A Generic, Adaptive Systems Engineering Information Model

Introduction

- Systems Engineering Masters Thesis
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- Produced by Joseph Simpson
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  - Dr. Scot Grasman

Overview of Discussion

- Definition of Systems Engineering
- Motivation for Generic, Adaptive Systems Engineering Information Model
- Literature Review
  - Systems Engineering History
  - Systems Engineering Current Practice
  - Systems Engineering Standards
  - Requirements Models
  - Process Models
  - Information Models

Overview of Discussion

- Relational Database Selection
  - MySQL Database
  - HSQL Database
  - PostgreSQL Database
- Model Development
- Logical Data Model
- Discussion
- Summary

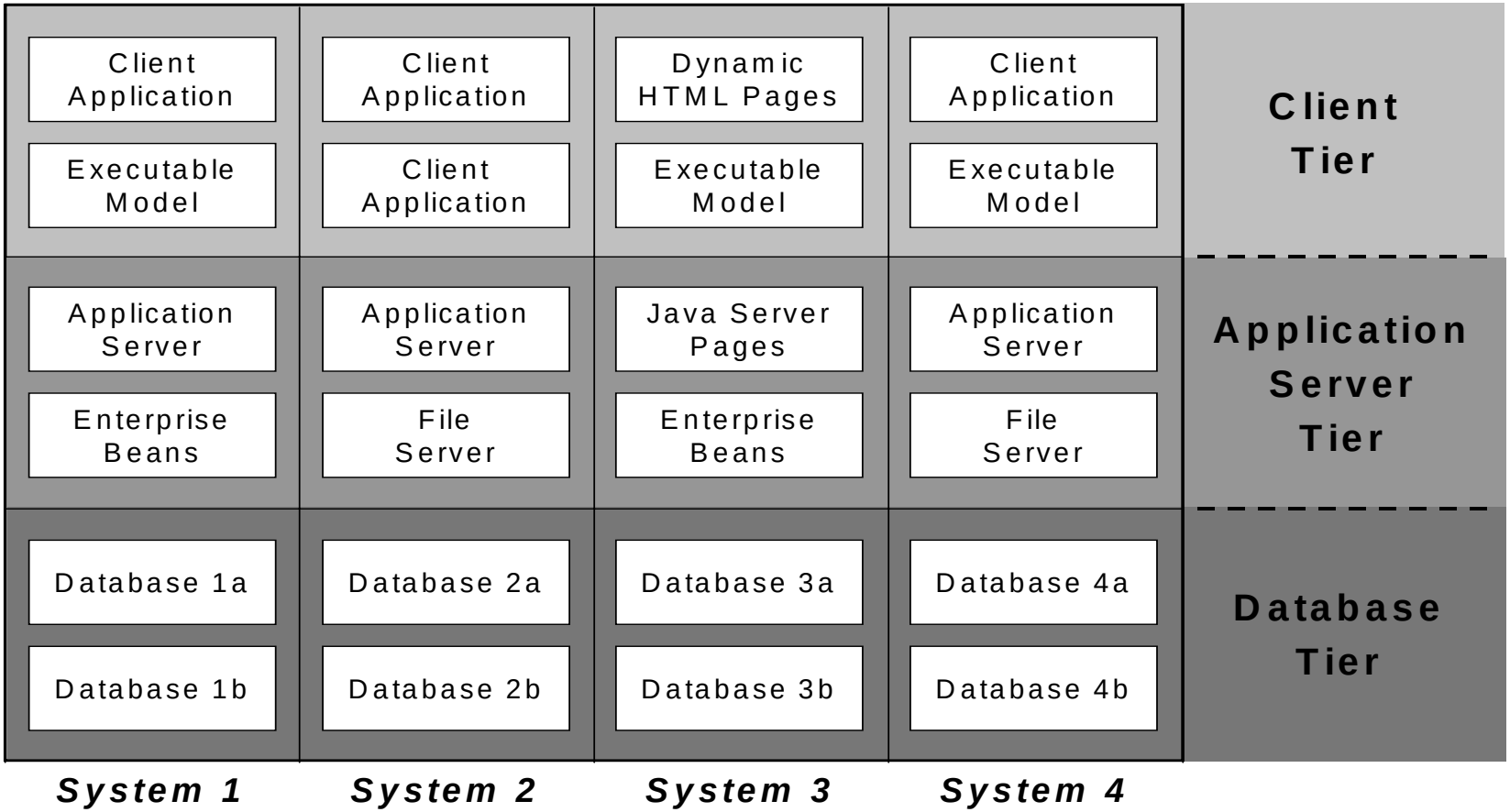
Definition of Systems Engineering

- Systems engineering is a structured technical management and control process used in the design, development, production and operation of large-scale complex systems.

Motivation for SE Information Model

- Integrate different types of systems engineering tools
- Reduce risk of supportability and interoperability problems
- Support wide range of computer-based SE tools
- Utilize open standards applications
- Facilitate loosely coupled information constructs
- Support viable operation over total system lifecycle
- Provide flexible application development and application
- Enforce basic system rules and documentation
- Support new models from users and development partners
- Encourage incremental development and deployment
- Enable activity and task pattern recognition

Three Tier System Types



Literature Review, SE History

- Large scale civil and military projects
- United States Military:
  - Air Force Systems Command Manual 1964
  - Department of Defense MIL-STD-499 1969
  - Army Field Manual 770-78 “Systems Engineering”
  - Defense Systems Management College (DSMC) “Systems Engineering Management Guide” 1983.

Literature Review, Current SE

- Large scale civil and military projects
- Different customer types and expectations
- Common Systems Engineering Standards
  - Electronics Industries Association (EIA) 632
  - Institute of Electrical and Electronic Engineers (IEEE) 1220
  - EIA 731 “Systems Engineering Capability Model”

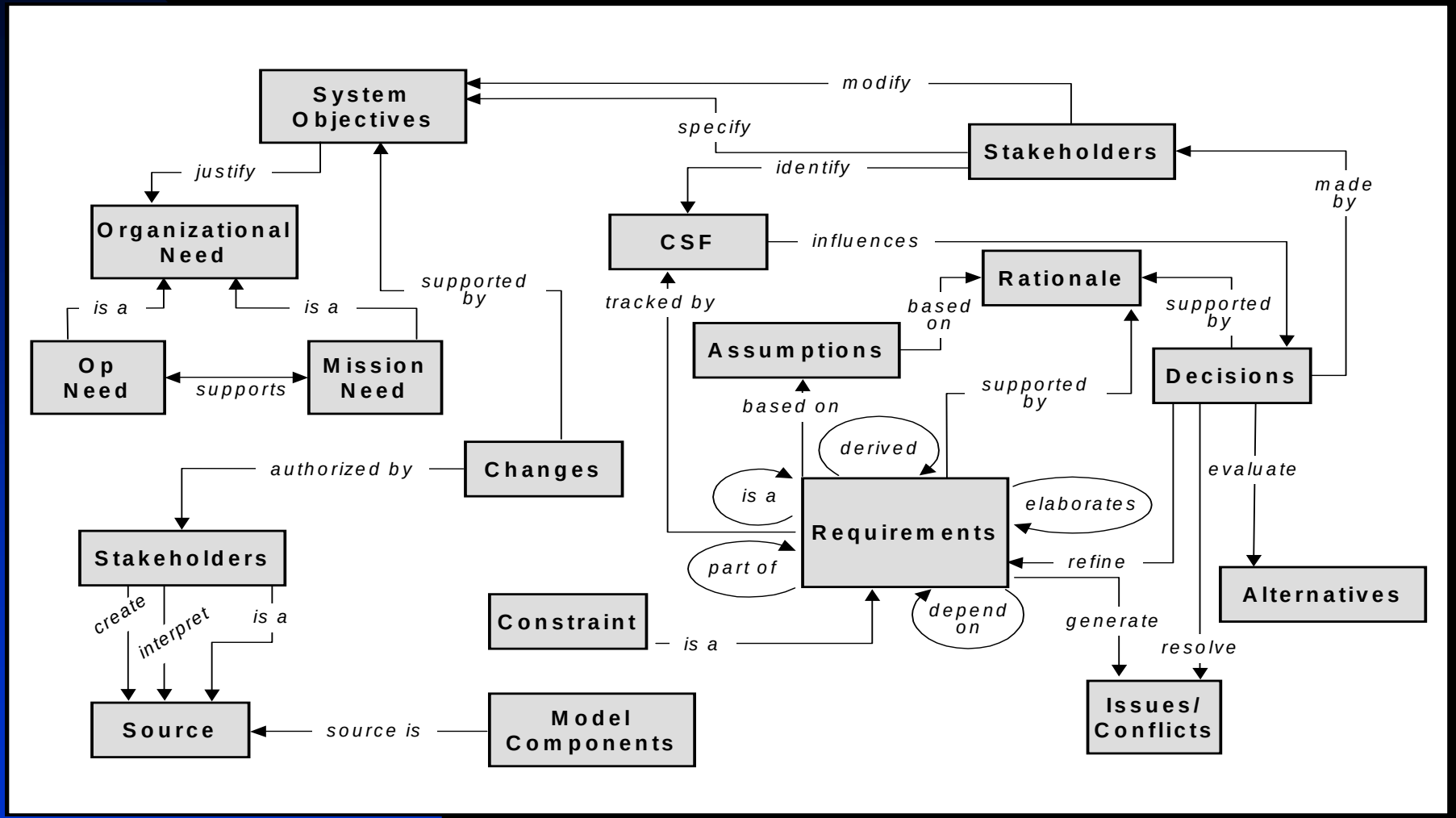
Literature Review, Software Development

- Modern military projects with high percentage of software
- DoD-STD-2167A, mandated requirements traceability
- Based on a document centric view of requirements management
- No mandated process, method or approach.

