

# A new academic discipline:

Advancing factory science, economics and artifacts science

Professor Masayuki Matsui from The University of Electro-Communications, Tokyo, proposes that Industrial Engineering and Operational Research (IEOR) can be viewed as the art of his 3M&I-body system. His methods have led to a new academic discipline that contribute to the integration of knowledge and intelligence in nature versus artifacts science. This research facilitates the realisation of the cyber/real world, including enterprise robots, cloud-coordinated supply chain management and has the potential to be applied to smart cities in the near future.

Industrial engineering focuses on the development, improvement, implementation, and integration of resources to optimise complex processes, systems, and organisations. The advanced analytical methods of operational research are often employed by industrial engineers to help them make decisions, which are further informed by big data analytics.

Professor Masayuki Matsui from the University of Electro-Communications, Tokyo, proposes that Industrial Engineering and Operational Research (IE&OR) can be viewed as the art of his 3M&I-body system. The '3M' refers to huMan (labour), Material/Machine (manufacturing process) and Money (capital) resources and 'I' denotes information resources. In our competitive, global and AI-aided environment, Professor Matsui's methods have led to a new academic discipline which aids the construction of harmonic worlds such as win-win (a trade off where both parties gain wealth) and the sharing

society. Professor Matsui offers a white-box approach to nature versus artifacts science and dynamism with his matrix and wave method, together with his clock system of artifacts.

### ORIGINATING WITH ARCHIMEDES

The study of a body, or object, is rooted in Archimedes' work where he investigated attributes of objects using his balancing and area method. Archimedes was able to use his knowledge of levers to compare and contrast the areas and volumes of various geometric figures by balancing them, like on a see-saw, using the law of the lever. Where Newton's laws of inertia, equations of motion and action and reaction can be applied to nature, Matsui's laws correspond and enable the 3M&I-body to be applied to artifacts.

### 3M&I SCIENCE VERSUS CYBERNETICS

Professor Matsui explains how the science of 3M&I is a post-cybernetic concept as it is related to both the natural body (entities not modified by humans) and the artifact body (artificial things created and

modified by humans) in multidimensional space; whereas cybernetics is related to the communication and control methods of animal (biological systems) and machine (non-biological or artificial systems). There are two approaches to the systemisation and control of 3M&I-body: by inventing the pair map of rotating microcosm type on the base of pair matrix (input, output) with input-min versus output-max, together. These incorporate artificial intelligence and the internet of things, together with Matsui's matrix and 3D modelling. The first offers an analogical and visual approach to real entity. The latter offers a digital and logical approach to system decisions that can be applied to the robotics of bodies.

### A BLACK-BOX APPROACH

A black-box approach is concerned with the input/stimulus and output/response but not the actual workings of the system. This approach has traditionally been taken with research into the artificial, or artifacts. Contrasting with the natural sciences' immersion in 'how things are', the sciences of the artificial are interested in 'how things might be' i.e. their design. This underpins the mathematical and scientific methods on offer to explore human decision making and problem solving with computer simulation and artificial intelligence.

### A WHITE-BOX APPROACH

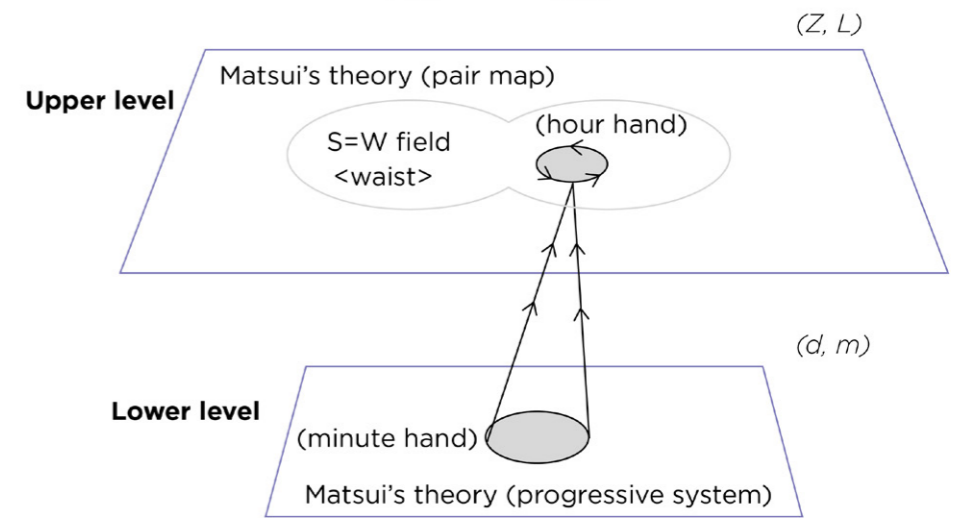
A white-box approach means that the internal mechanism can be accessed, but not altered. Professor Matsui adopts the white-box approach to 3M&I-body artifacts formulation. He bases this approach on a matrix/3D method, where 3D refers to the 3-dimensional graphical method for real-time and dynamism.

