On the Use of Knowledge Modeling Tools and Techniques to Characterize the NOAA Observing System Architecture

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Abstract. The National Oceanic and Atmospheric Administration (NOAA) in the United States has a very broad charter that includes making "observations" of environmental phenomena worldwide. These observing systems are used to provide accurate and timely information to various stakeholders who depend on this information to make critical decisions about farming, construction, fishing, military operations, traffic safety, and so on. This paper describes a project to develop the NOAA Observing System Architecture to assist NOAA in formulating its strategic plans and invest its funding more effectively. We used "knowledge modeling" as the basic approach to capture information about the systems and other entities associated with the architecture. We are using the Metis enterprise architecture tool along with DOORS for requirements, NOAA Forge for team collaboration, and ArcIMS for geospatial data visualization.

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Introduction

An Action Group led by the Chief Information Officer, Rob Mairs, of the National Environmental Satellite, Data, and Information Service (NESDIS) was established to develop the NOAA Observing System Architecture (NOSA). Up to this point the National Oceanic and Atmospheric Administration (NOAA) had not had well-defined coordination of its observing systems and had not had an observing system architecture to use in assessing proposed new requirements for observing systems. This decentralization of observing responsibility and lack of a comprehensive architecture has made it difficult to ensure that observing systems are:

designed to provide the maximum value to NOAA, .a

not duplicative of existing systems, and .b

operated efficiently and in a cost-effective manner. .c

With this new architecture, NOAA can manage its collection of observing systems more efficiently and effectively. To this end, the NOSA model was developed. It defines a consistent set of principles, policies, and standards that will guide the engineering of NOAA's observing systems and infrastructure in a way that ensures alignment with mission requirements.

Figure 1 shows the primary information flow for an observing system. The basic observations are ingested into analytical models that perform various environment-related activities like weather forecasting, storm tracking, fish population monitoring, climate prediction, and so on. The resulting information from these models is captured in special reports suitable for public consumption. (Some of the observational data will proceed directly to the users, especially for groups like scientists who perform scientific research on fundamental environmental phenomenology.)

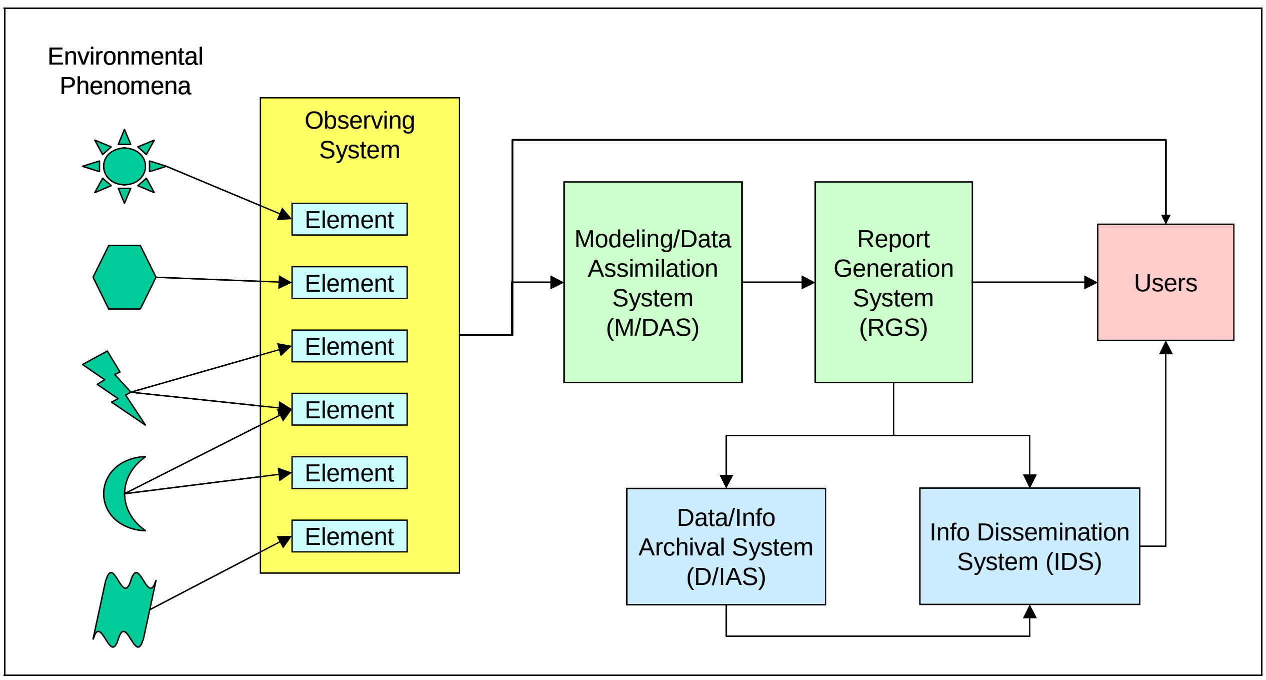


Figure 1. Primary information flows for NOAA Observing Systems from

environmental phenomena to users

The National Oceanic and Atmospheric Administration (NOAA) in the United States has a very broad charter that includes making "observations" of environmental phenomena worldwide in order to provide accurate and timely information to various stakeholders. These people and organizations depend on this information to make critical decisions about farming, construction, fishing, military operations, traffic safety, and so on.

Overview

This paper describes a project to develop the NOAA Observing System Architecture (NOSA) to assist NOAA in formulating its strategic plans and invest its funding more effectively. There are about one hundred different observing system "types" currently in use throughout NOAA. Some of the system types will have hundreds or thousands of "instances" of that type in locations throughout the world. For example, there are hundreds of floating buoys that gather environmental data about sea surface temperatures, winds, ocean currents, etc. About half the observing system types in NOAA are used primarily for research purposes to gather additional knowledge about environmental phenomena and to update the modeling algorithms used to convert observations into forecasts and more complex information reports.

We are using "knowledge modeling" as the basic approach to capture information about the systems and other entities associated with the architecture. We are using the Metis enterprise architecture tool along with DOORS for requirements, NOAA Forge for team collaboration, and ArcIMS for geospatial data visualization. The knowledge model characterizes architectural elements like the observing system itself, sensing elements contained within each observing system, environmental parameters measured by these sensing elements, and so on. It also captures knowledge about who owns, operates, supports, funds, and acquires these systems, and who used the raw data and refined observational information downstream.

The NOAA Enterprise Architecture Framework

The NOAA Enterprise Architecture is made up of seven technology domains and seven Line Office Domains as shown in Figure 2. The vertical bars in this diagram are the Line Offices within NOAA that represent various aspects of NOAA's charter:

Environmental space, data and information services (NESDIS) (a)
Ocean services (NOS) (b)
Marine fisheries (NMFS) (c)
Weather services (NWS) (d)
Atmospheric research (OAR) (e)
Finance and administration (OFA) (f)
Marine and aviation ops (OMAO) (g)

Notice that the observing systems are one of the "cross-cutting" activities that affect all line offices. Other cross-cutting items are the traditional information technology items like security, computing, telecommunications and networking.

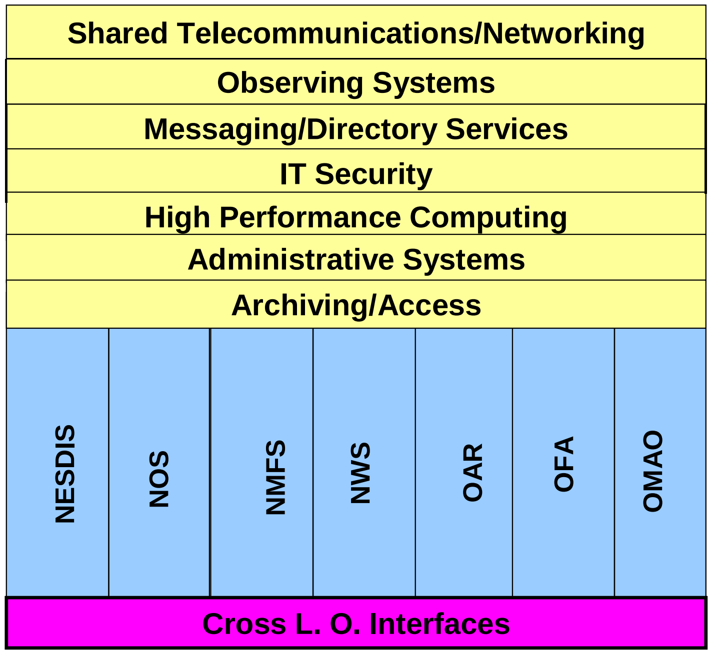


Figure 2. NOAA enterprise architecture framework

The architecture framework for NOAA is described further in (Grossman 2003) along with how they use this framework to created a “federated” information technology architecture.

The NOAA Observing System Architecture (NOSA)

NOSA is defined as the composition of:

- NOAA’s observing systems and other observing systems required to support NOAA’s mission,
- The relationship among observing systems including how they contribute individually and collectively to support NOAA’s mission and associated observing requirements, and
- The guidelines governing the design of a target architecture and the evolution to this target architecture

The target architecture will:

- Provide an integrated view of NOAA’s observing systems linked to mission
- Provide a framework for examining future requirements and cost, and allows evolutionary improvements
- Support discovery of gaps and duplication
- Lead to a more cost-effective overall observation system
- Allow all NOAA observations to be accessible by all NOAA customers
- Assist NOAA in its participation in international observing systems
- Help to identify opportunities for migrating research observations into operational status when appropriate.

Key questions for the definition of the architecture:

- What were and are the driving needs?
- What are the current systems that satisfy these needs?
- What is the gap (current and future) between the driving needs and current capabilities?
- When will current capabilities start degrading or disappearing?
- What competing systems provide these capabilities?
- Who benefits from the current and future capabilities?
- Who are the users? Operators? Owners? Suppliers?
- Who are the NOAA partners that contribute to providing these capabilities?
- How are the NOAA systems tied together with systems outside NOAA responsibility?

Figure 3 is a simplified diagram that represents some of the key elements that will be examined in the NOAA Observing System Architecture (NOSA). The various data handling systems will be treated as a "black box" since they are outside the scope of this effort. These data handling systems will be explored in greater detail in a follow-on project after the observing systems are fully characterized.

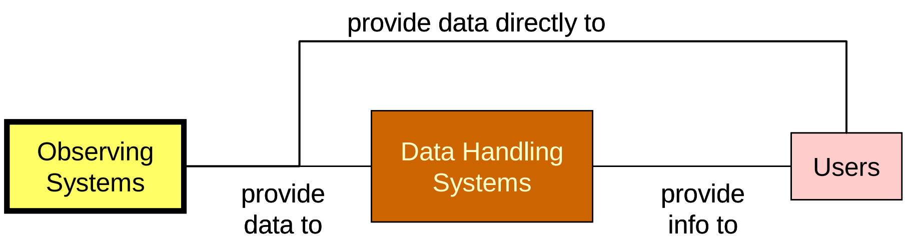


Figure 3. Data Handling Systems convert "observations" into "information" for NOAA's user communities

There are two major phases involved in this project. Phase 1 deals with capturing the baseline systems—those that are currently deployed and those to be deployed in the next two years. Phase 2 deals with developing the "target" architecture—the set of prospective systems that will be needed in ten to twenty years. Phase 2 will also examine gaps between the baseline and target architecture and develop the transition plan and technology roadmaps.

Architecture and Requirements

The target architecture will be based on validated requirements using a requirements-based management process. Figure 4 shows how the stakeholder requirements determine the "services" to be provided by NOAA to its various user communities. Users do not normally care about what environmental parameters are measured nor how these measurements are taken. Instead they are usually most concerned about higher-level environmental "phenomena" that more directly affect their lives such as clouds, storms, floods, etc.

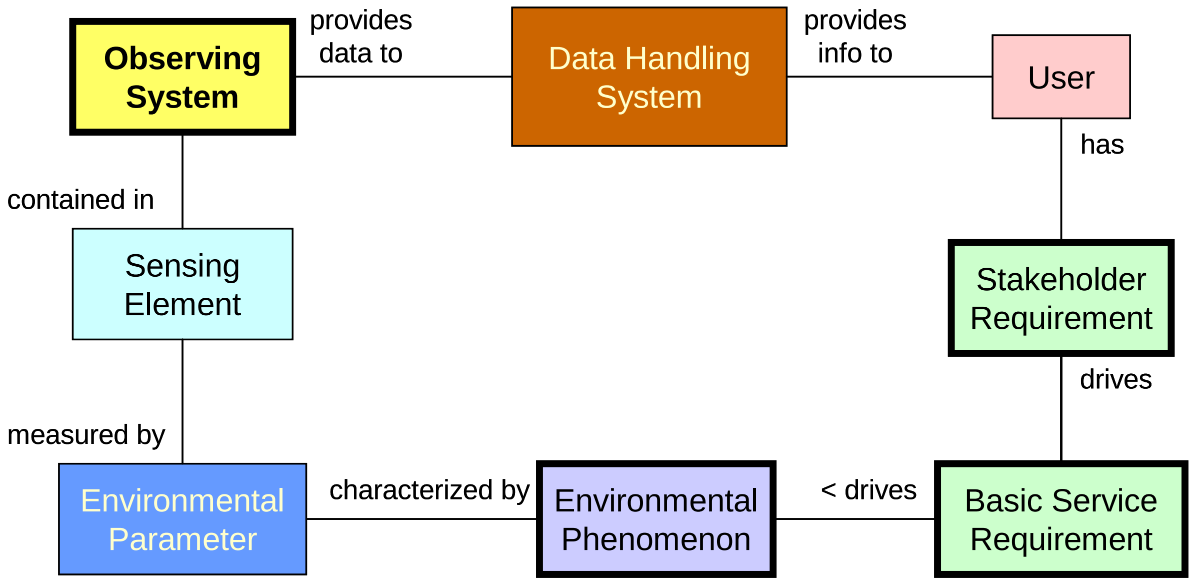


Figure 4. The requirements-driven development process (from user to observing system)

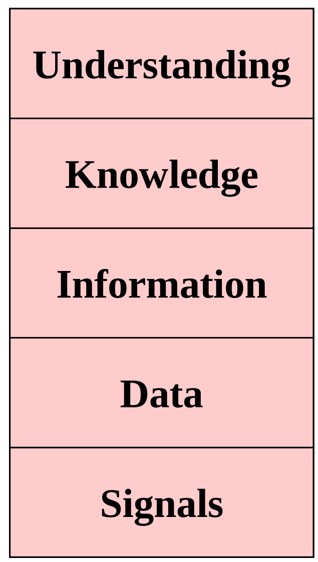
Shown below is an example of real elements for a portion of the NOAA Observing System Architecture. This is the set of objects related to a single observing system called the Automated Surface Observing System (ASOS). From this example, you should get a sense of the total scope of the NOSA project. There will be about one hundred observing system types with several hundred environmental parameter measurement types overall.

Object Type	Instance
Users	Pilots, Air Traffic Control
Stakeholder Requirements	Safe landing and takeoff
Basic Service Requirements	Report on environmental conditions near landing zones at airports
Environmental Phenomena	Clouds, fog, winds, rain
Environmental Parameters	Cloud height, visibility index, wind speed and direction, precipitation rate and accumulation, ambient temperature, dew point temperature
Sensing Elements	Laser ceilometer, forward scatter meter, anemometer, precipitation identifier, heated tipping bucket, resistive temperature device, chilled mirror device
Observing System	**Automated Surface Observing System (ASOS)**
Data Handling System	Automated Weather Information Processing System (AWIPS)

It is often a scientific decision to determine what parameters are relevant to the characterization of certain environmental phenomena. Once the parameters are identified, it then becomes an engineering decision as to what type of sensing element to use, how the measurements are taken, how observations are derived from measurement samples, and so on. Of course, it is not always straight-forward as this. There is often back-and-forth iteration between what the scientists *want* to measure and what is practical and efficient to measure. This is where the architecture can be used by systems engineering to better understand the trade-offs to be made.

The NOAA Observing System Architecture will consist of much more than just the observing systems, their subsystems, and other physical items. It will comprise many “abstract” elements like parameters, phenomena, locations, requirements, data, and information. Furthermore, the architectural trade-offs will involve who owns, operates, supports, acquires, and funds these observing systems. Given that geographic coverage is important in assessing the effectiveness of observing systems, something must be known about their locations and the extent of remote measurements performed by the sensing elements. For example, some sensors can measure things that are hundreds of kilometer away from the sensor location.

Knowledge Modeling

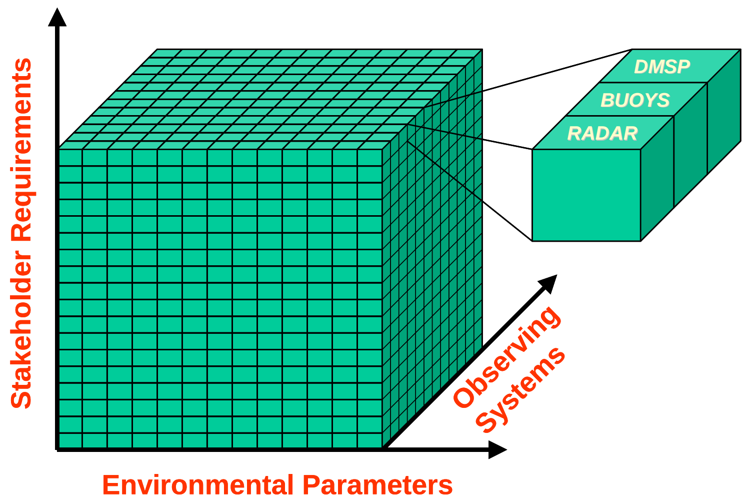


The purpose of the NOAA Observing System Architecture is to explore various ways of transforming environmental signals into environmental understanding (partially through casting the architectural elements into the “information value stack” on the right).

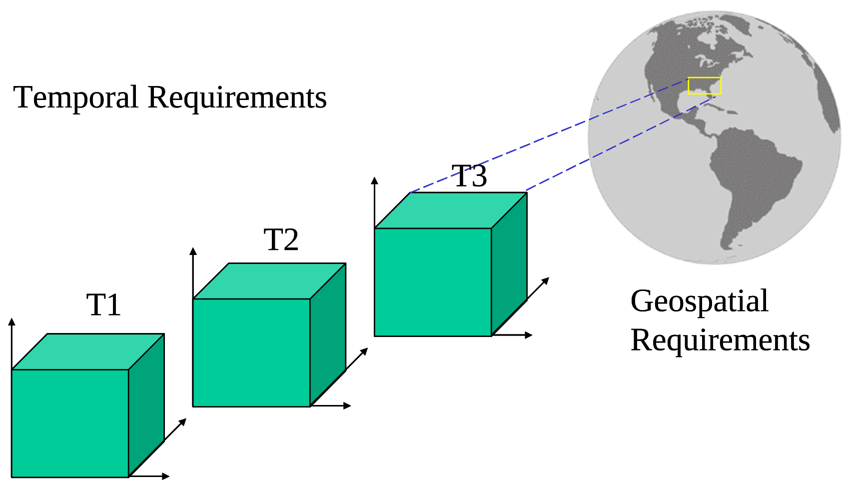
Sensing elements measure signals from nature. The signals are converted into data that can be processed by machines or humans. Modeling and analysis converts the data to information which is the set of “facts” that are known about the environment. Knowledge is the relationship between the facts (e.g., Do I know the probability of rain at this particular location on this date?). Understanding is gained when the knowledge can be applied to a particular situation (e.g., I understand how my actions on the highway will affect other drivers now that I know the likely weather conditions.).

The architecture will also help to identify and quantify sources of transformation “value” in the architecture and in the relationships between architectural elements. Furthermore, it will be used to focus research and development efforts on the architectural elements of greatest value to the overall required depth of environmental understanding.

Essential to understanding the value of these observing systems is to know the relationship between the systems and the environmental parameters measured by their sensing elements. Furthermore, how do these environmental parameters relate to the requirements of various stakeholders for these systems? The relationship between these three things is illustrated in the figure below.



In addition to knowing what is measured, it is important to know when and where. The temporal and geospatial requirements are also an important part of the architecture (see figure below).



Modeling is, by definition, developing a simplified description of a complex entity or process. The next section describes the architectural entities we identified as important to gaining an adequate understanding of the environmental challenges facing NOAA in the next decade.

This understanding will be gained by using knowledge modeling of the NOAA Observing System Architecture and tying this back to the key stakeholders that represent NOAA's user communities and other affected organizations and individuals throughout the world.

Architecture Entities and Relationships

When we examine all the entities that are relevant to the architecture, and the relationships between these entities we get a diagram that looks like Figure 5. This diagram was found to be instrumental in getting NOAA leadership to understand the architectural scope and complexity. It helped them understand why it has in the past been difficult to gain an understanding of what they have and what they are doing with what they have. Without knowing well what they have and where they need to go, it was always difficult for them to formulate a plan for the way ahead. Having this architecture has helped them already in understanding where they need to go and it will be used further as the basis for on-going investment planning and organizational change.

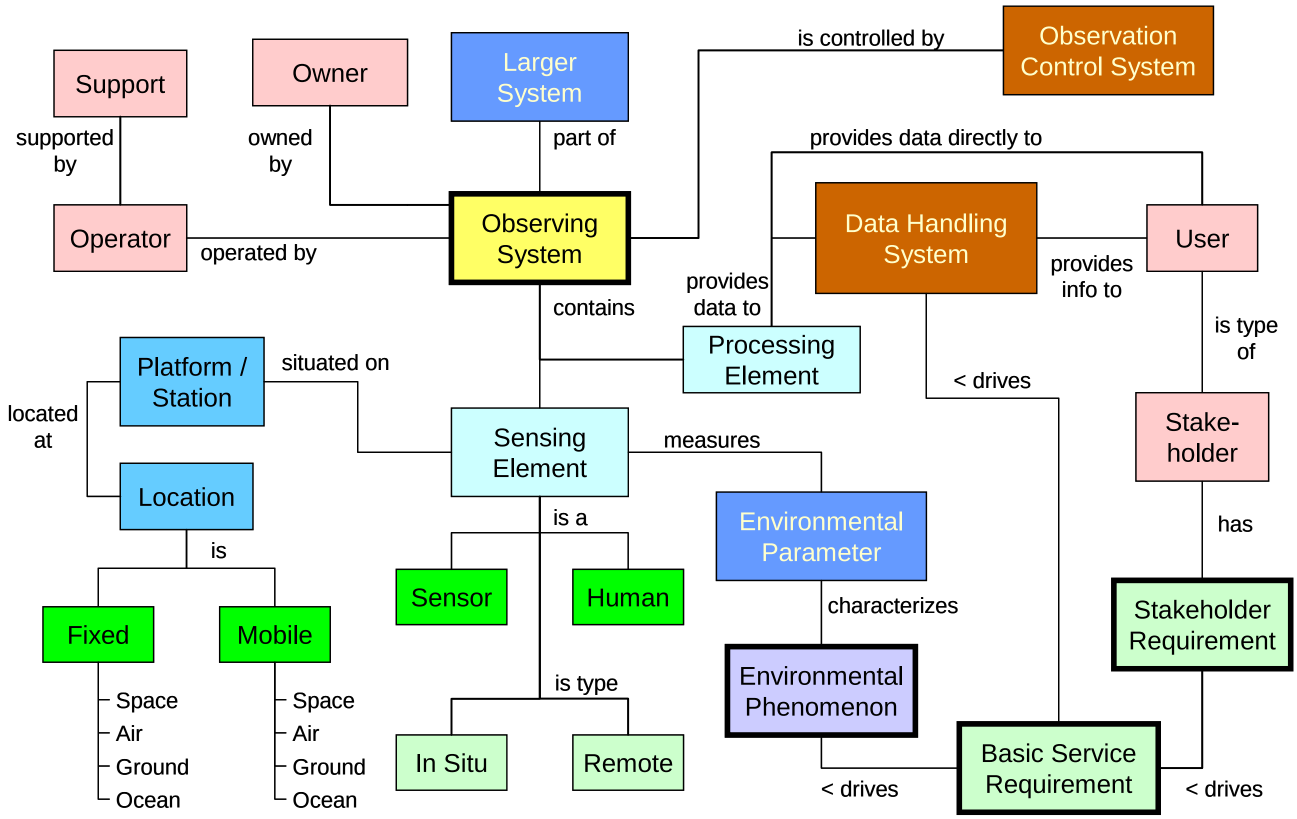


Figure 5. Entity relationship diagram (ERD) for the NOAA Observing System Architecture (NOSA)

Figure 6 shows how a typical system called the Automated Observing System Architecture (ASOS) maps into the structure shown above. This structure was used as the "framework" for capturing the architectural descriptions for the hundreds of observing systems throughout NOAA. This structure was also used to develop the survey forms. The 164 questions used in the survey are shown in Appendix 1.

