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Social Systems of Systems Thinking to Improve Decision-Making Processes Towards the Sustainable Transition

Gerrit Muller[a], Henri Giudici[a]*

[a] *University of South-Eastern Norway, Hasbergsvei 36, 3616 Kongsberg (Norway)*

Abstract

In this reflective paper, the authors present how systems thinking approaches could mitigate the broad challenges related to the decision-making process. We observe a few major roles: experts, who analyze and propose plans and actions, decision makers, for instance politicians with power, and implementers, who carry out the actions. How do these roles relate and interact? We use the climate crisis as example. The paper concludes that there is a need for transdisciplinary competence. Systems thinking at societal level, which inherently is a rather complex Systems of Systems, is proposed to fulfill this need. Research is required to address this need for transdisciplinary competence.

Keywords: Type *Sustainable Transition; Systems thinking; Complex Systems; Systems of Systems;*

1 Introduction

To reduce the consequences of the global warming there is a need to transform our current world into a more sustainable one. Transitioning towards sustainability is not a trivial task. On the contrary, it requires a significant effort that needs to be dealt with a holistic and systematic perspective (United Nations, 2015a; TWI2050, 2018; Sachs, 2012; Brundtland, 1987; Messerli et al., 2019; World Bank, 2019).

The United Nations envisioned in the Paris Agreement and the Agenda 2030 a framework of actions towards such transition (United Nations, 2015a; United Nations, 2015b). In the same line, also the European Union released its vision with the A European Green Deal (European Union, 2019). Such a European Green Deal is supported by a framework of policies. To keep these regulations effective and based on evidence, decision-makers are in continuous dialog with stakeholders of different kinds. Among the stakeholders, the technical experts play a major role. Although

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the vision of transitioning towards sustainability may be common, decision-makers and technical experts have different working principles. The different working principles may challenge the realization of evidence-based regulations. This is especially true in the complex landscape of the sustainable transition. There is a need to overcome this challenge and to make the evidence-based decision-making process more effective.

Research in industrial settings has been extensively working to fill the gap between decision-makers and technical experts. Such a gap needs to be filled rather quickly to realize projects in a healthy and competitive way. Industrial research has an extensive literature of tools and methods that can support the balancing act among different stakeholders.

This work presents how system science approaches can be adopted to make more agile decision-making process. After introducing the methods within system science, this work extends the use of the same from the industrial practices to the decision-making processes related to the sustainable transition. The presented article aims to bring the attention of the readers in the use of in this regard.

2 Systems Science and Transdisciplinary Competence

2.1 Systems Engineering

INCOSE defines the Systems Engineering discipline as "Systems Engineering is a transdisciplinary and integrative approach to enable the successful realization, use, and retirement of engineered systems, using systems principles and concepts, and scientific, technological, and management methods"[†]. This definition shows that Systems Engineering has grown beyond the technical aspects and considers itself transdisciplinary. INCOSE's Vision 2025 (Beihoff et al, 2014) incorporates these global challenges as an area where Systems Engineering must contribute. Akeel and Bell (2013) describe this view on systems engineering as 'meta-methodology': "*Systems engineering is conceived as an all-encompassing problem-solving paradigm. The discourse represents systems engineering as a methodology that is applicable to all kinds of problems in all spheres of human life – a universal method of addressing complex world problems.*" They, (Akeel & Bell, 2013), also state "*In summary, systems engineering as a 'meta-methodology' views the field as a universal problem-solving paradigm, superior to many, if not all, other approaches. It is applicable to all spheres of human life, including health, policing, security, and the environment. It originates in diverse disciplines including general systems theory, operations research and ancient philosophy, emphasizing systems thinking and holism.*" This statement is a vision where systems engineering may evolve.

