Problem Framing:
Identifying the Right Models for the Job

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Enterprise Systems Engineering

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Model-Based Systems Engineering

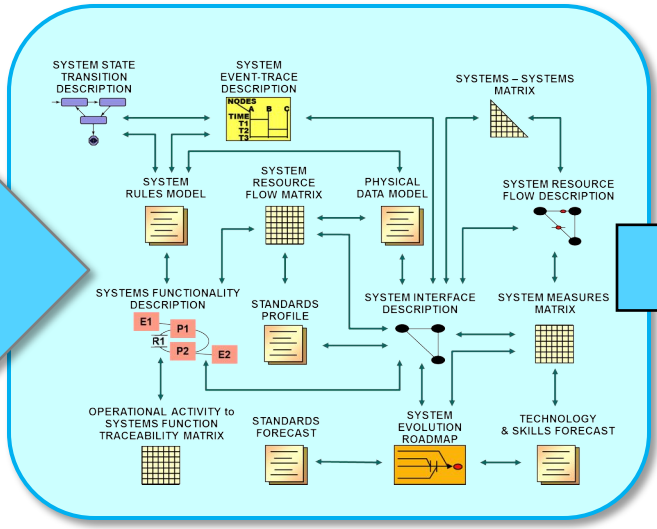
Traditional Systems Engineering

Documents:

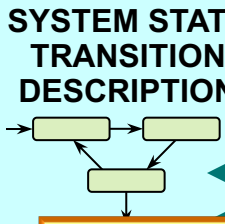
- ❑ Architecture
- ❑ Requirements
- ❑ Design
- ❑ Process
- ❑ Etcetera…

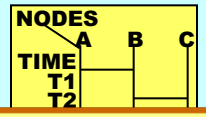
Design Engineering

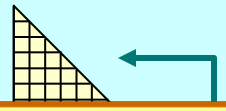
Model-Based Systems Engineering



Design Engineering

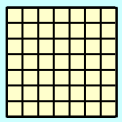


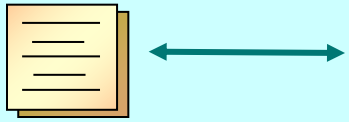


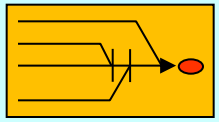


Benefits

- ✓ Greater Understanding of the Problem
- ✓ More Rapid Convergence on the Solution
- ✓ Better Communication of Architectural Intent
- ✓ Improved Evaluation of Suitability & Feasibility







All models are wrong
but some are useful

George E.P. Box

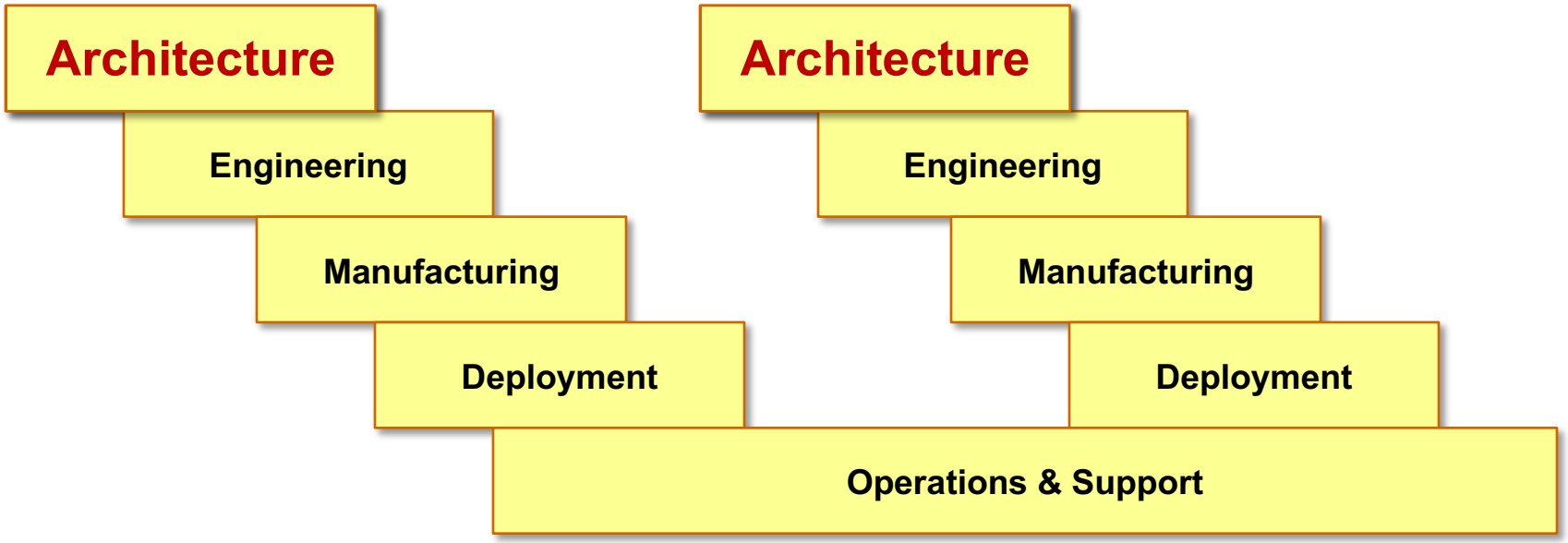
How to get “useful” models?

- Make sure that every Model can answer important Questions for key Stakeholders

- And the Answers they provide are
  - *Accurate (enough)*
  - *Timely*
  - *Insightful*

Models are Used Throughout the System Lifecycle

Architecture can build a good foundation for subsequent activities



The "Problem Framing" approach can be used to help identify the best models to use for your situation

Architecture Models

		Ways							Means							Ends		
		Behavior (Doing)					Links (Tying)		Resources (Being)							Results (Arriving)		
									Performers									
ID	Models	Activity	Event	Measure	Condition	Rule/Std	Relationships	Interactions	System	Service	Organization	Person / Skill	Materiel/Hw/Sw	Info / Data	Project / Task	Capability	Goal / Effect	Location
CV-1	Vision															x	x	
CV-2	Capability Taxonomy						x									x		
CV-3	Capability Phasing	x		x	x	x	x						x			x	x	
OV-1	High Level Operational Concept Graphic	x								x	x	x	o	o		x		x
OV-2	Operational Resource Flow Description	x						x	o	o	o	o	o	o				
OV-3	Operational Resource Flow Matrix							x	o	o	o	o	o	o				
OV-4	Organizational Relationships Chart						x				x	x						x
OV-5a	Operational Activity Decomposition Tree	x					x									x		
OV-5b	Operational Activity Model	x					x						o	o		x		
PV-1	Project Portfolio Relationships						x				x				x			
PV-2	Project Timelines		x				x								x			
PV-3	Project to Capability Mapping														x	x		
SvcV-1	Services Context Description							x		x			x	x				x
SvcV-2	Services Resource Flow Description							x		x			o	o				
SV-1	Systems Interface Description							x	x				x	x				x
SV-2	Systems Resource Flow Description							x	x				o	o				
SV-3	Systems-Systems Matrix						x		x									
SV-4	Systems Functionality Description	x							x					x				

52 Models in DODAF*

			Ways							Means							Ends		
			Behavior (Doing)					Links (Tying)		Resources (Being)							Results (Arriving)		
										Performers									
VP	ID	Models	Activity	Event	Measure	Condition	Rule/Std	Relationships	Interactions	System	Service	Organization	Person / Skill	Materiel/Hw/Sw	Info / Data	Project / Task	Capability	Goal / Effect	Location
All VP	AV-1	Overview and Summary Information	x	x	x	x										x		x	
	AV-2	Integrated Dictionary	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Capability Viewpoint	CV-1	Vision															x	x	
	CV-2	Capability Taxonomy						x									x		
	CV-3	Capability Phasing	x		x	x	x	x						x			x	x	
	CV-4	Capability Dependencies						x									x		
	CV-5	Capability to Org Development Mapping						x		x	x	x	x				x		x
	CV-6	Capability to Opnl Activities Mapping	x														x		
	CV-7	Capability to Services Mapping									x						x		
Data & Info VP	DIV-1	Conceptual Data Model													x				
	DIV-2	Logical Data Model					x								x				
	DIV-3	Physical Data Model													x				
Operational Viewpoint	OV-1	High Level Operational Concept Graphic	x								x	x	x	o	o		x		x
	OV-2	Operational Resource Flow Description	x						x	o	o	o	o	o	o				
	OV-3	Operational Resource Flow Matrix							x	o	o	o	o	o	o				
	OV-4	Organizational Relationships Chart						x				x	x						x
	OV-5a	Operational Activity Decomposition Tree	x					x									x		
	OV-5b	Operational Activity Model	x					x						o	o		x		
	OV-6a	Operational Rules Model	x	x			x												x
	OV-6b	State Transition Description	x	x		x												x	
	OV-6c	Event-Trace Description	x	x				x											
Project VP	PV-1	Project Portfolio Relationships						x				x				x			
	PV-2	Project Timelines		x				x								x			
	PV-3	Project to Capability Mapping														x	x		
Stds VP	StdV-1	Standards Profile		x			x			x	x			x	x				
	StdV-2	Standards Forecast					x			x	x			x	x				
Services Viewpoint	SvcV-1	Services Context Description							x		x			x	x				x
	SvcV-2	Services Resource Flow Description							x		x			o	o				
	SvcV-3a	Systems-Services Matrix						x		x	x								
	SvcV-3b	Services-Services Matrix						x			x								
	SvcV-4	Services Functionality Description	x								x				x				
	SvcV-5	Opnl Activity to Services Trace Matrix	x								x								
	SvcV-6	Services Resource Flow Matrix							x		x			o	o				
	SvcV-7	Services Measures Matrix			x						x								
	SvcV-8	Services Evolution Description		x				x			x								x
	SvcV-9	Services Technology & Skills Forecast									x		x	x					
	SvcV-10a	Services Rules Model		x			x				x								x
	SvcV-10b	Services State Transition Description		x		x					x							x	
	SvcV-10c	Services Event-Trace Description		x				x			x								
Systems Viewpoint	SV-1	Systems Interface Description							x	x				x	x				x
	SV-2	Systems Resource Flow Description							x	x				o	o				
	SV-3	Systems-Systems Matrix						x		x									
	SV-4	Systems Functionality Description	x							x					x				
	SV-5a	Opnl Activity to Sys Func Trace Matrix	x							x									
	SV-5b	Opnl Activity to Systems Trace Matrix	x							x									
	SV-6	Systems Resource Flow Matrix							x	x				o	o				
	SV-7	Systems Measures Matrix			x					x									
	SV-8	Systems Evolution Description		x				x		x									x
	SV-9	Systems Technology & Skills Forecast								x			x	x					
	SV-10a	Systems Rules Model		x			x			x									x
	SV-10b	Systems State Transition Description		x		x				x								x	
	SV-10c	Systems Event-Trace Description		x				x		x									