Moving towards this white-box paradigm, Professor Matsui describes the natural-box phase: "The term 'natural-box' means that our society/body and its environment is probably not clarified and is not necessarily white-box, but is natural- or black-box. My theory could contribute to the move from natural- to white-box."

### SANDWICH AND BALANCING THEORY

In his recent books, Professor Matsui fuses both theory and applications in the study of the 3M&I-body. He clarifies the meaning of the classical Matsui equation using mathematical sciences. He uses

**Clock System:** Long hand ↔ Short hand  
 Second hand ↔ Minute hand  
 Fast ↔ Slow



Fractal dynamism of artifacts: Clock type.

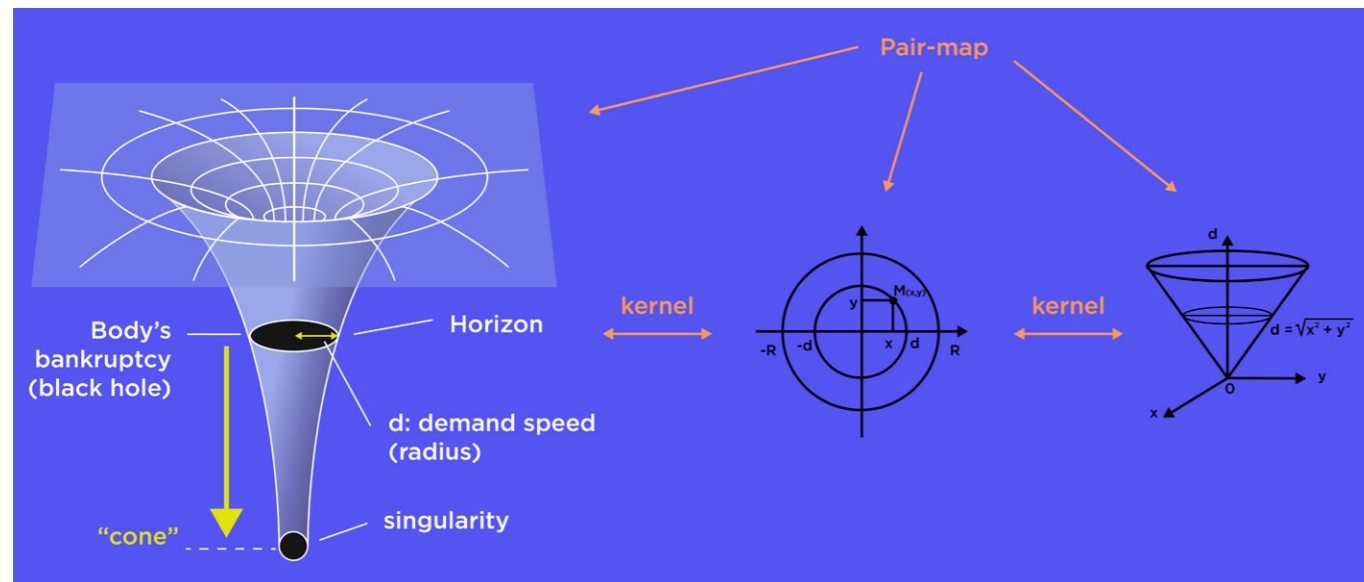
## His theory has developed from factory science, to economics and now artifacts science.

the sandwich theory, which models the behaviour of a beam made up of three layers comprising two face sheets and a core, and incorporates the squeeze, or pinching, theorem, together with balancing theories derived from the work of Archimedes. With these, he solves fundamental problems from two perspectives: that of the specific gravity in economic allocation, and from the physical size, using the lever rule. Based on the pair matrix, the sandwich model (a form of Matsui's matrix equation) was formulated to model enterprise, particles and motor bodies towards advanced artifacts.

