ANTIFRAGILITY IN ARCHITECTURE
Improving architecture with appropriate reaction to positive stressors

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Abstract
Unpredictable building and neighbourhood stressors provoke a constant request for adaptability, threatening fragile systems with collapse if they are incapable of reacting. Inspired by evolutionary epigenetic mechanisms, strategies are proposed that increase the adaptability of the built environment. In applying consciously developed, partially controllable positive stressors to existing neighbourhoods and buildings, reactive processes occur that redirect fragile systems towards robustness, resilience or onto antifragility.

An assessment model is developed for the implementation of positive stressors in neighbourhoods, buildings and processes increasing the adaptability of the built environment and generating collective benefit.

Keywords: Evolution, epigenetic, antifragility, cooperation, resilience, open architecture, adaptability.

INTRODUCTION

Our buildings and cities are under constant pressure to adapt and this makes our buildings fragile. This pressure is applied by stressors that lead to change in areas such as economy, society, ecology etc. and cannot be immediately neutralised by architectural concepts. Solutions that are being put forward today must therefore also be considered with a view to their expiry date. Sustainable architecture must be able to react to change by deploying different strategies. During the conception phase, the challenges of dealing with uncertainties and acknowledging the unknown *are fundamental* (Habraken 2000, p. 31) for planning strategies.

It is important to bear in mind that depending on the buildings' adaptability (resistance characteristics), it will be able to resist at different degrees and that stressors have different effects. Stressors can endanger the built system. For example, they can destroy fragile buildings and cities but they can also strengthen the system by inducing it to transform to a higher system state. This condition is *referred to as an antifragile state, the opposite of a fragile state*. Antifragile systems benefit (to some degree) from uncertainty, disorder and the unknown, *and the fragile is penalised by them* (Taleb 2012, p. 26). Understood in this sense, stressors are transmitters of information that can have a positive or negative activating function within the complex system of the built environment and its interacting sub-systems.

Applying stressors in the conception of antifragile strategies necessitates a systemic view of the built environment. The entire built environment consists not only of constructional and technical systems, but also includes living space with complex spatial, social and economic interaction and its comprehension calls for a systemic approach. A systemic view includes 'an understanding of the environment that assumes interacting systems with dynamic relationships to everyday reality' (Fezer 1980, p. 16). That is why an antifragile architecture tends to have a specific form characterised by high demands, which is a basic requirement for the aspired high human-environment interaction. It calls for action and creates a range of possibilities (in the sense of Robert Musil 1930) to simulate everyday lives, which contribute to the strengthening of the entire system.

'Activating natural relations' (Habraken 2000, p. 29) and acknowledging 'the unknown as a basis' (Habraken 2000, p. 31) for planning strategies are basic requirements for antifragile architecture. This therefore raises the question: How can we use the potential of stressors for a sustainable, durable architecture with a high level of human-environment interaction, or how can we make architecture more antifragile, meaning stronger than today?

ANTIFRAGILITY IN ARCHITECTURE

Analogue to evolutionary processes in nature, it is not the built structure alone that decides on success or failure of architecture, but the combination of the potential of the built structure and its activation through stressors.

In nature, evolution, rapid change and adaption processes take place following the principle of epigenetic imprinting. **Epigenetics** is a special field in biology. It explores which factors determine (long-term) gene activity and cell development and whether certain determinants are inherited by subsequent generations. If the change in gene activity is short-term and easily reversible, it is known as gene regulation. It is based on changes to the chromosomes when entire or sections of chromosomes are influenced in their activity. It is also known as epigenetic modification or epigenetic imprinting'. This does not, however, cause changes in the DNA sequence.

Two levels of information are involved in epigenetic processes: The first information level is the genome (DNA) itself, whilst the second decides on activating or deactivating specific DNA sequences, that is to say 'when and which contents from the genetic hand book of an organism are to be used' (Trageser 2013, p. 3). Epigenetic tags 'are chemical mechanisms that can express (activate or suppress) genes to different degrees. They do not change DNA' (Miller 2012, p. 58).

Figure 1: *Epigenetics Tags can activate or deactivate some DNA sequences*

The interplay between potential and activation generates changes and adaption to new requirements without modifying the genotype in long-term processes. 'To some extent, the human genotype resembles the hardware of a computer. It determines which resources are at the organism's disposal. But how these resources are to be utilised is first decided by the epigenetic programme because they determine when which genes are to be activated. As such, it resembles computer software.' (Kegel 2013, p. 13). As is the case with a computer, there is hardware in evolution that is not able to function on its own. Its potential is activated and it becomes meaningful only in combination with software.

Architecture follows similar principles: The first information level is the form itself. The clearly defined building that can be represented in reality. 'Reality corresponds to tangible space which can be documented with mathematical precision. Only actual facts are gathered and recorded. This involves the designability of the space, the material's properties (…). Sometimes designers disregard the experiencing of space. Subjective perception, value, moods etc. are not taken into consideration at this stage. As a result, it is an artificial, abstracted representation that is, however, of importance for planning and theoretical work' (Schwehr 2002, p. 30). It is an artificial product because it disregards the second level of information and has first to be activated by this. The second level of information is the programme of human-environment interaction. It enlivens the building and lets it function. Without it, architecture would be like a computer without software – reducing it to a mere sculpture without a function.

It is the interaction between these two information levels, that is, the hardware in combination with various software programmes of human-environment interaction which makes architecture a complex, planning task with no clear-cut solution. This also explains why, similar to identical twins, identical buildings acquire different biographies depending on the ongoing human-environment interaction by developing structural-spatial potential in different ways. The buildings themselves are not active – but their potential is activated by the programme, which in turn leads to other results, in other words to adaption processes.

Figure 2: *Twins with same genes but different characteristics because of influence of epigenetic mechanisms*

'*Identical twins are born with the same DNA, but can become surprisingly different as they grow older. A booming field called epigenetics is revealing how factors like stress and nutrition can cause this divergence by changing how individual genes behave.'* (Miller 2012, p. 58).