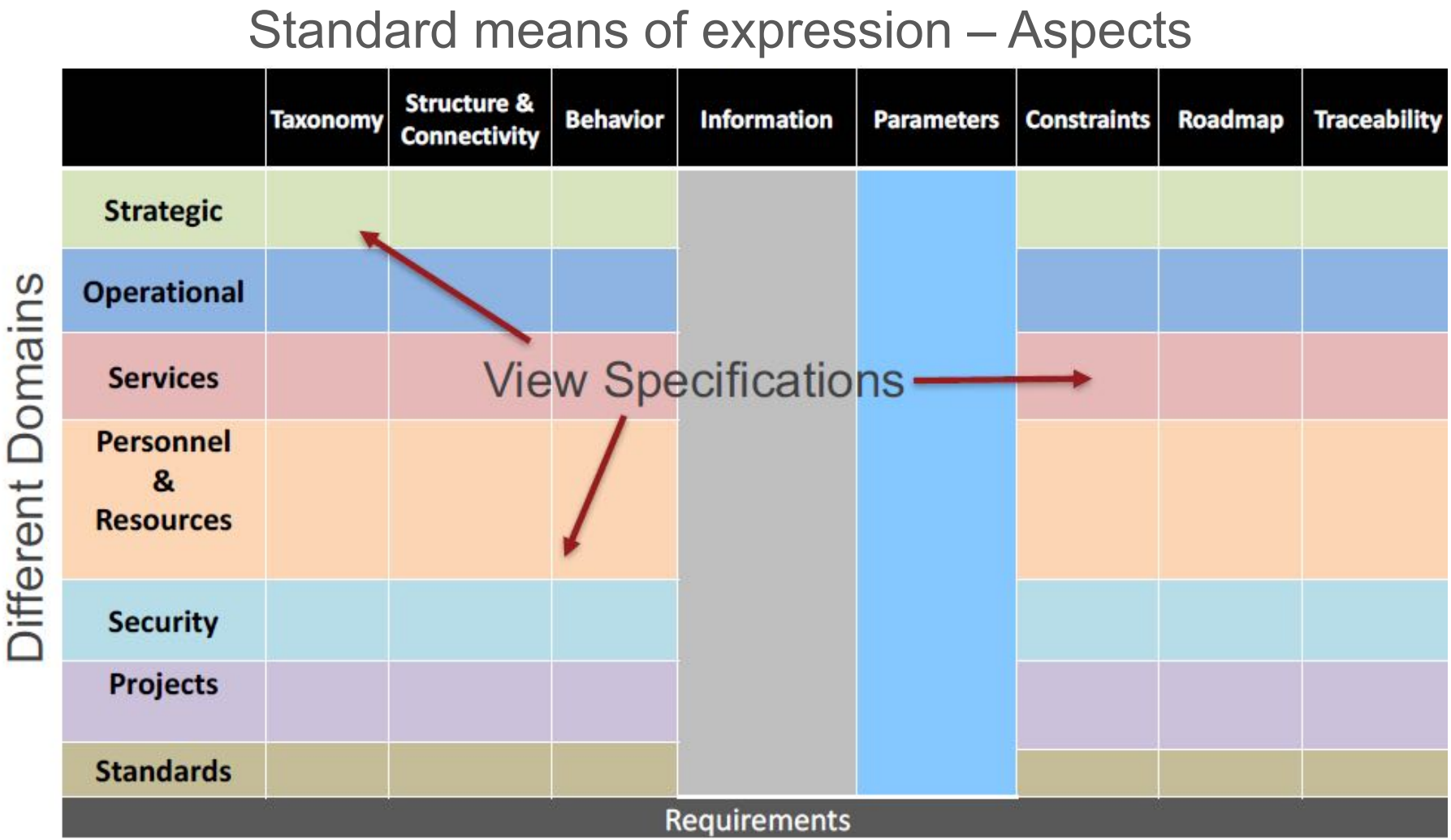
x = item depicted in this model, o = flow item depicted in this model

How do we choose the right models?

* *DOD Architecture Framework*

The Unified Architecture Framework (UAF)

UAF organizes its Architecture Views in a "matrix"-like grid



Structured as an 8 x 8 grid matrix (with Domain rows & Aspect columns)

UAF Views

71!

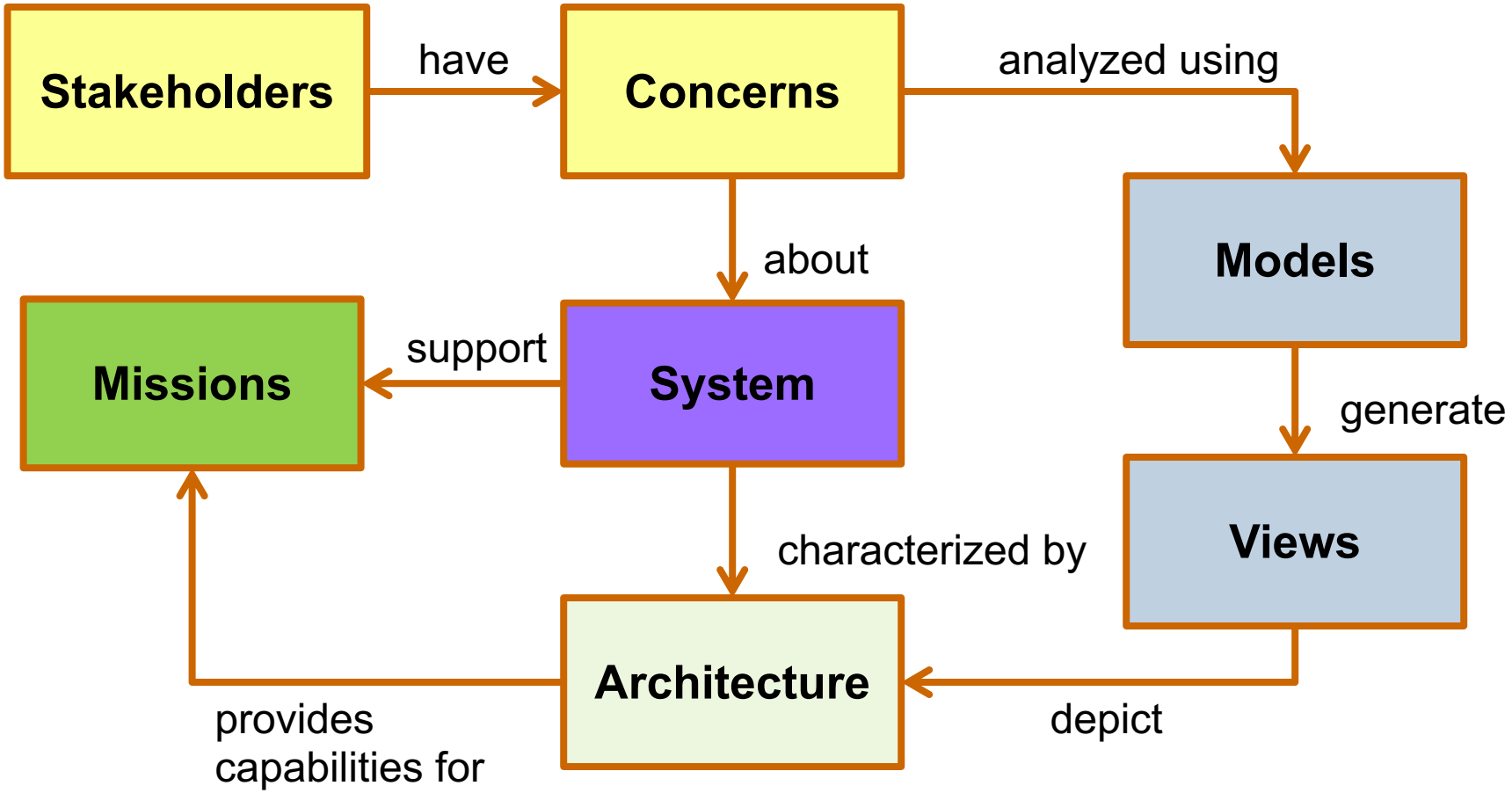
UAF	Taxonomy Tx	Structure Sr	Connectivity Cn	Processes Pr	States St	Interaction Scenarios Is	Information If	Parameters Pm	Constraints Ct	Roadmap Rm	Traceability Tr
Metadata Md	Metadata Taxonomy Md-Tx	Architecture Viewpoints [a] Md-Sr	Metadata Connectivity Md-Cn	Metadata Processes [a] Md-Pr							Metadata Traceability Md-Tr
Strategic St	Strategic Taxonomy St-Tx	Strategic Structure St-Sr	Strategic Connectivity St-Cn	-	Strategic States St-St	-			Strategic Constraints St-Ct	Strategic Deployment, St-Rm Strategic Phasing St-Rm	Strategic Traceability St-Tr
Operational Op	Operational Taxonomy Op-Tx	Operational Structure Op-Sr	Operational Connectivity Op-Cn	Operational Processes Op-Pr	Operational States Op-St	Operational Interaction Scenarios Op-Is			Operational Constraints Op-Ct	-	Operational Traceability Op-Tr
Services Sv	Service Taxonomy Sv-Tx	Service Structure Sv-Sr	Service Connectivity Sv-Cn	Service Processes Sv-Pr	Service States Sv-St	Service Interaction Scenarios Sv-Is	Conceptual Data Model,	Environment Pm-En	Service Constraints Sv-Ct	Service Roadmap Sv-Rm	Service Traceability Sv-Tr
Personnel Pr	Personnel Taxonomy Pr-Tx	Personnel Structure Pr-Sr	Personnel Connectivity Pr-Cn	Personnel Processes Pr-Pr	Personnel States Pr-St	Personnel Interaction Scenarios Pr-Is	Logical Data Model,		Competence, Drivers, Performance Pr-Ct	Personnel Availability, Personnel Evolution, Personnel Forecast Pr-Rm	Personnel Traceability Pr-Tr
Resources Rs	Resource Taxonomy Rs-Tx	Resource Structure Rs-Sr	Resource Connectivity Rs-Cn	Resource Processes Rs-Pr	Resource States Rs-St	Resource Interaction Scenarios Rs-Is	Physical Data Model	Measurements Pm-Me	Resource Constraints Rs-Ct	Resource evolution, Resource forecast Rs-Rm	Resource Traceability Rs-Tr
Security Sc	Security Taxonomy Sc-Tx	Security Structure Sc-Sr	Security Connectivity Sc-Cn	Security Processes Sc-Pr	-	-			Security Constraints Sc-Ct	-	Security Traceability Sc-Tr
Projects Pj	Project Taxonomy Pj-Tx	Project Structure Pj-Sr	Project Connectivity Pj-Cn	-	-	-			-	Project Roadmap Pj-Rm	Project Traceability Pj-Tr
Standards Sd	Standard Taxonomy Sd-Tx	Standards Structure Sd-Sr	-	-	-	-			-	Standards Roadmap Sd-Rm	Standards Traceability Sd-Tr
Actuals Resources Ar		Actual Resources Structure, Ar-Sr	Actual Resources Connectivity, Ar-Cn	Simulation [b]					Parametric Execution/ Evaluation [b]	-	-

