MIRCE Akademy

21st Industrial Summer School
12 – 16 July 2010
Woodbury Park
Exeter
EX5 1JJ
United Kingdom

Solving Functionability Problems
Using Complexity Science and Multi-Agent Technology

Functionability Problems

- Failure Prognostics
- Failure Diagnostics
- Failure Deferrals
- Planning of Maintenance
- Predicting Spare Parts Demands
- Real-Time Scheduling
- Despatch Reliability
- Allocation of Jobs to Staff
- Allocation of Budgets to Business Units
- Allocation of Supplies to Demands
- ……

Complexity is an Opportunity

"We have to accept that complexity, and therefore uncertainty, is a norm and that attempts to simplify complex situations and to eliminate uncertainty, which was a useful managerial and technological philosophy in industrial society when complexity was manageable and uncertainty was small, is now harmful

Complexity of functionability can be exploited - it offers rich opportunities for those who master the mindset, skills and tools of adaptation and resilience." **Professor. Rzevski**

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Starting points

Functionality vs. Functionability

Engineering products such as aircrafts and cars are designed as electromechanical structures expected to perform required function(s) with required performance. Hence, products are design for **functionality**.

Common experience teaches us that, irrespective how good design might have been; every product will fail sooner or later. Reasons for failures may be:

a) Built-in design or manufacturing errors
b) Errors due to change of components conditions with time due to wear and tear or fatigue
c) Unpredictable external forces due to collisions, harsh landings, extreme weather conditions, etc

Errors, failures and impacts interact with each other and product functionality through time and cannot be left to customers to deal with in isolation.

Hence, products should be considered as complex live systems with ever changing components interacting with each other and being affected by unpredictable external events. The ability of a product of being functional throughout its life has been named **functionability** by Dr Knezevic in 1992.

To deal effectively with functionability of products there is a need to link following functions:

(1) product design,
(2) manufacturing processes
(3) failure prognostics,
(4) failure diagnostics,
(5) maintenance and repair scheduling
(6) logistics support resources

into a single Functionability Goal. This is particularly important for aircrafts and similar means of transport for which it may be far more cost-effective to provide preventive maintenance and repair at locations where failures occur, or are anticipated to occur, rather than being forced to home base maintenance.

Solving functionability problems in desirable manner, which means at the design stage, has been considerably enhanced by advances in:

- **Complexity Science**
- **Multi-Agent Technology.**

Complicated vs. Complex

The use of the term complex is often confused with the term complicated. To understand the differences, it is best to examine the roots of the two words. “Complicated” uses the Latin ending “plic” that means, “to fold” while “complex” uses the “plex” that means, “to weave.” Thus, a complicated structure is one that is folded with hidden facets and stuffed into a smaller space. On the other hand, a complex structure uses interwoven components that introduce mutual dependencies and produce more than a sum of the parts… This means that complex is the opposite of independent, while complicated is the opposite of simple.

Following the train of thoughts suggested above, the intuitive interpretation of the term Complex as “difficult to understand” is correct as long as we accept that the main reason for the difficulty is the interdependence of constituent components.

An example that immediately comes to mind is the Internet-based Global Market, where consumers and suppliers are trading, each pursuing their own goals and targets, and where the overall distribution of resources to demands emerges from individual transactions rather than according to a given plan.

On a smaller scale we have a complex situation associated with availability of aircrafts where there is a need to manage interaction between aircraft failures, aircraft locations, maintenance and repair personnel schedules and supply of spare parts.

In general, the **behaviour of complex systems cannot be planned, controlled or predicted, and yet it is not random. It follows patterns, which may be difficult to discern. A complex system has a variety of possible behaviours and uncertainty which behaviour the system will pursue. The behaviour of complex systems is often said to be “at the edge of chaos”.**

Complex systems are said to operate “far from equilibrium”. They are not stable; the smallest external effects may cause large-scale shifts in system behaviour, the phenomenon known as “butterfly effect”, whilst on occasions, considerable disturbances may have no effect.

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Professors

Dr George Rzevski

George is an academic, entrepreneur and consultant. He is Professor Emeritus, Department of Design and Innovation at The Open University, Milton Keynes, UK and Visiting Professor of Multi-Agent Systems at Cologne University of Applied Sciences, Germany and Moratuwa University, Colombo, Sri Lanka, where he is involved in a number of advanced research projects in the fields of Complexity and Multi-Agent Systems.

Professor Rzevski has published widely and delivered keynote papers at numerous international conferences. Until recently he has been editor-in-chief of the Journal of Artificial Intelligence in Engineering, published by Elsevier. For several years George delivered a regular series of lectures on Economic, Social and Cultural Implications of the Internet to postgraduate students at London School of Economics.

