An Introduction to SEDRIS™

http://www.sedris.org

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Tim Gifford **tim_gifford@sedris.org**
Farid Mamaghani **farid@sedris.org**

Tutorial Outline

- Overview
- Environmental Data Challenges
- Using SEDRIS Products
- Data Models vs. a Data Representation Model
- Spatial Reference Model (SRM)
- Environmental Data Coding Specification (EDCS)
- Data Representation Model (DRM)
- SEDRIS Transmittal Format (STF)
- Application Program Interfaces (APIs)
- SEDRIS Software Development Kits (SDKs)
- SEDRIS-based Tools and Applications
- Conclusion

Overview

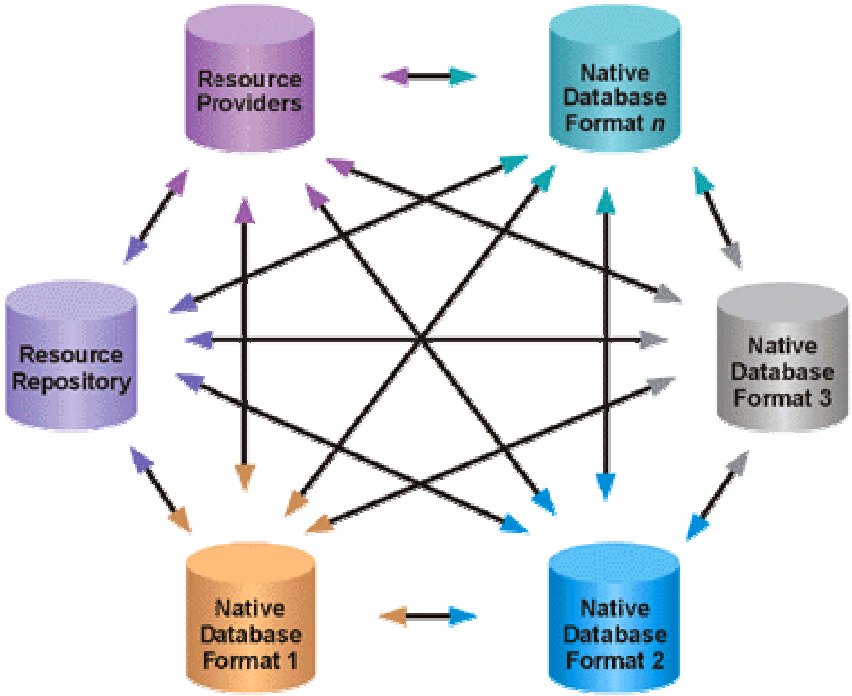
Context

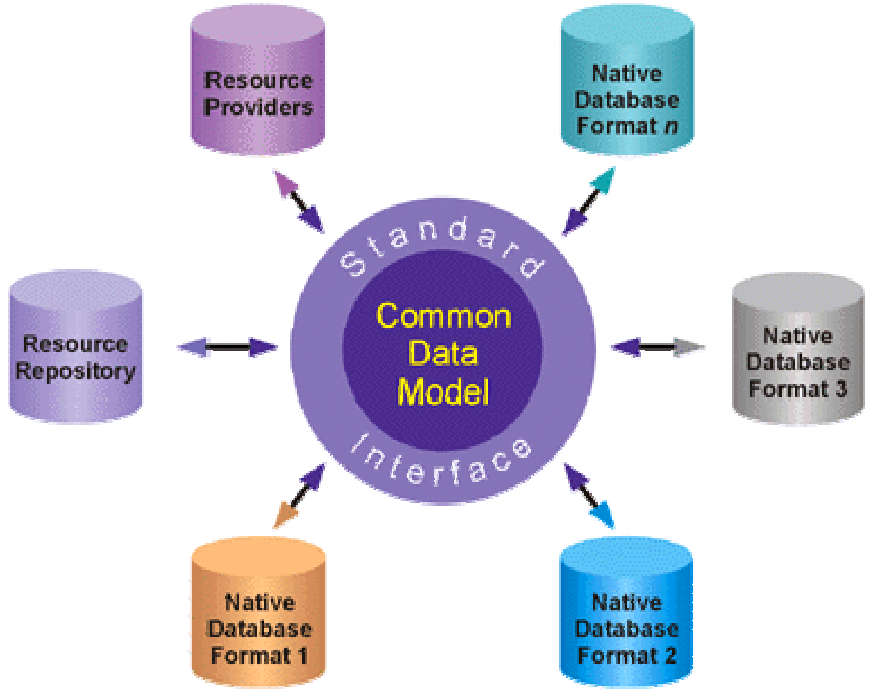
- **Environmental Data Requirements of Models and Simulations**
  - Models and simulations require environmental data to be complete and physically accurate
  - Environmental effects and impacts are becoming even more important in models and simulations than just the environmental conditions themselves
  - Higher resolution models require higher resolution environmental data to ensure complete physical accuracy in representation of environmental conditions, effects, and impacts
- **The Environmental Data Situation**
  - Data providers provide generic environmental products
  - Model developers must tailor these products to optimize the performance of their specific model
- **The Requirement-Resource Mismatch**
  - This requirement for customization leads to inefficiencies in model development and obstacles to environmental data reuse and interchange
  - These inefficiencies lead to high initial database development costs and increased recurring costs for updates and reuse