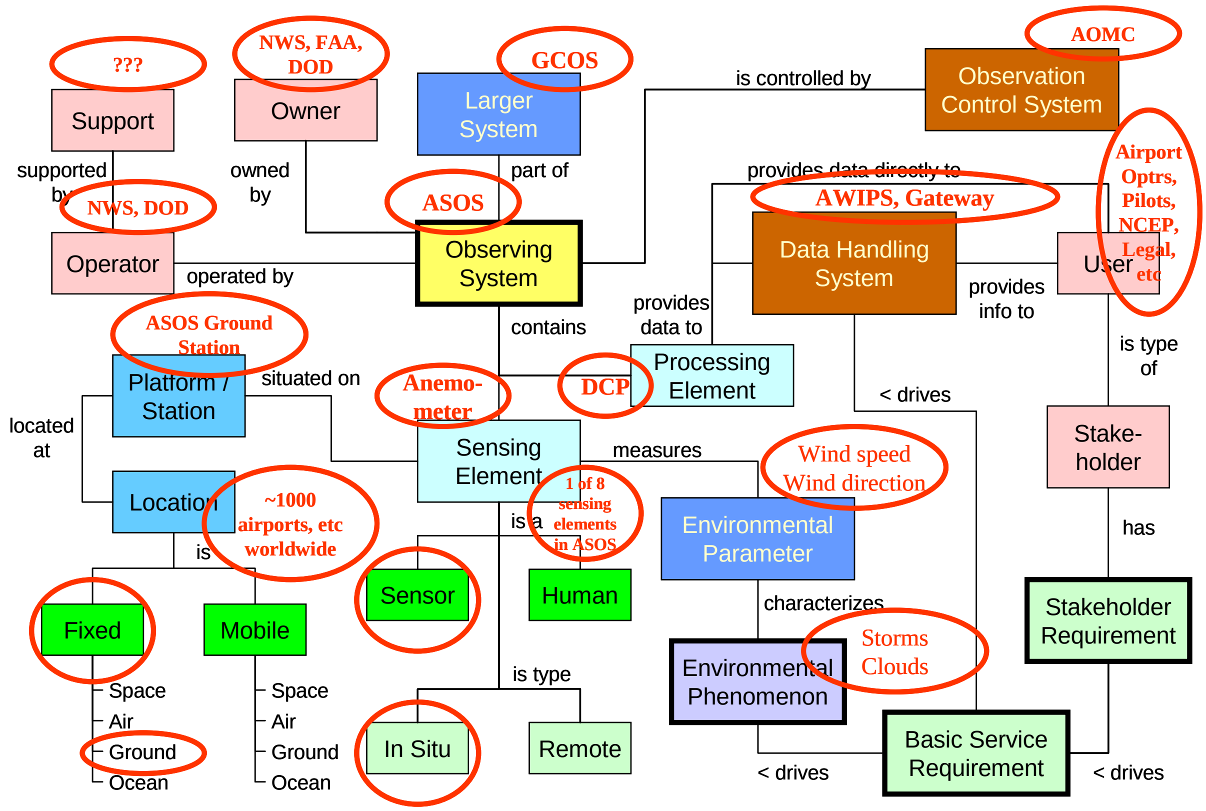


Figure 6. Example ERD with entities identified for the Automated Surface Observing System (ASOS)

Architecture Tool Suite

Development of the NOAA Observing System Architecture is a large undertaking and requires some investment in tools. Figure 7 shows the configuration of tools being used for this task. The key tool for this task is the enterprise architecture tool. Several architecture tools were investigated to determine the one used for this project:

Microsoft: Visio 2002 Professional (a)
Enterprise Architecture Management System (b)
Framework Software: Structure.net and Structure 2001 (c)
Casewise: Corporate Modeler (d)
Computas: Metis (e)
netViz: netViz Professional/webView (f)
Popkin Software: System Architect (g)
Ptech: Enterprise Framework (h)

Analysis of these tools is documented in (Census 2002). The architecture tool chosen for the NOSA project was the Metis tool from Computas. DOORS was the preferred tool for requirements management since it was already being used by several large programs within NOAA. ArcIMS is one of several geographical information system (GIS) tools used within NOAA to help visualize and analyze data in their geospatial databases.

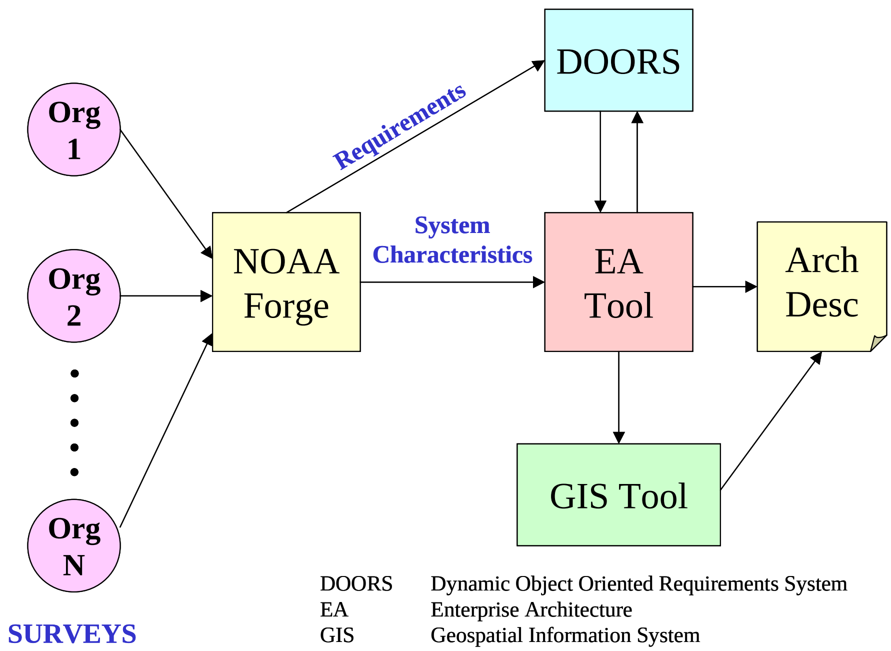


Figure 7. Tool suite for the NOAA Observing System Architecture project

NOAA Forge is an internally-developed, web-based collaboration tool. We used this for collecting basic information about the observing systems and other architectural elements from various system owners throughout NOAA. Further information about NOAA Forge and the other tools used on the project and how they were integrated can be found in (Martin 2003). This paper will focus on how Metis, the enterprise architecture tool, was used.

Building a Metamodel for the Metis Architecture Tool

The entities and their relationships were examined above in the entity relationship diagram (ERD) for the NOSA project (shown in Figure 5). These entities along with their properties were the basis for the metamodel used in the architecture tool. A metamodel is a "model of a model." In other words, the metamodel defines the modeling elements to be using in modeling something. Figure 8 shows a "model" of the metamodel as depicted in the Metis tool. This model shows a generic object for each object type and a generic relationship for each relationship type in the metamodel.

This figure shows the relationships between objects, but does not show the relationship "labels." The labels are hidden from view to avoid clutter, but they can be turned on at any time when it is necessary to examine the particular instances of a relationship. Notice that there are five different relationship types between the Organization object and the Observing System object. These relationship types consist of: owns, operates, supports, funds, and acquires. A similar set of relationship types exist between the Observing System and Stakeholders: has downstream user, has user, has primary stakeholder, has secondary stakeholder.

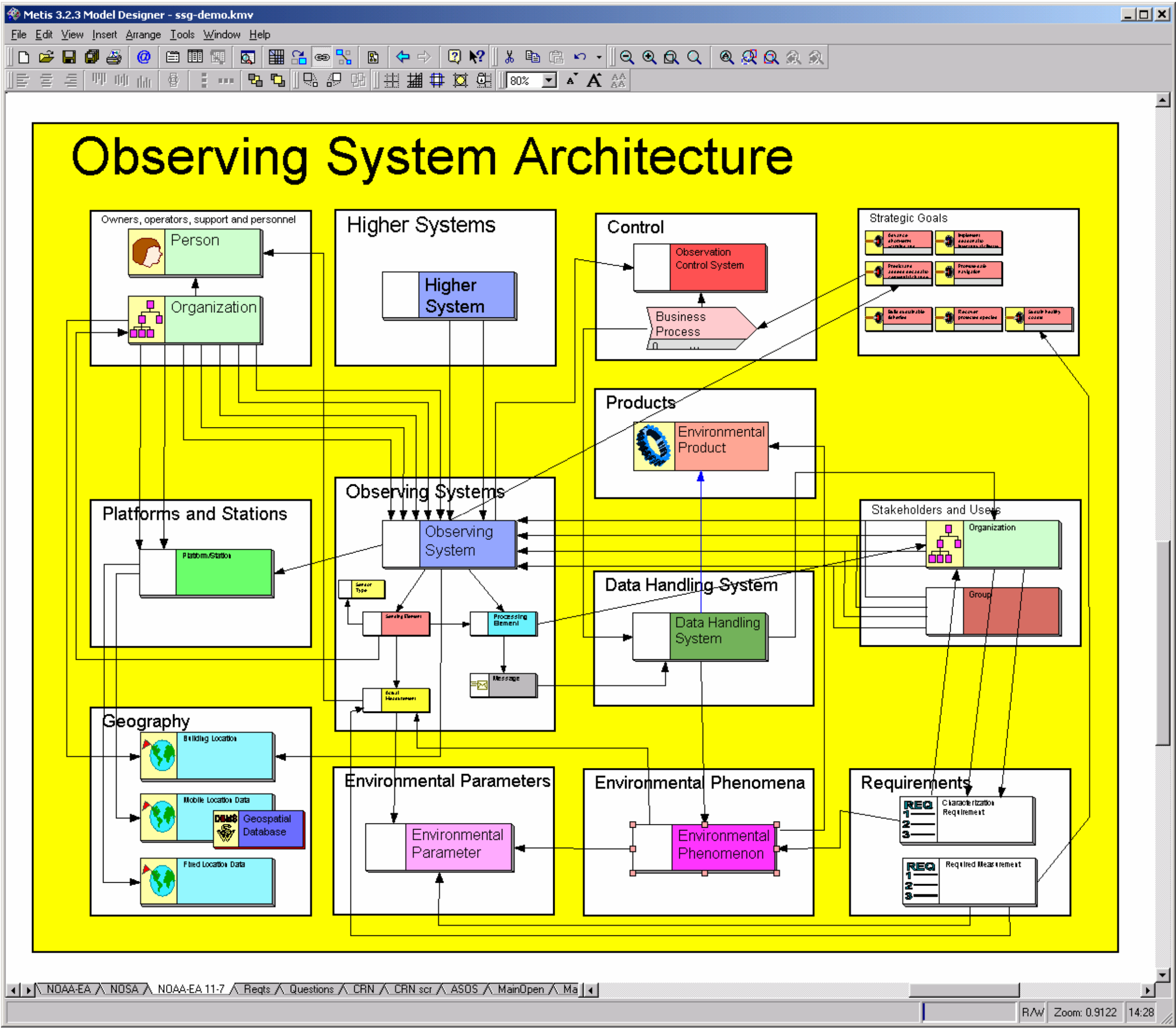


Figure 8. The NOAA Observing System Architecture metamodel as shown in the Metis enterprise architecture tool

Figure 9 shows the details regarding the observing system object and its two main constituents: sensing elements and processing elements. There are typically several sensing elements in each observing system and sometimes several dozen measurements per system. Usually there is a single processing element per system that collects data from several sensing elements. Messages containing observation reports are transmitted by the processing element to downstream data handling systems.

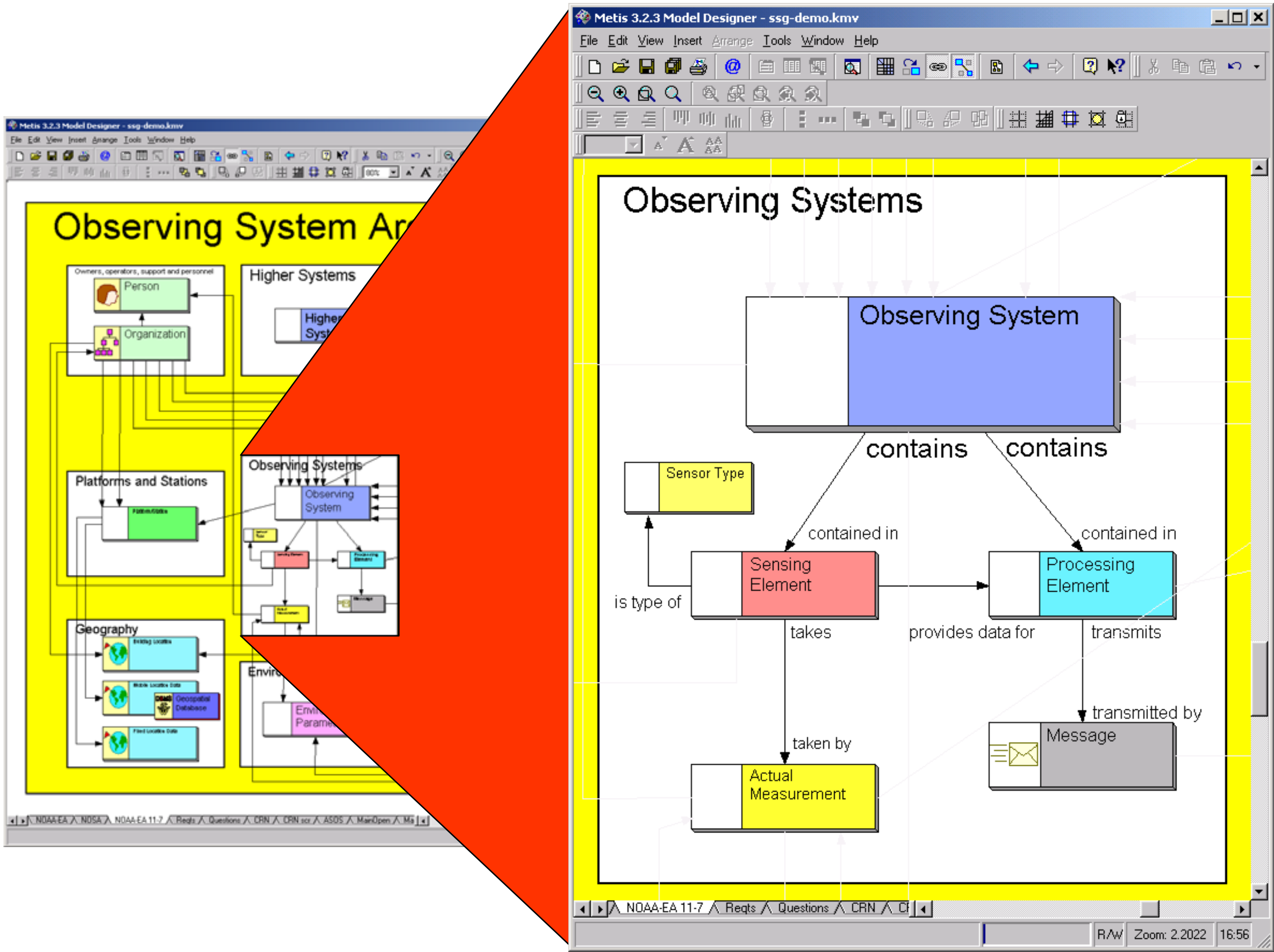


Figure 9. Zooming in on the Observing System objects and their relationships

Figure 10 shows an example of a fictional observing system with typical types of sensing elements and environmental parameters. In this case, the observing system has three sensing elements and two data handling systems. It is also situated at one type of station and at one type of platform. Two of the sensing elements measure two environmental parameters, while the third sensing element only measures a single parameter.

This is a very typical structure for the hundred different types of observing systems. Some systems will only measure a single parameter, while one system measures over fifty parameters. Many are in a fixed location while others are on a mobile platform.

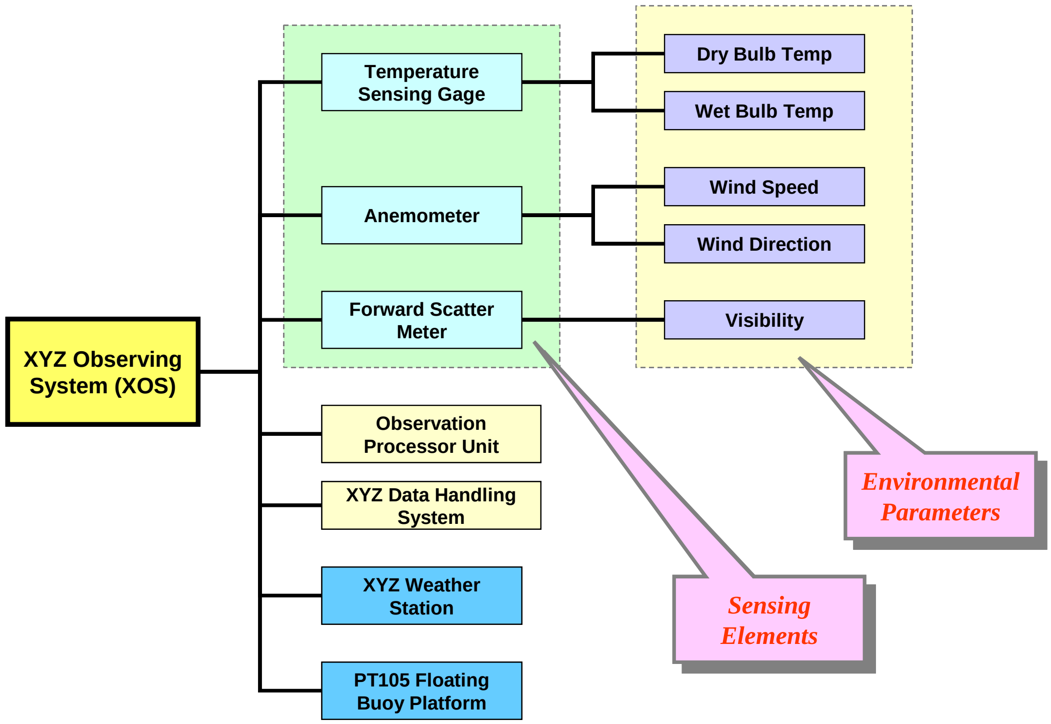


Figure 10. Example hierarchy for an observing system

Integrating the Observing System Architecture with the Enterprise Architecture

In addition to the technical elements from the ERD, this metamodel also includes some additional items like Strategic Goals. NOAA has seven strategic goals and these were mapped to architectural elements like the observing system itself, sensing elements, requirements, parameters, and so on.

NOAA STRATEGIC GOALS

Environmental Assessment and Prediction Mission (1
Advance short-term warning and forecast services (a
Implement seasonal to interannual climate forecasts (b
Predict and assess decadal to centennial change (c
Promote safe navigation (d
Environmental Stewardship Mission (2
Build sustainable fisheries (a
Recover protected species (b
Sustain healthy coasts (c

The Observing System Architecture will be integrated with the higher-level NOAA Enterprise Architecture as shown in Figure 11 on the next page. Figure 12 shows the actual NOSA model with all objects as portrayed in the Metis tool. Additional screen shots are shown in Appendix 2.

