# JUDO

# Business Intelligence

**Figure 1**. [Judo-BI – Uchi Mata]. Source: Author's original elaboration with AI-assisted generation.

**Judo-BI™**

*Adaptive Risk and Decision Support*

**A practitioner-oriented concept note**

**based on industry and audit experience**

*by Sergio Rubichi*

*CISA, CISM – Lead Auditor: ISO 9001, ISO 27001, ISO 22301*

*FIJLKAM Certified Technical Instructor*

*– operating within the International Judo Federation –*

This work explores how ***Judo match analysis***,

integrated with advanced technologies and statistical–computational methods,

could contribute to the analysis and management of *Risk* in complex systems.

The idea of writing these notes originates from extensive experience

as an ICT auditor and security manager,

and from studying and participating in activities

concerning various forms of *hand-to-hand close-combat*.

***The true strength of a judoka lies not in avoiding the fall,***

***but in rising again with balance, humility, and composure.***

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## *PRELIMINARY NOTE*

This document offers a concise, yet in places more extensive, representation of the material provided and available on the website https://is-auditing.net/; its contents and conceptual references have therefore been coherently reorganized in sequential form.
The paper intentionally uses largely popular language: although it addresses concepts and tools of perhaps advanced academic level, the exposition prioritizes clarity and accessibility, with the aim of reaching also a non-specialist audience, without compromising conceptual rigour.
This stylistic choice is functional to the applied nature of the work and to objective of facilitating knowledge transfer across different domains, in line with the principles of applied research and complex systems engineering. The work has been developed as an interdisciplinary *Proof of Concept*, integrating competencies and experience gained in the domains of Judo, systems engineering, *Risk Management*, and *organizational Governance*.
During the drafting process, *Artificial Intelligence* tools were used in a targeted and conscious manner to support linguistic reformulation, translation, stylistic harmonization and clarity of exposition, without delegating to such tools the definition of conceptual content, methodological choices, or conclusions. The contributions have been contextualized to ensure coherence, conceptual reliability and alignment with relevant ethical, regulatory and scientific principles.
The selection of theoretical references, the design of the *Judo-BI™* framework, the construction of conceptual analogies, the interpretation of results and the assessment of application limits were guided by the author on the basis of domain knowledge, professional experience and critical reasoning. The experiments and analyses presented are intended to substantiate the methodological paradigm; subsequent validation phases on broader samples and in real operational contexts will constitute future developments and will be the subject of extended study.

## 1. *INTRODUCTION*

The term *Business Intelligence* in *Judo-BI™* is used in a broader conceptual sense, rather than referring exclusively to traditional data analytics tools: it denotes an adaptive analytical capability inspired by Judo principles, aimed at detecting emerging imbalances, preparing appropriate responses and acting at the appropriate moment within complex *socio-technical systems*[1].

### 1.1 *Judo-BI™*: a Methodological Framework

Traditional Risk Management constitutes a fundamental safeguard for regulatory compliance and decision traceability. Based on periodic cycles of risk identification, assessment and treatment, it ensures methodological order and formal accountability. However, in contemporary systems – interconnected, distributed and characterized by non-linear interdependencies – clear limitations emerge: the difficulty of governing rapid dynamics, weak signals and sudden propagations.
In such contexts, risk no longer appears as an isolated event to be classified, but as a process of progressive imbalance. Responses grounded in fragmented information and predominantly reactive logic may prove delayed or disproportionate.
*Judo-BI™* is proposed as an evolutionary extension of the classical model. It does not replace it, but enhances its effectiveness by introducing a systemic and adaptive perspective [→ Fig.5]:

- identification becomes continuous detection of imbalances (*Kuzushi*)[2];
- planning transforms into dynamic configuration of the response (*Tsukuri*);
- intervention takes the form of proportionate and timely action (*Kake*).

[1] An organizational approach that integrates the social system (*people*) with the technical system (*technology*) to optimize organizational performance, transcending rigid models and emphasizing cooperation.
[2] Such signals often emerge from subtle variations in real operations (*work-as-done*), rather than from formally modelled processes (*work-as-imagined*) alone.

Through integrated observation, double-loop control and advanced analytical support, risk treatment evolves from a linear sequence into a continuous process, in which Artificial Intelligence (A.I.) does not replace human judgment but strengthens its timeliness and documentability.
Risk thus becomes a *dynamic* to be governed, not merely an *object* to be assessed periodically.

## 1.2 Objectives, Context and Rationale

This work explores not only the technical-tactical dynamics of *Judo*, but also the potential transposition of principles of stability, adaptation and transformation – observed at the "athlete level" – into indicators and strategies for the *Engineering Resilience* of economic and organizational processes. From this perspective, external perturbations (e.g., an *opponent's attack*, a *market shock*) are treated as *stress Inputs* to the observed dynamic systems; the capacity to reorganize *technical and decision-making assets* is modeled analogously to an athlete's ability to reconfigure posture and strategy in real time.
The proposed *pipeline* (processing chain) therefore provides not only tools for sports analysis, but also a common methodological language to translate kinematic and dynamic observations into operational metrics useful to managers, systems engineers and policymakers concerned with organizational resilience. The framework also shows affinities with the emerging field of *Decision Intelligence*, which integrates data analysis, contextual interpretation and human judgement in support of adaptive decision-making.
Thus, *Judo-BI™* can be interpreted as a point of convergence between three conceptual traditions:

- the dynamic logic of action derived from *Judo*;
- the systemic perspective of *Resilience Engineering*;
- the emerging field of *Decision Intelligence*, which integrates data analysis, contextual interpretation and human judgement.

In this sense, *Judo-BI™* represents an analytical–adaptive framework for risk management and decision support in complex systems. The approach outlined does not aim to define a rigid model, but rather to provide a dynamic interpretative framework capable of evolving alongside both the context and the individual applying it.

# 2. *JUDO* as a Complex Adaptive System

The discipline is based on the principles of maximum efficiency and mutual prosperity.
Judo, in particolar ("the way of yielding"), is used as a study model for dynamic 'attack-defense' systems. It is the first martial art to be fully included in the list of Olympic sports and remains a subject of study in schools in Japan and other countries today.
It derives from Jujutsu (a codified form of "no-holds-barred" close combat) and is the result of a long elaboration, thanks to a series of studies initially conducted by the Japanese master Jigoro Kano, who in 1882 founded a school of this style in Tokyo in a gym called *the Kodokan*, one of the primary points of reference for all practitioners. Kano eliminated those techniques from Jujutsu that could have permanently harmed one's opponent, focusing instead on the development and improvement of the quality and effectiveness of defensive and "light" attack movements; by advantageously exploiting the kinetic energy and angular momentum of the *Tori–Uke*[3] coupled system.
The spirit of Judo is based on the principle of *mutual prosperity* and its mastery requires a perfection of execution, which is achieved when the technique transcends the cognitive phase and reaches naturalness. To facilitate the learning of *fundamental motor patterns*, it is taught as a playful activity consisting of running, jumping, tumbling and falling.

[3] *Tori* is the athlete who *performs* the technique, while *Uke* is the one who *receives* it. However, especially in the context of training/exercise, roles are reversed when necessary; both actively participate in the dynamics of the action.

 

In the gym, comprehensive exercises are carried out that involve all muscle groups, heart and lungs in a balanced way, safeguarding and often correcting eventual *postural defects*.
Initially, competition techniques are not performed, but rather games, specifically designed by instructors, which reproduce technical gestures and help approach the discipline *gradually*.
Students will discover the technique by themselves at the appropriate time, acquiring it as a *new experience* and allowing "their own" Judo to evolve.
In play, it is indeed possible to demystify things or situations, bringing them under emotional control by overcoming a process of *dramatization*[4] that will enrich basic individual skills:

- a plurality of motor patterns, versatility of contents, individual interpretation and imagination.

Being widespread and successfully practiced worldwide, for both amateur and educational use as well as competitively, it is possible to demonstrate how Judo techniques are sufficient to control the attacks of an opponent *bare-handed* or armed (at close range).
We could qualify ***yielding*** as a necessary condition for the correct development of ***flexibility***:
as a matter of fact, by interpreting the realization of a motor pattern as a concept belonging to the domain of *communication and control of a system*, one realizes that initially "yielding" to an offensive action favors that process of knowledge and mechanism of counter-reaction to the event.
This process can lead, in a trained individual, to an effective response with the least expenditure of Energy. It is also important to provide some insights to be used for the finalization of the work on the *mat* ('tatami'), whether standing or on the ground, within a "regulated" situation.
By 'sports competition' one means a clash, governed by a code of conduct, between two athletes who come into contact (*Kumi Kata*) to start a confrontation.
This encounter involves a myriad of attack actions, defensive maneuvers and counterattacks that necessarily follow one another until one opponent prevails over the other.
The antagonists' effort to achieve victory is carried out according to certain general concepts from which the articles in the *Competition Regulations* derive and according to specific conditions of the competition, defined as *opportunities*, which arise from the personality and technical preparation of both oneself and the opponent. [1]

## 2.1 Strategic and Tactical Planning for *Engineering Resilience*

*Engineering Resilience* refers to the ability of a system, project or infrastructure to anticipate, absorb, adapt and recover quickly from unforeseen events, interruptions or disturbances, maintaining its functionality: minimizing negative effects and returning to its optimal state or to a new, improved state. In other words, it concerns the robustness and flexibility (as opposed to stiffness) of a system in relation to changes or risks, with the goal of maintaining performance and functionality even in the presence of *stress* or *disasters*.

## 2.2 Main components of *Engineering Resilience*

1. ***Prevention***: designing systems to minimize risk exposure (for example, in an engineering project, minimizing the probability of failures);
2. ***Adaptability***: the system's ability to adapt dynamically to changes or unforeseen events, just as a judoka changes *strategy* and *tactics* based on the contingent situation;
3. ***Rapid recovery***: the ability to recover quickly from interruptions or malfunctions, like a production system that recovers swiftly after an unexpected event, minimizing the impact on the process;
4. ***Flexibility***: the ability of a system to modify and optimize its behavior to reach objectives, even in unforeseen circumstances;

[4] A therapeutic technique, such as *psychodrama*, that uses theatrical performance and role-play to explore internal conflicts and improve self-understanding.

 

5. ***Sustainability***: not just reacting to risks, but designing to ensure that systems can continue to operate sustainably, without compromising future resources.

Engineering Resilience could involve the design of complex systems capable of resisting and adapting to risks identified through so-called *Judo match analysis*[2], leveraging predictive capacity aimed at situational adaptation. We can therefore consider *Engineering Resilience* as the ability of a complex system ***to manage uncertainty and risks dynamically***, to guarantee an advantageous result even within scenarios of high variability or perturbations.

## 2.3 Planning and *Control* as the Foundation of Operational Resilience

It is a critical industrial process that establishes production plans, allocates resources and continuously monitors progress in order to meet demand and deadlines.

Its effectiveness in supporting resilience lies in the ability to rapidly detect and correct deviations between planned expectations and actual performance. Efficient control depends on a short feedback loop, which allows the system to register a deviation and intervene promptly.

This *dynamic balancing* between demand, production capacity and quality is analogous to maintaining equilibrium in a complex system, which is fundamental to its resilience.

## 2.4 Judo Phases as a *Resilient Response* Cycle: 'Kuzushi', 'Tsukuri', 'Kake'

The **three interconnected phases** of a throwing technique in Judo – 'Kuzushi' (unbalancing), 'Tsukuri' (preparation/adjustment) and 'Kake' (execution of the throw) – can be reinterpreted as a fundamental adaptive cycle for *Engineering Resilience*:

- '**Kuzushi**' (Unbalancing / Recognition of the disturbance or Trigger of resilient change): It represents the act of *breaking* the existing equilibrium.
  In a resilience context, this can have two meanings:
  1. Recognition of an external disturbance: a market shock, a supply delay or an unforeseen variation in demand. This "unbalancing" exposes the vulnerabilities of the system and promptly requires a response.
  2. Deliberate introduction of a strategic change: a controlled "organisational Kuzushi", such as the implementation of new technologies or the reorganisation of processes, aimed at testing and strengthening the system's resilience *before* an external disturbance does so with greater intensity. The objective is to *unbalance* the organisation from its consolidated habits in order to foster effective renewal.

  This phase is essential to grasp and orient natural flows or *trends*, rather than confronting them directly, in line with the principle of maximum efficiency with minimum effort (*Seiryoku zen'yō*).
- '**Tsukuri**' (Preparation / Adaptation and operational reconfiguration):
  - It consists in positioning and preparing optimally after the unbalancing.
    From a resilience perspective, this phase represents the system's adaptive response to the disturbance or to the intentional change.
  - It involves detailed operational planning: reallocation of resources, recalibration of production lines, scheduling of material flows, alignment of machines and personnel. This is the moment to assume the optimal "posture" to absorb the impact or to exploit the new configuration.
- '**Kake**' (Execution of the throw / Return to a resilient or improved state):
  - It is the final execution of the technique, in which the unbalancing is fully exploited to complete the throw. In resilience terms, it represents the implementation of the updated plan or the operational materialisation of the change.
  - It includes the execution of the production plan, the overcoming of a "bottleneck" or the launch of a product. It corresponds to the achievement of a new state that is more resilient, more efficient or that has effectively mitigated the risk.

The importance of 'Kuzushi' deserves careful reflection[5]. The sequence « Unbalancing (understood as *Kuzushi*) → Breaking of equilibrium (*Tsukuri*) → Projection *(Kake)* » – considered preparatory to the necessary (as well as appropriate) waiting phase in order to "catch" a potential opponent in error and subsequently execute *Tsukuri* and *Kake* – would, however, limit the comparison to the mere 'defence–attack' paradigm (a dual scheme whereby ***defence*** corresponds to protection, resilience and stability; while ***attack*** corresponds to initiative, disruption of equilibrium, to *Kuzushi* in Judo or Innovation in the industrial domain), effectively downplaying the *TIME* [6] variable, which is essential and decisive for the effectiveness of the overall action.

For this reason, *attack* should sometimes be understood as a possible resolution to an ***actual danger*** (within the meaning of Article 52 of the Italian Penal Code), in "street" situations or in particularly competitive sporting and economic contexts, in the presence of a tangible threat.
This is achieved by applying 'Sen-No-Sen', a tactical concept (*anticipatory timing*) from Japanese martial arts, which means attacking *before or simultaneously* with the opponent's attack, anticipating the movement and/or correctly and unequivocally interpreting the opponent's intention.

The traditional order 'Kuzushi' → 'Tsukuri' → 'Kake' is often taught as a sequence to be followed, although in practice the phases may overlap. In any case, when 'Kuzushi', 'Tsukuri' and 'Kake' are synchronised and balanced, the technical gesture becomes simpler, just as the recovery or strengthening of the system becomes more effective from a *resilience perspective*.

### 2.4.1 Direct relationship between *tactical* concepts and *technical* phases

Given that:

- 'Sen' = taking the iniziative (direct action with one's own "special" (*Tokui-waza*); repeated with the same technique; repeated in successive combination with another technique (*Renzoku-waza*); execution and variation into another technique due to the opponent's anticipatory defense (*Renraku-waza*); following a feint (*Damashi-waza*);
- 'Go' = reacting to the opponent's initiative, 'Go-no-sen' = counterattack after the attack;
- 'Sen-no-sen' = anticipating the opponent's intention.