- **Despite This Mismatch…**
  - The use of environmental data in joint operations increasingly requires us to merge environmental data that have historically never been merged

Current Environmental Data Challenges

- **Environmental data producers provide domain-specific data in product- and producer-specific formats, based on existing production guidelines.**
  - **Effect: Constructs of environmental data/products are often incompatible across domain boundaries, making reuse and interchange difficult**
  - **Effect: Users tailor such data and create application- and platform-specific environmental data sets**
- **Many systems, missions, and applications require the integration of data**
  - **from many sources**
  - **that cross domain boundaries**
- **Creation, update, and tailoring for reuse of environmental data are resource-intensive and expensive (and have high recurring costs)**
- **Regardless of what format(s) or product(s) are utilized, to efficiently and methodically change, update, modify, or add environmental data (for systems or sub-systems), users must represent all of their data in a *unified manner***

Adopting A Middleware Approach





- Expensive and time consuming
- Often unreliable and non-interoperable
- Unique conversion needed for each source
- Increase in sources geometrically increases number of conversions

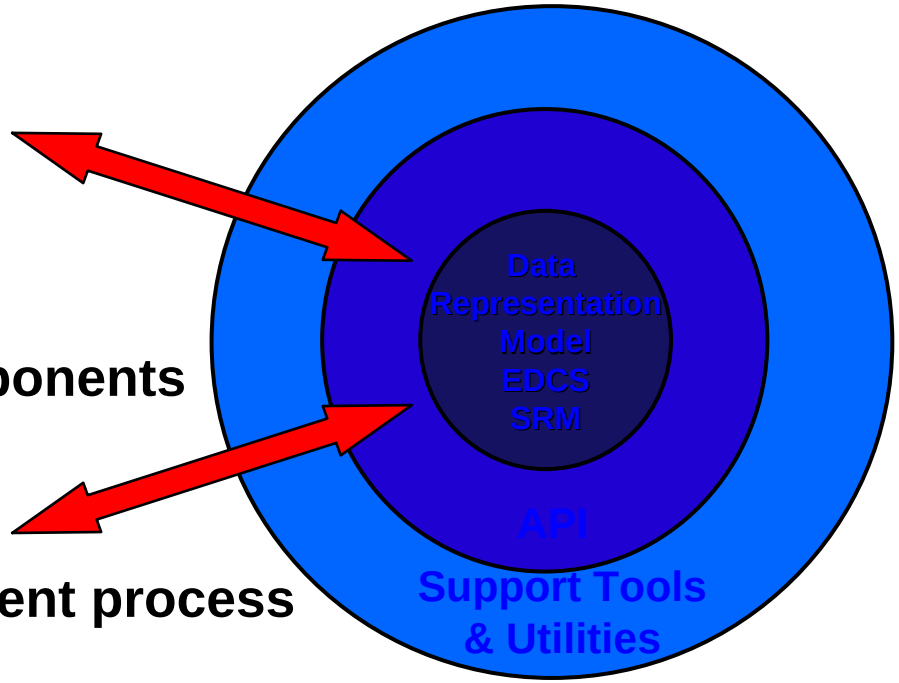
- Significant reduction in conversion cost
- Higher reliability, interoperability, integration, and reduction of correlation error
- Common and open standards, tools, and software reuse