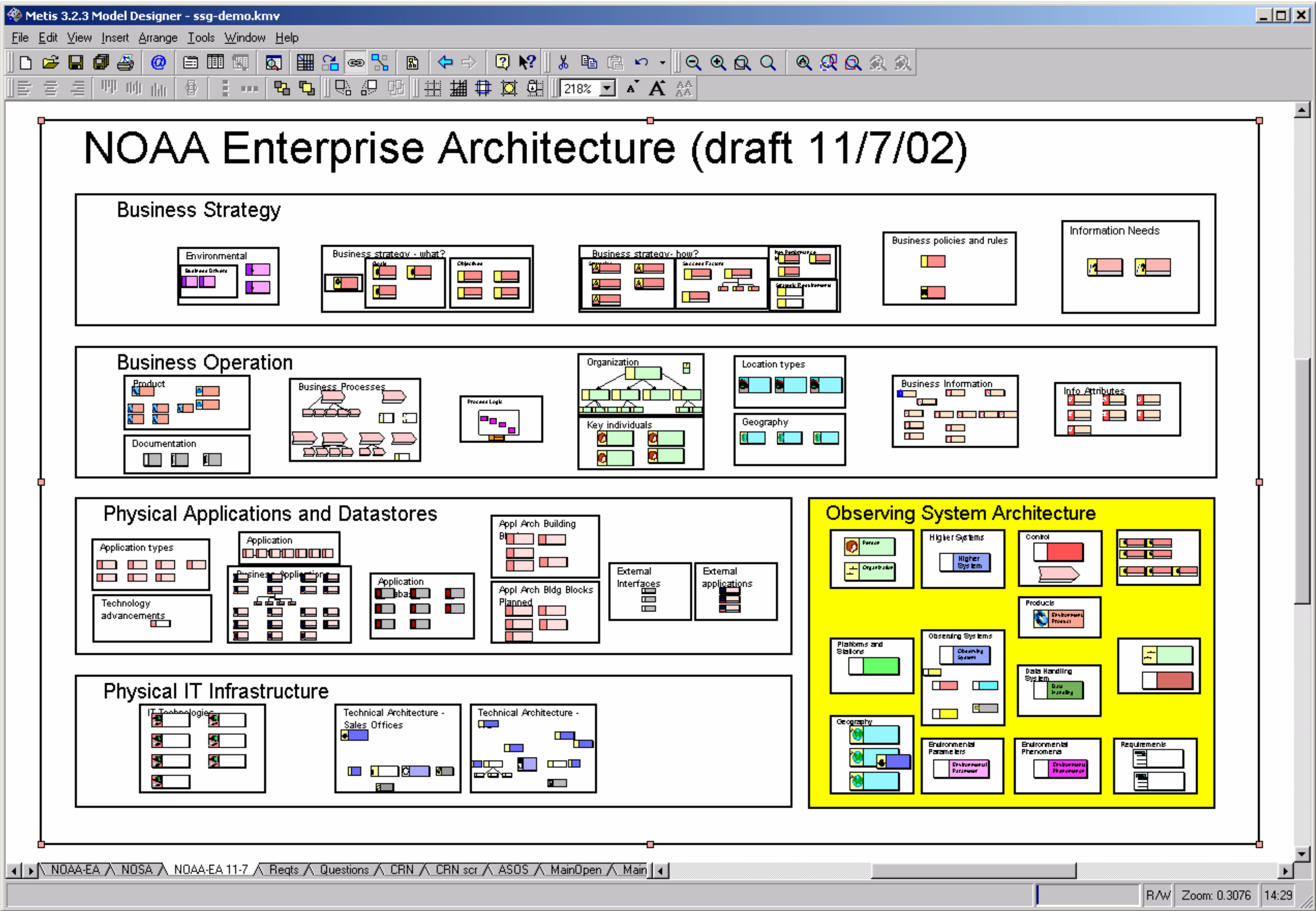

Metis 3.2.3 Model Designer - ssg-demo.kmv
NOAA Enterprise Architecture (draft 11/7/02)
Business Strategy
Environmental
Business strategy - what?
Business strategy- how?
Business policies and rules
Information Needs
Business Operation
Product
Documentation
Business Processes
Organization
Key individuals
Location types
Geography
Business Information
Info Attributes
Physical Applications and Datastores
Application types
Technology advancements
Application
Appl Arch Building
Appl Arch Bldg Blocks
External Interfaces
External applications
Observing System Architecture
Higher Systems
Control
Products
Platforms and Stations
Observing Systems
Data Handling System
Geography
Environmental Parameters
Environmental Phenomena
Requirements
Physical IT Infrastructure
IT Technologies
Technical Architecture - Sales Offices
Technical Architecture -
NOAA-EA
NOSA
NOAA-EA 11-7
Reqts
Questions
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Figure 11. The NOAA Enterprise Architecture framework as shown in the Metis enterprise architecture tool

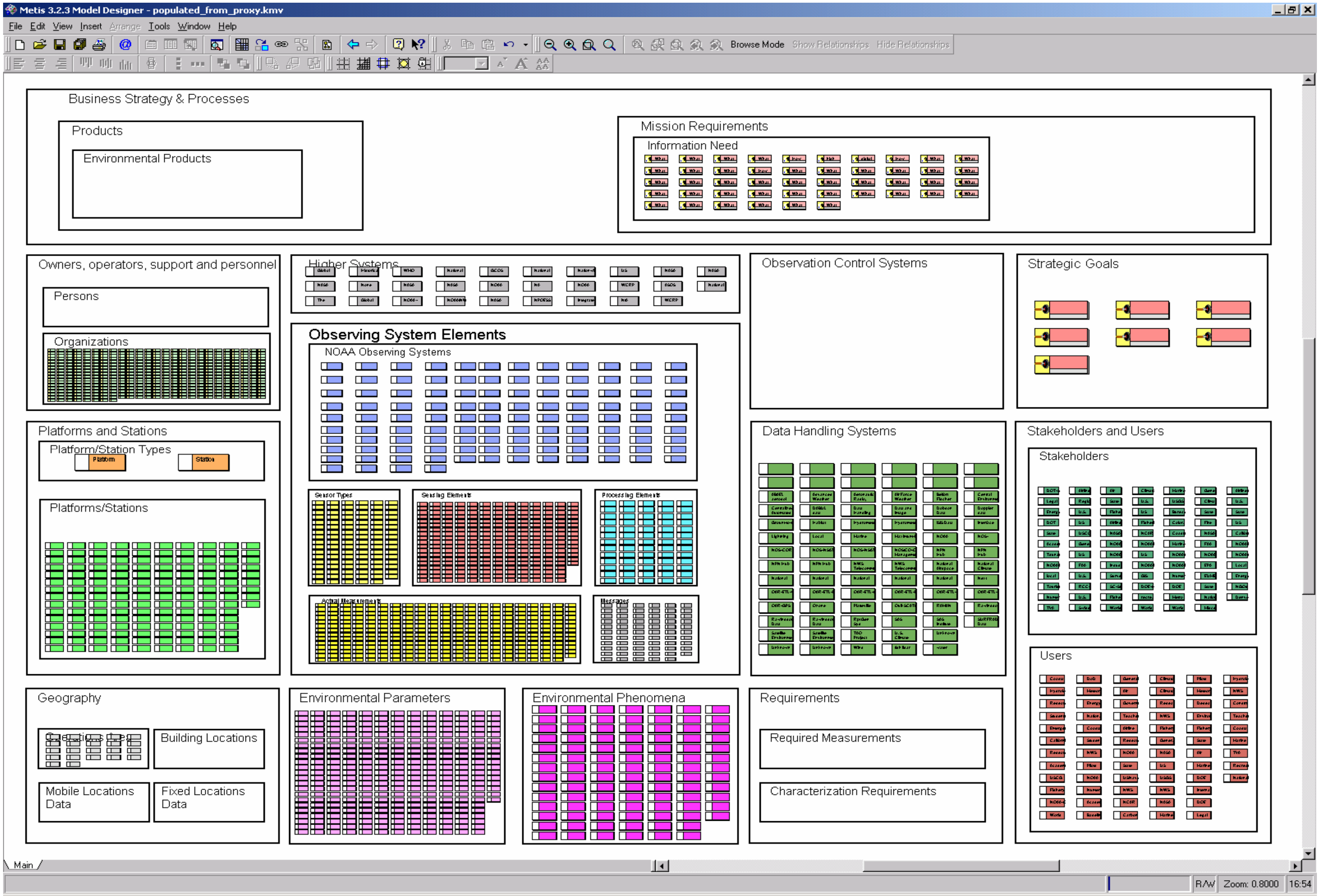


Figure 12. The NOAA Observing System Architecture as shown in the Metis enterprise architecture tool

The NOSA Model

The development of the NOSA is undoubtedly the most comprehensive compilation of observing system data in NOAA's 40-year history. At the completion of the data collection effort, architecture data has been captured on 99 operational and research observing systems, comprising 29,318 currently deployed system platforms or stations. For each observing system, 147 blocks of information were collected. These individual blocks of information range in complexity from as little as a single data point to as much as a full system briefing, schedule, spreadsheet of platform locations, or an image of the system. More than 500 different environmental parameters measured by those observing systems are described.

The NOSA database and is suite of software tools can respond to queries and produce a variety of reports. Examples include:

- Descriptions of NOAA's 99 observing systems, including system purpose, intended use (operational or research), life cycle phase (concept development, operations, retired, etc), schedule, and system quantities (currently deployed, programmed, and needed)
- Costs for each observing system including initial acquisition cost (or replacement cost), subsequent upgrade costs, and several categories of operations and maintenance (O&M) costs
- Environmental parameters measured by NOAA's observing systems
- Application of NOAA observing systems to the new NOAA strategic goals proposed in the Draft NOAA Strategic Plan.
- Maps of locations of observing platforms or stations can be overlaid and compared (as shown in the figure below).

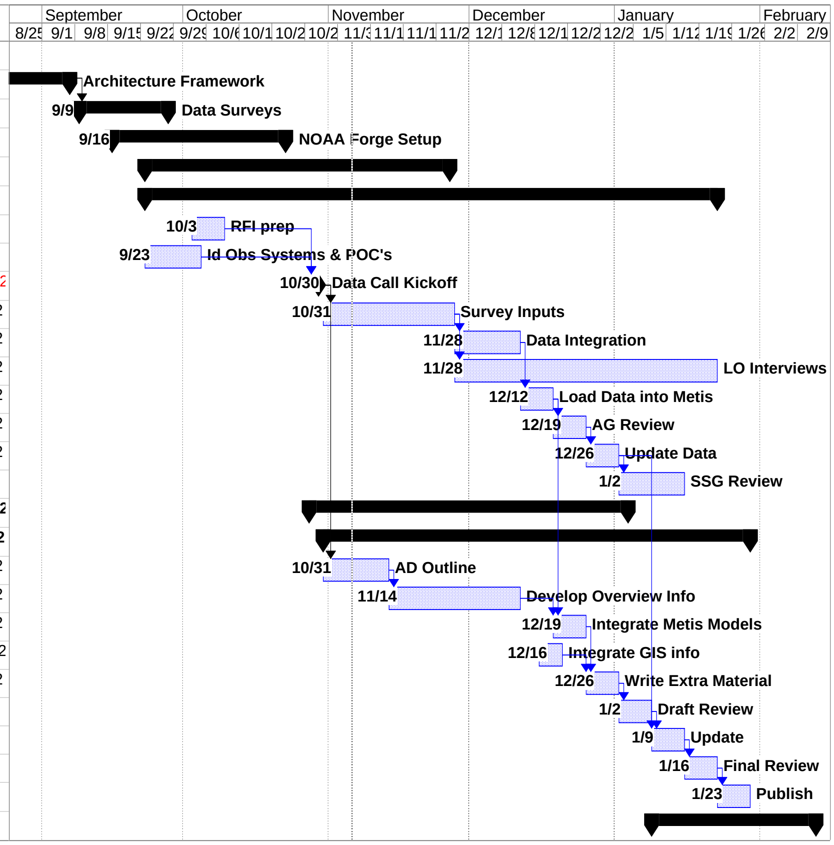
A variety of queries are possible, such as show the observing systems owned by NOS, or list observing systems that measure sea surface temperature, or show observing systems that support measurement of the heat content of the ocean. The results can be presented as tables or, where appropriate, as maps. The system also supports quality control and queries directly over the World Wide Web.

Figure 12 (above) shows the objects as arranged in "containers" in the tool. There are over 2000 objects and about 10,000 relationships between these objects. Additional screen shots from the Metis architecture tool showing the NOSA model are in Appendix 2.

Project Schedule

The baseline architecture was developed over a six month time period from August 2002 to January 2003 (see schedule below). The target architecture is still under development and should be completed by 4Q03. Approximately three person-years of effort was expended during this six month period to produce the baseline architecture model and description.

ID	Task Name	Duration	Start
1	**Startup**	11 days	Mon 8/5/02
5	**Architecture Framework**	15 days	Mon 8/19/02
9	**Data Surveys**	15 days	Mon 9/9/02
13	**NOAA Forge Setup**	27 days	Mon 9/16/02
20	**Metis Tool Setup**	47 days	Mon 9/23/02
32	**Data Call**	88 days	Mon 9/23/02
33	RFI prep	5 days	Thu 10/3/02
34	Id Obs Systems & POC	10 days	Mon 9/23/02
35	**Data Call Kickoff**	1 day	Wed 10/30/02
36	Survey Inputs	20 days	Thu 10/31/02
37	Data Integration	10 days	Thu 11/28/02
38	LO Interviews (as req'd)	40 days	Thu 11/28/02
39	Load Data into Metis	5 days	Thu 12/12/02
40	AG Review	5 days	Thu 12/19/02
41	Update Data	5 days	Thu 12/26/02
42	SSG Review	10 days	Thu 1/2/03
43	**Metis Tool Interfaces**	50 days	Mon 10/28/02
50	**Architecture Descriptior**	65 days	Thu 10/31/02
51	AD Outline	10 days	Thu 10/31/02
52	Develop Overview Info	20 days	Thu 11/14/02
53	Integrate Metis Models	5 days	Thu 12/19/02
54	Integrate GIS info	5 days	Mon 12/16/02
55	Write Extra Material	5 days	Thu 12/26/02
56	Draft Review	5 days	Thu 1/2/03
57	Update	5 days	Thu 1/9/03
58	Final Review	5 days	Thu 1/16/03
59	**Publish**	5 days	Thu 1/23/03
60	**Close-Out Phase 1**	25 days	Thu 1/9/03



Acknowledgments

Rob Mairs, the CIO of NESDIS, was the program leader for this task. Tom Adang was the Aerospace project lead. Ted Habermann from NGDC led the group of people developing the ArcIMS and GIS features of this model. Many thanks go to the team that filled out all the survey forms and those that integrated this into an integrated, cohesive model.

Summary

A NOAA Observing System Architecture (NOSA) Action Group, directed by the NOSA Senior Steering Group, was established to develop an architecture. Up to this point NOAA had not had well-defined coordination of its observing systems and had not had an observing system architecture to use in assessing proposed new requirements for observing systems. This decentralization of observing responsibility and lack of a comprehensive architecture has made it difficult to ensure that observing systems are:

designed to provide the maximum value to NOAA, .d

not duplicative of existing systems, and .e

operated efficiently and in a cost-effective manner. .f

With this new architecture, NOAA can manage its collection of observing systems more efficiently and effectively. To this end, the NOSA model was developed. It defines a consistent set of principles, policies, and standards that will guide the engineering of NOAA's observing systems and infrastructure in a way that ensures alignment with mission requirements.

The NOSA baseline architecture consists of about 30,000 stations or platforms for 100 observing systems that take over 500 environmental measurements for NOAA's dozens of stakeholders. We collected over 15,000 blocks of information about the architectural elements over a six week period and modeled the architecture using the Metis enterprise architecture tool. The NOSA target architecture (timeframe is 2015) is still under development.

Conclusions

The approach of developing an architecture using knowledge modeling was very successful. Without these techniques, we would have developed an architecture model using more traditional systems engineering techniques with less useful results. The model is now being used in various levels of the organization to perform requirements gap analysis, plan their budgets and schedules, assess the future path of capability development, and manage the scarce resources more effectively and efficiently.

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Martin, James N., "An Integrated Tool Suite for the NOAA Observing System Architecture." INCOSE Proceedings, INCOSE Symposium, 2003.

BIOGRAPHY

James Martin is a systems engineer at the Aerospace Corporation developing architectures for information systems and space systems. Mr. Martin led the working group responsible for developing ANSI/EIA 632, a US national standard that defines the processes for engineering a system. He previously worked for Raytheon Systems Company as a lead systems engineer and architect on airborne and satellite communications networks. He has also worked at AT&T Bell Labs on wireless telecommunications products and underwater fiber optic transmission products. His book, *Systems Engineering Guidebook*, was published by CRC Press. Mr. Martin is an INCOSE Fellow and leader of the Standards Technical Committee.

APPENDIX 1 – NOSA Baseline Survey
(164 Questions)

Survey Type: Observing System

Page 1. Identifying Information
1. System Name
2. Acronym
3. Identifier
4. Description
5. Mission Need Statement (Primary)
6. Mission Need Statement (Secondary)
7. System Purpose
8. Intended Use
9. Life Cycle Phase
10. Environmental Assessment and Prediction Mission
11. Environmental Stewardship Mission

Page 2. System Overview
1. Key Characteristics
2. System Functions
3. Major Modes of Operation
4. System Picture
5. Block Diagram
6. Schedule
7. System Webpage
8. Reference Documents Upload
9. System Documentation Webpage
10. System Owner (NOAA)
11. Non-NOAA Owners
12. System Operator (NOAA)
13. Non-NOAA Operators
14. System Support

Page 3. System Context
1. Area of Operations
2. Primary Stakeholders
3. Secondary Stakeholders
4. Users of System Data
5. Downstream Users
6. Observational Scope
7. Decision Making

Page 4. Programmatic Information
1. Acquiring Organization
2. Acquisition Authority
3. Initial Acquisition Cost
4. Replacement Cost
5. Subsequent Upgrade Cost
6. O&M Costs - Total
7. O&M Costs - Equipment
8. O&M Costs - Personnel
9. O&M Costs - Facilities
10. O&M Costs - Data
11. O&M Costs - Services
12. O&M Costs - Other
13. Schedule - IOC
14. Schedule - FOC
15. Schedule - EOFC
16. Schedule - EOL
17. Capital Asset Plan
18. Quantity Deployed (Current)
19. Quantity Deployed (Programmed)
20. Quantity Needed
21. Growth Plans
22. Funding Organizations
23. Funding - Higher Level Systems

Page 5. Relationships
1. Platform/Station
2. Sensing Elements
3. Processing Element
4. Data Handling System(s)
5. Higher Level System
6. Related Observing Systems

Survey Type: Platform/Station

Page 1. Identifying Information
1. Name
2. Acronym
3. Identifier
4. Type
5. Description
6. Owner
7. Operator
8. Operational Regime
9. Webpage
10. Location Map
11. Temporal Characteristics

Page 2. Station Location Data
1. Fixed Location Data
2. Location Data File Upload
3. Database Pointer
4. Database POC
5. Webpage

Page 3. Platform Location Data
1. Operational Area
2. Communications
3. Database Pointer
4. Database POC
5. Webpage

Survey Type: Data Handling System

General Information
1. System Name
2. Acronym
3. Identifier
4. System Functions
5. Description
6. Models
7. Data Collection
8. Data Request
9. Product Generation
10. Data Archival
11. Data Dissemination
12. Metadata

Survey Type: Sensing Element

Sensing Element Basic Info
1. Sensing Element Name
2. Acronym
3. Identifier
4. Sensing Element Type
5. Sensing Element Description
6. Supplier
7. Description Reference Document
8. Sensing Element Web Page
9. Related Environmental Parameter Surveys

Survey Type: Environmental Parameter

Page 1. Environmental Parameter Basic Info
1. Environmental Parameter Name
2. Description
3. Associated Environmental Phenomenon
4. Measurement Algorithm
5. Measurement Units
6. Minimum Measurement Value
7. Maximum Measurement Value
8. Representative Measurement Accuracy
9. Representative Measurement Precision
10. Representative Measurement Uncertainty
11. Environmental Parameter Timeline
12. Timeline Units
13. Reporting Frequency
14. Sampling Frequency
15. Sampling Duration
16. Measurement Stability
17. Measurement Extent
18. Other Key Parameters
19. Remote Sensing

Page 2. Remote Sensing Details
1. General Coverage Description
2. Representative Horizontal Spatial Resolution
3. Representative Vertical Spatial Resolution
4. Mapping Uncertainty
5. Associated Spectral Characteristics

6. Coverage in a GIS Formatted Geospatial Database
7. Database POC
8. Geographical Coverage Data
9. Coverage Description Web Page
10. Coverage Description Material

Page 3. Measurement Interest
1. Driving Requirements
2. Interested Community
3. Strategic Goals
4. Other Needs

Page 4. Key Questions
1. Ocean Climate
2. Lower Atmosphere Climate (0-85 km)
3. Upper Atmosphere (> 85 km)
4. Coastal Climate
5. Surface Climate (including Cryosphere)
6. Miscellaneous

Survey Type: Processing Element

Page 1. Processing Element Basic Info
1. Processing Element Name
2. Acronym
3. Identifier
4. Local Processing
5. Human Augmentation
6. Quality Control

Page 2. Data Characteristics
1. Media Formats - Hardcopy
2. Media Formats - Digital
3. Data Format
4. Metadata
5. Processing Levels
6. Data Outlets
7. Data Relay - Method
8. Data Relay - Scheduled vs On-Demand
9. Data Relay - Timing
10. Data Access
11. Data Retention - Storage
12. Data Retention - Period of Record
13. Data Retention - Latency

Page 3. Observational Messages
1. Basic Message Types
2. Summary Message Types
3. Message Description

Page 4. Communications
1. Sensor-Processor Link Type
2. Sensor-Processor Link Description
3. Processor-DHS Link Type
4. Processor-DHS Link Description

APPENDIX 2 – Example Screen Shots

See separate file.

An Integrated Tool Suite for the NOAA Observing System Architecture

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Abstract. The NOAA Observing System Architecture describes a number of observing systems that provide accurate and timely environmental information to various stakeholders who depend on this information to make critical decisions about farming, construction, fishing, military operations, traffic safety, and so on. This paper describes a project to develop the interfaces between several tools to assist in development of the NOAA Observing System Architecture. We used "knowledge modeling" as the basic approach to capture information about the systems and other entities associated with the architecture. We are using the Metis enterprise architecture tool along with DOORS for requirements, NOAA Forge for team collaboration, and ArcIMS for geospatial data visualization.

Introduction

Figure 1 shows the primary information flow for an observing system. The basic observations are ingested into analytical models that perform various environment-related activities like weather forecasting, storm tracking, fish population monitoring, climate prediction, and so on. The resulting information from these models is captured in special reports suitable for public consumption. (Some of the observational data will proceed directly to the users, especially for groups like scientists who perform scientific research on fundamental environmental phenomenology.)

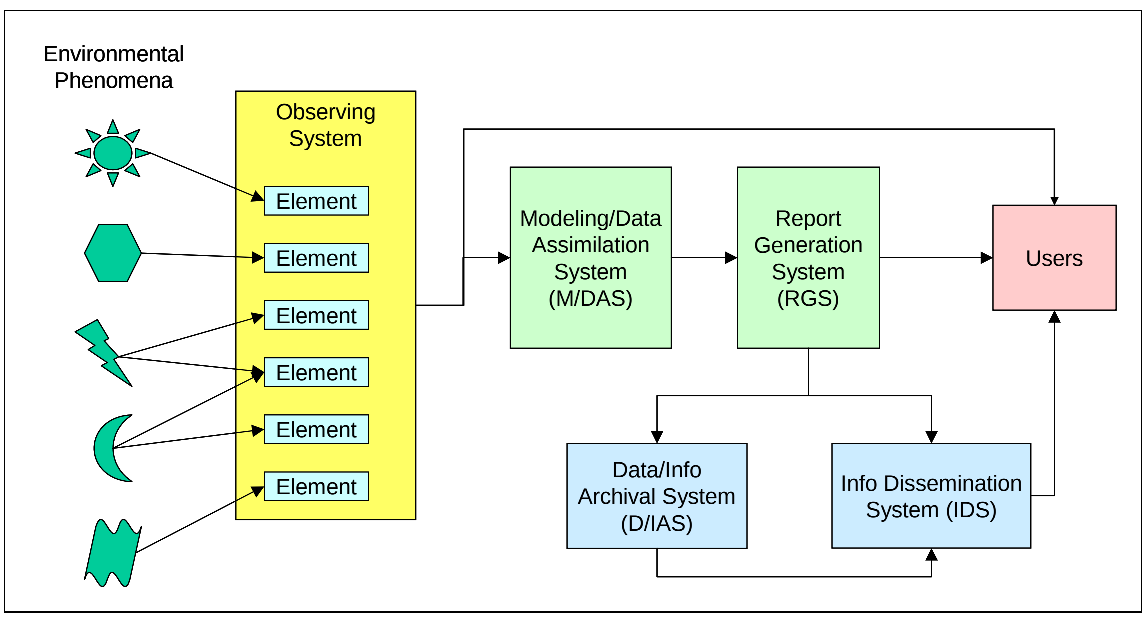


Figure 1. Primary information flows for NOAA Observing Systems from

environmental phenomena to users

The National Oceanic and Atmospheric Administration (NOAA) in the United States has a very broad charter that includes making "observations" of environmental phenomena worldwide in order to provide accurate and timely information to various stakeholders. These people and organizations depend on this information to make critical decisions about farming, construction, fishing, military operations, traffic safety, and so on.