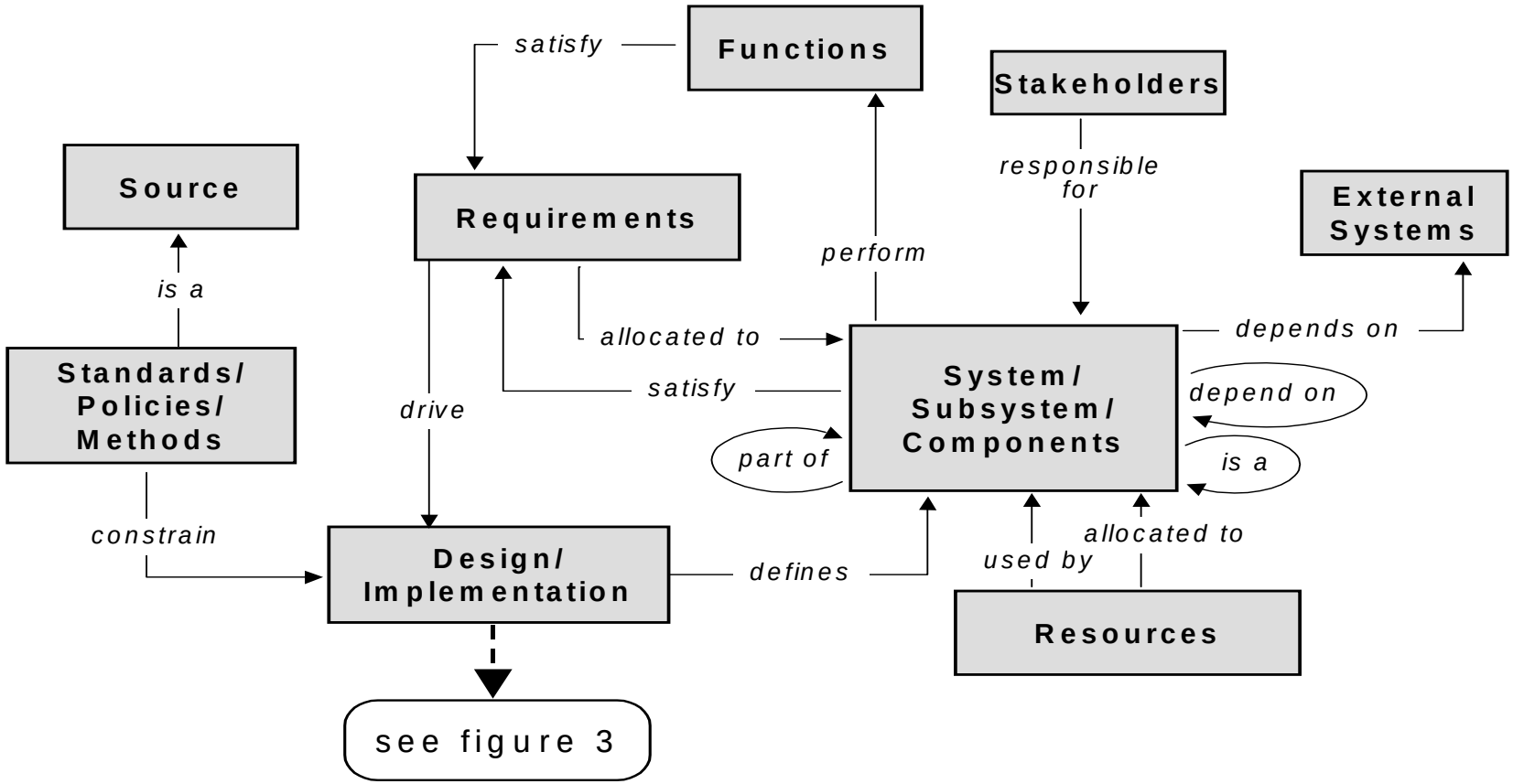
Literature Review, Traceability Studies

- Naval Postgraduate School Requirements Traceability studies
- Based on links between text documents.
- Four Models: (High End User Models)
  - Requirements Management Model
  - Design Allocation Model
  - Design/Implementation Decision Making Model
  - Compliance Verification Model

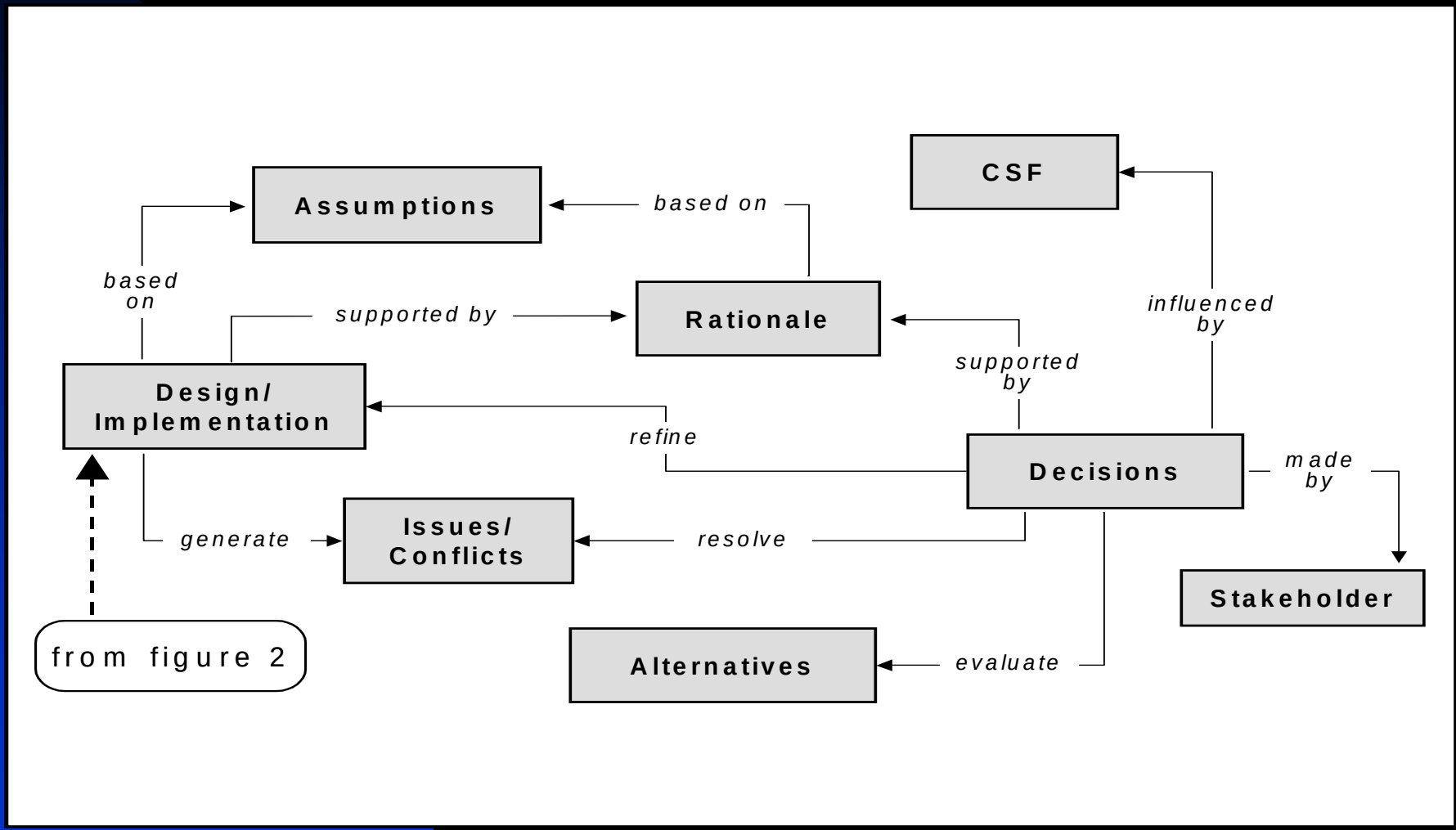
Literature Review, Requirements Management Model



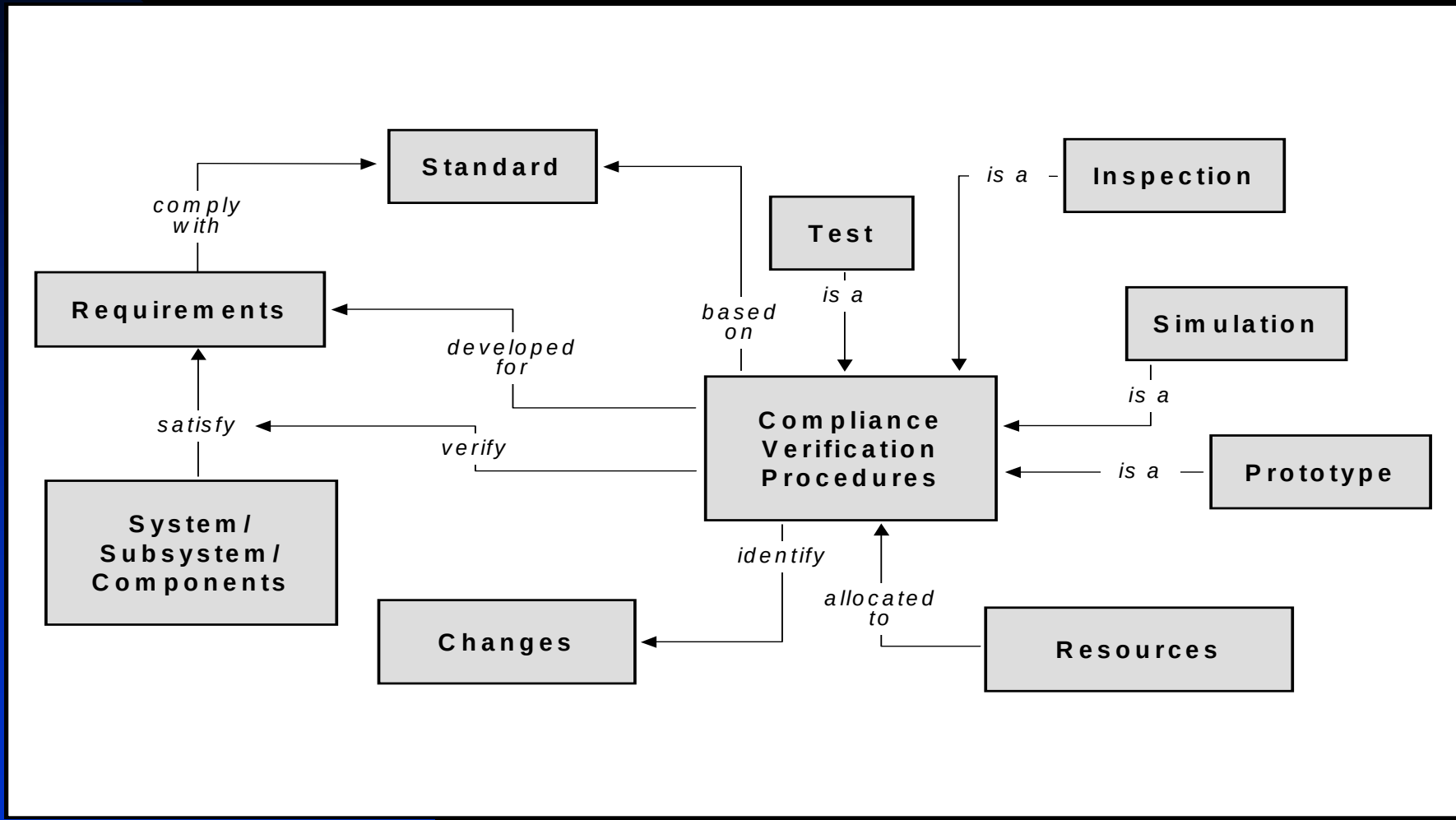
Literature Review, Design Allocation Model



