Objects, Relations and Clusters for System Analysis

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Overview

- Definitions
- Types of cluster analysis
- Role of system organizing relationship
- Abstract Relation Type (ART)
- Augmented Model-Exchange Isomorphism (AMEI)
- Connection to classical system engineering methods and techniques

Systems and Clusters

- **A ‘construction-rule’ system definition**

  A relationship mapped over a set of objects

- **A ‘function-rule’ system definition**

  A constraint on variation

- **Cluster**

  A group of objects occurring closely together

- **Object-based cluster identification**

  Based on object attributes

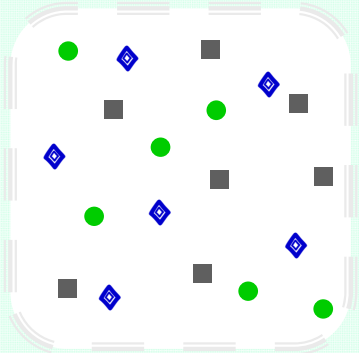
- **Space-based cluster identification**

  Based on relation properties

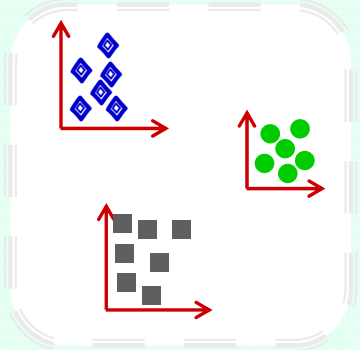
Cluster Types

Object-Based Cluster

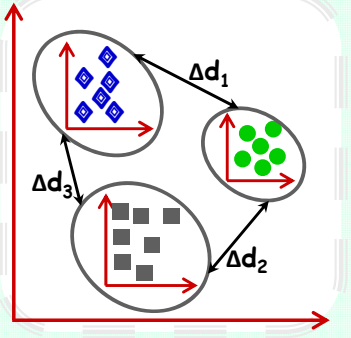
1. Identify, analyze objects



2. Determine cluster dimensions

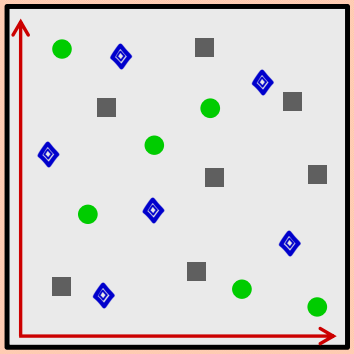


3. Analyze object clusters

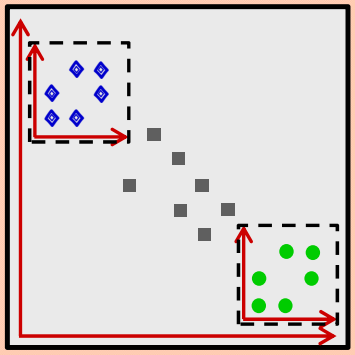


Space-Based Cluster

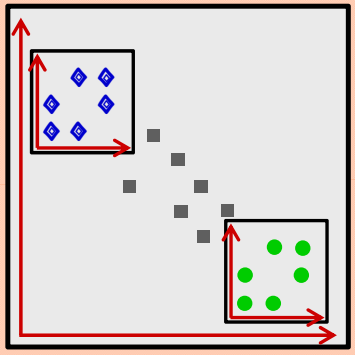
1. Identify analysis space using global system relation



2. Identify subspace(s) of interest



3. Enumerate objects in subspace



Variable and Object Analysis

- **Variable analysis based on object properties**

  Degree of similarity among variables used to identify and describe the controlling object properties of interest