Professor Matsui's sandwich, or S=W, theory of enterprise describes the dilemma of bottom up versus top-down approaches to organisational management depicted by a Venn diagram, where he refers to the intersection of the upper (W) and lower (S) levels as the 'waist'. He developed the dynamism of the sandwich artifacts into the matrix, wave and clock system. While developing the theory, Professor Matsui visualised the dynamism of artifacts

digitalisation and lot-sizing economics (methods to determine the quantity of an item that is required to be manufactured) in contrast to a sharing society—a model based on the peer-to-peer sharing of access to goods and services.

Professor Matsui's early research was motivated by queueing theory, a discipline based on mathematical probability. His sandwich model is supported by the Little Law, given by the equation  $L = \lambda W$ , where L represents the long-term average number of customers in a stable system,  $\lambda$  the long-term average effective arrival rate and W the average time a customer spends in the system. Matsui's theory has developed from his basic laws for factory science equation  $W = ZL$ , where W represents the asset value, Z its revenue and L its lead time per cycle. This equation models the inflow, outflow and loss system of assets, such as human and organisational resources, on the point of purchase or point of sale. Together with the Law of Muda (Japanese for wastefulness), his theory has developed from factory science, to economics and now artifacts science. Professor Matsui



has established a relationship between lot-sizing and sharing society built on his examination of modern economic growth.

The Matsui formula is a foundation of artifacts instead of the Little Law. Professor Matsui developed his formula with the Chameleon's criteria, aligning business processes with customer needs using technology that can be camouflaged and blend into its surroundings like a chameleon, in the harmonic world; thus clarifying and extending the roles of the Matsui's formulas with Muda in the 3M&I-body.

#### MATSUI'S MATRIX METHOD

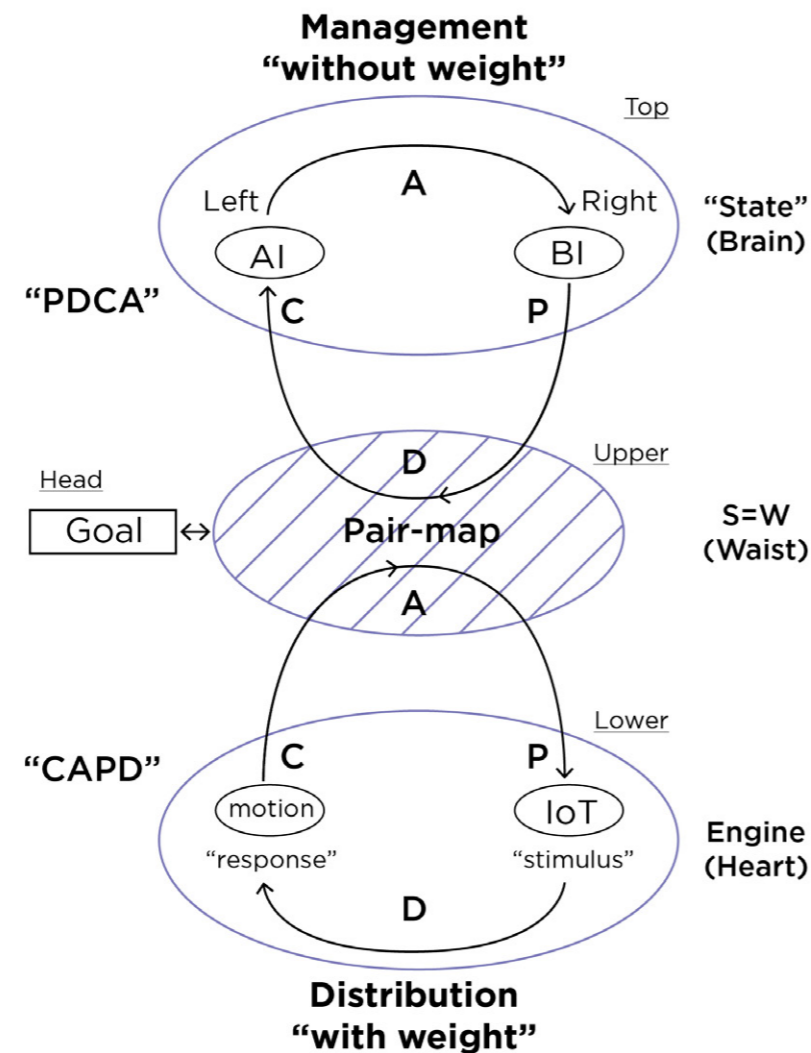
Matsui's matrix method comprises a matrix pair and Matsui's matrix equation. Matsui's matrix equation is based on six logics, and is similar to Chinese ki-sho-ten-ketsu style and Independent Component Analysis (ICA), used to reveal hidden factors underlying random variables in big data. This class of fractal-like type could also include the (interindustry) Input-Output Analysis in economics.