It follows that:

- 'Kuzushi' = point of contact between tactics and technique,
  the first concrete manifestation of the tactical choice:
  - 'Sen' → *creates* the imbalance
  - 'Go-no-sen' → *exploits* the imbalance caused by the opponent's attack
  - 'Sen-no-sen' → *intercepts* the opponent *before* their balance stabilizes
    (here it becomes clear why *Kuzushi* can function as a *guiding principle*)

[5] *Kuzushi* is understood as a process of progressive destabilization, not limited to the manifest breaking of balance but encompassing postural adjustments, center of mass management and modulation of *action timing* (cf. §5.5.1); it is achieved through the integration of kinetic chains and the directional application of forces in relation to the opponent's base of support.
*Respiratory dynamics* act as an implicit biomechanical factor: exhalation facilitates the activation of the body's center, the structural continuity of the system and the effective transmission of force, reducing stiffness and discontinuities.
*Kuzushi* thus results from the synchronization of internal pressure, displacement of the center of mass, and timing, configuring itself as a progressive loss of stability in the opponent's system rather than as the effect of a single isolated action.
Signals of *Kuzushi* often manifest themselves as wave-like transients: local oscillations, intermittent patterns and bursts that emerge and dissipate over varying time scales. At the same time, their observation is characterized by an intrinsic degree of indeterminacy: limited temporal resolution, operational noise and the variability of *work-as-done* make measurement and prediction inherently imperfect. Explicitly considering these aspects – both wave-like and probabilistic – helps explain why early detection requires tools capable of analysing transient components as well as methods for quantifying uncertainty.

[6] Time is treated as a fundamental operational variable for interpreting observed phenomena.
It emerges in relation to changes, transitions and perturbations within complex systems, rather than as an absolute entity.

- Human perception of time may also be understood as a *construct* linked to the ability *to register* variations and organize sequences of states.

References to concepts from modern physics (such as *emergent time* or system correlations) are intended in a purely conceptual and metaphorical sense, aiming to support an analysis attentive to temporal dynamics, operational variability and the role of transient signals in adaptive decision-making processes.

- 'Tsukuri' = tactical adaptation; it changes significantly depending on the chosen timing:
  - Sen → *full*, structured entry
  - Go-no-sen → *shorter* entry, often rotational
  - Sen-no-sen → *anticipated* entry, often almost simultaneous with *Kuzushi*

  Tactics shape the form of *Tsukuri*.
- 'Kake' = technical outcome, not tactical: technically decisive, tactically neutral.
  Tactics do not "reside" in *Kake*, but make it possible.

## 2.5 Brief argumentative outline on: *Principles, Technical Phases, Tactics, Strategies*

In Judo, the technical aspect does not exist on its own: it is nourished by philosophical principles, oriented by strategies and tactics, and realized through well-defined motor phases.

- At a first level are the ***principles*** – guiding ideas that shape the judoka's "gaze":
  terms such as *Chōwa* (harmony) and *Yawara* (softness) do not describe specific movements, but orient the attitude with which one approaches the opponent and the encounter.
  They legitimize the use of adaptation, the minimum necessary force and the search for reciprocal balance: values that condition technical and behavioral choices on the tatami.
- Descending from the level of the "why" to the level of the "when," we find the ***tactical categories***. Concepts such as *Sen*, *Go*, *Go-no-sen* and Sen-no-sen concern the timing of action: they determine whether to take the initiative, react, or anticipate the opponent's intention; at the limit, "reversing the direction" of time itself.
  Tactics are not a mere abstract calculation, but are immediately translated into the management of time and space, regulating the transitions between the individual technical phases.
- At the center of technical practice, instead, are the phases required by every projection:
  *Kuzushi*, *Tsukuri*, *Kake* – respectively the breaking of balance, the entry/positioning and the final execution of the technique. These phases are the place where philosophy and tactics become movement: the guiding principle can be transformed into attention to *Kuzushi*, while the tactical choice (for example attacking in Sen or exploiting a *Go-no-sen*) determines the timing and the form of *Tsukuri*; by ultimately conditioning the type of *Kake* necessary to complete the action.

Alongside these *operational levels* there are also *descriptive terms* that specify technical or directional variations: *Ura* indicates the "rear" or "inner" dimension of a technique, a variant that often modifies the leverage or the point of application without negating the fundamental 'Kuzushi–Tsukuri–Kake' structure. Finally, at a broader hierarchical level, ***strategies*** integrate principles, tactics and technical phases into more extensive combat plans – for example, a strategy based on the patient search for the opponent's error (consistent with *Chōwa* and *Yawara*) that favors *Go-no-sen* in situations of risk.
To speak of Judo means to move continuously between levels: *principles* give meaning, *strategies* develop plans, *tactics* set the timing of action and *technical phases* make execution possible.
Good technical judgment arises from harmonizing these elements.
Ultimately, without principle one "loses direction"; without tactics one "misjudges the moment"; without mastery of *Kuzushi–Tsukuri–Kake* even the best intention "lies inert".

### 2.5.1 Addendum [1] – *Conditioning* and *Automatism* in the described dynamics

The assimilation of technique involves both the physiology and the psychology of an individual / biomechanical entity. In the learning phase of a motor action (simple or complex), one must take into account the so-called reaction time, understood as the time interval between the stimulus (conscious or unconscious) and the muscular contraction that carries out the action itself.
Speed plays a fundamental role, both as the *relative* speed of execution of a technique and as the *absolute* speed of displacement of the paired system of subjects/athletes facing each other:
to each *rhythm* associated with such speed it is possible to link the execution of appropriate techniques. In close combat, moreover, it is possible to identify two extreme aspects, connected by a series of intermediate states without discontinuity: the psychological and the technical.
Obviously, the more complex the technique or motor action, the longer the reaction time will be.

- **Conditioning:** refers to the progressive formation of *stimulus–response*[7] associations through repeated pairing and reinforcement within the 'attack–defense' context.
  Simple *signal*–*response* links (classical conditioning, also from a *game-theory* perspective) and behavior modeling driven by rewards or consequences (*operant* conditioning) guide the judoka's action selection: specific grips, weight shifts or opponent signals become predictors that trigger preferential responses. At the neuro-psychological level, this learning is supported by *cortico-striatal*[8] circuits and *dopaminergic*[9] reinforcement signals (reward prediction and outcome monitoring), which strengthen the selected action policies; subcortical learning mechanisms make certain responses more likely in specific contexts.
  Conditioning therefore predisposes the athlete to identify and exploit specific "functional openings" in the opponent's behavior (immediately available action opportunities offered by the other's posture and movement), shaping the tactical level (i.e., when to attempt *Kuzushi*, which *Tsukuri* to prioritize, whether to seek *Sen* or wait for *Go-no-sen*).
- **Automatism:** denotes the transformation of complex sequences, initially controlled consciously, into fast and reliable motor routines – procedural memory or "motor programs".
  Through practice, these sequences are "compressed" and executed with reduced attentional demand and reduced sensorimotor latency.
  The main neural substrates involved include the cerebellum (timing and error correction), the basal ganglia (selection and initiation of habit), and the sensorimotor cortices (execution and fine control). In Judo this manifests with the ability to execute the *Kuzushi*→*Tsukuri*→*Kake* sequences in a fluid and rapid manner, often anticipatory, by feedforward control and minimal conscious deliberation.
- **Comparison and interaction**: conditioning and automatism operate at different but overlapping levels: *conditioning* guides which response is selected in a given tactical situation, while *automatism* determines how the selected response is executed and how quickly.
  Conditioned associations can therefore trigger automated motor programs; conversely, repeated execution of automated sequences reinforces the situational signals that activated them.
  At the neuro-psychological level, cortico-striatal reinforcement shapes action-selection policies, with repeated activation consolidating procedural *engrams*[10] in cerebellar–cortical and basal ganglia circuits. In practical terms, training that favors only *rigid* conditioned reflexes risks producing predictable behaviors, whereas training that builds *flexible* automatisms – automated routines that remain sensitive to subtle sensory feedback and contextual variation – best supports high-level tactical adaptability.

Operational training aimed at assimilating a technique therefore generally involves the successive repetition of a movement, in order to transfer the motor mechanism from the *primary cortical area*[11] to the *premotor area*, no longer exactly conscious (*conditioned reflex*).
However, the "excessive" repetition of a given movement under a particular stimulus can produce the negative outcome of a conditioned reflex that is certainly disadvantageous: always reacting in the same way to a given sensory stimulus can allow the opponent to take advantage (for example, through a *feint*) of this conditioned reflex that has become an *unconscious* reaction.
Therefore, together with the enhancement of *sensitivity* and *readiness*[12], it is certainly more useful to develop *automatisms* rather than *conditioning*.

[7] A pillar of behaviorism, according to which an organism reacts to an external stimulus with a predictable behavior, often learned or conditioned. Founded on studies such as those of Pavlov (*reflexes*) and Skinner (*operant conditioning*), the paradigm examines how environmental signals (*stimuli*) generate involuntary or voluntary physical or emotional responses.

[8] Neural pathways that connect the *cerebral cortex* to the *striatum* (a part of the brain), fundamental for motor control, procedural learning, and the management of habits.

[9] Fundamental brain mechanisms based on the release of the neurotransmitter dopamine, which acts as a signal of "reward," motivation, learning, and motor control.

[10] Stable dispositions of the *Nervous System* that make a certain response more likely. In other words, an engram is the way an experience is "written" into the brain.

[11] A specialized region of the cerebral cortex responsible for the initial processing of sensory inputs and the initiation of voluntary movements.

Thus automatism, like conditioning, is characterized by the ability to execute the technique or motor action *without* focusing particular *conscious* attention on the execution process.[13]

## 2.6 Strategic and Tactical Parallels with *Engineering Resilience*

The analogies between *Judo* and *Process Control* provide a powerful model for resilience:

- **Equilibrium vs. Deviations**: the control-oriented mindset aims at maintaining a dynamic equilibrium. Disturbances (of the 'Kuzushi' type) generate deviations and resilience lies in the ability to recover from these imbalances or to anticipate them.
- **Timing and Speed of Response**: essential elements in *Control*.
  A short feedback-loop enables a prompt response, just as exploiting an opponent's instability in Judo requires readiness and immediacy.
- **Integrated Risk Scenario**: the Judo 'attack–defence' model is used in *Risk Management* to simulate *shock scenarios* affecting industrial processes, helping to build more resilient systems through best practices in responding to attacks.
- **Final Objective: maximising the effectiveness of action**.
  In resilience terms, this means not only *absorbing* the impact but also *adapting* in order to improve the future capability to cope with perturbations.
- **Cyclical and Adaptive Process** (PDCA / Kaizen): the Judo paradigm encourages an adaptive, rather than *mechanical*/*deterministic*[14], process; external changes interpreted as *Kuzushi* require an adjustment of planning (*Tsukuri*) in order to exploit the leverage of change, within a continuous improvement cycle (*Kaizen*) that strengthens system resilience.

## 2.7 'Kuzushi' as a Guiding Principle for *Engineering Resilience*

Crucial aspects:

- **Breaking organisational inertia**: in the industrial context, 'Kuzushi' therefore means intervening *to break the inertia of the system*. This may translate into the introduction of a controlled-magnitude strategic change to *unbalance* the organisation from its consolidated habits, fostering renewal and preventing the rigidity that threatens resilience.

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[12] The ability of the judoka's perceptual–motor system to rapidly recognize a meaningful configuration and to activate the appropriate action without delay, with correct tactical timing and minimal conscious intervention.

[13] The definition is analogous to that of a conditioned reflex; however, what distinguishes these two types of physiological processes from each other is the degree of latent consciousness present: while in the case of *conditioned reflexes* the zone of latent consciousness is minimal, in the case of *automatic reflexes* it is greater, making the athlete more inclined to formulate a correct judgment in the face of any minimal variation in the action undertaken by the opponent, thereby allowing them to take the appropriate precautions or *countermeasures*.

[14] *Mechanical* vs. *Deterministic*:

- *Mechanical process*:
  - indicates something that proceeds in an automatic, repetitive, "machine-like" manner, without discretion or creativity;
  - it is a more *qualitative* and descriptive concept.
- *Deterministic process*:
  - indicates something that, given the same Inputs and the same initial conditions, will always produce the same Output;
  - it is a more mathematical and formal concept (as opposed to stochastic/probabilistic).
- A *mechanical* process is often also *deterministic*, because:
  - it follows rigid rules → leaving no room for chance;
  - it tends to produce repeatable outcomes.

However not all deterministic processes are "mechanical" (e.g. numerical simulations on a computer: deterministic but not "mechanical" in a physical sense) and not all mechanical processes are strictly deterministic (e.g. a real machine may experience variable friction, wear, noise → introducing variability).

Therefore: *Deterministic* is linked to the mathematical certainty of the Input → Output relationship; *Mechanical* is linked to the repetitiveness and automaticity of the process. We may finally state that a mechanical process is *ideally* deterministic, but in industrial reality a certain degree of *randomness* always arises (failures, variability, demand uncertainty).

- **Disrupt the organisational inertia with minimal force**: this metaphor highlights that a small, targeted *unbalancing* (a new idea, an improvement, a managed market perturbation) can trigger a process of resilience strengthening while reducing resistance.
  Without this "organizational Kuzushi", the company remains in the 'status quo', making any improvement or adaptation action difficult.
- **Mental agility and continuous improvement**: philosophically, *Kuzushi* represents the ability to break established patterns of thought and to proactively seek opportunities for improvement. This mental agility echoes the Eastern concept of 'Kaizen', which is essential for building intrinsic resilience.
- ***Soft can control hard***[15]: the philosophy of Judo, grounded in the principle of 'Seiryoku zen'yō', suggests that *flexible* and adaptive approaches ("the weak can control the strong") are more effective than *rigid* solutions; this represents a cornerstone of *Engineering Resilience*: not resisting disturbances head-on, but adapting to them and shaping their impact.
- **Generating controlled deviations**: a well-executed 'Kuzushi' allows 'Tsukuri' and 'Kake' to operate with greater *leverage*, enabling the execution of a controlled deviation that makes it possible to rapidly realign the production process towards a more resilient state.

The application of Judo principles, with particular emphasis on 'Kuzushi' as a strategic and tactical trigger, provides a practical framework for implementing and strengthening *Engineering Resilience*; enabling organizations to address disturbances not only by reacting, but by *anticipating and exploiting unbalance* in order to evolve towards more robust and adaptive systems.

## 3. *SELF-DEFENSE* – The Dynamics of Confrontation

*Self-Defense* is here interpreted as an applied particularization of Judo, rather than its generalization. This methodological choice stems from the recognition that, while sharing a common set of founding principles – such as balance management ('Kuzushi'), distance control ('Ma-ai'), action timing and the efficient use of force – the two fields operate in radically different contexts:

- In *Sport Judo*, action is regulated by normative constraints, competitive objectives and codified evaluation criteria; performance is measured in terms of technical effectiveness, scoring and opponent control.
- In *Self-Defense*, the context is unstructured and potentially hostile: operational priorities include the protection of personal safety, the management of unpredictable situations (irregular surfaces, presence of objects or third parties, multiple attackers) and compliance with legal limits.
  Consequently, Judo techniques are not applied in their canonical form, but are instead adapted, simplified or abbreviated based on immediate effectiveness and the possibility of *disengagement*.

From a methodological perspective, this distinction elevates *match analysis* from mere technical observation to an analytical instrument for investigating the underlying dynamic principles.
The configurations observed in the *Tori-Uke* relationship are interpreted as general models for interaction and risk management, transferable – subject to contextualization – to self-defense scenarios and, more generally, to complex systems characterized by high uncertainty and variable operational constraints.
*Self-Defense* teaches how to manage "real" situations rather than competitions governed by regulations; technical effectiveness and the protection/integrity of the defender are therefore essential. Specifically, this is a practice aimed at a form of defense that cuts across various cultures and *Martial Arts*, based on the principles of *yielding* and *flexibility*: its strategy is realized by complying with the aggressor's movements to turn his own applied force back against him. It is not a combat sport or a classical martial art, but it develops a study of two situations: *self-defense* in the strict sense (where no choice exists and one is forced to defend oneself) and *close combat*.

[15] In the context of physical–engineering systems, structures and processes:
'Soft control can govern rigid systems' or 'Adaptive (soft) control mechanisms can govern rigid (hard) systems.