Literature Review, Design/ Implementation Decision Making Model



Literature Review, Compliance Verification Model

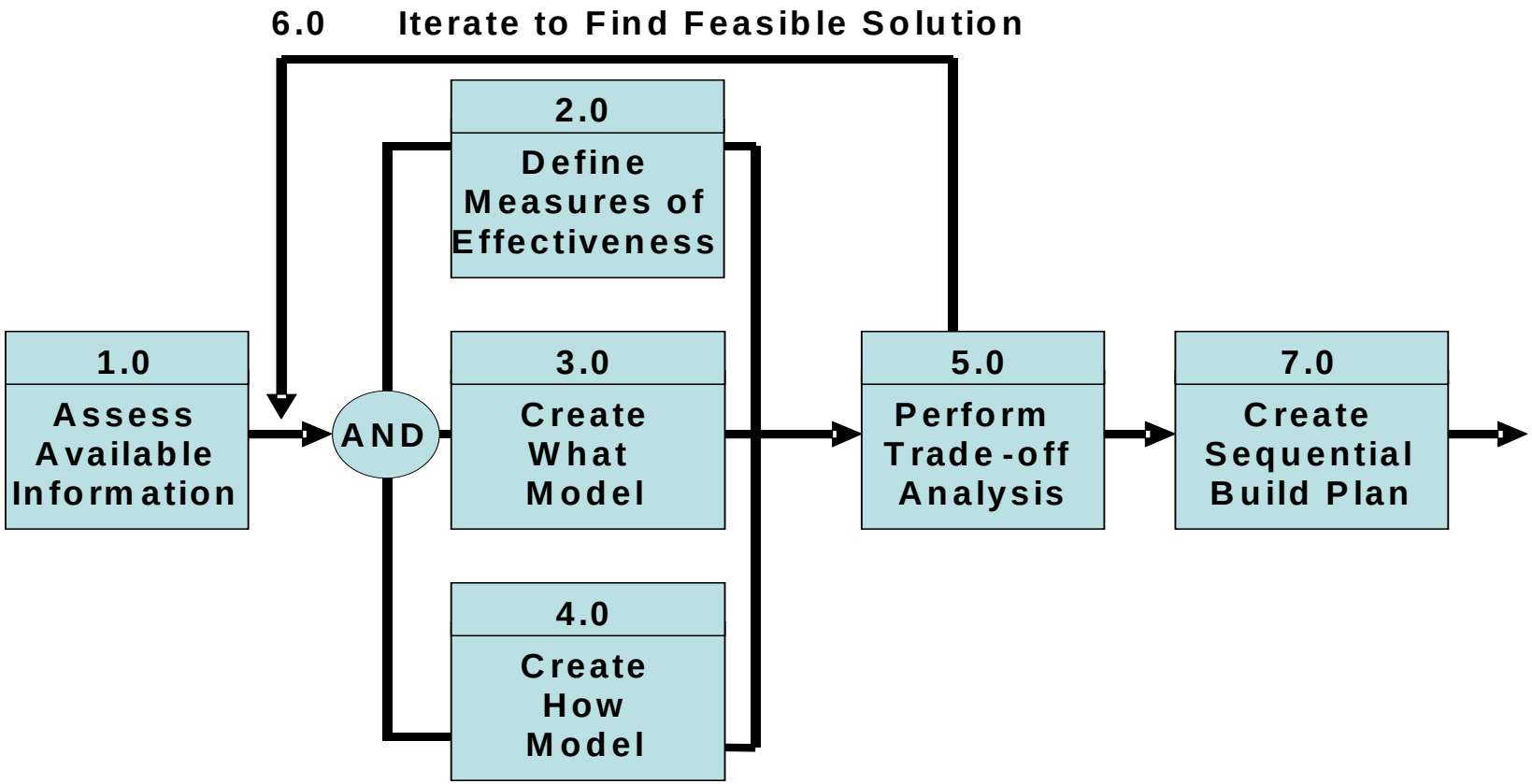


Literature Review, SE Process Implementation

Steps to Apply Scientific Method to Problem Solving	Early Man Developing Cultural Patterns	Basic Research	Operations Research	System Design
1 Recognize problem	Unsatisfied Physiological Need	Identify gap in body of scientific knowledge	Identify operational objective to be achieved	Describe mission or use requirements
2 Describe problem	Discover alternative ways to increase satisfaction of need	Develop theory of probable cause and effect relationships	Define situation & resources which can be used to attain objectives	Define req'd operation and logistic functions to attain use objectives
3 Select hypothesis for solving problem	Select favored way of satisfying need	Select hypothesis for investigation	Describe tailorable variables to achieve desired objectives	Specify the system performance / design requirements
4 Develop model for testing hypothesis	Devise implements & techniques to practice favored way	Describe experimental model to test hypothesis	Construct statistical model to interrelate variable conditions	Accomplish detail design & qualification testing of components
5 Conduct tests under controlled conditions	Use selected techniques for some period of time	Conduct controlled lab/field investigation to obtain data	Perform computation to obtain statistical values	Build, assemble, test complete prototype system
6 Analyze and evaluate test data	Decide if techniques result in tolerable satisfaction of need	Analyze and evaluate collected data	Analyze and evaluate summary statistical data	Analyze and evaluate test data
7 Derive conclusions to confirm, deny, modify hypothesis	Transmit techniques to others & establish cultural pattern	Derive conclusions to confirm, deny, modify hypothesis	Recommend actions to achieve desired objectives	Recommend modifications for production system

* Chase, Wilton P., *Management of System Engineering,* Robert E Krieger Publishing Company, Inc., 1974

Literature Review, SE Information Views



* Oliver, D., Kelliher, T., Keegan, J., *Engineering Complex Systems with Models and Objects, McGraw-Hill*, 1997

Literature Review, Core Information Models

- Seven Core Information Models
  - System Behavior
  - System Input and Output
  - System Structure and Behavior
  - System Requirements
  - Effectiveness Measure Creation
  - Text Requirements, Behavior and Content
  - Build and Test Plan

Literature Review, SE Information Views

- Joint Technical Architecture
- Department of Defense Architecture Framework
- Function, Requirement, Architecture, and Test
- Environment, Informational, Functional, Behavioral, and Implementation
- Logical, Process, Physical, Development, and Scenario
- Context, Concept, Function, Requirement, Architecture, and Test.

Literature Review, SE Requirements Models

- Historically Text Based
- Support SE Process Model Steps
- History of Semantic Confusion
- Executable Requirements Models Are Needed
- RDD-100, IDEF0 Tools
- UML 2.0, SYSML
- Custom Built Requirements Tools

Literature Review, SE Process Models

- Different types, military and civilian
- Most SE process models are flexible
- Two main areas of application:
  - System under design
  - Design support systems
- Model driven design process
- System architecture
- Detailed phase and support process models

Literature Review, SE Information Models

- Relational and object-oriented databases are most often used on SE projects.
- Some basic design approaches:
  - Model based on SE process
  - Model based on:
    - Product architecture
    - Process architecture
- Two groups of relational tables:
  - Management activities
  - System architecture evolution

Relational Database Management Systems

- Three Open Source Relational Database Management Systems:
  - MySQL Database
  - HSQL Database Engine
  - PostgreSQL Object Relational Database System
    - ACID Transactions
    - SQL 92
    - SQL 99

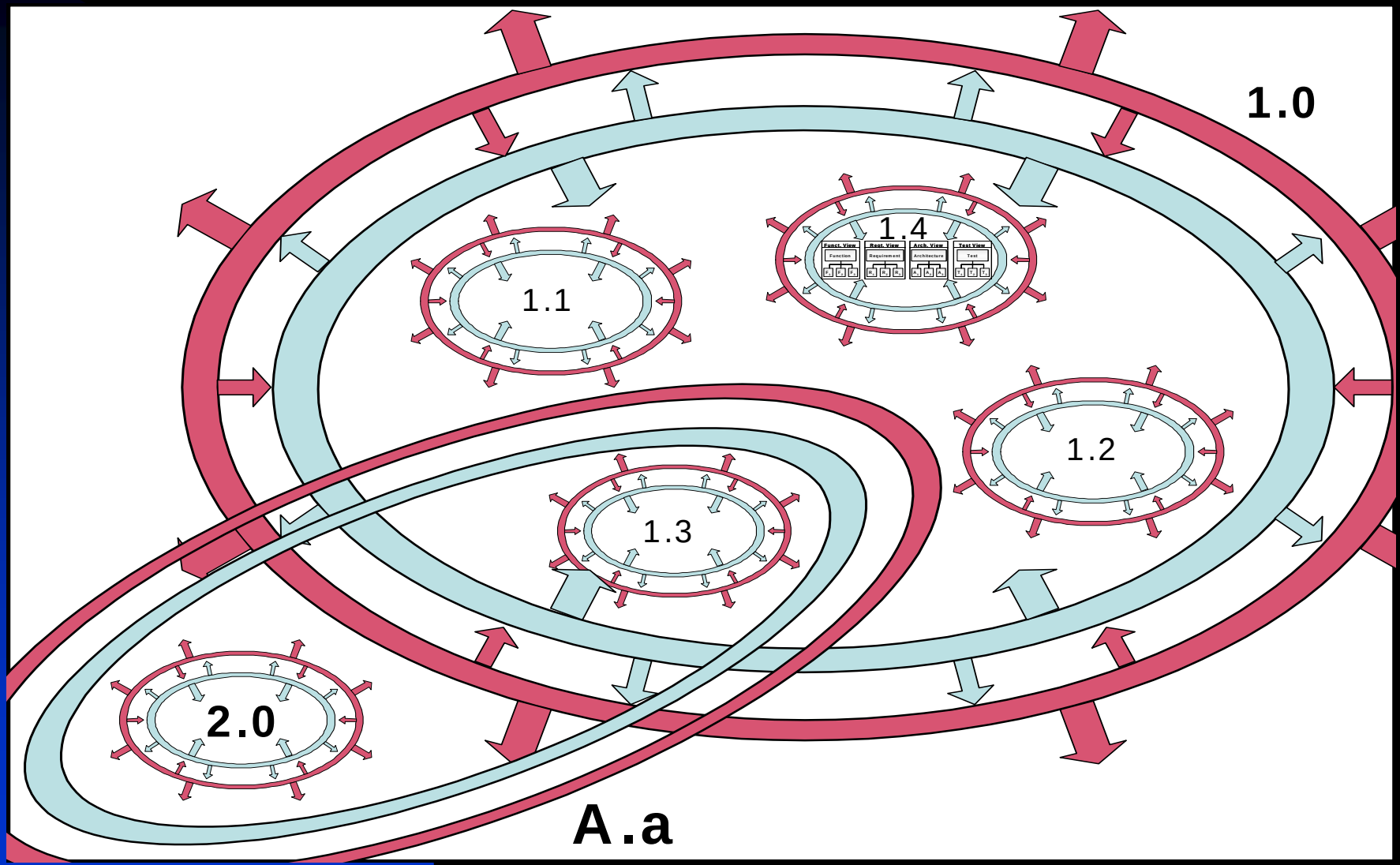
Global Model Development

- Generic SE Information Model Design Criteria
- Conceptual Information Model Design
- Base Systems Conceptual Models
  - System Context View Data Model
  - System Concept View Data Model
  - System Functional View Data Model
  - System Requirement View Data Model
  - System Architecture View Data Model
  - System Test View Data Model

Logical Model Development

- Logical Models for the “three basic systems”
- Environmental System
  - Includes all other systems
- Product System
  - The system under design
  - What the customer wants
- Process System
  - The system that produces the product system
  - Includes people, equipment and processes.