Dictionary * Dc

Summary & Overview Sm-Ov

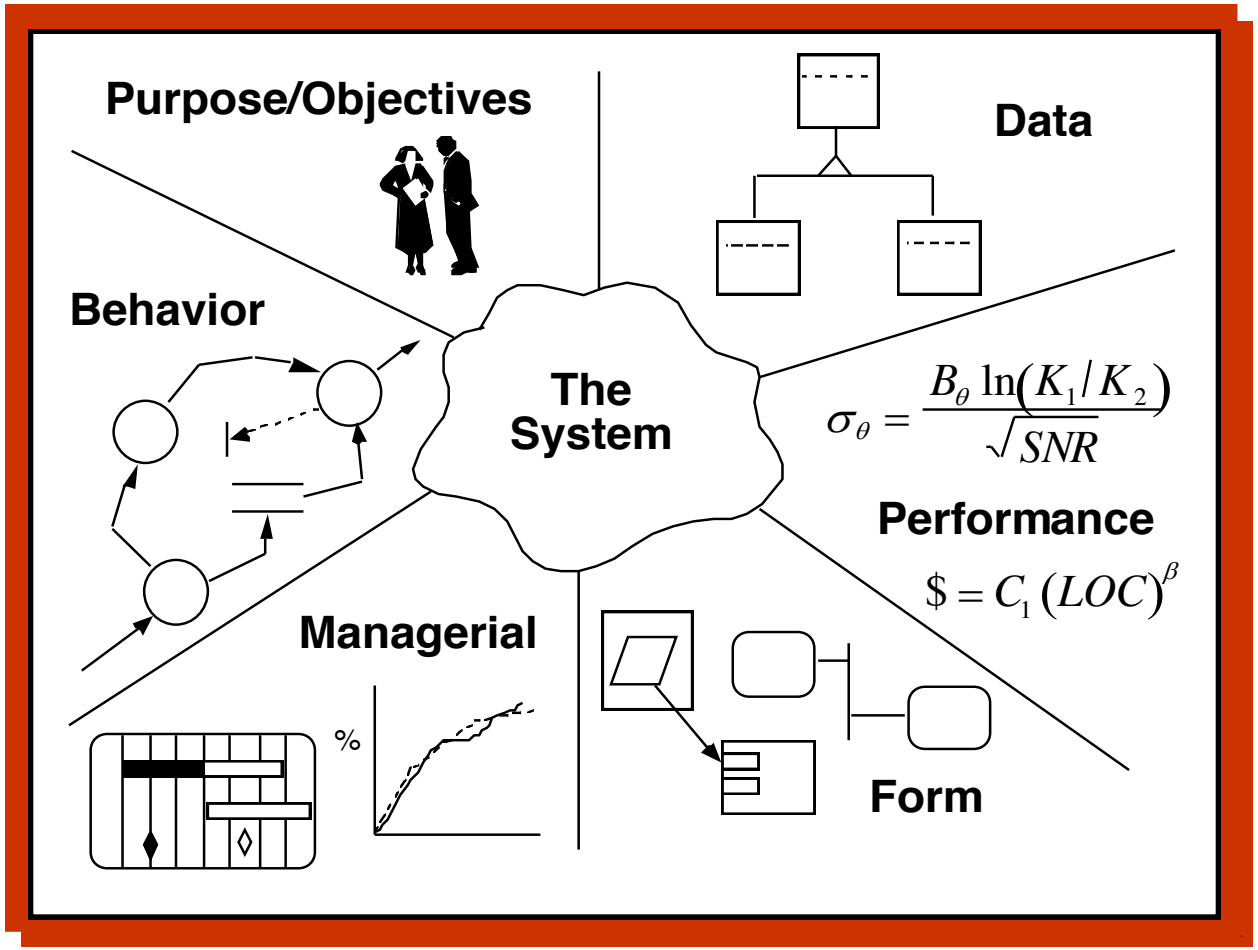
Requirements Req

Stakeholders & their Concerns should Drive the Architecture



Categories of Stakeholder Concerns

A Way to Partition the Problem into Smaller Chunks



SOURCE: Rechtin and Maier, "The Art of Systems Architecting"

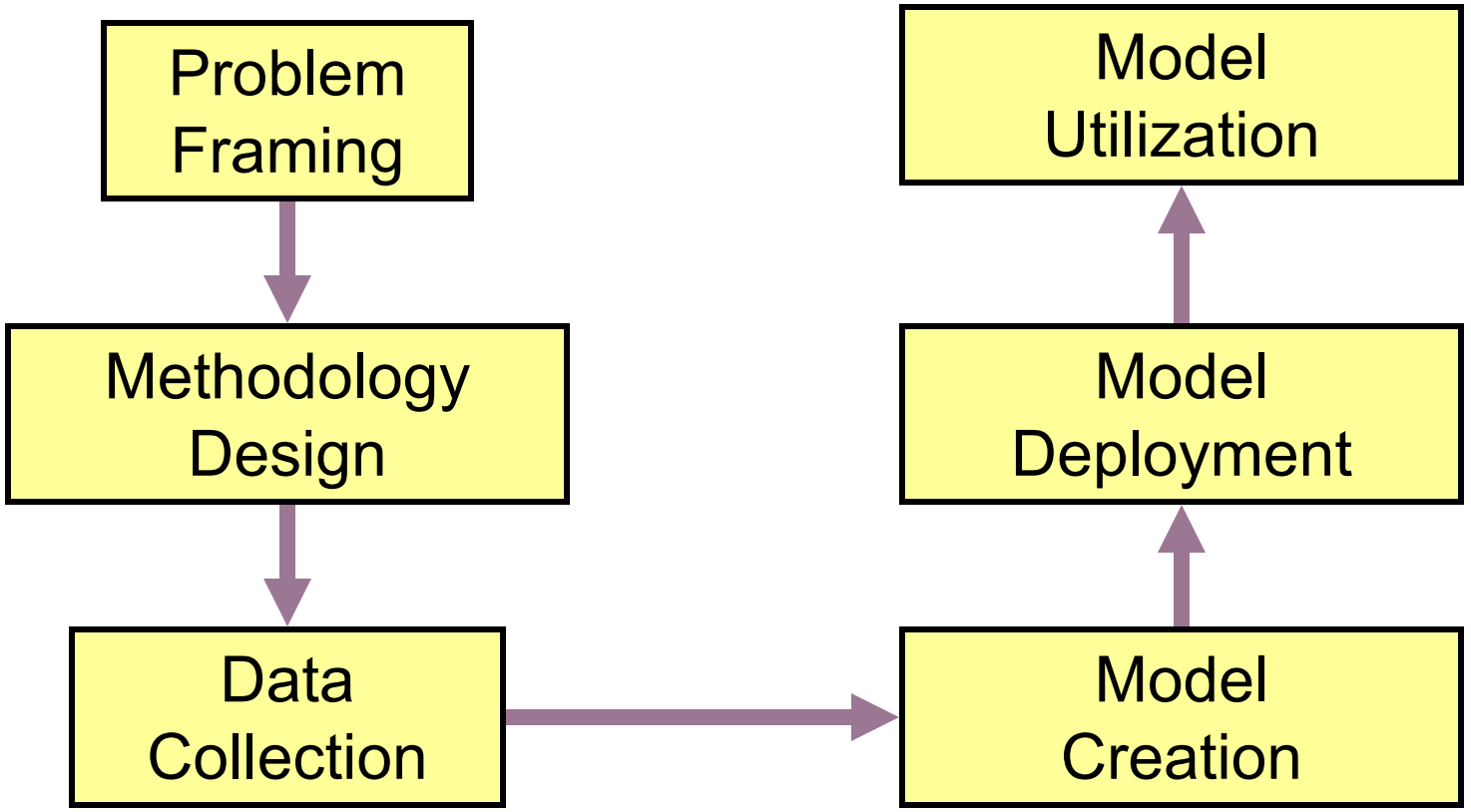
Many Kinds of Stakeholders & Concerns

- **Example Stakeholders:** users, operators, maintainers, owners, sponsors, acquirers, developers, builders, integrators, suppliers, industrial base, labor force, third parties (eg, environmental impacts), evaluators, policy makers, certification authorities, auditors, etc.

- **Example Concerns:** affordability, agility, alignment with business goals and strategies, assurance, autonomy, availability, behaviour, business impact, capability, complexity, compliance to regulation, concurrency, control, cost, customer experience, data accessibility, deadlock, disposability, evolvability, feasibility, flexibility, functionality, information assurance, interoperability, inter-process communication, known limitations, maintainability, mission impact, misuse, modifiability, modularity, openness, performance, privacy, quality of service, reliability, resilience, resource utilization, schedule, security, shortcomings, state change, structure, subsystem integration, system features, system properties, system purposes, usability, usage, viability, etc.

The Six-Step Process for Model Development

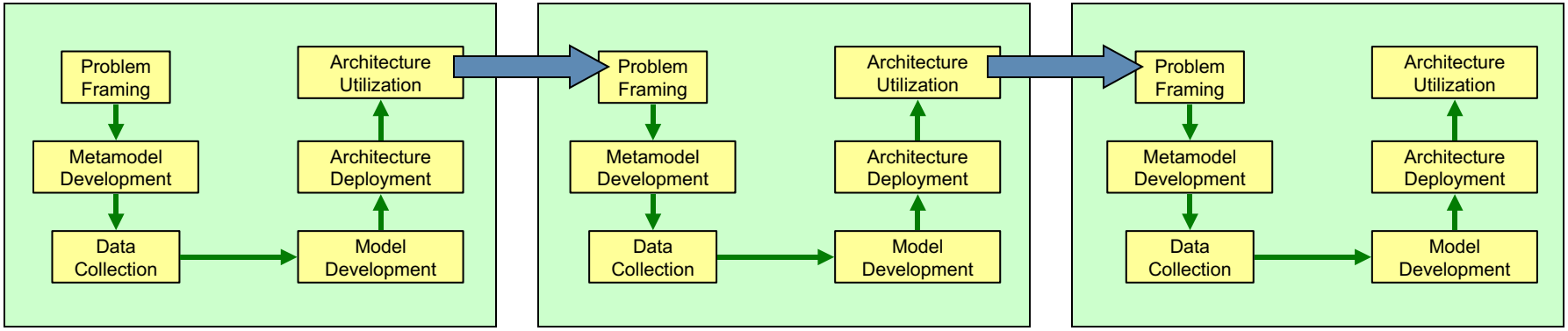
Based on common practice in the Enterprise Architecture domain



Provides structured way of building the right models and getting maximum utility

Multiple Sprints Using the Agile Approach

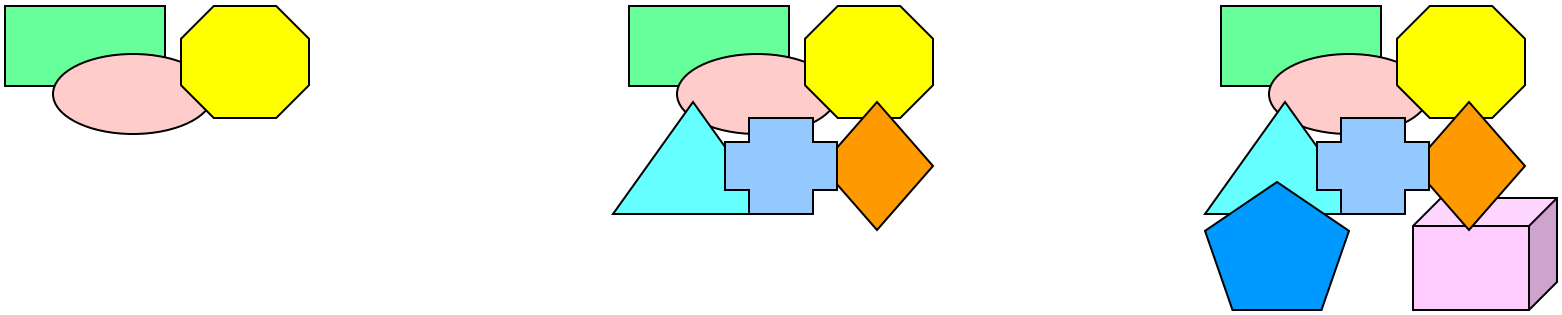
Creating useful results early and often…



