# System Descriptions: System Patterns


## Abstract

This document contains abstract system descriptions that form a set of system patterns that can be used in various types of systems.

The following system patterns are included in this document:

- A Control System (basic feedback system)
- An Adaptive Control System.
- A System of Systems.
- A Sampled Data Control System.
- A Stochastic System.
- A Viable System.

Other system patterns may be added as they are identified.

Link to the System Patterns PDF

Link to the Top System Classifications PDF


## Author and Version

Bruce McNaughton, Version 0.0, 05-July-2019

## Contents



## Revision History

V0.0 20-June-2019 Initial Draft

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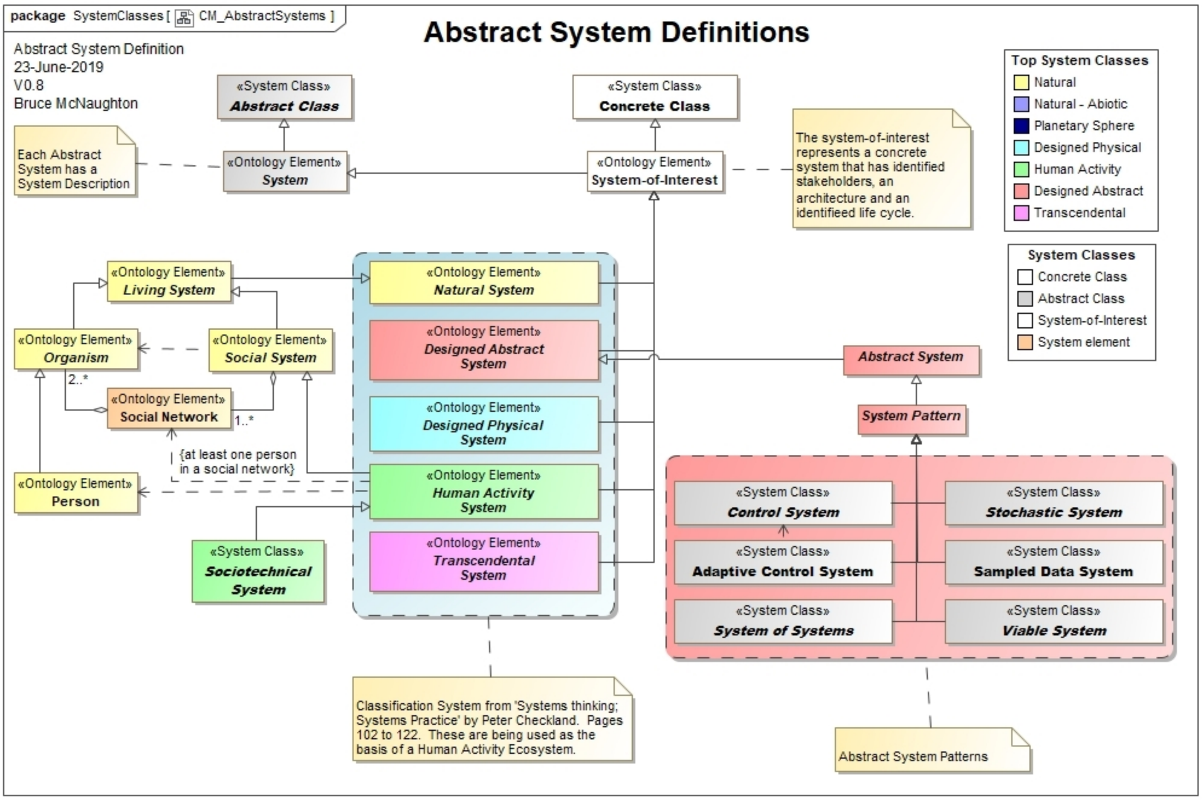


# Abstract System: Control System

## View: System Name and Class

**Name:** Control System

**Based on:** System (Abstract)

**Abstract System:** This system has been identified as an abstract system that cannot be implemented directly. The abstract system establishes a shared pattern of characteristics that any system can use to describe its unique characteristics when referenced in the 'based on' list above. These references are described using a generalization association in UML.

The Control System pattern is also known as a **regulator**.

## View: System Purpose

A control system provides a way to manage a set of system properties within a target control range. The system makes use of feedback elements to sense and respond to changes in the outputs or results and take appropriate corrective action to maintain the desired state of the outputs. Typical control systems are:

- Thermostat for a room
- Statistical Process Control for a production process.
- Temperature in an oven

The control system is a type of regulatory system. These concepts are used in the Viable System Model (VSM).

System properties of the system are generally regulated as part of a control system.

## View: System Properties

### Systemic Measurable Variables

The emergent properties created or used through the interaction of the elements. This includes both desired and undesired.

The following are typical variables for a control system:

- **Reference Input**: Command for specific action or output setting
- **Feedback Signal:** representation of the output at a given time
- **Controlled output**: the actual output value from the System.
- **Actuating Signal**: difference between the reference and the feedback signal

NOTE: the names vary depending upon the control system model used.

### Systemic Capabilities or Functions

The capabilities of the control system are to provide a regulation capability of the Controlled Output variable. These functions are generally embodied in a combination of control elements and plant.

### System States

The various defined states that the system-of-interest can be in.

- **Architectural states:** Generally defined in the enabling system
- **Transformational States** Generally defined in an enabling or adaptive system associated with the control system.
- **Operational States**: These are typically initialising, Reference input change, stable, shutting down.

## View: System Stakeholders and Concerns

Identify the key stakeholders and their concerns for this system. Each stakeholder is identified and their concerns and interests are identified. The list below is an example. Each system will have a specific set of stakeholders and concerns.

- **Owner / manager**: Is this a sustainable / stable system? will our customers be satisfied?
- **System Architect**: Are the system concepts understood? Are the system properties sufficient to deliver the objectives? Is the feedback mechanism sufficient to maintain / track outputs / outcomes?
- **People in the environment** Will the people confirm or use the benefits of the system?
- **Change Agents** Do we have the ability to change the system in a planned way?
- **People who are part of the system** Will I understand my contribution to the system?

## View: System Environment (Context)

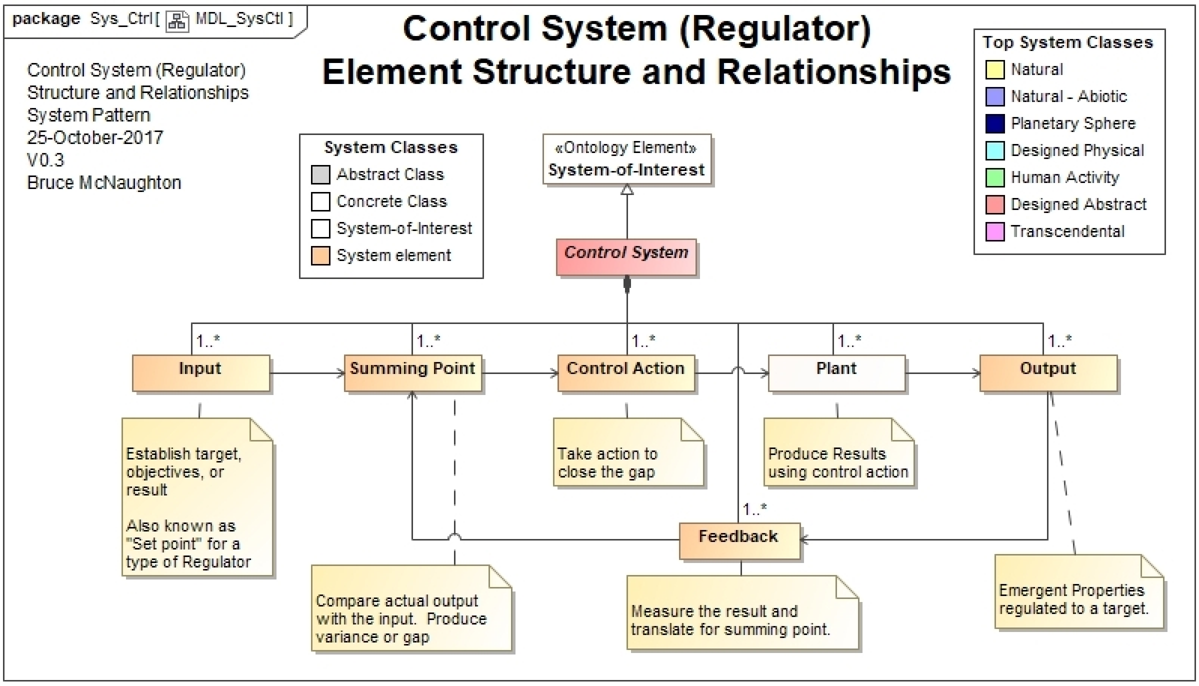
The environment and the potential impacts on the system-of-interest.