- **Object analysis based on class construction**

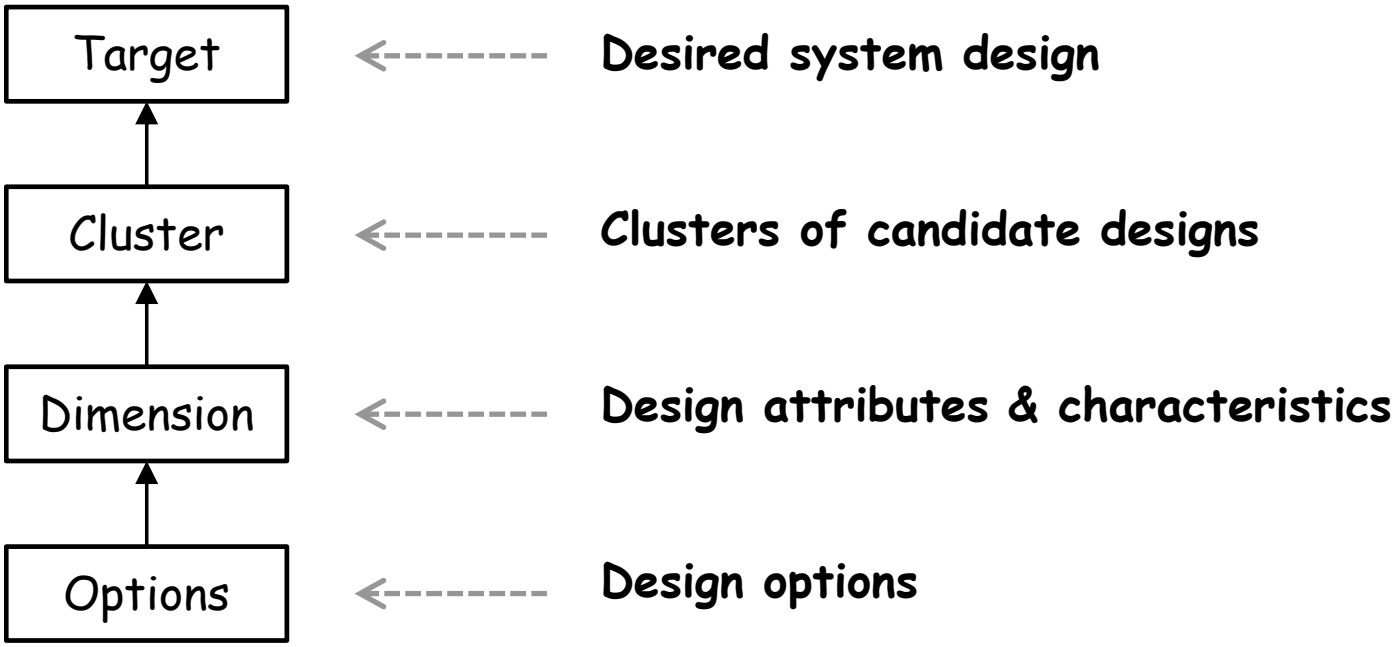
  The activity of identifying the general types into which the objects may be categorized or classed

Object analysis requires a large amount of, and greater depth of, contextual information.

As a result, it requires more specific application subject matter expertise than variable analysis.

Context for Cluster Application

Warfield's 'Four Level Inclusion Hierarchy for Design'



This represents a generalized 'included-in' relation, that becomes more specialized as the Target is achieved.

The following logical relation properties apply to 'included-in'

- **Irreflexive**
- **Asymmetric**
- **Transitive**

Adapted from Figure 2.20, Warfield, 1994.

Logical Relation Properties

Hi-Level Logical Characteristics of Three Dyadic Relations - v1.1

Reflexivity *Involves one individual*	***Symmetry*** *Involves two individuals*	***Transitivity*** *Involves three (or more) individuals*
Reflexive A relation, R, is reflexive iff any individual that enters into the relation bears R to itself. *Identical with; Divisible by	**Symmetric** If any individual bears the relation to a second individual, then the second bears it to the first. *Touching	**Transitive** If any individual bears this relation to a second and the second bears it to a third, then the first bears it to the third. *Greater than; North of; Included in
Irreflexive A relation, R, is irreflexive iff no individual bears R to itself. *Stand next to; Father of	**Asymmetric** A relation, R, is asymmetrical iff, if any individual bears R to a second, then the second does not bear R to the first. *North of; Heavier than; Child of	**Intransitive** A relation, R, is intransitive iff, if any individual bears R to a second and the second bears R to a third, then the first does not bear R to the third. *Father of; 2" taller than
Nonreflexive A relation which is neither reflexive nor irreflexive is nonreflexive. *Respecting; Killing	**Nonsymmetric** A relation which is neither symmetrical nor asymmetrical is nonsymmetric. *Likes; Seeing	**Nontransitive** A relation which is neither transitive nor intransitive is nontransitive. *Admiring; Fearing