Throughout his academic career George worked as a consultant for private companies, government administrations and European Union on various issues related to advanced information technologies. He was founder and chief scientist of Magenta Corporation where he developed a set of Multi-Agent Tools for practical applications.

Full details: http://www.rzevski.net

Dr Jezdimir Knezevic

Researcher, educator and entrepreneur with over 300 publications disseminated world-wide through books, papers, monographs and reports are attributed to his name. In addition, he has delivered numerous technical presentations, key note addresses and speeches; has been congress, conference, symposium chairman, track leader, workshop presenter, round table moderator on many hundreds international events which took part in all continents.

Dr Knezevic, the father of **Mirce Mechanics**, the science of the motion of functionability phenomena through the system operational process. He is the Founder and President of the MIRCE Akademy, an independent research and educational institution based in UK.

His multi-disciplinary theoretical knowledge, considerable hands-on practical experience and endless passion for the subject have attracted over 6000 engineers, managers and students to his courses and educational programmes in over 40 countries in Europe, North and South America, Asia, Australia and Africa, at universities, professional institutions, industry and government.

Dr Knezevic has worked in the field of functionability engineering and management for over 30 years.

Full details www.mirceakademy.com

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Programme

Day One

Functionability Concept

Aim: to introduce participants to the concept of Functionability and enable them to systematically address the complexity of the motion of functionability through the system operational process and to observe the physical causes and human actions that shape it

- System Functionability Concept (Definition, Laws, Rules, Case Study)
- System Functionability: Processes, Events, States, Trajectory
- System Functionability Drivers:
  - **Physical l Environnent** (Atoms, Molecules, Materials, Components, Machines, Systems)
  - **Natural Environment** (Solar System, Earth, Climate, Weather)
  - **Human Environment** (Physical, Cognitive, Cultural, Organisational)

Functionability Measures

- Number of Negative Functionability Events in stated time
- Number of Positive Functionability Events in stated time
- Cumulative Time in Operation
- Cumulative Time in Maintenance
- Cumulative Time in Logistics Support

Functionability Problems

- Failure Mechanisms, Diagnostics and Prognostics
- Maintenance planning and scheduling
- Logistics support predictions and allocations
- Organisational divisions and job allocations
- ……

Day Two

Concept of Complexity

A situation is complex if: It consists of a large number of diverse components engaged in unpredictable interaction (**Variety** and **Uncertainty**)

- Its global behaviour emerges from the interaction of local behaviours of its components (**Emergence**)
- It **self-organises** to accommodate unpredictable external or internal events and therefore its global behaviour is "far from equilibrium" or "at the edge of chaos" (**Adaptability** and **Resilience**)
- It **co-evolves** with its environment (**Irreversibility**)

Complex Systems

- Molecules of air subjected to a heat input; autocatalytic chemical processes; self-reproduction of cells; brain
- Colonies of ants; swarms of bees; ecology
- Civilisations; human communities; epidemics; terrorist networks; language
- Free market; global economy; supply chains; teams
- Artificial Complex Systems: multi-agent systems; the Internet; intelligent geometry compressors; a family of robots; a swarm of satellites; lifespan of products.

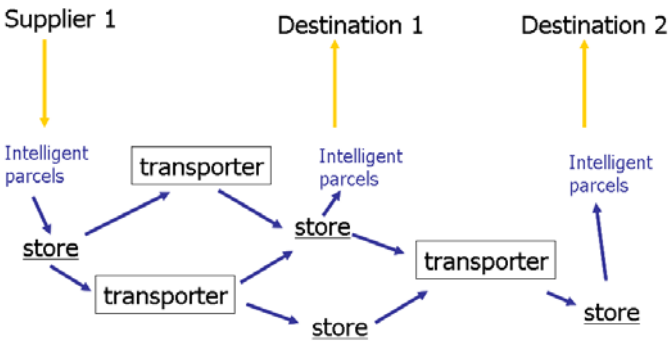
Complexity and Engineering

Design complexity into engineering products to achieve adaptability and resilience:

- Insert sensors to provide information on product behaviour
- Replace control systems with multi-agent software to enable adaptation, resilience and emergence
- Design actuators to enable multi-agent software to modify the product behaviour

Engineering Out Functionability Problems

- A Swarm of Agents Controlling a Machine Tool
- A Family of Space Robots
- Intelligent Geometry Compressor
- A Colony of Agricultural Machinery
- Global Logistics Network
- Intelligent Tagging in Retail
- Aircraft Wing Design



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Day Three

Multi-Agent Technology Concept

An **Agent** is a small computer object capable of composing, sending, receiving and interpreting messages. Agents operate in **Swarms**

Ontology is conceptual knowledge of a problem domain, and it is structured as a network where classes of objects (characterised by attributes, and rules of behaviour) are nodes and relations between objects are links.

