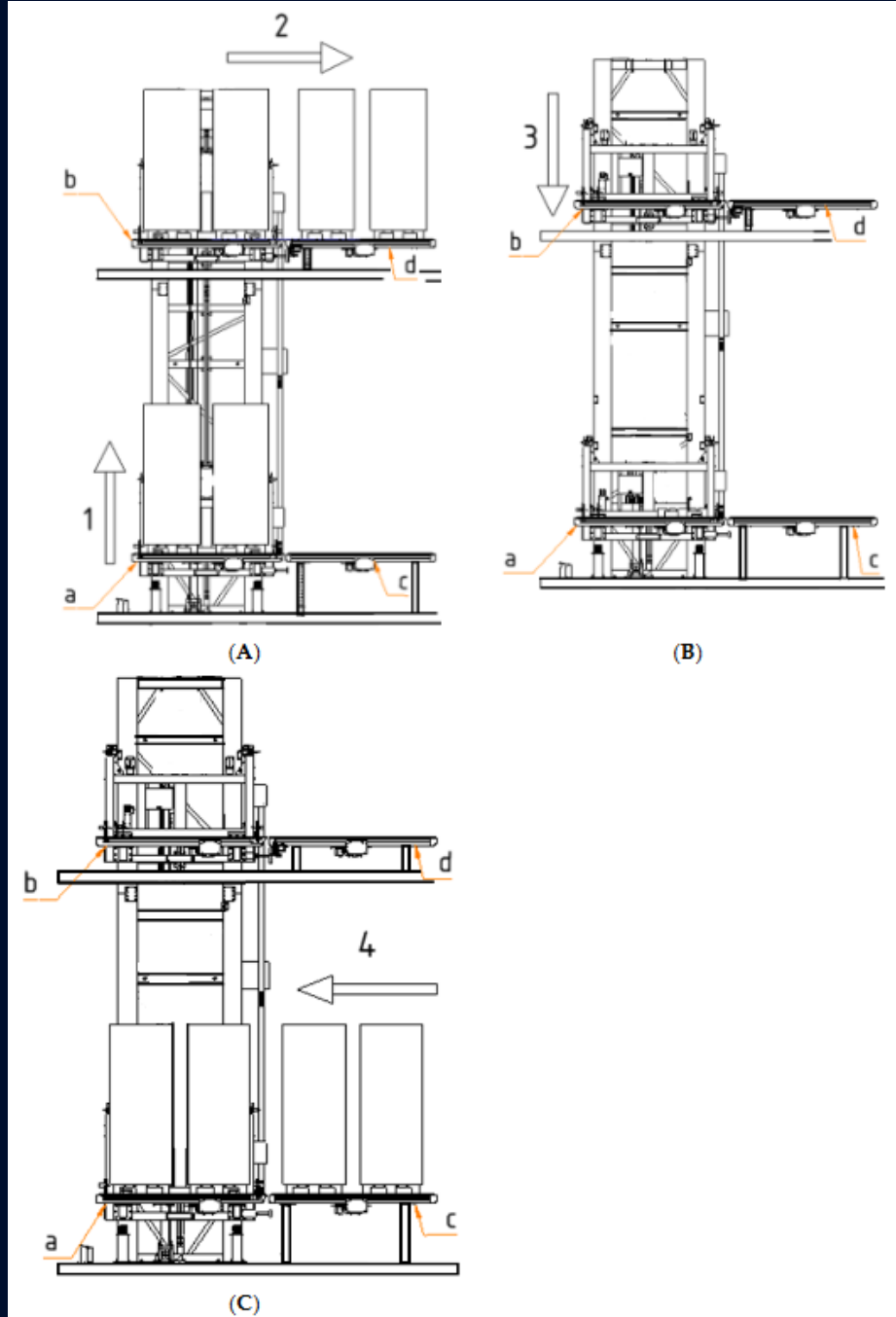
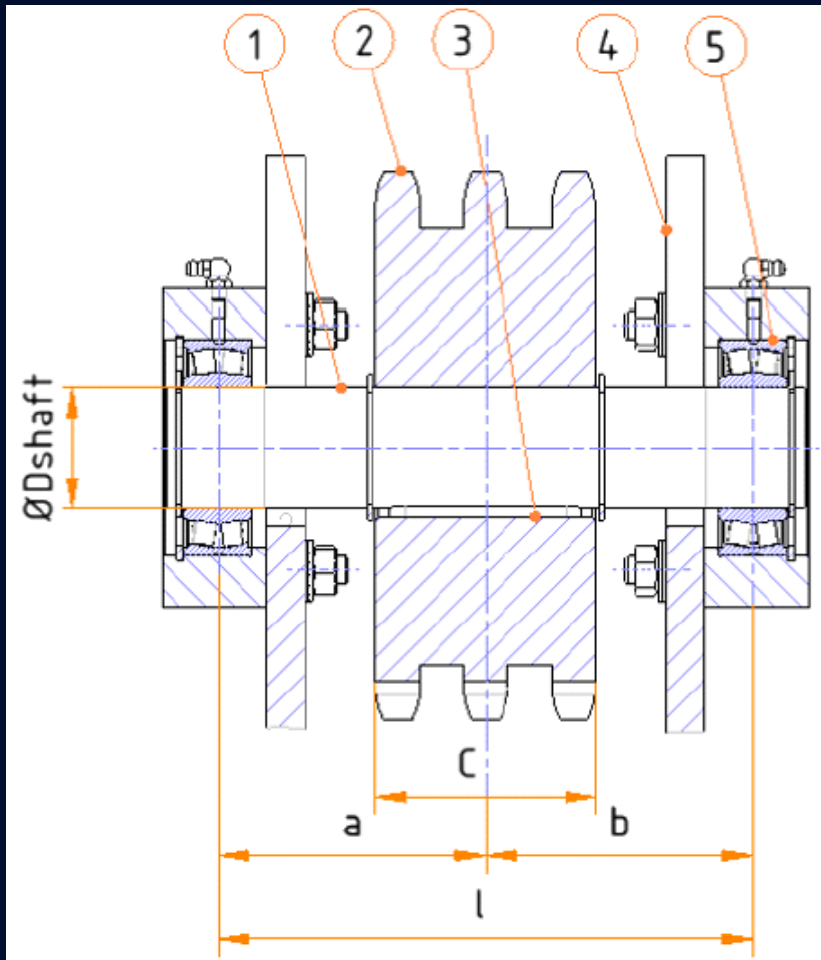
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Striation Spacing and Global Position