*Examples

Adapted from *Predicate Logic* and *Handbook of Discrete & Combinatorial Mathematics*

The ART Construct

Abstract Relation Type (ART)

Prose Description (text, words)

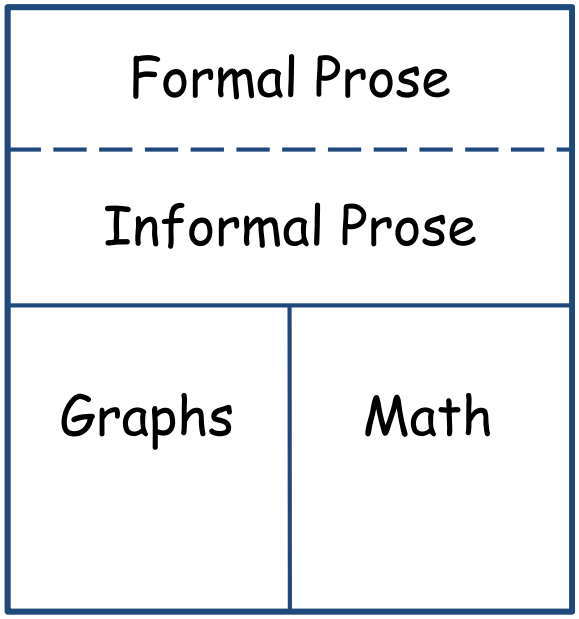
- Formal pattern
- Informal prose

Graphic Representation
(directed graphs)

- Must have formal graphs
- Can also have informal graphs

Mathematics & Computer Representation

- Math equations
- Computer codes
- One or both

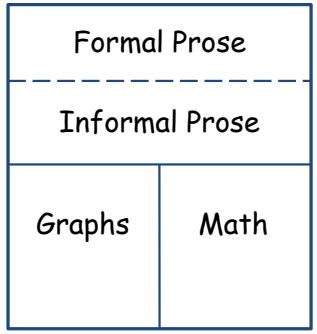


Augmented Model-Exchange Isomorphism

Abstract Relation Type

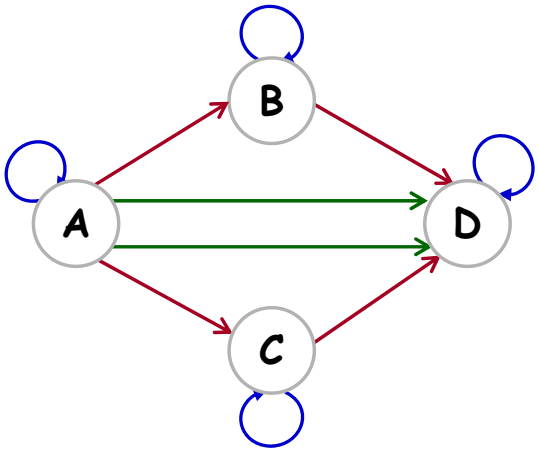
Reflected in

Augmented Model Exchange Isomorphism (AMEI)



Formal Prose	Graphs	Math
Prose	Structured Graph	Matrix
Informal Prose		
Context	Notes	

ART reflected in AMEI

Prose	Structured Graph	Matrix
Relation 'Connected-to' • **Reflexive** • **Asymmetric** • **Transitive** **RAT-[1,2,1] v1.1**		