For family accommodation, different configurations will be activated or deactivated than for single accommodation. Some spatial areas or spatial configurations are activated, in other words, adopted in a similar manner, whilst others are adopted differently or not at all. In addition, a programme for family accommodation is, for example, laid out according to the family as well as between the individual members of the family.

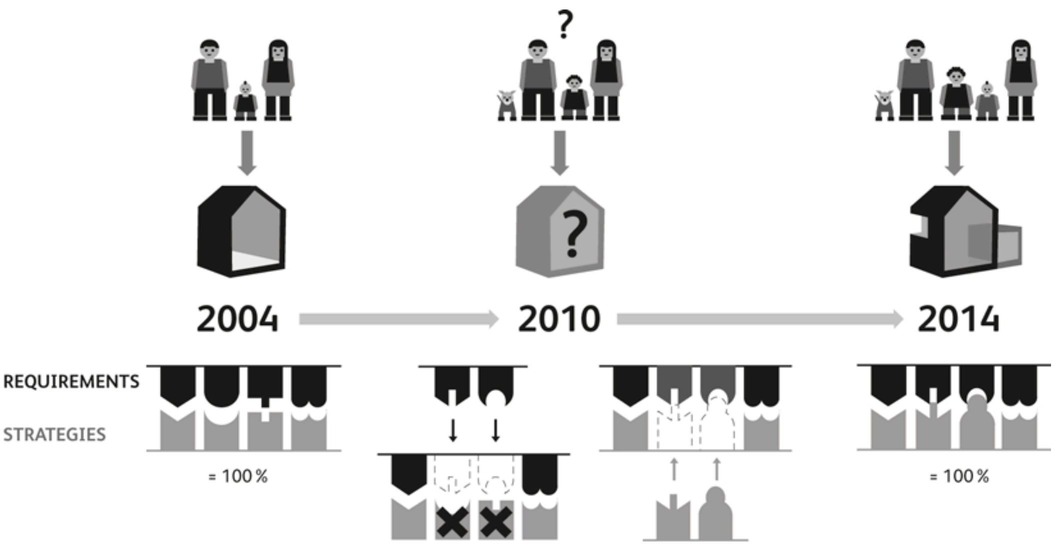

Figure 3*: Variation, Selection and Reproduction in the design process*

Although there are certain inter-subjective similarities, the programmes of human-environment interaction, as opposed to bought computer software, are always self rewritten with humans in mind, are highly flexible and adapt constantly to new requirements. Buildings that are to be sustainable over the longest possible time period must therefore draw their strengths from factors such as the uncertainty of an exact adoption, the unknown or possibly even from disorder.

'The extended disorder family (or cluster): 1. uncertainty; 2. variability; 3. imperfect, incomplete knowledge; 4. chance; 5. chaos; 6. instability, volatility; 7. disorder; 8. entropy; 9. time; 10. the unknown; 11. randomness; 12. turmoil; 13. stressor; 14. error; 15. dispersion of outcomes; 16. ignorance;' (Taleb 2012, p. 26).

Reflecting on Taleb's disorder family, we have to ask ourselves whether we can even plan sustainable architecture if the aspired high level of human-environment interaction is encompassed by issues such as uncertainty, randomness, probability, disorder, and what to do in a world *(and that we also should plan it – comment by schwehr, plagaro)* which we do not understand, a world with unseen elements and properties, the random and the complex; that is, decision making under opacity, in other words, inscrutable (Taleb 2012, p. 26).

Bruno Latour argues in a similar way when he demands: 'What we need is to turn this process around: ...the problem with buildings is that they look desperately static. It seems almost impossible to grasp them as movement, as flight, as a series of transformations. Everybody knows... and especially architects know ... that a building is not a static object but a moving project: It also ages after completion, is altered by its users, changes because of everything that happens on the inside and on the outside and is often renovated, falsified or converted beyond recognition' (Latour 2008, p. 81).

So what could strategies look like that take on a dynamic overall view and even benefit and extract added value from this unknown, uncertainty and disorder, in the sense of John Habraken's *the Unknown as a Basis* (Habraken 2000, p. 31)? How can we succeed in having programmes at our disposal that activate available structural-spatial potential and have a positive influence on our built environment?

POSITIVE STRESSORS INFLUENCE ARCHITECTURE AND ACTIVATE INTERACTIONS

Activating human-environment interaction is an information-carrying process that occurs on different levels. 'Like genetic systems in evolution, buildings can also, only fulfil their function in close cooperation with their environment' according to Bauer (Bauer 2008) and because of this, are significantly influenced by environmental factors. Changes in environmental factors trigger stressors that constantly pressurise our buildings to adapt. We distinguish between stressors at neighbourhood level (e.g. location – a new road in the neighbourhood), at the process level (e.g. use – the desire for more space), and at a construction level (e.g. building element – normal wear and tear – windows not sealed). The stressors are often combined and overlap (Schwehr & Plagaro Cowee 2011).