Since one is faced with *real* attacks that require *real* defenses, the *identification* of an event, so that it may be controlled, is all the more important and rapid the more varied the training is.

At this stage, the concept of the *VOID* emerges as a condition for operational clarity: it does not express lack, but rather openness to *reading the context*: a mind "empty" of rigidity, prejudice and unnecessary automatisms is better able to detect weak signals, avoid forcing a response, and allow the most appropriate solution to emerge at the right moment.[16]
When viewed from a strategic business perspective, the *void* represents the space preceding decision-making: it suspends what is already known, reduces *cognitive noise*, and allows the "unsaid" to emerge – that is, what the context suggests *before* it is formalised.
In this sense, *emptiness* is not inactivity, but the precondition for effective choice.
Notably, the brain responds more quickly and efficiently to stimuli it has already been exposed to; a correct identification will correspond to a rapid decision and thus the appropriate reaction.
But that is not all: the *surprise effect*, usually exerted in the case of an attack, does not allow (in general and regardless of how timely one may be in defending oneself) for the adoption of a *countermeasure* in a sufficiently sudden manner.
By initially and appropriately *yielding* (in a manner that safeguards one's own safety) to the force of the aggression, that is, by conceding to the direction imposed by the ongoing dynamic, one gains the time necessary to carry out the crucial identification process that enables an adequate "response", consistent with the customary standards of *legitimate self-defense* – namely, by calibrating the reaction to the magnitude of the attack suffered (*proportional response*).
The main objective must remain *Tactic*, the *tool* for realizing *Technique*.
We also observe that the development of the *stimulus-response* phenomenon, in a dynamic 'cause-effect' situation taking place between complex organisms, can actually involve a succession of actions detached from the 'time factor' (a reaction *following* an attack); for this reason, it appears evident that, while respecting the maintenance of integrity and a rapid and continuous 'cost-benefit' evaluation, resorting to the choice of "anticipatory play" (strictly functional to the circumstance, *flexible*) rewards the "sacrifice" of a strategic-tactical choice that is almost always winning. [3]

As both an example and a direct testimony grounded in long-standing experience as a competitive athlete, I continue to regard the following reflections, formulated by the great Judo champion *Isao Okano*, as fully valid:

**«** My approach to Judo can be summarized in the idea of the *last match*.
Once it has begun, I size up the man and decide which techniques might be most effective.
But I do this only at the beginning; afterward, I conform my actions to the way things evolve, while naturally striving to maintain the initiative.
Obviously, during the match, two or three possibilities for certain techniques may arise, but in any case, the attempt to force these possibilities and apply techniques without considering the course of action alters one's timing. For this reason, I try to constantly keep things in motion and seize whatever opportunity presents itself.
In other words, it is essential to face potential attacks and have well-applied techniques follow one another in rapid succession, increasing the possibility for a final attack.
Strength and technical skill alone do not ensure victory in matches: an acute mental activity is necessary. One must be skilled at predicting the moves the opponent will make and accurately assessing their reactions to our moves.

[**...**] No one is completely strong without weaknesses, but a knowledge of them with a sincere desire to overcome them can become springboards for the birth of a greater strength. [**...**] **»**

[16] The formulation closest to the concept of the "empty mind", understood as a cognitive state free from *fixations and rigid intentionality*, can be attributed to the 17th-century Japanese martial artist *Miyamoto Musashi*, a renowned strategist and author of 'The Book of Five Rings':
"The *Void* is that which has no beginning and no end, and the Way of strategy coincides with this *Void*."

 

# 4. *Balance*, *Mobility* and *Dexterity* in *MARTIAL ARTS* practice

## 4.1 Body Balance in Space

### 4.1.1 The Balance System

An important sensory-motor function intervenes especially during body movements and allows for maintaining an upright position even in opposition to the force of gravity. The function of balance gradually develops in each individual over the course of growth and experience and can be defined as the correct relationship between *body schema* and *spatial schema*. In other words, its purpose is to regulate the static and dynamic relationship between the body and the space-environment.

### 4.1.2 The Apparatus that Regulates Balance

The regulatory centers for balance are located in the *Central Nervous System*.
Information reaches them from the periphery, specifically:

- from the vestibular receptors located in the inner ear;
- from the organ of sight;
- from the muscles and joints (*proprioceptive receptors*).

All this information updates the nervous centers on the slightest variations in body position relative to the environment.

## 4.2 The maintenance of balance

The correct perception of the position of our body in space is the basis of maintaining balance, based on the information coming from the *vestibular*, visual and proprioceptive (muscles and joints) system. The integration between such inputs and the coordination of the motor response takes place at the level of the nervous centers. The coordination between the vestibular system, the visual system and the proprioceptive system is automatic.
Thanks to this mechanism, when for any reason one of the three pieces of information is missing (for example, by closing the eyes), the other two compensate, allowing the body to maintain balance. Recent research has analyzed, using kinematic techniques, the way in which body orientation is controlled during the execution of jumps or somersaults by gymnasts and it has been seen – for example – that in the same type of jump or somersault, the moment of inertia of the body undergoes modifications depending on whether the exercise is performed with eyes open or closed.[17]

### 4.2.1 Beneficial Effects of *Judo* on Balance

Judo tends to improve the balance function, by developing a sense of physical and mental stability in all positions. The balance function is first important in Judo with regard to maintaining the upright position, both the *fundamental* one (*Shizentai*) and the *defensive* one (*Jigotai*).
Furthermore, some positions of the body in space, which are normally absolutely unusual in everyday life, are instead assumed regularly and frequently during Judo training.
In the practice of breakfalls, as well as in certain throws that one may undergo, it is necessary that – within a few instants – movements be coordinated automatically while maintaining, during the airborne phase, awareness of one's body position in space.
It is therefore understandable how the practice of Judo, when carried out with consistent regularity, constitutes training of unquestionable and particular importance and effectiveness, even in the most diverse situations.

[17] A conflict of information between the vestibular, visual and proprioceptive systems is the basis of "motion sickness" (car sickness, sea sickness, etc.) and is the cause of vertigo symptoms characterized by an illusory sensation of movement or imbalance, sometimes with nausea and vomiting.

## 4.3 Mental Processes in Motor Activities

*Targeted human movement*, that is, the capacity for motor interaction with the natural or urbanized environment, is made possible by the series of nervous functions and processes that precede, organize and follow the movement itself.

Mental processes therefore represent the set of functions that the *human brain* and nervous system carry out to:

- gather information from the environment;
- analyze and compare incoming information;
- finalize and design the response;
- program the motor sequence and control its execution;
- evaluate the result of the action.

Highly specialized structures and functions can be divided into the following structural components:

- ***sensory system***, exteroceptive and proprioceptive, which gathers information from the *external* environment – with which the individual must interact – and from *inside* the body;
- ***memories***, components responsible for storing information, enabling recognition of the incoming signal;
- ***response system***, which handles the choice, programming of the response and – where necessary – its correction;
- ***control system***, which manages all operations necessary to ensure each planned phase proceeds correctly, based on the situation and the set objective;
- the ***effector***: it must be mentioned because it has the function of executing the movement in space and time, but above all because *feedback* information – so-called "return" information – emerges from it, which is used for controlling the movement itself.

However, the system as a whole has limitations in its capacity to process sensory-perceptual and sensory-motor information. For this reason, only that which is truly significant for the processes to be carried out must be considered. *Attention* takes care of this, determining both the entry conditions of the information (*selection*) and the *processing* methods.

Consequently, attention acts as both a filter and a regulator, with the following characteristics:

- limited capacity; variable scope; operates selectively.

This essentially determines two limits:

- one of capacity to process *all* available information,
- the other of *duration* over time.

Since our brain is capable of processing only a limited amount of information, it therefore performs a selection by directing resources toward what is deemed significant, neglecting what is not essential for decision-making processes. This is therefore a *selective* mode of operation.

Duration, that is, the capacity *to function over* ***time***, is in turn limited[18]: it is a mechanism that operates at very high energy costs (nervous); consequently, the duration of its maximum operational capacity is limited, after which it is necessary to reduce the effort or recover.

[18] Even if, at a fundamental level, time may not be a primary feature, the human brain *constructs* a very strong perception of "past → present → future". This occurs for at least three key reasons, from the following perspective:

1) The brain is a system that registers change:
   our nervous system is designed to compare states (*before*/*after*), detect variations and construct sequences.
   Structures such as the hippocampus organise memories in temporal order. Without memory, even the sensation of time would not exist. In other words, we perceive time because we remember the past and not the future.
2) Asymmetry (the arrow of time): in physics, many laws operate equally well forward and backward. However, in real life we observe only one direction. This is related to entropy, which tends to increase: states become more "disordered" over time. The brain exploits this asymmetry: we remember more ordered states (the *past*) and experience the transition towards more disordered states (the *future*). This provides the physical basis for the sensation of temporal "flow".
3) The "present" is a construction: what we call "now" is not an infinitesimal instant, but a short temporal window – on the order of a few milliseconds – within which the brain integrates sensory information. This integration produces a continuous flow, even if at a fundamental level there may not be a "movie", but rather a sequence of *states*.

All these processes, summarized here, are an essential condition for the capacity to interact with the environment, to learn, to modify and to evolve individual behavior in *all* its dimensions and expressions.

## 5. *DYNAMIC RISK MANAGEMENT* – Integrated Perspective on Modeling and Analytical Architecture: *Judo Match Analysis* as 'Use-Case'

Within the scope of this work, *Judo-BI™* constitutes a *Proof of Concept* aimed at the practical enhancement of the Risk Management process, with the objective of demonstrating value in a real-world context. The traditional method indeed ensures order and compliance, but it "struggles" to capture the interdependencies and weak signals that precede many modern *incidents*.

A *Dynamic Risk Management* approach therefore becomes necessary – one capable of introducing innovative tools and logics to map dependencies (DSM)[19], model mixed effects (e.g. FREM[20]), and integrate Digital Twins technologies for scenario simulation and support of rapid and proportionate decision-making. The purpose is to transform *Risk* from a managed event into a process governed in real time: from "event management" to effective Process Control.

Pragmatically modular, *Judo-BI™* operates as a *Decision-Support* layer that integrates biometric and sensor-based data with *Artificial Intelligence* to enable dynamic Risk Management.

It interfaces with the C-ISMS (Cyber-Information Security Management System) to enhance responsiveness in Risk Management, identifying critical patterns or dependencies in order to generate operational recommendations aligned with security controls.

Effective Risk Management in today's highly interconnected and rapidly evolving environments requires methodologies capable of responding in *real time* to emerging threats.

This work outlines a hybrid framework that integrates – by adapting them – advanced Machine Learning techniques, statistical modelling, and quantum-inspired optimisation, mapped to practical use cases drawn from high-level Judo competitions, in order to develop decision-making capabilities on the order of milliseconds or similarly infinitesimal time scales.

- By combining 3D motion capture and inertial sensing ('IMU – Inertial Measurement Unit') with Reinforcement Learning (RL)[21], such a system learns to recognise *biomechanical configurations* of unbalancing and counter-attack, while configurable ethical parameters (so-called "fair play" rewards) ensure compliance with international sporting or organisational regulations.
- By integrating Artificial Intelligence into a *Design Structure Matrix* (DSM) to dynamically reconfigure system dependencies, *mixed-effects models* (FREM) are employed to capture variability and uncertainty in covariates and parameters.

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[19] A modelling tool that represents, in matrix form, the functional, informational or causal interdependencies among the elements of a complex system (e.g. processes, actors, decisions, risks or events). Within the context of risk analysis and *match analysis*, the DSM makes the structure of relationships explicit, enabling the identification of critical couplings, effect propagation and points of vulnerability, thereby providing a formal basis for dynamic analysis, learning and decision support. The DSM therefore constitutes a compact representation of the relationships among components of a complex system, useful for analysing how actions, events or decisions may propagate and generate emerging risks. See in particular **[4]**.

[20] 'Full Random Effects Model' (FREM), used to explicitly model *inter-athlete* variability and to support conceptual transferability toward complex socio-technical systems.

It is a method used to determine the effects of covariates in *mixed-effects models* (also referred to as mixed error-component models, i.e. statistical models containing both well-defined fixed effects and random effects); it is useful for representing structural variability at both local and global levels, in order to understand "how much an effect varies".

A *covariate* is a variable that may influence an outcome, but whose effect may vary across different subjects or situations; such variability is estimated by the model rather than being ignored. Covariates are therefore modelled as random variables, characterised by a *mean* and a *variance*.

- The FREM method captures the effects of covariates through the estimated covariances between individual parameters and the covariates themselves.
- As an influencing factor on the object of study, an illustrative example is the outcome "being able to throw the opponent", with possible covariates including: fatigue, height, experience, stress and the presence of a sensor.

[21] A learning method in which learning occurs through trial and error, guided by feedback from the environment.

In parallel, in order to identify the external settings that drive model behaviour (*hyperparameters*)[22], optimisation algorithms inspired by quantum methods are explored, since such configuration parameters cannot be derived directly from training data, yet they nonetheless determine the performance and stability of the overall system.

## 5.1 Structural Modeling of Interdependencies

- The DSM represents the "map" of relationships (*who influences whom*).
- When AI is integrated, the DSM is no longer static: weights and connections are updated in real time based on signals from sensors, refereeing annotations and other sources.
  Practical example: if an IMU signal indicates repeated unbalancing in a given phase, the cell connecting "phase X" → "projection risk" increases its weight within the *neural network* schema.

Here follows the representation of a 'Judo-Resilience' flow, with *Multilevel Structural Dependency*:

**Match Analysis in Judo, applied to Engineering Resilience**

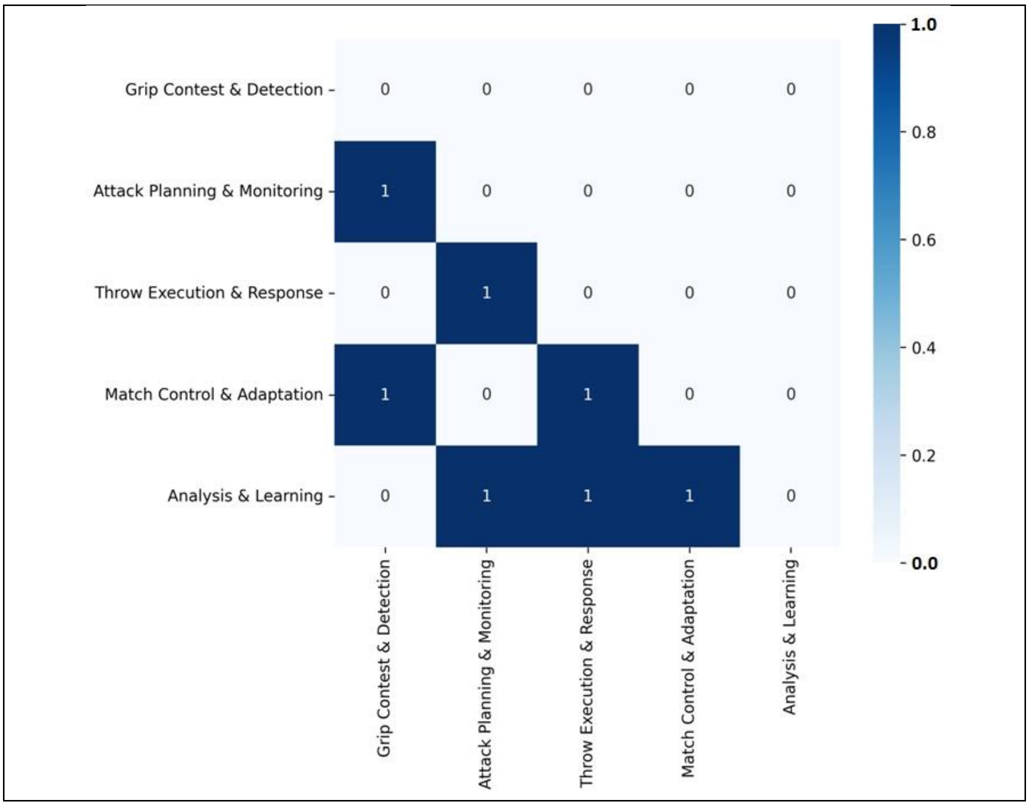


**Figure 2**. [*DSM-Judo*]. Source: Author's original elaboration with AI-assisted generation.

Legend:

- The DSM visualizes interdependencies (1 = strong dependency, 0 = absent);
- rows depend on columns, highlighting sequential flows with feedback for adaptive resilience.