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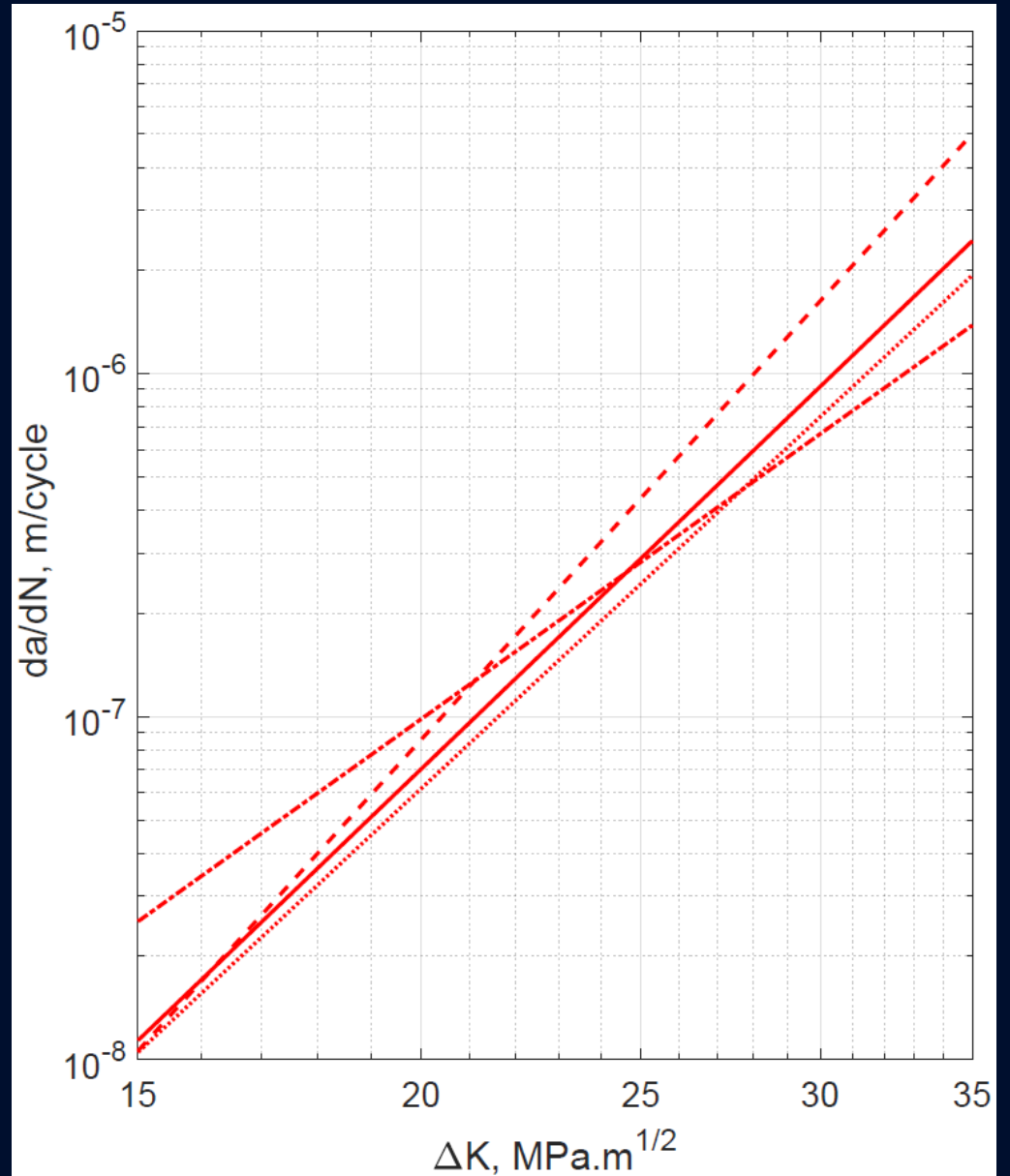
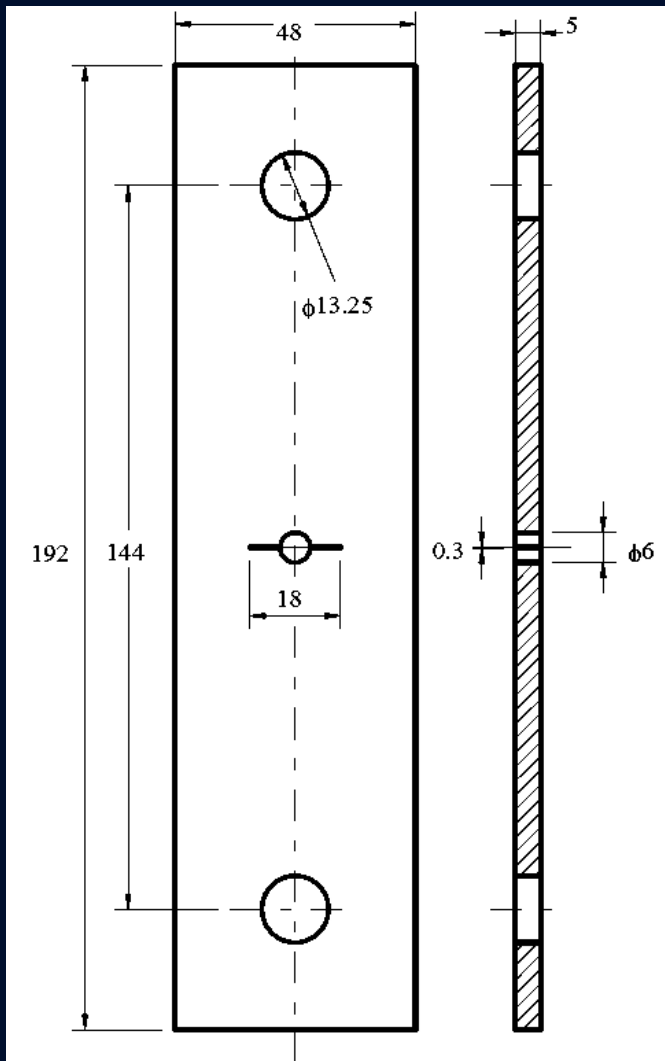
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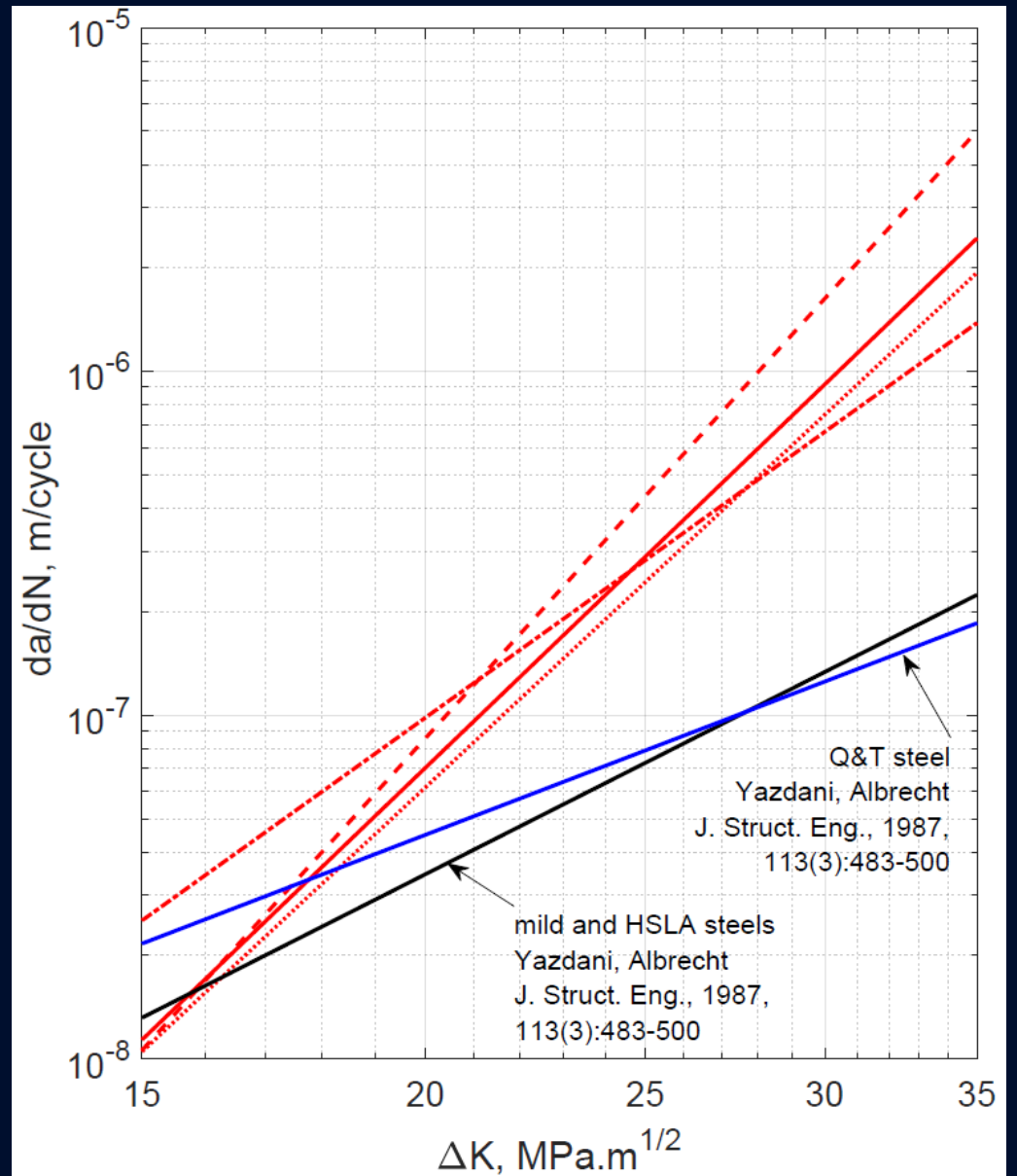
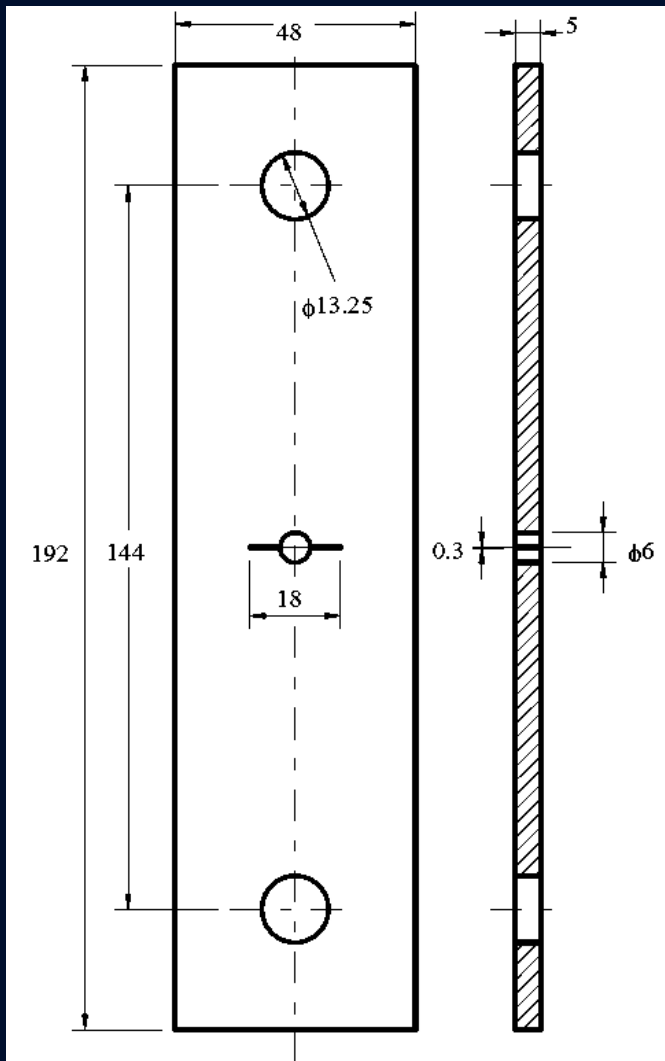
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João Paulo Gonçalves
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Paulo Tavares de Castro
Antônio Augusto Fernandes

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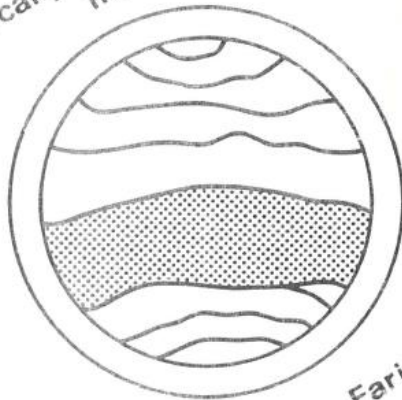
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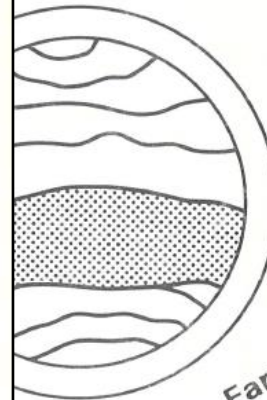
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materials and structures



Editor L. Faria
Lisbon, Portugal 1984

vol. II

Life assessment of
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Preliminary Programme

Monday

17th

Morning Meeting of Task Groups
Afternoon Official opening
Plenary session

Tuesday

18th

Morning Technical sessions
Plenary session
Afternoon Technical sessions
Reception of EGF by the
Mayor of Lisbon

Wednesday

19th

Morning Technical sessions
Plenary session
Afternoon Technical visits
Evening Conference dinner

Thursday

20th

Morning Technical sessions
Plenary session
Afternoon Technical sessions
Meeting of EGF

Friday

21st

Morning Technical sessions
Afternoon Technical sessions

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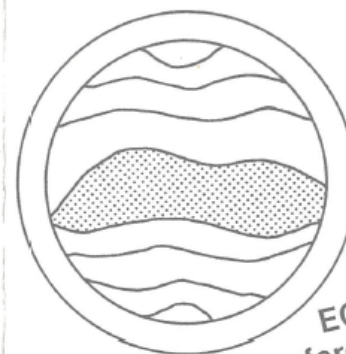
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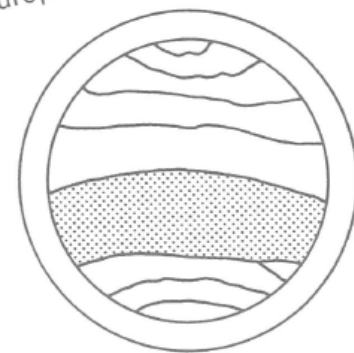
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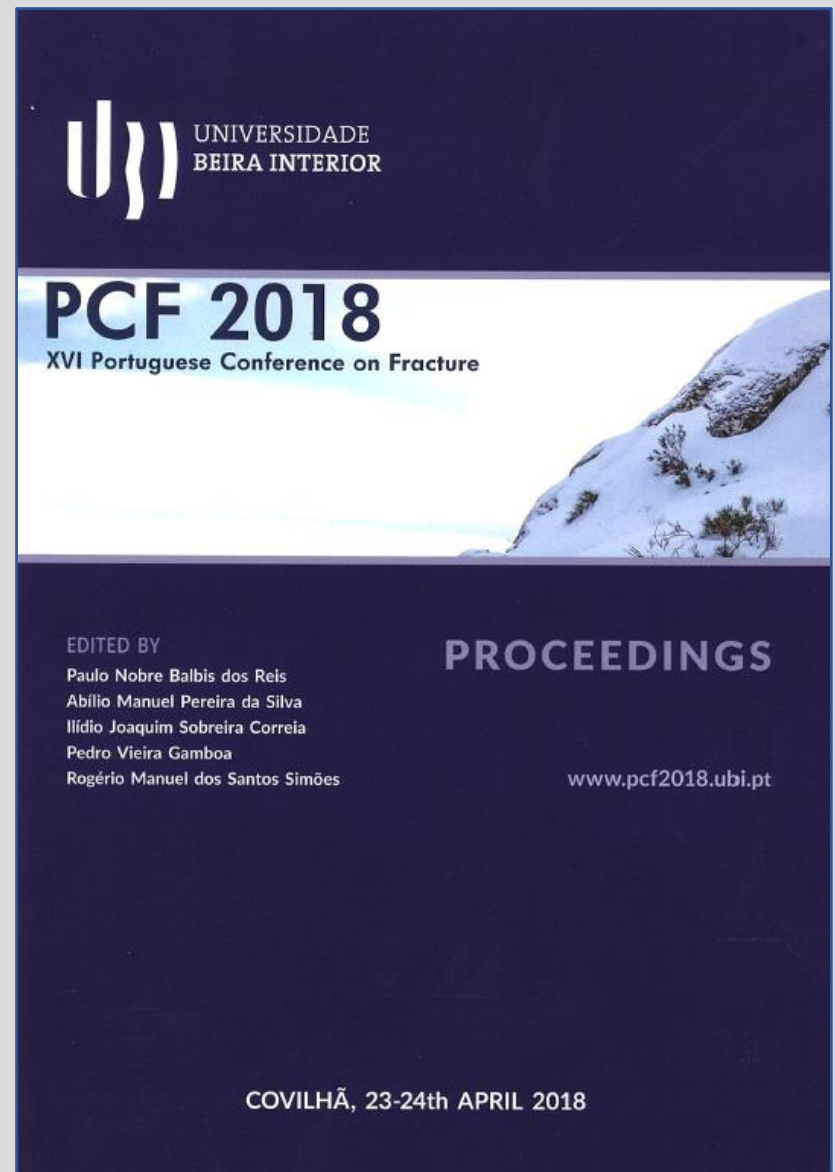
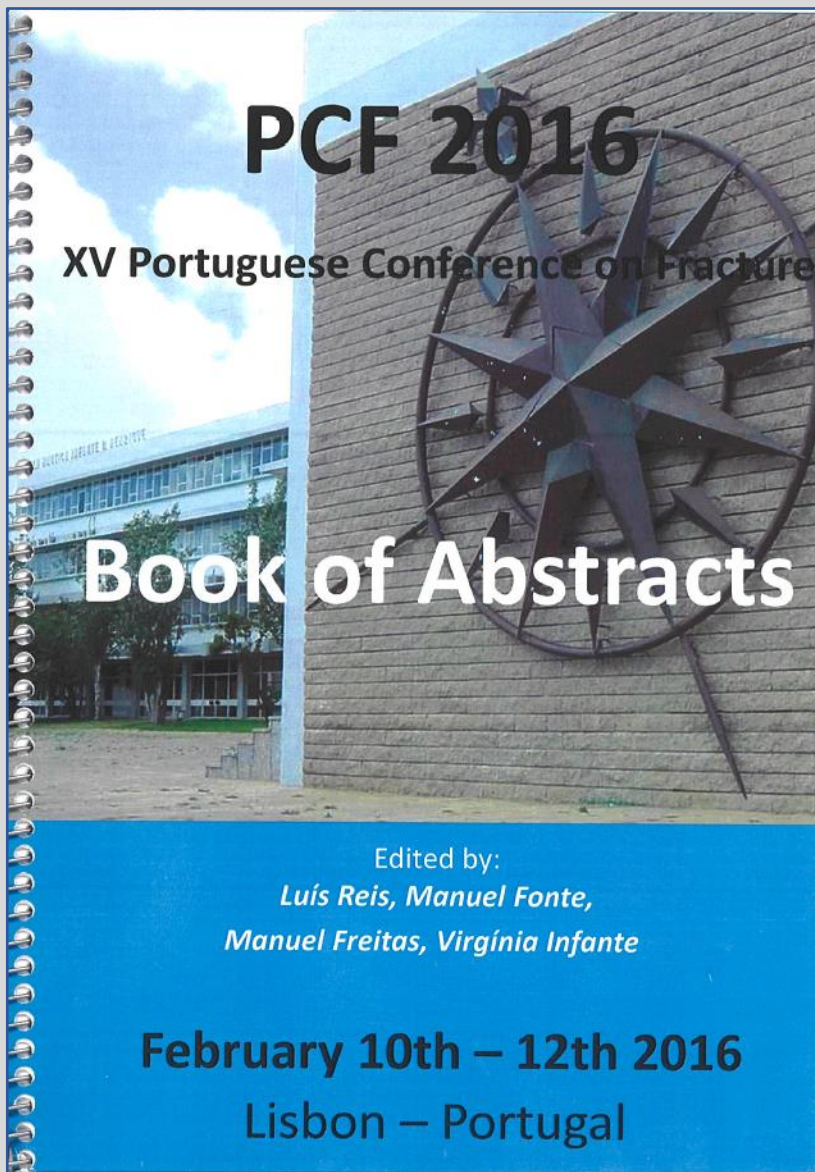
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Multiple-site damage in riveted lap-joints: experimental simulation and finite element prediction