2.2 Complex Problem Solving

Snowden and Boone (2007) propose the Cynefin framework classifying problems in Simple, Complicated, Complex, and Chaotic. Complex problems require a different style of management. They write, "*That is why, instead of attempting to impose a course of action, leaders must patiently allow the path forward to reveal itself. They need to probe first, then sense, and then respond*." There is a clear tension in following this path, during a crisis. However, the essence is that leaders are aware that, in complex problems, they need to probe and sense to find proper solutions; complex problems do not have any straightforward solutions. There are many methodologies extending systems engineering beyond the technical space. For instance, Newell and Proust (2012) propose Collaborative Conceptual Modelling to facilitate transdisciplinary understanding, communication, and reasoning. Checkland developed the Soft Systems Methodology (SSM). He reflects on it in (Checkland & Tsouvalis, 1997). One of the core means in SSM is CATWOE, which stands for Customers, Actors, Transformation process, Weltanschauung (Worldview), Owners, and Environmental constraints. This acronym shows the breadth of SSM, going much broader than technical aspects.

2.3 Systems Thinking

Systems thinking and many related types of thinking are recurring themes in many publications, see (Cabrera, 2006) (Bonnema & Broenink, 2016) for a good overview. Bonnema and Broenink (2016) elaborate several thinking tracks, among others *Dynamic Thinking*. Forrester in the 1950s introduced system dynamics, which is a forerunner of systems

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thinking and especially Dynamic Thinking. In a paper from 1971, Forrester (1971) makes the link to social systems. Senge (2006) calls systems thinking the fifth discipline, integrating the other disciplines. *Dynamic Thinking* is an example of the type of thinking that plays a crucial role in the climate crisis. Humans seem to have significant problems to understand and see the consequences of exponential growth (Schonger M, 2020) and of latency or hysteresis.

2.4 Systems of Systems Engineering

Dahmann and Baldwin (2008) propose various types of Systems of Systems (SoSs), from Virtual to Directed. These types have an increasing amount of cooperation or management in creating and operating the SoS. A fundamental challenge is that the SoS architect role (e.g. the role in the technical hierarchy) is implicit. Best case, e.g. in a Directed SoS, there is a person or team taking ownership. The SoSE field has overlap with other fields, such as complex problem solving. An example is the Complex Adaptive Systems Engineering (CASE) Methodology (White, 2016).

2.5 Decision Making and Politics

The formal owners of decision-making are the governments consisting of politicians. In politics, emotion plays a big role. For instance, (Crawford, 2000) discusses the role of emotion in global politics. Aristotle sees lawgiver as the main task of the politician (Miller, 2017). However, Aristotle asserts happiness as the main virtue to achieve. Aristotle provides a rather balanced view on politics. Miller (2017) states *"... he offers a remarkable synthesis of idealism and realpolitik unfolding in deep and thought-provoking discussions of perennial concerns of political philosophy: the role of human nature in politics, the relation of the individual to the state, the place of morality in politics, the theory of political justice, the rule of law, the analysis and evaluation of constitutions, the relevance of ideals to practical politics, the causes and cures of political change and revolution, and the importance of a morally educated citizenry*". Fundamental to the decision makers' role, and at the core of politicians, is that they cope with emotions and perceptions. As Westen (2007) states "*In politics, when reason and emotion collide, emotion invariably wins*." Thaler and Sunstein (2009) describe how people make choices, indicating how important emotions are in decision making. Lakoff elaborates this in (Lakoff, 2009).

2.6 PESTEL

We argue that societal problems are inherently complex (wicked/chaotic at times) with a multitude of aspects. All these aspects require specific expertise from far apart perspectives; Gupta (2013) proposes to use the Political, Economic, Social, Technical, Environmental, and Legal (PESTEL) perspectives.

3 A Framework for Power and Expert Roles

Fig. 1 shows a simple model of the interaction between experts, decision-makers (politicians, governments), and the executing parties. In this role model, the decision-makers integrate the expert and socio-political views as discussed later in the article.