[22] A *hyperparameter* is a quantity that governs the behavior of a statistical or probabilistic model, but is not estimated directly from the data in the same way as the model parameters. In particular:

- *Parameter*: an internal quantity that the model learns from the data;
- *Hyperparameter*: a design choice that conditions *how* the model learns.

In the Bayesian framework (a statistical and probabilistic approach used to update the probability of a hypothesis as new evidence or data become available), *hyperparameters* are typically the parameters of the prior distribution (formalizing prior experience, domain knowledge or reasonable assumptions *before* the data "speak") or, more generally, the parameters that determine the structure of the model; a hyperparameter is therefore a parameter that serves to regulate how the model learns from data. In the practice of Judo-BI™ (FREM, dynamic DSM, RL), hyperparameters act as *design levers* that require justified selection, prior verification and sensitivity analysis in order to ensure robust estimates, explainability and reliable operability.
In the context under consideration, the prior distribution is therefore a formalization of the available domain knowledge *prior* to data observation, allowing the inference to be stabilized, the estimates to be contextualized and the robustness of the model to be improved without imposing deterministic relationships.

Represented Elements:

- 'Grip & Detection': Initial *Kumi-kata*[23] and early detection of imbalances (*Kuzushi*-like);
- '*Kuzushi* & Monitoring': Imbalancing and continuous process monitoring;
- '*Tsukuri* & Adaptation': Preparation/posture and dynamic reconfiguration;
- '*Kake* & Response': Projection execution and perturbation response;
- 'Analysis & Learning': *Post-match analysis* with DSM/FREM for learning (resilient cycle).

Meaning of Interdependencies:

- The matrix reflects the *Judo-BI*™ cycle: grip detects, *Kuzushi* monitors, *Tsukuri* adapts, *Kake* responds, analysis learns and provides feedback to all, promoting resilience.

## 5.2 Statistical Modeling

- FREM allows modelling of subjective variability (different athletes, conditions, sensors) and estimation of how "noisy" covariates (e.g. fatigue, presence of sensors) influence performance parameters.
- In practice, FREM separates the general effect (*fixed effect*) from the variable (*random*) effect, yielding more robust estimates that feed the dynamic DSM.
- In the *Judo-BI*™ context, FREM captures inter-athlete/hierarchical variability for performance and risk, integrating DSM for dynamic structures.

Follows an illustrative image of an FREM model, coherent with the previous DSM: 'Variance-Covariance' matrix of random effects between the respective 5 factors (e.g., high covariance between 'Planning/Monitoring' and 'Execution/Response', reflecting 'Judo-Resilience' interdependencies).

FREM: **Variance-Covariance Matrix**

(*Random Effects for 'Judo-Resilience' Factors*)

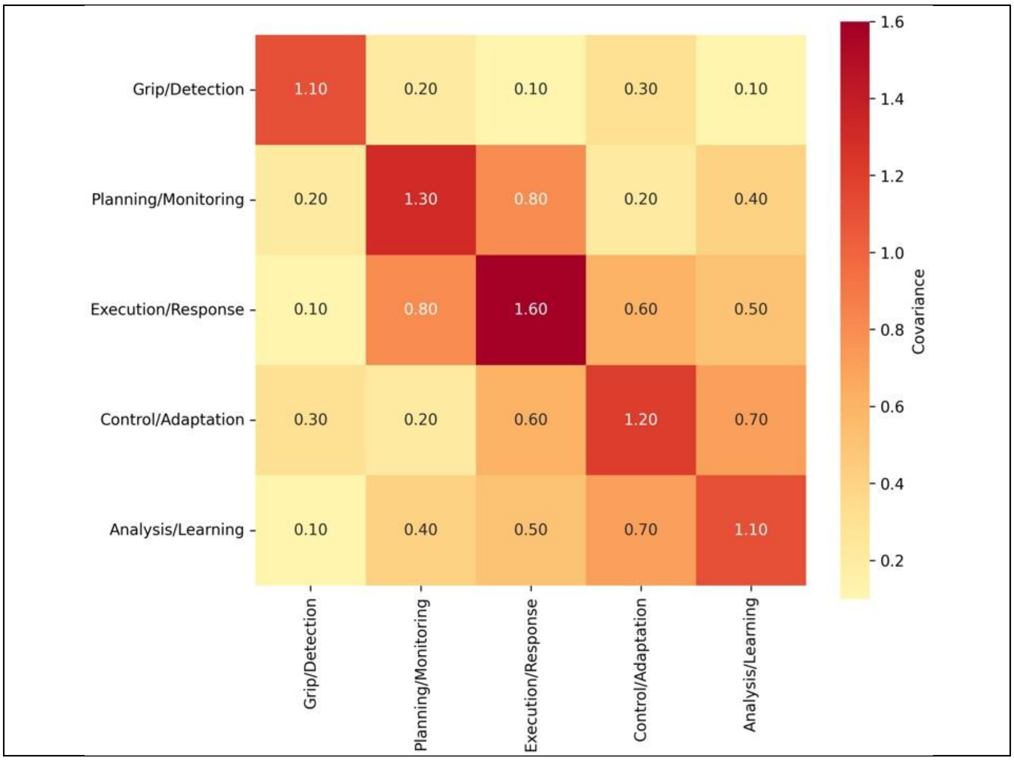


**Figure 3**. [*FREM-Judo*]. Source: Author's original elaboration with AI-assisted generation.

[23] The Japanese term *Kumi-kata* (組手形) can be effectively translated as 'grip form'.

In Judo practice, this expression refers not only to the act of grabbing the opponent but represents a true codified control system. To better understand the translation, it is useful to analyze the term's components:

- *Kumi* (組): Indicates the action of "putting together," "uniting," or "confronting."
- *Kata* (形/型): Means "form," "model," or "pattern."

Legend:

- *Main diagonal* – Individual variances (e.g., 1.0-1.5 for intrinsic variability);
- *Off-diagonal covariances* – Random effects correlations (e.g., 0.8 between Planning and Execution, high where DSM shows dependencies; symmetric for positive definiteness);
- *DSM coherence* – Elevated covariances along DSM links (rows/columns with 1), modeling heterogeneity as in judo match analysis.

Interpretation of Key Elements:

- *Main diagonal* – Individual variances for each factor (values ~1.0-1.5), representing intrinsic variability between athletes/systems for that specific component.
    - For example, *'Execution/Response'* shows variance 1.5, indicating high natural heterogeneity in projection executions.
- *Off-diagonal* (Covariances) – Systematic correlations between random effects of factor pairs. High positive values (e.g., 0.8 between *'Planning/Monitoring'* and *'Execution/Response'*) mean that athletes/systems with high Planning capability also tend to have high Execution effectiveness (structural covariation reflecting real DSM interdependencies, with *Execution* dependent on *Planning*).

Statistical Meaning:

- *Symmetry* – Symmetric and positive definite matrix (requirement for valid covariance).
- *Coherent patterns with Judo-BI™* – High covariances along the typical Judo sequence ('Grip → Planning → Execution → Control → Analysis'), capturing how variability in one phase transmits to subsequent phases (e.g., 0.6-0.8 *'Control-Execution'* for real-time adaptations).
- *Gradients* – Covariance decreases with sequential distance (e.g., low 0.1 *'Grip-Analysis'*), but final feedback high (~0.7 *'Analysis-Control'*) for cyclical learning.

Practical Application:

- In Judo *Match Analysis*, FREM estimates these random effects for predictive purposes of individual performance beyond fixed averages, accounting for athlete-specific heterogeneity.
    - For example, high *'Planning-Execution'* covariance suggests: athletes with good planning have more consistent projections.

***Hyperparameters*** are design choices (e.g. regularisation weight, signal threshold, clustering resolution[24], RL reward coefficient) that govern the behaviour of the algorithm, rather than the process that generated the data. Since they are design decisions (*meta-parameters*), they cannot be "learned" from the dataset in the same way as network weights, but must instead be selected/optimised through search procedures that explore the space of possible configurations.

**Live data** are used to train/update the models (FREM, RL, classifiers); these updates modify the weights within the DSM, which in turn reconfigures monitoring and control priorities.
In parallel, an optimiser searches for the best hyperparameter settings in order to maximise performance metrics (robustness, accuracy, reaction time) and these settings *guide* the behaviour of the AI agents and the sensitivity of the DSM.

*Quantum-inspired* **optimisation algorithms** will help do provide strategies to explore complex spaces more effectively and to identify improved configurations within reasonable timeframes.[25]

[24] The level of granularity at which system elements are grouped; this parameter governs the trade-off between analytical detail and model interpretability and is therefore treated as a 'configuration hyperparameter'.

[25] "Quantum-inspired" means that the algorithm draws inspiration from concepts from quantum mechanics while "running" on classical hardware; the availability of a quantum computer is not required.
Furthermore, the reference to "quantum" imagery (or to the notion of *indeterminacy*, where appropriate) is intended in a strictly metaphorical and conceptual sense. It does not imply the direct applicability of quantum mechanics to macroscopic phenomena within the domain under study. Rather, it suggests the use of probabilistic and analytical formalisms better suited to addressing uncertainty and wave-like behaviour at the macroscopic scale.

## 5.3 Functional Modeling – A Note on Potential Integration

An additional interpretative contribution, worthy of further investigation, is represented by the Functional Resonance Analysis Method (FRAM)[5], developed within the field of Resilience Engineering to model complex socio-technical systems (e.g., industrial plants, aviation, hospitals) and to understand how work is actually performed, as well as how performance variability may lead to unexpected outcomes, both positive and negative.

In the FRAM, attention is not placed on individual components, but on operational functions ('what the system must do') and their interactions, attributing equal value to both *successes* and *failures*.

Socio-technical systems are therefore described not as linear sequences of events but as sets of interdependent operational functions, each characterised by six specific aspects (*Input*, *Output*, *Preconditions*, *Resources*, *Control* and *Time*). Each function is represented through graphical models that help identify how small variations may combine and "resonate", generating unexpected outcomes[26]: by revealing points of operational resonance that may not be evident from dependency matrices (DSM) or statistical analyses (FREM) alone.

In this respect, FRAM can be seen as a complementary analytical perspective:

- while DSM highlights structural dependencies among system elements and FREM supports quantitative modelling of probabilistic relationships,
- FRAM helps explore how operational variability and functional interactions may generate emergent behaviours within the system.

Without altering the quantitative structure of the *Judo-BI*™ framework, FRAM may therefore be considered an exploratory tool to be used during pilot phases — for example in workshops with athletes and coaches — in order to:

- highlight critical functions and their variable aspects
- suggest covariates and latent variables to be included in FREM
- update the DSM with newly identified functional dependencies

The method provides qualitative interpretative insights and does not replace quantitative modelling. Rather, its purpose is to enrich the understanding of the operational context, guiding modelling and measurement choices. In this perspective, particular relevance is given to the variability of 'work-as-done', that is, the inevitable micro-adaptations through which activities are actually carried out in practice, often in ways partially different from the 'work-as-imagined' described in procedures and formal models. According to FRAM, such variations do not necessarily constitute errors; rather, they represent an intrinsic property of complex systems.

When multiple variations interact, they may produce emergent effects – sometimes beneficial, sometimes critical – defined precisely as phenomena of functional resonance.

Within the context of the present work, FRAM can therefore be considered a qualitative complement to structural analyses (DSM) and probabilistic or statistical modelling (FREM).

The mapping of operational functions and their interdependencies may contribute to identifying early signals of imbalance and suggesting additional observation variables useful for dynamic risk management.

Furthermore, regarding the *Judo-BI*™ framework, the concept aligns naturally with:

- *Kuzushi* → detection of small deviations or emerging instabilities
- *Tsukuri* → adaptive configuration of the response
- *Kake* → execution of the action at the appropriate moment

It follows that operational variability becomes a source of *useful information* rather than mere noise.

Although FRAM offers a holistic perspective capable of explaining anomalous scenarios not captured by numerical analysis alone, its qualitative nature necessarily requires expert judgement, which makes full automation of the process difficult.

A more systematic exploration of the integration between *FRAM* and the *Judo-BI*™ paradigm nevertheless represents a promising direction for future research.

[26] Each function is represented by a hexagon with the aforementioned 6 'aspects' that define how it couples with the others.

## 5.4 Conceptual Foundations: *Emptiness*, *Indeterminacy* and *Temporal Alignment*[27]

The proposed framework may also be interpreted through a broader conceptual lens, in which cognitive, temporal and dynamic aspects of adaptive behaviour are explicitly considered.

The notion of "**emptiness of mind**" represents a condition of ***cognitive openness*** that enables the observer to engage with system dynamics without premature commitment to fixed interpretations.

As previously mentioned, rather than implying absence, it denotes the suspension of rigid schemas, allowing perception to remain sensitive to contextual variation and emerging signals.
In complex systems, observable behaviour rarely unfolds as a sequence of discrete and fully predictable events. Instead, it may be more appropriately described in terms of *wave-like dynamics*, where patterns emerge from continuous interactions among system components.
Such dynamics are inherently associated with a degree of *indeterminacy*, understood here not as pure randomness, but as the coexistence of multiple potential trajectories whose realisation depends on *context*, *interaction* and *timing*.

Here, *time* should not be considered solely as a linear parameter, but as a functional dimension within which perception, interpretation and action are continuously synchronised.

The effectiveness of adaptive behaviour depends on the ability to align these processes within an appropriate temporal window. In this sense, the operational sequence *Kuzushi–Tsukuri–Kake* may be interpreted as a temporally structured mechanism: the detection of imbalance (*Kuzushi*), the adaptive configuration of response (*Tsukuri*), and the execution of action at the appropriate moment (*Kake*). The quality of this process is critically dependent on the ability to maintain a state of *emptiness of mind*, which reduces *cognitive noise*, prevents premature reactions and allows the most appropriate course of action to emerge.

Therefore, *emptiness* is not to be understood as inactivity, but as a prerequisite for effective action within complex and dynamically evolving environments.

## 5.5 Overcoming the "Classical" Risk Management Model

By proposing a complementary alternative, *Judo-BI™* substantially enhances the effectiveness of traditional Risk Management where complexity demands it, for the following main reasons:

- **Limitations of the Traditional Model**
  - Static nature and low frequency: periodic assessments that fail to capture rapid changes (e.g., supply shocks, targeted attacks);
  - Information silos: data distributed across departments remain difficult to correlate ($O_{perational}T_{echnology}$, $I_{nformation}T_{echnology}$, operational management of infrastructures/systems);
  - Predominantly reactive posture: interventions occur after the problem has manifested, with high costs and impact; Targeted sampling (not statistically-probabilistic): audit or inspection activities conducted on a sampling basis may miss early warning signals;
  - Limited organizational learning: reduced capacity to incorporate past experience into updated operational rules.

[27] *Methodological Note*: the use of terms such as *wave-like dynamics*, *indeterminacy* and *emptiness of mind* in this work is intended in a conceptual and metaphorical sense: the corresponding terms do not imply the applicability of *quantum mechanical* formalisms to the macroscopic domain under investigation. Rather, they serve as heuristic constructs to describe variability, multiple potential system trajectories and adaptive behaviour under conditions of uncertainty.
Accordingly, the framework adopts a systems-oriented and probabilistic perspective, in which such notions support the interpretation of complex interactions without assuming strict physical equivalence.