Scene is a current (perpetually changing) model of a problem situation, and it is structured as a network where instances of objects (defined as classes in ontology) are nodes and relations between them are links.

Engine is a collection of algorithms which
- Activate and deactivate Agents
- Allocate roles (Demand or Resource) to Agents
- Update the current Scene

An Agent is assigned to every **Demand** and **Resource** with a task to negotiate the best possible deal for its client
Demand Agents and Resource Agents **negotiate** deals until the best possible match between Demands and Resources is achieved

Whenever an **Event** (new order, failure, delay) occurs they **re-negotiate** previously agreed deals

The allocation of Resources to Demands is represented as a current **Scene** (a network where Resources and Demands are nodes and their matchings are links)

Day Four

Functionability Ontology and Scenes

- Operational Process
  - Continuous vs. Seasonal
  - Normal vs. Training
  - Peace vs. War
- Failure Mechanisms
  - Inherent
  - Accidental
  - Ageing
- Maintenance Process
  - Organic vs. Outsource
  - Corrective vs. Preventive Maintenance
  - Inspection vs. Examination
- Logistics Support Process
  - Level of Support
  - Discard vs. Repair
  - Fill rate vs. Expected Back Order

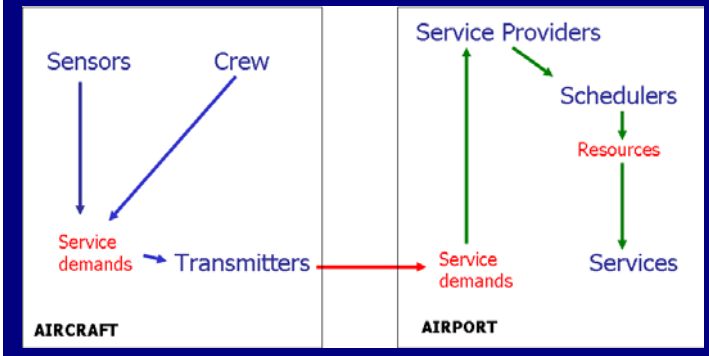
Day Five

Case Study: Real-Time Functionability Scheduling

During the product operation (e.g., for aircrafts during flights, and for cars when they are on the road) **monitor Functionability Sensors and broadcast the signals to the nearest maintenance and repair shop** for signals to be analysed for indications of possible imminent failures.

Based on long-term plans and on results of real time functionability monitoring, **perform Real-Time Scheduling of Servicing and Spare Parts Supply** with the aim to arrange for servicing personnel to meet the aircrafts/trains/buses/ships/cars at their destination and execute required maintenance or repair task, if required. Spare parts will be supplied where and when required.

Under this scheme **servicing intervals are dynamic** and depend on operating conditions and the conditions of the product; they change as the requirements for maintenance and repair change. Costs of storing spare parts may be reduced dramatically..



Closing Remarks:

Availability, Reliability, Readiness, maintenance, logistics and similar problems, can be effectively solved by embracing concepts, principles and methods of **:**

- **Functionality**
- **Functionability**
- **Mirce Mechanics**
- **Complex Science**
- **Multi-Agent Technology**

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Venue

Woodbury Park is a magnificent 500 acre leisure and sporting complex set among green rolling hills above the South West English coastline, only a few miles from the ancient city of Exeter.

Communication between Exeter and other parts of the United Kingdom are excellent.

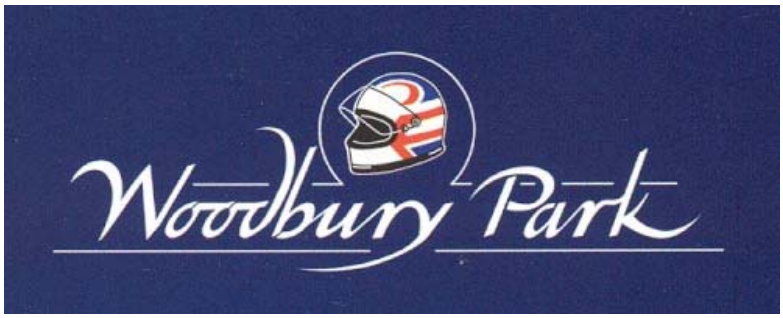
By road, the M5 motorway links Exeter to London, the Midlands, Scotland and Wales. Regular rapid coaches run services to and from London and Heathrow Airport.

By rail, a regular fast service is available to and from Exeter (St David's Station) and London (Paddington Station).

By air, Exeter Airport offers regular flights to many British and Continental destinations and is situated near to Woodbury Park.

Travel between Exeter and Woodbury requires a car or taxi and takes about thirty minutes.