	A	B	C	D
A	1	1	1	1
B	0	1	0	1
C	0	0	1	1
D	0	0	0	1

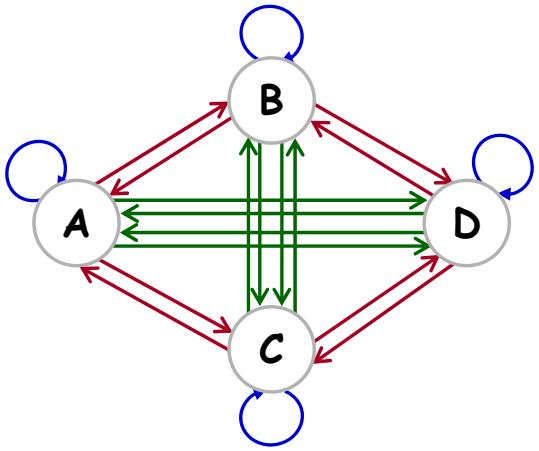
Context

1. Directional connections
2. Single direction
3. Self-connection required

Notes

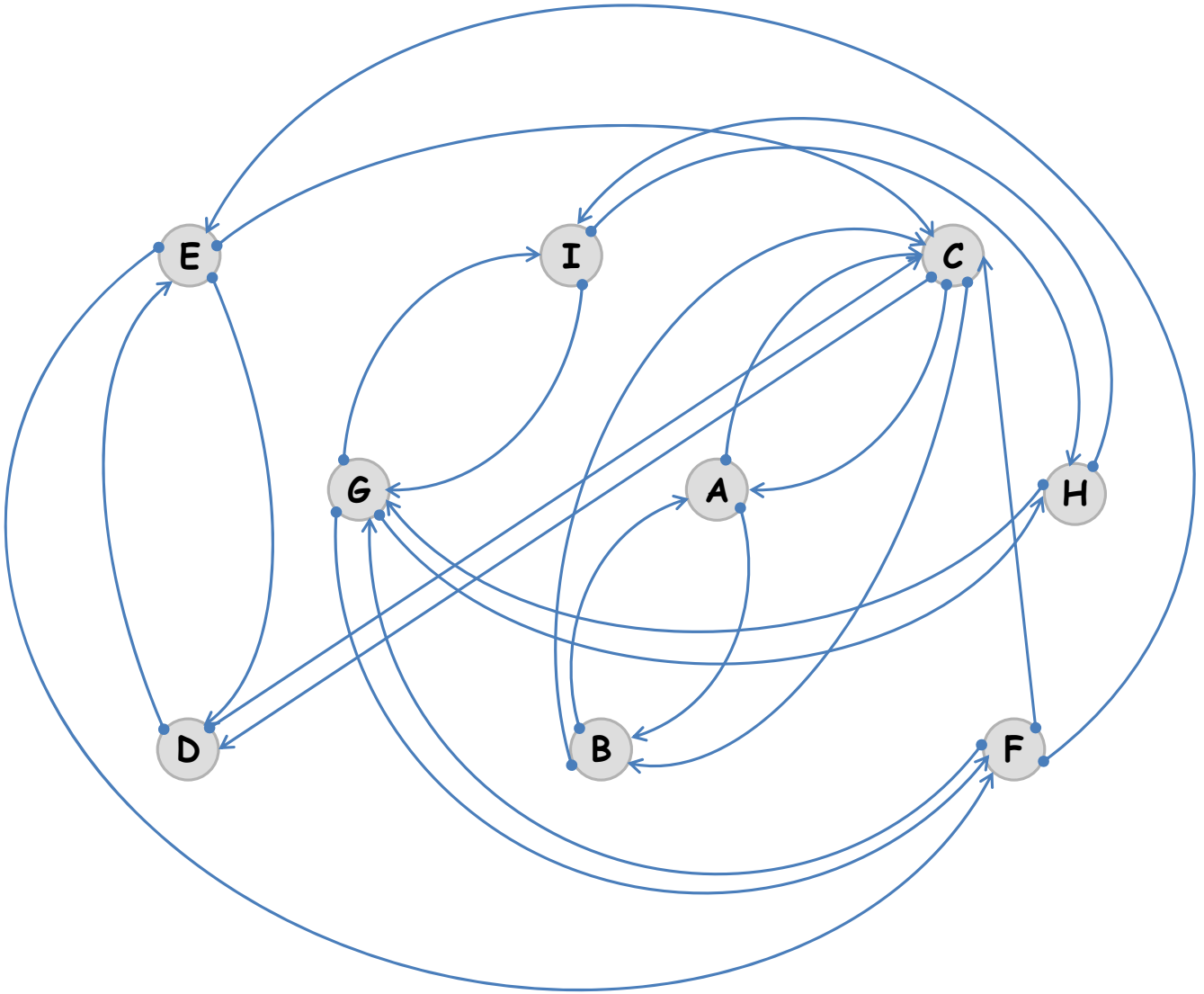
1. Shows transitive links

ART reflected in AMEI

Prose	Structured Graph	Matrix
Relation 'Connected-to' • **Reflexive** • **Symmetric** • **Transitive** **RST-[1,1,1] v1.1**		A B C D A 1 1 1 1 B 1 1 1 1 C 1 1 1 1 D 1 1 1 1