this section includes

- **Transactional**: Ensure the delivery of the controlled output or respond to problems
- **External** Possible disruptions due to external factors: temperature, environment (e.g. flood, etc.).
- **Regulator** : Extra requirements or unexpected (magnitude or frequency) of changes to the reference inputs.

## View: System Structure (Pattern of Organization)

The system-of-interest consists of a number of identified system elements. .These are typically shown in a 'system breakdown structure'.




Each of the system elements may be defined in this section.

Note: some of the system elements may be systems their own right. These systems may become a system-of-interest and may be described using a Link to the System Description Template.

The relationships or interactions are also shown in the diagram above and shows the way the system elements inter-act.

In this picture, the lines between the system elements are defined. These may represent formal interfaces, such as, communication interactions, protocols, information flows, Contracts, etc. In this section, the relationships may be defined.

The following approaches also have a similar pattern to the control system:

- P-D-C-A cycle Plan - Do - Check - Act
- SSM Learning Cycle (Page A55: from "A Thirty Year Retrospective)"
- Typical problem solving approaches: Six Sigma, Diagnose, Identify Solutions, Implement,
- Typical life cycle for ISO 15288: consisting of many feedback loops.

## View: System Behavior (Structural Changes)

### Configuration / Scenario:

Describes any configuration / scenario attributes for a specific system-of-interest. This may not be appropriate for all system descriptions (e.g. patterns or abstract systems).

### Cyclical (Repeating / Regular) Processes

The processes to translate requirements and architecture into an operational system. An example of a set of life cycle processes can be found in ISO 15288.

NOTE: The Shannon Sampling Theorem applies to the dynamic behavior of the control system. If the sampling rate is too slow, the control system may become unstable or unable to control or regulate the process. The sampling rate is generally at least twice the underlying base frequency of the system being controlled.

## Development Life Cycle Processes

This area describes the life cycle for creating, using or releasing a system. This allows for the replication of an existing system into other areas.

# Abstract System: Adaptive Control System

## View: System Name and Class

**Name:** Adaptive Control System

**Based on:** System (Abstract)

**Abstract System:** This system has been identified as an abstract system that cannot be implemented directly. The abstract system establishes a shared pattern of characteristics that any system can use to describe its unique characteristics when referenced in the 'based on' list above. These references are described using a generalization association in UML.

## View: System Purpose

An Adaptive Control System provides a way to manage a set of system properties within a target control range when the environment is changing. The system makes use of feedback elements to sense and respond to changes in the outputs or results and take appropriate corrective action to maintain the desired state of the outputs. Typical control systems are:

- Performance Management.
- Automatic Pilot Landing Systems in an Aircraft

The control system is a type of regulatory system. These concepts are used in the Viable System Model (VSM).

System properties of the system are generally regulated as part of a control system.

## View: System Properties

### Systemic Measurable Variables

The emergent properties created or used through the interaction of the elements. This includes both desired and undesired.

The following are typical variables for a control system:

- **Reference Input**: Command for specific action or output setting
- **Feedback Signal:** representation of the output at a given time
- **Controlled output**: the actual output value from the System.
- **Actuating Signal**: difference between the reference and the feedback signal

NOTE: the names vary depending upon the control system model used.

### Systemic Capabilities or Functions

The capabilities of the control system are to provide a regulation capability of the Controlled Output variable. These functions are generally embodied in a combination of control elements and plant.

### System States

The various defined states that the system-of-interest can be in.

- **Architectural states:** Generally defined in the enabling system
- **Transformational States** Generally defined in an enabling or adaptive system associated with the control system.
- **Operational States**: These are typically initialising, Reference input change, stable, shutting down.

## View: System Stakeholders and Concerns

Identify the key stakeholders and their concerns for this system. Each stakeholder is identified and their concerns and interests are identified. The list below is an example. Each system will have a specific set of stakeholders and concerns.

- **Owner / manager**: Is this a sustainable / stable system? will our customers be satisfied?
- **System Architect**: Are the system concepts understood? Are the system properties sufficient to deliver the objectives? Is the feedback mechanism sufficient to maintain / track outputs / outcomes?
- **People in the environment** Will the people confirm or use the benefits of the system?
- **Change Agents** Do we have the ability to change the system in a planned way?
- **People who are part of the system** Will I understand my contribution to the system?

## View: System Environment (Context)

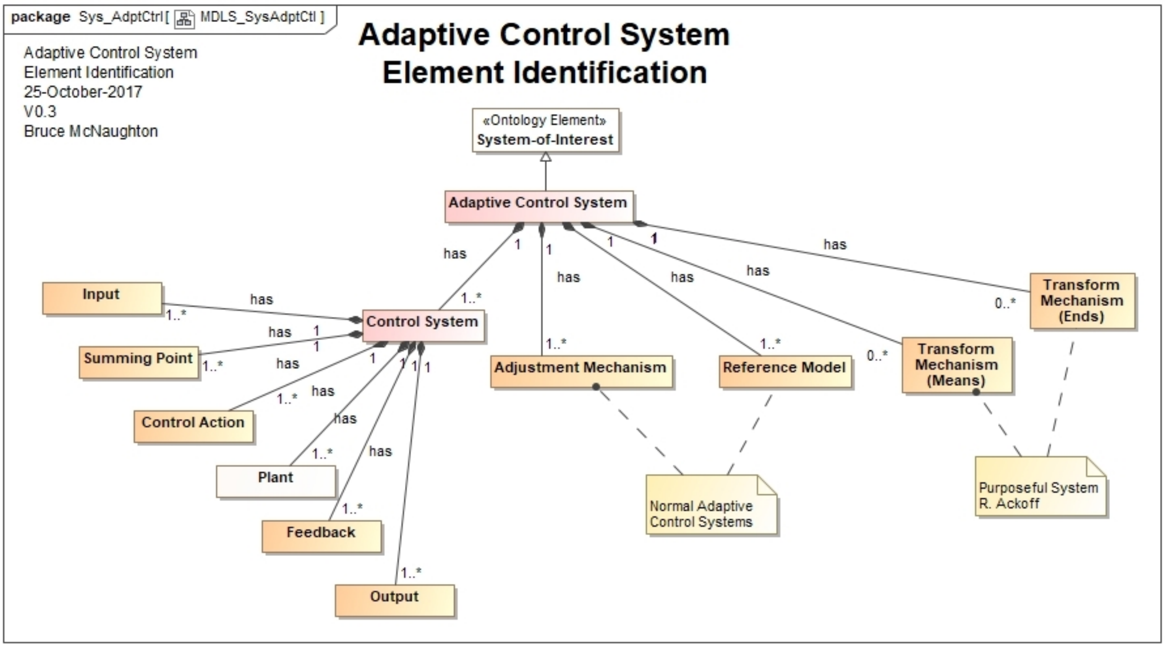
The environment and the potential impacts on the system-of-interest.

this section includes

- **Transactional**: Ensure the delivery of the controlled output or respond to problems
- **External** Possible disruptions due to external factors: temperature, environment (e.g. flood, etc.).
- **Regulator** : Extra requirements or unexpected (magnitude or frequency) of changes to the reference inputs.