This paper describes a project to develop the NOAA Observing System Architecture (NOSA) to assist NOAA in formulating its strategic plans and invest its funding more effectively. There are about one hundred different observing system "types" currently in use throughout NOAA. Some of the system types will have hundreds or thousands of "instances" of that type in locations throughout the world. For example, there are hundreds of floating buoys that gather environmental data about sea surface temperatures, winds, ocean currents, etc. About half the observing system types in NOAA are used primarily for research purposes to gather additional knowledge about environmental phenomena and to update the modeling algorithms used to convert observations into forecasts and more complex information reports.

We are using "knowledge modeling" as the basic approach to capture information about the systems and other entities associated with the architecture. We are using the Metis enterprise architecture tool along with DOORS for requirements, NOAA Forge for team collaboration, and ArcIMS for geospatial data visualization. The knowledge model characterizes architectural elements like the observing system itself, sensing elements contained within each observing system, environmental parameters measured by these sensing elements, and so on. It also captures knowledge about who owns, operates, supports, funds, and acquires these systems.

NOAA Observing System Architecture (NOSA)

Figure 2 is a simplified diagram that represents some of the key elements that will be examined in the NOAA Observing System Architecture (NOSA). The various data handling systems will be treated as a "black box" since they are outside the scope of this effort. These data handling systems will be explored in greater detail in a follow-on project after the observing systems are fully characterized.

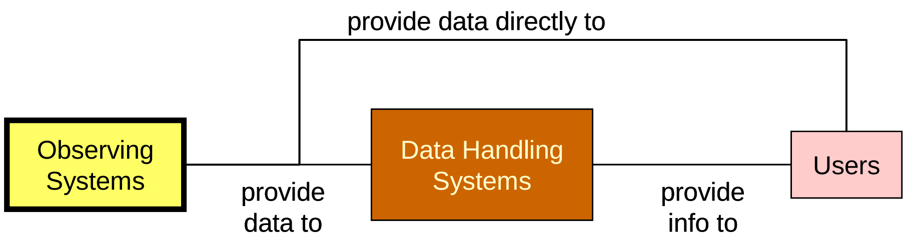


Figure 2. Data Handling Systems convert "observations" into "information" for NOAA's user communities

There are two major phases involved in this project. Phase 1 deals with capturing the baseline systems—those that are currently deployed and those to be deployed in the next two years.

Phase 2 deals with developing the "target" architecture—the set of prospective systems that will be needed in ten to twenty years.

Architecture and Requirements

The target architecture will be based on validated requirements using a requirements-based management process. Figure 3 shows how the stakeholder requirements determine the "services" to be provided by NOAA to its various user communities. Users do not normally care about what environmental parameters are measured nor how these measurements are taken. Instead they are usually most concerned about higher-level environmental "phenomena" that more directly affect their lives such as clouds, storms, floods, etc.

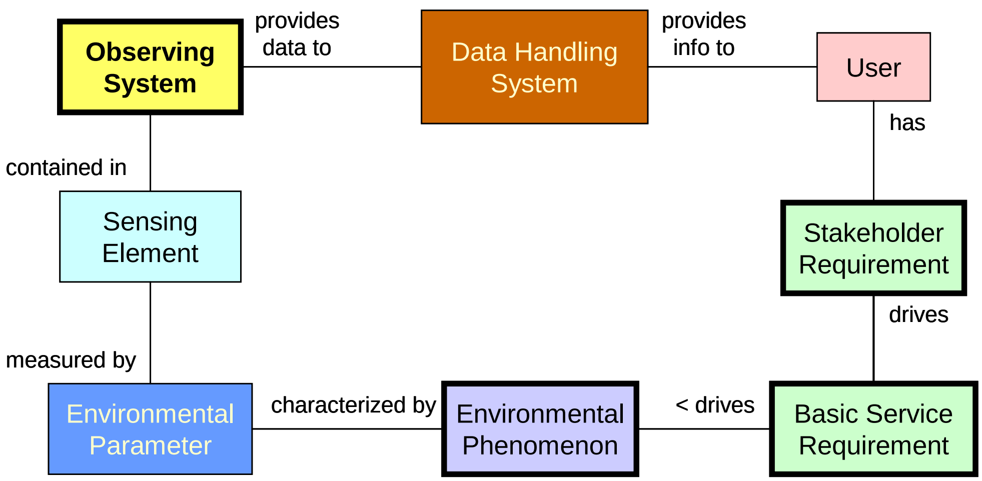


Figure 3. The requirements-driven development process (from user to observing system)

It is clear that the target architecture (2010-20) needs to be based on validated requirements from NOAA's user communities and other stakeholders. This required us to integrate the Metis architecture tool with the DOORS requirements tool to maintain the linkage between requirements and architecture and to ensure that the architecture is a proper reflection of what is really needed to solve the user's problems.

Architecture Tool Suite

Development of the NOAA Observing System Architecture is a large undertaking and requires some investment in tools. Figure 4 shows the configuration of tools being used for this task. The key tool for this task is the enterprise architecture tool. Several architecture tools were investigated to determine the one to be used by this project:

Microsoft: Visio 2002 Professional (a)
Enterprise Architecture Management System (b)
Framework Software: Structure.net and Structure 2001 (c)
Casewise: Corporate Modeler (d)
Computas: Metis (e)
netViz: netViz Professional/webView (f)
Popkin Software: System Architect (g)

Analysis of these tools is documented in (Census 2002). The architecture tool chosen for the NOSA project was the Metis tool from Computas. DOORS was the preferred tool for requirements management since it was already being used by several large programs within NOAA. ArcIMS is one of several geographical information system (GIS) tools used within NOAA to help visualize and analyze data in their geospatial databases.

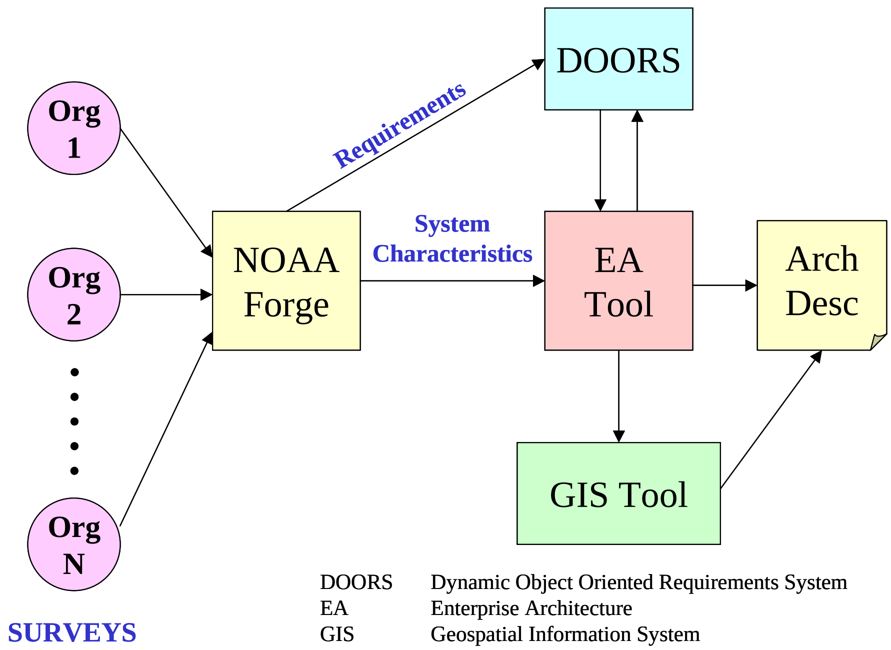


Figure 4. Tool suite for the NOAA Observing System Architecture project

NOAA Forge is an internally-developed, web-based collaboration tool. We used this for collecting basic information about the observing systems and other architectural elements from various system owners throughout NOAA using special survey questionnaires (more about this later).

A discussion of how the Metis tool was used to develop the architecture is contained in a companion paper (Martin 2003). This paper will focus on the other tools in the suite that helped on the front-end where information about existing systems was collected and on the back-end where data is extracted from the architecture tool to support requirements analysis and visualization of the geospatial characteristics of system performance.

NOAA Forge Collaboration Tool

"NOAAForge is a collaborative development and management environment based on SourceForge 2.0 Open Source development software. It provides easy access to the best in CVS, mailing lists, bug tracking, message boards/forums, task management, permanent file archival, full backups, and total web-based administration." (http://class1.nesdis-hq.noaa.gov/)

"SourceForge Enterprise Edition provides a unified development environment for managing code, content and process. SourceForge delivers Development Intelligence by combining collaborative development tools with the ability to track, measure and report on software project)http://sourceforge.net/activity in real time." (

For the NOSA project, we primarily used the survey feature in NOAA Forge to collect basic information about the systems in the NOAA Observing System Architecture. We collected this information from system developers and operators using a set of six survey forms as shown in Figure 5. The structure and contents of these surveys were developed based on the metamodel used in the Metis architecture tool. The metamodel and the survey questions are described in (Martin 2003).

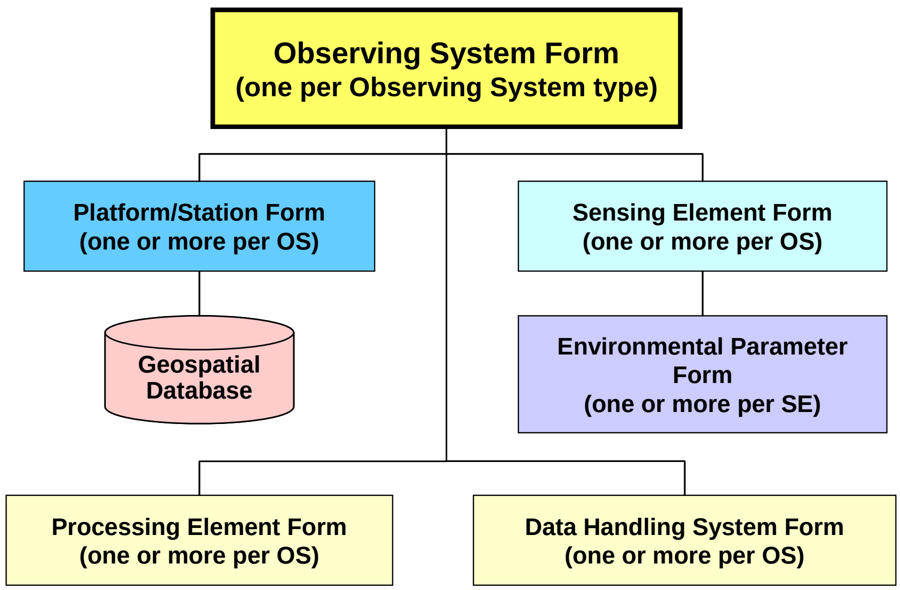


Figure 5. Survey forms used to collect information about the NOSA observing systems and their related elements

The survey form for platforms and stations has a place to identify the location and owner of the relevant geospatial databases for the observing system. Instead of importing location data into the Metis tool, it was more efficient to point to an existing database maintained by others.

For the purpose of this effort, we defined a platform to be a mobile environmental observatory, for example a ship or aircraft. A station is defined to be a fixed environmental observatory, for example a tower or moored buoy.

Data Collection

Figure 6 shows an example of a hierarchy of surveys in NOAA Forge (for a fictional observing system). This example was constructed as a way to show the system owners how we planned to collect information from them using NOAA Forge. The survey "data call" lasted six weeks and we collected information on about one hundred observing systems.

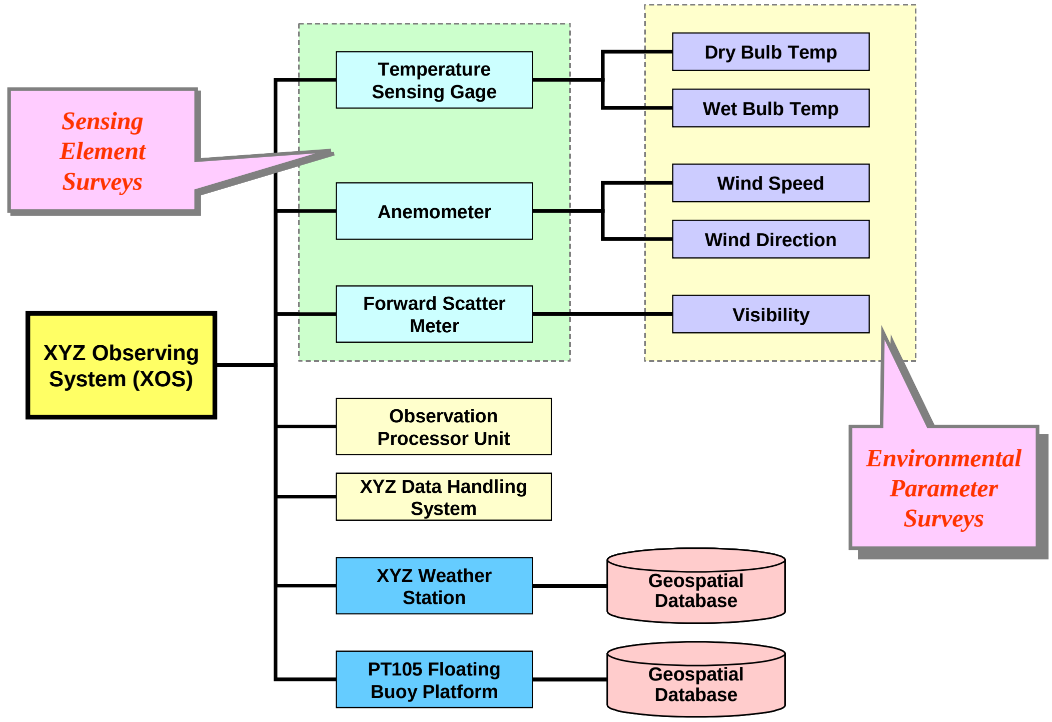


Figure 6. Example survey tree

There were about two to three sensing elements on the average for each observing system and between one and two environmental parameters for each sensing elements. This resulted in over 1000 survey questionnaires filled out by over one hundred people. The average time to fill out each survey ranged from about 10 hours for the observing system survey to a few minutes for each environmental parameter. The total number of survey types is shown below.

Survey Type	Number
Observing System	99
Platform/Station	175
Processing Element	77
Sensing Element	243
Environmental Parameter	334
Data Handling System	87

). This tool is http://class1.nesdis-hq.noaa.gov/Figure 7 shows the home page for NOAA Forge (very easy to use and required minimal training of users. We developed an eleven-page user's guide to assist in its use (with screen shots like this to guide the user). We provided a two-hour training workshop for about forty people. We found that those who did not receive the training made more mistakes and were much less likely to complete the surveys as instructed. It is highly recommended that all participants in the future attend the training workshop.

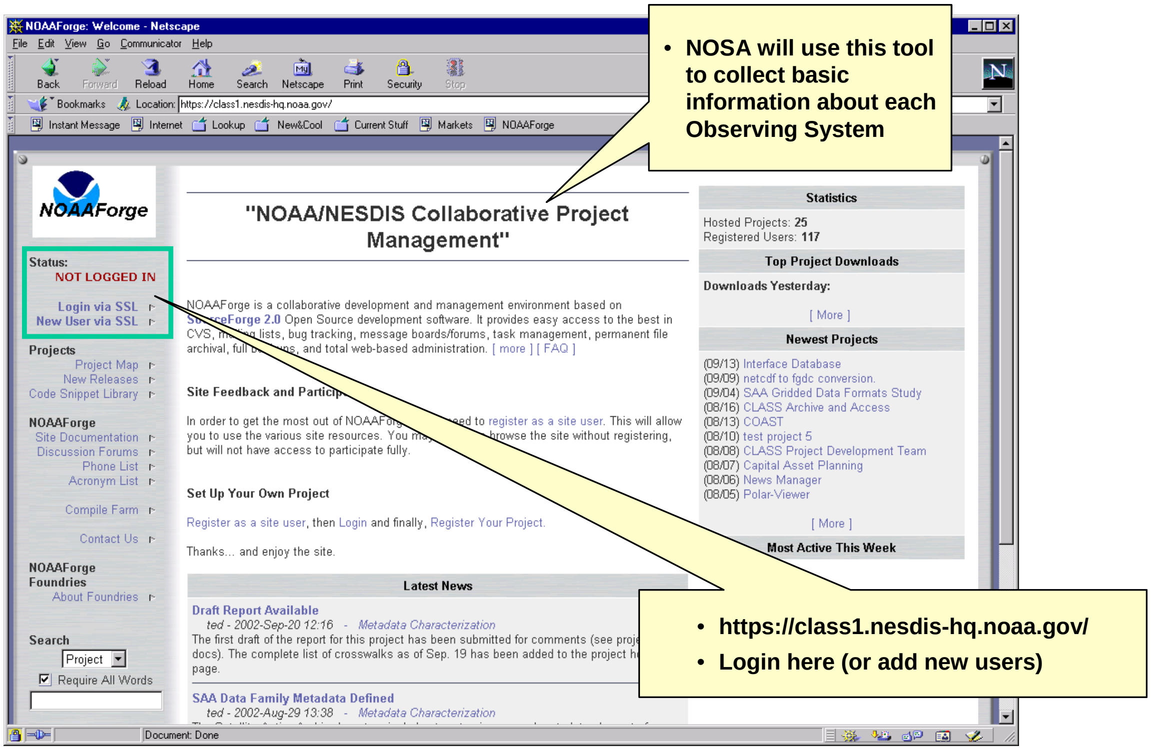


Figure 7. NOAA Forge—the web-based collaboration tool used to manage the hundreds of survey forms and the underlying database

NOAA Forge Surveys

Figure 8 shows the survey webpage for the NOSA project. At the top of the webpage you can see some of the basic functions provided by NOAA Forge:

Function	Purpose
Main	Top page for basic information about the project
Homepage	Place for a homepage, if any, for the project
Forums	Place for threaded discussions about issues and other topics of interest
Bugs	To submit found bugs and feature requests and do bug tracking
Support	For submitting and coordinating requests for support
Tasks	Task assignments and tracking
Docs	Repository for project documents
Surveys	Place for creating survey templates and answering surveys
News	Information about what’s happening on the project
Files	Repository for file packages used by the project

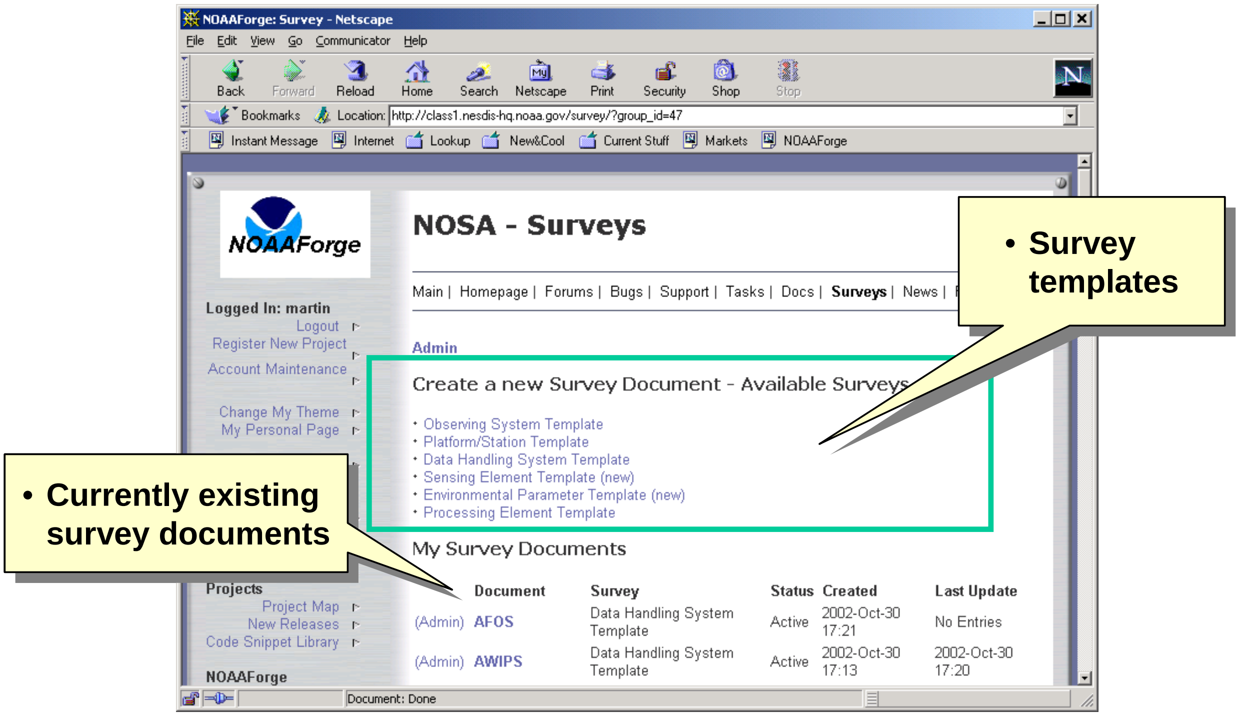


Figure 8. Survey templates and survey documents as seen in the NOAA Forge tool

The main feature used in the NOSA project was the Surveys page. Figure 8 shows six survey templates that match the survey types shown in Figure 5. Below the survey template list is a list of my survey documents that are being worked on. And below my list of documents is a list of all other survey documents in the NOSA project. Each participant has read-only access to all other survey documents and is able to review these documents and provide comments on the answers provided.

Figure 9 shows an example survey page (for a Sensing Element). There are one or more survey pages in each document. Each survey page has several questions. The answers to each question are stored in an SQL database that is integral to NOAA Forge. The database technology used here is mySQL, a freeware package available as open-source code. The SQL data was transferred to an Oracle database for import into the Metis tool. The import scripts were developed using the Metis Database Interface (DBIF) tool.

A detailed list of the survey questions are included in Appendix 1.