Architecture Version 1

Architecture Version 2

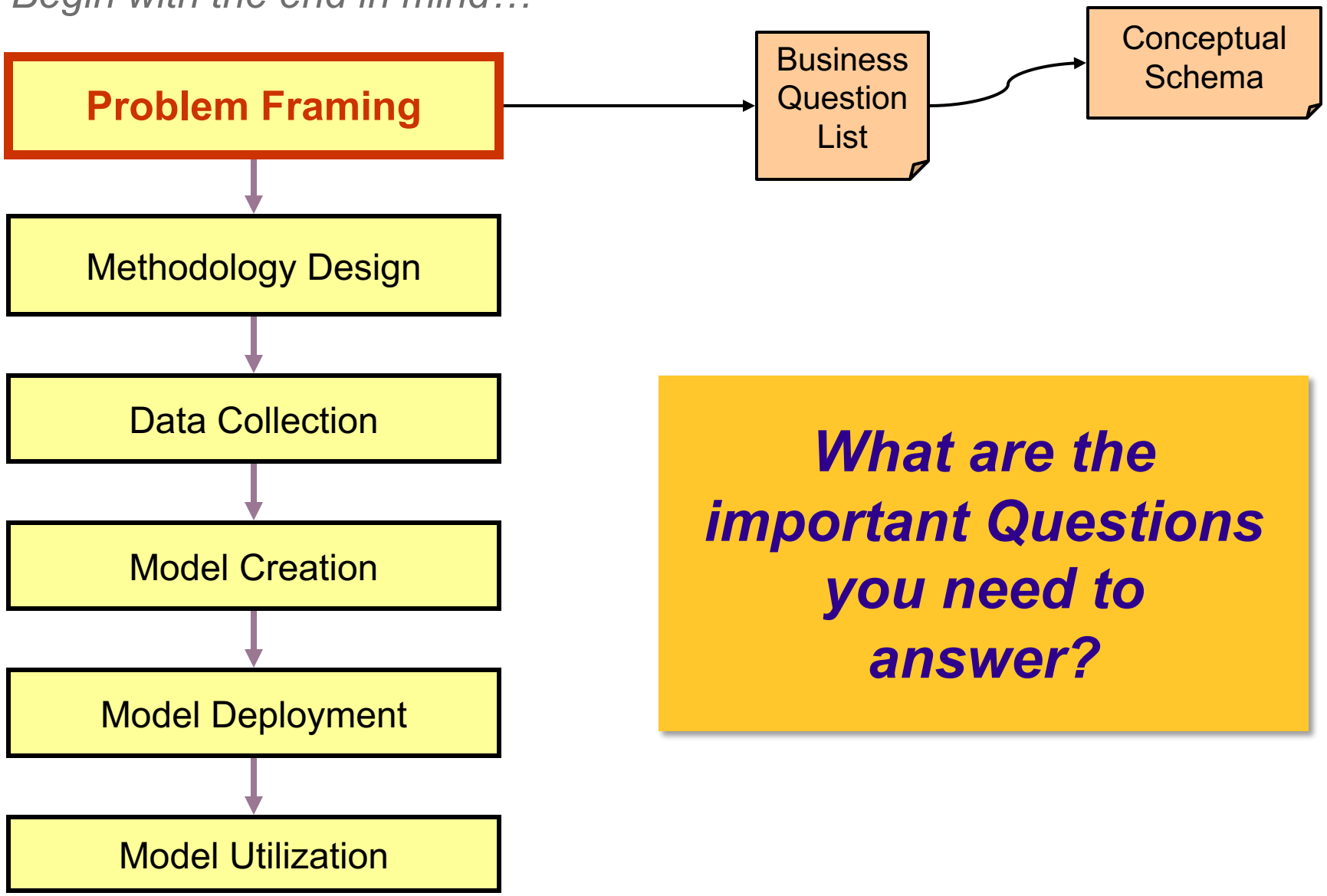
Architecture Version 3



Learning through each cycle of the process

Step 1: Problem Framing

Begin with the end in mind…



What are the important Questions you need to answer?

National Oceanic and Atmospheric Administration

Weather

Watches, warnings, floods, hurricanes, Weather Radio...

Ocean

Coral reefs, tides, currents, buoys, marine sanctuaries, estuaries, diving, spills

Satellites

Real-time imagery, environmental, geostationary and polar satellites

Fisheries

Protecting marine mammals, sea turtles, habitats, statistics, economics, enforcement

Climate

El Niño & La Niña, global warming, drought, climate prediction, archived weather data, paleoclimatology

Research

Environmental labs, air quality, atmospheric processes, climate and human interactions

Coasts

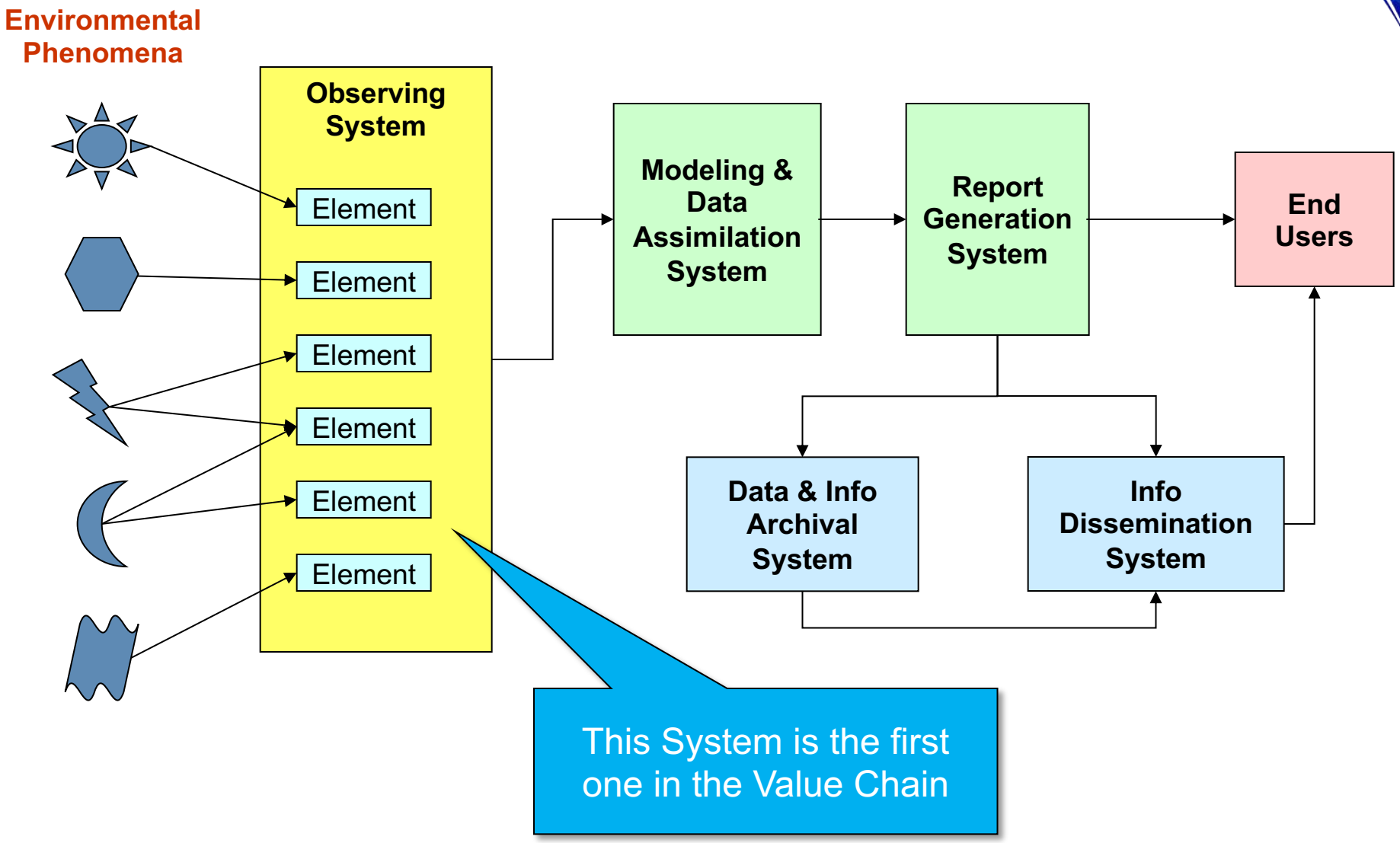
Coastal services & products, Great Lakes, coastal zone management

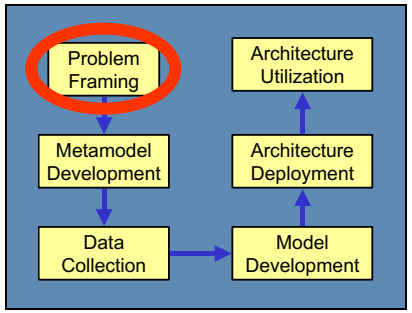
Charting & Navigation

Nautical & navigational charts, mapping, remote sensing, safe navigation

NOAA Observing System Architecture (NOSA)

Our "Reference Architecture" that provides a good modeling pattern

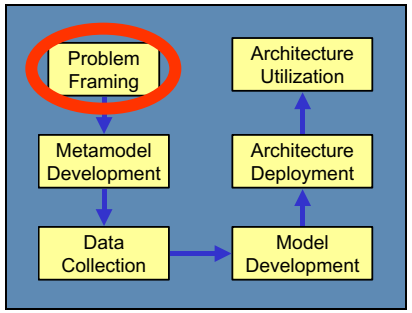




Conceptual Schema for NOAA

Step 1

Support
supported by
Operator
operated by
Owner
owned by
Larger System
part of
Observing System
is controlled by
Observation Control System
provides data directly to
Data Handling System
provides data to
provides info to
User
is type of
Stake-holder
has
Stakeholder Requirement
< drives
Basic Service Requirement
< drives
Platform / Station
situated on
located at
Location
is
Fixed
Mobile
Space
Air
Ground
Ocean
Space
Air
Ground
Ocean
contains
Sensing Element
measures
is a
Sensor
Human
Environmental Parameter
characterizes
Environmental Phenomenon
< drives



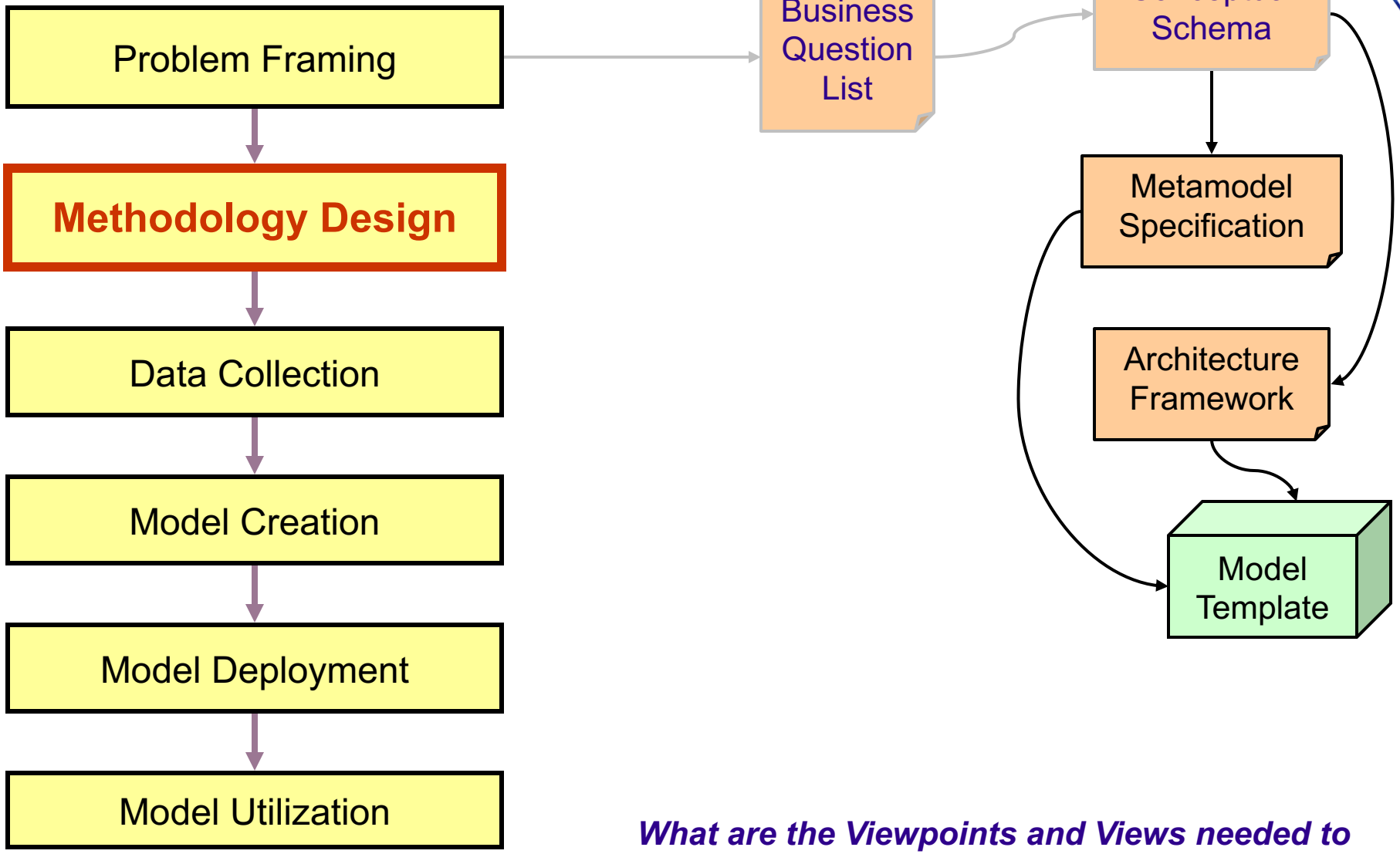
Example Business Questions

Step 1

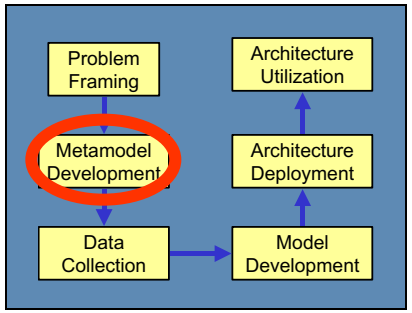
1. **What Observing Systems are owned by a particular Line Office?**
2. **Which Climate Requirements are not being met by current Observing Systems?**
3. **What Observing Systems are supporting our ability to measure the heat content of the ocean?**
4. **Which Organizations operate Airplanes?**
5. **What Observing Systems are associated with each Environmental Phenomenon?**