Lucas F.M. Silva, J.P.M. Gonçalves, F.M.F. Oliveira, P.M.S.T. de Castro *

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Received 8 February 1999; received in revised form 11 November 1999; accepted 5 December 1999

Abstract

The multiple-site damage (MSD) phenomenon is discussed, and exemplified by the behaviour of riveted lap-joint specimens of aluminium alloy 2024-T3 clad. The tests performed, on which the paper is based, are part of the contribution of IDMEC to a project on the fatigue behaviour of ageing aeronautical structures—the BRITE-EURAM project 'SMAAC', partially funded by the European Union. The study involves fatigue testing under constant amplitude loading of 1.6-mm-thick riveted lap-joints, and includes examination of the specimens during and subsequent to testing (post-mortem analysis of the fracture surface in a scanning electron microscope) in order to determine the time of occurrence, location and extent of fatigue damage. Crack growth rates are determined from periodic crack length measurements with a travelling microscope. Stress measurements are made using extensometry and the SPATE infrared technique to determine loading distribution of the lap-joints and redistribution due to cracking of fastener holes. Data on the initiation and growth of cracks and on residual static strength are used to assess the predictive model based on the finite element method. © 2000 Elsevier Science Ltd. All rights reserved.

Keywords: Multiple-site damage; Crack initiation; Crack growth; Residual strength

1. Introduction

This work is part of the BRITE/EURAM project BE95-1053, 'Structural Maintenance of Ageing Aircraft' (SMAAC) [1]. 'Ageing aircraft' is a technical term indicating that the aircraft has reached its original design goal. The light alloy structures used in commercial aircraft could be susceptible to widespread fatigue damage (WFD). WFD as an effect of multiple-site damage (MSD) can be regarded as the major problem of ageing aircraft. This problem may be divided roughly into three parts:

- the initiation of MSD (which assesses the initial damage scenario),
- the crack propagation of MSD (simultaneously at different sites), and
- the residual strength in the presence of MSD and

possible further deteriorating effects like corrosion, debonding or manufacturing defects.

The objective is to generate basic material crack propagation data; to study the initiation and growth of cracks in laboratory specimens which simulate the key features of aircraft joints in which WFD is present; and to derive data on crack initiation, crack growth and residual static strength which will be used to assess the predictive model based in the FRANC2D/L finite element programme. This brings us to focus the literature review on four points: loading and stress distribution of a longitudinal fuselage splice, crack initiation, crack growth and residual static strength. Although the specimens tested are simple riveted lap-joints, it is important to be aware of the loading present in practice.

2. Literature review

2.1. Loading and stress distribution of a longitudinal fuselage splice

Eastaugh et al. [2] present a comprehensive description of this aspect. Fuselage pressurisation is the main

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**Spiros Pantelakis, University of Patras; Paulo de Castro, University of Porto; Mario Guagliano, Politechnical University of Milan
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S. Pantelakis, P. de Castro, M. Guagliano, F. Berto, guest-editors, 'Fatigue of aeronautical materials and structures', special issue of: *Fatigue and Fracture of Engineering Materials and Structures*, vol.40, (10), 2017

An overview of fatigue in aircraft structures

S. M. O. TAVARES  and P. M. S. T. DE CASTRO 

Faculdade de Engenharia da Universidade do Porto, 4200-465 Porto, Portugal

Received Date: 1 March 2017; Accepted Date: 18 April 2017; Published Online: 17 May 2017

ABSTRACT From safe-life to fail-safe and damage-tolerance approaches, the last one emerged as the main design philosophy for aerostructures, allowing weight savings and at the same time increasing reliability and structural integrity in the presence of damages which may have occurred during the manufacturing process or during service. The application of damage-tolerance philosophy requires extensive know-how of the fatigue and fracture properties, corrosion strength, potential failure modes and non-destructive inspection techniques, particularly minimum detectable defect and inspection intervals.

To face scatter in material properties, conservative approaches considering the worst scenario or statistical methods dealing with the variability of material have been employed in the fatigue assessment of structures. The fatigue life estimation can display substantial variability, illustrating the need for a probabilistic assessment in practical applications. As an example, the variation in the fatigue life for the common scenario of a through crack in an Al alloy plate was evaluated taking into account scatter of properties.

The 2010 FAA rule establishing a limit of validity (LOV) puts a bound in the indefinite operational life allowed for by earlier regulations. This requirement, together with the diminishing role of aluminium in airframes, will certainly shape the directions of fatigue, fracture and damage mechanics research in years to come, expanding the knowledge base upon which substantiation of LOV values is made, and ensuring safety under sustainable conditions.

Keywords aerostructures; airframe; crack growth; damage tolerance; fatigue.

INTRODUCTION

From safe-life to damage tolerance

This article reviews concisely the different design philosophies which have been employed in fatigue design of aircraft structures and the recent evolution of the subject. Table 1 contrasts percentage of failures in general engineering components and in aircraft components and shows that fatigue is the main source of failure in aircraft, a trend that is expected to continue for metallic materials. Alterations in regulations are taking place to cope with the evolution of airframes – from mostly metallic to the current use of a variety of materials.

Damage-tolerant design has emerged as the main structural design philosophy in aeronautics, requiring deep knowledge on fatigue and corrosion, potential failure modes and non-destructive inspection techniques. Damage-tolerant design is documented in countless

technical literature, including military documents as the USAF 'Damage Tolerance Design Handbook'^{1,4} or civil as 14 CFR 25, the US Airworthiness Standards for Transport Category Airplanes.⁵ Different strategies may be considered to minimize the occurrence of a fatigue failure in service as regards design (*i.e.* target life, long crack initiation life, fail-safe) and as regards NDE (*i.e.* crack detectability, suitable inspection threshold).⁶

Before proceeding, reference should be made to designations used in the context of airworthiness standards for transport category airplanes. 14 CFR means 'Title 14 of the US Code of Federal Regulations, Aeronautics and Space'. Within 14 CFR, there is Part 25, (14 CFR 25), dedicated to airworthiness standards for transport category airplanes. Section 25.571 'Damage-tolerance and fatigue evaluation of structure', one of the sections of particular interest for this presentation, is included in Subpart C – Structure, 'Fatigue evaluation' of Part 25. Rotorcraft and small airplanes have their own parts of title 14 respectively, part 23 and part 27; these will not be considered in this