## View: System Structure (Pattern of Organization)

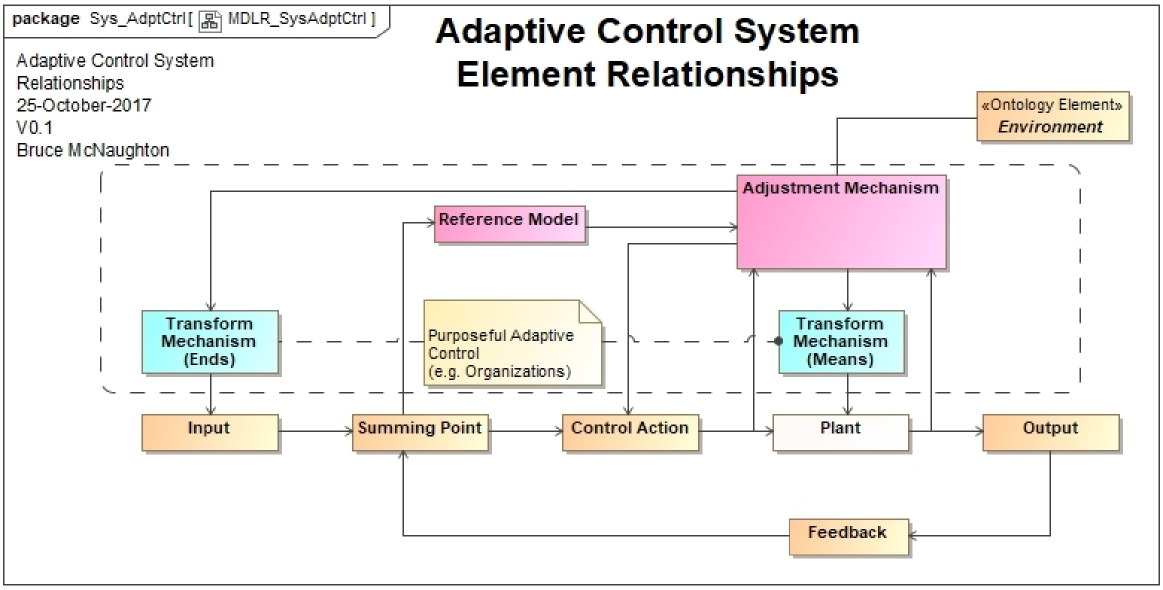
The system-of-interest consists of a number of identified system elements. .These are typically shown in a 'system breakdown structure'.




Note: The adaptive control system builds on the basic control system model.

Note: some of the system elements may be systems their own right. These systems may become a system-of-interest and may be described using a Link to the System Description Template.

The relationships or interactions are defined in this section. The picture included in this section shows the way the system elements interact.




In this picture, the lines between the system elements are defined. These may represent formal interfaces, such as, communication interactions, protocols, information flows, Contracts, etc. In this section, the relationships may be defined.

The following approaches also have a similar pattern to the adaptive control system:

- The Viable System based upon the Viable System Model
- The Adaptation and Learning Cycle, Russell Ackoff.

## View: System Behavior (Structural Changes)

### Configuration / Scenario:

Describes any configuration / scenario attributes for a specific system-of-interest. This may not be appropriate for all system descriptions (e.g. patterns or abstract systems).

### Cyclical (Repeating / Regular) Processes

The processes to translate requirements and architecture into an operational system. An example of a set of life cycle processes can be found in ISO 15288.

NOTE: The Shannon Sampling Theorem applies to the dynamic behavior of the control system. If the sampling rate is too slow, the control system may become unstable or unable to control or regulate the process. The sampling rate is generally at least twice the underlying base frequency of the system being controlled.

### Development Life Cycle Processes

This area describes the life cycle for creating, using or releasing a system. The Adaptive Control System is created through a normal life cycle model such as ISO 15288:2015. There are various models that can be used to shape the adaptive control systems for the enterprise. These are shown in the Viable System system description

# Abstract System: System of Systems

## View: System Name and Class

**Name:** System of Systems

**Based on:** System (Abstract)

**Abstract System:** This system has been identified as an abstract system that cannot be implemented directly. The abstract system establishes a shared pattern of characteristics that any system can use to describe its unique characteristics when referenced in the 'based on' list above. These references are described using a generalization association in UML.

## View: System Purpose

The System of Systems is very similar to the basic system structure. There are a number of conditions that the system elements of the System of Systems must meet.

See Wikipedia System of Systems

See SEBoK System of Systems

For example, an industry can be considered a System of Systems. This would include a number of independent enterprises to participate in this SoS.

There are other areas that may be considered a System of Systems:

- smart cities
- Information Systems (The Internet or IoT).

> The remainder of this system description is the same as a system. This description will evolve as more work is done highlighting some of the variations in approach.
>
> Appendix G of ISO 15288:2015 also provides a good description of a System of Systems.

The primary **purpose** or **reason for being** for the **system-of-interest** is included in this section. There may be a number of purpose statements that may be based upon the estakeholders identified below.

The purpose statement is for the whole System-of-Interest situated in its environment.

## View: System Properties

### Systemic Measurable Variables

The measurable variables for the system-of-interest provide the means of determining performance, quality, response times, and effectiveness of change. The variable description included in this specification provides the key and top level variables for this system-of-interest. These variables provide meaning for stakeholders externally and internally. A full definition of these system variables contains the following:

- Units and definition of the scale.
- How and when the variable is measured
- Key markers on the scale: Minimum acceptable, Objective (goal), Target, Stretch, etc.

### Systemic Capabilities or Functions

The capabilities of the system-of-interest or the individual functions that transform inputs to desired results are identified in this section. There may be a number of capabilities or functions this system-of-interest provides. Some of these are desired and expected and some may be undesired and unexpected.

### System States

There may be a number of types of states that may be defined in this section. The various defined states that the system-of-interest can be in.

- **Architectural states**: These are states that align to a specific version of the Architecture Description for a system. For example, there may be:
  - a Current Architecture Description,
  - a number of intermediate Architecture Descriptions (representing key operational points)
  - and the Target Architecture Description for a revision.
- **Transformational States**: These transformational states tend to align to key stages in the development process. These are typically

    - Designed
    - Built
    - Integrated
    - Released
    - Operational
- **Operational States**: Operational States relate to the type of outcomes that are expected. Some may relate to the delivery of products and services while others relate to specific operational states and objectives. These states are identified in the capabilities and processes used during operation. These operational states are designed and implemented into the way the operational system performs.