Step 2: Methodology Design

Includes the Architecture Framework of Viewpoints and Views

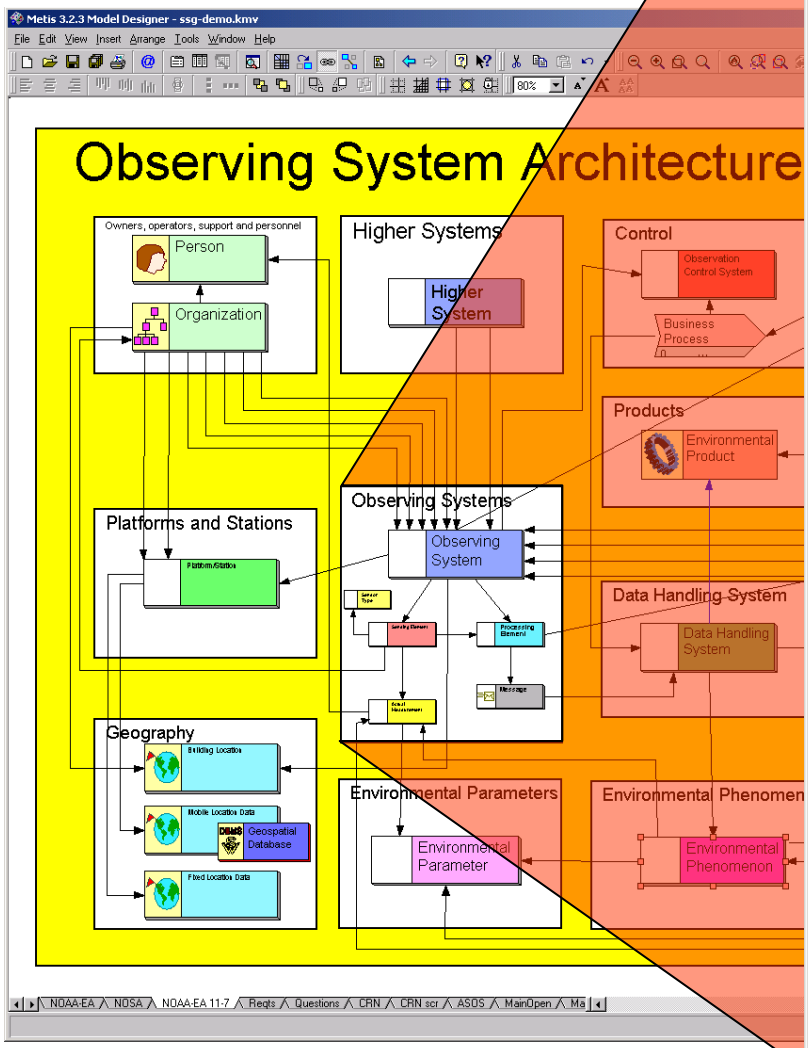


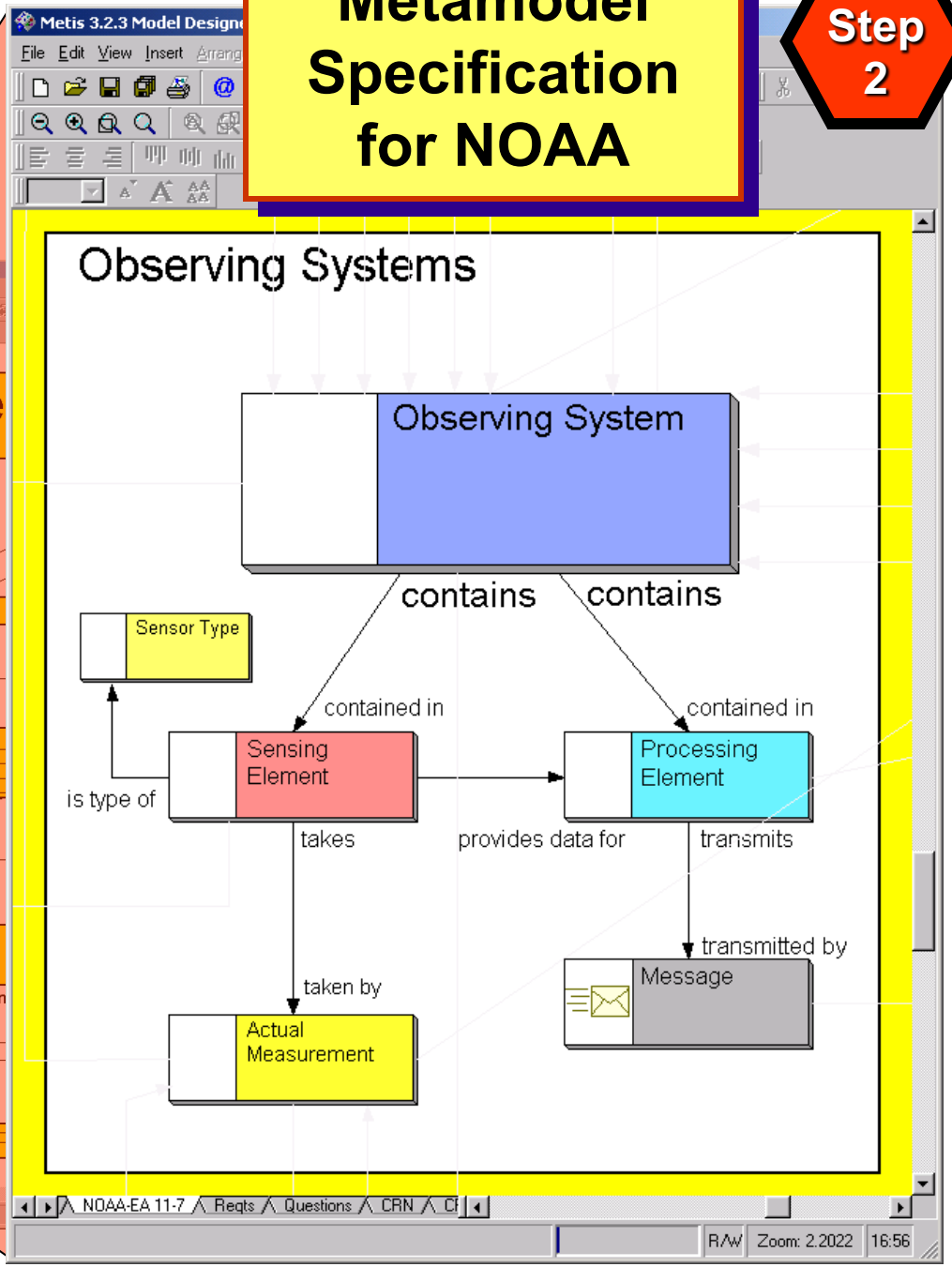
What are the Viewpoints and Views needed to answer the important Business Questions?



Metamodel Specification for NOAA

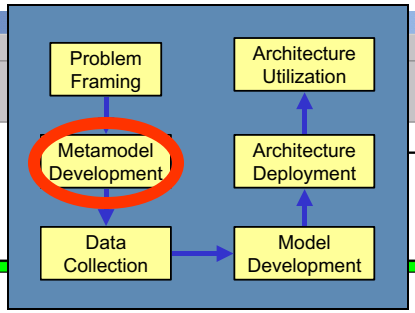
Step 2





Metis 3.2.3 Model Designer - noaa-bus-model.kmv

File Edit View Insert Arrange Tools Window Help



Step 2

NOAA Enterprise Architecture

Change

Business Strategy

Business Operation

Observing Systems

Physical Applications

IT Infrastructure

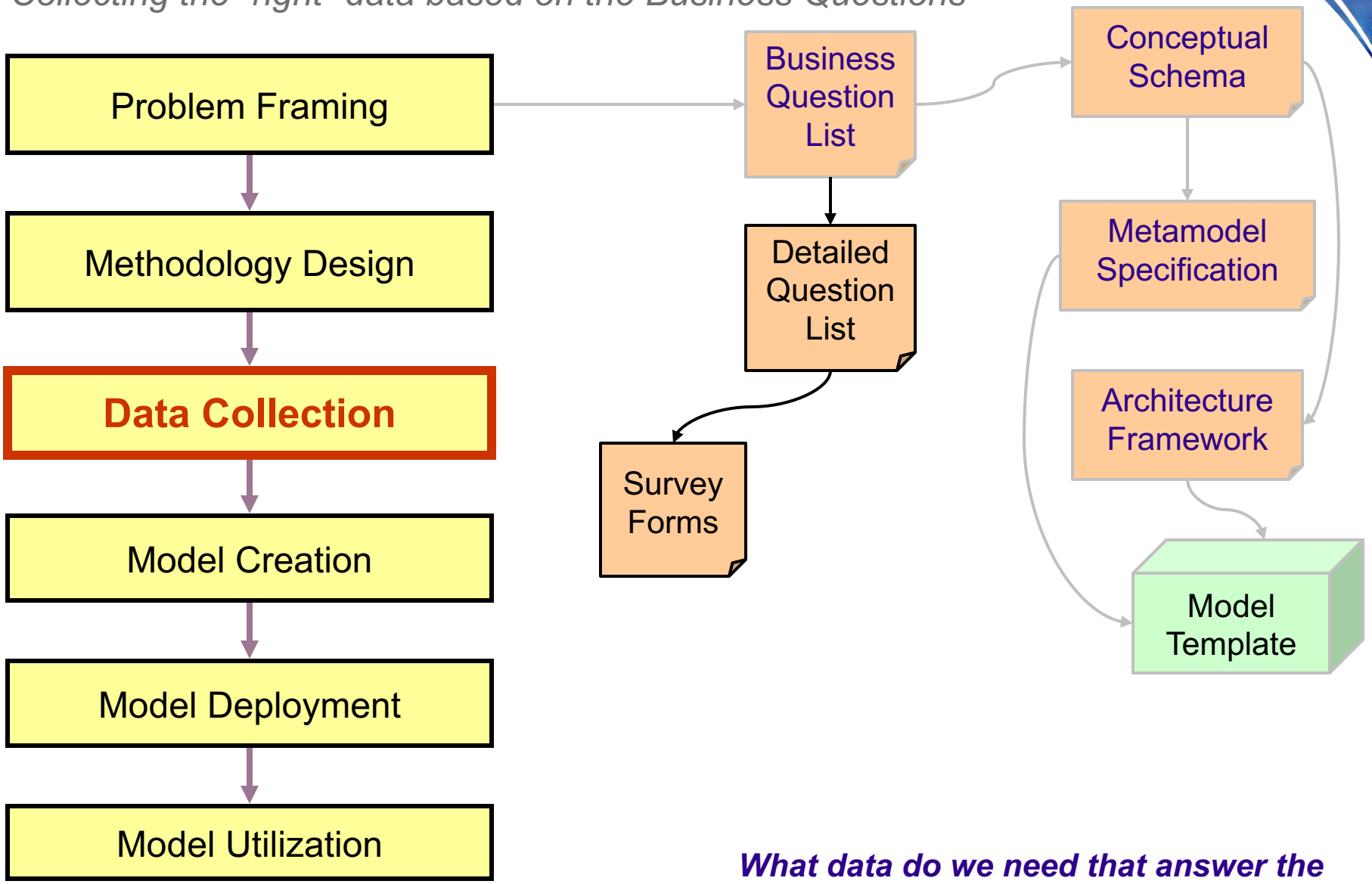
Example Architecture Framework

NOAA EA | Main | BsnsViewofAppl | ApplImpl | TransitionView | InfoView | ITReqView | ApplFuncView | StratVal | Proc-Appl | ArchEr

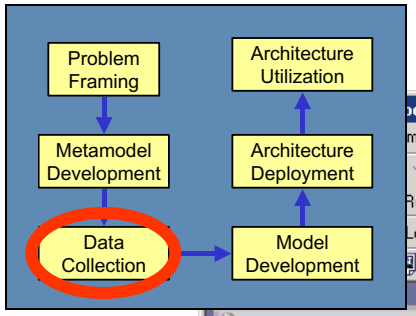
R/W Zoom: 0.3740 17:32

Step 3: Data Collection

Collecting the "right" data based on the Business Questions



What data do we need that answer the important Business Questions?