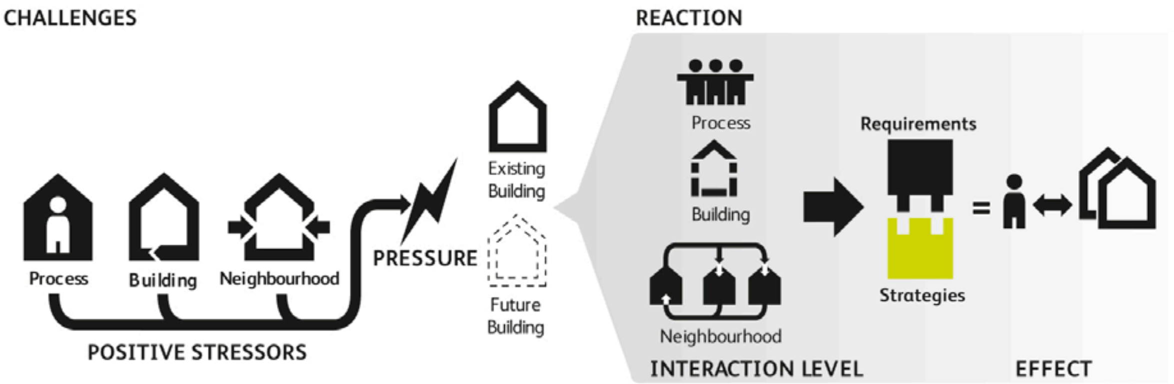

Figure 4: *Stressors on Processes, Buildings and Neighbourhoods, requiring reaction and strategies for improving their acceptance.*

Requirements on the built structure are formulated on all of these levels. If these requirements change, the entire system of the built environment, i.e. our buildings or suburbs, becomes stressed since certain components can no longer fulfil their function or meet the new requirements. If the pressure to adapt is greater than the building's resistance, the building becomes stressed and its entire system is endangered. The pressure to adapt, in other words, information on the necessity to adapt, is transferred by stressors. Stressors can either endanger, maintain or strengthen the system and are therefore indicators for the adaptability of the building. To measure the effect of stressors and its consequences, the following definition on the adaptability of buildings and suburbs applies:

Adaptability in architecture refers to 'the ability of a building to react within a short time to new circumstances with minimal effort and at justifiable cost. Adaptability is therefore an indicator of flexibility and of long-term value retention' (Plagaro Cowee & Schwehr 2012, p. 14).

1.) **Stressors destroying the system**
The pressure to adapt is greater than the building's potential to adapt and endangers the entire system.

For example, demolition / loss of value – the effort required to renovate the building exceeds the renovation potential.

2.) **Stressors maintaining the system**
The pressure to adapt triggers faults that can be appropriately remedied and the entire system functions again.

For example, complete renovation and value retention – a complete renovation strategy has adapted the building to the new requirements.

3.) **Stressors strengthening or transforming the system**
The pressure to adapt has transformed the entire system into a higher-value functioning system.

For example by using synergies, densifying or increasing the value in the course of a complete renovation, additional living space has been created for a greater number of occupants.

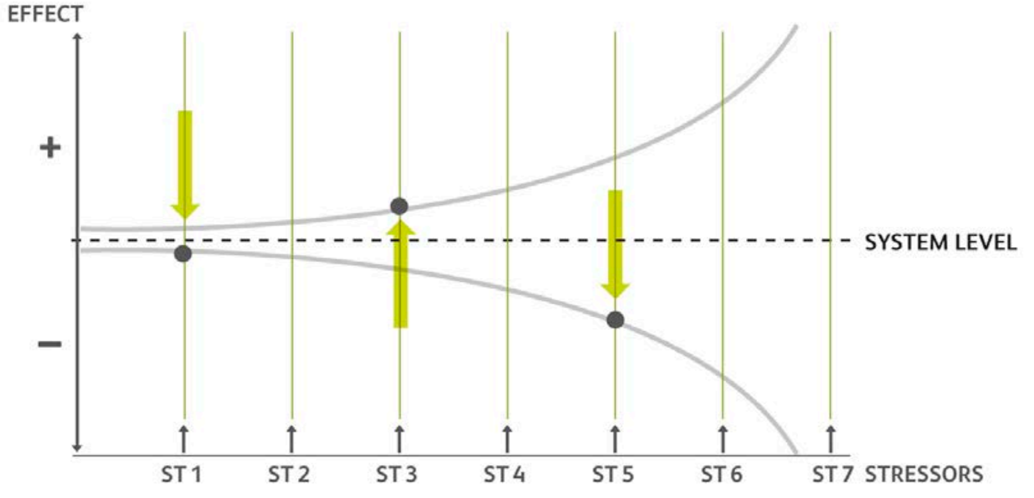

Figure 5: *Positive or negative effects of stressors in systems*

Understood in this sense, stressors are transmitters of information between the complex system of the built environment and its interacting sub systems. They can have a positive or negative effect on the system and are responsible for the form and intensity of human-environment interaction.

ANTIFRAGILITY MAKES ARCHITECTURE MORE SUSTAINABLE

The different effects of stressors are reflected in the 'degree of resistance' assessment model. This model represents different system states of the built environment on a scale related to its adaptability. The assessment scale aims at answering the following questions: What would happen to the built system if it were subjected to a specific pressure to adapt? Where, how and which stressors have an effect on the system? As such, the assessment scale is not unlike a stress test that is to be applied when evaluating planning measures.

In line with the effect of the system stressors introduced previously *destroying–maintaining–strengthening* and in taking Taleb's triad *antifragile–robust–fragile* into consideration (Taleb 2012, p. 34), processes, buildings or neighbourhoods are grouped into four categories. These categories are not entirely separable and overlap in certain areas.

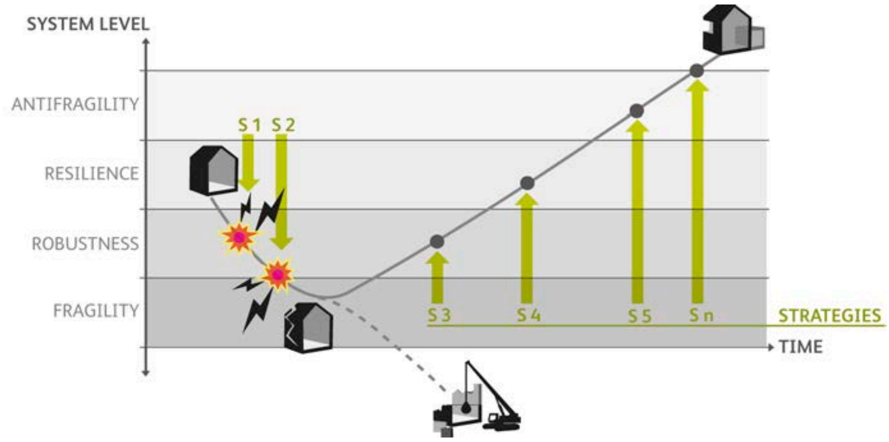

Figure 6: *Degree of resistance to adaptability. Improving architecture with appropriate reaction to positive stressors.*

The assessment scale ranges from *fragile* to *antifragile* states. The criteria between these two poles on the x-axis are *robust* and *resilient*. The y-axis shows the functionality and system state in view of the adaptability potential.