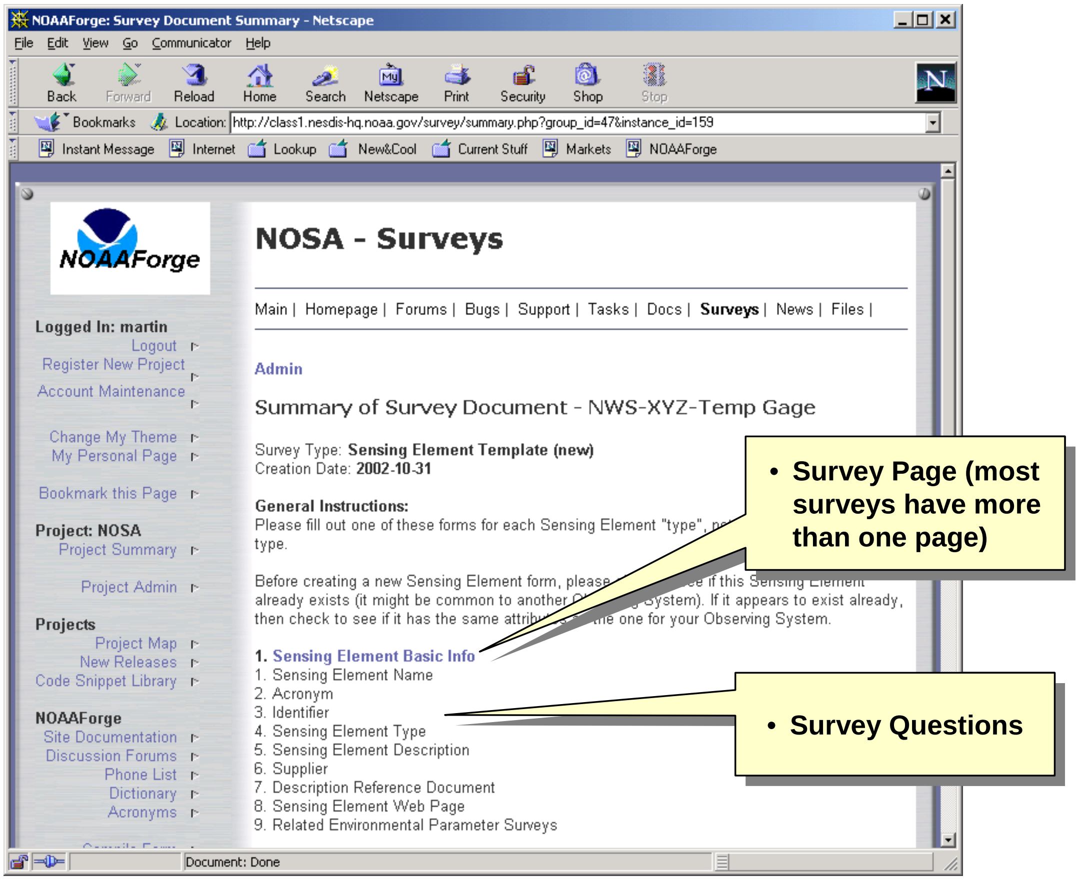


Figure 9. Example survey document for a sensing element

Geospatial Database Interface

The interactions between the various tools used on the NOSA project are shown in Figure 10 (Habermann 2002). All of these tools are web-based, which means that everyone can reach any information they need in the tools using standard web browsers (i.e., Netscape and Internet Explorer). The Metis tool is the central repository for architectural information. When an architectural query is dealing with geospatial attributes of the architecture, then in most cases this will involve a GIS tool like ArcIMS.

The Metis tool will receive a query from a user and, if necessary, will transmit a request to the GIS tool via a request handler. All tool interfaces use XML (extensible markup language) as the means for transferring information between tools. Computas has a special database interface (DBIF) tool for constructing the SQL queries that create the XML files for import into Metis.

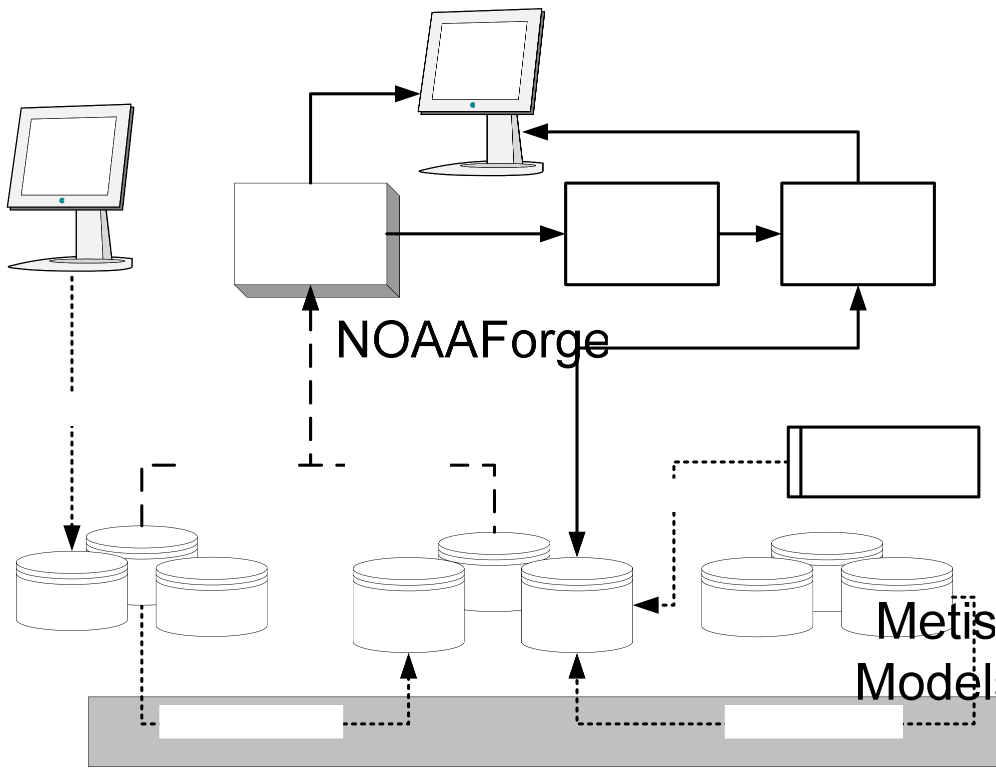


Figure 10. Integration of the Metis architecture tool with geospatial databases and GIS tools and with the NOAA Forge collaboration tool

Visualizing System Locations

NOAA has hundreds of geospatial databases located at many sites around the country. Some of these databases are administered by NOAA data centers:

(a) National Geophysical Data Center

(b) National Climatic Data Center

(c) National Oceanographic Data Center

Other databases are maintained at the National Center for Environmental Prediction (NCEP) located in Suitland, Maryland, and at other organizations like research centers, universities, military organizations, other government agencies, etc.

Figure 11 shows a typical web-based front-end for a GIS tool. This particular diagram can show various observing systems, each in its own “layer” that can be turned on and off depending on which systems are of interest. Layers can also contain geographic and political boundaries, geographic features like rivers, lakes, oceans, and mountains, and man-made features like roads, buildings, dams, and airports.

This “overlaying” feature of GIS tools is crucial in doing some of the architectural analyses of the NOAA Observing System Architecture since much of the value of these systems is dependent on the geospatial relationship with the things that they measure and interaction with geographic features of the earth.

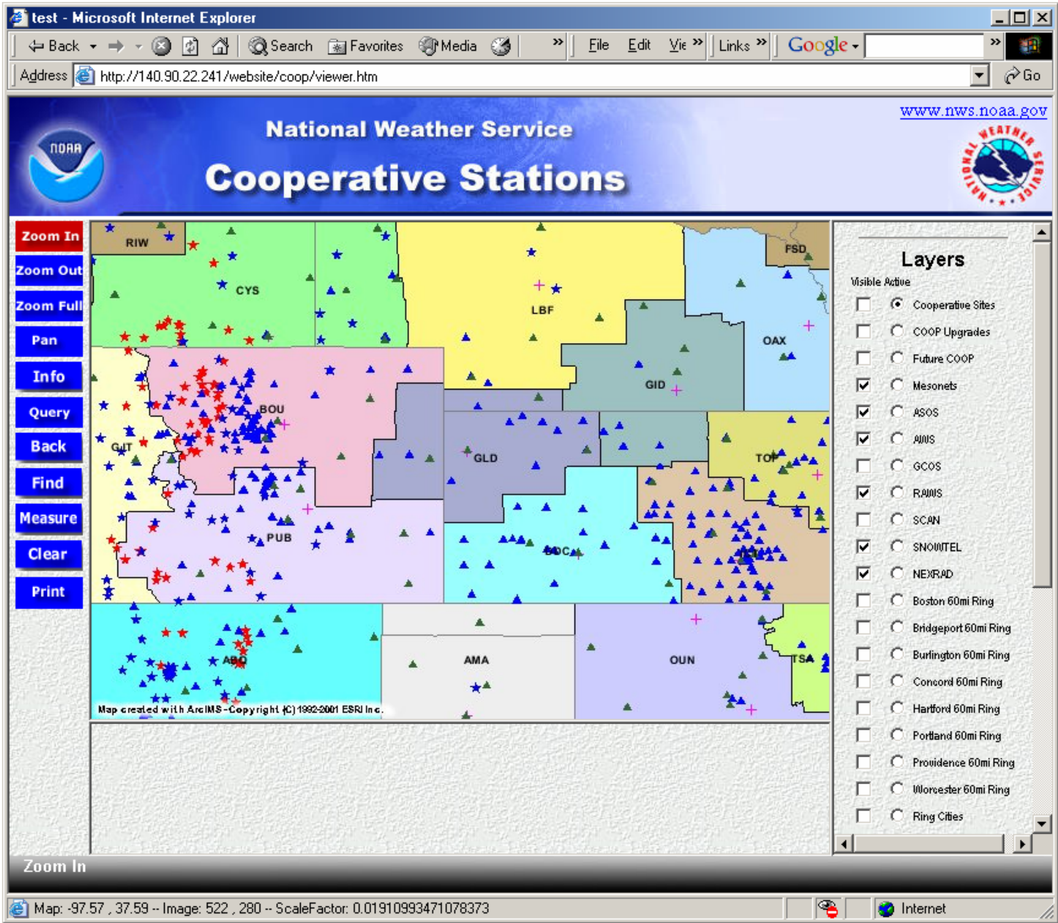


Figure 11. Example depiction of geospatial information using a web-based GIS tool

Visualizing Environmental Phenomena

Figure 12 shows another example with hurricane tracks. A single track (i.e., environmental *phenomenon*) could be the results of thousands of observations (i.e., environmental *parameter*) from several types of observing systems situated at various stations or on various platforms:

(a) Low-earth orbiting satellites

(b) Geostationary satellites

(c) Floating buoys

(d) Moored buoys

(e) Land-based Doppler radar

(f) Hurricane tracking aircraft

(g) Commercial shipping vessels

(h) Private fishermen acting as "scouts"

As you can see from the list above, the creation of high-level weather information can be the result of thousands of observations from hundreds of different observing systems. These hundreds of systems can be of several different "types" with different functions and performance with respect to the environmental parameters associated with that system (for example: accuracy, uncertainty, sampling frequency, reporting interval). The complexity of the environmental monitoring enterprise is what requires us to use sophisticated architectural modeling tools like Metis to develop the architecture and analyze it for key questions from the leadership of NOAA.

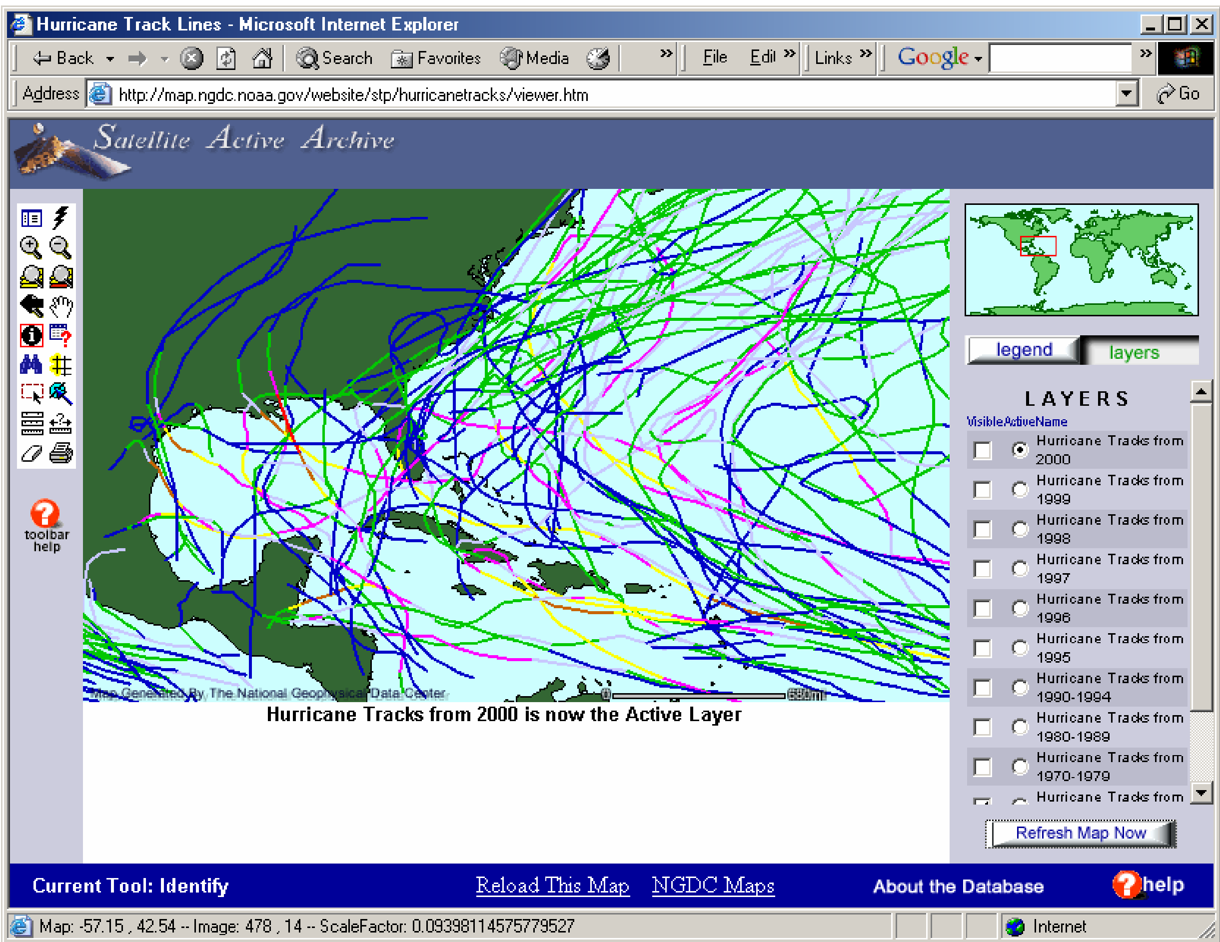


Figure 12. Hurricane tracking using a GIS tool

Visualizing Architectural Properties and Relationships

The main view of the NOSA model is shown in Figure 13. Architectural queries can be performed on the modeling objects and their properties. One of the queries is to "map" the selected observing systems using the GIS tool. The observing system "selection" is often the result of other queries performed on the NOSA model. Figure 14 shows the results of performing a query to determine the modeling elements related to a "key question" relating to a critical climate issue being addressed by NOAA. For further details about the NOSA model, see (Martin 2003).

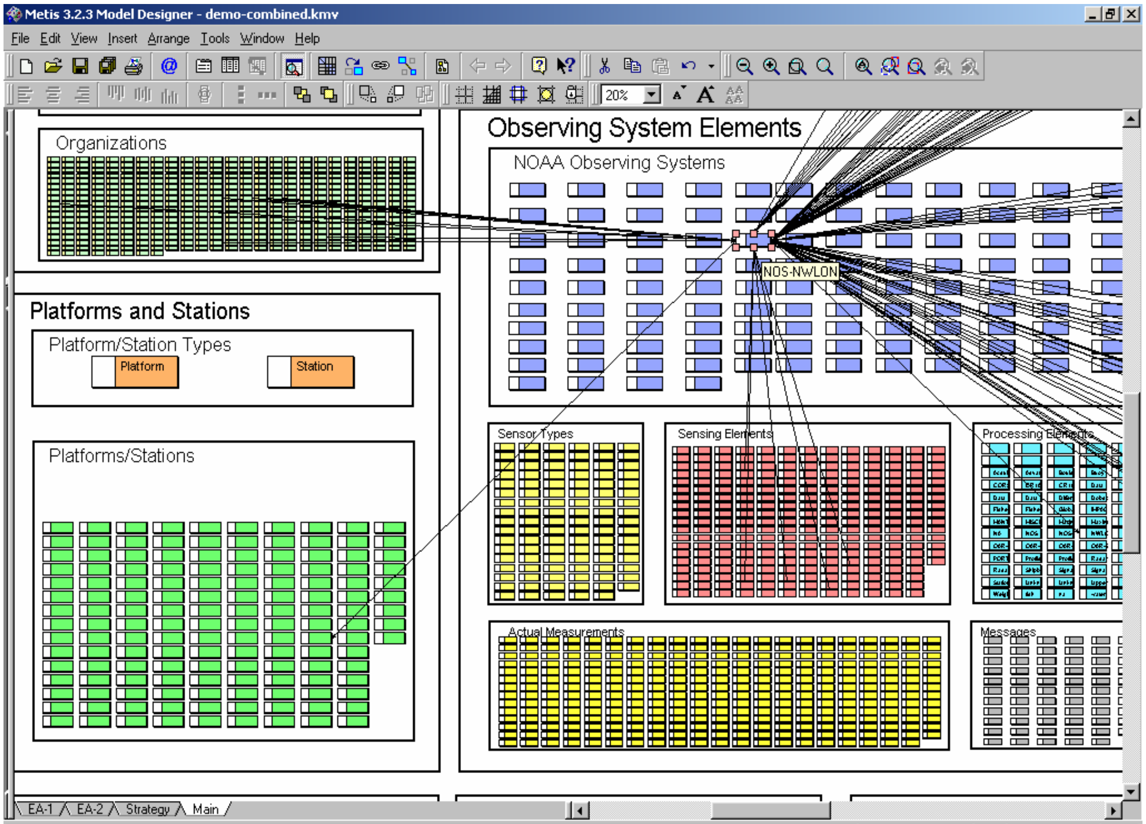


Figure 13. The NOSA model showing the relationships to the National Water Level Observation Network (NWLON)

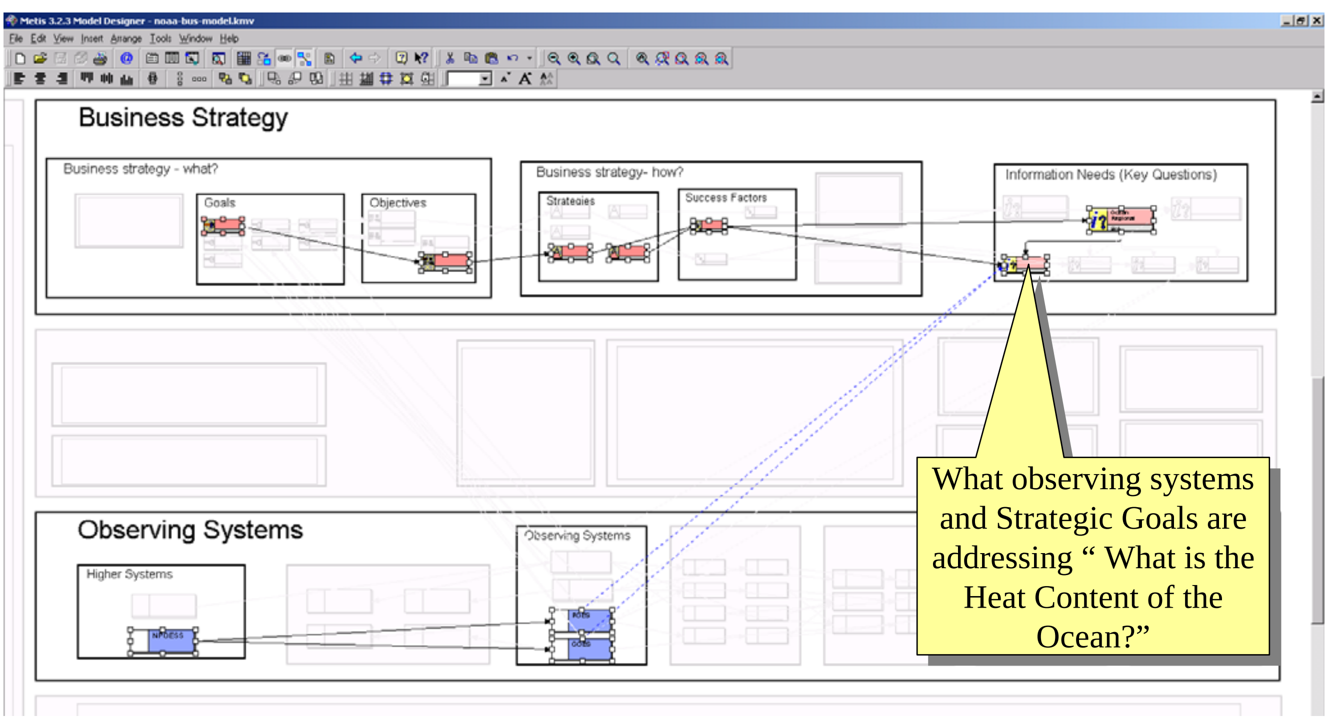


Figure 14. Performing an architectural query on the NOSA model

Visualizing Geospatial Characteristics

The main focus of this paper has been on the interaction between the Metis architecture modeling tool and other tools like ArcIMS that will be used to assist in architectural and requirements analyses. Figure 15 shows a typical result from the ArcIMS tool after the appropriate set of observing systems are selected within the Metis tool.