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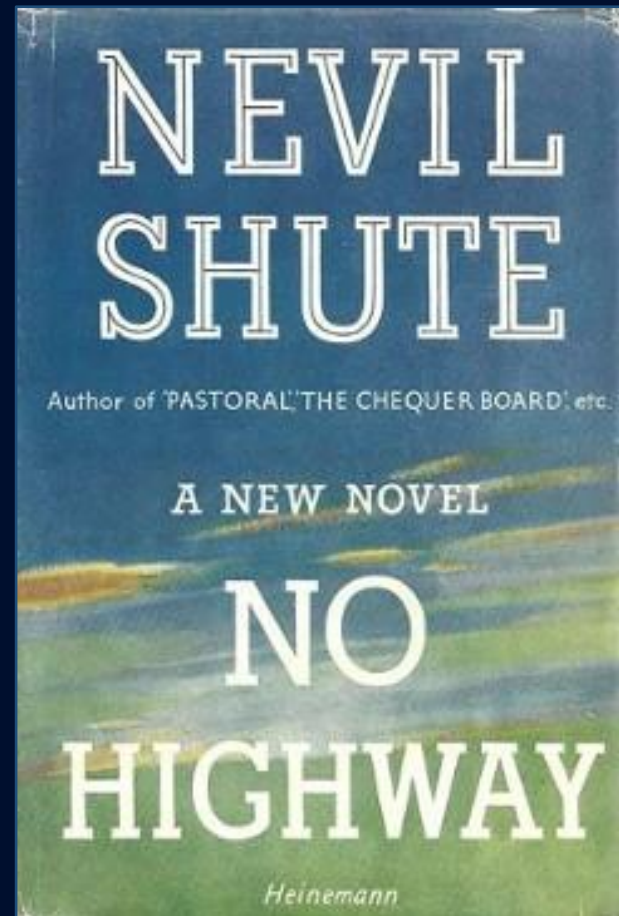
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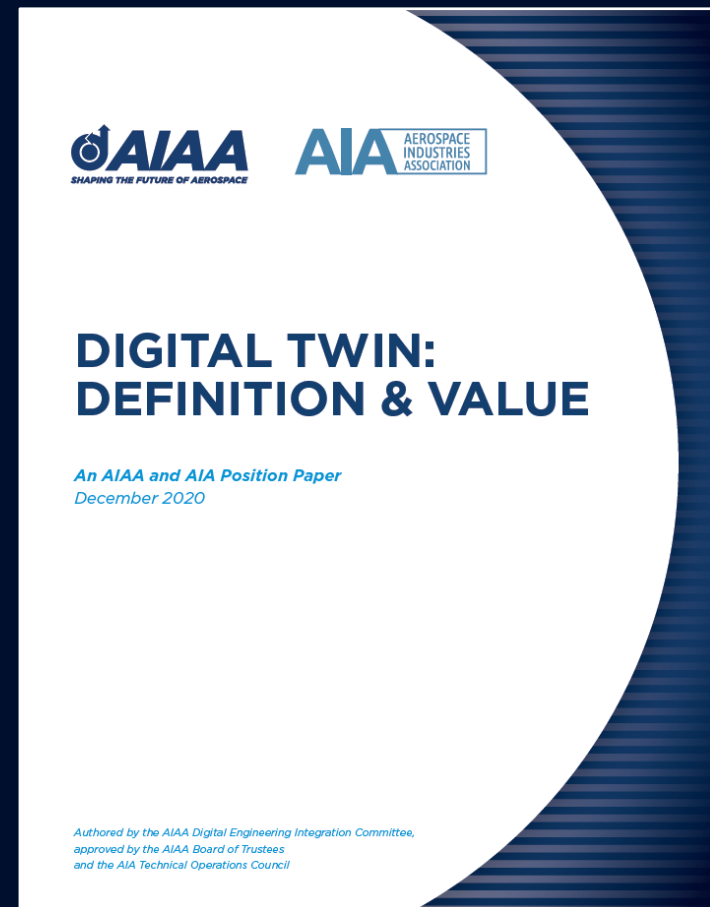
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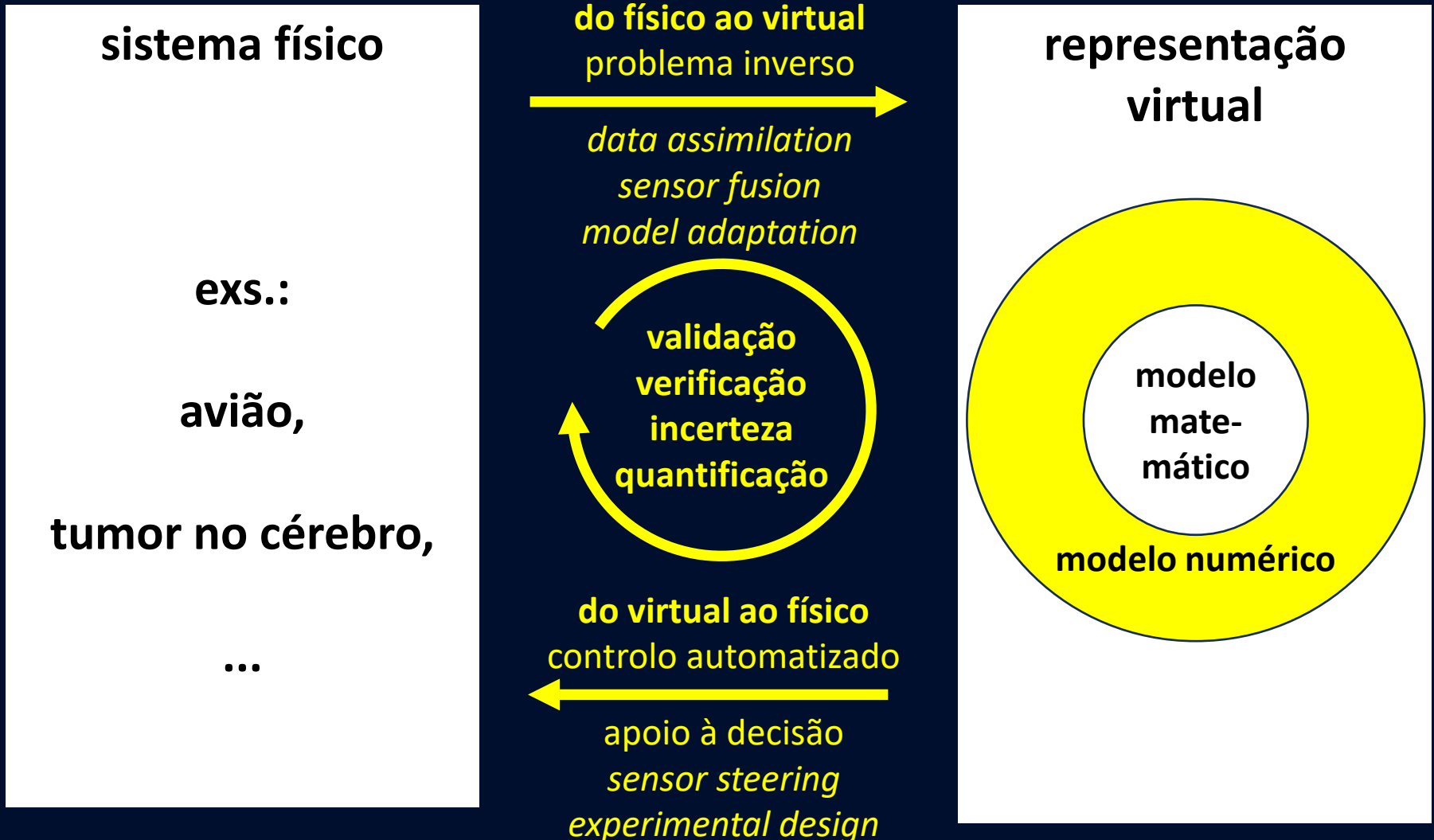
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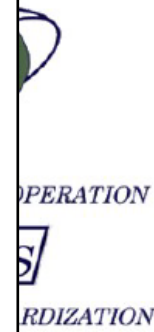
- Karen Willcox, 'Digital twins and applications in aerospace engineering', 172nd Meeting of the Aeronautics and Space Engineering Board, US National Academies, Irvine, CA, Oct. 17-18, 2023. <https://vimeo.com/event/3792250>
- S. M. O. Tavares, J. A. Ribeiro, J. Belinha, P. M. S. T. de Castro, 'Aircraft structures life-cycle simulation through digital twins and model updating techniques', XLIV Ibero-Latin American Congress on Computational Methods in Engineering - CILAMCE 2023, Porto, Portugal, 13-16 Nov. 2023

A Digital Twin is defined as

*A set of **virtual information** constructs that mimics the **structure, context and behavior** of an **individual / unique physical asset**, or a group of physical assets, is **dynamically updated** with data from its physical twin **throughout its life cycle** and **informs decisions that realize value**.*







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MAY 24, 2005

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M. Windisch (presenter), N. Eigen, U. Glaser, H. Masny, G. Bartesch, M. Wimmer, U. Düfert, H.-U. Jüngling, G. Sinnema, K.-H. Trautmann, J. Schneider, P. M. G. P. Moreira, A. M. P. de Jesus, P. C. M. Azevedo, M. V. A. de Figueiredo, P. M. S. Tavares de Castro, E. Sattler, "Damage tolerance characterization of 2195 base material and friction stir welds", Workshop on Fracture Control of Spacecraft, Launchers and their Payloads and Experiments, ESA/ESTEC, Noordwijk, The Netherlands, 9 - 10 Feb. 2009.



Damage Tolerance Characterization of 2195 Base Material and Friction Stir Welds

Workshop on Fracture Control of Spacecraft, Launchers and their Payloads and Experiments
9 - 10 February 2009
ESA/ESTEC, Noordwijk, The Netherlands



The given presentation is a summary of a study, which has been performed within the ESA Technology and Research Programme:

**Damage Tolerance of Cryogenic Pressure Vessels
(TRP T401-02 MC)**

Reference: TEC-MCS/2006/1450/In/GS

The work has been mainly performed with the contribution of the following laboratories and experts:

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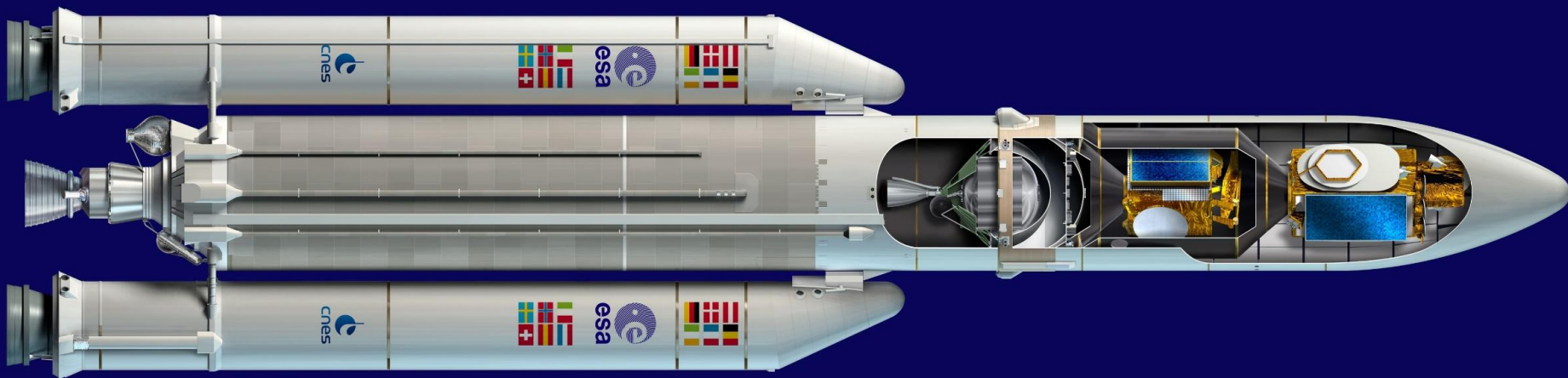
Target: Net Shape Formed Tank Tank Domes of AA2195 (incl. FSW)

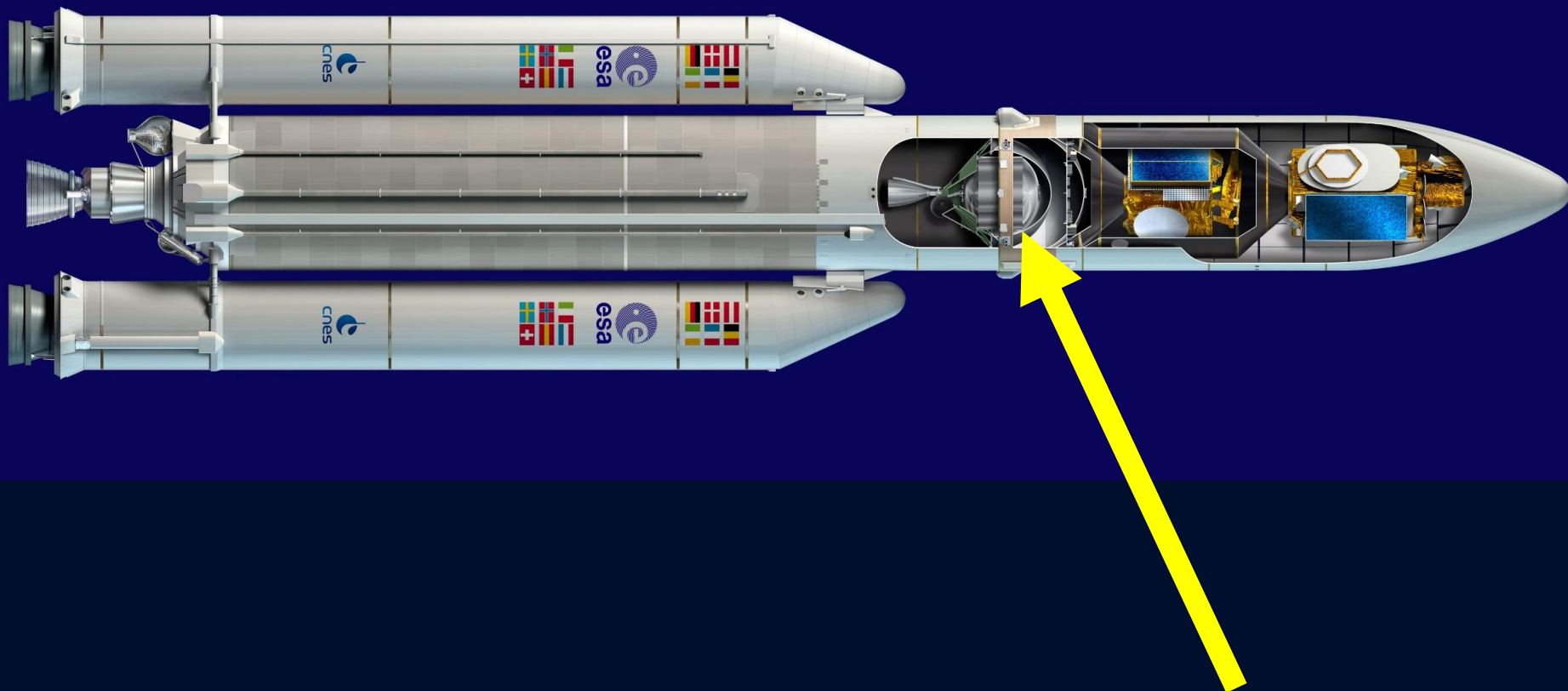
Spin formed integral dome of FSW plate made of AA2219



Spin formed small scale dome of AA2195









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Fatigue and fracture behaviour of friction stir welded aluminium–lithium 2195

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DAMAGE TOLERANCE CHARACTERIZATION OF 2195 BASE MATERIAL AND FRICTION STIR WELDS

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1. ABSTRACT

The given paper is a summary of damage tolerance investigations which have been performed within the ESA Technology and Research Programme - Damage Tolerance of Cryogenic Pressure Vessels (TRP T401-02 MC). The main goal of the study was to analyze the potential of aluminium lithium alloy 2195 and its friction stir weld (FSW) for the potential future application of European upper stage cryogenic tank structures. Strength, fatigue crack growth and fracture testing has been performed both at RT and cryogenic temperatures. The fracture test results were evaluated with non-linear fracture mechanics methods and compared with data from open literature data of the space shuttle program. It could be demonstrated that the material shows high damage tolerance potential and that the general findings from literature could be confirmed in most cases. The basic microstructure and material investigations are presented in [1].