Fragile
The disturbance causes the built system to break down. It is unable to react to the necessary adaptions with a reasonable amount of effort, and to adapt its system state to the new requirements. It may come as a surprise that buildings or parts of building are classified as being fragile, although they usually appear to be robust, unlike glass that has to be placed in a cupboard for protection or wrapped in cotton wool during transport. But solidity has little to do with fitness and we ask ourselves how many building with a reasonable amount of effort can be made 'fit' again?

'(...) that fragility – a term that had been lacking a technical definition – could be expressed as what does not like volatility, and that what does not like volatility does not like randomness, uncertainty, disorder, errors, stressors, etc. Think of anything fragile, say, objects in your living room such as the glass frame, the television set, or, even better, the china in the cupboards. If you label them "fragile", then you necessarily want them to be left alone in peace, quiet, order, and predictability. A fragile object would not possibly benefit from an earthquake or the visit of your hyperactive nephew. Further, everything that does not like volatility does not like stressors, harm, chaos, events, disorder, "unforeseen" consequences, uncertainty, and, critically, time' (Taleb 2012, p. 25).

Robust

The stressors do not lead to recognisable adaption pressure of the built system and do not affect its functionality. However, unlike resilient or antifragile systems, a robust system cannot react to changes. It behaves like the proverbial thick skin of an elephant. Disturbances rebound. Until the point where the disturbance becomes so strong ('the threshold' – (Walker et al. 2004)) that the system crashes. The robust is '(…) neither harmed nor helped by volatility and disorder' (Taleb 2012, p. 31). 'The "robust" here in the middle column is not equivalent to Aristotle’s "golden middle" in the way that, say, generosity is the middle between profligacy and stinginess—it can be, but it is not necessarily so. And (…) it is hard to consider robustness as always desirable—to quote Nietzsche, one can die from being immortal' (Taleb 2012, p. 35).

Resilient

A resilient system absorbs disturbance and reorganises itself so that its function is retained and it can continue without restriction.

'Resilience is the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedback' (Walker et al. 2004). Adaptability is defined as 'the capacity of actors in a system to influence resilience' (Walker et al. 2004). Assigned in this way, neither fragile nor robust systems can react with reasonable effort to change and adaption processes. *There are three aspects of resilience which can apply to a whole system or the subsystem that make it up* (Walker et al. 2004):

1.) Latitude: the maxim amount a system can be changed before losing its ability to recover (before crossing a threshold, which, if breached, makes recovery difficult or impossible).
2.) Resistance: the ease or difficulty of changing the system; how 'resistant' it is to being changed.
3.) Precariousness: how close the current state of the system is to a limit or 'threshold'.

The characteristics listed above guide the criteria in evaluating various influencing factors of stressors that will be explained in detail in the following chapter.

Antifragile

Following the principle of hormesis where disturbances strengthen the system, the antifragile system is made stronger and takes the system to a higher level. This condition is *referred to as an antifragile state, the opposite of a fragile state*. Antifragile systems benefit (to some degree) from uncertainty, disorder and the unknown*, and the fragile is penalised by them* (Taleb 2012, p. 26). '*Antifragility likes volatility et al. It also likes time.* (Taleb 2012, p 25). The antifragile loves randomness and uncertainty, which also means – crucially – a love of errors, a certain class of errors. Antifragility has a singular property of allowing us to deal with the unknown, to do things without understanding them – and do them well.' (Taleb 2012, p. 17).

The possibility of a system to transform is defined by Walker et al. as '*the capacity to create a fundamentally new system when ecological, economic, or social (including political)* *conditions make the existing system untenable'*. This process of improvement (Taleb 2012, p.34) is an emergent process and leads to development of the old system into a new one.

Weak points exist in all system states. Even the antifragile cannot indefinitely resist the pressure to adapt as it continuously transforms into new systems. There are also fragile, robust, resilient or antifragile elements within a built structure. When working with the assessment model, it is therefore important to bear in mind that a structure *per se* is neither fragile nor antifragile. It may well be that *'some parts on the inside of a system may be required to be fragile in order to make the system antifragile as a result* (Taleb 2012, p. 81) or: *Could it be that the issue of fragility or antifragility is one of several characters of a structure?'* (Taleb 2012, p. 81). Crucial factors are the points targeted by the disturbances, the intensity of the stressors and their effect on the built system.

A MODEL FOR SYSTEMS TO GAIN ROBUSTNESS, RESILIENCE AND ANTIFRAGILITY

These considerations lead to the conviction that processes, buildings or neighbourhoods can be improved by strategies that make them robust, resilient or antifragile. Such strategies can be implemented during or after the planning process.

The model identifies the kind of stressors acting at different levels of process, building and neighbourhood. It diagnoses the problems and the characteristics (P1, P2, P3, Pn) of fragile systems brought about by such stressors. The model offers the appropriate strategies (S1, S2, S3, Sn) that can contribute to making systems robust, resilient or antifragile. The resulting projects can be described, evaluated and subordinated to their new properties related to robustness, resilience or antifragility.