The SEDRIS Solution

- SEDRIS provides cost-effective technology for the unified representation and interchange of environmental data (eliminates expensive recurrent costs)
  - Compatible across domain boundaries
  - Covers multiple product formats
- SEDRIS supports both legacy and new environmental data applications
- SEDRIS technology use decreases both initial (development) and recurring (maintenance and update) costs. Value maximized when using joint and networked applications.
- SEDRIS tools improve validation quality and decrease validation time. Without these tools, it is difficult to validate environmental data and find errors.

A Team-based Open Development Approach

- ***SEDRIS Associates*** (key environmental database developers/users)
  - **Review and feedback**
  - **Native-model mapping**
  - **Interchange experiments**
  - **Value-added tools/utilities**
- ***Core Team***
  - **Manage evolution of the components**
  - **Reference implementation(s)**
  - **Common tools & applications**
- **Conducted as an open development process**



- **Based on a philosophy of practical solutions built upon solid technologies, and incremental prototyping and experimentation that can feed into released implementations**
- **Core technologies heavily influenced and shaped by industry and other community participants**

Industry Associate Developers ...

- *3D Pipeline*
- *Accent Geographic, Inc.*
- *AcuSoft, Inc.*
- *Advanced Interactive Systems (AIS), Inc.*
- *Applied Research Associates, Inc.*
- *The Boeing Company*
- *CAE*
- *Charles River Analytics, Inc. (CRA)*
- *DataMat S.p.A.*
- *ERDAS, Inc.*
- *European Aeronautic Defence & Space (EADS)*
- *Evans and Sutherland (E&S)*
- *Flight Safety international, Inc.*
- *Indra*
- *JRM Technologies, Inc.*
- *L3 Communications - Link Simulation & Training*
- *Lockheed Martin Simulation, Training & Support*
- *Lockheed Martin Tactical Defense Systems (LMTDS)*
- *Magnetar Games*
- *MultiGen - Paradigm Inc. (MPI)*
- *Northrop Grumman Information Technology (NGIT)*
- *Object Raku Technology, Inc.*
- *OKTAL*
- *ProLogic, Inc.*
- *Raytheon Company Electronic Systems*
- *Rheinmetall Defence Electronics GmbH*
- *Science Applications International Corporation (SAIC)*
- *SGI*
- *Sogitec Industries S.A.*
- *Tenix Defence Pty. Ltd.*
- *Terrain Experts, Inc.*
- *TerraSim, Inc.*
- *Thales Training & Simulation (TT&S)*
- *Vcom3D, Inc.*
- *Veridian*

More Associate Implementers

Government

- ***U.S. Navy Modeling & Simulation Standards Steering Group (MS3G)***
- ***U.S. Army Communications Electronics Command (CECOM) Night Vision & Electronic Sensors Directorate (NVESD)***
- ***U.S. Army Training and Doctrine Command (TRADOC) Analysis Center White Sands Missile Range***
- ***U.S. Naval Sea Systems Command - Dahlgren Division***
- ***U.S. Joint Warfare System (JWARS) Joint Program Office / CACI***
- ***U.S. Army Yuma Proving Ground***
- ***Netherlands Organization for Applied Scientific Research (TNO)***

Academia

- ***University of Central Florida - Institute for Simulation and Training (UCF - IST)***

International Participation

- *Australia*
- *Canada*
- *Czech Republic*
- *France*
- *Germany*
- *Italy*
- *Japan*
- *Korea*
- *The Netherlands*
- *Spain*
- *Sweden*
- *United Kingdom*
- *United States*
- *others*