 

- **What *Judo-BI*™ Introduces** (Key Innovations)
  - Continuous observation and *sensor fusion*:
    integration of telemetry, logs[28], human inputs, and open-source data for a unified view;
  - Double-loop control (inner / outer loop): low-latency reactions to contain impact, combined with strategic cycles to review rules and policies;
  - 'Kuzushi–Tsukuri–Kake' approach applied to Risk;
  - AIaaS (*Artificial Intelligence as a Service*) and Digital Twin: predictive analytics, what-if simulations, and decision support that keep the human being in the loop (continuous control process); Traceability and explainability: evidence that makes decisions verifiable and auditable (time-stamped logs, model versioning, supporting explanations).

- **Practical and Measurable Advantages**
  - Early detection of events and error chains, reducing $M_{ean}T_{ime}T_{o}D_{etect}$;
  - Faster and less disruptive responses, reducing $M_{ean}T_{ime}T_{o}R_{ecover}$ and operational impact;
  - More informed and justifiable decisions, valuable in regulatory contexts and for legal accountability;
  - Resource allocation based on actual priorities (dynamic risk-based sampling);
  - Organizational learning capability: rules evolve based on aggregated evidence, not solely on opinions or isolated cases.

- **Risks and Mitigation Measures**
  - Excessive reliance on algorithms
    → human-override[29] policies and defined operational limits;
  - Bias (cognitive distortions) and model drift
    → continuous validation, fairness monitoring[30], and remediation plans;
  - Privacy and compliance issues
    → privacy-by-design, pseudonymization, and *data contracts*[31];
  - Integration complexity
    → phased deployment, pilot projects on critical perimeters, and structured data governance.

## 5.6 Critical issues, objections and validation protocols

### 5.6.1 *Kuzushi* vs. *Symmetry Breaking* – conceptual clarification

In the context of high-level competitions, the term 'symmetry breaking' is frequently used to describe the opening of a space for action. This expression is not in contradiction with the traditional concept of *Kuzushi*: the latter should be understood in extended operational terms, encompassing not only the macroscopic manifestation of unbalancing (symmetry "breaking"), but also a preparatory phase consisting of micro-variant postural signals and the athlete's cognitive predisposition.

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[28] In computing, a *log* (or *log file*) is a chronological and automatic record that tracks operations, events, errors or accesses of a program, Operating System or Server. It functions as a "logbook" for monitoring the system's "health," performing diagnostics (*troubleshooting*) and ensuring security; by storing details such as timestamp, type of event and user involved.
The English term *log* originally means "ship's logbook."

[29] Also referred to as *Human-In-The-Loop* (HITL), in the ICT domain these are security and governance procedures that ensure human intervention to review, modify, or override decisions made autonomously by automated systems or Artificial Intelligence (AI). Such policies are essential for regulatory compliance (GDPR, AI Act) and for managing risk in critical operations, ensuring accountability, fairness and security.

[30] It refers to the design and use of algorithmic systems and Artificial Intelligence that operate impartially, ensuring non-discriminatory outcomes toward individuals or groups. Its primary objective is to identify and mitigate biases in Machine Learning models in order to prevent discrimination based on race, gender, age or socio-economic background.

[31] Formal and technical agreements between data *producers* and data *consumers*, aimed at defining rules, quality standards and modalities for data exchange. They represent a fundamental instrument in modern information architecture to ensure that exchanged data are reliable, consistent and clearly defined.

- From an experimental perspective, this means that *Kuzushi* can be measured across multiple temporal and spatial scales – for example through shifts in the centre of mass (CoM)[32], variations in the centre of pressure (CoP)[33] and temporal indicators of preparation (EMG[34] pre-activation, step timing).
  The approach adopted herein interprets 'symmetry breaking' as the observable manifestation of a *Kuzushi* process, which can be anticipated and described through weaker, precursor signals.

Therefore, *Kuzushi* and *Symmetry breaking* are compatible concepts: *Kuzushi* encompasses both the macroscopic disruption of equilibrium and the micro-signals (postural and mental) that make it preparatory to action. It is, of course, necessary to clearly define the relevant concepts and measurable quantities (CoM, CoP, Timing).

### 5.6.2 Impact of Sensors

The application of sensor technology on athletes raises the legitimate concern about the possible alteration of the naturalness of the confrontation.
To mitigate this risk, two synergistic strategies are adopted:

a) use of *minimally invasive* technologies (miniaturized IMUs, low-profile adhesive patches, low-latency telemetry) and *habituation* protocols that ensure the athlete perceives the device as "non-intrusive";
b) contactless options, such as 3D vision/pose-estimation systems and integrated high-frequency cameras.

In addition, control studies (matches *without* sensors vs. matches *with* sensors) should be conducted to quantify any behavioral differences and statistically model the sensor effect (via FREM), thus ensuring that the collected data faithfully correspond to natural performance.
To evaluate and separate the effect induced by the device from natural behavior, the FREM model is particularly suitable: the 'sensor' factor is treated as a *random covariate*[35] that might correlate with performance parameters.
In this way, the *variance* associated with the device is estimated, enabling "debiased" (*bias*-free) estimates of the metrics of interest: for example, the *probability of success* of the technique.

### 5.6.3 Referees and video-review

The refereeing function, with its real-time decisions and video review systems, is a complex but valuable element for analysis. Referee judgments, whether immediate or after video review, constitute labels and feedback signals that can be integrated into the learning system.

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[32] *Centre of Mass* (CoM): a physical quantity with a dynamical role; it governs, for example, the motion of a system subject to external forces, where the *weights* are physical masses. *Barycenter* is a mathematical concept: it denotes the "barycentrically" mean locus of discrete points with respect to numbers ("weights") that represent a measurement (such as lengths, areas, resultants of [forces]-*weight*, probabilities). *CoM* and *Barycenter* coincide only if the gravitational field is uniform (i.e., if the barycentric weights are equal to the mass distribution). In particular, when the CM leaves the base of support, balance is lost; in Judo, shifting the opponent's CoM is the key to *unbalancing*.

[33] *Centre of Pressure* (CoP): It is the point where the greatest pressure is exerted on a surface.
Usually the CoP *moves continuously*; even when appearing stationary, the CoP oscillates. The more rapidly the CoP moves, the more stability is lost. In Judo (practiced standing), the CoP changes *before* the body falls: it is an anticipatory signal of *Kuzushi*.

[34] *Electromyography* (EMG): This technique measures the electrical activity of muscles.
Specifically, when a muscle prepares to move, it emits microelectrical signals; EMG "listens" to these signals and allows us to understand *when* a muscle is activated, *how much* and with *what intensity*.
In Judo, EMG can reveal the *intention* of a technique *before* the movement is visible (the prodromal phase of *Kuzushi*).

[35] A *random covariate* is one that is not the same in every case; it is not perfectly controlled, it can vary from person to person or from situation to situation. In other words: instead of *pretending* it is always the same, its variation is accepted, leaving it to the model to estimate its average effect and variability.
Practical example: imagining studying whether a Judo technique works, it can happen that some athletes feel / notice the presence of the sensor, others do not; some "forget" it after 5 minutes, others do not; it is not possible to measure exactly *how much* it bothers them. The model is then told: "The sensor might influence performance, but in different ways for each athlete".

In the proposed model, refereeing is represented as a *node* in the DSM (interacting with athletes, rules and support technology), with referee decisions analyzed 'ex-post' to identify biases, variability and contextual conditions.
Such information feeds the training phase and the construction of more robust metrics, as well as being usable to design decision-making strategies that respect regulatory and fair-play constraints.

Refereeing is therefore a source of very useful data; it must be modeled as a system component and finally analyzed.
Then, referee evaluations are valuable inputs for training and validation, not just *noise*.[36]

## 5.7 The psychological component of athletes

Expressed through a composite indicator of *biorhythms* (sleep quality, heart rate variability, stress level), it is incorporated as an additional variable within the phases of relevant feature extraction and statistical modelling. This indicator[37] is used to contextualise the observed performances, modulate the interpretation of biomechanical signals and contribute to the estimation of *inter*- and *intra*-individual variability, particularly within mixed-effects models, without assuming a direct deterministic relationship with the outcome of the action.
The indicator is therefore not interpreted in a deterministic sense, but rather as a contextual factor useful for explaining performance variations and improving model robustness.

# 6. *COMPUTATIONAL FLOW* and Data Processing 'Pipeline'

The quantitative and technical indications presented in the following two sections (§ *Operating principle*; § *Concrete example*) are primarily theoretical and intended as a Proof-of-Concept.

Although they are supported by authoritative literature and references, the actual operational specifications depend on experimental conditions, hardware/software configurations and measurement protocols that must be verified through controlled testing and laboratory benchmarking.
The values reported should therefore be regarded as indicative estimates useful for experimental design, rather than as performance figures definitively validated for operational applications.

## 6.1 Operating principle

### a) Multimodal data collection

- 3D vision: cameras and *pose estimation*[6] algorithms track in real time the position and movement of *Tori* and *Uke*.
- Inertial sensing (‘IMU’): small sensors worn by the athletes measure accelerations and rotations, in order to capture every instance of unbalancing or torsion.
- Human evaluation: referees’ judgements (fair-play, verification of technical correctness) are synchronised with motion data.

[36] It represents unpredictable fluctuations in the data, which obscure the useful signal, deriving from intrinsic or external phenomena; it manifests as *random variability* around a mean value. It is described probabilistically and measured via the Signal-to-Noise Ratio ('SNR'), fundamental in electronics, acoustics and radiology to evaluate the *quality* of a measurement.
[37] The goal is not the clinical assessment of the psychological state, but rather the integration of indirect physiological signals as indicators/surrogates of the athlete's state of readiness.

## b) Training of the *intelligent agent*

- Use of *Reinforcement Learning* ('RL'): an algorithm that "learns through trial and error", being rewarded when it recognises and applies effective offensive or defensive actions.
- *Reward shaping*[38]: modulation of the *reward function* by assigning small bonuses or penalties (e.g. '+5' for good balance, '−10' for an illegal move), allowing the agent to learn correct and safe strategies.

## c) Ultra-fast pipeline

- The decision model (via *neural network*) is optimised to run on devices located close to the tatami, so as to return output within a few milliseconds.
- "Live" data also feed an *ex post* database, used for statistical analysis and to refine the model between matches.

In particular, the automated and optimised process:

1. Receives data in real time
2. Processes them extremely rapidly (on the order of milliseconds or microseconds)
3. Provides immediate responses or decisions

A *pipeline* is a chain of processing steps used to handle data. For example, in an AI system for Judo:

1. Input: visual or sensor-based acquisition (cameras, IMUs)
2. Pre-processing: filtering, cleaning and normalisation of data
3. Feature extraction: automatic identification of gestures or unbalancing
4. Decision: RL algorithm that decides the action (attack, defence, etc.)
5. Output: visualisation, recommendation or automatic intervention

What makes the pipeline *ultra-fast*:

i. Low latency: minimal time between input and output (e.g. <10 ms).
ii. Real-time processing: suitable for dynamic scenarios, such as combat situations or industrial risk contexts.
iii. Hardware and software *optimisation*[39]: "lightweight" neural networks, compressed models, GPUs (Graphics Processing Units) or *edge* processors (located close to the data source).

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[38] A technique used in *Reinforcement Learning* (RL) to better guide the agent during its learning process, by modifying the reward function in order to:

- speed up learning,
- steer the agent's behaviour towards desired strategies or incorporate ethical, practical or tactical constraints.

When imagining the training of an *RL agent* "motivated" to win a Judo match, consider for example a base reward of '+100' points for winning by *Ippon* and '0' for losing. However, the agent would not know what to do at each moment of the match. Through reward shaping, small rewards or penalties can therefore be added during execution, such as the following:

| (Partial) Action | Reward function modelling |
|---|---|
| Good balance control (*Uke* unbalanced) | +5 |
| Incorrect or rough movement | −10 (for ethics / fair play) |
| Well-executed technical attack attempt | +20 |
| Successful defence against an effective technique | +15 |
| Passive or overly cautious behaviour | −5 |

The objective is to help the agent understand not only *what* to do in order to win, but also *how* to behave along the way, thereby accelerating the learning of useful strategies that are consistent with rules and constraints (cf. industrial safety, ethics, compliance with regulations).

Application within the project:

- Encourage techniques compliant with Kodokan rules
- Penalise borderline or dangerous behaviours
- Promote biomechanically efficient strategies
- Integrate flexible and updatable ethical criteria over time

In the industrial domain, the same principle can be applied to reward operational decisions that minimise risk while respecting regulatory and corporate ethical constraints.

[39] In the present discussion, the concept of *Optimality* generally refers to a set of techniques aimed at identifying the best configuration of variables or parameters within a solution space, according to one or more performance criteria. More specifically, it concerns the search for the best system configuration by exploiting analytical tools, heuristics and *quantum-inspired* algorithms (the latter being used to accelerate and improve the quality of solutions in very large search spaces).

In the context under consideration, an *ultra-fast pipeline* is what enables the system to detect an ongoing action (e.g. an unbalancing), evaluate it in real time and propose or execute a response *at run time* (tactical decision, alert, technical adaptation) without perceptible delay.

### d) Connection to industrial Risk Management

- The 'attack–defence' dynamics observed in matches (unbalancing, counter-move, control) are analogous to *shocks* or *emergencies* in a plant or within a Supply Chain.
- In the pilot project, a correspondence would be tested between *risk scenarios* (sudden failures, load peaks, cyber-attacks) and automatic countermeasures, using the same logic adopted for a Judo match.

### e) Ethical aspects and flexibility

- *Ethical weights* (fair-play, safety) are *configurable*, in order to comply with sporting rules, Corporate regulations or Safety guidelines.
- Every decision made by the algorithm might be traceable and explainable, ensuring transparency towards Coaches, Referees or corporate Stakeholders.

## 6.2 Concrete example (*Ultra-Fast Pipeline – Judo Match Analysis*)

The scenario concerns a *real-time Judo match*, with an AI system supporting referees and coaches in recognising techniques, unbalancing situations or borderline behaviours.

**Step 1.** Data input (time: ~1 ms)

- 4 × 3D cameras + IMU sensors positioned on the athletes
- Acquisition of position, orientation and impact force

**Step 2.** Pre-processing (time: ~5 ms)

- *Noise* filtering
- Image/sensor synchronisation
- Conversion of movements into normalised biomechanical coordinates

**Step 3.** Feature extraction (time: ~5–10 ms)

- Recognition of technical patterns (*Kuzushi, Tsukuri, Kake*)
- Detection of unbalancing, critical postures, irregular grips
- The psychological component of the athletes, expressed through a composite biorhythm indicator, is incorporated as an additional variable at this stage, enabling more comprehensive statistical modelling.
  An initial weight of 10–20% on the overall feature impact ensures that the system *recognises* and *adapts* to fluctuations in mental condition, thereby improving decision reliability.

**Step 4.** Decision engine – Reinforcement Learning (time: ~10–15 ms)
The AI *agent*, by evaluating the ongoing action:

- Estimates risk (fall, infringement, counter-move)
- Provides an assessment: "high probability of *Ippon* (maximum score)", "possible penalty", etc.

**Step 5.** Output (time: ~2 ms)

- Visual or auditory feedback to the coach/referee
- Recording of the sequence for post-match review

Total cycle time: ~30–35 milliseconds, sufficient to take decisions ***before*** the action is completed.