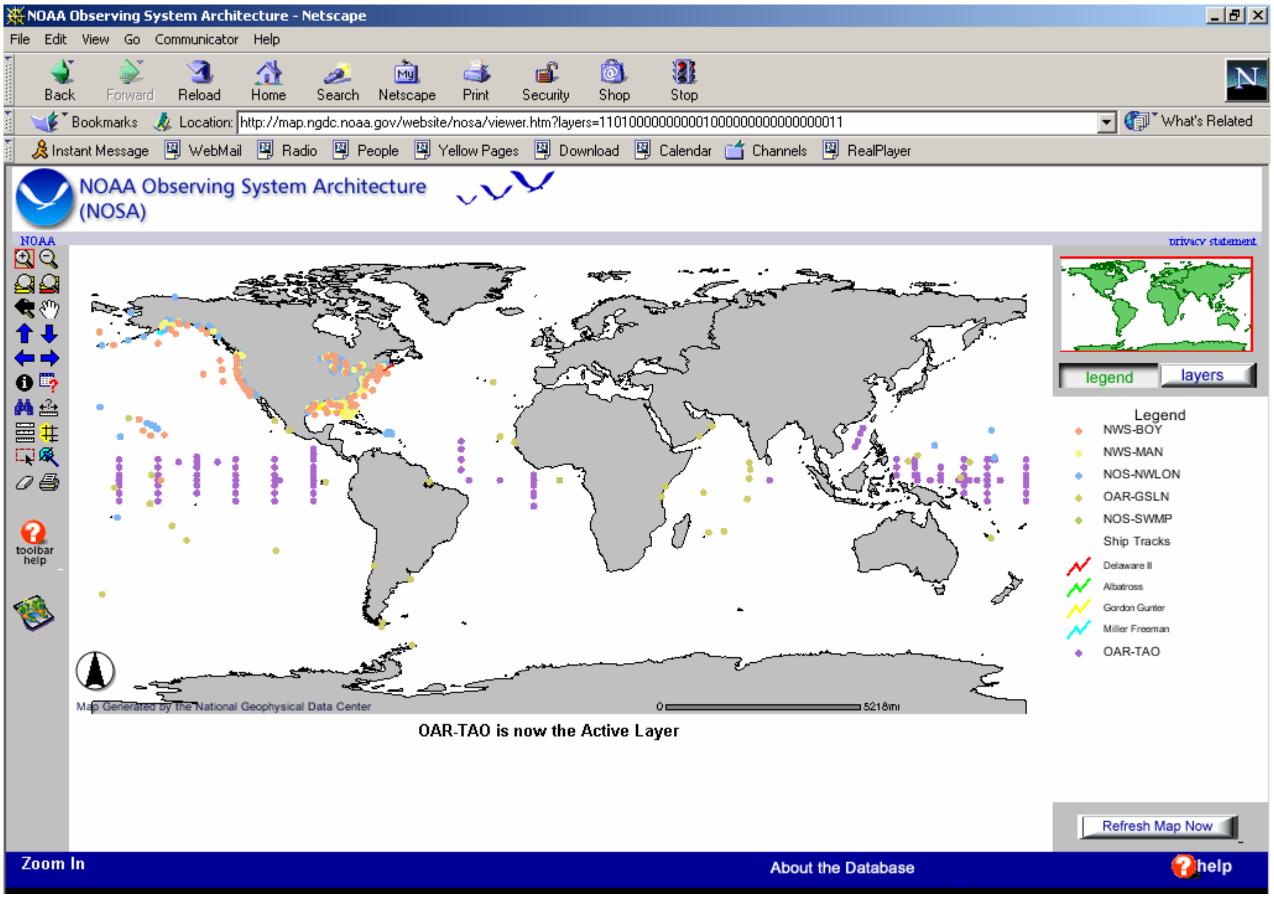


Figure 15. Performing an architectural query on the NOSA model and displaying the geospatial characteristics in ArcIMS

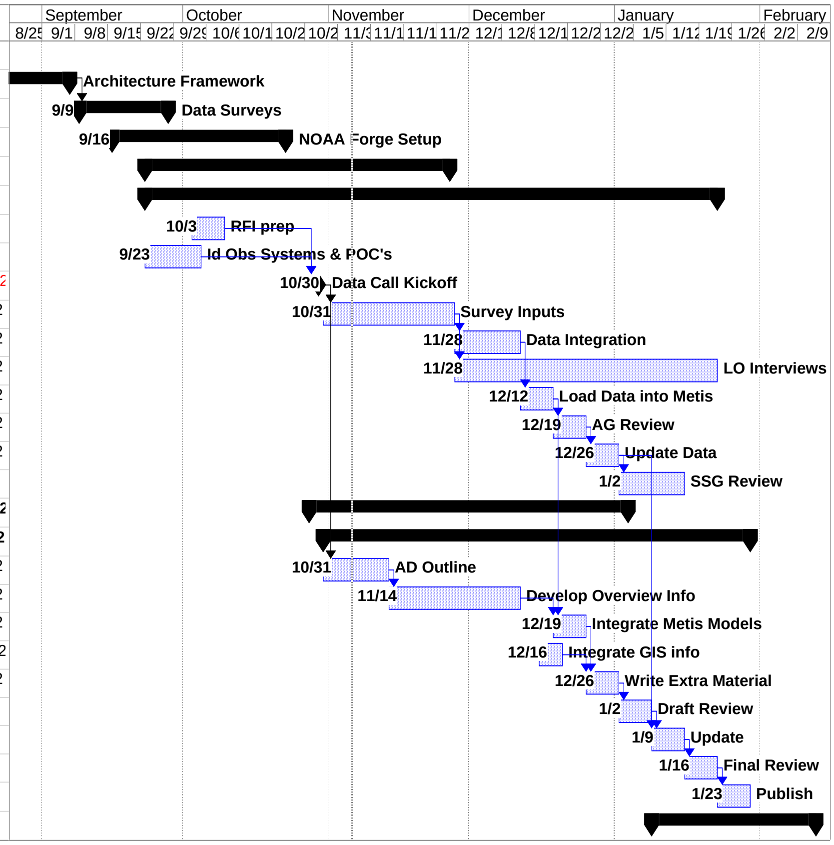
Visualizing Requirements

The interface with the DOORS requirements management tool was still under development at the time this paper was completed. But it has been prototyped and will be used soon to capture the requirements and link them to the architectural elements in Metis.

Project Schedule

The baseline architecture was developed over a six month time period from August 2002 to January 2003 (see schedule below). The target architecture is still under development and should be completed by 4Q03. Approximately three person-years of effort was expended during this six month period to produce the baseline architecture model and description.

ID	Task Name	Duration	Start
1	**Startup**	**11 days**	**Mon 8/5/02**
5	**Architecture Framework**	**15 days**	**Mon 8/19/02**
9	**Data Surveys**	**15 days**	**Mon 9/9/02**
13	**NOAA Forge Setup**	**27 days**	**Mon 9/16/02**
20	**Metis Tool Setup**	**47 days**	**Mon 9/23/02**
32	**Data Call**	**88 days**	**Mon 9/23/02**
33	RFI prep	5 days	Thu 10/3/02
34	Id Obs Systems & POC	10 days	Mon 9/23/02
35	**Data Call Kickoff**	**1 day**	Wed 10/30/02
36	Survey Inputs	20 days	Thu 10/31/02
37	Data Integration	10 days	Thu 11/28/02
38	LO Interviews (as req'd)	40 days	Thu 11/28/02
39	Load Data into Metis	5 days	Thu 12/12/02
40	AG Review	5 days	Thu 12/19/02
41	Update Data	5 days	Thu 12/26/02
42	SSG Review	10 days	Thu 1/2/03
43	**Metis Tool Interfaces**	**50 days**	**Mon 10/28/02**
50	**Architecture Descriptior**	**65 days**	**Thu 10/31/02**
51	AD Outline	10 days	Thu 10/31/02
52	Develop Overview Info	20 days	Thu 11/14/02
53	Integrate Metis Models	5 days	Thu 12/19/02
54	Integrate GIS info	5 days	Mon 12/16/02
55	Write Extra Material	5 days	Thu 12/26/02
56	Draft Review	5 days	Thu 1/2/03
57	Update	5 days	Thu 1/9/03
58	Final Review	5 days	Thu 1/16/03
59	**Publish**	5 days	Thu 1/23/03
60	**Close-Out Phase 1**	**25 days**	**Thu 1/9/03**



Acknowledgments

Rob Mairs, the CIO of NESDIS, was the program leader for this task. Tom Adang was the Aerospace project lead. Ted Habermann from NGDC led the group of people developing the ArcIMS and GIS features of this model. Many thanks go to the team that filled out all the survey forms and those that integrated this into an integrated, cohesive model.

Summary

A NOAA Observing System Architecture (NOSA) Action Group, directed by the NOSA Senior Steering Group, was established to develop an architecture. Up to this point NOAA had not had well-defined coordination of its observing systems and has not had an observing system architecture to use in assessing proposed new requirements for observing systems. This decentralization of observing responsibility and lack of a comprehensive architecture has made it difficult to ensure that observing systems are:

designed to provide the maximum value to NOAA, .a

not duplicative of existing systems, and .b

operated efficiently and in a cost-effective manner. .c

With this new architecture, NOAA can manage its collection of observing systems more efficiently and effectively. To this end, the NOSA model was developed. It defines a consistent set of principles, policies, and standards that will guide the engineering of NOAA's observing systems and infrastructure in a way that ensures alignment with mission requirements.

The NOSA baseline architecture consists of about 30,000 stations or platforms for 100 observing systems that take over 500 environmental measurements for NOAA's dozens of stakeholders. We collected over 15,000 blocks of information about the architectural elements over a six week period and modeled the architecture using the Metis enterprise architecture tool. The NOSA target architecture (timeframe is 2015) is still under development.

Especially helpful was the integration of the Metis and ArcIMS tools to perform geospatial analysis of system performance. This allowed us to display observing systems on a map using standard Geospatial Information System (GIS) tool features. The Metis tool can identify which of the hundred observing systems in the NOAA Observing System Architecture match specific analysis criteria such as:

(1) Which observing systems measure particular environmental parameters (e.g., sea surface temperature)?
(2) Which observing systems support the needs of a particular stakeholder (e.g., airline pilots)?
(3) Which observing systems support the accomplishment of NOAA's strategic goals?
(4) Which observing systems support key scientific questions or mission requirements?
(5) Which observing systems are owned and/or operated by a particular organization?

After the observing systems are identified using programmed queries, the Metis tool interacts with the GIS tool to display the geographic locations of these systems on a map. Different maps can be used with overlays to represent geophysical and other features like rivers, cities, boundaries, weather events, etc. This capability is being used to perform requirements gap analysis in support of program planning and budgeting process.

Conclusions

The approach of developing an architecture using knowledge modeling was very successful. Without these techniques, we would have developed an architecture model using more traditional systems engineering techniques with less useful results. The model is now being used in various levels of the organization to perform requirements gap analysis, plan their budgets and schedules, assess the future path of capability development, and manage the scarce resources more effectively and efficiently.

The suite of tools used for this task were essential for getting the overall results and integration of these tools took advantage of the strengths of each tool for a more effective combination of modeling and analysis capabilities.

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Martin, James N., “On the Use of Knowledge Modeling Tools and Techniques to Characterize the NOAA Observing System Architecture.” INCOSE Proceedings, INCOSE Symposium, 2003.

BIOGRAPHY

James Martin is a systems engineer at the Aerospace Corporation developing architectures for information systems and space systems. Mr. Martin led the working group responsible for developing ANSI/EIA 632, a US national standard that defines the processes for engineering a system. He previously worked for Raytheon Systems Company as a lead systems engineer and architect on airborne and satellite communications networks. He has also worked at AT&T Bell Labs on wireless telecommunications products and underwater fiber optic transmission products. His book, *Systems Engineering Guidebook*, was published by CRC Press. Mr. Martin is an INCOSE Fellow and leader of the Standards Technical Committee.

APPENDIX 1 – NOSA Baseline Survey
(164 Questions)

Survey Type: Observing System

Page 1. Identifying Information
1. System Name
2. Acronym
3. Identifier
4. Description
5. Mission Need Statement (Primary)
6. Mission Need Statement (Secondary)
7. System Purpose
8. Intended Use
9. Life Cycle Phase
10. Environmental Assessment and Prediction Mission
11. Environmental Stewardship Mission

Page 2. System Overview
1. Key Characteristics
2. System Functions
3. Major Modes of Operation
4. System Picture
5. Block Diagram
6. Schedule
7. System Webpage
8. Reference Documents Upload
9. System Documentation Webpage
10. System Owner (NOAA)
11. Non-NOAA Owners
12. System Operator (NOAA)
13. Non-NOAA Operators
14. System Support

Page 3. System Context
1. Area of Operations
2. Primary Stakeholders
3. Secondary Stakeholders
4. Users of System Data
5. Downstream Users
6. Observational Scope
7. Decision Making

Page 4. Programmatic Information
1. Acquiring Organization
2. Acquisition Authority
3. Initial Acquisition Cost
4. Replacement Cost
5. Subsequent Upgrade Cost
6. O&M Costs - Total
7. O&M Costs - Equipment
8. O&M Costs - Personnel
9. O&M Costs - Facilities
10. O&M Costs - Data
11. O&M Costs - Services
12. O&M Costs - Other
13. Schedule - IOC
14. Schedule - FOC
15. Schedule - EOFC
16. Schedule - EOL
17. Capital Asset Plan
18. Quantity Deployed (Current)
19. Quantity Deployed (Programmed)
20. Quantity Needed
21. Growth Plans
22. Funding Organizations
23. Funding - Higher Level Systems

Page 5. Relationships
1. Platform/Station
2. Sensing Elements
3. Processing Element
4. Data Handling System(s)
5. Higher Level System
6. Related Observing Systems

Survey Type: Platform/Station

Page 1. Identifying Information
1. Name
2. Acronym
3. Identifier
4. Type
5. Description
6. Owner
7. Operator
8. Operational Regime
9. Webpage
10. Location Map
11. Temporal Characteristics

Page 2. Station Location Data
1. Fixed Location Data
2. Location Data File Upload
3. Database Pointer
4. Database POC
5. Webpage

Page 3. Platform Location Data
1. Operational Area
2. Communications
3. Database Pointer
4. Database POC
5. Webpage

Survey Type: Data Handling System

General Information
1. System Name
2. Acronym
3. Identifier
4. System Functions
5. Description
6. Models
7. Data Collection
8. Data Request
9. Product Generation
10. Data Archival
11. Data Dissemination
12. Metadata

Survey Type: Sensing Element

Sensing Element Basic Info
1. Sensing Element Name
2. Acronym
3. Identifier
4. Sensing Element Type
5. Sensing Element Description
6. Supplier
7. Description Reference Document
8. Sensing Element Web Page
9. Related Environmental Parameter Surveys

Survey Type: Environmental Parameter

Page 1. Environmental Parameter Basic Info
1. Environmental Parameter Name
2. Description
3. Associated Environmental Phenomenon
4. Measurement Algorithm
5. Measurement Units
6. Minimum Measurement Value
7. Maximum Measurement Value
8. Representative Measurement Accuracy
9. Representative Measurement Precision
10. Representative Measurement Uncertainty
11. Environmental Parameter Timeline
12. Timeline Units
13. Reporting Frequency
14. Sampling Frequency
15. Sampling Duration
16. Measurement Stability
17. Measurement Extent
18. Other Key Parameters
19. Remote Sensing

Page 2. Remote Sensing Details
1. General Coverage Description
2. Representative Horizontal Spatial Resolution
3. Representative Vertical Spatial Resolution
4. Mapping Uncertainty
5. Associated Spectral Characteristics

6. Coverage in a GIS Formatted Geospatial Database
7. Database POC
8. Geographical Coverage Data
9. Coverage Description Web Page
10. Coverage Description Material

Page 3. Measurement Interest

1. Driving Requirements
2. Interested Community
3. Strategic Goals
4. Other Needs

Page 4. Key Questions

1. Ocean Climate
2. Lower Atmosphere Climate (0-85 km)
3. Upper Atmosphere (> 85 km)
4. Coastal Climate
5. Surface Climate (including Cryosphere)
6. Miscellaneous

Survey Type: Processing Element

Page 1. Processing Element Basic Info

1. Processing Element Name
2. Acronym
3. Identifier
4. Local Processing
5. Human Augmentation
6. Quality Control

Page 2. Data Characteristics

1. Media Formats - Hardcopy
2. Media Formats - Digital
3. Data Format
4. Metadata
5. Processing Levels
6. Data Outlets
7. Data Relay - Method
8. Data Relay - Scheduled vs On-Demand
9. Data Relay - Timing
10. Data Access
11. Data Retention - Storage
12. Data Retention - Period of Record
13. Data Retention - Latency

Page 3. Observational Messages

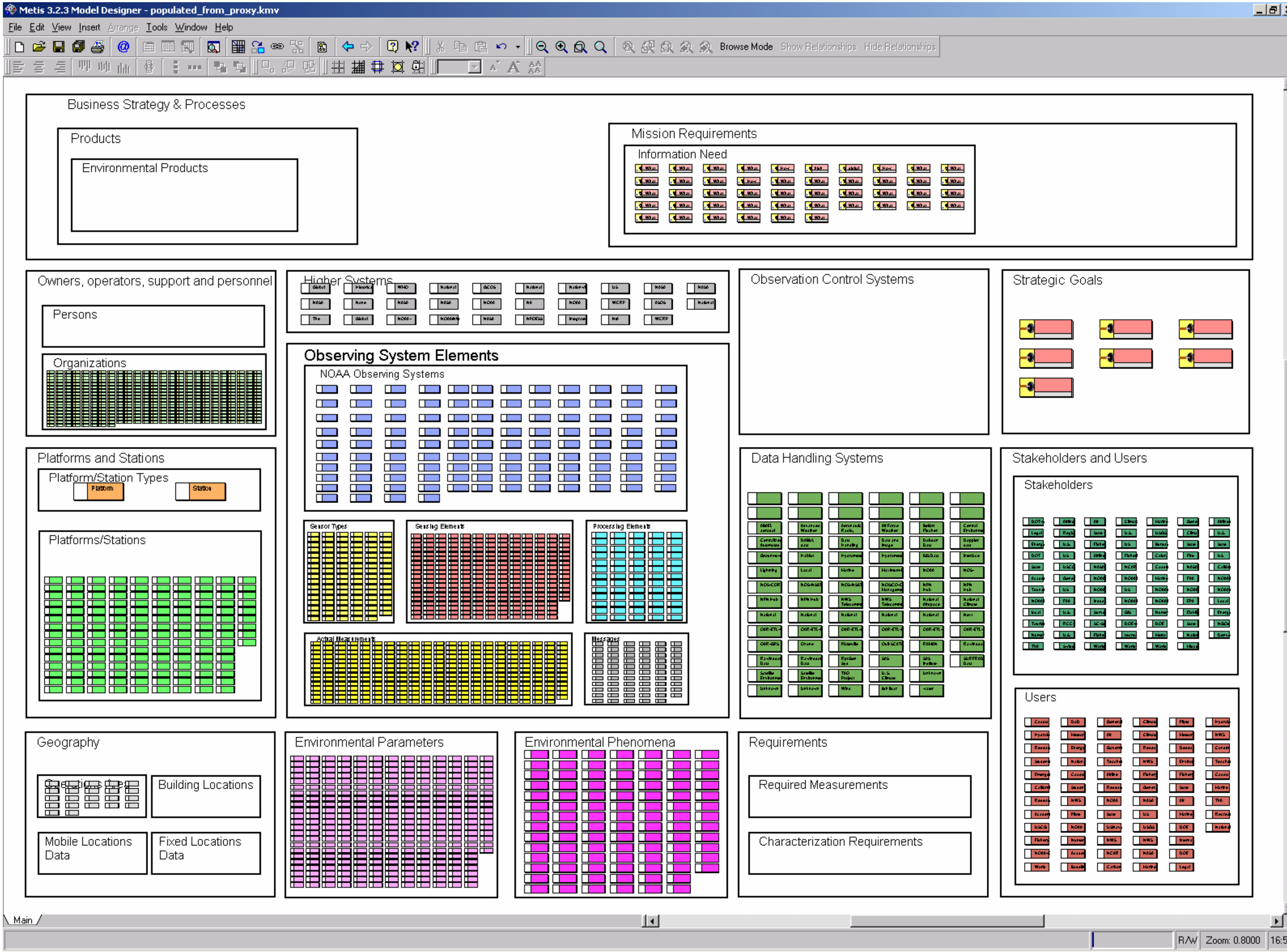
1. Basic Message Types
2. Summary Message Types
3. Message Description

Page 4. Communications

1. Sensor-Processor Link Type
2. Sensor-Processor Link Description
3. Processor-DHS Link Type
4. Processor-DHS Link Description

Appendix 2

Example Screen Shots from the Metis Architecture Tool of the NOSA Model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Browse Mode
Show Relationships
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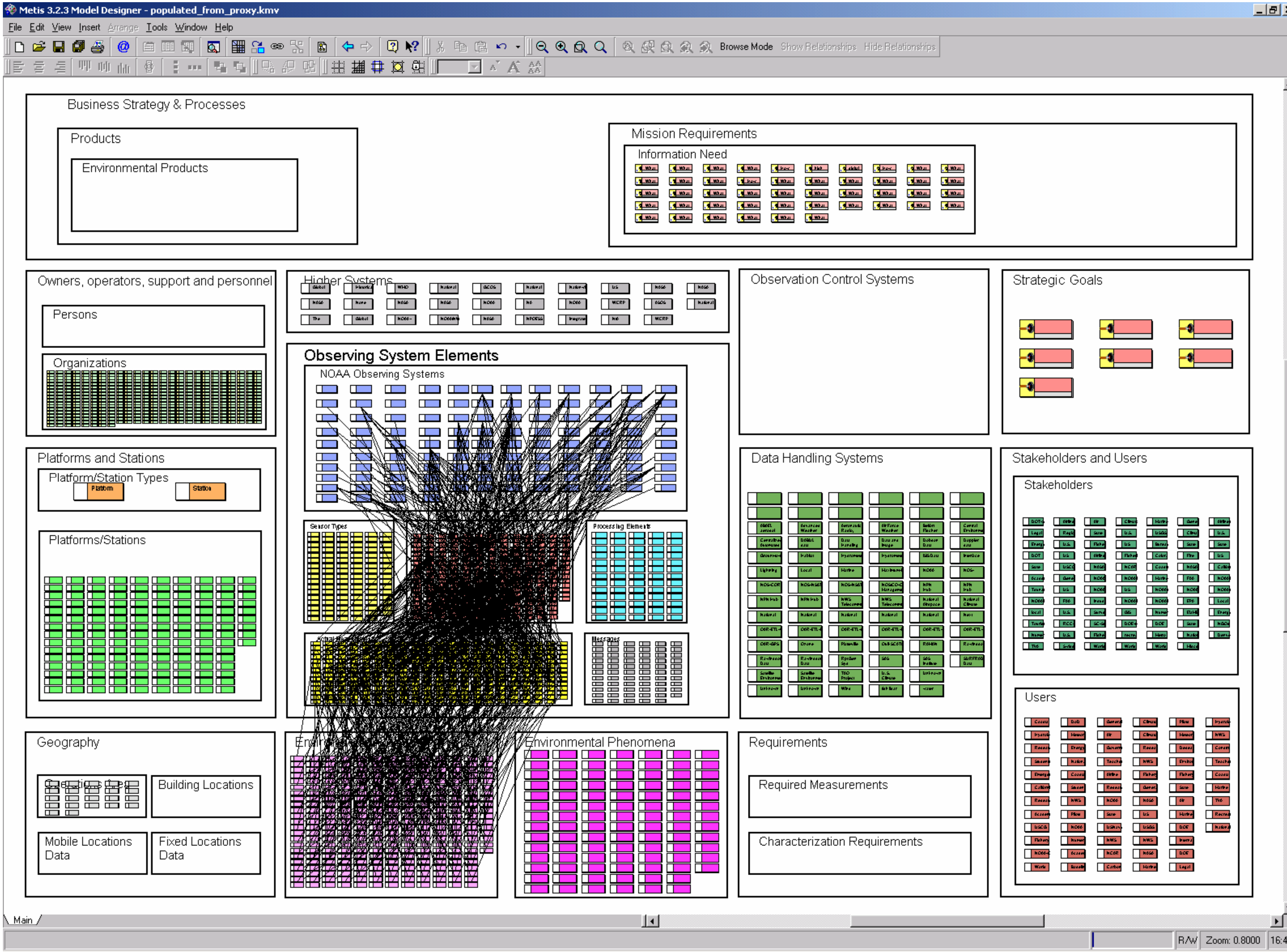
Business Strategy & Processes
Products
Environmental Products
Mission Requirements
Information Need
Owners, operators, support and personnel
Persons
Organizations
Higher Systems
Observation Control Systems
Strategic Goals
Observing System Elements
NOAA Observing Systems
Platforms and Stations
Platform/Station Types
Platform
Station
Platforms/Stations
Sensor Types
Sensing Elements
Processing Elements
Actual Measurements
Messages
Data Handling Systems
Stakeholders and Users
Stakeholders
Users
Geography
Building Locations
Mobile Locations Data
Fixed Locations Data
Environmental Parameters
Environmental Phenomena
Requirements
Required Measurements
Characterization Requirements
Main
R/W
Zoom: 0.8000
16:54