2. FRACTURE MECHANICS ANALYSIS

The test results of the fracture mechanics type tests of

$$K_r = \frac{K_{applied}}{K_{material}} \tag{1}$$

$$L_r = \frac{\sigma_{ref}}{\sigma_{collapse}} \tag{2}$$

$$J = \frac{K^2}{E'} \cdot [f(L_r)]^{-2} \tag{3}$$

$E' = E$ in plane stress and $E' = E / (1-\nu^2)$ in plane strain

$$f(L_r) = \left[\frac{E \cdot \epsilon_{ref}}{\sigma_{ref}} + \frac{L_r^2}{2 \cdot (E \cdot \epsilon_{ref} / \sigma_{ref})} \right]^{-\frac{1}{2}} \tag{4}$$

for $0 \leq L_r \leq L_{r,max}$ (5)

$$L_{r,max} = \frac{1}{2} \cdot \left(\frac{R_{p0.2} + R_m}{R_{p0.2}} \right) \tag{6}$$

$$\sigma = I \cdot R \tag{7}$$

Microstructure and Properties of AA 2195 T8 Material and Friction Stir Welds

N. Eigen⁽¹⁾, M. Windisch⁽¹⁾, H. Masny⁽¹⁾, U. Glaser⁽¹⁾, G. Sinnema⁽²⁾, P. M. G. P. Moreira⁽³⁾, J. Schneider⁽⁴⁾,
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1. ABSTRACT

The study shows the main properties of AA2195 in relation to the microstructure developing in the friction stir weld process, which were comprehensively investigated in the ESA Technology and Research Programme – Damage Tolerance of Cryogenic Pressure Vessels (TRP T401-02 MC). Friction Stir Welding (FSW) on 5 mm sheets of AA2195 in T8 condition was performed and process parameters were optimized. Non-destructive Inspection (NDI) methods were used to detect potential defects and metallographic investigations were applied in order to detect their origin. The properties on the friction stir joints were determined and the influence of temperature down to 20 K is shown.

Particular attention is given to the microstructure and the fracture characteristics of the friction stir welds and base material. Optical and scanning electron microscopy investigations are used to determine the failure mode. Additionally, the influence of temperature is discussed on the basis of samples fractured at RT, 77 K, 20 K and 4 K.

The Friction Stir Welding (FSW) process as joining technique is chosen due to its good applicability to a variety of aluminum alloys, such as AA2195 and AA2219, as well as to combination of these alloys. The layout of these tanks requires a reliable data base for strength, fracture toughness, crack propagation data etc. down to temperature of 20K. Already, a large data basis for properties relevant for cryogenic tank application is present for AA2195. These data were verified by a comprehensive material characterization program, ESA-TRP – Damage Tolerance of Cryogenic Pressure Vessels, including tests on friction stir welds in order to evaluate the potential of the material for a European launch vehicle [1]. These tests also include fatigue tests in view of reusable launcher applications.

In order to evaluate these test results with respect to the applicability in a potential serial production of launcher components and tanks, it is necessary to understand the influence of the process and thus the microstructure on these properties. Therefore, in the present paper the fracture behavior is related to the microstructure of the material and thus to the

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Development, manufacturing and testing of small launcher structures from Portugal

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Abstract

During the last decades the Aerospace Industry has seen the number of Earth orbiting satellites rise at a stunning rate. This race stems from the need to monitor Earth and better understand its environments at different scales as well as to establish global communication networks, for example. Nano, micro, and small satellites have been a prime tool for answering these needs, with large and mega constellations planned for the near future, leading to a potential launch gap that can only be answered by an increase on the number of yearly launches, to keep up with demand as well as replenish established capacity. An effective and commercially appealing solution is the development of small launchers. These can complement the current available launch opportunity offer, serving a large pool of different types of clients, with a flexible and custom service that large conventional launchers cannot adequately assure. Rocket Factory Augsburg, who has been developing its own small launcher for the last two years, has partnered with CEiiA, a Portuguese engineering and product development centre, for the development of several structures for the RFA One rocket. The objective has been the design of solutions that are low-cost, light, and custom-made, applying design and manufacturing concepts as well as technologies from other industries, like the aeronautical and automotive, to the aerospace one. This allows for the implementation of a New Space approach to the launcher segment, while also building a supply chain and a set of solutions that enables the industrialisation of such structures for this and future small launchers. The two main systems under development have been a versatile Kick-Stage, for payload carrying and orbit insertion, and a sturdy Payload Fairing, both with multiple configurations. Even though the use of components off-the-shelf have been widely accepted in the space industry for satellites, these two systems pose different challenges as they must be: highly reliable during the most extreme conditions imposed by the launch, so that they can be considered safe to launch all types of payloads; while allowing for the maximum payload mass and volume, making its business case sustainable. Additionally, the manufacturing methods had to be such to allow the easy scale up and ultimately the creation of a production line for these structures. This paper thus dives deep on the solutions developed in the last few years, presenting also lessons learned during the manufacturing and testing of these structures.

Keywords: Small Launcher, New Space, Structural Design, Structural Analysis, Structural Tests, Space System Engineering

Acronyms/Abbreviations

PF Payload Fairing	SIF Separation Interface Flanges
KST Kick-Stage	RPN Risk Priority Number
S Severity	FMEA Failure Mode and Effect Analysis
O Occurrence	RFA Rocket Factory Augsburg
P Probability	ESPA Expendable Secondary Payload Adapter
D Detection	LV Launch Vehicle

1. INTRODUCTION

1.1. MAGELLAN PROJECT

The projected number of satellites to be launched has been increasing at a substantial rate, with a significant portion of those future satellites as part of large constellations, in some cases ascending to the hundreds

of elements, mainly from the commercial sector (over 60%) and linked to Earth observation (45%) and communications (19%) [1]. These missions, besides the number of planned satellites, require an increased launcher flexibility or even dedicated launches, so not to incur in loss of revenue or opportunities.

Several projects for micro-launcher development or adaptation of large launcher capacity have been initiated around the globe to answer this clear market need for increased launcher capabilities. In Europe there are several initiatives like the one from the European Space Agency (ESA) for Light satellites Low-cost Launch service [2] or the one from Rocket Factory Augsburg (RFA) with their RFA ONE rocket.

Portugal has a unique and important opportunity in this expanding strategic market. The growing Portuguese installed competences, in alignment with the Portuguese space strategy [3], allows Magellan to bring together two

7 – Sustentabilidade na aeronáutica: Clean Sky, Clean Aviation

Next Decade European Aeronautics Research Programme (2020-2030)

A paper prepared by the Clean Sky Scientific Committee (SciCom) for
submission to the Clean Sky Joint Undertaking (CSJU)

26 May 2019

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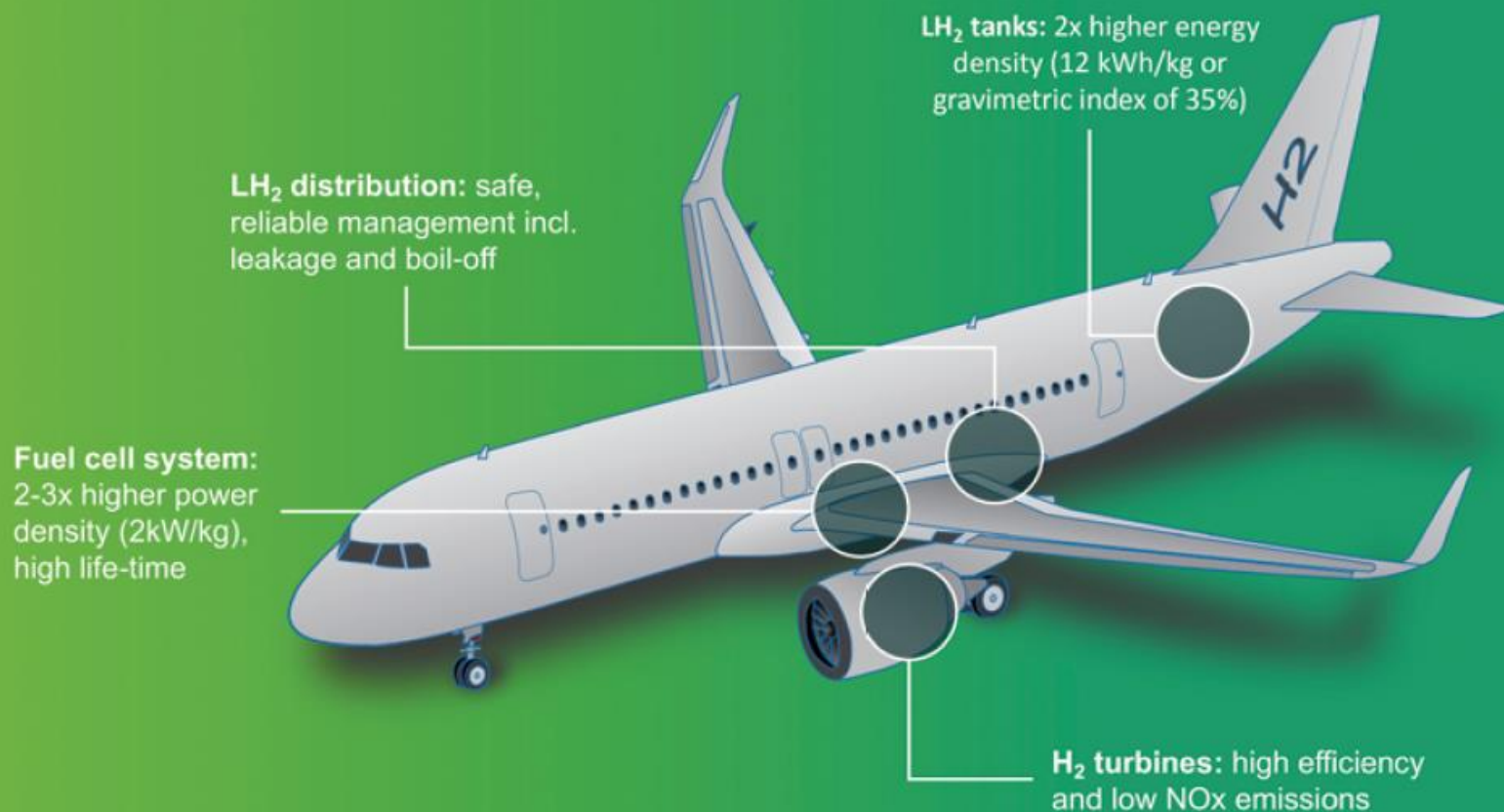
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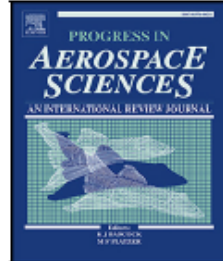
Clean Aviation Joint Undertaking

- hydrogen propulsion to power future aircraft
 - hydrogen-direct burn (replacing kerosene by hydrogen)
 - fuel cell-based propulsion (the potential of mixing both oxygen through the air and hydrogen to produce electricity.
-
- hydrogen storage onboard aircraft.
 - aircraft architecture,
 - storage device
 - keep the liquified hydrogen at – 253 degrees Celsius.
-
- how to re-fuel,
 - how to integrate it all into airport infrastructure
 - ensure that everything is safe both on the ground and during flight.

European Union Aviation Safety Agency (EASA) participates in Clean Aviation projects to comply with certification requirements.

Aircraft design: four technology improvements...