Basic System Model Relationships



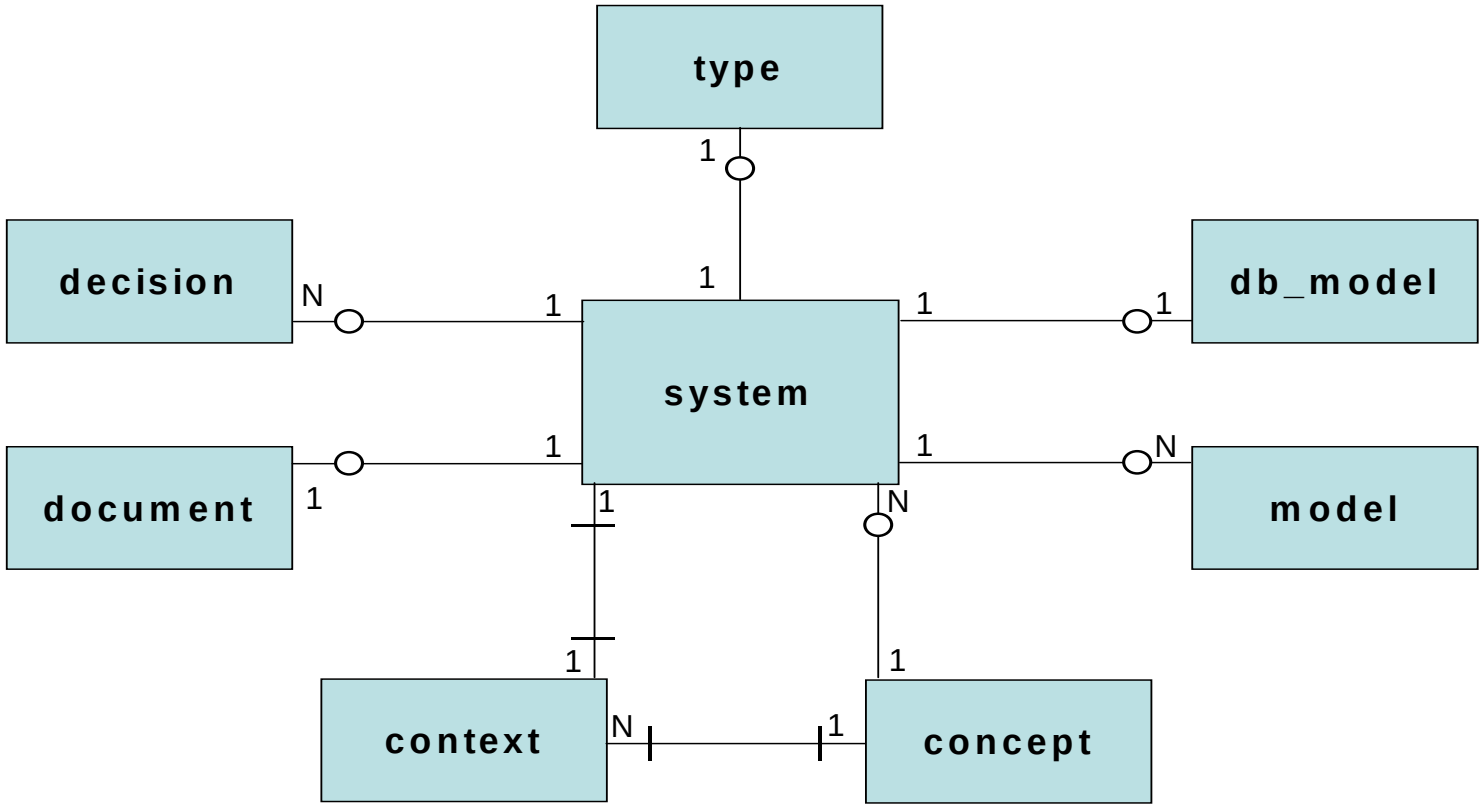
Logical Model Development

- Logical data models were developed for the following entities:
  - System
  - Context
  - Concept
  - Function
  - Requirement
  - Architecture
  - Test

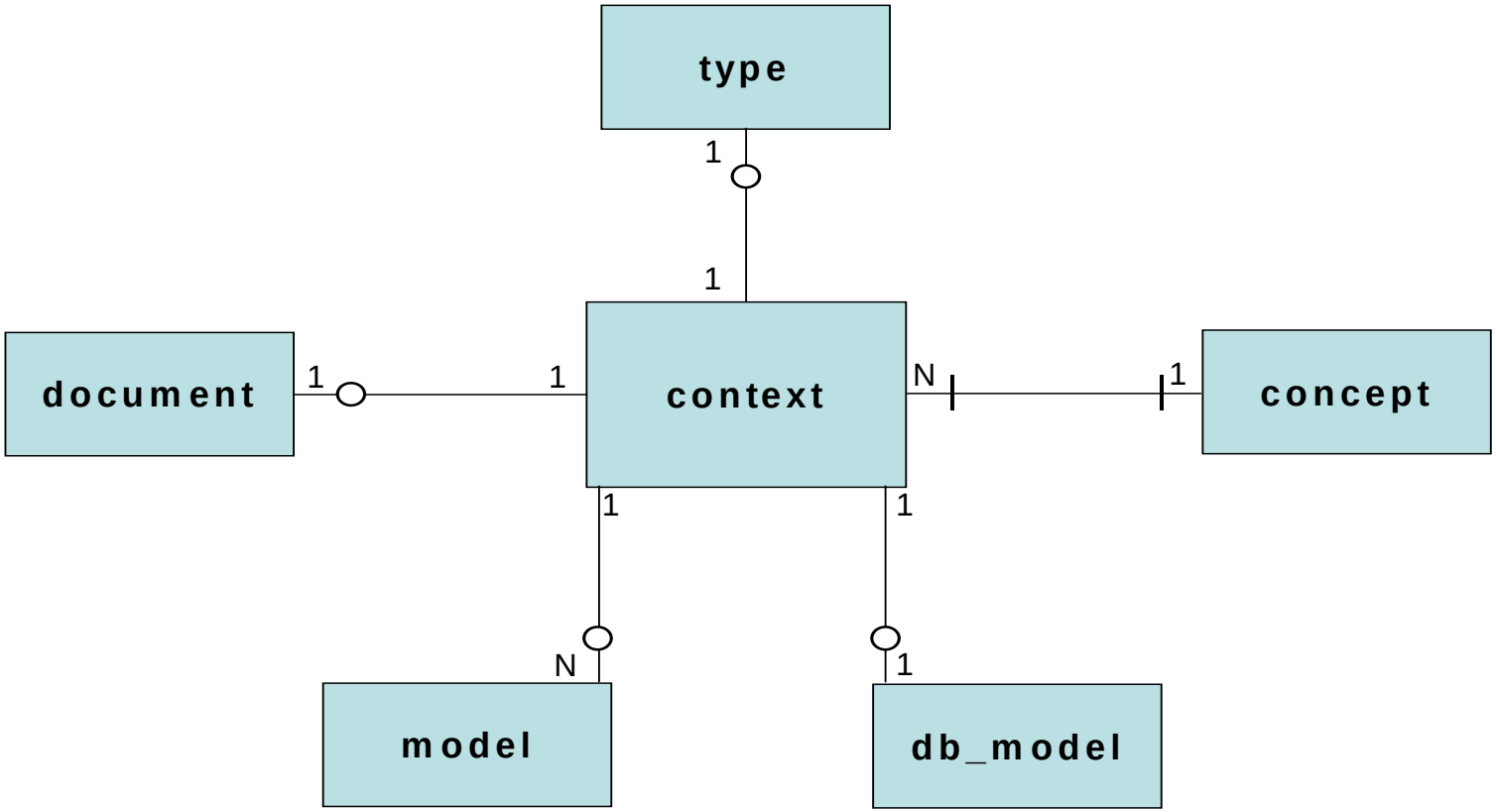
Logical Model Development (con't)

- Logical data models were developed for the following entities:
  - Decision
  - Type
  - Document
  - Model
  - Database model
  - Fr_link
  - Fa_link
  - At_link

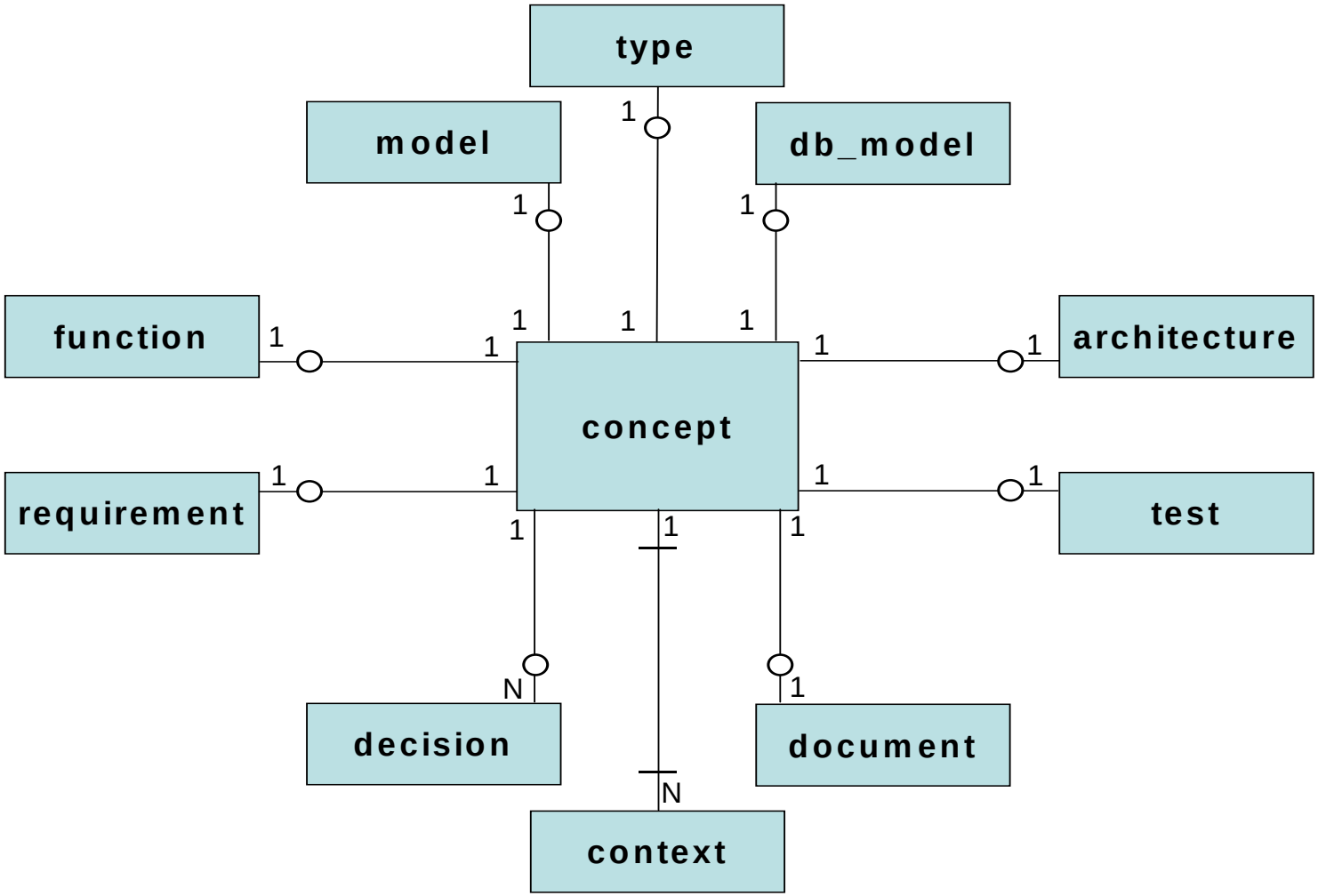
System ER Model



Context ER Model



Concept ER Model



Summary

- Flexible conceptual data model
- Can be applied and adapted to almost any type of system project
- Provides a connection to standard networked information system applications.
- Provides basis of automation of SE tasks and activities

Conclusions

- Standards-based SE tools, utilizing standard computer languages, reduce the risk of unsupported, unusable systems information data stores.
- The systems engineering information models developed in this work provide a foundation for a wide range of standards-based SE tools and data stores.