Example Survey Form for NOAA

Step 3

ocument Questionnaire Page - Netscape

municator Help

Reload Home Search Netscape Print Security Shop Stop

Location: http://class1.nesdis-hq.noaa.gov/survey/page.php?group_id=47&instance_id=82&pa

Internet Lookup New&Cool Current Stuff Markets NOAAFor

NOAAForge

Logged In: martin
Logout
Register New Project
Account Maintenance
Change My Theme
My Personal Page
Bookmark this Page

Project: NOSA
Project Summary
Project Admin

Projects
Project Map
New Releases
Code Snippet Library

NOAAForge
Site Documentation
Discussion Forums
Phone List
Dictionary
Acronyms
Contact Us

Search
Project
Require All Words
Search

NOSA - Surveys

Main | Homepage | Forums | Bugs | Support | Tasks | Docs | **Surveys** | News | Files |

Admin

Summary

READ ONLY - You are not a member of this document

Identifying Information - NWS-ASOS

This page covers summary identifying information for the observing system. This survey should be filled out for each "type" of Observing System, not for each "instance". There might be hundreds of instances for a given type. The instances will be identified on the Platform/Station survey form by either loading in a file with location data, or pointing to a database that contains the location data.

1. System Name (Clarification[0]/ Comment[0]/ Footnotes[0])

Enter the name of this observing system. — Automated Surface Observing System

2. Acronym (Clarification[0]/ Comment[0]/ Footnotes[0])

Enter the acronym that this system is known by. — ASOS

3. Identifier (Clarification[1]/ Comment[0]/ Footnotes[0])

Enter the system's identifier, if any. For example, WSR-88D is the identifier for NEXRAD. — N/A

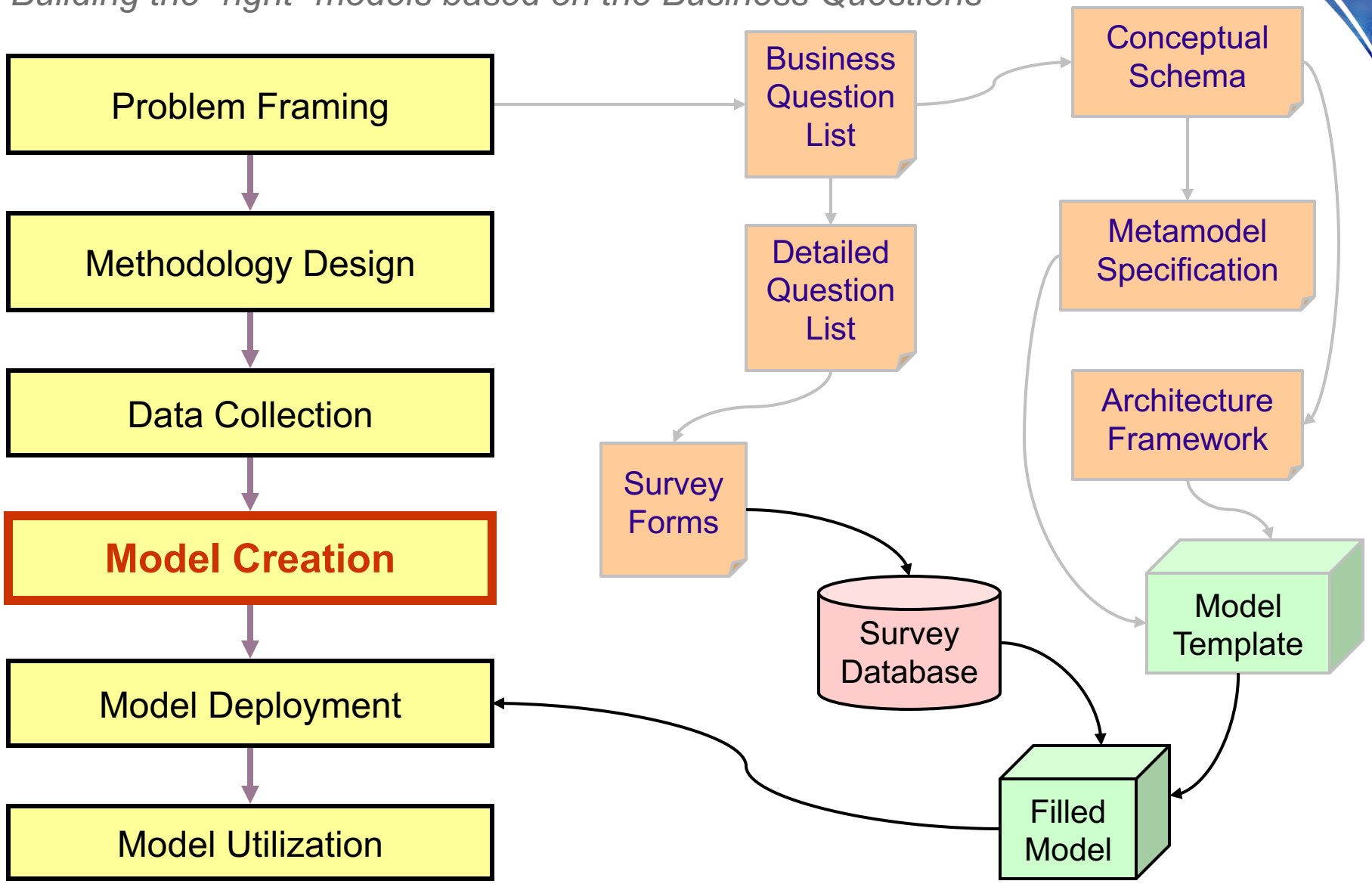
4. Description (Clarification[2]/ Comment[0]/ Footnotes[0])

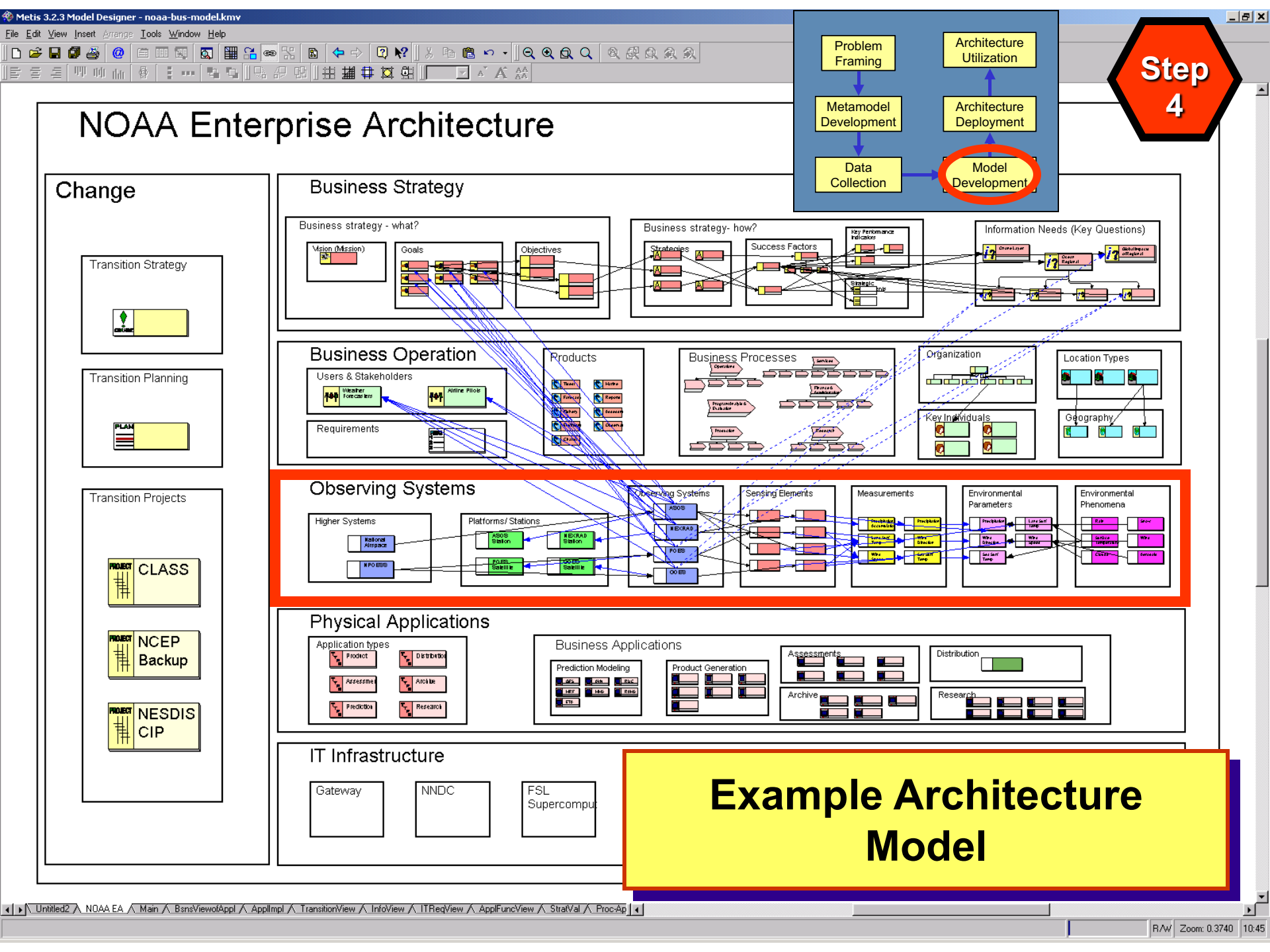
Enter a high-level description of this Observing System. (Details will be provided on subsequent survey pages.) — The ASOS is a fully automated weather observing system. The system provides meteorological information to a wide variety of users.