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Strategies towards a more sustainable aviation: A systematic review

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Progress in Aerospace Sciences

journal homepage: www.elsevier.com/locate/paerosci



Strategies towards a more sustainable aviation: A systematic review

Frederico Afonso^a, Martin Sohst^b, Carlos M.A. Diogo^c, Simão S. Rodrigues^d, Ana Ferreira^a,
Inês Ribeiro^a, Ricardo Marques^b, Francisco F.C. Rego^e, Abdolrasoul Sohoul^b,
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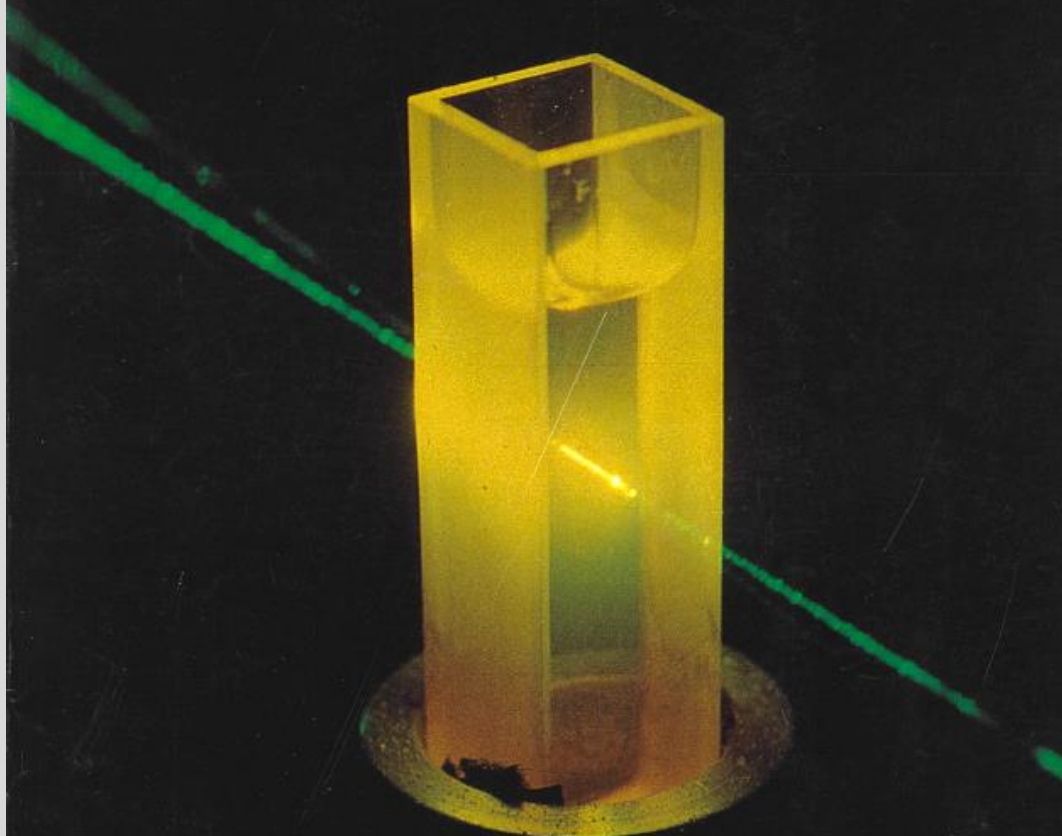
ⁱ UNIDEMI, Faculdade de Ciências e Tecnologia, Universidade Nova de Lisboa, Campus da Caparica, 2829-516, Caparica, Portugal

8 – CTS, revistas

COLÓQUIO / CIÊNCIAS

REVISTA DE CULTURA CIENTÍFICA

NÚMERO 1 FEVEREIRO 1988





Dois impulsos laser ultracurtos (100 ps, 1 MW, 532 nm), de intensidade diferente, cruzam-se numa 'cavete' contendo uma solução de moléculas de "Rodamina B" (corante orgânico utilizado como meio laser em lasers sintonizáveis) em álcool. Um dos impulsos (o mais intenso), excita as moléculas orgânicas para estados quânticos superiores; o outro impulso, com um atraso variável no tempo, é mais ou menos atenuado em função deste tempo de atraso. Esta experiência permite, em particular, medir de uma forma directa a constante de difusão rotacional das moléculas na solução. (experiência realizada no Centro de Física da Universidade do Porto).

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CTS

REVISTA DE
CIÊNCIA
TECNOLOGIA
E SOCIEDADE

JANEIRO 1987

N.º 1

REVISTA QUADRIMESTRAL



*Ciência sem fronteiras, fronteiras sem ciência • Inovação, tecnologia e mudança • Novas tecnologias da
informação e direito • O caldeirão industrial • A ciência é para todos • Livros • Banda desenhada*

CTS

CIÊNCIA
TECNOLOGIA
SOCIEDADE

Abril 93
Número 18

Número
Temático:
**Ciência,
Técnica
e Valores**



PUBLICO 20/11/95

ACTD extingue-se

A ASSOCIAÇÃO de Ciência e Tecnologia para o Desenvolvimento (ACTD) deverá extinguir-se no próximo dia 15 de Fevereiro. O desaparecimento desta organização de cientistas e tecnólogos que, pela primeira vez, tentou criar um "lobby" da comunidade científica portuguesa deve-se ao facto de não ter aparecido qualquer lista para a eleição dos seus dirigentes. Segundo o presidente da mesa da assembleia geral da ACTD, Artur Ravara, a marcação de uma assembleia eleitoral para 30 de Janeiro estava dependente do aparecimento de listas até sexta-feira da semana passada. No convite à apresentação de novas listas para os corpos sociais, a actual liderança lembrava aos membros da associação que, caso não aparecessem candidatos, a ACTD se extinguiria. Por isso, segundo Artur Ravara, a assembleia eleitoral foi cancelada e em seu lugar haverá outra assembleia "tendo como ponto único a extinção da ACTD". ■

<https://agc.sg.mai.gov.pt/details?id=587962>

ADCT - Associação para a Divulgação da Ciência e Tecnologia, anteriormente designada de Associação de Ciência e Tecnologia para o Desenvolvimento – ACTD

Anteriormente denominada de Associação de Ciência e Tecnologia para o Desenvolvimento - ACTD. Sediada no Taguspark, Parque da Ciência e Tecnologia, Núcleo Central, sala 309, na freguesia de Porto Salvo, no concelho de Oeiras. (Anteriormente sediada no Instituto de Física e Matemática, na Avenida Professor Gama Pinto, nº 2/Nossa Senhora de Fátima/Lisboa). Alteração de estatutos em 1998-10-21. Dissolução em 2001-12-18. Natureza da Associação: científica e tecnológica. Data da constituição da Associação: 16 de setembro de 1985.

■ *Algunas Considerações sobre as Reformas da Educação* ■ M. Tavares Emídio, E. Marçal Grilo, J.J.R. Fraústo da Silva

■ *Formação e Espaço Europeu* ■ Joaquim Aguiar

■ *Sociedade da Informação; Sociedade de Educação* ■ J. P. Barata

■ *Do Livro Aberto aos Sonhos Adiados* ■ Luís Bernardo Honwana

COLÓQUIO EDUCAÇÃO E SOCIEDADE

■ *A Escolha de...* Mário Soares (um texto de António Sérgio)

■ *Europa-Unidade e Diversidade, Educação e Cidadania* ■ Guilherme d'Oliveira Martins

1

OUTUBRO DE 1992

“Mantenha-se Informado, Mantendo-nos Informados”

A partir do próximo mês de Setembro, a JNICT editará **ID — Investigação & Desenvolvimento**, boletim semanal cujo número zero é agora publicado. Este boletim será fundamentalmente um veículo de informação ao serviço da comunidade científica nacional.

Assim, e numa primeira fase, o boletim incluirá predominantemente excertos de notícias do mundo da ciência e da tecnologia, recolhidos de algumas das mais prestigiadas publicações científicas internacionais. Pretendemos com isto proporcionar a cada cientista, técnico e restantes actores do sistema científico e tecnológico nacional, uma informação actualizada, sucinta e de qualidade,

respeitante não apenas ao seu campo específico de trabalho, mas também de outras áreas do conhecimento.

De igual modo incluir-se-ão notícias relevantes sobre política científica e tecnológica, bem como sobre inovações nas empresas.

Esperamos que a partir dos excertos publicados os leitores vejam facilitada a pesquisa posterior de informações mais completas. Esperamos ainda que a inclusão de material informativo proveniente de diversas áreas permita um cruzamento de ideias enriquecedor.

NESTE NÚMERO:

- ENGENHARIA GENÉTICA CRIA CARNEIROS GIGANTES
- PORTUGAL PEDE ADESÃO AO JET
- NOVA SUPERNOVA
- EXPLOSÕES SOVIÉTICAS IDENTIFICAM MINÉRIOS

É também objectivo central do boletim **ID**, fornecer outras informações úteis, nomeadamente no que toca à realização de reuniões científicas, publicação de livros ou relatórios, cursos, bolsas etc.

No que respeita à informação nacional, **ID** espera contar com a melhor rede de informação possível: a própria comunidade científica, para quem a nossa palavra de ordem será precisamente **“Mantenha-se Informado, Mantendo-nos Informados”**. Até lá deixamo-vos com este número zero que prefigura os traços essenciais do boletim que, depois do Verão, passará a estar semanalmente convosco.

Transplantation in the Central Nervous System

Transplanted embryonic neurons can establish functional connections in the adult brain and spinal cord, long believed to be immutable in mammals. Such grafts might reverse damage from disease or injury

by Alan Fine

Can damage done to the brain or the spinal cord by disease or injury be repaired? Neurons, or nerve cells, cannot regenerate in adult mammals. The great majority of them are in place by the end of infancy, and in primates, including human beings, the development of the nervous system is complete by puberty. Axons, the threadlike extensions of nerve cells along which messages travel, can re-grow after damage—a capacity underlying the slow return of feeling and

movement after certain injuries—but they generally do so only in peripheral nerves. In the brain or spinal cord a damaged pathway rarely re-forms. Even though the mammalian central nervous system (the brain and spinal cord) shows little capacity on its own for regeneration, over the past decade it has been found capable of sustaining new growth of another kind. In a series of experiments done mainly in rats, other investigators and I have shown that grafts of embryonic

brain tissue can be anatomically and functionally incorporated into the adult central nervous system. The interactions of grafts and their host nervous system have revealed much about the factors governing development and regeneration in the central nervous system. The success of certain transplantation experiments has also suggested ways to treat currently incurable disorders, such as Parkinson's disease and Alzheimer's disease, in which parts of the central nervous system degenerate.

Anti-genes attack AIDS virus

FINDING an agent that will stop the growth of the AIDS virus is not proving an easy task. The results of recent experiments using synthetic “anti-genes” suggest a possible new approach. Paul Zamecnik, of the Worcester Foundation for Experimental Biology, Massachusetts, and colleagues found that anti-genes—specially designed pieces of synthetic DNA—can bind directly to the genes of the virus and prevent the genes from being expressed (*Proceedings of the National Academy of Sciences*, vol 83, p 4143).

The researchers made a variety of DNA fragments complementary to the known structure of the AIDS virus and added them to cultures of human cells infected with the virus. The fragments inhibited viral replication and prevented the virus from manufacturing some of its key proteins. Some fragments were very effective, producing up to 95 per cent inhibition; others were not so effective, and produced only 10 per cent inhibition. The researchers hope that soon they might be able to produce different fragments that are consistently very effective.

Researchers looking for a vaccine against the AIDS virus face some difficult problems. First, the AIDS virus disables part of the immune system on which a vaccine depends. To confound matters further, the virus changes its structure spontaneously, and a vaccine can only work against a fixed target. By hitting the virus at the genetic level, anti-genes avoid these particular problems.

So far, there are few runners in the race to find an agent to combat the AIDS virus. The current leader is a class of compounds called nucleoside analogues. Like the anti-genes, these strike at viral RNA. Zamecnik's results are not as good as those given by the best nucleoside analogues, but they are comparable. Once he and his team have found a way to “fine tune” their anti-genes and make them more stable, they could close the gap. And, if anti-genes can work against the AIDS virus, they might also work against other problem pathogens, such as the herpes virus. Jeremy Green

New Scientist 28 August 1986

- ENGENHARIA GENÉTICA NA AGRICULTURA
- FUTURO DE ARIANE EM SUSPENSO
- MINISTRO BRASILEIRO DA CIÊNCIA VEM A PORTUGAL

FEVEREIRO DO PAÇO - LISBOA TACA PAGA

ID

INVESTIGAÇÃO & DESENVOLVIMENTO

JNICT

BOLETIM MENSAL
ISSN 0870 - 6700
N.º 1 - 3.ª SÉRIE
1997

Lançado pela Fundação da Juventude

IX Concurso Europeu para Jovens Cientistas

Concurso Europeu para Jovens Cientistas, da responsabilidade da Comissão das Comunidades Europeias e organizado em Portugal, desde 1991, pela Fundação da Juventude, com o apoio técnico da Junta Nacional de Investigação Científica e Tecnológica, foi criado para promover os ideais da cooperação e do intercâmbio entre jovens cientistas e para estimular o aparecimento de jovens talentos. Pretende-se, ainda, com este Concurso atrair os jovens para carreiras profissionais ligadas à Ciência e à Tecnologia, à Investigação e ao Desenvolvimento.