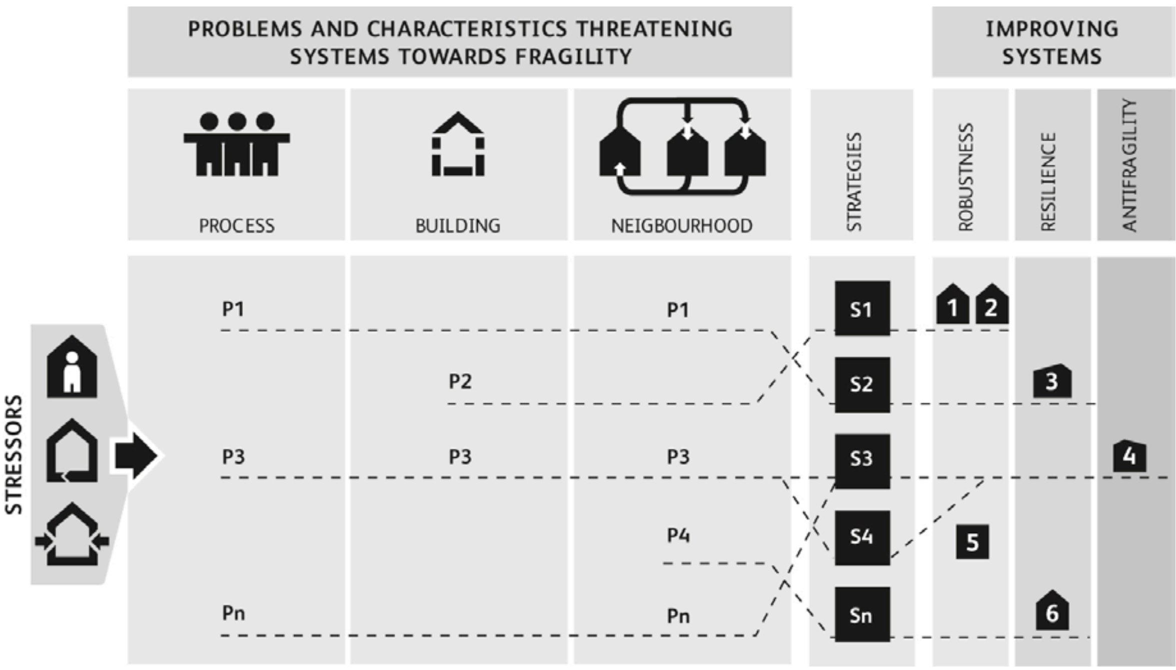

Figure 7: *Improving fragile systems by reacting to problems caused by stressors, applying strategies and gaining in robustness, resilience or antifragility*

Application of the assessment model

Problems or characteristics which make systems fragile

Application of the assessment model is explained below using specifically chosen exemplary problems in architecture. The identified fragile mechanisms are of a general nature and can be viewed at different levels of the process, the building or the neighbourhood. They are not clearly separable and may occur simultaneously.

Our aim is to be able to diagnose systems that tend toward the precarious fields of fragility by recognizing a number of characteristics that are known to cause such tendencies. Identifying such problems or characteristics will help to take appropriate measures to redirect the tendency. Below, we list some examples of actual tendencies with specific, current architectural challenges.

Problem: Renovation

- Focussing on a certain aspect (e.g. energy) | The system border is often limited to the building and not further | Other relevant aspects (e.g. overall appearance of the locality, rental price index) are faded out. Renovation becomes a purely technical matter. And in doing so, every building should be able to fulfil all (sometimes incompatible) requirements. This leads to an inappropriate use of technology | It results in closed technical systems that do not use synergies with other buildings and only react to further developments with great difficulty. |

Problem: Urban Sprawl

- Increase in land use due to single-family homes (SFHs) | It leads to urban sprawl, waste of valuable land resources, and an increase in commuter traffic | Although at the same time, the majority of building plots have unused potential suitable for higher-density quality development | The desire for one's own home is dictated by financial aspects and is often realised with architecturally questionable and poor quality (small rooms, cheap materials, unskilled craftsmen etc.) | Such SFHs are often isolated buildings which do not contribute to a sustainable town development |

Problem: Office Planning

- Cost pressure on individual workplaces leads to open space structures | Individual workplaces are under pressure. 'My workplace has to be able to do everything' (a place to concentrate; for virtual communication; for meetings; storage space etc.) | Employees often have no opportunity to control social interaction and interpersonal distance, which leads to a significant loss of comfort | Seemingly plausible economic reasons for desk sharing can also lead employees to a loss of identification with their company. At the same time, open space structures do not have the necessary spatial variety to meet the demands of the new working environment (developing team innovation; more collaboration instead of pure administration; meetings held more often etc.) |

In summary, it is possible to identify the following problems or characteristics that make systems fragile. The list provides indications of a fragile tendency in architecture and is based on our own experiences as construction and research architects as well as many analyses of buildings and discussions with experts. It is a collection of typical phenomena, by which we have consciously not abstained from the local level of consideration and is therefore not to be understood as being complete.