SEDRIS Is…

- An international standard for describing, interchanging, sharing, and reusing environmental data
- A standardized software interface for accessing environmental data sets
- A standardized syntax, semantics, and structure used to represent environmental data (independent of its source or whether it is geo-specific or geo-typical)
- A framework and approach for thinking about environmental concepts and their representations
- A proven, cost-effective technology in use today

SEDRIS Technology Components

SEDRIS Data Representation Model (DRM)

Gives the constructs to express and "shape" environmental data

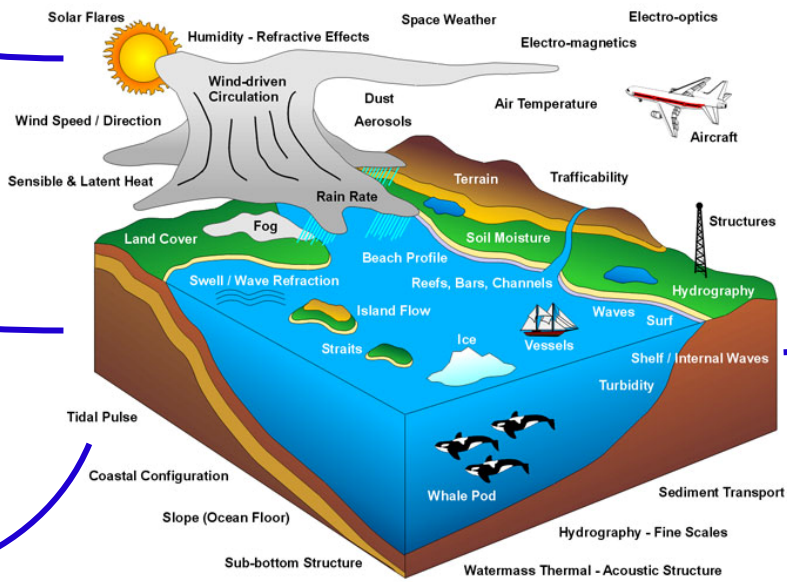
SEDRIS Spatial Reference Model (SRM)

Makes the environmental description readable in other coordinates

SEDRIS Application Program Interface (API)

Provides software access to individual elements of environmental data

DRM, EDCS, and SRM are used together to describe the environment



API and STF are used to exchange the description of the environment

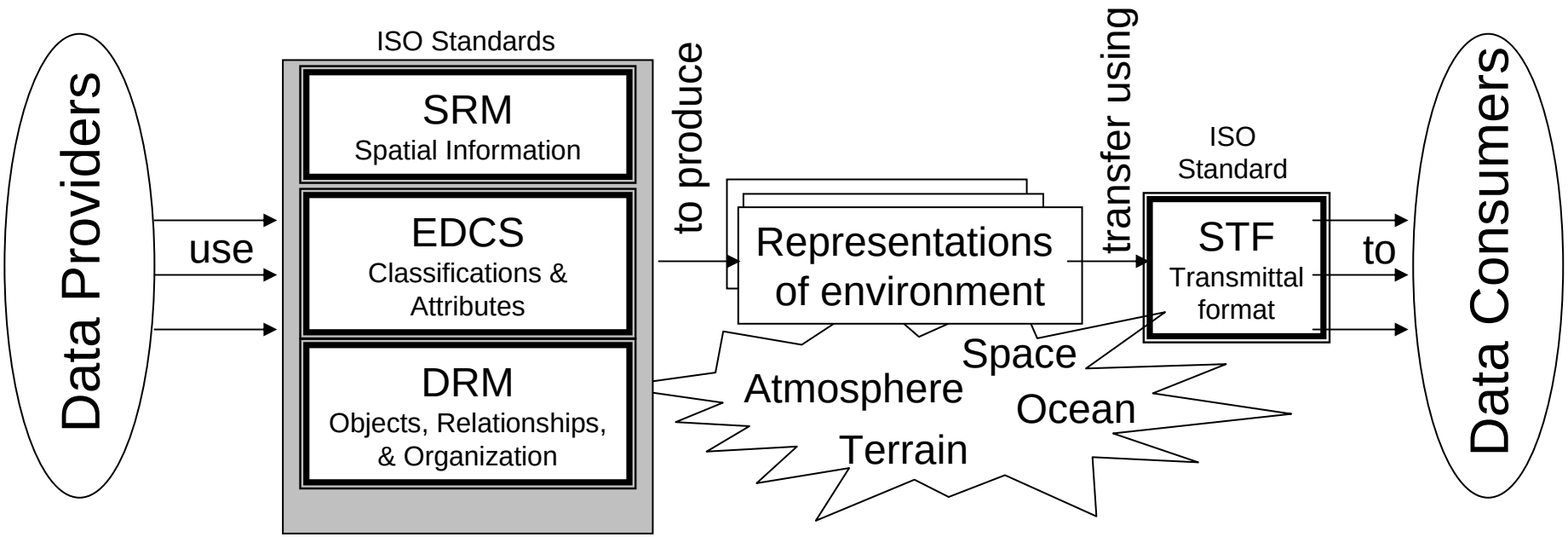
Environmental Data Coding Specification (EDCS)