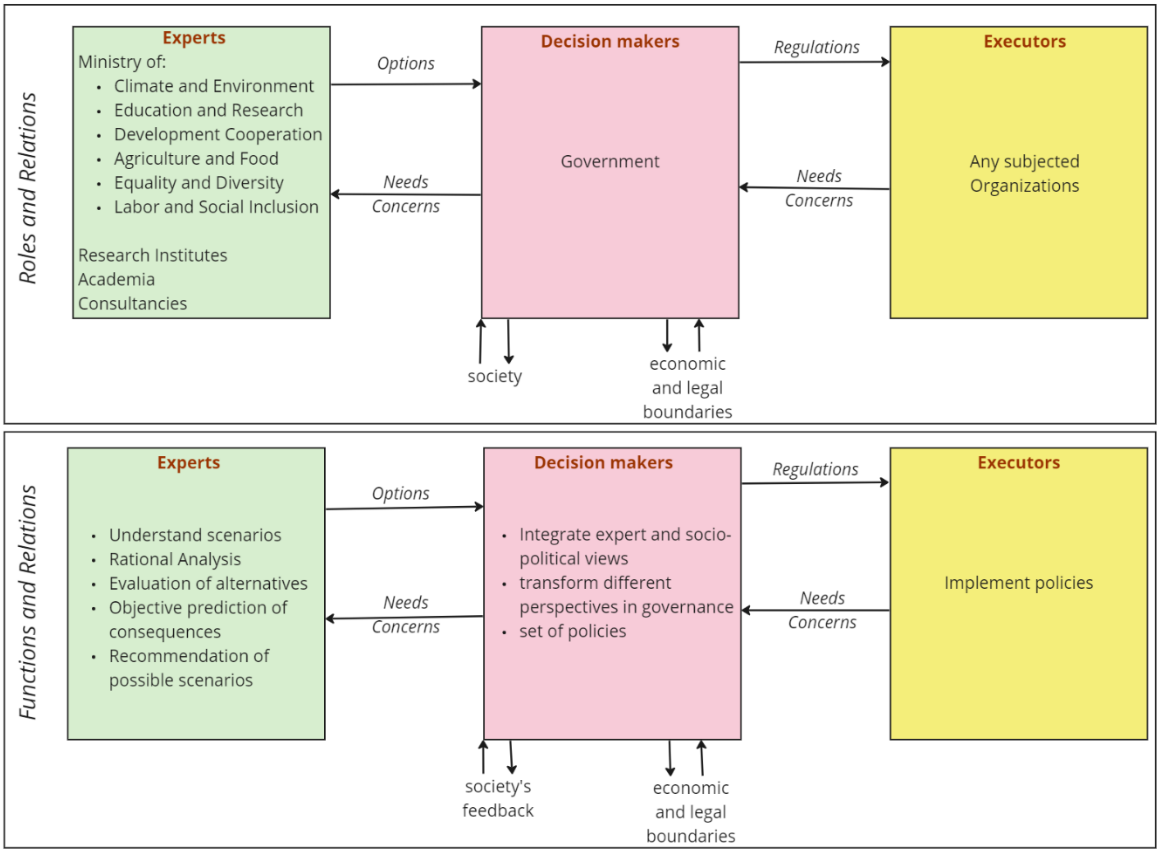

Fig. 1 Roles, functions and relations in the decision-making process

Fig. 2 elaborates this decision-making process, showing the many inputs to this process. The outputs of the decision-making are regulations and allocation of resources, and an approach to communicate the decision. In this figure, the various types of information are color-coded. In green, there is the factual and objective information, in orange uncertain, subjective, interest driven, or emotionally colored information. The fundamental challenge in the sustainable transition is decision making, while the available information is often uncomplete.

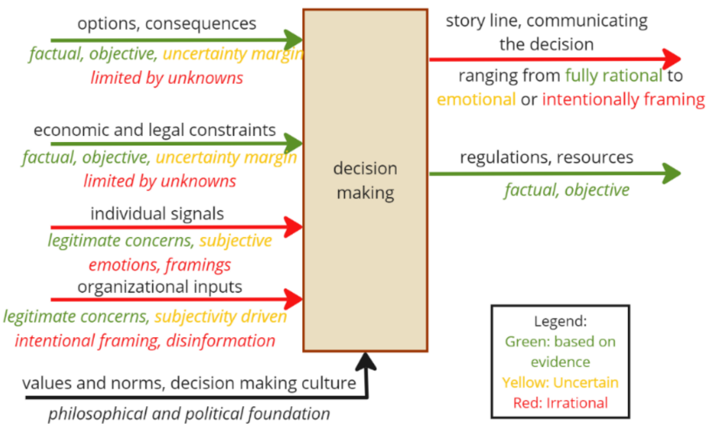

Fig. 2 Decision making inputs and outputs

Decision makers depend on the support of the population to function in their role with power. That makes the communication about the decisions essential. Such communication is a balancing act (and an expertise in itself). Experts tend to communicate factual and objectively, e.g. a rational approach. We observe that politicians connect to perceptions and emotions in their communication and in that way may be more effective in connecting to a significant part of the population. Fig. 3 shows a four quadrant model of decision-makers and experts, where the strength of one category stands opposite to the weaknesses of the other category. This representation shows how complementary both roles are.