P1	*Top-down oriented* Urban planning or building construction continues to have the tendency of being top-down oriented with decisions being made by a few selected members, without including all the actors who will be involved in the overall scheme. The more a design scheme refrains from involving all actors and the narrower the circle of decision makers, the more vulnerable the system will be to bottom-up dysfunctions, complaints.
P2	*High repetition without variation* High repetition without variation fails to cover the diverse necessities of a complex society. Modular and repetitive post-war reallocation schemes were efficient solutions at a precise moment of history, derived from an urgency to provide quick and cheap accommodation to a large homeless population. In the same way as repetitive speculation housing schemes, such developments fail to adapt to the necessities (stressors) of a merging society with additional requirements. No scenario planning was used to anticipate failure.
P3	*'Perfectly' planned system with trouble-free environment* System creators have the tendency of longing for perfection, disregarding the fate of constant stressors, change and its consequences. Those considered as a trouble-free environment have more difficulty to react to sudden change. The trouble-free period (and therefore the period in which the system seems to be 'perfect') is in fact a slow process towards fragility. It can be said that the perfection of a system can only be provisional; provisional until change comes and alters the conditions of stability. There is no way of learning and improving for future in a flawless system.
P4	*Specialisation, Optimisation* We understand specialisation and optimisation as the end phase of a development process which includes the risk of not being able to confront the unpredictable or being unable to react to change. Specialisation and optimisation often lead to rigidity and are the result of prioritising some aspects at the cost of others whilst loosing the holistic approach.
P5	*Artificiality* Artificiality can be understood as a stressor that provokes even more artificiality as a reaction in the system it is acting on. The further our models are from mother nature, the higher the complexity and artificiality of the problem solving. High-tech buildings with complex control systems can be fragile when unexpected failure occurs.
P6	*Lack of fault tolerance* Considering that the only constant is change (Heraclitus of Ephesus, 535–475 BC), to design a system for constancy is inducing failure in advance. A system that has no margin for absorbing failure, risks collapse because of its ineptitude for adaptability.
P7	*Lack of holistic approach* In many cases, systems are isolated within their narrow borders without being part of other systems or interacting with them. Many other important system-relevant aspects are faded out when finding solutions and therefore not taken into consideration.

Strategies and mechanisms that contribute to redirect a system towards robustness, resilience or antifragility

Having identified problems and characteristics that make a system fragile, what could be the source of antifragility in the built environment? Which mechanisms should be promoted in normal practice that could enhance robustness, resilience or antifragility? In reaction to the mentioned problems inherent to fragile systems, we list a number of strategies below that have the ultimate objective of increasing human-environment interaction. We understand it to be an open list that may be completed.

P1 S	*Top-down oriented* **Bottom-up ǀ Participation ǀ Cooperation ǀ Resonance ǀ User evaluated ǀ Interdisciplinarity** In reaction to top-down oriented systems, bottom-up oriented systems consider constant cooperation and resonance from the outside in, and the inside out. Examples of this are the interrelation of sub-systems within the building, interaction between the building and its users or its location, collaboration in interdisciplinary planning teams etc. This approach leads to a systematic understanding of a building in which various tangible and intangible sub-systems are in constant interaction with each other (Schwehr & Plagaro Cowee 2011).
P2 S	*High repetition without variation* **Variation ǀ Scenarios** Working with scenarios is rarely used in everyday planning practice. Scenarios are often based on mathematical models that are difficult to place and too abstract for planning sustainable buildings and suburbs. Only a few companies such as Ove Arup, the leading global interdisciplinary consulting engineers, work with scenarios, systematically record the consequences for users, buildings and suburbs, (drivers of change) and enable specific planning statements. 'Design thinking' offers a methodological approach on how to face the future. (Schwehr 2011).
P3 S	*'Perfectly' planned system with trouble-free environment* **Occasional fragility ǀ Translating adversity into an advantage ǀ Allowing reserve for the unpredictable** For specific cases in cities like Hamburg, Lucerne and Olten, the *Living Shell* project (Sturm & Schwehr, 2013) translates the demand of densification (adversity) into the opportunity of improving the quality of neighbourhoods through the refurbishment of façades and activation of lofts (advantage). Value retention, densification as well as improved living standards are achieved. Urban sprawl is avoided.
P4 S	*Specialisation, Optimisation* **Allowing reserve for the unpredictable ǀ Avoidance of unsustainable optimisation ǀ Avoidance of unilateral specialisation ǀ Adaptability** Excess optimisation and specialisation are end phases of a refinement process in which properties such as variety, adaptability, reserves, multi-functionality and redundancy have often been suppressed. Such properties are actually those which can make a system more resistant to change and therefore more antifragile.

P5 S	*Artificiality* **Life-cycle awareness ǀ Working with nature ǀ Passive architecture** The more buildings or neighbourhoods work with nature in a passive way, the less the need for artificial support and means. Energy efficient neighbourhoods, for example, use the potential of buildings which produce more energy than they consume (Power Station House) as well as other ecological oriented strategies (Minergie-P, interaction with urban network, mechanical engineering, social aspects, etc.) (Schwehr, 2009).
P6 S	*Lack of Fault tolerance* **System oriented ǀ Occasional fragility ǀ Life-cycle awareness ǀ Epigenetic manoeuvres ǀ Adaptability** Strategies can be applied in order to upgrade existing structures and profit from new uses. The *Indoor Units* project (Schwehr & Bürgin 2012, p. 43-45) researches how to profit from the unused potential (occasional fragility) of existing industrial buildings. A modular indoor-unit is developed which allows permanent or provisional operation. A life-cycle awareness of the building is considered. Epigenetic manoeuvres allow us to activate new uses. The new dynamic revitalises the area and improves its image. Additional occupation of ground is avoided thus contributing to ecology. A participative policy for the new uses is promoted. Neighbourhoods are adapted to new requirements.
P7 S	*Lack of holistic approach* **Using synergies ǀ Seeking cooperation ǀ Promoting collective over individual benefit** Using synergies and cooperation can substantially increase the quality of a system. For example, the project *Wohnen im Alter in ländlichen Gemeinden im Kanton Zürich* with the problematic of elderly people's housing quality in the countryside. The Canton of Zürich supports small municipalities in increasing the offer and quality of housing for elderly. The following strategies amplifying the intervention radius are implemented: Synergies with nearby facilities, cooperation with institutions, promoting multi-generational apartments, choosing strategic locations, including social aspects (services, networks) (Mayer et al. 2012).

CASE STUDIES

Case studies at the three different levels (process, building and neighbourhood) are presented to illustrate how fragile systems can gain in robustness, resilience or antifragility through the application of precise strategies.