Document: Done

Step 4: Architecture Model Creation

Building the "right" models based on the Business Questions




Metis 3.2.3 Model Designer - noaa-bus-model.kmv
File Edit View Insert Arrange Tools Window Help
Problem Framing
Architecture Utilization
Metamodel Development
Architecture Deployment
Data Collection
Model Development
Step 4
NOAA Enterprise Architecture
Change
Transition Strategy
Transition Planning
Transition Projects
CLASS
NCEP Backup
NESDIS CIP
Business Strategy
Business strategy - what?
Vision (Mission)
Goals
Objectives
Business strategy- how?
Strategies
Success Factors
Key Performance Indicators
Information Needs (Key Questions)
Business Operation
Users & Stakeholders
Requirements
Products
Business Processes
Organization
Location Types
Key Individuals
Geography
Observing Systems
Higher Systems
Platforms/ Stations
Observing Systems
Sensing Elements
Measurements
Environmental Parameters
Environmental Phenomena
Physical Applications
Application types
Business Applications
Prediction Modeling
Product Generation
Assessments
Distribution
Archive
Research
IT Infrastructure
Gateway
NNDC
FSL Supercomput
Example Architecture Model
Untitled2 NOAA EA Main BsnsViewofAppl AppImpl TransitionView InfoView ITReqView ApplFuncView StratVal Proc-Ap
R/W Zoom: 0.3740 10:45

Observing Systems by Strategic Goal

Step 5

Display Observing Systems vs Goal Matrix

Strategic Goals

Weather and Water

Select | # Stations /Platform

Commerce & Transportation

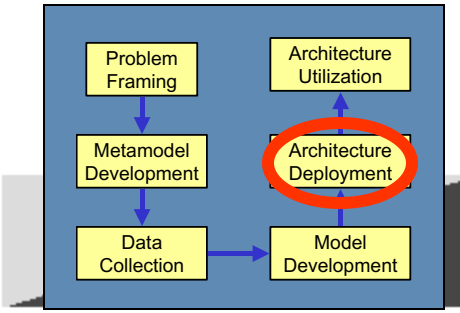
Select | # Stations /Platform

Climate

Select | # Stations /Platform

Ecosystems

Select | # Stations /Platform



Tutorial: # Stations /Platforms

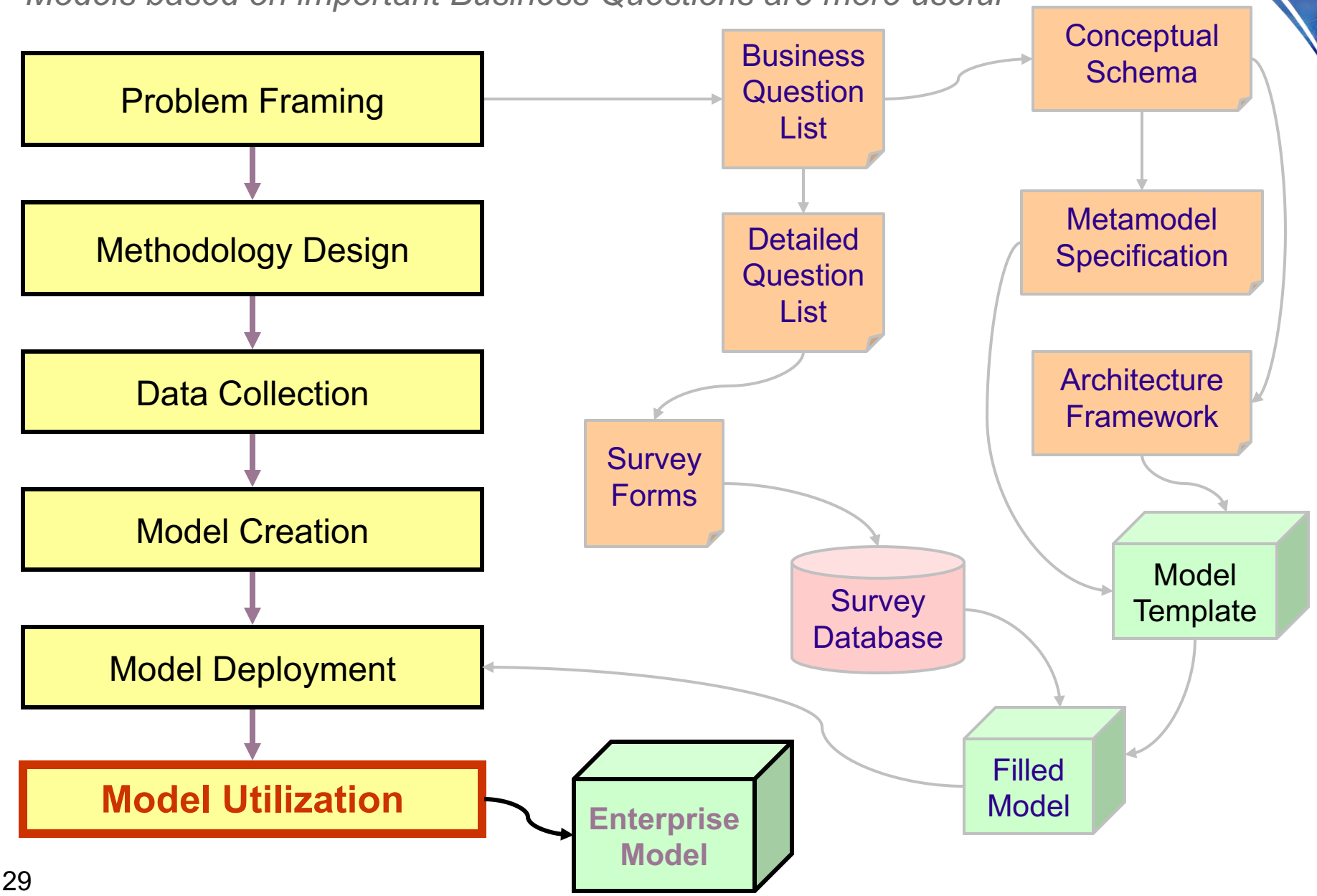
NOAA Observing Systems

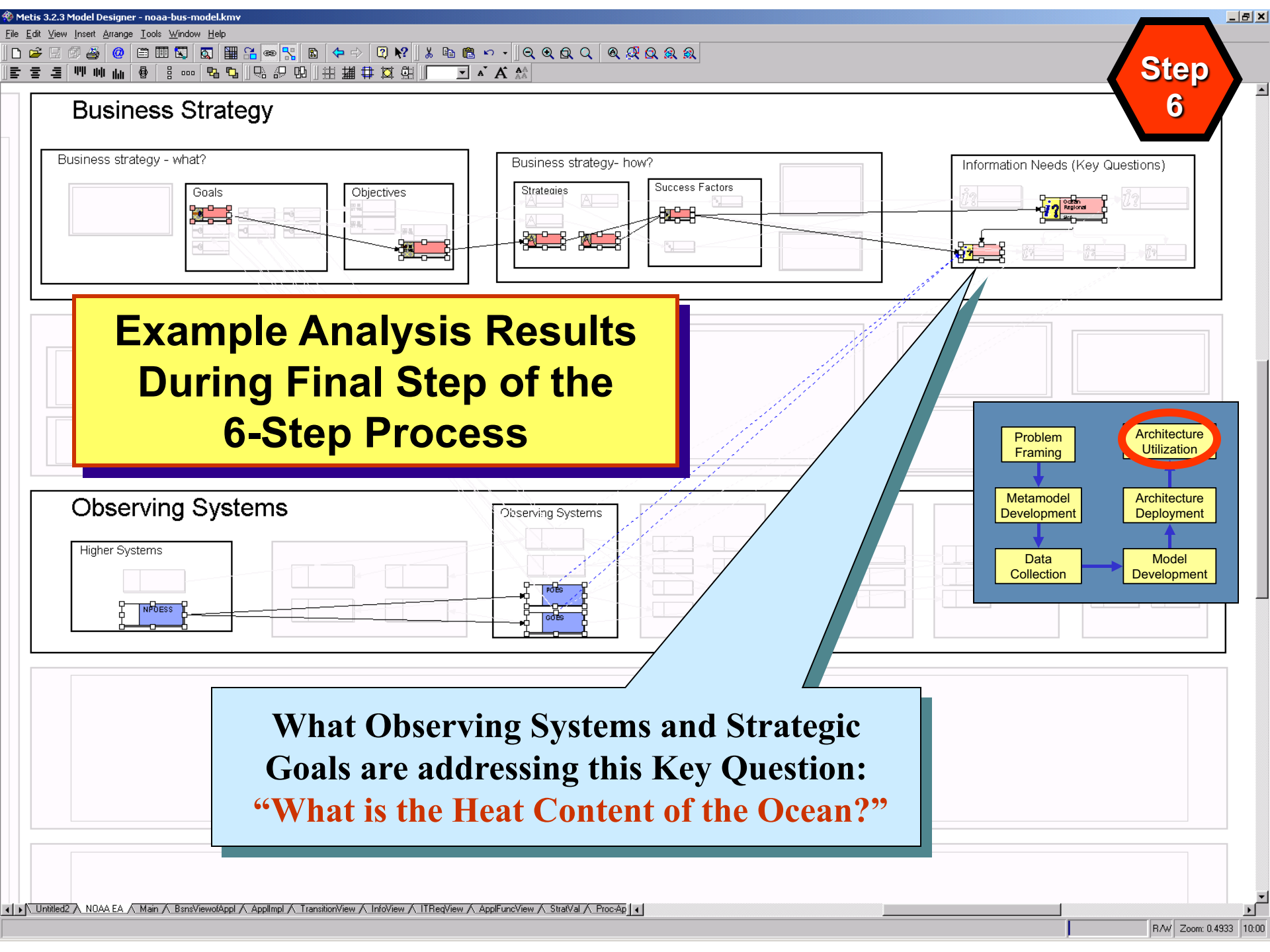
449 MHz | 5mm | AEROSO | Airborne | Airborne | Alaska | Atmosphe | Atmosphe | Automated | Automated | Boulder |
Coastal-M | Compact | Continuo | Cooperati | Cooperati | Coral | Defense | Depolariz | Detection | Dual | ENSO | ENSO |
East | Electronic | Fischer | Fish | Fisheries | Fishery | GOOS/W | Geostatio | Geostatio | Global | Global | GroundHy |
Habitat | Halocarbo | High | High | Hughes | Hydrogra | INEEL | IR | Infrasonic | Integrated | Lightning | Limited |
Living | Long-term | Marine | Marine | Marine | Measuren | Meteorol | Mobile | NDBC | NMFS | NOAA | NOAA |
NPOESS | NSST | Narrow | National | | | | | | | | |
Platteville | Polar-orb | Polar-orb | Polarimet | | | | | | | | |
Rawindso | Regional | Regional | Sierra | | | | | | | | |
Wind | Wind | Wind | Wind and | | | | | | | | |

Special View that shows Mapping from “Goals” to “Systems”