## View: System Stakeholders and Concerns

Identify the key stakeholders and their concerns for this system-of-interest. Each stakeholder is identified and their concerns and interests are identified. The list below is an example. Each system-of-interest will have a specific set of stakeholders and concerns.

- **Owner / manager**: Is this a sustainable / stable system? will our customers be satisfied?
- **System Architect**: Are the system concepts understood? Are the system properties sufficient to deliver the objectives?
- **People in the environment** Will the people confirm or use the benefits of the system?
- **Change Agents** Do we have the ability to change the system in a planned way?
- **People who are part of the system** Will I understand my contribution to the system?

## View: System Environment (Context)

The system-of-interest interacts with the environment as an open system. This section describes some of the key interactions and the relationship to the various properties of the system.

The environment and the potential impacts on the system-of-interest.

this section includes

- **Transactional**: This typically relates to an exchange of goods or services with a customer or user. Typically the system-of-interest may have influence without control.
- **Contextual**: This type of environment cannot be influenced or controlled but may have an impact on the system. This includes natural disasters, wars, etc.
- **Regulatory**: Regulatory requirements constrain the actions of the system-of-interest and may require specific types of interaction with external regulators.

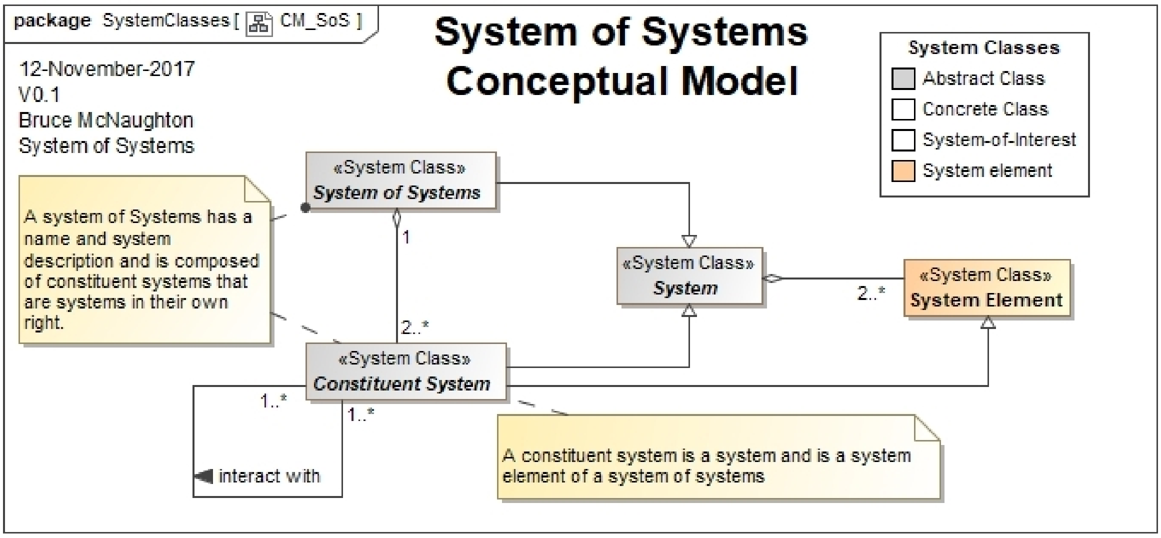
The system-of-interest is situated in its environment as an open system. The environment that can influence the purpose and properties as a whole of the system-of-interest are identified here. These can be:

- the physical environment (weather, earthquakes, rivers, etc.)
- local communities
- transportation
- the government
- competition
- education.
- etc.

For systems that can be described in a similar way to Figure 2 Page 12 of ISO 15288:2015, each of the systems identified in the hierarchy will participate as a system element and have the containing system serve as an environment. This provides a fractal model for systems within an overall system-of-interest.

## View: System Structure (Pattern of Organization)

The following diagram shows the relationship of a System of Systems to the System Conceptual Model.




This model of a System of Systems that the main elements of this type of system are constituent systems. These constituent systems form a network of interacting systems. These systems are generally autonomous and independently managed and aligned to create a result that is more than any one of the constituent systems. These constituent systems are both a system element of a system and a system in their own right.

Note: These constituent systems may become a separate system-of-interest and may be described using a Link to the System Description Template.

The relationships are defined in this section. The System Behavior section describes the interactions and processes that create the emergent properties of the System of Systems.

## View: System Behavior (Structural Changes)

### Configuration / Scenario:

Describes any configuration / scenario attributes for a specific system-of-interest. This may not be appropriate for all system descriptions (e.g. patterns or abstract systems).

### Cyclical (Repeating / Regular) Processes

Some of the systems involved in the creation, of the system-of-interest, may need to create, change or transform system elements within the system-of-interest. These life cycles relate to the system elements that make up the system-of-interest. This also provides a structure for the various state transitions for the system-of-interest (e.g. architectural, transformational and operational).

### Development Life Cycle Processes

These life cycle elements describe the overall approach to create, use and release / retire a system-of-interest. This is the normal life cycle of the system-of-interest. This section identifies the systems involved in the elements of this life cycle. These may be external systems or internal systems that create this system-of-interest

# Abstract System: Sampled Data System

## View: System Name and Class

**Name:** Sampled Data System

**Based on:** Control System, Adaptive Control System

**Abstract System:** This system has been identified as an abstract system that cannot be implemented directly. The abstract system establishes a shared pattern of characteristics that any system can use to describe its unique characteristics when referenced in the 'based on' list above. These references are described using a generalization association in UML.

## View: System Purpose

The Sampled Data System is a type of control system that includes sampling points at a specific frequency rather than a continuous variable.

The sampling is common in organizations and computer systems where samples are taken at a specific frequency and the signals are used to construct the state of the variables.

This type of system uses Shannon's sampling theorem to accurately reconstruct the underlying variables. If the frequency is too slow an accurate representation of the signal is not possible and the stability of the system may be compromised.

The basic structure of the system is the same; however, there are different types of system elements that are responsible for sampling of the variables.

A control system provides a way to manage a set of system properties within a target control range. The system makes use of feedback elements to sense and respond to changes in the outputs or results and take appropriate corrective action to maintain the desired state of the outputs. Typical control systems are:

- Thermostat for a room
- Statistical Process Control for a production process.
- Temperature in an oven

The control system is a type of regulatory system. These concepts are used in the Viable System Model (VSM).

Emergent properties of the system are generally regulated as part of a control system.

## View: System Properties

### Systemic Measurable Variables

The emergent properties created or used through the interaction of the elements. This includes both desired and undesired.

The following are typical variables for a control system:

- **Reference Input**: Command for specific action or output setting
- **Feedback Signal:** representation of the output at a given time
- **Controlled output**: the actual output value from the System.
- **Actuating Signal**: difference between the reference and the feedback signal

NOTE: the names vary depending upon the control system model used.

### Systemic Capabilities or Functions

The capabilities of the control system are to provide a regulation capability of the Controlled Output variable. These functions are generally embodied in a combination of control elements and plant.

### System States

The various defined states that the system-of-interest can be in.

- **Architectural states:** Generally defined in the enabling system
- **Transformational States** Generally defined in an enabling or adaptive system associated with the control system.
- **Operational States**: These are typically initialising, Reference input change, stable, shutting down.