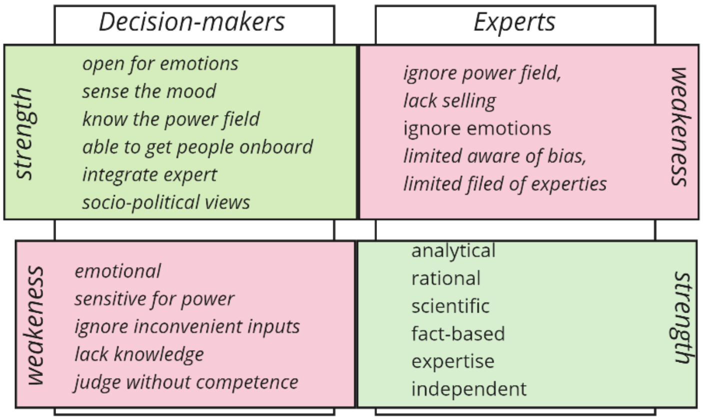

Fig. 3 Four Quadrant Model decision-makers and experts

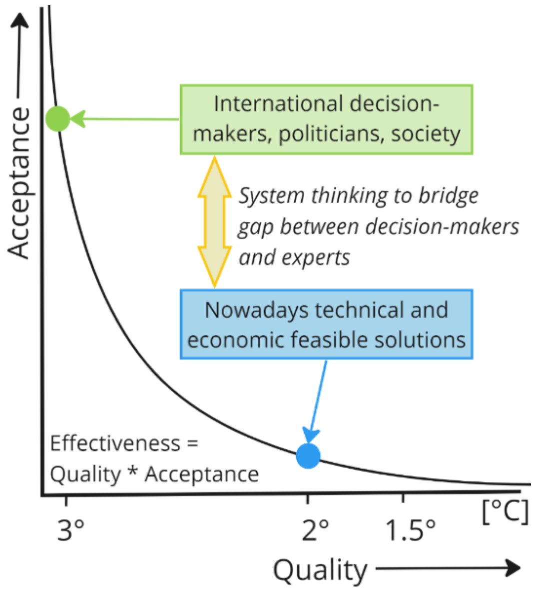

Fig. 4 Decision makers and experts on global warming

Decision-makers recognize the importance of achieving the sustainable transition by reducing of 3 degrees the global temperature by the end of the century. There is a high level of acceptance in recognizing the challenge of global warming. However, decision-makers do not have specific solutions for this challenge. On contrary, experts recognize in actionable and feasible solutions the possibility to overcome the global warming. Compared to decision-makers, the level of acceptance of these technical solutions is low. The combination of these two views may bring a required effective balance between the technical solutions and the acceptance of reducing global warming. System thinking may support the bridging between these two perspectives.

4 Bridging the Gap between Decision Makers and Experts: the Lesson from Industrial Practices

In this section, the industrial practices are taken as an example to show how systems thinking tools and methods can bridge the expectations of decision-makers and the technical solutions from experts. At first the authors shows how they envision the systems role at the various system scopes, from complicated constituent system, to complex system of systems, to the complex to chaotic societal systems.

4.1 Constituent Systems

Fig. 5 (1.14 in (Muller 2011)), shows that programs and projects typically have 3 main roles: Operational (Project Leader or Program Manager), Technical (Systems engineer, architect, lead designer, chief engineer or one of the many more variants), and Commercial (marketing, product, or sales manager). These 3 roles require specific competence to make their contribution. In small projects, these roles may be a single person, while in larger organizations a team may fulfil the role.