Next Steps

- Select components for the application server tier and client tier
- Design an incremental, spiral approach to the development of the application logic and data connection to the application server tier
- Incrementally develop and test application components.

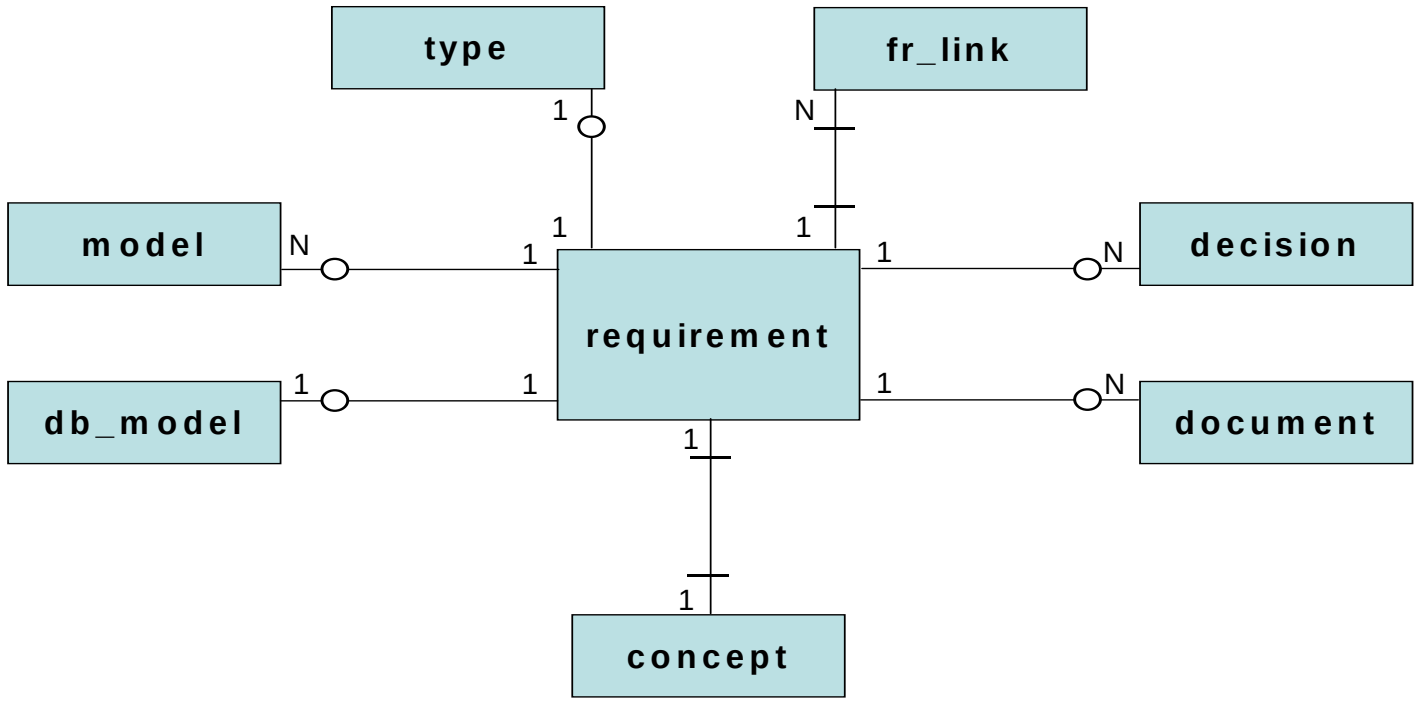
Questions?

Back Up Slides

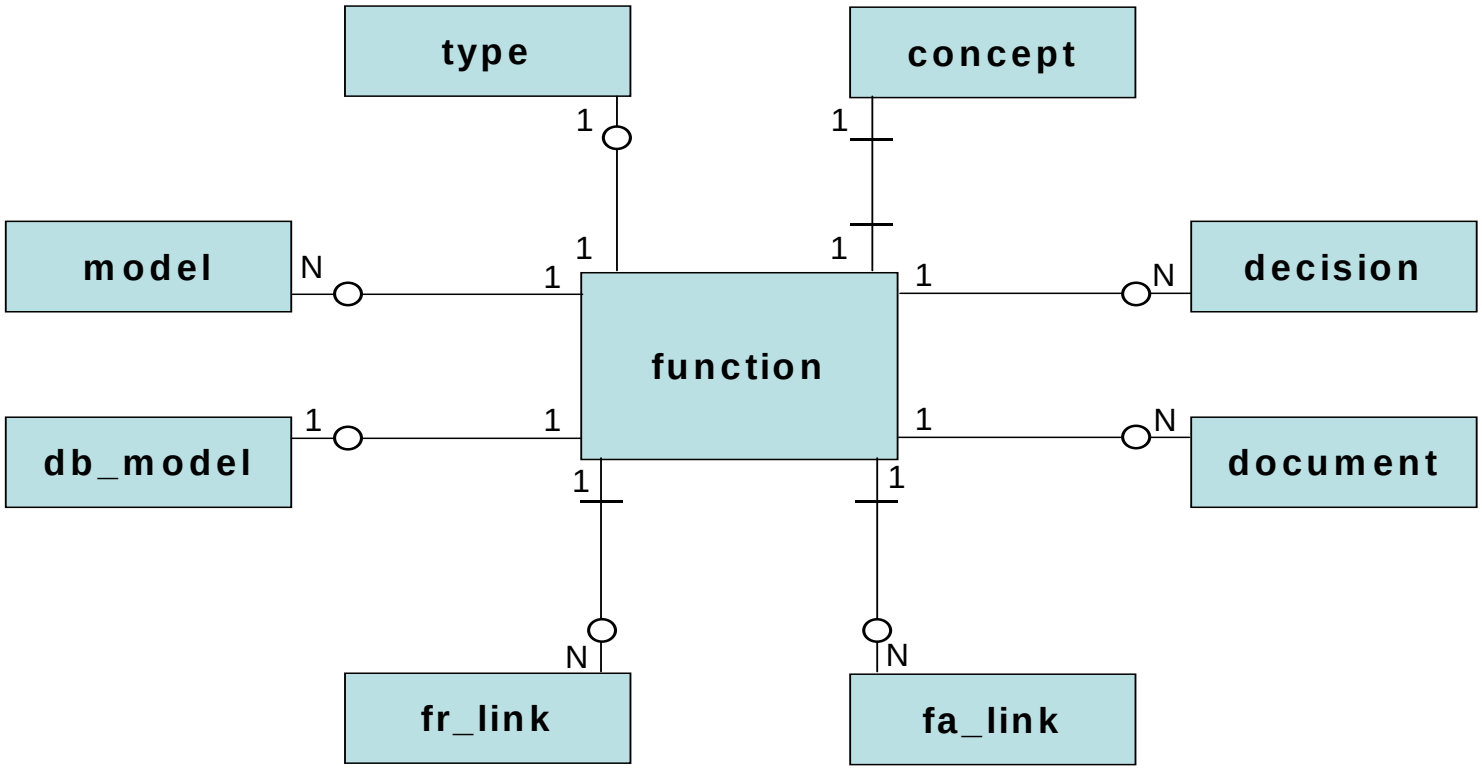
Acronyms and Abbreviations

- MIL-STD = Military Standard
- DoD-STD = Department of Defense Standard
- CFS = Critical Success Factors
- Op Need = Operational Need
- RDD-100 = Requirements Driven Design 100
- IDEF0 = Integration Definition for Function Modeling
- UML = Unified Modeling Language
- SYSML = Systems Engineering Modeling Language
- SQL = Structured Query Language
- ACID = Atomicity, Consistency, Isolation, Durability
- SE = Systems Engineering
- Fr_link = Function Requirement link table
- Fa_link = Function Architecture link table
- At_link = Architecture Test link table