#### FRactal/Harmonic Principles in Artifacts

Professor Matsui has completed an investigation of lot-sizing economics and sharing society, as well as the characteristics of the Matsui matrix equation together with pair-map duality, towards the growth of GDP. Consequently, the design method matrix leads to equilibrium, a saddle point similar to the classical Nash problem solution and the control problem's min-max stable point. This has led to his proposing a third principle. Prof Matsui explains his third principle: "The fractal/harmonic-like structure (mechanism) of the cosmos, life, and capitalism types that is again found in the matrix and 2-level approach to the 3M&I-artifacts structure and its modelling". The fractal structure refers to the ordered-entry structure or dynamism from conveyor theory. The harmonic structure is the harmonic mean as used in rate balancing. In a similar way to the sharing and balancing structure in duality, Professor Matsui refers to these classes as the fractal/harmonic-like principle of artifacts science.

#### 3M&I-ARTIFACTS DYNAMISM

The 3M&I-artifacts dynamism is made up of Matsui's matrix equation and the fractal/harmonic structure of space and time, in



### Outline of humanized artifacts with pair-map in the 3-phase

## A new academic discipline which aids the construction of harmonic worlds such as win-win and the sharing society.

rate balancing. This can be seen in dual PDCA (plan-do-check-act) cycle for the reverse and dual (design) problems. Its robot-body style can be constructed from the cyclic processes of PDCA in analysis and synthesis. This dynamism corresponds to the clock system of short hand in the upper and long hand in the lower, and would accompany the new dynamic method and time management.

#### BROADER IMPLICATIONS

This research could be applied to other types of stochastic assembly line planning that incorporate pair-map

strategies for line production, and also for demand-to-supply maps for job-shop and lot-production, particularly in enterprise robots. In addition, it would contribute to digital and look-ahead operations and control technology, specially under delay/loss. Professor Matsui contributes to the integration of knowledge and intelligence in nature versus artifacts science. His work has facilitated the realisation of the cyber/real world, including enterprise robots and cloud-coordinated supply chain management, and has the potential to be applied to smart cities in the near future.



# Behind the Research

## Professor Masayuki Matsui

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### Research Objectives

Professor Masayuki Matsui's research interests include industrial engineering, production and operations management, operations research, artifacts science and management.

### Detail

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#### Bio

Professor Masayuki Matsui is Emeritus Professor at the UEC Tokyo and Visiting Professor of Kanagawa University, Japan. He received a BS and MS in Industrial Engineering (Hiroshima University) and a DEng (Tokyo Institute of Technology). Prof Matsui was visiting scholar of UC Berkeley and Purdue University in 1996-97. He is Board member of the International Federation for Production Research. He was awarded the Sir Issac Newton-related Awards in 2012 & 2016 and won the Marquis Who's Who Lifetime Achievement Award in 2018 & 2019.

#### Academic societies

- OUKAN (Transdisciplinary Federation of Science and Technology)
- JIMA (Japan Industrial Management Association)

#### Mathematical advisors

Dr Kiyomasa Narita, Emeritus Professor of Kanagawa University



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### Personal Response

#### What are you planning for the next key developments in 3M&I-body?

From the 3-skyme (S=W), we are developing the pair-hierarchy theory of nature versus artifacts body in the pair-like type, similar to the relativity theory in physics. For this purpose, we are taking an engineering approach to 'how things might be', by performing the artifacts realisation and management method of humanised robotisation. There is the classical problem of dualism and skewness (creaking) on the upper versus lower level in the nature and artifacts. For example, the interesting issues on the motion versus energy system in Newton's Law and the amount versus value system in Matsui's Law would usually originate in a little delay-like gap of input (demand) versus output (supply). "