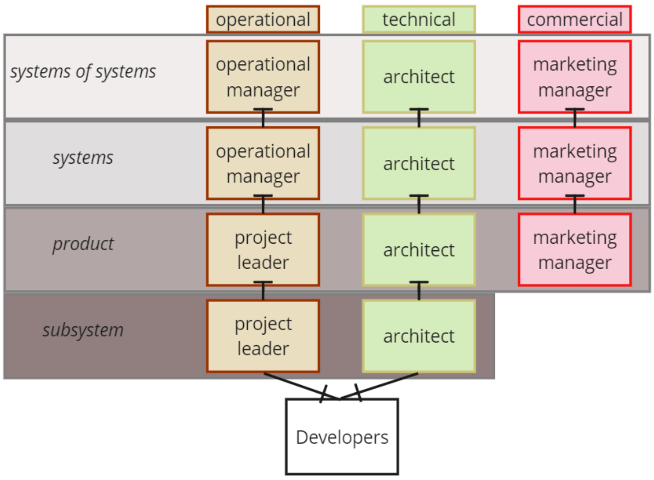

Fig. 5 The three main roles in product creation redrawn from p14 in (Muller, 2011)

We focus in this paper on the middle column labeled "technical". With the insights of today, the term "technical" relates to the smaller scope of a subsystem of product. When increasing the scope, the essence of this role is that it connects knowledge of the internals of the system of interest with knowledge of the context of that system of interest. This role has prime responsibility to ensure that we architect a system that is fit-for-purpose. This relates to terms as "integrating" (ensuring that parts work together in the system's environment), "holistic" or "big picture" (seeing the whole), The challenge with all these terms is to handle the paradox of losing meaning when abstracting. We abstract to gain insights that are more fundamental. However, at the same time, the abstraction may become so abstract that it becomes (near) impossible to use the abstraction.

A typical distribution of responsibility and power is that operational and commercial roles may have power, e.g. the mandate to make decisions with a program charter. The architect role requires influencing competence; architects work on the basis of authority and trust.

4.2 Systems of Systems

We argue that the term "technical" for the SoS architecting role becomes less and less appropriate. Integrating a SoS requires integration of all PESTEL perspectives. The essence of the architect's role is the integration of these aspects in a rational and objective way (as far as possible within the human limitations and biases). The Holy Grail for architects is a (SoS) solution that is fit-for-purpose and hence satisfies all stakeholders sufficiently.

We observe that in the SoSs as discussed in (Muller, 2016), most of the SoSs lack explicit architect roles. In other words, the SoS functionality and performance emerges with little pro-active architecting effort. We acknowledge that the complex nature of most SoSs puts limits to the degree of pro-activity that is effective. We assert that this extends to the architect, who has a leadership role too.

4.3 Societal Systems of Systems

When we zoom out further, we get societal SoSs like infrastructure systems (e.g. transportation, water management, and energy), regional systems (e.g. urban), application systems (e.g. health care or defense), or ecosystems, (e.g. supply chains). Many of these systems operate within a regulatory framework. Governments are major stakeholders. These systems may have a local scope (e.g. neighborhood or municipality), or a broader scope (regional, national, federal, or global).

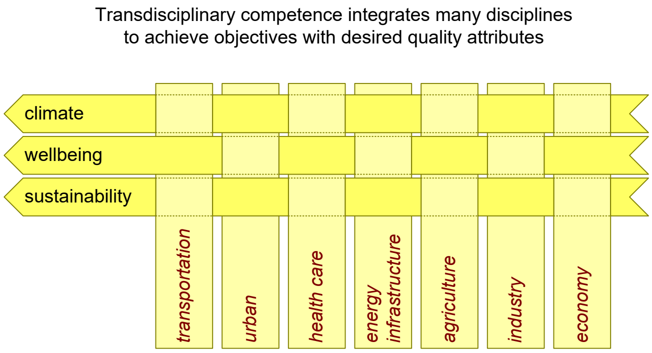

Fig. 6 Transdisciplinary competence integrating many expertise areas

In the last decades, the trend has been that organizations focus on core tasks, and outsource non-core tasks. In the Netherlands, the examples are the departments Ministry of Transport, Public Works, and Water Management and of Housing and Spatial Planning that have shifted most competence to commercial providers. Where in the previous century, these departments were in charge, had the overview, and were able to provide direction, we nowadays have a much more diffuse situation. The departments rely on consultancies and engineering firms to define requests for proposals and their evaluations. The consequence is that we see more specialization and more parties that are involved. This move may have brought improvements, e.g. less inbreeding, more openness, and more (local) expertise focus. However, at the same time, this fragmentation over multiple roles causes a loss of overview where a knowledgeable party that provides direction is missing.