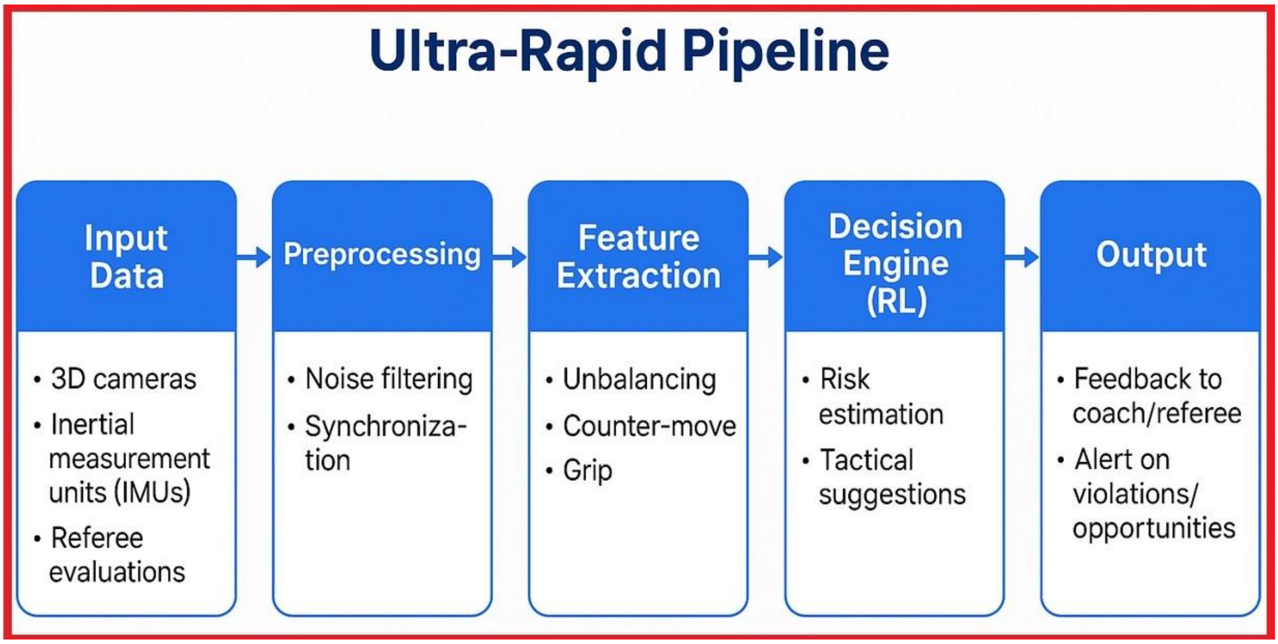


**Figure 4**. [*Ultra-Rapid Pipeline*]. Source: Author's original elaboration with AI-assisted generation.

## 6.3 Why starting from Judo is advantageous

- It is a context of high technical/biomechanical level, with immediate feedback (success/failure);
- Clear rules, together with refereeing assessments, provide an excellent basis for *training* AI systems;
- Moreover, among martial arts, it is one in which particular attention is paid to the protection of the individuals involved, who – within a codified system – can express *maximum energy*, sufficient to counter "any type" of attack when properly trained;
- The rapid alternation between defence and attack can simulate ***dynamic risk*** scenarios that are also found in industrial (organisational/economic) contexts.

# *7. EXPECTED OUTCOME*

A *transferable pilot project* – initially validated within the Judo domain – capable of simulating 'attack–defence' scenarios within economic and industrial control processes, ensuring the *RESILIENCE* of a system and enabling ultra-fast risk *mitigation* in a transparent manner consistent with *ethical principles*.

- Traditional Risk Management organizes risk treatment as a linear sequence of Identification, Assessment and *Control*.
- *Judo-BI™* retains this structure but reinterprets it dynamically: identification becomes the detection of emerging imbalances (*Kuzushi*)[40], planning becomes the adaptive configuration of the response (*Tsukuri*) and implementation takes the form of proportionate and timely intervention (*Kake*).

In this way, risk is no longer merely an object to be periodically classified, but a dynamic process to be continuously monitored and governed.

[40] A crucial element in detecting the signals of *Kuzushi* is 'listening': approaching the other with a readiness to *receive* ("open heart and empty mind"), rather than merely waiting for one's turn to act – a disposition that transforms observation into relationship and makes it possible to recognise the subtle variations that may herald emerging imbalance. In any operational or observational context, such an attitude creates the space to understand *before* reacting: acceptance and recognition precede the search for solutions. Applied to *Kuzushi* or to FRAM mapping of 'work-as-done', this transformative approach enables the detection of weak signals and a deeper understanding of operational variability, activating proportionate responses grounded in relationship and trust rather than in mere "reactive mechanics".

It is worth noting that this three-phase operational logic shows a conceptual affinity with *Resilience Engineering* models of adaptive systems.
In particular, the sequence *Kuzushi–Tsukuri–Kake* closely parallels the well-known resilience capabilities described by Hollnagel[5] – namely *monitoring*, *anticipating* and *responding*.
So, the Judo-inspired framework may also be interpreted as an intuitive operational representation of adaptive system resilience. The *learning* dimension naturally emerges through the iterative cycles of observation, adaptation and feedback that characterise *Judo-BI™*.

A related conceptual analogy can also be found in the 'OODA loop' (*Observe–Orient–Decide–Act*) proposed by John Boyd in the field of strategic decision-making. The OODA framework describes a rapid adaptive cycle in which observation of the environment, contextual interpretation, decision configuration and action execution continuously interact through feedback. Within this perspective, the *Kuzushi–Tsukuri–Kake* sequence may be interpreted as an operational analogue: imbalance detection (*Kuzushi*) relates to observation and orientation, adaptive preparation (*Tsukuri*) corresponds to decision configuration, and execution (*Kake*) represents the action phase.

A further parallel can be observed with the logic of adaptive control systems in systems engineering. Many control architectures follow a sequence of deviation detection, configuration adjustment and control action, aimed at maintaining system stability under changing conditions.
The *Kuzushi–Tsukuri–Kake* sequence may thus be interpreted as an operational analogue of such adaptive control logic: detecting imbalance, preparing an appropriate configuration, and executing the corrective action at the appropriate moment.

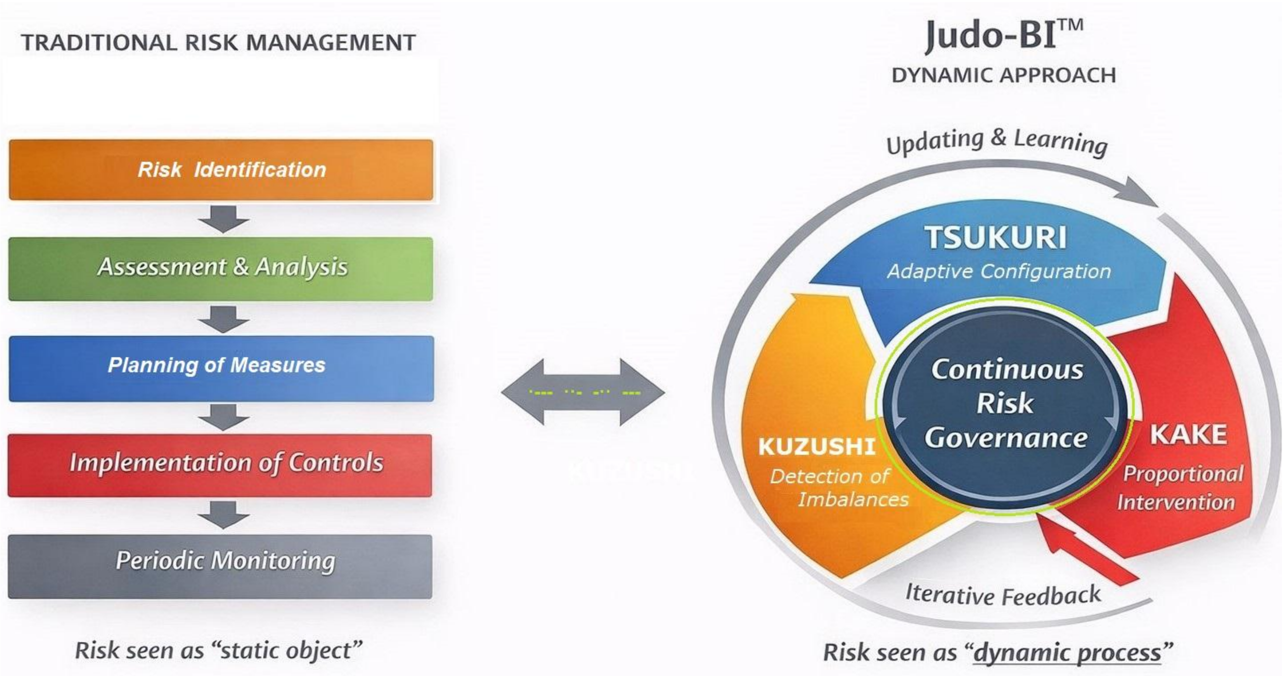


**Figure 5**. [*Risk Management mapping*]. Source: Author's original elaboration with AI-assisted generation.

**Fundamental difference:**

- Classical model (structured for stability):
  risk assessment as an object.
- *Judo-BI™* model (structured for adaptivity):
  interpretation of risk as a dynamic imbalance in evolution.

## 7.1 Simple Use Case (Cyber Risk in the Maritime Domain) – Scenario

**A shipping company uses integrated digital systems for:**

- navigation, cargo management, predictive maintenance, satellite communications.

**Traditional Approach**
- Risk identification: risk of a ransomware attack on onboard systems.
- Assessment: medium probability, high impact.
- Measures: firewalls, network segmentation, periodic backups, access policies, annual audit.
- The system is protected, but it reacts only when the event materializes.

***Judo-BI™* Approach**
- *Kuzushi* – Imbalance Detection
  - micro-anomalies in system logs, unusual network latency,
  - variations in user behavior, telemetry deviations.
  - The approach does not wait for a confirmed attack; it observes weak signals.
- *Tsukuri* – Configuration Preparation
  - dynamic isolation of subnetworks, traffic-priority reallocation,
  - impact simulation within a Digital Twin
- *Kake* – Proportionate Intervention
  - micro-containment, selective blocking, activation of continuity protocols.
  - External Cycle (Process Level)
  - updating detection thresholds, revision of policies, crew training.

**Perceived Added Value**
- In the traditional model:
  - *Control* is primarily preventive and documentary.
- In the *Judo-BI™* model:
  - *Control* becomes dynamic and time-sensitive.
  - The change is not only technical but also conceptual: it transforms the role of *time* in risk.
  - Risk is no longer merely a *future probability*, but a *process in formation*.

## 8. *APPLICATIONS and TRANSFERABILITY*: Development Perspectives

The *Method* outlined so far does not exhaust itself in the original reference context but is configured as a conceptual and operational model with high *transferability*.
Its effectiveness lies in its ability to adapt to complex and dynamic systems, keeping the fundamental principles unchanged – *balance*, *timing*, *adaptation* and *awareness* – while modulating the application modalities according to the context. The associated applications should not be understood as mere technical transpositions but as processes of strategic reinterpretation, in which the logic of confrontation – proper to competitive and relational dynamics—is brought back to a broader dimension that includes *cognitive, decisional* and *behavioral* aspects.

The structure of this chapter follows a progression that moves from general application principles toward increasingly specific domains, up to encompassing training implications and development perspectives. In this light, *Judo-BI™* reveals itself not only as a tool for action but as a path to awareness, in which operational effectiveness is accompanied by the ability to 'empty oneself' of rigid patterns, to grasp—each time—the true nature of the situation.

The conceptual and technological framework illustrated so far is therefore widely and intrinsically transferable to numerous fields across the technological and organisational spectrum, characterised by: high levels of complexity, often non-linear interdependencies and the need for *rapid responses to shocks*. Taken together, these applications outline an evolutionary pathway which, starting from *pilot* and non-critical use cases, may lead to increasingly robust, adaptive and ethically governable decision-making systems, capable not only of reacting to shocks but also of anticipating them and exploiting them as a lever for the continuous improvement of overall system resilience.

All these applications require pragmatic validation pathways, with particular attention to ***Ethical governance***[41] and *Human involvement* ("human-in-the-loop"), Privacy protection and progressive rollout phases starting from non-critical advisory and maintenance-oriented functions and subsequently evolving – supported by evidence and certification – towards assistive and autonomous functionalities.

Specifically, *a reasoned ordering* is proposed, accompanied by a brief motivation for each level.

## 8.1 Critical and manufacturing industrial systems

In critical and manufacturing industrial systems, characterized by strong interdependencies among physical subsystems (automotive, plant engineering, discrete and process manufacturing), stringent safety constraints and non-linear operational dynamics, the *Judo-BI™* framework can provide a meaningful methodological contribution to enhancing operational and decision-making resilience.
In such contexts, the objective is not automation per se, but rather the ability to detect early signs of imbalance, prepare adaptive responses and execute proportionate interventions, while preserving production continuity, safety and quality.

The integration of Digital Twins models, dynamic Design Structure Matrices and predictive analytics, enables an explicit representation of dependencies across components, production lines and processes, supporting both *near-real*-time operational control and a strategic learning loop.
Within this feedback-driven architecture, local anomalies are interpreted as early indicators of potential systemic issues, allowing parameters, maintenance policies and production configurations to be recalibrated *before* degradation becomes irreversible.

*Judo-BI™* thus acts as a decision-support framework that complements operators, engineers and plant managers, strengthening their ability to understand, simulate and govern complex systems under uncertainty. Its added value lies in combining *Control*, learning and continuous adaptation, while maintaining human oversight over safety-critical decisions and ensuring traceability, explainability and alignment with industrial and regulatory requirements.

## 8.2 Logistics and Transport (Supply Chain)

In the domain of logistics and transportation, and more broadly in the management of complex supply chains, the *Judo-BI™* framework finds a particularly natural application, as it operates at the intersection of physical, digital and distributed (organizational) socio-technical systems.
In such environments, marked by high variability, strong interdependence and exposure to external shocks, the primary value lies in the ability to detect early signs of imbalance and to orchestrate adaptive responses *before* local disruptions escalate into systemic crises.

By integrating heterogeneous data sources – operational, environmental, infrastructural and market-related – *Judo-BI™* enables delays, congestion, extreme weather events or supply interruptions to be interpreted as early indicators of instability. These signals can be analyzed and contextualized through dynamic models and *Digital Twins* of the logistics network, supporting adaptive preparedness that includes scenario simulation, route reconfiguration and the reallocation of fleets and loads.

[41] The set of principles, roles, operational rules and control mechanisms aimed at ensuring that the use of technologies, decision-making processes and analytical tools (particularly those based on *Artificial Intelligence*) complies with criteria of responsibility, fairness, protection of individuals and respect for regulations.
Implementing ethical governance therefore means not only adopting technical measures, but also defining an organizational structure, policies and verifiable practices that link design, development and operations to ethical values and stakeholders' rights. Within the context of Judo-BI™, this approach ensures that the proposed tools are used as reliable and responsible support to human decision-making, preserving dignity, safety and legal protection.

Corrective actions thus become targeted, proportionate and aligned with objectives of service continuity, sustainability and risk containment.
In this context, the 'attack–defense' paradigm translates into the ability to cope with sudden shocks – demand fluctuations, the unavailability of critical nodes, geopolitical or environmental events – through resilient decision policies supported by *Reinforcement Learning* techniques and the progressive optimization of control hyperparameters.

The framework does not aim to replace the expertise of operators and decision-makers, but rather to enhance their evaluative capacity by making interdependencies and decision propagation effects along the supply chain more explicit.
Overall, the application of *Judo-BI*™ to logistics and transportation supports a view of the supply chain as an adaptive system, in which *Control* is not static but evolutionary and resilience emerges from the combination of continuous observation, learning and the capacity to rebalance in response to an ever-changing context.

## 8.3 Energy, Utilities and Critical Infrastructure

Here the *systemic nature* of the framework is further reinforced (continuous, strongly regulated systems); it benefits from adaptive control strategies for load–demand balancing and fault response (*smart-grids*).
This domain therefore represents one of the most emblematic contexts for the application of *Judo-BI*™, as it is characterised by continuous, highly interdependent, regulated and *safety-critical* physical systems. Power grids, water systems, gas pipelines, transport and telecommunications infrastructures share the need to maintain a dynamic balance between demand, production capacity, safety and ***service continuity***.