Among the outstanding leisure facilities at Woodbury Park are two golf courses including the magnificent Oaks Championship course, tennis courts, a swimming pool, spa, sauna and fully equipped gymnasium and well appointed lounge areas and bars.



Woodbury Park is also home to the **Nigel Mansell World of Racing** that celebrates the remarkable career of one of the world's great champions. The exhibition includes Formula 1 racing cars, video coverage of many outstanding racing achievements, in addition to trophies and memorabilia, marking Nigel Mansell's world-wide successes in the '92 Formula 1 and '93 Indy World Championships.

Key Information

Price (GB Pounds £)

Package	Fee	VAT	Total
Participant	1295.00	226.63	**1521.63**
MIRCE Member	1245.00	217.88	**1462.88**
MIRCE Student	995.00	174.13	**1169.13**

The Price includes:

- Tuition
- Study Materials
- Lunches
- Light Refreshments
- Summer School Dinner on 14th June
- Visit to the Nigel Mansell World of

Group Discounts For Standard Participants

Groups of 3 or more booking at the same time from the same organisation will receive a 10% discount. For 5 or more there will be a 15%

Location and Accommodation

The Congress will be held at **Woodbury Park Hotel, Golf and Country Club**, which is approximately eight miles from Exeter by road.

Participants are responsible for the arrangement and payment of their own travel and accommodation. Participants wishing to take advantage of preferential room rates should contact Woodbury Park Hotel Reservations quoting 'MIRCE'.

The contact details are:

Woodbury Park Hotel, Golf and Country Club, Woodbury, Exeter, EX5 1JJ, United Kingdom

Tel +44 (0) 1395 233 382
Fax +44 (0) 1395 233 384
Email **enquiries@woodburypark.co.uk**
Web www.woodburypark.co.uk

A list of alternative accommodation in other hotels and guesthouses in the vicinity is available from MIRCE Akademy on request

Travel

For travel details to Woodbury Park and a map visit our website at www.mirceakademy.com.

Messages

During the Summer School participants may be contacted by telephone on +44 (0) 1395 233 856 or by fax on +44 (0) 1395 233 899. Messages will be passed to participants during breaks.

Language

The Summer School language will be English.

Recommended Attire

Smart casual is recommended dress code for the Summer School and in the in the grounds of Woodbury Park.

No formal dress is required for the Summer School Dinner.

Smoking

Woodbury Park does not permit smoking in any of the leisure and sport complex facilities and in the hotel.

Mobile Phones

Out of consideration to speakers and the audience, mobile phones should be switched off during the formal sessions.

Further Information

☎ **+44 (0) 1395 233 856**
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Booking Form

Please photocopy for each additional participant

Terms and Conditions

Substitution of participants may be made at any time. If you intend to do this, please advise MIRCE Akademy as soon as possible.

Cancellation of a booking must be received in writing by the organiser at least 14 days before the commencement of the event in order to receive a refund of payment. Mirce Akademy regrets that no refunds will be made after the deadline.

MIRCE Akademy reserves the right to change the advertised programme or location or to cancel the event at its discretion. In the event of cancellation of the event by MIRCE Akademy payments received at the cancellation date will be refunded. All places offered are subject to availability.

MIRCE Akademy is not responsible for any loss or damage as a result of substitution, alteration or cancellation of the event.

Participant Details

Surname	
First Name	
Position	
Department	
Organisation	
Address	
Zip/Post Code	Country
Telephone	Fax
Email	
Special Dietary Requirements	
I understand and accept the terms and conditions and payment as shown.	
Signature	Date

Payment Method

☐ Cheque

I enclose a cheque for GB £ **payable to Mirce Science Ltd.**

☐ Bank Direct Transfer

Bank details (please quote Summer School on remittance advice):
National Westminster Bank plc, Exeter Bank Branch, 59 High Street, Exeter, EX4 3DL, United Kingdom. Sort Code: 56 – 00 – 49 Account: MIRCE Science Limited Account No. 25189603 IBAN: GB07 NWBK 5600 4925 1896 03 BIC: NWBK GB 2L.

☐ **Credit Card**

Please debit my credit card ☐ Visa ☐ MasterCard ☐ Amex	
Cardholder	
Card No.	Expiry Date
Cardholder's Signature	Security Code

☐ **Invoice**

Please invoice my organisation	
For the attention of	
Purchase Order No.	
Address (if different from above)	
Zip/Post Code	Country

Value Added Tax (VAT)

Unless special exemption arrangements exist, under UK Customs and Excise regulations participants from all countries are required to pay UK VAT @ 17.5% at the time of publication. Non-UK participants may be able to recover VAT incurred via the relevant tax authority in their country of origin.