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Environmental Products
Mission Requirements
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Organizations
Higher Systems
Observation Control Systems
Strategic Goals
Observing System Elements
NOAA Observing Systems
Platforms and Stations
Platform/Station Types
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Station
Platforms/Stations
Sensor Types
Processing Elements
Messages
Data Handling Systems
Stakeholders and Users
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Required Measurements
Characterization Requirements
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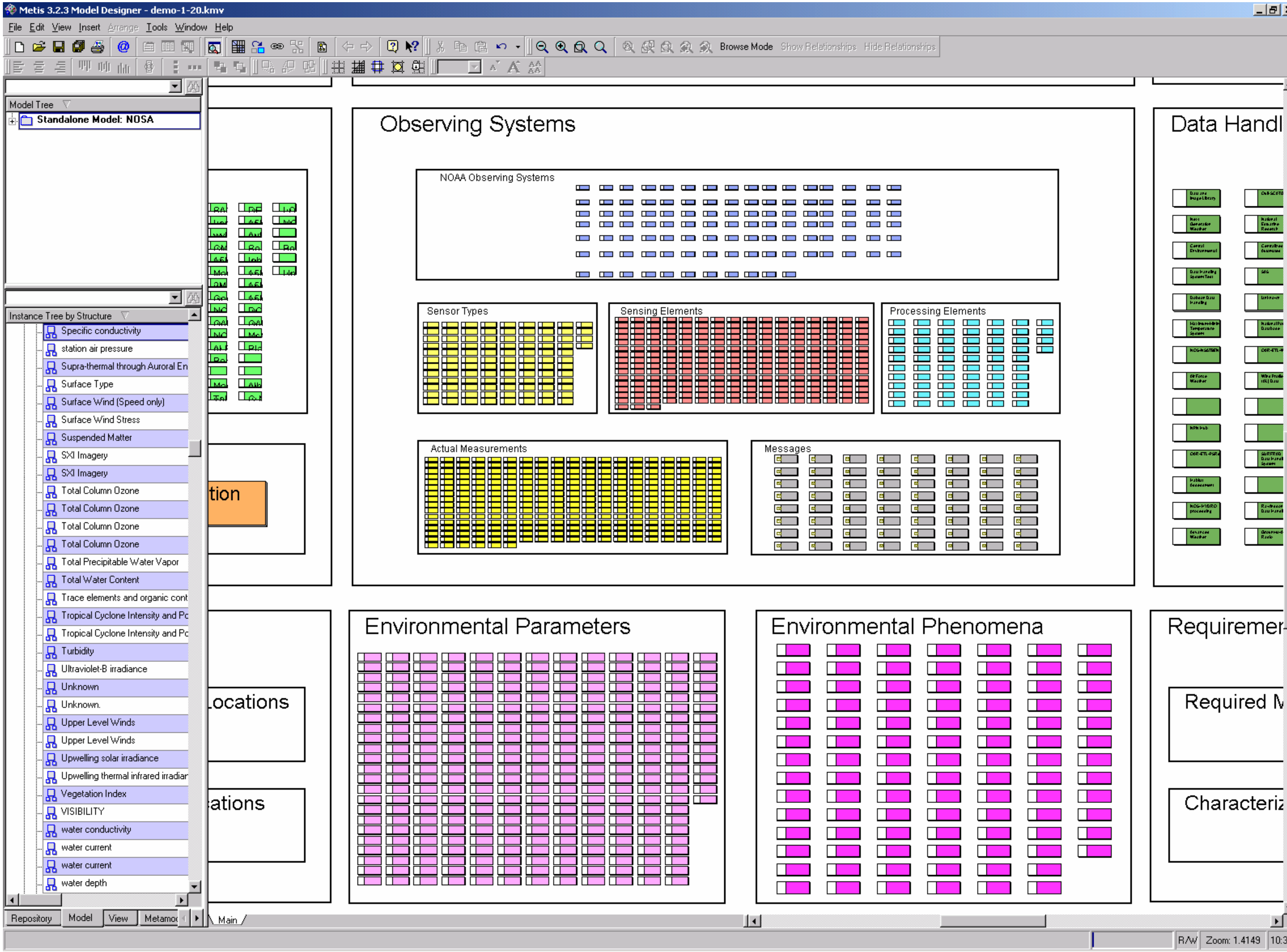
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Browse Mode Show Relationships Hide Relationships
Model Tree
Standalone Model: NOSA
Instance Tree by Structure
Specific conductivity
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Supra-thermal through Auroral En
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Surface Wind (Speed only)
Surface Wind Stress
Suspended Matter
SXI Imagery
SXI Imagery
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Total Water Content
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Tropical Cyclone Intensity and Pc
Tropical Cyclone Intensity and Pc
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Ultraviolet-B irradiance
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Unknown.
Upper Level Winds
Upper Level Winds
Upwelling solar irradiance
Upwelling thermal infrared irradiar
Vegetation Index
VISIBILITY
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water current
water current
water depth
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Observing Systems
NOAA Observing Systems
Sensor Types
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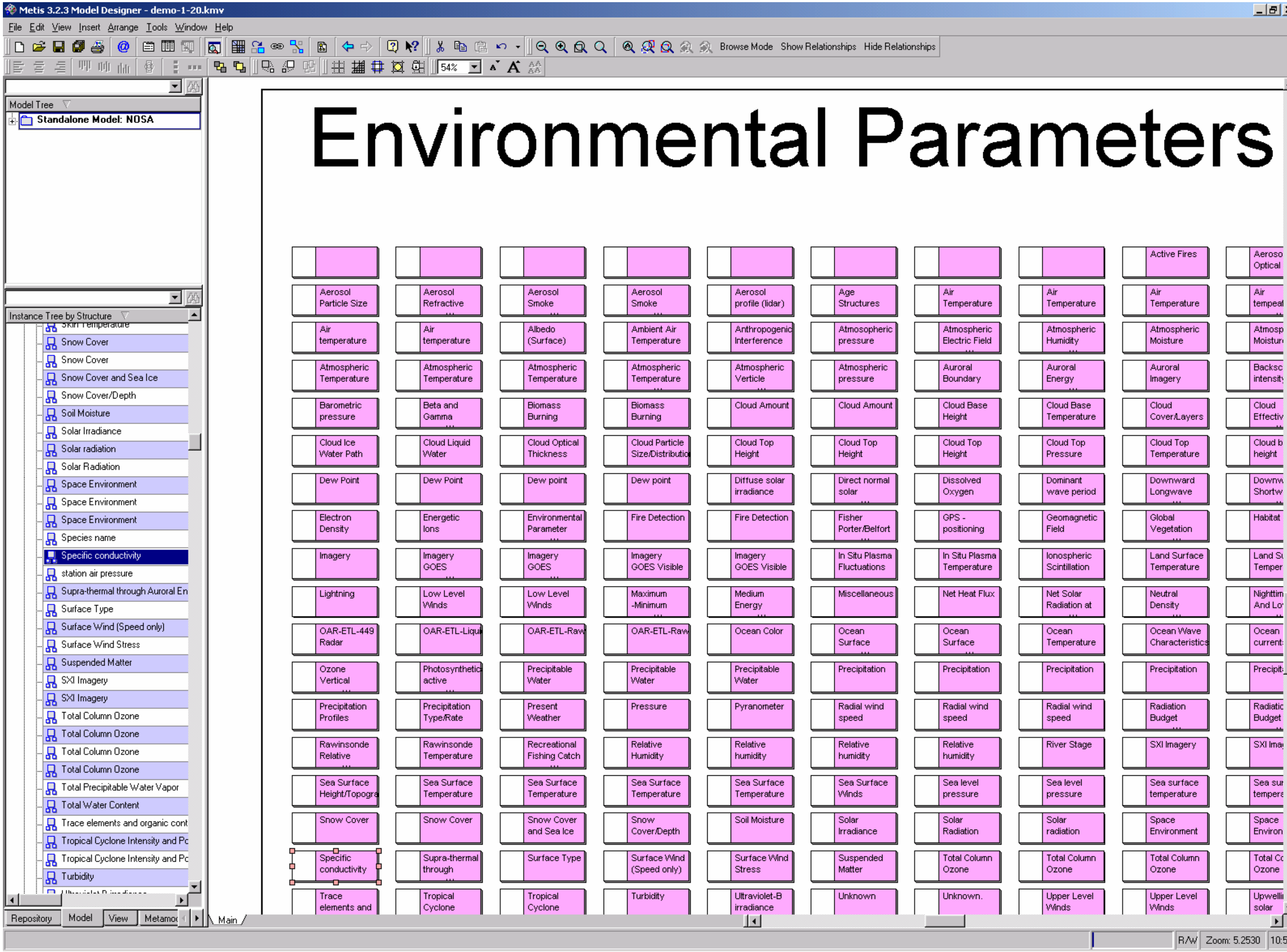
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Browse Mode Show Relationships Hide Relationships
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Model Tree
Standalone Model: NOSA
Instance Tree by Structure
Snow Cover
Snow Cover
Snow Cover and Sea Ice
Snow Cover/Depth
Soil Moisture
Solar Irradiance
Solar radiation
Solar Radiation
Space Environment
Space Environment
Space Environment
Species name
Specific conductivity
station air pressure
Supra-thermal through Auroral En
Surface Type
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Surface Wind Stress
Suspended Matter
SXI Imagery
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Tropical Cyclone Intensity and Pc
Tropical Cyclone Intensity and Pc
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Aerosol Smoke
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Age Structures
Air Temperature
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Ambient Air Temperature
Anthropogenic Interference
Atmospheric pressure
Atmospheric Electric Field
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Atmospheric Verticle
Atmospheric pressure
Auroral Boundary
Auroral Energy
Auroral Imagery
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Barometric pressure
Beta and Gamma
Biomass Burning
Biomass Burning
Cloud Amount
Cloud Amount
Cloud Base Height
Cloud Base Temperature
Cloud Cover/Layers
Cloud Effectiv
Cloud Ice Water Path
Cloud Liquid Water
Cloud Optical Thickness
Cloud Particle Size/Distributio
Cloud Top Height
Cloud Top Height
Cloud Top Height
Cloud Top Pressure
Cloud Top Temperature
Cloud b height
Dew Point
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Dew point
Diffuse solar irradiance
Direct normal solar
Dissolved Oxygen
Dominant wave period
Downward Longwave
Downw Shortw
Electron Density
Energetic Ions
Environmental Parameter
Fire Detection
Fire Detection
Fisher Porter/Belfort
GPS - positioning
Geomagnetic Field
Global Vegetation
Habitat
Imagery
Imagery GOES
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In Situ Plasma Fluctuations
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Maximum -Minimum
Medium Energy
Miscellaneous
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OAR-ETL-Raw
Ocean Color
Ocean Surface
Ocean Surface
Ocean Temperature
Ocean Wave Characteristics
Ocean current
Ozone Vertical
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Precipitable Water
Precipitable Water
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Precipitation Profiles
Precipitation Type/Rate
Present Weather
Pressure
Pyranometer
Radial wind speed
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Radial wind speed
Radiation Budget
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SXI Imagery
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Soil Moisture
Solar Irradiance
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Surface Type
Surface Wind (Speed only)
Surface Wind Stress
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Tropical Cyclone
Turbidity
Ultraviolet-B irradiance
Unknown
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Upper Level Winds
Upper Level Winds
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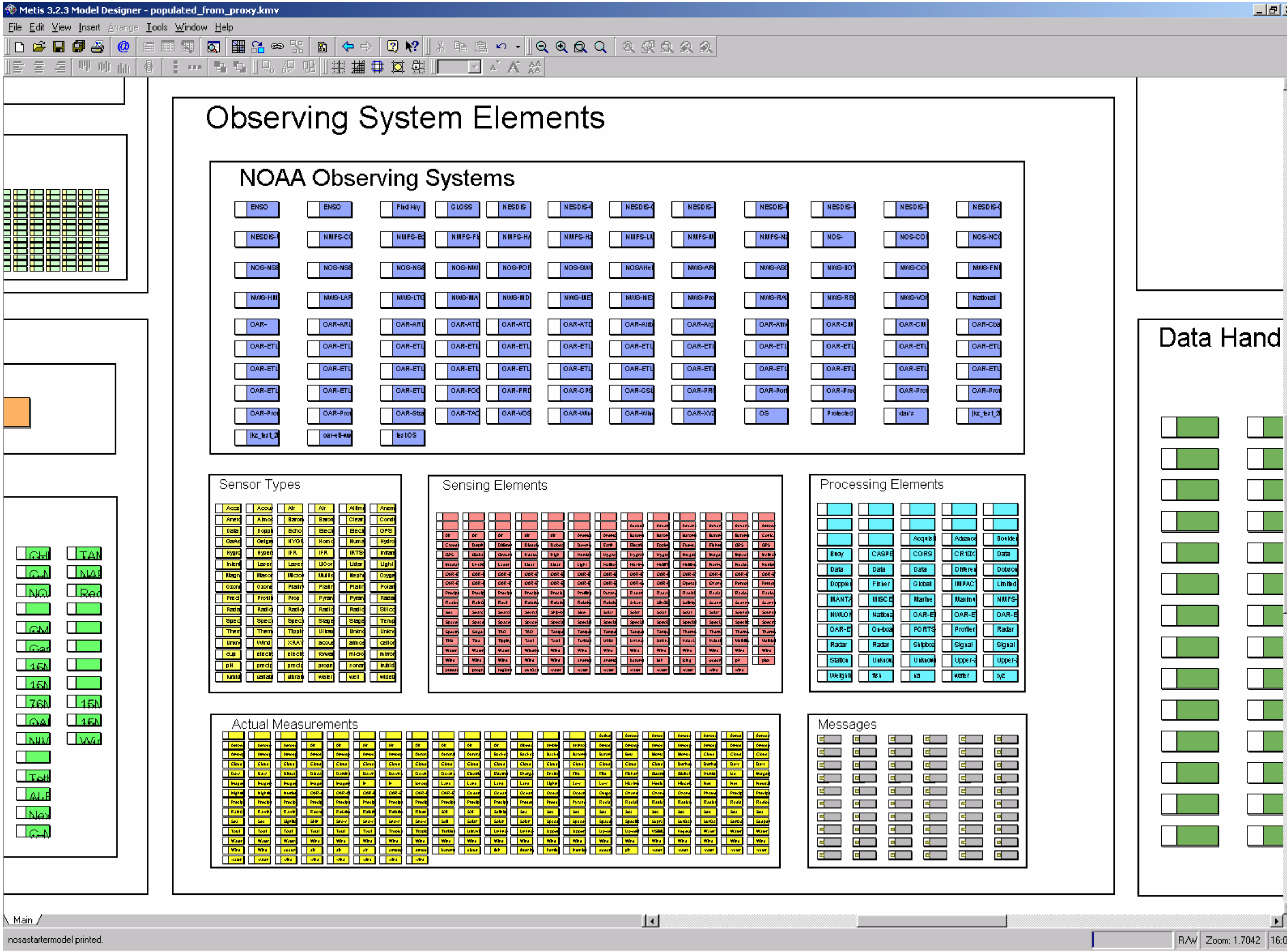
R/W Zoom: 5.2530 10:56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NOAA Observing Systems
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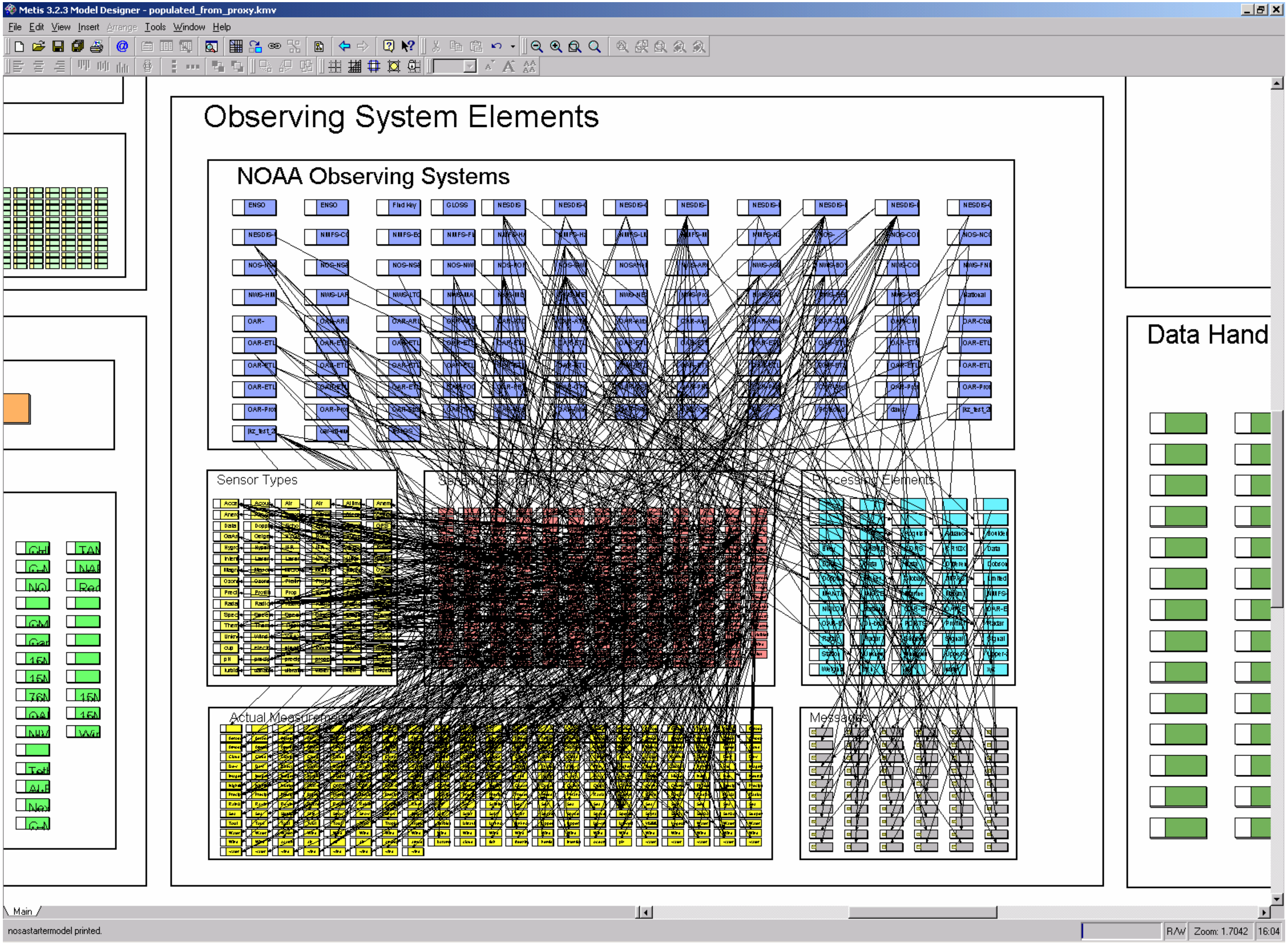
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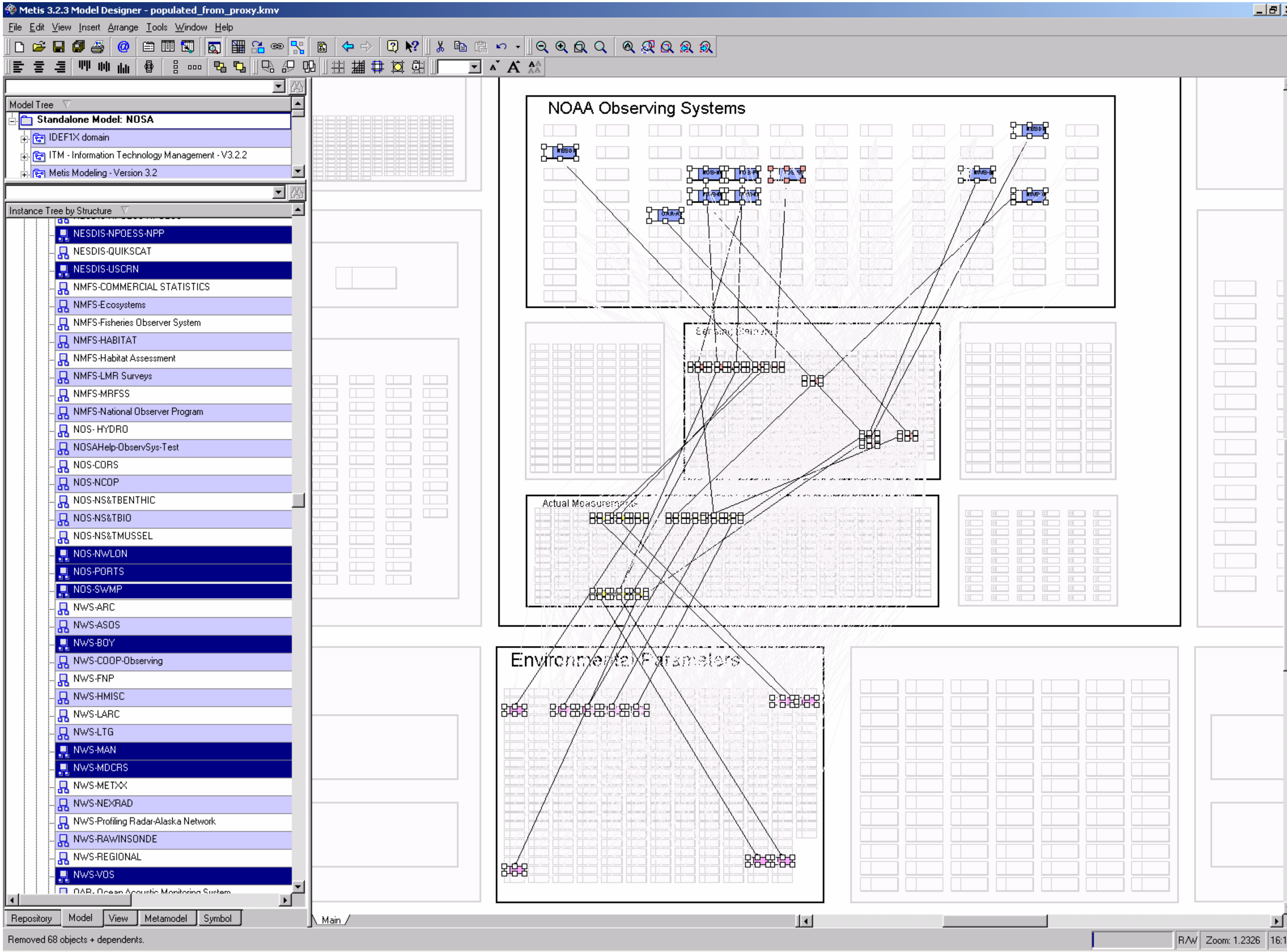
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Model Tree
Standalone Model: NOSA
IDEF1X domain
ITM - Information Technology Management - V3.2.2
Metis Modeling - Version 3.2
Instance Tree by Structure
NESDIS-NPOESS-NPP
NESDIS-QUIKSCAT
NESDIS-USCRN
NMFS-COMMERCIAL STATISTICS
NMFS-Ecosystems
NMFS-Fisheries Observer System
NMFS-HABITAT
NMFS-Habitat Assessment
NMFS-LMR Surveys
NMFS-MRFSS
NMFS-National Observer Program
NOS- HYDRO
NOSAHelp-ObservSys-Test
NOS-CORS
NOS-NCOP
NOS-NS&TBENTHIC
NOS-NS&TBIO
NOS-NS&TMUSSEL
NOS-NWLON
NOS-PORTS
NOS-SWMP
NWS-ARC
NWS-ASOS
NWS-BOY
NWS-COOP-Observing
NWS-FNP
NWS-HMISC
NWS-LARC
NWS-LTG
NWS-MAN
NWS-MDCRS
NWS-METXX
NWS-NEXRAD
NWS-Profiling Radar-Alaska Network
NWS-RAWINSONDE
NWS-REGIONAL
NWS-VOS
OAR- Ocean Acoustic Monitoring System
Repository
Model
View
Metamodel
Symbol
NOAA Observing Systems
Actual Measurements
Environmental Parameters
Main
Removed 68 objects + dependents.
R/W
Zoom: 1.2326
16:19