In this context:
- the concept of *Kuzushi* can be interpreted as the early detection of operational deviations (overloads, network instabilities, local failures, extreme weather events), which act as leading indicators of potential systemic crises;
- the *Tsukuri* and *Kake* phases correspond respectively to the adaptive reconfiguration of the system (load redistribution, controlled isolation of network segments, activation of backup resources) and to the execution of corrective actions aimed at restoring or strengthening equilibrium.

The integration of predictive models, adaptive controls and *Digital Twins* makes it possible to simulate stress scenarios and to assess the impact of decisions in *real time*, thereby improving the overall resilience of the infrastructure. Also in this case, the framework operates as a *decision-support* tool, preserving the central role of the human operator and ensuring compliance with regulatory constraints, safety requirements and long-term reliability criteria.

## 8.4 Telecommunications and Cybersecurity as a Systemic Resilience Paradigm

In the telecommunications domain, the *Judo-BI*™ framework finds natural application in contexts characterized by distributed systems, non-linear dynamics and stringent requirements for service continuity and low decision latency.
In particular, the evolution toward ***Edge Computing*** architectures makes it possible to move processing, analysis and decision-making capabilities closer to data collection points and service delivery locations, reducing reaction times and increasing the overall resilience of the Network.
- In this scenario, "imbalance" (*Kuzushi*) may manifest as local performance degradation, cell congestion, radio interference, traffic anomalies or emerging cyber threats.

- The adaptation phases (*Tsukuri*) include the dynamic reconfiguration of network resources, adaptive network slicing and the intelligent allocation of computational workloads between the edge and the core (base station).
- An emblematic example of corrective action (*Kake*) is represented by *adaptive antenna tilting*, namely the dynamic adjustment of the inclination of radiating systems in order to optimize coverage, signal quality and radio load balancing as a function of network operating conditions.
  Such a mechanism, when supported by predictive models and adaptive controls, makes it possible to improve spectral efficiency, reduce interference and mitigate congestion or service degradation situations in *near real time*.

Similar principles apply to ***Cybersecurity***, where the 'attack–defense' cycle is interpreted as a continuous process of detection, isolation and mitigation of dynamic threats, supported by distributed processing capabilities, network self-healing[42] and human decision support.
In this methodological construct, *Judo-BI™* functions as a tool to support resilience, preserving transparency, explainability and *ethical governance* of automated decisions.
Particularly promising applications also emerge in the fields of *maritime* ***Navigation*** and *aeronautics/aerospace*, where the need for resilience, low decision latency and the management of safety-critical systems makes the 'Kuzushi–Tsukuri–Kake' paradigm – reinterpreted in terms of Engineering Resilience – highly relevant: from adaptive network slicing and network self-healing, to resilient navigation and naval damage control, up to predictive maintenance, flight decision support and the management of complex aerospace systems.

### 8.4.1 Systemic Resilience and Digital Governance in the Maritime Domain

Along the same line of application, a relevant focus concerns IT Governance within naval certification bodies and, more generally, the management of Cyber Risk in the maritime domain.
In this context, the *Judo-BI™* conceptual model does not merely provide analytical tools; rather, it proposes an interpretative key consistent with the systemic, interdependent and safety-critical nature of the contemporary maritime ecosystem.
Modern ships, as well as port infrastructures and shore-based control centers, constitute highly integrated techno-organizational environments in which digital systems, mechanical components, communication networks and the human factor jointly contribute to navigation safety and operational continuity. In this scenario, the distinction between technical risk and cyber risk tends to dissolve:
a cyber vulnerability may translate into an operational event, and vice versa. Naval certification bodies therefore operate in a space where compliance verification is no longer merely documentary or inspection-based, but requires the capability to interpret systems dynamically.
It is precisely here that the 'Kuzushi–Tsukuri–Kake' triad, reinterpreted in terms of engineering resilience, demonstrates its relevance:

- *Kuzushi* can be understood as the capability to identify early signals of imbalance: anomalies in system behavior, inconsistencies in information flows, and deviations from expected operational parameters. The objective is not merely to intercept a fully manifested critical event, but to recognize the conditions that precede its emergence. In the maritime domain, this means moving from a *post-incident reaction* logic to a *proactive vigilance posture*.
- *Tsukuri* represents the phase of organizational preparation and adaptation.
  For a certification body, this implies the ability to integrate such evidence into its decision-making processes by revising criteria, alert thresholds, and inspection methods.
  The objective is not to replace the professional judgment of the surveyor, but rather to enrich it with tools capable of better understanding the interdependencies between digital and physical systems, thereby enabling a more comprehensive assessment of the robustness of the certified asset. Governance thus becomes an evolutionary process, grounded in continuous learning and the periodic revision of rules.

[42] Logical segmentation (into independent virtual slices) and self-healing of telecommunications networks.

- *Kake* translates into proportionate and timely interventions: corrective actions, technical prescriptions, possible operational limitations, or requests for compliance adjustments.
  The defining element is not the severity of the intervention, but its consistency with the level of risk actually detected. In a maritime context—where decisions must reconcile safety, commercial continuity, and legal responsibility—proportionality becomes an essential criterion of legitimacy.

The adoption of such an approach makes it possible to move beyond the *static vision of certification*, traditionally based on point-in-time verification, toward a form of *dynamic supervision*.

- From this perspective, IT Governance is not separate from maritime safety but constitutes an intrinsic dimension of it.
- Likewise, Cyber Risk is not an "additional" risk, but rather a structural component of overall operational risk.

In broader terms, the application of the framework contributes to strengthening the resilience of the entire maritime system: not only by preventing incidents, but also by fostering an organizational culture capable of learning from deviations, adapting its rules, and effectively coordinating diverse actors—shipowners, *classification societies*[43], port authorities, and technology providers—within a perspective of shared responsibility.
In this sense, the extension of the 'Kuzushi–Tsukuri–Kake' paradigm IT Governance and maritime Cyber Risk represents a natural evolution of the applications already referenced in the naval and aerospace domains: a transition from *technical resilience* to *institutional and systemic resilience*, fully consistent with the safety and reliability requirements typical of safety-critical domains.

The systemic resilience dynamics observed in the domain of *Telecommunications* and *Cybersecurity* find a natural extension in complex urban contexts, where the integration between physical and digital infrastructures becomes an essential element for the coordinated management of risks and emergencies, while simultaneously requiring the ability to operate under conditions of uncertainty and apparent absence of stable references.

## 8.5 Smart Cities and Civil Protection

In the context of Smart Cities and Civil Protection, the *Judo-BI™* framework emerges as a methodological synthesis linking industrial systems, network infrastructures, public services and the human factor.
These domains are characterized by time-critical decisions, high uncertainty and the involvement of multiple institutional/operational stakeholders, each with distinct responsibilities and constraints. In such a setting, the core value of the paradigm does not lie in automation alone, but in its ability to enhance coordination, prevention and the overall quality of collective decision-making.
By integrating heterogeneous data from the urban environment, critical infrastructures and emergency services, *Judo-BI™* enables anomalous events and weak signals to be interpreted as early indicators of potential crises. Dynamic models and urban *Digital Twins* provide the means to contextualize these signals, simulate stress scenarios and prepare adaptive responses, supporting timely and proportionate resource reallocation.

[43] Technically independent organizations that develop and maintain technical standards for ships and offshore structures, verifying compliance through surveys and certification across the vessel's lifecycle (design, construction, operation, and maintenance), often acting under delegation from flag administrations for certain statutory functions.
They define technical standards for hull structures, machinery and onboard systems; conduct inspections and periodic surveys; issue or maintain the vessel's class (a necessary condition for insurance coverage and commercial operation); and may suspend or withdraw class in cases of serious Non-Conformity.
*(Well-known examples include: Lloyd's Register, DNV, Bureau Veritas, RINA, and ABS – American Bureau of Shipping.)*
In the present context (IT Governance and Cyber Risk), the reference concerns their role in integrating cybersecurity requirements into technical regulations, verifying the adequacy of onboard digital systems, assessing the impact of cyber incidents on *seaworthiness* and operational safety and evolving from a "static" certification model toward a more *dynamic* form of supervision supported by digital evidence.

As a result, operational actions become more coherent, coordinated and focused on mitigating impacts on citizens, territories and essential services.
Within the *Civil Protection* and Defense domain, the framework also supports simulation, training and decision management in high-risk scenarios (without military connotations), strengthening response capabilities through realistic exercises and continuous learning processes.
The emphasis on the human factor, decision transparency and *ethical governance* ensures that advanced technologies remain firmly embedded within institutional accountability and the protection of individuals.
Overall, the application of *Judo-BI™* to Smart Cities contributes to a vision of urban safety and resilience as dynamic processes, grounded in the balance between observation, adaptation and coordinated intervention.

## 8.6 Healthcare

Healthcare is a domain of very high social relevance and systemic complexity, for which the adoption of the framework requires particular caution and robust ethical safeguards.
The *Judo-BI™* paradigm can operate as an adaptive *decision-support system*, integrating clinical, biometric and organizational data to facilitate patient monitoring, dynamic management of hospital resources and the early identification of critical conditions, always with the primary objective of safeguarding human life and dignity.

In this context, "imbalance" (*Kuzushi*) can be interpreted as an anomalous variation in physiological parameters, care workloads or resource availability, triggering progressive responses of adaptation (*Tsukuri*) and intervention (*Kake*).
The approach remains explicitly non-deterministic and *human-in-the-loop*: the tools support and enhance clinical judgment without replacing it and must be used in a manner that respects Patient autonomy, *Privacy* and *Safety*, as well as the well-being and professionalism of healthcare Operators.

The objective is to strengthen the overall resilience of the healthcare system – by improving prevention, efficient resource allocation and responsiveness to emergencies – while preserving ethical and compassionate attention to every individual involved.

## 8.7 Finance and Economic Policy

The approach proves effective as a conceptual transfer to the financial domain, which is characterised by high complexity, strong interdependence among actors and non-linear dynamics.
Similar mechanisms can be applied to dynamic risk management, the early detection of *market shocks* and the optimisation of operational strategies in highly volatile contexts, while preserving transparency and the explainability of algorithmic decisions.

Within this perspective, the concept of *financial equilibrium* is interpreted as a *dynamic balance* among liquidity, risk, expectations and systemic stability, subject to continuous perturbations.
Macroeconomic shocks, interest-rate changes, crises of confidence or geopolitical tensions can be understood as *Kuzushi* signals, namely emerging imbalances to be identified and governed.

At the level of monetary and economic policy, both local and global, the framework enables the modelling of interdependencies among regulatory decisions, market reactions and macroeconomic impacts, fostering adaptive approaches oriented not only towards *ex post stabilisation*, but also towards the anticipation and *preventive* mitigation of systemic imbalances.

## 8.8 Environmental Protection and ESG Criteria [44]

The domain of Environmental Protection and ESG (*Environmental*, *Social*, *Governance*) criteria represents a cross-cutting axis spanning industry, logistics, energy, finance and public governance, making it particularly well suited to the application of the *Judo-BI*™ framework.
In these contexts, resilience concerns not only *operational continuity*, but also the ability to prevent environmental damage, ensure long-term sustainability and maintain stakeholder trust.
The *Kuzushi–Tsukuri–Kake* paradigm can be reinterpreted as a mechanism for the early detection of environmental stress signals (*Kuzushi*), such as anomalies in emissions, ecosystem degradation, breaches of regulatory thresholds or extreme climatic events; this is followed by a phase of adaptation and reorientation of operational policies (*Tsukuri*), through the reallocation of resources, modification of production processes or activation of countermeasures; finally, the implementation phase (*Kake*) coincides with the concrete execution of corrective and *preventive* actions.
The integration of real-time data streams (environmental sensor networks, satellite monitoring, ESG indicators) into dynamic dependency structures enables the anticipation of compliance risks, supports sustainability-oriented decision-making and improves reporting capabilities and *explainability* towards regulatory authorities and investors. Within this framework, *Judo-BI*™ is configured as a decision-support tool capable of combining operational resilience, environmental responsibility and *ethical governance*, without "falling" into deterministic or merely reactive approaches.
Environmental implications and *ESG criteria* inevitably reflect also in regulatory systems and decision-making processes, requiring tools capable of supporting complex assessments in areas such as the legal field and the protection of cultural heritage, especially where the very distinction of value confronts elements that are not immediately measurable.

## 8.9 Legal domain and Cultural Heritage: indirect and decision-support applications

*Judo-BI*™ primarily strengthens the generality of the application context: in areas where the main value is qualitative, procedural or symbolic, the framework operates as a decision-support tool rather than as a substitute for professional judgment.

- In the legal, procedural and regulatory domain, it may contribute to the structured analysis of sequences of events (forensic timelines, temporal correlation of evidence), to the identification of recurring patterns that signal operational risk or compliance drift and to the systemic management of organizational risk (escalation procedures, chain of custody of evidence, support to discovery and audit activities). The system may provide concise summaries/briefs, correlation metrics and risk-based sampling suggestions that facilitate the work of judges, lawyers, supervisory authorities and compliance officers, while leaving the evaluative and interpretative responsibility of the human operator unchanged.
- In the Cultural Heritage sector and in humanistic contexts, the potential is particularly relevant from a preventive and managerial perspective: integrated sensor systems and adaptive models may enable predictive conservation (microclimate monitoring, vibrations, material degradation), the preventive protection of artworks and historical sites, as well as the dynamic planning of visitor flows to minimize anthropogenic impacts and ensure sustainable access.
  Digital Twin tools and simulation scenarios would allow the evaluation of restoration interventions, emergency plans and surveillance strategies with comparative costs and risks; anomaly detection modules may identify suspicious activities or risk conditions *before* they turn into damage.

[44] ESG ("Environmental, Social, Governance") is an acronym identifying the three pillars used to assess a company's ***Sustainability*** and *ethical impact*. These criteria are employed by investors and by companies themselves to measure performance not only in financial terms but also across social and environmental dimensions, covering aspects such as climate impact, workers' rights and management transparency; factors that help to evaluate long-term risk management and value creation, going *beyond* profit alone.

In both domains, the key elements for responsible adoption are: transparency of algorithmic logics, traceability of evidence, protection of Privacy (in particular for sensitive data relating to individuals and culturally sensitive objects) and *ethical governance* involving legal experts, conservators, art historians and field operators.

Concrete proposals may include controlled *pilots* with pseudonymized datasets, *human-in-the-loop* workflows for the validation of alerts and specific KeyPerformanceIndicators.
For example:

- reduction of false positives in forensic alerts;
- average time to identify critical conditions for artworks.

In summary, *Judo-BI*™ would offer significant added value also in indirect and qualitative domains, enhancing observation, prevention and response capabilities while preserving the central role of human expertise and the professional responsibilities typical of the legal and cultural heritage sectors.

The integration between the regulatory, cultural and decisional dimensions also assumes relevance on a supranational scale, contributing to the definition of broader and more structured models of strategic resilience, in which the ability *to read* what is not explicitly visible becomes a determining factor.

## 8.10 Application of the *Judo-BI™* framework to European strategic resilience

The contemporary geopolitical context is characterized by a high degree of interdependence among economic, technological, social and security dimensions, as well as by increasing systemic instability.
In this scenario, the need to strengthen the strategic resilience of the Union would serve to improve the ability to anticipate imbalances, manage complex risks and coordinate proportionate responses at local, regional and global levels.

The application of the framework offers, in this regard, a useful methodological contribution, through an adaptive governance model inspired by the paradigm of 'double-loop control': enabling the integration of an internal *operational* cycle, oriented toward continuous monitoring and the management of deviations, with an external *strategic* cycle dedicated to the review of the "rules" together with the risk assumptions that guide collective action.
The objective would not be mere reactive optimization, but the ability to learn from the context by adapting decision-making and coordination mechanisms over time.