## View: System Stakeholders and Concerns

Identify the key stakeholders and their concerns for this system. Each stakeholder is identified and their concerns and interests are identified. The list below is an example. Each system will have a specific set of stakeholders and concerns.

- **Owner / manager**: Is this a sustainable / stable system? will our customers be satisfied?
- **System Architect**: Are the system concepts understood? Are the system properties sufficient to deliver the objectives? Is the feedback mechanism sufficient to maintain / track outputs / outcomes?
- **People in the environment** Will the people confirm or use the benefits of the system?
- **Change Agents** Do we have the ability to change the system in a planned way?
- **People who are part of the system** Will I understand my contribution to the system?

## View: System Environment (Context)

The environment and the potential impacts on the system-of-interest.

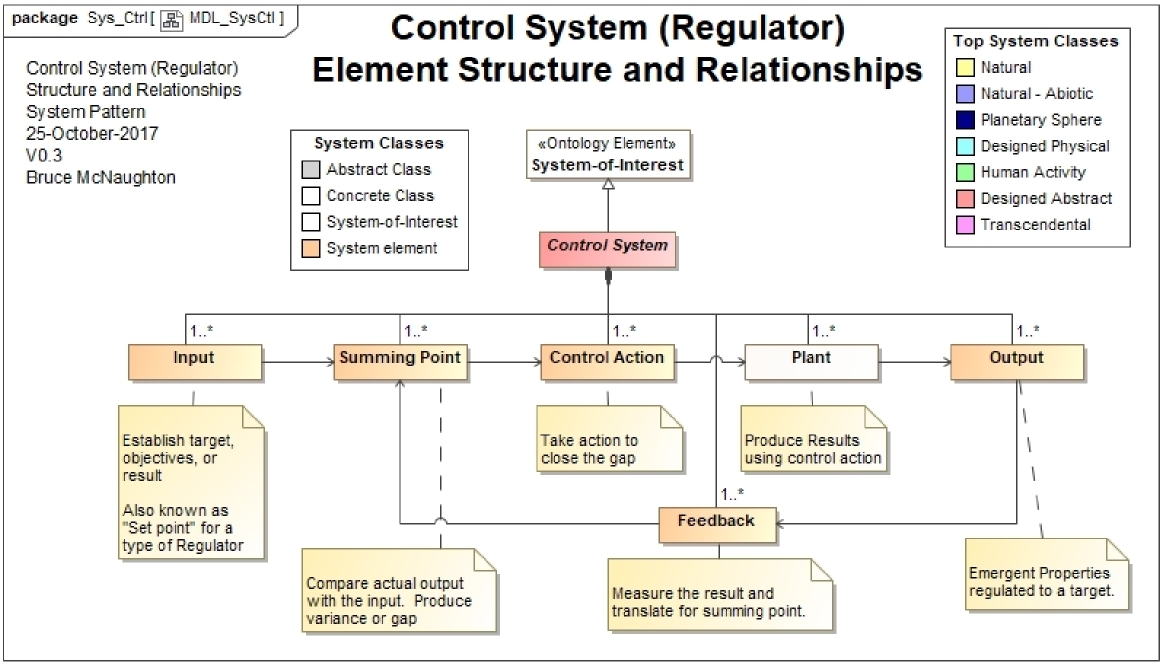
this section includes

- **Transactional**: Ensure the delivery of the controlled output or respond to problems
- **External** Possible disruptions due to external factors: temperature, environment (e.g. flood, etc.).
- **Regulator** : Extra requirements or unexpected (magnitude or frequency) of changes to the reference inputs.

## View: System Structure (Pattern of Organization)

A sampled data system is typically a system that takes a measurement or control action at regular intervals rather than continuously. The feedback, or summing point, and / or control action system element may take samples of the inputs or provide fixed outputs for a period of time. The basic conceptual model may be the same as a control system however, the properties of the system elements would need to identify the type of actions taken. Note that Shannon's sampling theorem is important to understand that the sampling rate is allowing the full signals to be determined during the operation of the system.

The system-of-interest consists of a number of identified system elements. .These are typically shown in a 'system breakdown structure'.




Each of the system elements may be defined in this section.

Note: some of the system elements may be systems their own right. These systems may become a system-of-interest and may be described using a Link to the System Description Template.

The relationships or interactions are also shown in the diagram above and shows the way the system elements interact.

In this picture, the lines between the system elements are defined. These may represent formal interfaces, such as, communication interactions, protocols, information flows, Contracts, etc. In this section, the relationships may be defined.

The following approaches also have a similar pattern to the control system:

- P-D-C-A cycle Plan - Do - Check - Act
- SSM Learning Cycle (Page A55: from "A Thirty Year Retrospective)"

- Typical problem solving approaches: Six Sigma, Diagnose, Identify Solutions, Implement,
- Typical life cycle for ISO 15288: consisting of many feedback loops.

Note: some of the system elements may be systems their own right. These systems may become a system-of-interest and may be described using a Link to the System Description Template.

## View: System Behavior (Structural Changes)

### Configuration / Scenario:

Describes any configuration / scenario attributes for a specific system-of-interest. This may not be appropriate for all system descriptions (e.g. patterns or abstract systems).

NOTE:  system elements that operate at specific rates need to be identified in the configuration as the rates are important for stability and accuracy of the sampling processes. The Shannon sampling theorem is an important consideration for system stability.

### Cyclical (Repeating / Regular) Processes

The processes to translate requirements and architecture into an operational system. An example of a set of life cycle processes can be found in ISO 15288.

NOTE: The Shannon Sampling Theorem applies to the dynamic behavior of the control system. If the sampling rate is too slow, the control system may become unstable or unable to control or regulate the process. The sampling rate is generally at least twice the underlying base frequency of the system being controlled.

### Development Life Cycle Processes

This area describes the life cycle for creating, using or releasing a system. This allows for the replication of an existing system into other areas.

# Abstract System: Stochastic System

## View: System Name and Class

**Name:** : Stochastic System

**Based on:** System (Abstract)

**Abstract System:** This system has been identified as an abstract system that cannot be implemented directly. The abstract system establishes a shared pattern of characteristics that any system can use to describe its unique characteristics when referenced in the 'based on' list above. These references are described using a generalization association in UML.

## View: System Purpose

The Stochastic System is a type of system where there are random elements that are part of the system. This also implies that there are probabilities associated with the variables and states of the system. See the wikipedia article:

See Stochastic System

See Wikipedia Stochastic.

This is a general type of system that includes noise or random variations. Examples are:

- Decision making processes in organizations
- Sensors that sample variables within a system.
- Accuracy of plans and estimates in organizations.

In the type of system, the structure of the system may be identical to a non stochastic system however, the behaviour of the system starts to exhibit random variations and wider stability swings.

The purpose for accurate reviews and audits provide for a stabilizing influence on the performance of a stochastic system.

May also be considered as a probabilistic system where the system can be described as a set of probabilities.

## View: System Properties

### Systemic Measurable Variables

The measurable variables for the system-of-interest provide the means of determining performance, quality, response times, and effectiveness of change. The variable description included in this specification provides the key and top level variables for this system-of-interest. These variables provide meaning for stakeholders externally and internally. A full definition of these system variables contains the following:

- Units and definition of the scale.
- How and when the variable is measured
- Key markers on the scale: Minimum acceptable, Objective (goal), Target, Stretch, etc.

### Systemic Capabilities or Functions

The capabilities of the system-of-interest or the individual functions that transform inputs to desired results are identified in this section. There may be a number of capabilities or functions this system-of-interest provides. Some of these are desired and expected and some may be undesired and unexpected.