Case study 1 - Process level

Project/Subject:

Office in Motion - Workplace of the future. Need of transforming/adapting office space to new requirements or uses
(Amstutz & Schwehr 2012)

Problem or characteristic of a fragile system:

The way of working has changed. A homogeneous offer of office space does not respond to the manifold need of the market; costs pressure optimises and standardises space; difficulty to combine common space and privacy; challenge of dealing with distance/closeness of workplaces.

Diagnosis:

Fragile system that leads to empty unused spaces. Employees don't identify with their workplace.

Strategies:

The *Office in Motion* project (Amstutz & Schwehr 2012) implements a number of strategies to increase the quality of the office environment: increase of user's identification with the workplace, providing a controlled freedom; from workplace to taskplace, offering a variety of spaces (to meet, create, concentrate, communicate, socialise, for isolation and celebration); user-friendly technology is used in new office space to communicate and enlarge the concept of office space; promotion of reserve for unpredictable use; high adaptability of spaces for use-flexibility; user-evaluated spaces.

Improvement/Achievement:

Resilient spaces capable of being rearranged when confronted with new stressors. High user acceptance.

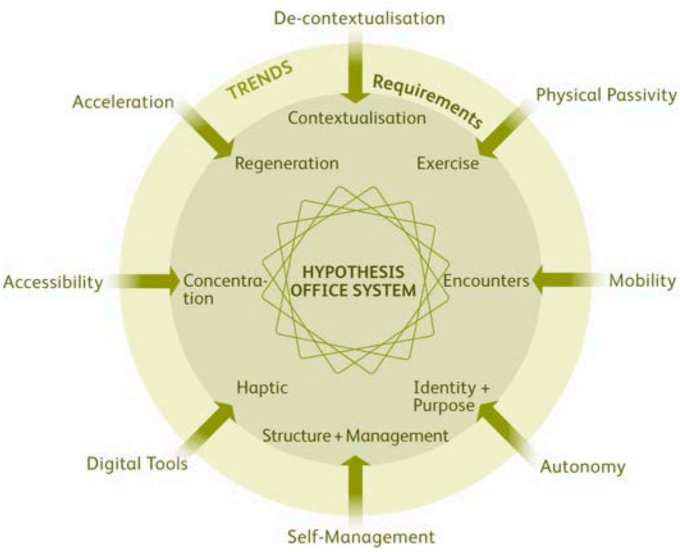

Figure 8: *Scheme integrating the complexity of office space requirements*

Case study 2 - Building level
Project/Subject:
SAN-STRAT Refurbishment Strategies
(Schwehr & Ehrbar 2012)

Problem or characteristic of a fragile system:
In Switzerland, one in four apartments (i.e. 890,0000 apartments) are in an apartment block built between the 40s and 70s. Although the majority are not (currently) listed buildings, there is growing interest in their preservation. Clash of public interest between reducing energy consumption and conserving architectural culture often leads to undesirable results so that renovation of these residential buildings and estates are either severely delayed or not carried out at all.

Diagnosis:
Case A: The residential estate is not renovated. The apartment vacancy rate increases. Buildings are not renovated and fall into disrepair. Case B: Renovation is carried out solely from an energy conservation point of view. Architectural heritage is lost in the process.

Strategies:
Systemic evaluation. Workshops with everyone involved. Residential buildings and estates are viewed holistically and their entire life cycle is taken into consideration, additive and reversible measures with minor levels of intervention are deployed, and everyone (owners, energy and conservation planners) is involved in developing carefully considered and mutually agreed renovation strategies.

Improvement/Achievement:
Heating energy requirements of residential buildings and estates built between the 40s and 70s can be reduced by around 50% without compromising on architectural culture. Holistic renovation strategies are relatively easy to implement and are to a large extent able to meet heating demands with renewable energy.

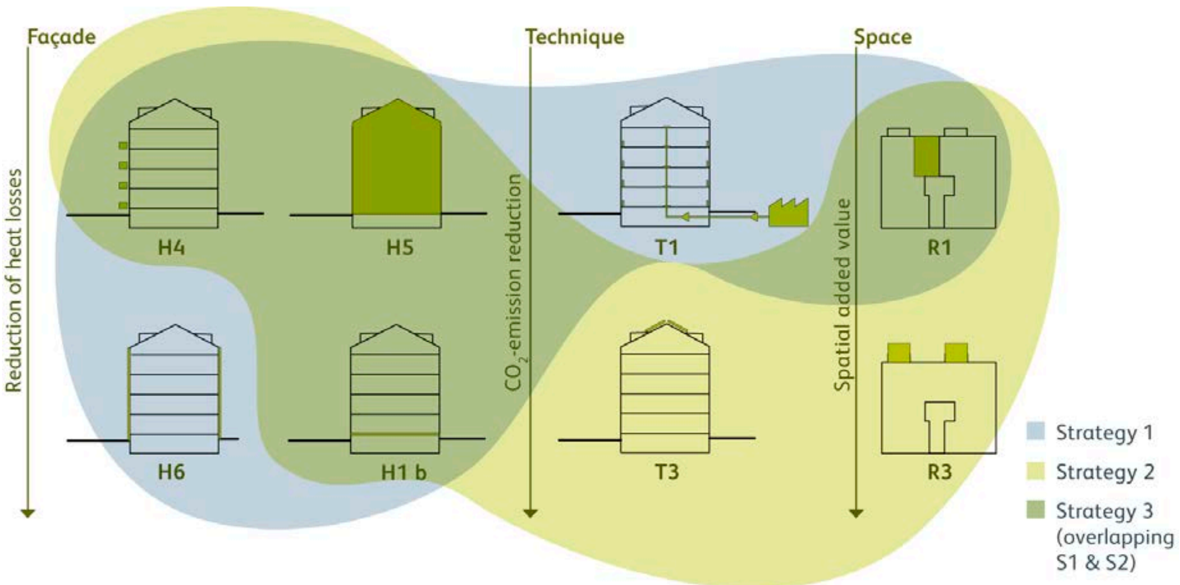

Figure 9: *The planning tools, coordination matrix and cloud graphic developed in this project can be used in the strategic planning phase in order to solve complex issues in refurbishment schemes.*

Case study 3 – Neighbourhood level
Project/Subject:
Transferring the qualities of single-family homes (SFH) to multi-family housing (MFH)
(Meier & Sturm & Schwehr 2012)

Problem or characteristic:
Undesired urban sprawl through single-family houses; homogeneity of urban outskirts; top-down originated developments; high repetition of housing without variation; system limitation to 'house'; high optimisation of means; artificiality; closed planned system; 'perfectly planned future'.