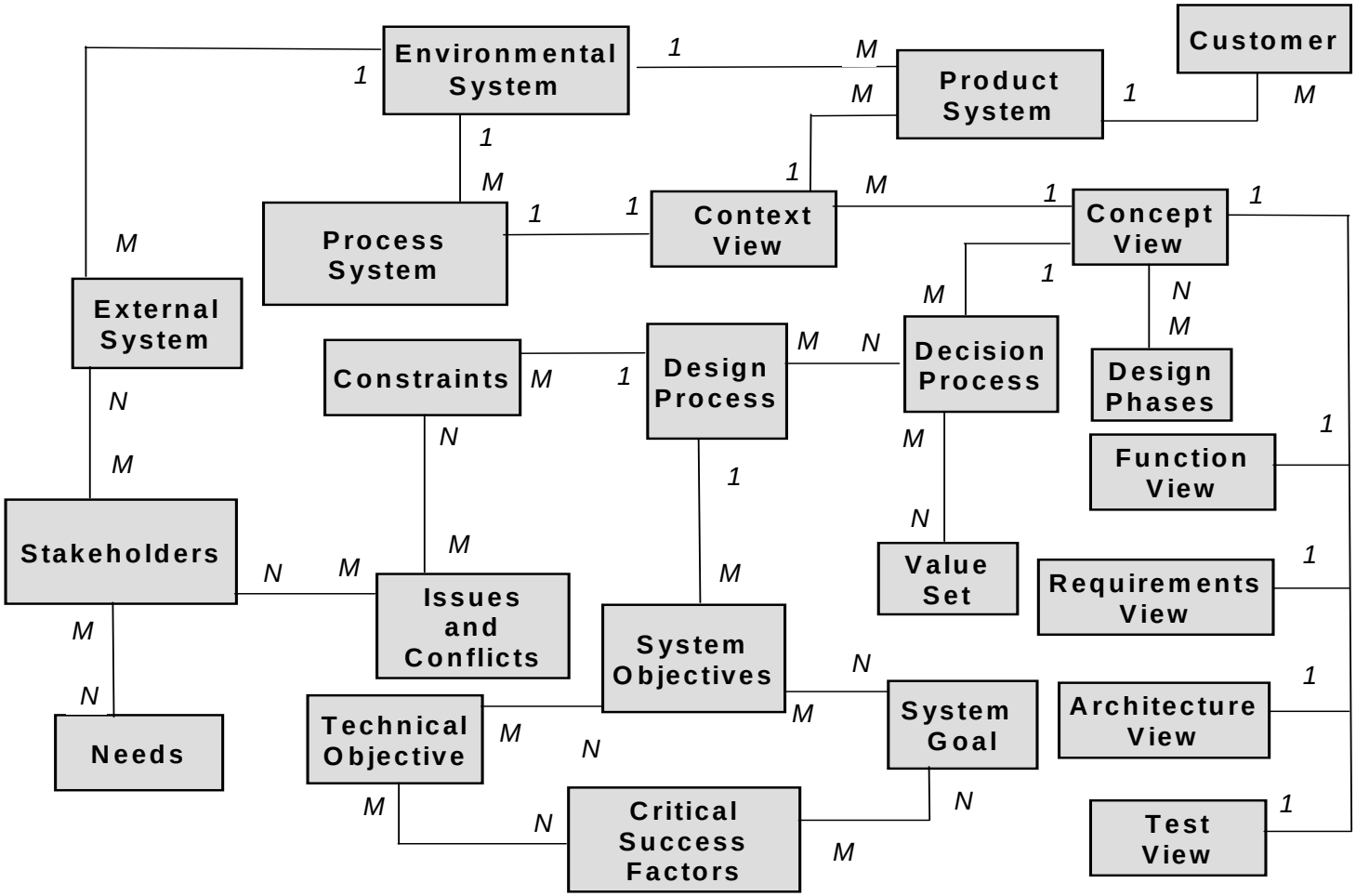
Requirements ER Model



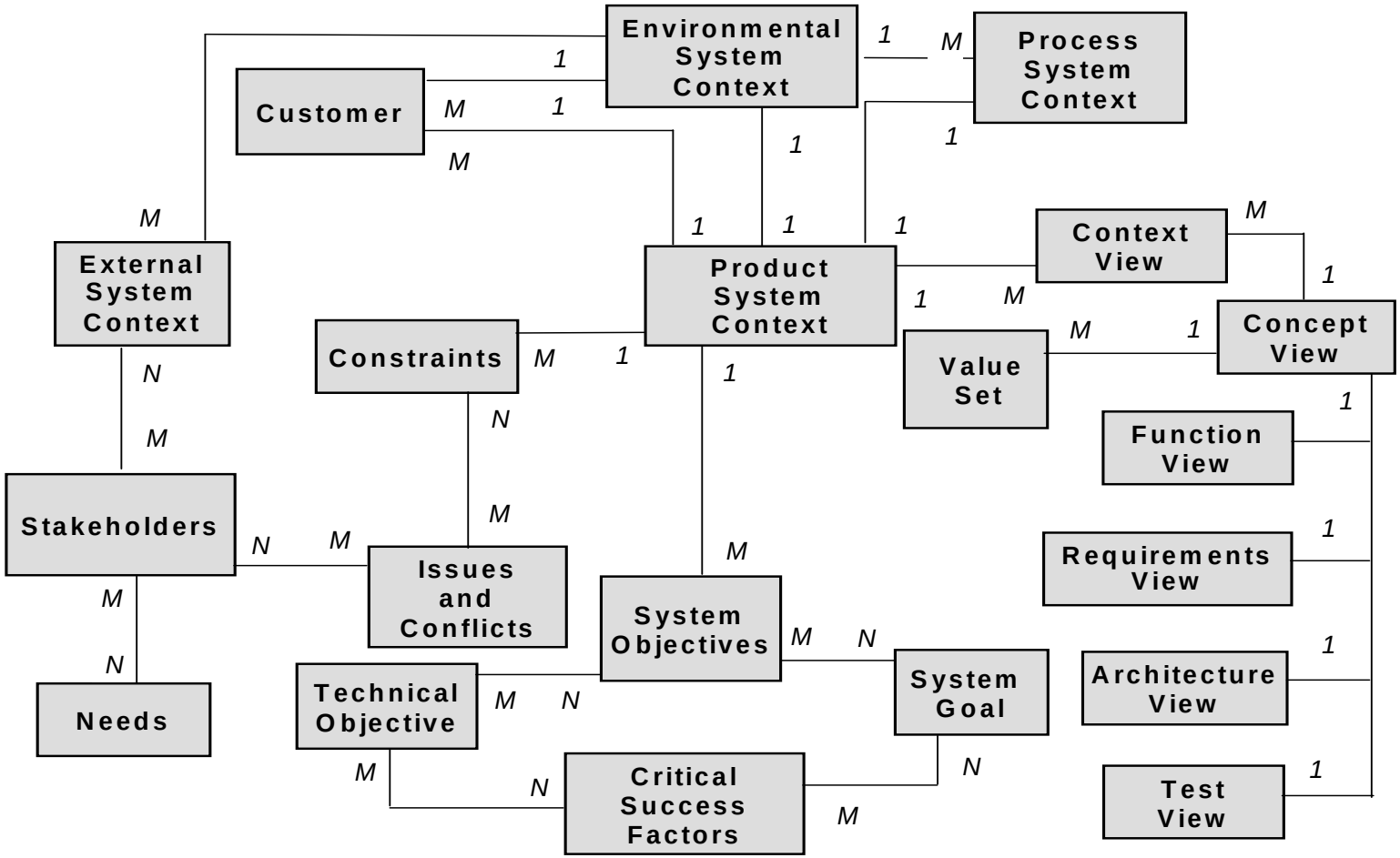
Function ER Model



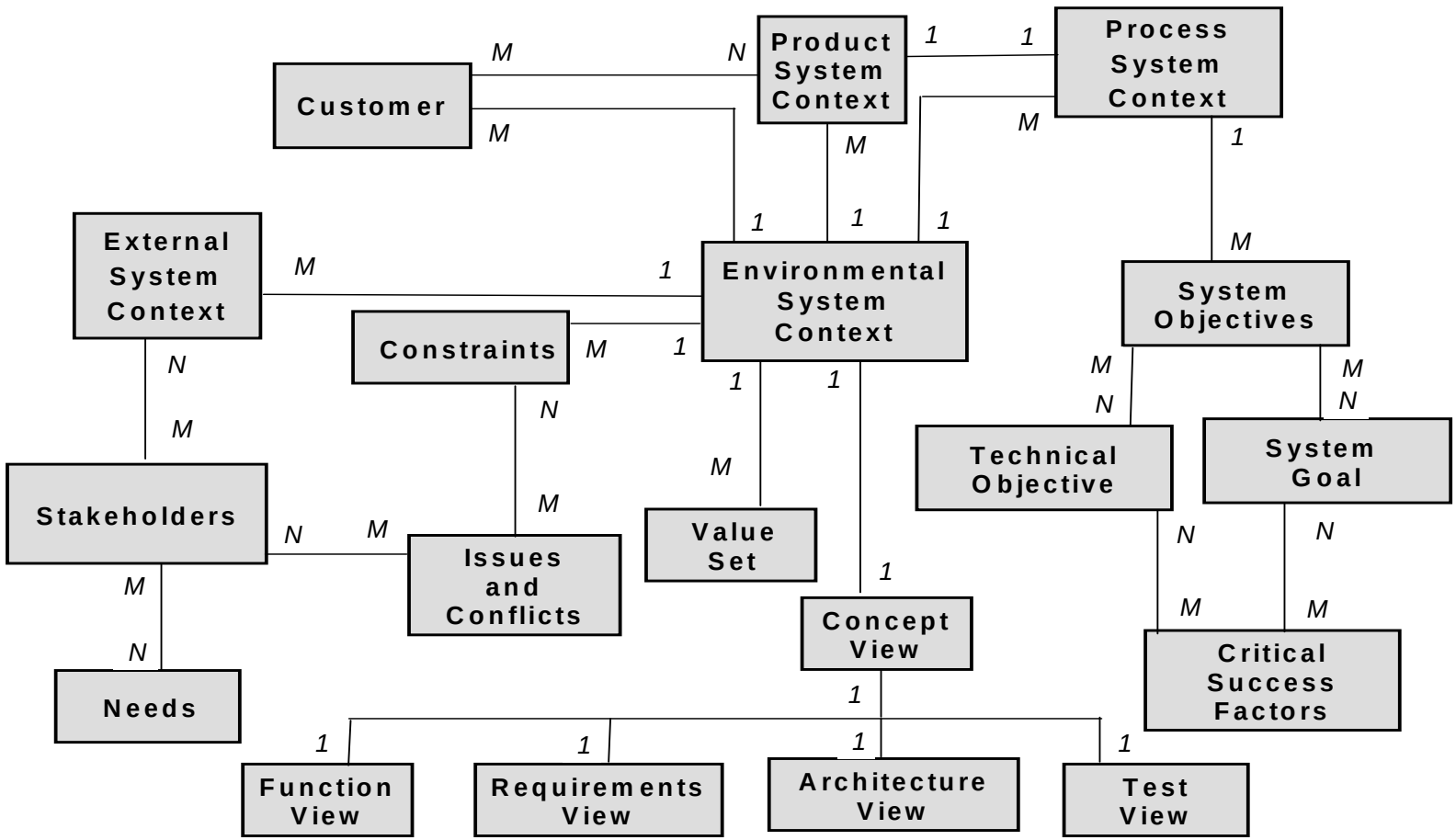
Process System Logical Model



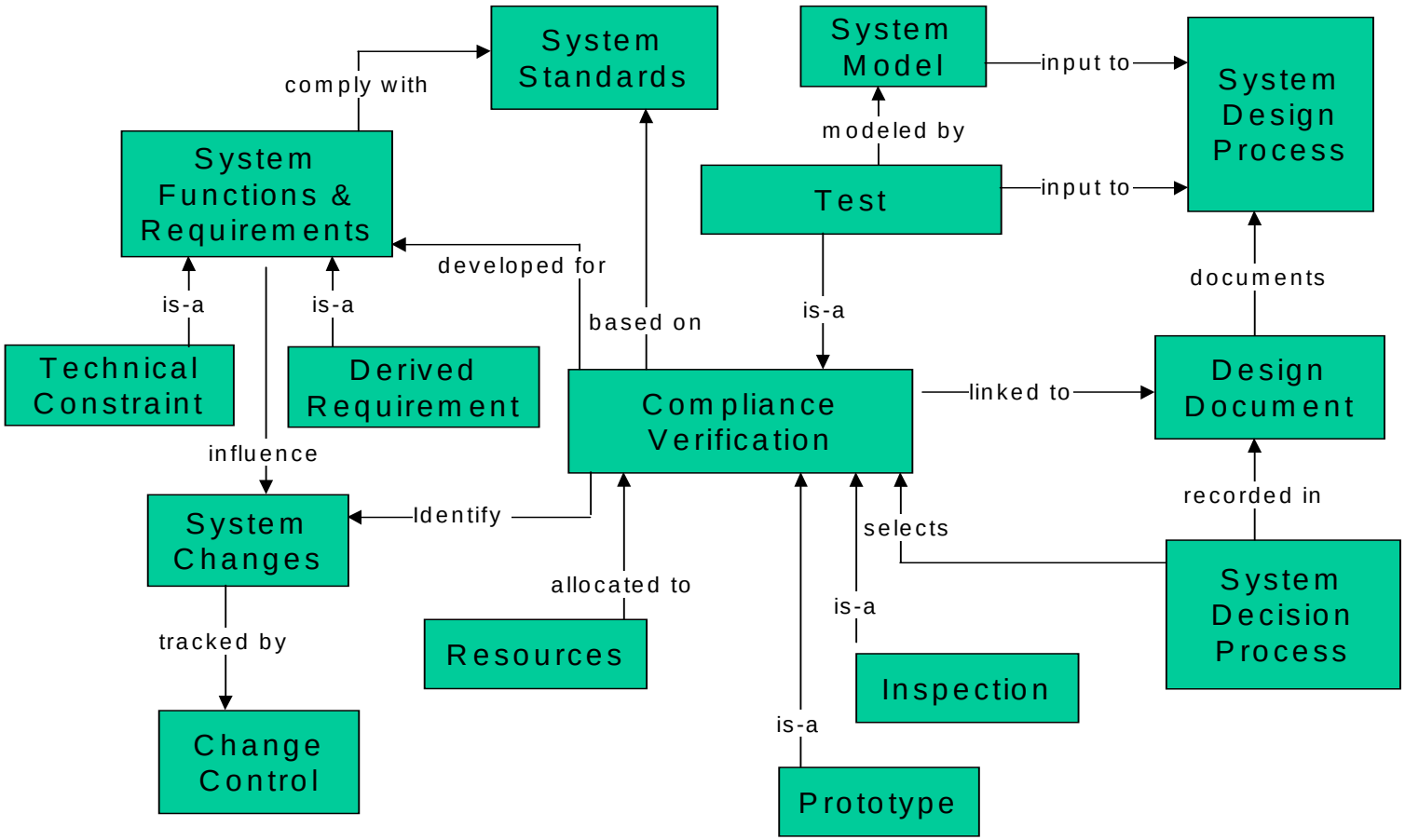
Product System Logical Model