### System States

There may be a number of types of states that may be defined in this section. The various defined states that the system-of-interest can be in.

- **Architectural states**: These are states that align to a specific version of the Architecture Description for a system. For example, there may be:
  - a Current Architecture Description,
  - a number of intermediate Architecture Descriptions (representing key operational points)
  - and the Target Architecture Description for a revision.
- **Transformational States**: These transformational states tend to align to key stages in the development process. These are typically
  - Designed
  - Built
  - Integrated

    - Released
    - Operational
- **Operational States**: Operational States relate to the type of outcomes that are expected. Some may relate to the delivery of products and services while others relate to specific operational states and objectives. These states are identified in the capabilities and processes used during operation. These operational states are designed and implemented into the way the operational system performs.

## View: System Stakeholders and Concerns

Identify the key stakeholders and their concerns for this system-of-interest. Each stakeholder is identified and their concerns and interests are identified. The list below is an example. Each system-of-interest will have a specific set of stakeholders and concerns.

- **Owner / manager**: Is this a sustainable / stable system? will our customers be satisfied?
- **System Architect**: Are the system concepts understood? Are the system properties sufficient to deliver the objectives?
- **People in the environment** Will the people confirm or use the benefits of the system?
- **Change Agents** Do we have the ability to change the system in a planned way?
- **People who are part of the system** Will I understand my contribution to the system?

## View: System Environment (Context)

The following definitions are used for Environment:

- ISO 42010: 2011 and ISO 15288:2015: **Environment**: (system) context determining the setting and circumstances of all influences upon a system
- ISO 9000:2015: **Context of the Organization**: combination of internal and external issues that can have an effect on an organization's approach to developing and achieving its objectives

The system-of-interest interacts with the environment as an open system. This section describes some of the key interactions and the relationship to the various properties of the system.

The environment and the potential impacts on the system-of-interest.

this section includes

- **Transactional**: This typically relates to an exchange of goods or services with a customer or user. Typically the system-of-interest may have influence without control.
- **Contextual**: This type of environment cannot be influenced or controlled but may have an impact on the system. This includes natural disasters, wars, etc.
- **Regulatory**: Regulatory requirements constrain the actions of the system-of-interest and may require specific types of interaction with external regulators.

The system-of-interest is situated in its environment as an open system. The environment that can influence the purpose and properties as a whole of the system-of-interest are identified here. These can be:

- the physical environment (weather, earthquakes, rivers, etc)
- local communities
- transportation
- the government
- competition
- education.
- etc..

For systems that can be described in a similar way to Figure 2 Page 12 of ISO 15288:2015, each of the systems identified in the hierarchy will participate as a system element and have the containing system serve as an environment. This provides a fractal model for systems within an overall system-of-interest.

## View: System Structure (Pattern of Organization)

Stochastic Systems use a conceptual model of the structure of the system similar to any other type of system. The model may highlight some areas where the system elements or holons have probabilitiy distributions of various actions occurring. This structural information provides the type of parameters for a behavioral analysis of the specific configuration of a system.

Identifying the probabilities of occurrence of a range of outcomes or results resulting from stochastic processes can provide insight into the complexity of predicting the performance or stability of a Stochastic System.

So, stochastic systems would include a normal conceptual System Breakdown Structure (SBS) with identified areas of high stochastic processes potential. The behavior section would provide more information on the probability distributions of the interactions.

## View: System Behavior (Structural Changes)

The interactions of the system elements are documented here. Each of the system element interactions is identified in this section and modeled. Behavioral and state models provide views of the dynamic aspects of the interaction of the system elements that creates the system properties. At a high level, the sentences that describe the interaction and relationships provide a high level specification of this interaction. Stochastic Processes will be identified along with any data or mathematical methods that have been identified. Typically any system that includes living systems will have some elements of stochastic processes.

The relationships or interactions are defined in this section. The picture included in this section shows the way the system elements interact.

In this picture, the lines between the system elements are defined. These may represent formal interfaces, such as, communication interactions, protocols, information flows, Contracts, etc. In this section, the relationships may be defined.

### Configuration / Scenario:

Describes any configuration / scenario attributes for a specific system-of-interest. This may not be appropriate for all system descriptions (e.g. patterns or abstract systems).

### Cyclical (Repeating / Regular) Processes

Some of the systems involved in the creation, of the system-of-interest, may need to create, change or transform system elements within the system-of-interest. These life cycles relate to the system elements that make up the system-of-interest. This also provides a structure for the various state transitions for the system-of-interest (e.g. architectural, transformational and operational).

Causal Loop Diagrams (CLD), Activity Diagrams, Markov Chains, Monte Carlo Methods, Decision trees, etc. all fit in this area.

### Development Life Cycle Processes

These life cycle elements describe the overall approach to create, use and release / retire a system-of-interest. This is the normal life cycle of the system-of-interest. This section identifies the systems involved in the elements of this life cycle. These may be external systems or internal systems that create this system-of-interest

# Abstract System: Viable System

## View: System Name and Class

**Name:** Viable System

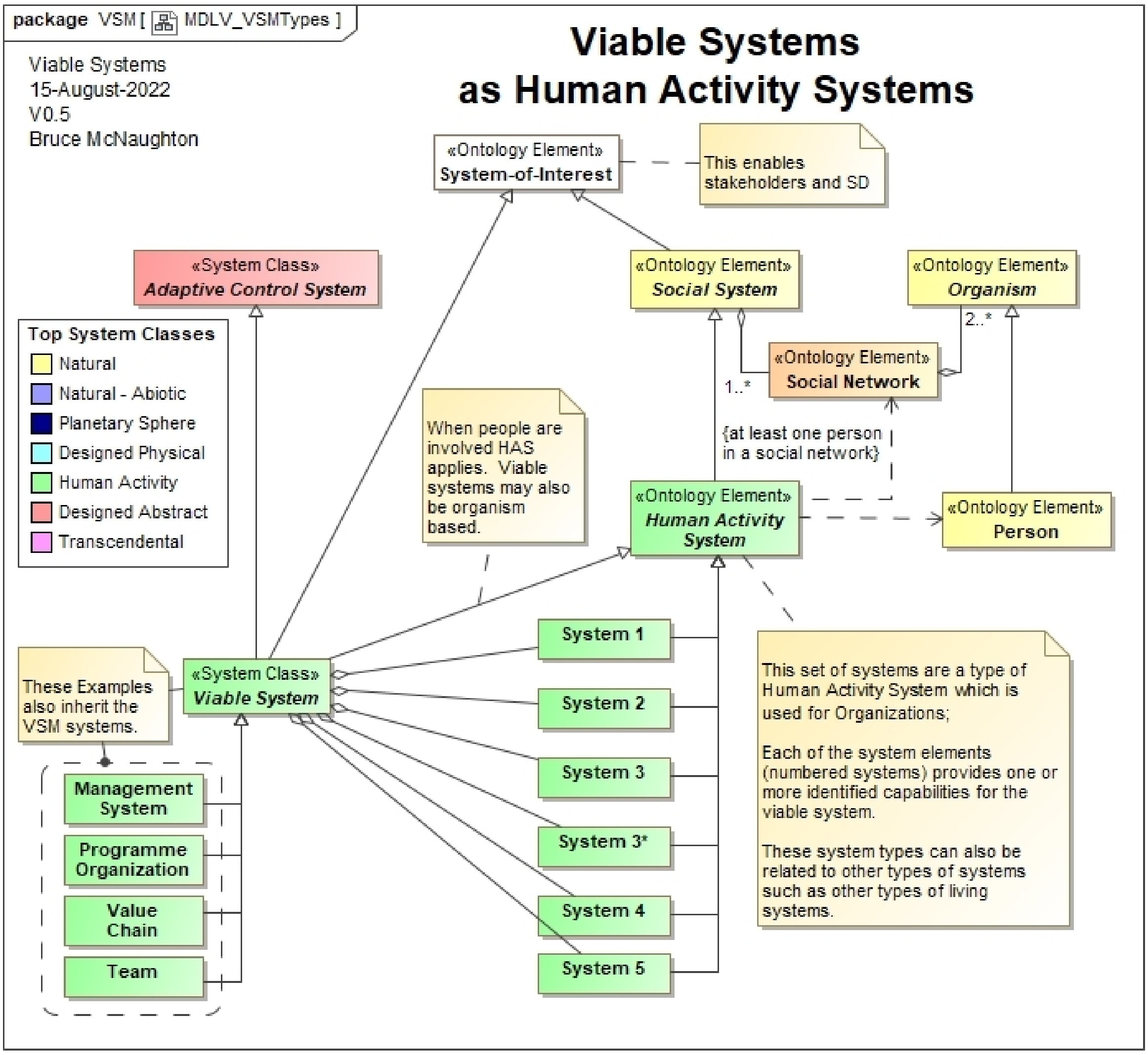
**Based on:** System (Abstract) using Adaptive Control System pattern