Property List

Type	Origin	Target
Contains	NESDIS-NPOESS-NPP	Vaisala Temperature and RH probe
Contains	NESDIS-USCRN	Air Temperature
Contains	NOS-NWLON	Air Temperature
Contains	NOS-PORTS	Air Temperature
Contains	NOS-SWMP	Air temperature
Contains	NWS-BOY	Thermistor
Contains	NWS-MAN	Thermistor
Contains	NWS-MDCRS	Air Data Total Air Temperature Sensors
Contains	NWS-VOS	Hygrometer
Contains	OAR-ARL-SURFRAD	Vaisala Temperature and RH probe
Measures	air temperature	air temperature
Measures	air temperature	air temperature
Measures	air temperature	air temperature
Measures	Air temperature	Air temperature
Measures	Air temperature	Air temperature
Measures	Air temperature	Air temperature
Measures	Air temperature	Air temperature
Measures	Air Temperature	Air Temperature
Measures	Air Temperature	Air Temperature
Measures	Air Temperature	Air Temperature
Takes	Air Data Total Air Temperature Sensors	Air temperature
Takes	Air temperature	Air Temperature
Takes	Air Temperature	air temperature
Takes	Air Temperature	air temperature
Takes	Air Temperature	Air Temperature
Takes	Hygrometer	Air temperature
Takes	Thermistor	Air temperature
Takes	Thermistor	Air temperature
Takes	Vaisala Temperature and RH probe	air temperature

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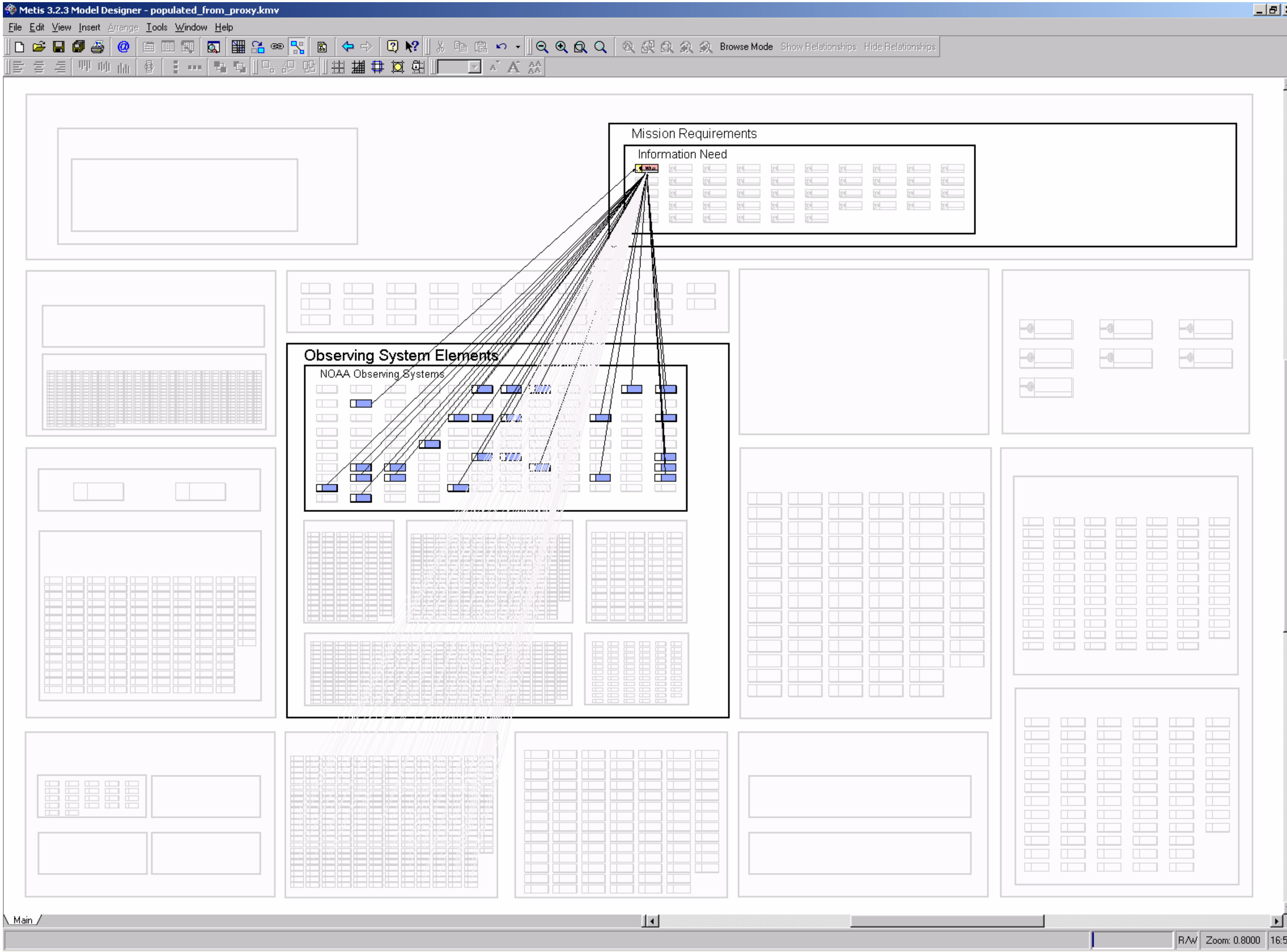
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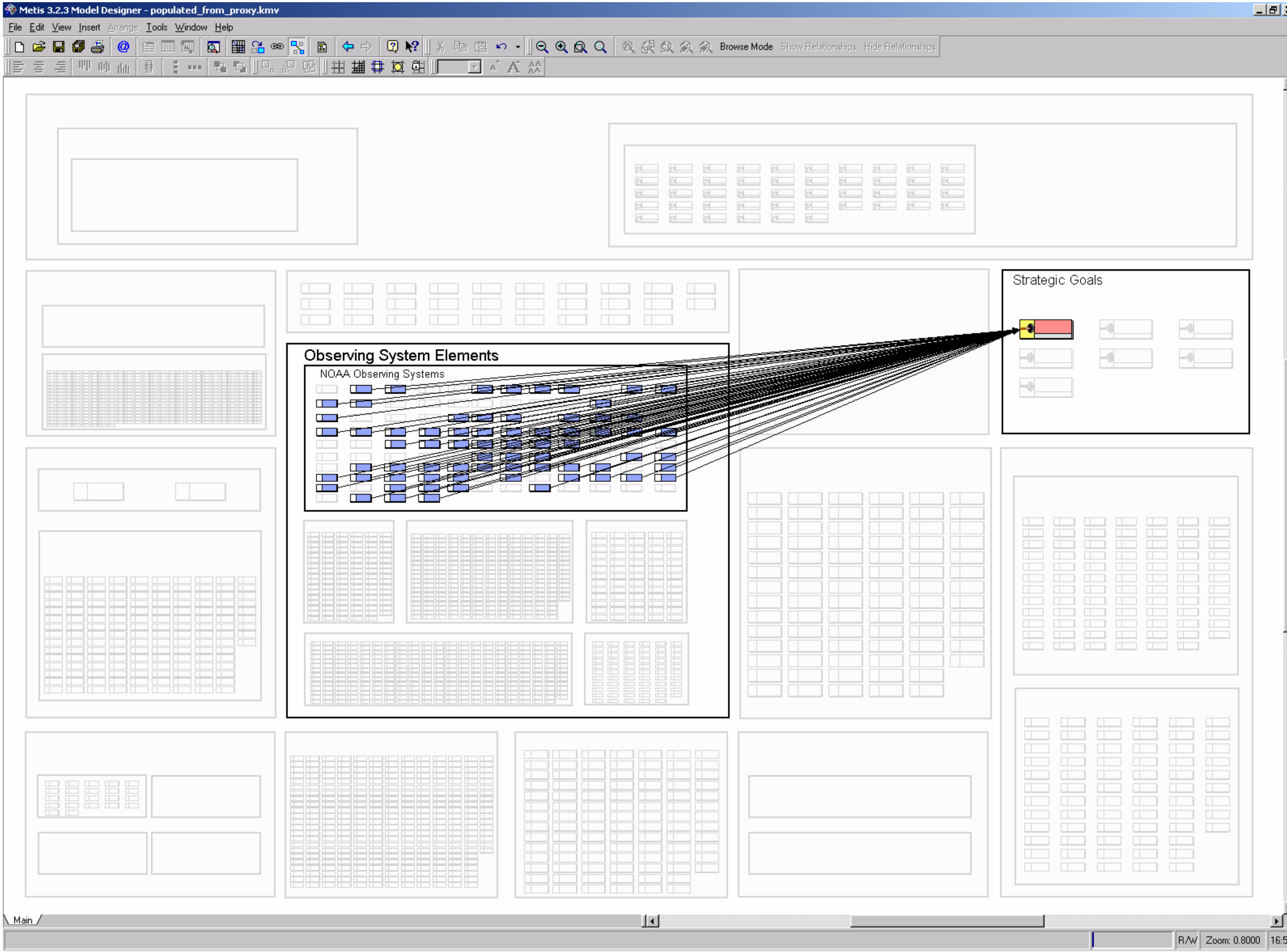
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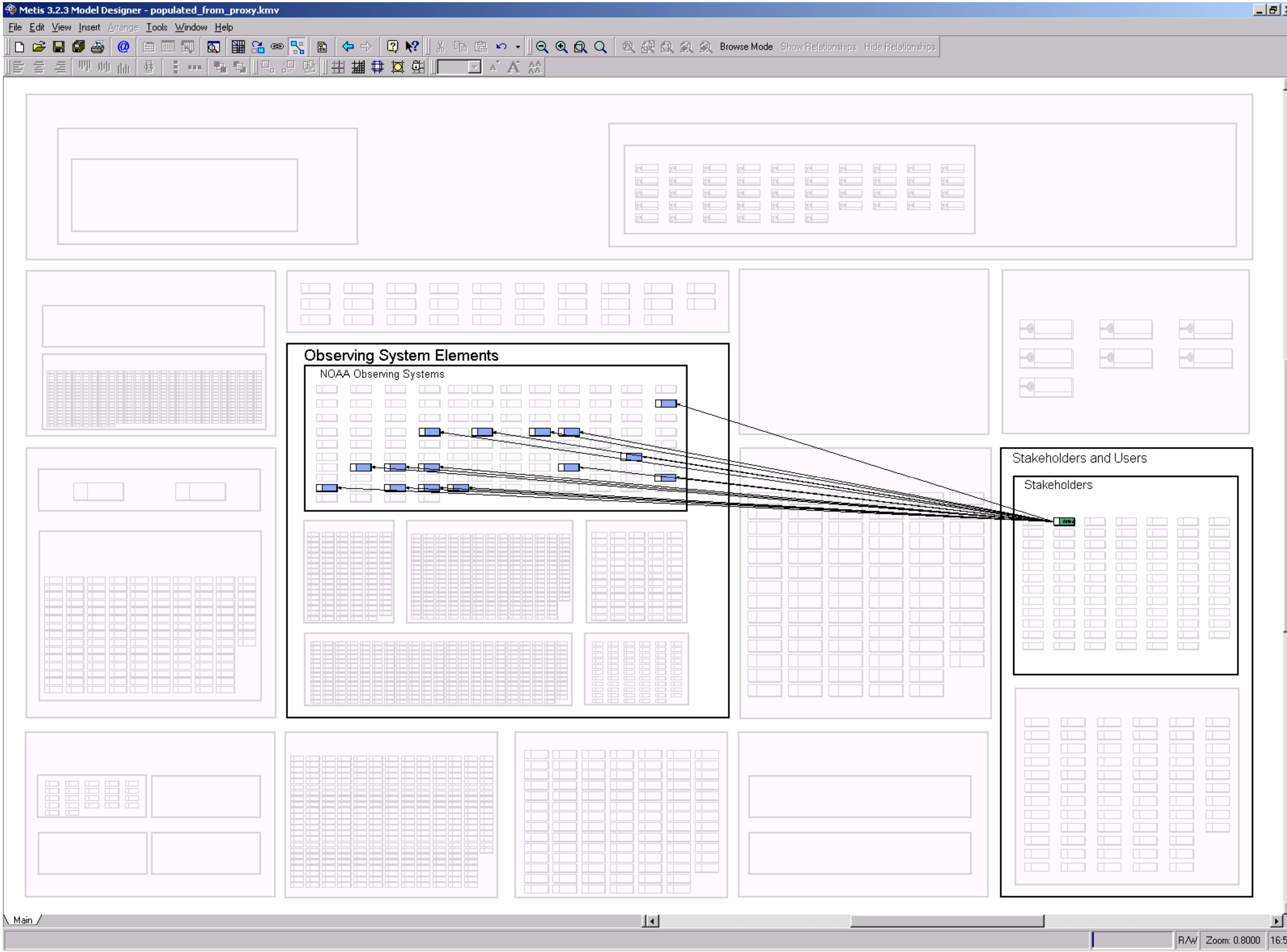
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NOAA Observing Systems
Stakeholders and Users
Stakeholders
Main
R/W
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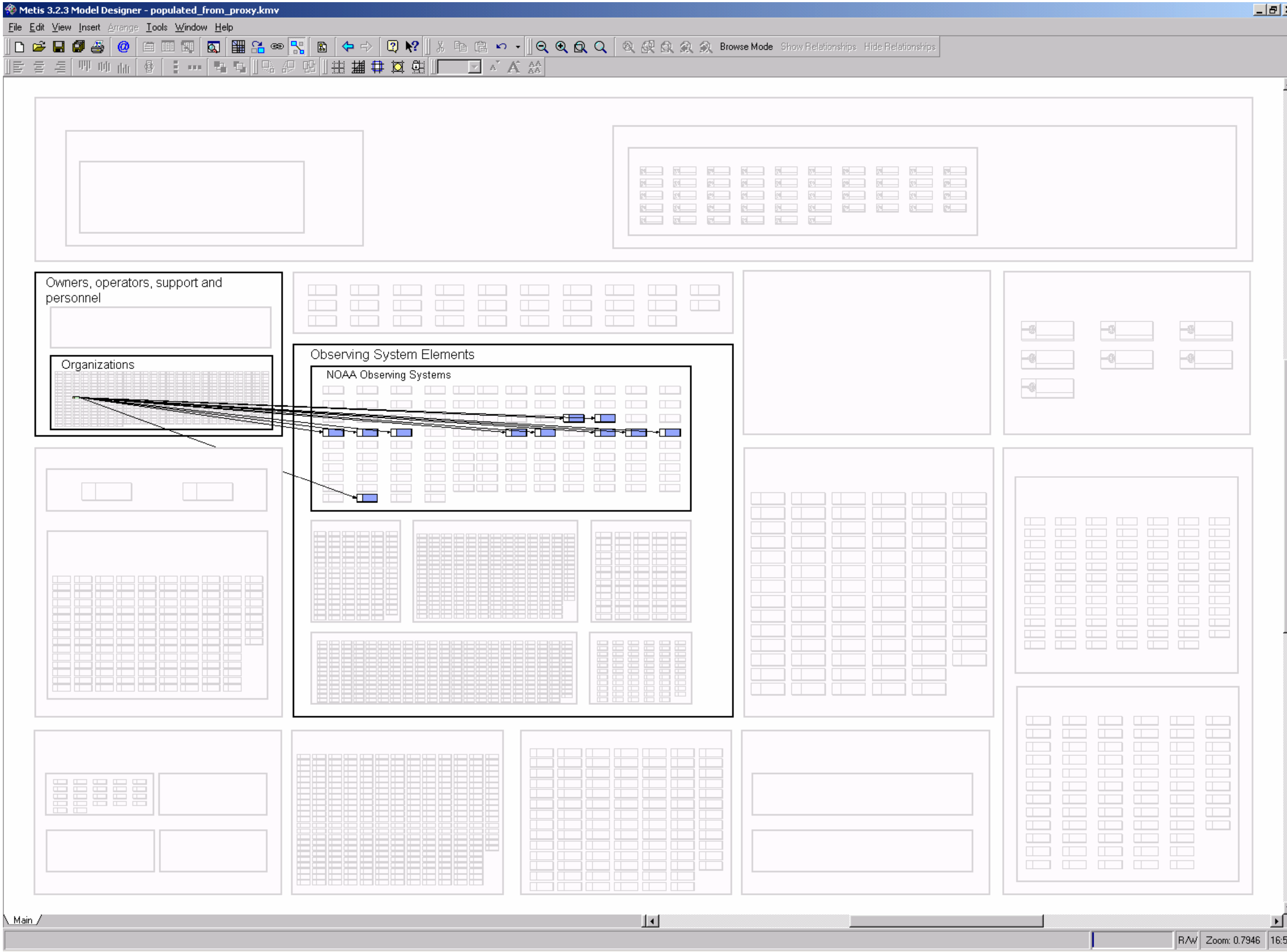
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Owners, operators, support and personnel
Organizations
Observing System Elements
NOAA Observing Systems
Main
R/W
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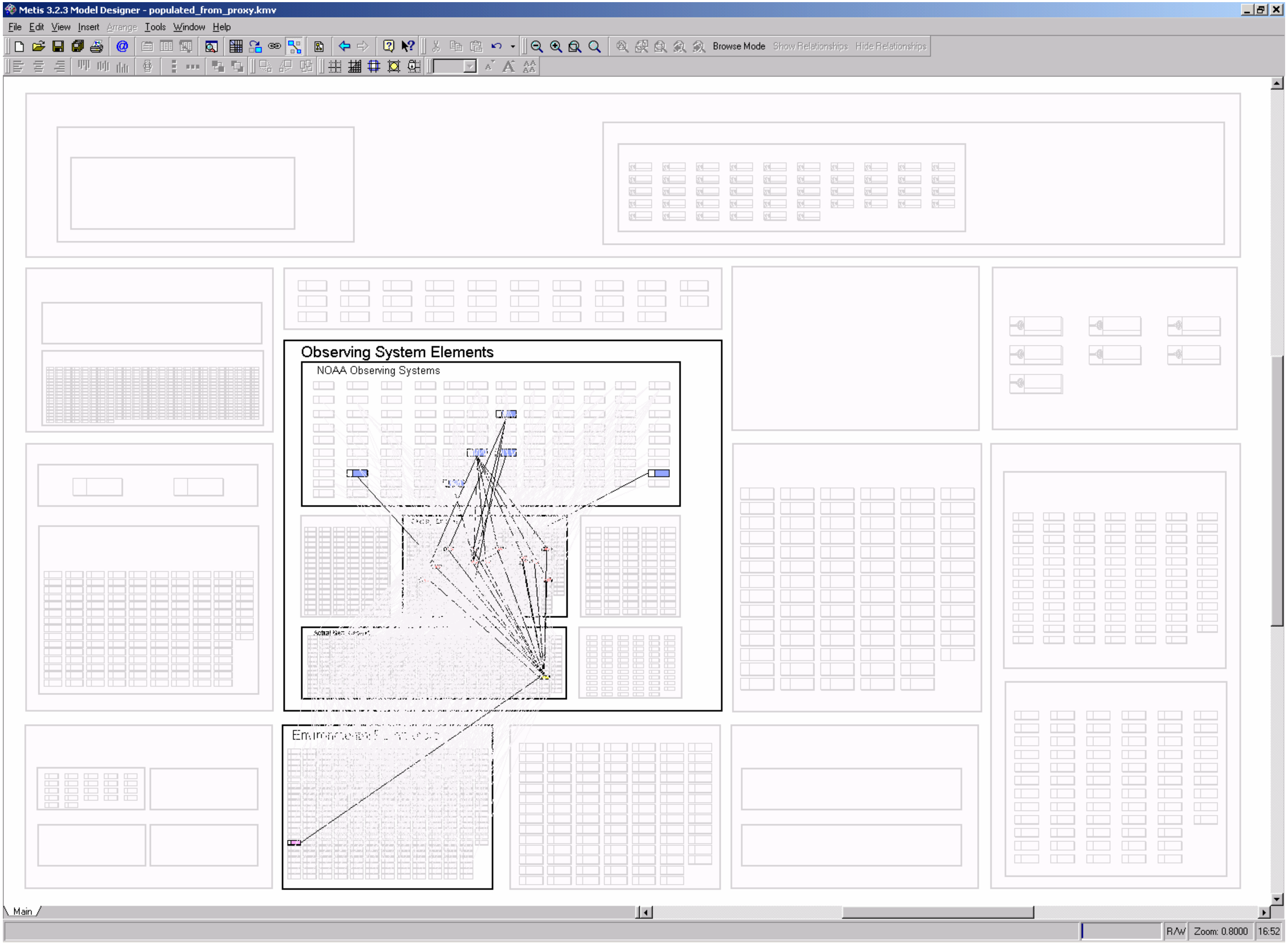

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Show Relationships
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NOAA Observing Systems
Main
R/W
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