Context	Notes
1. Directional connections 2. Double directions 3. Self-connection required	1. Shows transitive links

Logical Properties?



Adapted from Figure 8.13, Hitchins, 2003.

Identify Clusters

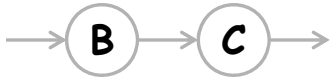
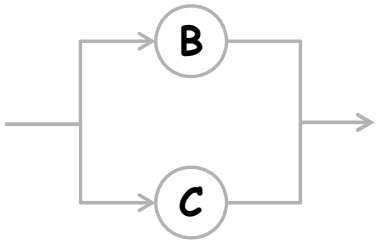
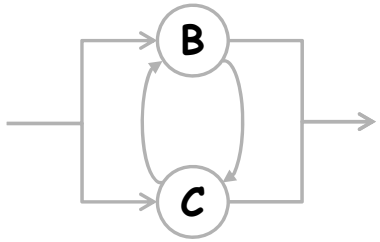
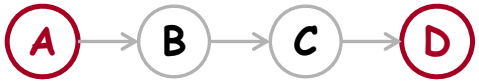
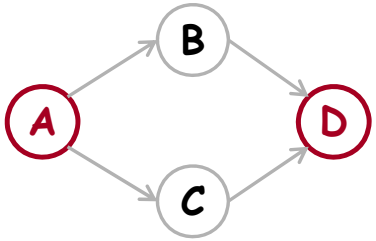
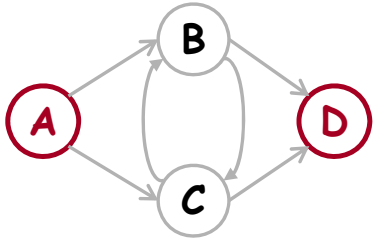
Disordered System Configuration

E	0	1	0	0	0	1	0	1
0	I	0	1	0	1	0	0	0
0	0	C	0	1	0	1	1	0
0	1	0	G	0	1	0	0	1
0	0	1	0	A	0	0	1	0
0	1	0	1	0	H	0	0	0
1	0	1	0	0	0	D	0	0
0	0	1	0	1	0	0	B	0
1	0	1	1	0	0	0	0	F

Ordered System Configuration

A	1	1	0	0	0	0	0	0
1	B	1	0	0	0	0	0	0
1	1	C	1	0	0	0	0	0
0	0	1	D	1	0	0	0	0
0	0	1	1	E	1	0	0	0
0	0	1	0	1	F	1	0	0
0	0	0	0	0	1	G	1	1
0	0	0	0	0	0	1	H	1
0	0	0	0	0	0	1	1	I

No Relationship!