**Abstract System:** This system has been identified as an abstract system that cannot be implemented directly. The abstract system establishes a shared pattern of characteristics that any system can use to describe its unique characteristics when referenced in the 'based on' list above. These references are described using a generalization association in UML.

**Viable**: means 'able to maintain a separate existence', The Oxford English Dictionary

An organization as a viable system is able to sustain it's own existence, grow and adapt in response to changes in the environment.

The following diagram provides classifications for the various systems in the viable system model for a human activity system (organization).




The viable system based upon the Viable System Model is a pattern that identifies a set of systems that represent a set of capabilities that are expected to be realized in a human activity system. This set of capabilities can be mapped on to any existing organization or help shape the capabilities of new organizations. This pattern can also be mapped to other types of living systems or designed systems.

Three references are available to understand the viable system:

- Diagnosing the System for Organizations, Stafford Beer
- Fractal Organizations, Patrick Hoverstadt
- Viable Systems Model, Wikipedia

The Viable System Model provides a way to look at the essential capabilities needed for an organization to be viable in the longer term.

The following examples of using the Viable System Model are:

- Porter Value Chain
- Management System for ISO 9001:2015
- Programme Organization.
- Team

The Viable System also fits nicely with the Russell Ackoff definition for a purposeful system:

**An entity is purposeful if it can select both means and ends in two or more environments.**

PDF: System Description: Viable System, Version 0.4, 15-August-2022

## View: System Purpose

The purpose of a viable system as a system-of-interest is its reason for being. The purpose also relates to the functions and capabilities provided by the viable system (e.g. what the system does). The purpose is unique to each type of viable system seen as a system-of-interest.

## View: System Properties

### Systemic Measurable Variables

The emergent properties created or used through the interaction of the elements. This includes both desired and undesired.

- Performance variables and their associated measurements
- High customer satisfaction and continued use
- Positive and motivating culture within the organisation
- Positive contribution to society and the economy
- Achieve the purpose of the Viable System
- Achieve performance objectives and targets

### Systemic Capabilities or Functions

The capabilities or functions are produced through the work in system 1.

- Delivery of products and services
- Easily adapt to changes in the environment
- Development of suppliers capabilities to enable the organisation to meet its objectives.

### System States

The various defined states that the Viable System can be in.

- Architectural states
- Transformational States
- Operational States

The way the organisation senses and responds to any of the emergent properties leading to undesired properties can determine the long term sustainability of the organisation.

## View: System Stakeholders and Concerns

Managers

- Will this organisation achieve its objectives and purpose?
- Is the organisation sustainable for the long term?
- Are our customers satisfied?

Team members

- Are the managers ensuring the long term viability of this organization?
- Will I be able to achieve my full potential in this organization?

## View: System Environment (Context)

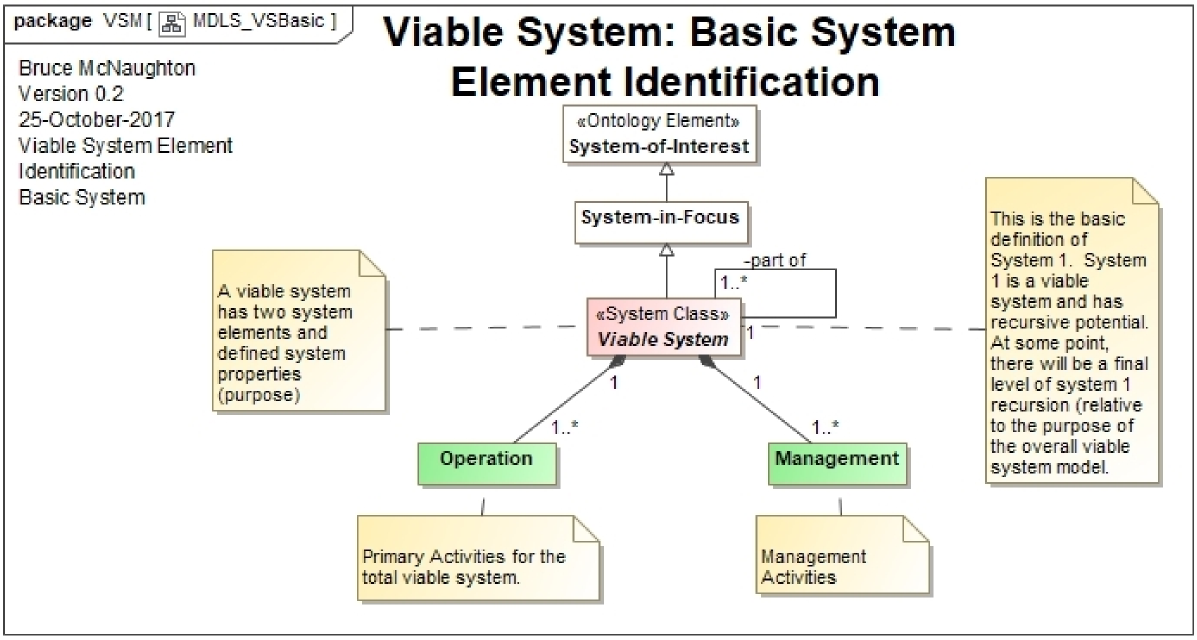
The environment and the potential impacts on the Viable System.

this section includes

- The operational interface with the environment related to the current products and services (variety)
- The future environment looking at the longer term sustainability of the organisation