O Concurso consiste numa série de provas finais de âmbito nacional, a realizar nos 15 Estados Membros da União Europeia, e ainda na Noruega, Liechtenstein, Suíça, Polónia, Ucrânia, Hungria, Islândia, Lituânia e Rússia, culminando numa final Europeia, que se realizará no ano de 1997, em Milão/Itália, entre 9 e 14 de Setembro.

Que prémios?
A prova nacional do Concurso é organizada pela Fundação da Juventude, sendo a selecção dos candidatos nacionais a Prova Final Europeia da responsabilidade da Fundação e da JNICT.

Os prémios nacionais a atribuir serão: 1.º, 2.º e 3.º Prémios: material científico diverso, no valor comercial de 350.000\$000 (trezentos e cinquenta mil escudos); 250.000\$000 (duzentos e cinquenta mil escudos) e 150.000\$000 (cento e cinquenta mil escudos), respectivamente, sempre que possível, respeitando os interesses e as necessidades dos jovens premiados.

É os Europeus: Três primeiros prémios de 5000 ECU (cerca de 1000 contos), três segundos prémios de 3000 ECU (cerca de 600 contos) e seis terceiros prémios de 1500 ECU (cerca de 300 contos). Para além disso, haverá viagens ao Fórum Internacional de Ciência/Londres, ao Seminário Internacional de Ciência Jovens/Estocolmo, e à Feira Internacional de Ciência e Engenharia a realizar nos Estados Unidos da América.

Quem pode concorrer?
Jovens estudantes, com idades compreendidas entre os 15 e os 20 anos inclusive, a frequentar o Ensino Secundário ou o 1.º ano do Superior, individualmente ou em grupos (máximo de 3 elementos). Todavia, quando se tratar de uma candidatura de grupo, cada um dos seus elementos deverá preencher um formulário.

De salientar, ainda, que jovens premiados em edições anteriores deste Concurso e que tenham participado na respectiva Final Europeia, só poderão participar na fase nacional do Certame.

Data limite
Os projectos deverão ser remetidos até 30 de Abril de 1997 (data limite de recepção de candidaturas, fazendo

VIII CONCURSO EUROPEU PARA JOVENS INVESTIGADORES NA ÁREA DO AMBIENTE Pág. 3

D-net

O boletim ID poderá ser consultado através da Internet em:
<http://www.jnict.pt/id-net/>



Newsletter

from the NATO Science Committee and the Committee on the Challenges of Modern Society

ISSUE No. 1.

1984

EDITORIAL

The Third Dimension of the Atlantic Alliance

Twenty-five years ago, a new orientation was given to the activities of the Atlantic Alliance with the opening of what has since been called its "Third Dimension". In addition to the Alliance's military and political aspects, a purely civilian programme was launched, aimed at fostering international exchanges of scientists and promoting the dissemination of knowledge within Alliance countries. This was an early recognition of the increasingly important rôle which **Science and Technology** play in the modern world. The originality of NATO's Science Programme lies chiefly in the awareness that good science relies to a great extent on the **quality of scientists**; the Programme's emphasis is therefore placed on the excellence of the individual projects supported. NATO has become the largest international institution in terms of individual awards and in sponsoring international scientific meetings: several thousand scientists and engineers benefit each year from its financial support.

A new aspect of international scientific and technological cooperation has recently been added, aimed this time, through a "project-oriented" approach, at mobilizing the potential of the three less prosperous countries of the Alliance - *Greece, Portugal and Turkey*. It consists of multidisciplinary, applied research projects which help create conditions favourable to the technological and economic development of these three countries.

In total, almost 800 million Belgian francs (about US\$ 15 million) are spent every year by Alliance countries on NATO's Science Programme.

Almost fifteen years ago, the "Third Dimension" was enriched through the establishment of an intergovernmental Committee, the **Committee on the Challenges of Modern Society** (CCMS). The Committee aims at bringing together the experiences of our nations to face the threats created by the very rapid development of our societies: protection against the physical degradation of the environment, prevention of major catastrophes, enhancement of public safety, are examples of studies performed so far, within the broader context of improving the well-being of our nations.

These two programmes have a very broad following amongst specialists; most scientists know about NATO's Science Programme, most environmentalists refer to NATO CCMS pilot studies. However, these activities are not at the moment very well publicized amongst non-specialists. The objective we hope to achieve through the launching of this quarterly NEWSLETTER is to make them known to all those who are interested in improving international cooperation within Western countries: policy-makers, decision-makers, journalists, public opinion leaders, national and international personalities, as well as the more traditional audience of scientists and engineers. Nearly 8000 people have been selected for our first mailing list. More will be added.

The "Third Dimension" of the Alliance is a reflection of the cohesion and understanding between our nations; it helps improve the "visibility" of the Alliance. The present NEWSLETTER, named after the two key words of our programmes, aims at contributing to this ambitious objective.

Henry Durand
NATO Assistant Secretary General
Scientific and Environmental Affairs

NATO Science and Society in the Newsletter of the Scientific Affairs Division of the North Atlantic Treaty Organization. It reports events, activities and programmes carried out under the auspices of the NATO Science Committee and the Committee on the Challenges of Modern Society. The consortium of publishers of the NATO ASI Series have helped greatly in assuring a wide distribution of this Newsletter. The NATO Science and Society Newsletter welcomes submissions from readers. Correspondence and enquiries, as well as requests to be put on our mailing list, should be addressed to:

The Editor
NATO Science and Society
Scientific Affairs Division
NATO - 1110 Brussels, Belgium.

SPAIN JOINS NATO SCIENCE PROGRAMME

Although *Spain* has been a member of the Alliance since May 30, 1982 it was only recently that her active participation in NATO's Science Programme was finalized after the happy conclusion of the negotiations on the Spanish contribution to NATO's Civil Budget. Some modest activities have already been initiated by NATO in the support of Spanish scientists since 1982. Now the full scope of NATO's scientific co-operation is open to Spanish scientists and engineers. Under the guidance of **Professor F. Garcia Olmedo** (see inside) recently appointed delegate of *Spain* to the NATO Science Committee, a National Fellowships Committee is being set up with the help of **Sr. Aragón** from the Secretariat of State for Universities and Research as National Administrator.

A visit to Madrid by Professor **Henry Durand**, NATO Assistant Secretary General for Science and Environment, has confirmed the deep mutual interest in developing such scientific activities. *Spain* has already agreed to lead a CCMS pilot study on the problems of training in the environmental field.

Science, Technology



& Society

Curriculum Newsletter of the Lehigh University STS Program
& Technology Studies Resource Center

Editor: Stephen H. Cutcliffe
Guest Editor: Michael R. Notis

No. 85, September 1991
ISSN: 0275-8075

KNOWLEDGE, POWER AND BLACK BOXES: AN APOLOGIA FOR THE SOCIOLOGY OF TECHNOLOGY

When I was twelve years old, I was sure that I would grow up to be an aeronautical engineer (in those far-off days the term "aerospace" had not been coined). After a number of academic twists and turns I ended up a sociologist. Yet my interest in technological hardware had not left me, and with my first academic appointment I began to teach a course on the sociology of technology. (I am somewhat embarrassed to report that the course was entitled "Men and Machines"--we have made some progress since then in reducing sexist language!). Then, as now, the field was peripheral to mainstream sociology, and there was no standard set of themes, topics, facts, and methodologies. This left me free to define the course as I saw fit, a process that continues to this day.

Although a sociological inquiry into technology is not part of the established sociology curriculum, it is still grounded in

the central concerns of the discipline, for there are many natural connections between the sociology of technology and the kinds of issues that engage sociologists of all descriptions and specialties. The sociological relevance of the study of technology follows from the axiomatic principle that technology is a social creation. Tools, techniques, materials, and the organizational systems that tie them together do not appear through spontaneous generation, nor are they simply the product of individual human genius. The technologies found in a particular society have been shaped by the distribution of wealth and income, cultural patterns, and power relationships. A course on the sociology of technology therefore will naturally gravitate towards such themes as the rise of the factory system, the role of the military, corporate and governmental influence over technological development, and the "modernization" of "traditional" societies.

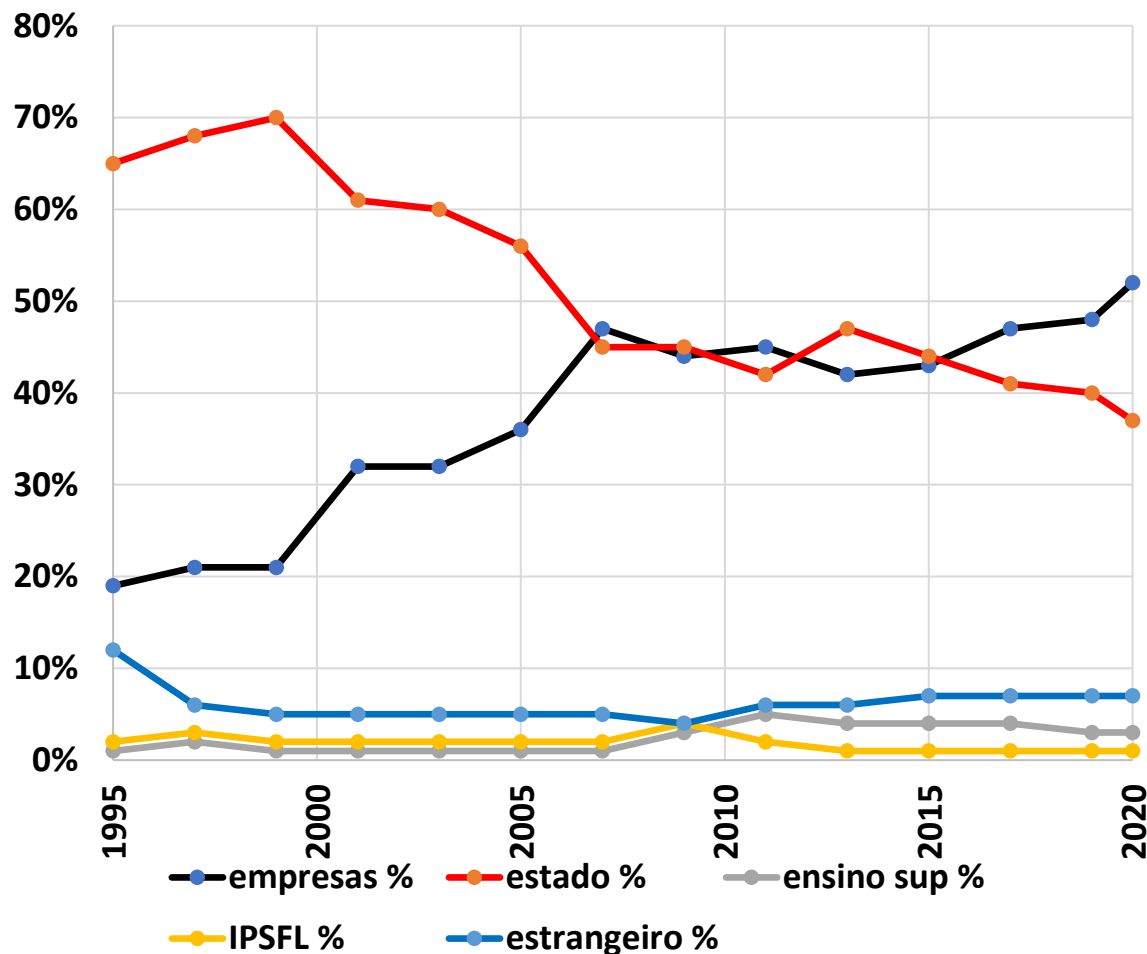
BULLETIN OF SCIENCE, TECHNOLOGY & SOCIETY

VOLUME 5 • NUMBER 2
1985

STS Press
University Park, Pennsylvania

9 – alguns dados sobre i&d

despesa I&D, preços correntes, por origem
financiamento.
de 'I&D: 25 anos de estatísticas oficiais em
Portugal'