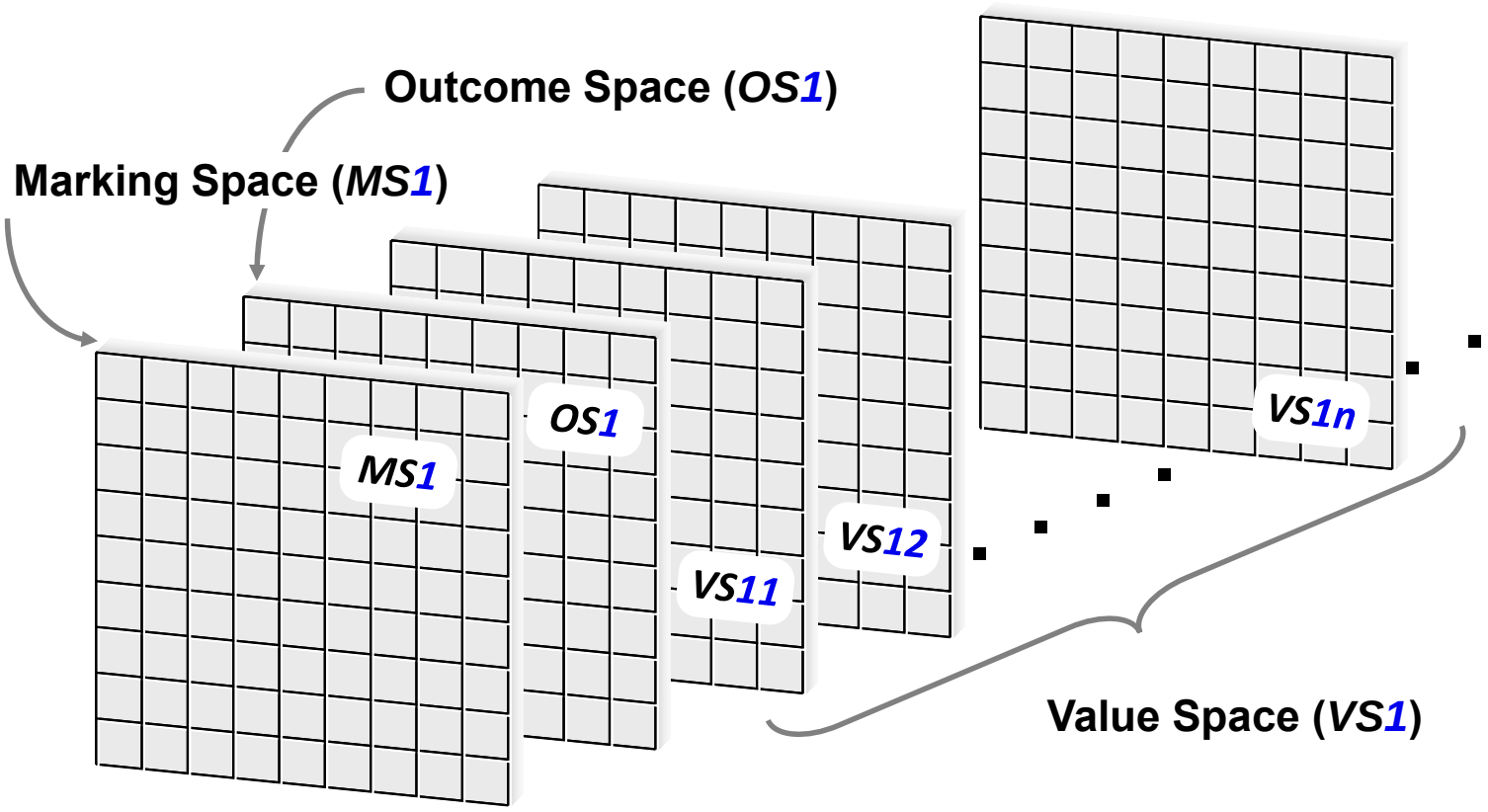
Dependent (Series)	Independent (Parallel)	Interdependent (Coupled)
Eppinger's Representation		
		
Add Missing Vertices, Repair Malformed Arcs		
		
Matrix Forms		

	A	B	C	D
A	0	1	0	0
B	0	0	1	0
C	0	0	0	1
D	0	0	0	0

	A	B	C	D
A	0	1	1	0
B	0	0	0	1
C	0	0	0	1
D	0	0	0	0

	A	B	C	D
A	0	1	1	0
B	0	0	1	1
C	0	1	0	1
D	0	0	0	0

ART 'Spaces'



Abstract Relation Type (*ART*) ≡ ʃ [*MS, OS*]

Outcome Space (*OS*) ≡ ʃ [VS_1, VS_2, …VS_n, VS_{n+1}, …]

Summary

- Relationships create systems
- Abstract Relation Types focus on relationships
- Relationship logical properties create classes of system types
- Classical systems engineering methods and techniques support clustering

Additional Information

Additional information is available

- http://systemsconcept.org/
- https://github.com/jjs0sbw

To join in the discussion and activity

Contact jjs0sbw@gmail.com

This presentation hits the highlights

More detail in the Thursday tutorial

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Questions?