Applied to European policies, this paradigm would help interpret economic or technological perturbations as early signals of potential systemic imbalances (*Kuzushi*), fostering adaptive preparedness (*Tsukuri*) and targeted, proportionate interventions (*Kake*), with an orientation toward prevention, anticipatory risk management and the strengthening of multilateral cooperation.

- A practical example of this logic would be the establishment of a *common European cyber defense*, supported by a federated network of data centers[45] distributed across the EU, capable of providing shared services for analysis, storage and coordinated response.

In particular, Artificial Intelligence, conceived as a shared and verifiable service (*AI as a Service*), can act as a methodological enabler by supporting data analysis, weak-signal detection and complex scenario simulation; it is intended as a tool to support human decision-making and is aligned with European principles of transparency, accountability and *ethical governance*.

[45] The expression 'federated data centers' refers to a distributed architecture composed of interoperable nodes coordinated through common protocols and standards, designed to ensure functional redundancy, operational continuity, and resilience against failures or targeted attacks, while avoiding excessive centralization of critical resources.

Overall, the *Judo-BI™* approach would contribute to a vision of *European governance* oriented toward dynamic stability, in which *Control* would not be *static* but *adaptive*, with Security (in the broadest sense of the term) pursued through the capacity for rebalancing and continuous learning.

Moreover, such an approach could foster the construction of an organized system of peaceful coexistence at the global level, founded on prevention, proportionality of responses and shared responsibility.

## 8.11 Support to auditing activities [46]

*Judo-BI™* can support control, monitoring and verification activities on organizational frameworks in general and on ISO schemes in particular, as a decision-support tool: by providing structured collections of verifiable artifacts/evidence[47] (time-stamped logs, synchronized video, metrics and model-based scores) as well as suggestions for risk-based sampling and prioritization of *Compliance* (*legal* & *regulatory* obligations / *ICT*) audits[48].

Operational adoption, however, requires the establishment of clear governance rules (audit scope and perimeter, consents, roles), appropriate privacy protection measures and guarantees of transparency of algorithmic results, as well as procedures for model validation and updating that ensure decision traceability, reproducibility of analyses and consistency over time with regulatory organizational and risk requirements.
In any case, the outputs produced by the audited systems must always be contextualized and validated by the certified auditor / subject-matter expert, who retains final responsibility for conclusions and recommendations.

Moreover:

- The combination of skills derived from experience in *Self-Defense* – integrating situational analysis, stress management, de-escalation techniques and the design of "minimum-force" interventions – adds concrete operational value to *Information Systems Auditing* by improving the timely recognition of weak signals, human-centered threat modeling (*insider risk*, *coercion*[49], *social engineering*), the effectiveness of *Red-Team*[50] exercises and the optimization of *Incident Response* procedures.
- The expert can contribute to designing collections of physical and sensor-based evidence that are less invasive yet more probative, as well as to training auditors and operators on what realistically influences the quality of audits, teaching them to identify and value good practices (rather than adopting an inquisitorial approach).

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[46] Like a "cognitive prosthesis", it will serve to facilitate the amplification of the auditor's capabilities, simplify administrative obligations and optimize the sampling phase. By this framework, AI is not meant to "decide in place of" the human being, but to strengthen human perception, evaluation and learning capabilities, reducing the gap between *expected quality* and the *quality actually achieved* by the audited processes; making auditing more continuous, adaptive and capable of learning.

[47] Evidence handled with a 'tamper-proof' chain of custody.

[48] Indicates the conformity of corporate activities with laws, regulations, procedures and standards – both external and internal – with the aim of preventing sanctions and legal, financial and reputational risks, while ensuring ethical, transparent and secure operations.

[49] A manipulation tactic in which an attacker forces a victim, through threats, extortion or psychological pressure, to perform harmful actions or disclose sensitive information, often violating corporate policies.
It is an extreme form of social engineering that exploits fear to compromise security.

[50] A group of ethical experts that simulates realistic and complex cyberattacks to assess an organization's *security posture*. Using real-world tactics, techniques and procedures (TTPs), red teamers attempt to bypass defenses (*Blue Team*) to identify technical, physical and human vulnerabilities, providing crucial feedback for improvement.
The defining characteristic of a *Red Team* is its proactive and "offensive approach": they act as real adversaries (*ethical hackers*) to test the effectiveness of defenses, not merely to find technical *bugs* as in *penetration testing*.

The contribution lies in combining technical resilience with practical competence in the operational space where technology and people interact.

## 8.12 Contribution to fundamental research (*Physics, Chemistry, Biology*)

The *Judo-BI™* framework can also provide relevant contributions to fundamental research by offering tools for modelling, experimentation and analysis of complex, multi-scale systems.
The dynamic DSM helps to make explicit dependencies and effect-propagation pathways among components of physical or biological systems; mixed-effects models (FREM) capture intrinsic variability and allow the separation of systematic effects from experimental noise; *sensor fusion*[51] and ultra-fast pipelines enable high-frequency data acquisition and real-time experimental control (useful for chemical reaction experiments, non-linear physical systems or cellular dynamics).

The use of RL and *active* learning / experiment design strategies might accelerate discovery (for example: optimisation of reaction conditions, material screening, adaptation of biological protocols), while quantum-inspired algorithms are useful for exploring extremely large parameter spaces.

Overall, the paradigm enables the design of controlled perturbations (*Kuzushi* analogy) to probe system responses, study emergent phenomena and validate theoretical models in highly controlled settings – thus promoting reproducibility, experimental adaptability and knowledge transfer across different (albeit related) scales or domains.

As with any application to fundamental research, careful attention to *ethical constraints*, validated experimental protocols and close collaboration with domain experts is required.
The transversality of the applications described highlights how the *Method* can be further enhanced through structured learning pathways, capable of promoting its dissemination and adaptation across different contexts, while simultaneously developing an open 'mentis forma' not constrained by rigid patterns.

Last, but not least:

## 8.13 *Training* as a Strategic Lever for Development and Competitive Advantage

*Judo-BI™* can also extend to training contexts, understood in the broadest sense: general schooling, university, professional, and organizational.
In such domains, the *Method* would retain its adaptive structure, allowing the learning process to be read as a succession of imbalances, preparation, and execution:
- identification of the training need (*Kuzushi*),
- construction of the most suitable learning environment and tools (*Tsukuri*),
- transformation of knowledge into observable and applicable competence (*Kake*).

In *school* settings, this fosters more inclusive and progressive teaching, capable of valuing individual times, rhythms, and differences; in *university* contexts, the Method supports the development of critical thinking, systemic analysis capabilities, and the translation of theoretical models into applied cases; in *organizational/corporate* settings, it becomes support for continuous training, skills updating, and the construction of more resilient, adaptive, and decision-oriented 'teams'.

[51] *Multisensory integration*: it is the set of methods and techniques that combine data from multiple distinct and heterogeneous sensors to obtain a more accurate, robust and informative estimate of a system's state; an integration process that enables a representation that is also more reliable and comprehensive than that which could be provided by each individual sensor considered separately.

In this perspective, the concept of *emptyness* also assumes a pedagogical meaning: mind available, open attention, willingness to unlearn rigidities and automatisms no longer useful.
Effective training does not limit itself to transmitting content but creates the conditions for the learner to internalize principles, recognize contexts, and act with autonomous judgment.
Training represents the main vector of transferability of the *framework* across the different application domains described above.
Ultimately, its effectiveness lies not only in the multiplicity of its application areas but in its ability to adapt to different contexts while maintaining internal coherence, enabling the capture—even in the absence of predefined schemas—of the essential nature of situations and acting accordingly.

## 9. Value for the discipline of *JUDO* itself and for 'Match Analysis'

The *Proof of Concept* presented in this work also delivers meaningful contributions to the practice and science of Judo. The integration of multimodal acquisition, quantitative analysis and adaptive models provides objective, time-stamped metrics useful to coaches, referees and researchers:

- early recognition of technical patterns,
- anticipatory indicators of unbalancing,
- reproducible assessments of manoeuvres,
- signals supportive of injury prevention.

Moreover, decision-support tools developed in the PoC can improve the consistency of refereeing (with recorded material for *ex-post review*) and provide an empirical basis for refining training methods and judgement criteria.
It is essential that these innovations be adopted in a non-invasive, transparent manner and under human supervision, so as to augment technical expertise without replacing it, while promoting research, safety and quality in competitive practice.

## 10. *FINAL CONSIDERATIONS*

### 10.1 Added Value and Conditions for Adoption

*Judo-BI*™ enables early detection of anomalies, reducing response times and facilitating interventions proportionate to the evolution of events.
The systemic correlation of data and the traceability of decisions strengthen transparency, verifiability and operational consistency – central aspects in regulated environments.
The continuous learning cycle transforms operational experience into structured rule updates, overcoming informational fragmentation and dependence on episodic reviews.
Within this framework, predictive models support – without replacing – human responsibility.
However, innovation requires rigorous governance: explicit human oversight, continuous model validation, bias control, privacy protection and clear attribution of responsibilities.
Adoption should therefore be gradual, initiated through pilot projects within critical operational domains, with shared KPIs and a dual decision-making structure (operational and strategic).

Furthermore: our *Method* integrates traditional Risk Management, making it more adaptive and anticipatory; to the stability of the classical model it adds a form of dynamic resilience, measurable and sustainable over time.
From a broader methodological perspective, the proposed framework can also be interpreted as a three-layer analytical architecture. Structural dependencies within the system are captured through tools such as DSM, dynamic behaviour and operational variability may be explored through probabilistic or functional models (e.g., FREM and FRAM), while the *Judo-BI*™ paradigm provides the decision-oriented layer, guiding adaptive responses through the *Kuzushi–Tsukuri–Kake* sequence.
In this sense, the framework integrates structural understanding, dynamic analysis and adaptive decision-making within a coherent operational perspective for managing complex systems.

## 10.2 *Rising Again* as an Operational Principle

In Judo, practice is also measured by the ability to rise again: learning from the fall, correcting posture, and returning to action with clarity of mind.
This attitude – both humble and determined – should likewise inspire the design of organizational and technological systems.
It is not always possible to prevent every error or failure; however, it is possible to configure structures that facilitate recovery, reduce impact and transform experience into learning.

Integrating a *culture of rising again* means combining technical effectiveness with responsibility, making resilience not only an operational objective but a practiced value.

## 10.3 Responsible Use of Artificial Intelligence and Social/Environmental Impacts

It is legitimate to acknowledge the fears raised by "apocalyptic scenarios" concerning the social impact of automation and AI: technology can reshape labor markets, concentrate wealth, and amplify inequalities if managed without rules and without attention to *social sustainability*.
However, the risk is not intrinsic to the tool itself but rather to the political, economic, and design choices that guide its use.

In line with the *Judo-BI*™ paradigm, the most effective response is a proactive and proportionate approach that applies the principles of *Kuzushi–Tsukuri–Kake* at the socio-economic level:

- identifying emerging imbalances at an early stage (signals of structural unemployment, loss of institutional trust, erosion of the social fabric);
- preparing rebalancing measures (redistributive policies, reskilling programs, participatory mechanisms);
- implementing targeted and verifiable interventions.

The "proper use" of A.I. therefore implies a combination of technical practices and *Governance* choices: designing algorithms according to *privacy-by-design*, transparency, and fairness principles; integrating human-in-the-loop mechanisms for critical decisions; adopting social impact metrics; promoting *data trusts* (fiduciary agreements) and data-sharing contracts that protect communities, users, and organizations.

From an environmental perspective, AI can become a powerful tool for protecting natural capital – from optimizing energy networks (smart grids and storage systems) to predictive management of water resources, from biodiversity monitoring to preventive infrastructure maintenance – contributing to the reduction of waste and emissions and strengthening territorial resilience.

At the political and economic level, transferring part of the value created by automation toward social protection policies and investments in skills is essential. Measures such as the taxation of productivity gains linked to automation, public funds for reskilling, pilot programs of *conditional basic income*[52] and incentives for companies that reinvest in local employment represent viable options.

Democratic participation – public consultations, worker representation in corporate decision-making, and *independent audits* of algorithmic impacts – is the prerequisite for a *just and inclusive transition*.

In summary, rejecting AI out of "fear" means losing opportunities; conversely, leaving it entirely to the logic of profit leads to the very risks rightly highlighted by alarmist narratives.

By applying the methodological principles discussed here – anticipation, adaptive preparation, and proportionate intervention – and through rules, institutions, and technical practices oriented toward social and environmental sustainability, it is possible to channel innovation toward greater equity, improved quality of life and harmony with the environment.

## 10.4 General Conclusions

The proposed *framework* does not aim to provide a definitive model, but rather a conceptual structure through which adaptive behaviour in complex systems may be observed, interpreted and progressively refined. By integrating principles derived from Judo with perspectives from Engineering Resilience, probabilistic modelling and decision intelligence, *Judo-BI™* highlights the importance of timing, contextual awareness and adaptive alignment in decision-making processes.
Effectiveness does not arise from rigid optimisation, but from the ability to perceive emerging conditions, configure appropriate responses and act at the appropriate moment.
Ultimately, the value of the framework lies not only in its analytical components, but in its capacity to support a mode of thinking that remains open, responsive and context-sensitive, where *emptiness of mind* enables the transition from observation to action in dynamically evolving environments.

In complex systems, the decisive advantage lies not in acting faster, but in *perceiving earlier* and aligning action with the right moment.

The present work – including those hypotheses and perspectives that may appear as conjectural or not yet fully supported by experimental evidence – stems from a long-standing process of observation, understanding and practical experience.
The ideas discussed are not the result of purely abstract theorisation, but rather of a progressively consolidated vision shaped by applications and outcomes achieved within complex, multinational organisational contexts.
The guiding thread underpinning the entire conceptual framework is the paradigm of a ***counter-reacted logical engine*** (double-feedback *Control*, understood as a hierarchical control architecture with multi-level feedback)[53], in which an *inner* loop acts on operational parameters to ensure expected performance and quality, while an *outer* loop allows the rules of the process itself to be reviewed, calibrated and adapted.

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[52] The concept refers to welfare models based on reciprocity, in which income support functions as a lever for social and labor inclusion, making the benefit conditional upon the recipient's commitment to participate in reskilling programs or activities of public utility.

[53] {Low-latency operational loop that regulates parameters and actions in real time} **+** {Outer loop operating over a relatively longer time horizon that calibrates hyperparameters, operational rules and governance policies}. Cf.:

a) 'Second-order cybernetics'
(a model inspired by *N. Wiener*, aimed at the overcoming/evolution of the classical Input-Output approach);
b) 'Double-loop learning' [by *Chris Argyris*, 1977] – (form *The Institute of Strategic Risk Management* – ISRM).

This overlap of feedback cycles allows not only for performance optimisation, but also for systemic evolution in response to changing conditions, thereby enhancing resilience and adaptive capacity.

The proposed suggestions should be regarded as methodological hypotheses and development pathways, to be always validated through dedicated experimental activities and controlled laboratory protocols.

The aim is not to provide definitive solutions, but rather to contribute to an open conceptual framework, encouraging responsible discussion and collaboration among researchers, practitioners and professionals interested in refining, developing and extending both ***Judo-BI™*** and its potential application domains.

The outlined path leads to a progressive integration between *method* and *application*, between *analysis* and *action*: the *Method* ceases to be an external tool and becomes an integral part of the decision-making process itself.

It is no longer a matter of applying a schema, but of developing a capacity for reading and intervention that naturally adapts to situations, grasping their essential elements each time.

The full maturity of the framework is realized when it is no longer necessary to make explicit reference to it, but when it manifests *implicitly* in the quality of the decisions and actions undertaken.

 

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[54] The figures are simplified conceptual representations provided for illustrative purposes only.