	GDP 2021 The World Bank current USD	Population 2021 The World Bank	GDP per capita 2021 The World Bank current USD
Germany	4,26 x 10¹²	83,196 x 10⁶	51,2 x 10³
Portugal	253,7 x 10⁹	10,325 x 10⁶	24,6 x 10³

ratio	GDP	population	GDP per capita
Germany/Portugal	16,8 x	8,1 x	2,1 x

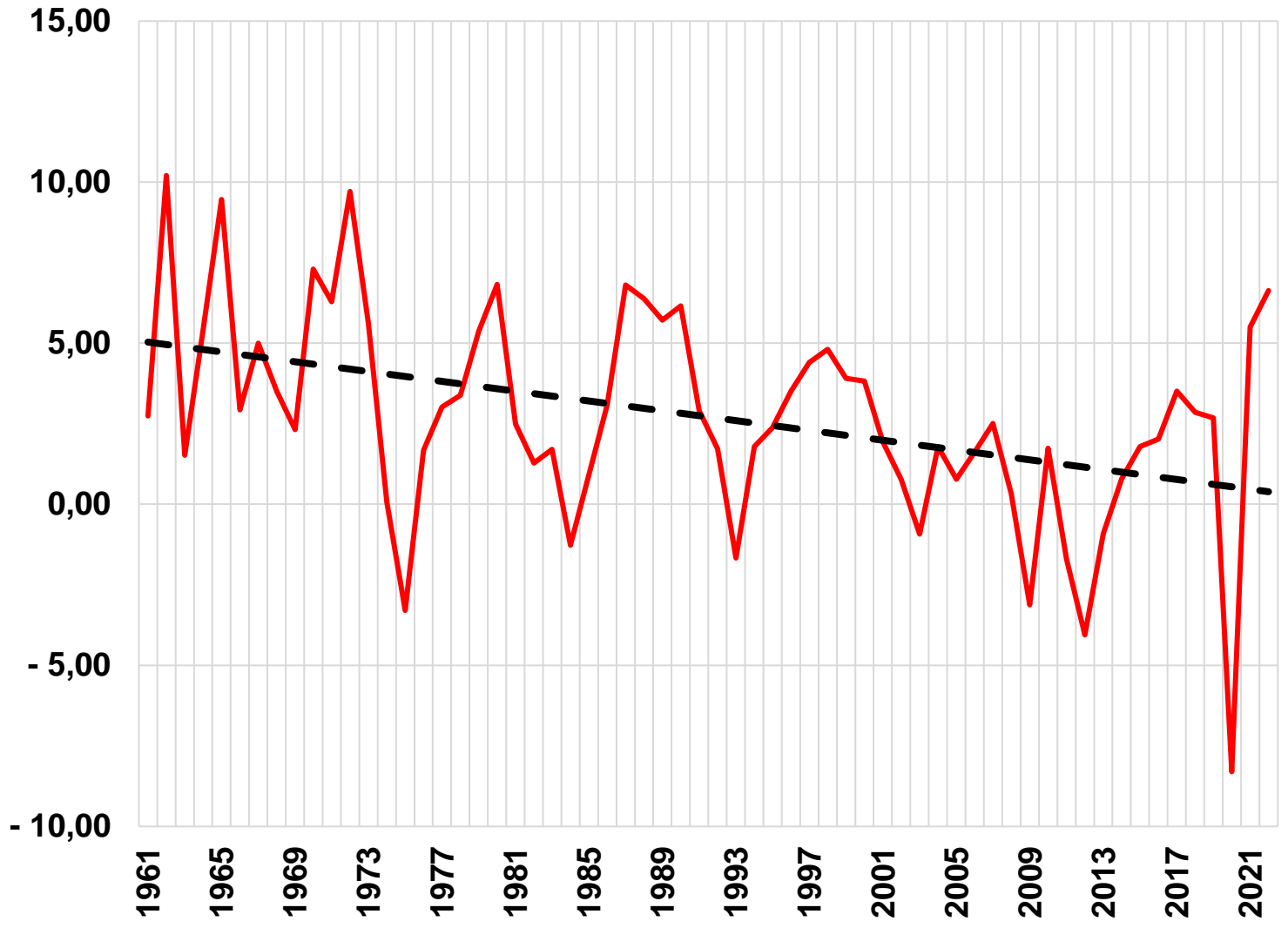
<https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=PT-DE>

Ratios (2020)	Germany	Portugal
Manufacturing/BERD	59314/71032 83,5%	666,2/1843,6 36,1%
Financiacional/BERD	352/71032 0,5%	147,7/1843,6 9,0%

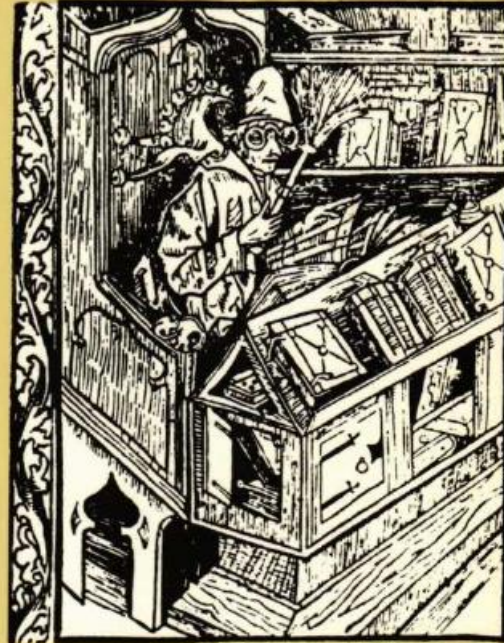
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https://ec.europa.eu/eurostat/databrowser/view/RD_E_BERDINDR2__custom_5508483/default/table

10 – PIB e literacia

Portugal - taxa de crescimento real do PIB, % Pordata



The LEGACIES



of LITERACY

CONTINUITIES AND CONTRADICTIONS
IN WESTERN CULTURE AND SOCIETY

Harvey J. Graff

Lord Kelvin:
'When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind.'

<https://physicsworld.com/a/in-praise-of-lord-kelvin/>

educational reports umeå

no 12 1977

THE HISTORY OF LITERACY IN SWEDEN

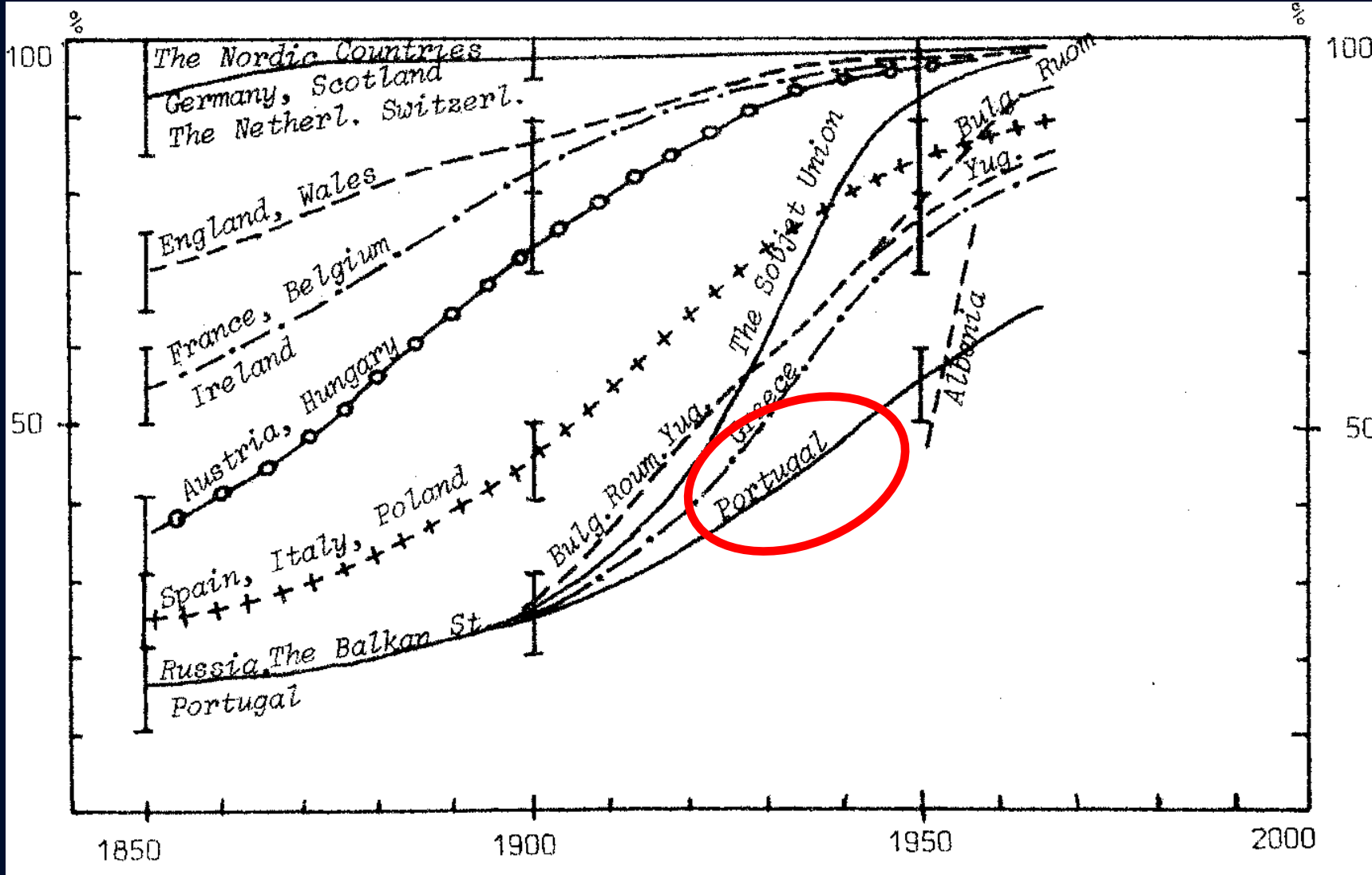
In comparison with some other countries

Egil Johansson



UMEA UNIVERSITY AND UMEA SCHOOL OF EDUCATION - SWEDEN

E. Johansson, 'The history of literacy in Sweden : in comparison with some other countries', 1977
<https://www.semanticscholar.org/paper/The-history-of-literacy-in-Sweden-%3A-in-comparison-Johansson/0085cbb42c19182d7f33770c27b5b6f24fd360af>



coda ou codetta

'.... The model shines especially when tasked to make connections between different areas of knowledge. Here is an example where we ask the model to produce a poem in the style of a particular author, and then use the response to garner additional insights into the topic and other creative avenues for exploration (to develop a deeper understanding of concepts and relationships across disciplines).

Write a poem about brittle fracture, in the style of Goethe.

*Once upon a time, in a land of matter,
A phenomenon occurred with such fury and clatter.
Brittle fracture, a crack so sharp and clear,
Cut through substances with a vengeance so dear.
Atom after atom, a tale so small,
A crack grew and spread, leaving none.
With a pop and a snap, the bond broke strong,
The cry of failure, a sound so wrong.
The world around trembled and shook,
As the crack grew and spread, left and right.
Until finally, the last bond broke,
And the cry of failure, a sound so bright.*

The poem tells the story of brittle fracture, a phenomenon that occurs when a crack grows and spreads until it reaches and breaks the last bond. The poem is written in the style of Goethe, known for his poetic works such as *Faust* and *The Sorrows of Young Werther* ...'

An effect of dwell time and environment on the resilience
of a strain-aged specimen of academia

Being a brief history of Fracture Mechanics up to the time to
the Second Symposium on Elastic-Plastic Methods, 1981

A cycle in ten stanzas :

1. In the beginning was simplicity
2. And crystallinity
3. Then came stress intensity
4. Which used a singularity
5. To strip yield of its complexity
6. And so help plasticity
7. To spread to a wider community
8. In which instability
9. Helped design curves
10. Of simplicity

THE DILBERT PRINCIPLE



A Cubicle's-
Eye View of
Bosses, Meetings,
Management Fads &
Other Workplace Afflictions

SCOTT ADAMS

Creator of Dilbert



**The #1
New York
Times
Bestseller**

THE DILBERT PRINCIPLE



A Cubicle's-
Eye View of
Bosses, Meetings,
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DILBERT TALKS TO A CLASS
ABOUT CAREER OPTIONS.



THE GOAL OF EVERY
ENGINEER IS TO
RETIRE WITHOUT
GETTING BLAMED
FOR A MAJOR
CATASTROPHE.



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