Step 6: The Enterprise Architecture Model

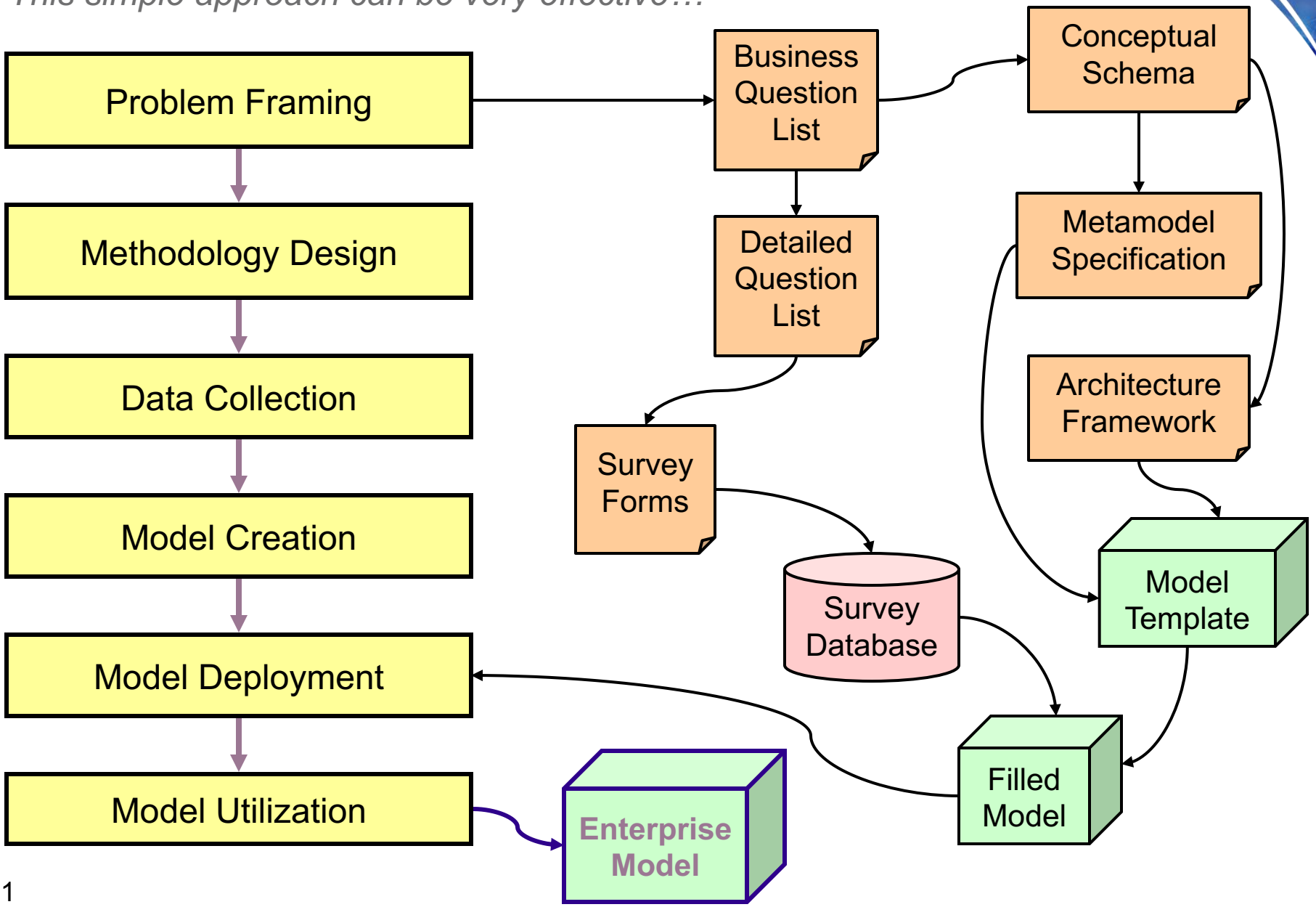
Models based on important Business Questions are more useful




Metis 3.2.3 Model Designer - noaa-bus-model.kmv
File Edit View Insert Arrange Tools Window Help
Step 6
Business Strategy
Business strategy - what?
Goals
Objectives
Business strategy- how?
Strategies
Success Factors
Information Needs (Key Questions)
Example Analysis Results During Final Step of the 6-Step Process
Problem Framing
Architecture Utilization
Metamodel Development
Architecture Deployment
Data Collection
Model Development
Observing Systems
Higher Systems
NPOESS
Observing Systems
POES
GOES
What Observing Systems and Strategic Goals are addressing this Key Question:
"What is the Heat Content of the Ocean?"
Untitled2 NOAA EA Main BsnsViewofAppl AppImpl TransitionView InfoView ITReqView ApplFuncView StratVal Proc-Ap
R/W Zoom: 0.4933 10:00

Enterprise Model Development Artifacts

This simple approach can be very effective…



Problem Framing (Steps 1-2)

Laying the foundation…

- **Step 1 – Intended Users & Uses of the Models**
  - *a) Decisions to be supported by the models (eg, milestone, KDP, activity)*
  - *b) Uses and Users of the models and related views*
  - *c) Purpose of the models and views*
    - ✓ Issues to be explored with the models
    - ✓ Questions to be answered using the models
    - ✓ Types of analysis to be performed using the models
    - ✓ Interests and perspectives of intended audience and users

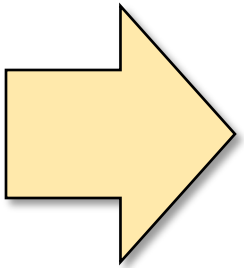
- **Step 2 – Scope & Context of the Models**
  - *a) Scope (ie, Activities, functions, organizations, timeframes, boundaries, layers, etc)*
  - *b) Context (ie, What is the bigger picture? Who are the mission partners?)*
  - *c) Points of view (eg, EA, SE, PM, program office, end user, operator, maintainer, etc)*
  - *d) Environment (eg, Technology, budget, programmatic)*
  - *e) Operational scenarios, situation(s), geographical areas*
  - *f) Major constraints (eg, mandated products/formats, frameworks/tools)*
  - *g) Other key assumptions*

Problem Framing (Steps 3-4)

Building upon the foundation…

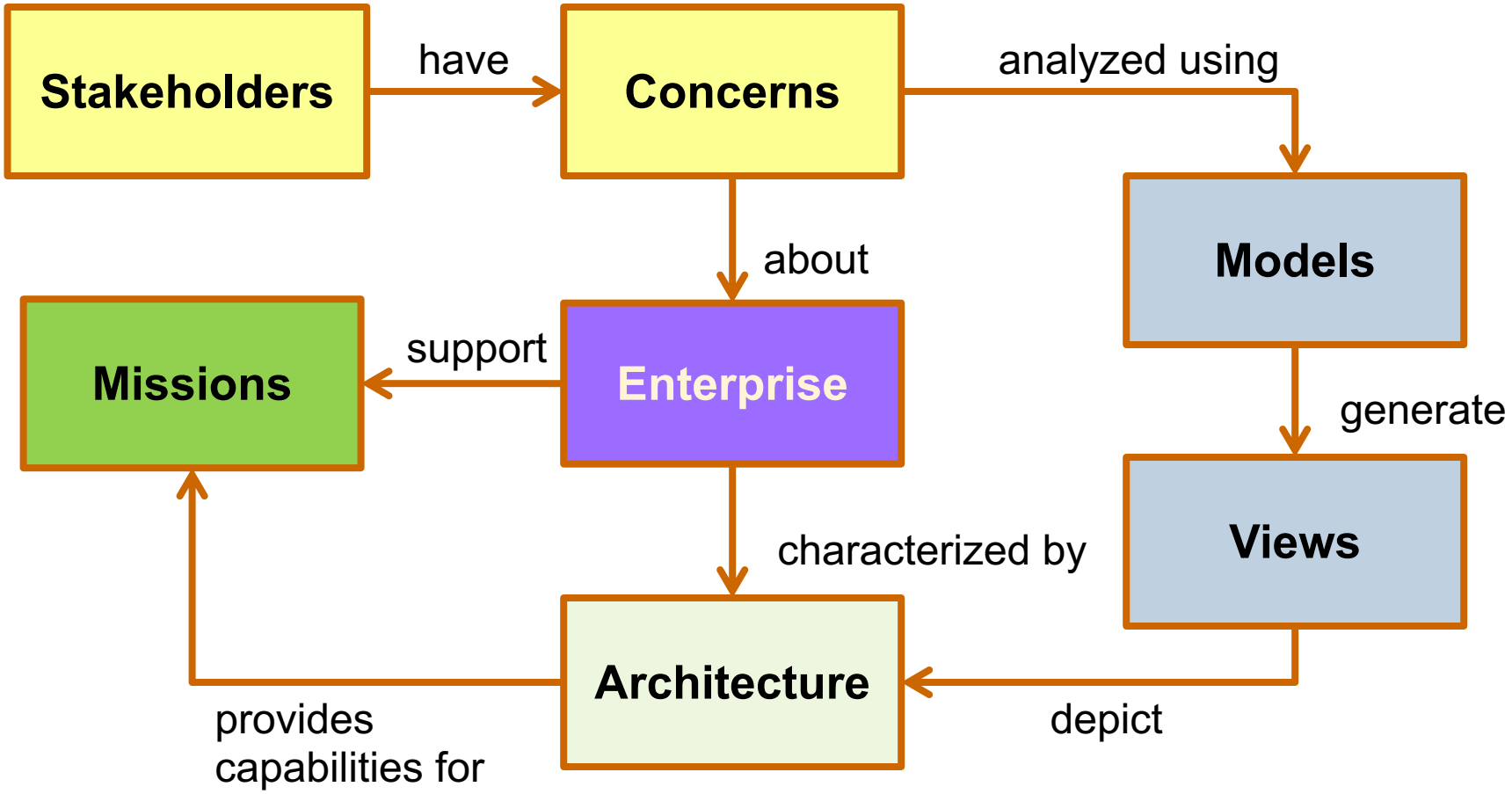
- **Step 3 – Information & Data Needs**
  - *a) Information to be collected for use in generating the products*
  - *b) Precision and granularity of needed information*
  - *c) Expected presentation form or method*
  - *d) Previous or related architectures that can be "mined" for information or data*
  - *e) Potential sources of this information or related data*

- **Step 4 –Views & Models**
  - *a) Types of views and models needed (that serve the intended uses from Step 1)*
  - *b) Identify specific views and models that address the needs*
    - Existing views and models (if applicable)
    - New views and models
  - *c) Contents, structure and form of each item*
    - Questions addressed by each
    - Activities support by each
  - *d) Tools, templates and other resources needed to develop these views and models*
  - *e) Frameworks and modeling approaches to be used*



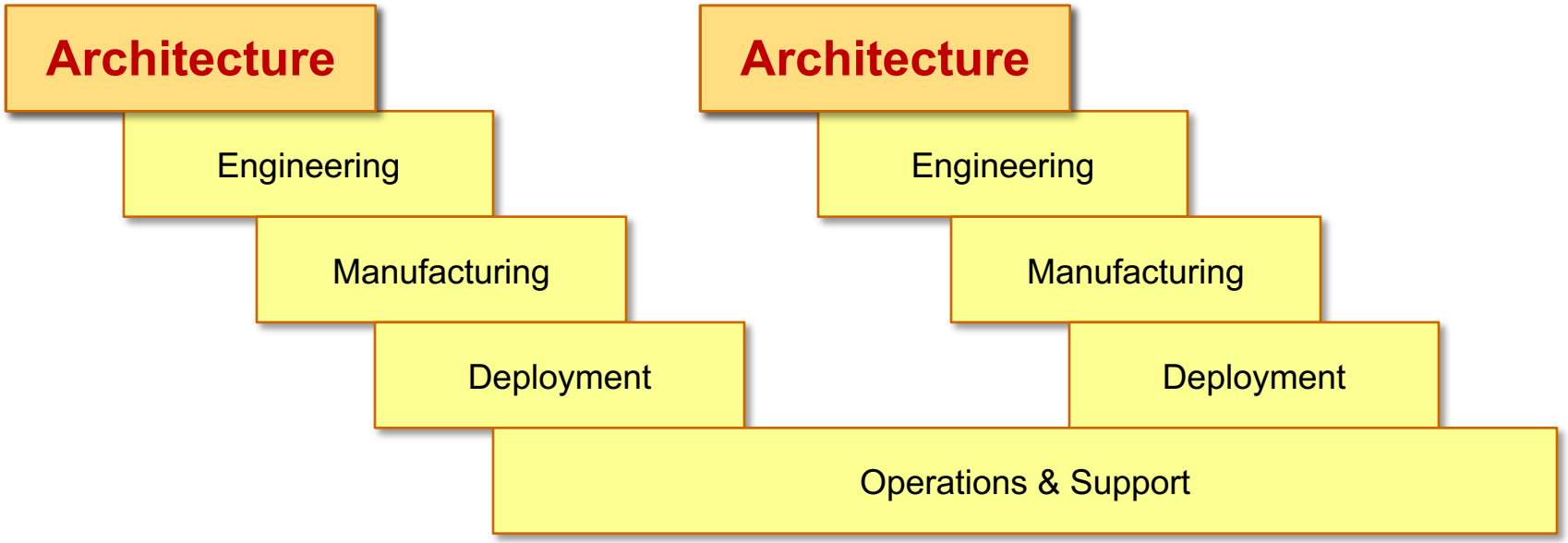
Captured in a Conceptual Schema and Storyboards

Stakeholders & their Concerns Captured in Business Questions about the Enterprise



Question-based approach helped us to remain focused on the most important issues relevant to key decision makers

Architecture Models Set the Stage for All that Follows



The "Problem Framing" approach is a good way to help identify the best models to use for your situation

All models are wrong
but some are useful

George E.P. Box