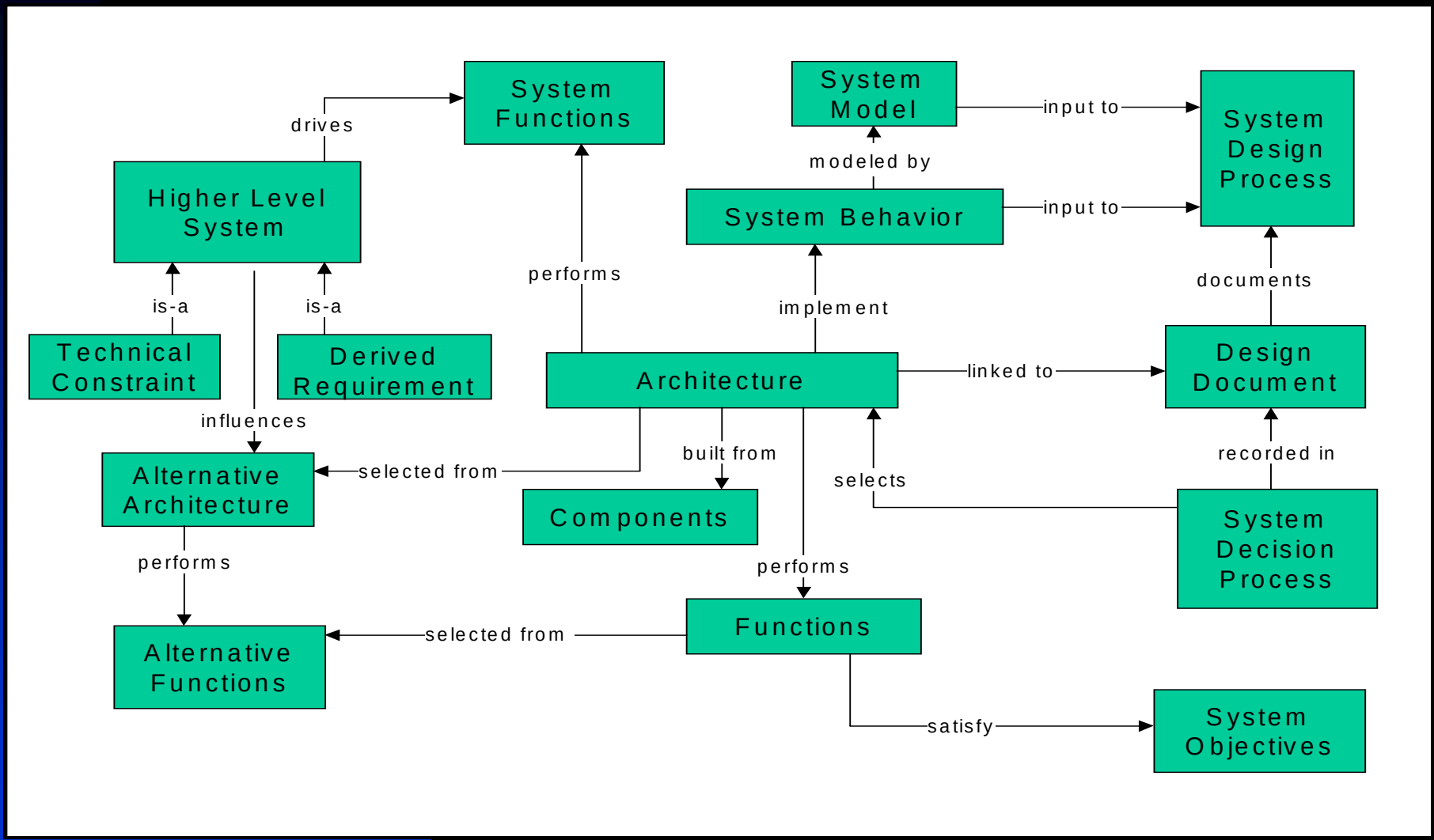
Environmental System Logical Model



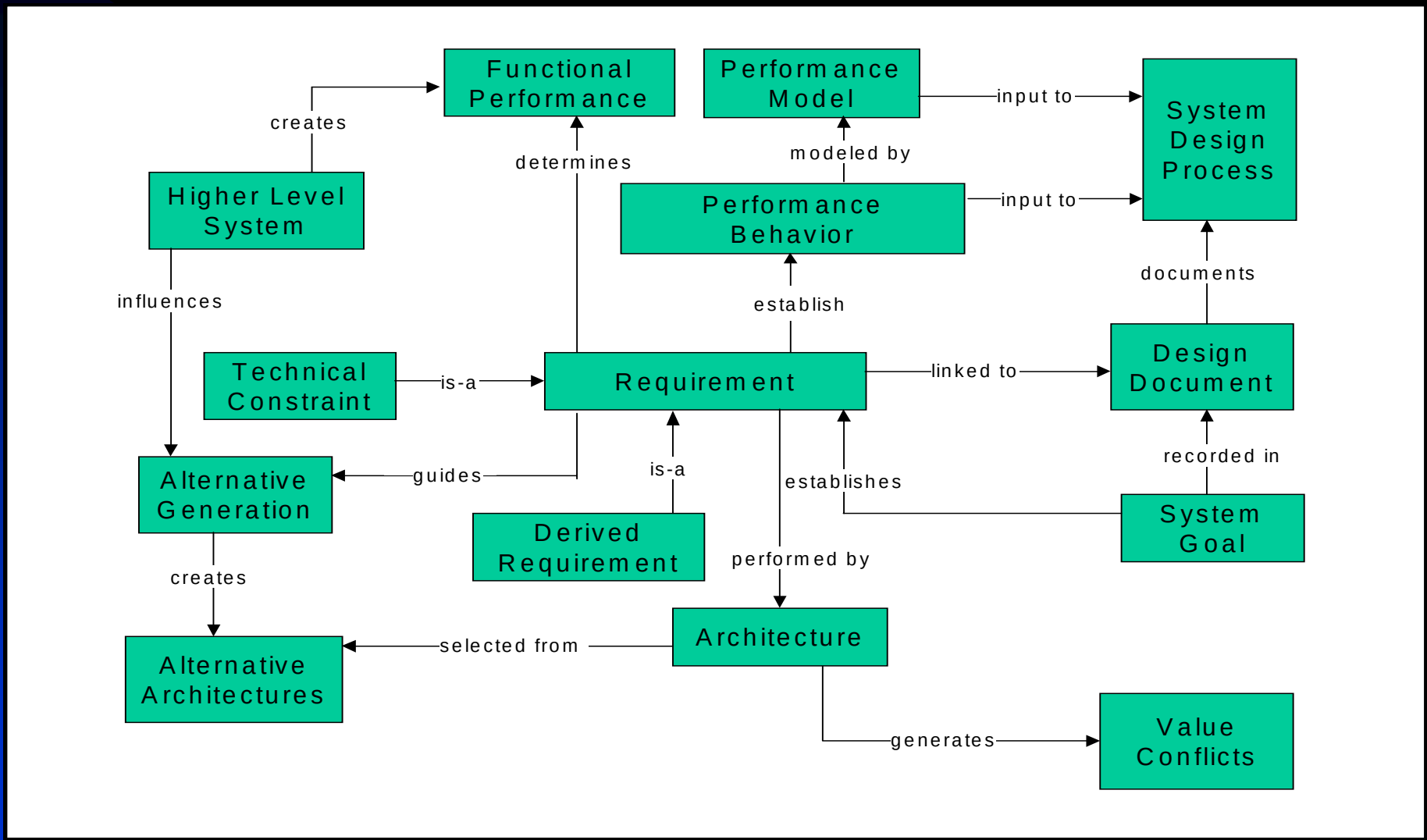
System Test View Data Model



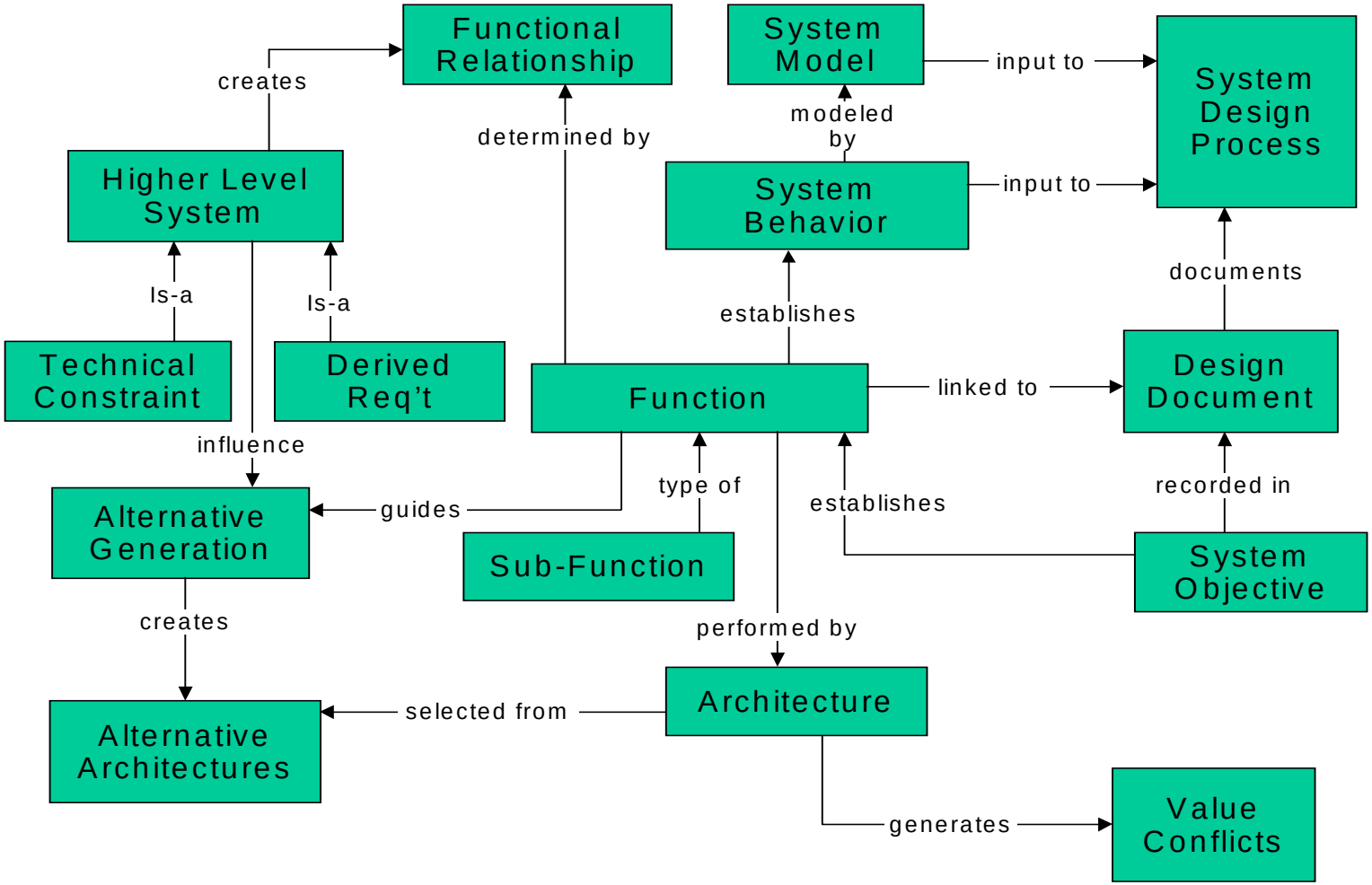
System Architecture View Data Model