The Netherlands is well known for its "polder culture", where many stakeholders in long meetings work towards a pragmatic consensus. An example is the climate agreement (anonymous, 2019), which does not have any clear authorship. It is the result of discussion in five "tables", where many interest groups met for years. This consensus process strives for acceptance, assuming that this will imply support in later phases.

From a systems perspective this climate agreement has sacrificed objectives (achieving the Paris agreement) for acceptance. The process to come to the agreement lacked expertise and systems overview. An example is the Regional Energy Strategy (RES). The RES is using an entirely bottom-up process to come to an offer of renewable energy contribution per municipality. The result of the RES process is beautiful looking, however, nearly information void documentation (Eindhoven, 2021). At the same time, this climate agreement makes assumptions about these contributions without clearly communicating them. There is nowhere a clear decomposition of contributions and targets. Such lack of decomposition makes it challenging for experts to offer technical solutions in line with the climate agreement. In this scenario, the RES's working group strives to provide clear visions for technical experts. Systems thinking and engineering tools has been observed to facilitate this gap between RES and technical experts (Elvebakk & Muller, 2020).

Dutch ministries struggle with large infrastructure projects (Van den Berg & Riemersma, 2021a). The analysis is that direction is missing; there is no director with overview and expertise. The root cause is that the ministry is following a doctrine that anything is outsourced, unless there is a compelling reason not to do so (van den Berg & Riemersma, 2021)b.

5 Discussion and Conclusions

The framework for power and expert roles has a weakness. The weakness is that experts reside in silos (Neely et al., 2019). The consequence is that options and consequences offered to the decision makers are limited to the silo of the experts in the team. Taking the example of the Covid-19 crisis, these experts were a subset of medical experts and directly related disciplines such as statisticians. Other experts, such as economic, social, or psychological, were missing. Also absent were behavior and communication experts, who may have helped in elaborating the communication strategy (Vermeer, 2023).

Fig. 6 visualizes the transdisciplinary competence that is required for the sustainability challenges. A climate that stays within the United Nations and European goals requires expertise across all sectors, e.g. transportation, urban life, industry, and many more. At the same time, we need to work on many other aspects of sustainability, such as clean water and air, and responsible use of resources. In addition, we must ensure a good standard of living for everyone, the wellbeing of the global population. The global challenges are so complex and so multi-faceted that this visualization of transdisciplinary competence is an oversimplification. As in engineering systems, the actual organization will be some kind of hierarchy, with a recursion of (mono-) disciplines and integrating disciplines. Each pillar in Fig. 6 is a complex transdisciplinary SoS, which will require a similar transdisciplinary competence.

Introduction of such transdisciplinary competence is not a silver bullet. We expect that adding this competence will help to tackle cross expertise tensions and trade-offs. However, constructive behavior and contribution of all experts, decision makers, and implementers is essential to achieve the objectives.

In this paper, we have used the societal and political developments around the sustainable transition to explore the role of experts in societal decision-making. We observe a few major roles: experts, who analyze and propose plans and actions, decision makers, for instance politicians with power, and implementers, who carry out the actions. We argue that this model has several tensions and a weakness in integrating insights across experts. We propose a generalized kind of systems engineering as transdisciplinary competence that facilitates integration across experts. Core of this transdisciplinary competence is Societal Systems Thinking. Research is needed to facilitate the integration across experts.

Competence in Social Systems Thinking may be used to better implement EU policies within the European Green Deal. These policies aim to improve the decision-making process by promoting specific interventions that are agile, evidence-based, inclusive and transparent as shown in (European Commission, 2021). The complexity underneath such policy-making process has to iteratively consider on one hand specific interventions that fit for a purpose and on the other an holistic (European Commission, 2021) being in line with the sustainable transition (Brudtland, 1987) and the industrial practices (Muller, 2011; Roustaei et al., 2024; Gaza et al., 2024; Giudici et al., 2023; Giudici et al., 2024). This may be done by acting specifically and observing the impact at large scale. This continuous and systemic zoom-in and zoom-out perspective, is the challenge to be faced to capture exhaustively the complexity related to the decision-making processes of such policies.

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