Diagnosis:
Fragile and unsustainable system

Strategies:
Transfer of SFH qualities to MFH; introduction of variety (e.g. multi-generational apartments); controlled freedom to allow identity (definition of spaces of own design and decision); promotion of collective rather than individual benefit (developments are concentrated in high density areas in order to prevent urban sprawl); increase of adaptability in order to be able to react to changing stressors (new requirements of occupants, changing laws); epigenetic manoeuvres (e.g. addition or suppression of rooms to adapt to new family structure).

Improvement/Achievement:
MFH neighbourhoods appear attractive and gain acceptance. MFH schemes can be multiplied and successfully host a higher number of population yielding collective benefit. MFHs are not only good, but have even more advantages than SFHs. The system is antifragile. The more MFHs, the better the overall system.

Figure 10: *Example of a multifamily house with single-family house qualities*

Case study 4 – Integral case
Project/Subject:
Housing cooperative Kalkbreite, Zürich, *www.anleitung.kalkbreite.net.*
Architects: Müller Sigrist

Problem and challenges:
To avoid speculation and achieve collective values, a great effort is made by housing cooperatives in Switzerland to encourage common objectives such as solidarity, democracy, transparency, cooperation, subsidiarity, being locally rooted, as well as ecological and energy awareness. The Kalkbreite Housing Cooperative is offered as the third alternative between ownership and rental. It was founded in Zürich in order to establish a social and ecological pioneering urban development.

Diagnosis:
The project, which was situated on a challenging site which had to cover the tram parking halls, has been accomplished in 2014. Cooperation between communities, neighbourhoods and the town council was backed by the following strategies.

Strategies:
Process level – Establishing low interest rates for land procurement, involving all actors in the early planning and decision making stages, providing childcare during community meetings, solidarity financial trust, opening the system to the neighbourhoods and friends, sustainability monitoring, establishing degrees and strategies of conflict management, down-top decision making, strong communication platform, etc.

Building level - Innovative and experimental apartment types to cover lifelong changes (living with children, large family, cluster apartments (for young and elderly)), living & working apartments, studio rental (as "granny apartment" or for guests), rental of meeting rooms, collective offices, hobby workshop and music rehearsal room, rental, event kitchen and dining room, community freezer, laundry facilities, indoor and outdoor shared community spaces and services (front desk assistant, library, sauna, etc.).

Neighbourhood level – The following services are offered for indoor and outdoor users: cinema, "Bed without Breakfast" hostel, medical practice, café, take away, shops, roof gardens and courtyard. Neighbours and friends are also welcome to community meetings.

Improvement/Achievement:
Holistic approach combining living, work and culture; high acceptance and community life; this is a scheme which considered all possible scenarios except, maybe, the unpredictable.

Figure 11: *An experimental and innovative housing "city part"*

CONCLUSION

The core element of this document is the thesis that analogue to epigenetic processes in evolution, architecture has to be activated before it can become effective. Two levels of information play a key role in this process: The first level of information is the building as a static object ('hardware', e.g. materials, spatial concepts etc.). It includes the structural-spatial potential. The second is a higher level of information which functions as the 'software' (immaterial aspects, acceptance etc.). Their programmes activate the structural-spatial potential of the object and are responsible for the human-environment interaction.

'In the same way, a building has to start in the immeasurable aura and go through the measurable to be accomplished. It is the only way you can build, the only way you can get it into being is through the measurable. You must follow the laws but in the end when the building becomes part of living it evokes immeasurable qualities. The design involving quantities of brick, method of construction, engineering is over and the spirit of its existence takes over. (…) This interplay is the constant excitement of architecture' (Kahn, 1960).

When planning architecture, if one succeeds in consciously taking the interplay between these information levels into consideration, fragile (object oriented) states can be transformed into antifragile states (human-environment interaction oriented). Since the aspired level of high human-environment interaction assumes specific consideration of use, building and context and already considers the *Unknown as a Basis* as a principle in design (Habraken, 1961, p.31). As soon as the building is seen as an isolated (material) object without taking its (immaterial) human-environment interaction into account, the process leads to an undue reduction of complex interrelations and unsatisfactory evaluations of the architectural effect increasing the risk of fragility. This method can be used to classify system states in architecture according to their fragility, and develop strategies for sustainable architecture in relation to antifragility.

One of the main challenges for applying such strategies is the lack of influence in private developments that prioritises individual benefit above the collective. Current highly optimised processes in which time and cost, of construction and planning, are reduced to insensible extremes, do not allow the implementation of additional strategies which could redirect systems towards antifragility.

One of the most recent successfully completed schemes is the Kalkbreite housing cooperative (http://www.kalkbreite.net/): an exemplary process of high participatory cooperation between members of two former cooperatives and the city of Zürich; an innovative and creative scheme designed by architects Müller Sigrist. It is as a complex mechanism of shared spaces, dwellings and services which can adapt to needs of actual and future users, with a strong interaction with the neighbourhood.

Working with possible development scenarios and model variants in view of the aspired human-environment interaction is of great importance. 'Activating natural relations' is only made possible through interaction (Habraken, 1961, p.29). It is fundamental for developing sustainable architecture.

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