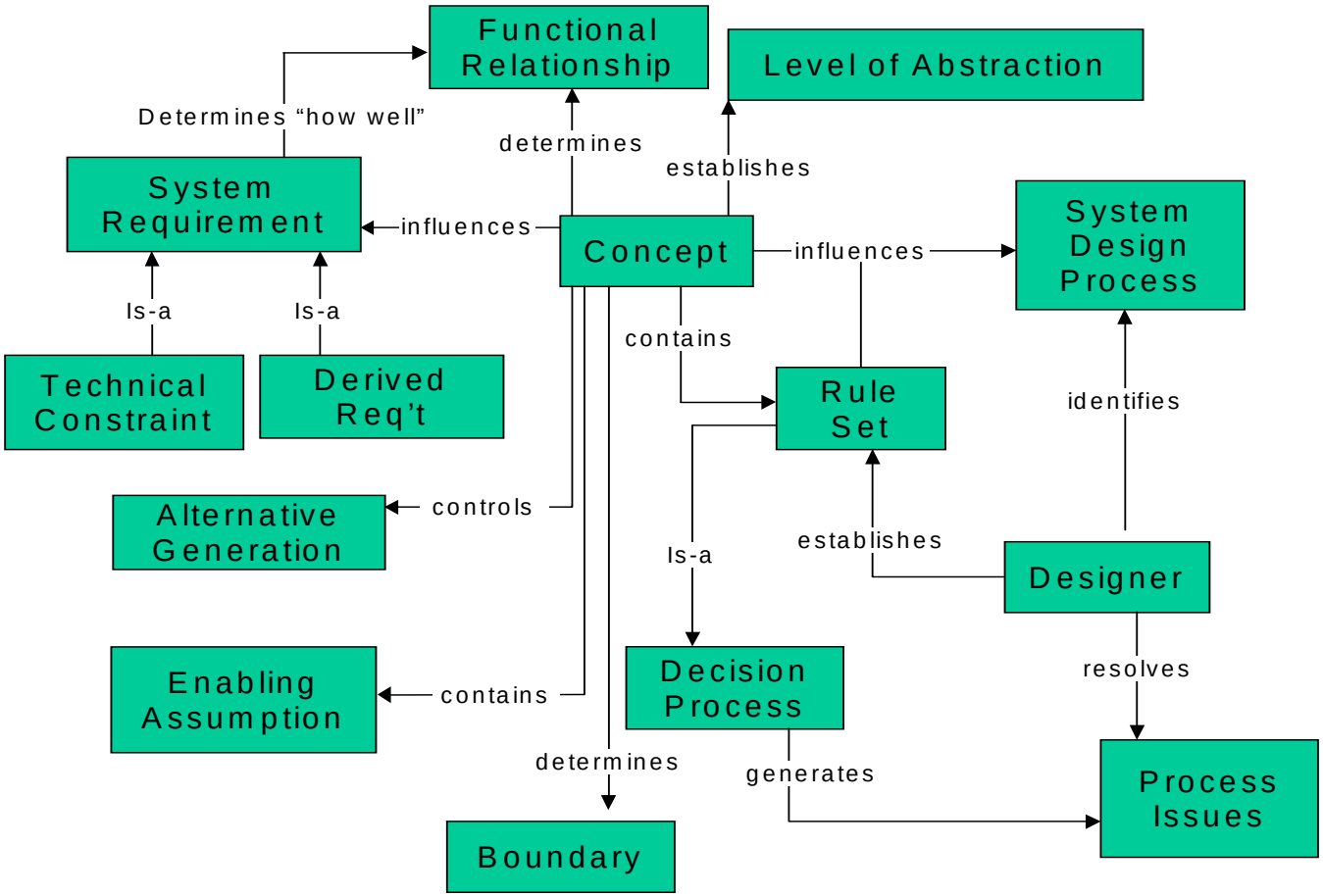
System Requirement View Data Model



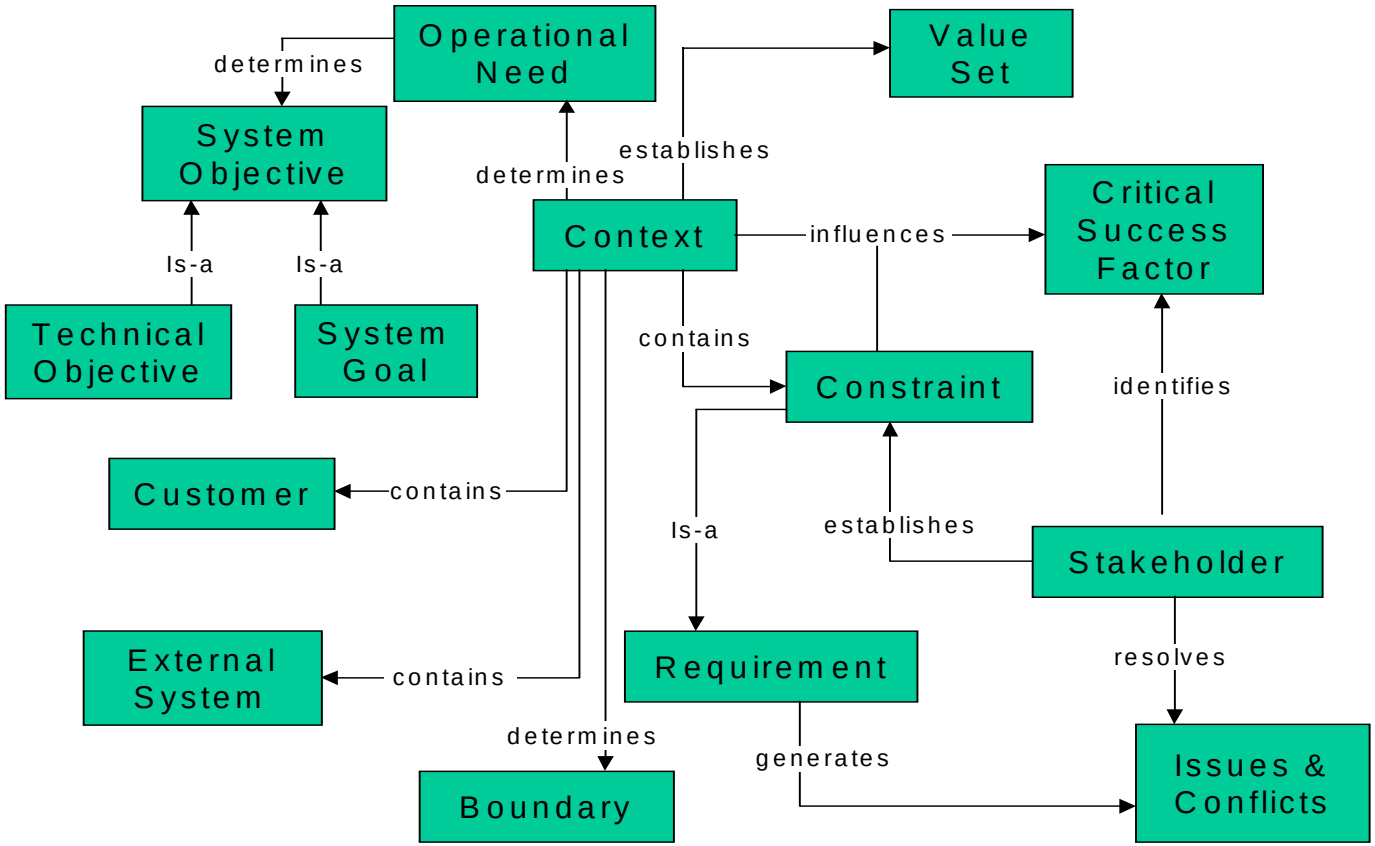
System Functional View Data Model



System Concept View Data Model



System Context View Data Model



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