## View: System Structure (Pattern of Organization)

### System Element: Identification

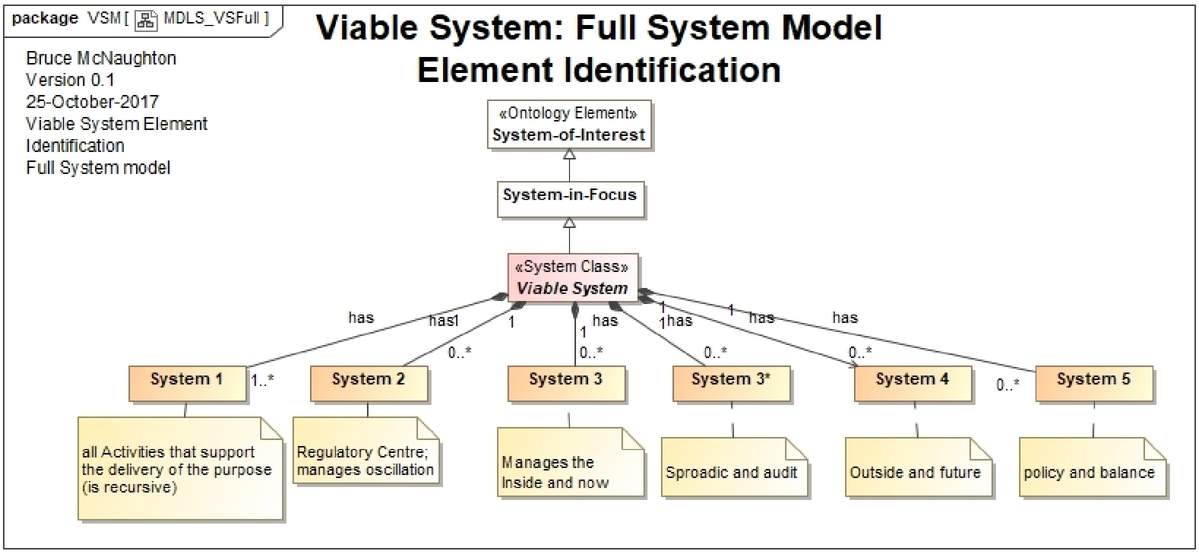



Each recursion then implements the full model where the full set of system elements are shown:

Full list of system elements and which are actually candidates for recursion.

There is a need to be very clear about the system-in-focus and the identification of those that deliver the organization's purpose.

The full model system elements are shown below:




### System Element: Relationships

The relationships are shown in the top level viable system (operations and management) and then shown in the full Viable System Model. See [Viable Systems Model, Wikipedia]

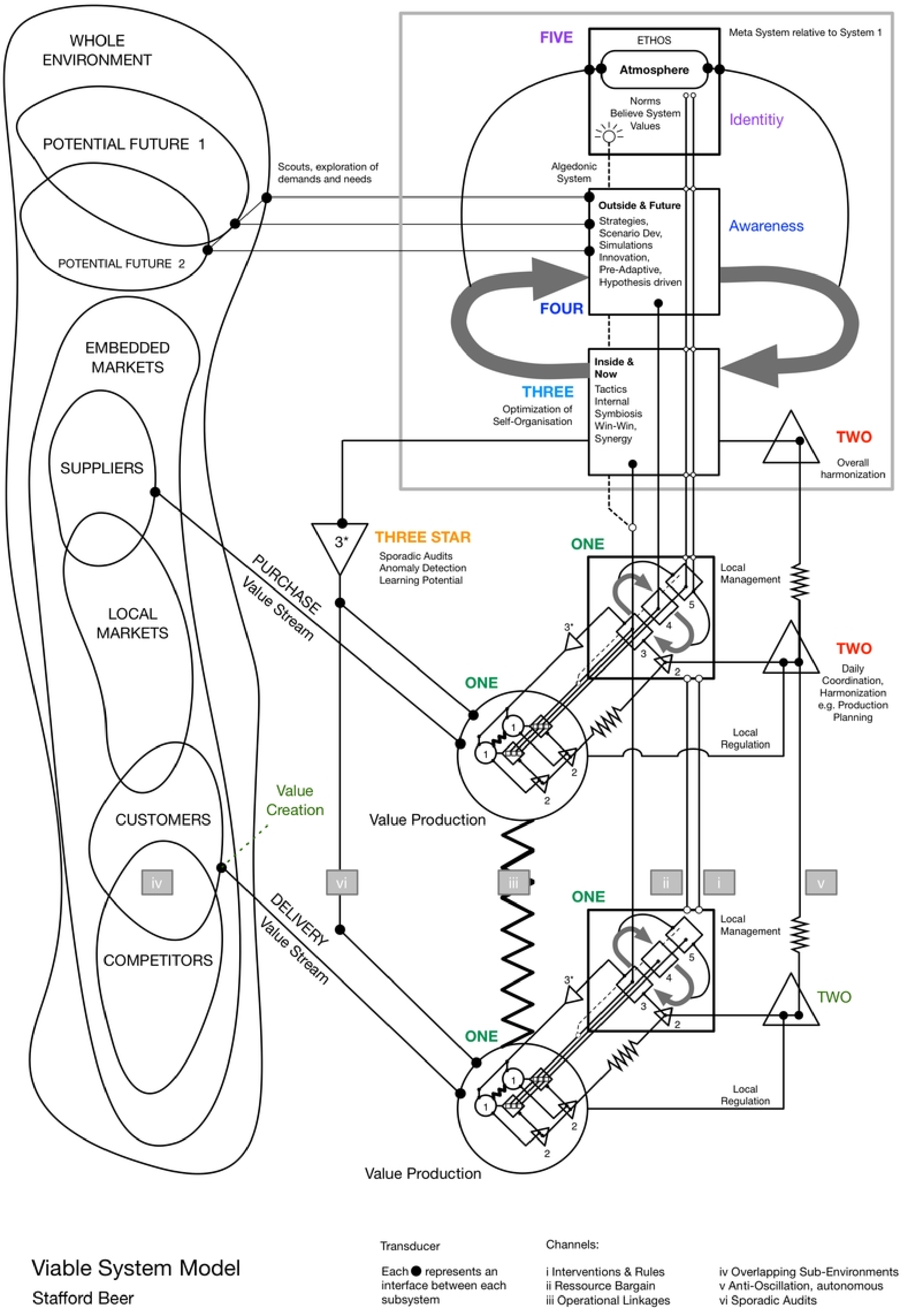



Image from Wikipedia article. Link referenced above.

See the following PDF for examples of viable systems.

[PDF: System Description: Viable System, Version 0.4, 15-August-2022]

**View: System Behavior (Structural Changes)**

**Configuration / Scenario:**

Describes any configuration / scenario attributes for a specific system-of-interest. This may not be appropriate for all system descriptions (e.g. patterns or abstract systems).

**Cyclical (Repeating / Regular) Processes**

Typically the repeating / regular processes relate to the set of processes supporting the capabilities of the viable system. These processes form part of the management system established and implemented within a viable system.

Regular / repeating processes also include the audits and assessments conducted on a regular basis to test the effectiveness of the system. Minor corrective actions can be taken to improve performance.

See the Integrated Management System PDF for a list of the standards that can be used to establish capabilities..

PDF: System Description: Integrated Management System, Version 0.17, 10-October-2023

**Development Life Cycle Processes**

The Viable Systems are created through the management practices in the viable system using the organizing activity of the manager. The management practices provide the ability to create the various systems and the overall structure of the resulting viable system.

Creating this viable system or management system uses a set of management capabilities and associated processes. See the examples for the types of capabilities that are generaly used and included.

The various models such as the VSM or the Management System requirements identify the capabilities that should be identified and designed through a viable system life cycle (typical life cycle is provided by ISO 15288:2015).. This system if established and implemented successfully will yield the following.

- Improved organizational maturity and culture
- Improved performance
- Improved ability to adapt and improve as a response to changes in the environment
- (NOTE: these are all viable system emergent properties).