Names and identifies types of objects in an environmental description

SEDRIS Transmittal Format (STF)

Transfers complete "chunks" of environmental data

How SEDRIS Works



What Does SEDRIS Do

- **Saves cost and promotes environmental database reuse among heterogeneous applications through a standard interchange mechanism**
- **Provides users the capability to correlate and integrate data from multiple sources**
- **Provides the concepts to represent all environmental domains (terrain, ocean, atmosphere, and space) in an integrated manner, to include urban and littoral areas**
- **Provides an integrated model of multiple constructs for environmental representation**
- **Provides for 3D model representations of structures, vehicles, and artifacts**
- **Provides constructs for the full range of applications (analysis, visualization, etc.) across all environmental domains**

Examples - SEDRIS in Use

- U.S. Army Combined Arms Tactical Trainer: using SEDRIS has saved at least $25M due to streamlined database generation (no longer completely dependent upon proprietary formats)
- U.S. Navy Tactical Environmental Data Services (TEDServices): "significant development cost savings" and "anxious for JAVA implementation of SRM"
- U.S. Army WARSIM: saved over $500K for IOC GOTS tools development and over $350K for coordinate conversion services
- Joint Strike Fighter: used SEDRIS to integrate Government and proprietary formats for open systems use
- U.S. DoD Test and Training Enabling Architecture (TENA): uses SEDRIS Spatial Reference Model for all geospatial information representation and exchange
- Virtual Cities: SEDRIS facilitated security planning for Salt Lake City Olympics

Examples - SEDRIS in Use

- **Republic of Korea Ministry of Commerce, Industry, and Energy: established the Korean SEDRIS Forum: SEDRIS key interchange support for domestic "digital contents industry"—online games (including cell phone technologies), 3D animation, proprietary CAD exchange (Japan is monitoring carefully…)**
- **Sweden: initiating use of SEDRIS to support Net-Centric Warfare in Defence Research and Defence Materiel Administration**
- **EuroFighter: data required for delivery in SEDRIS Transmittal Format**
- **NATO: STANAGs initiated**
- **SEDRIS ISO/IEC Standards used extensively in Europe: NATO Helicopter Program, Tornado GR4 Fast Jet (TT&S), Nimrod Maritime Patrol Aircraft (TT&S), European Union Technology Exploration Projects (EUCLID), EuroFighter, among others**

ISO / IEC Standards

Eight SEDRIS specifications - international standards in 2005/06

International standards — published April 2005:

- **Environmental Data Coding Specification (EDCS)** - ***ISO / IEC 18025***
- **EDCS C Binding** - ***ISO / IEC 18041-4***

At final draft international standard (FDIS) stage:

- **SEDRIS Functional Specification (includes DRM and API)** - ***ISO / IEC 18023-1***
- **SEDRIS Abstract Transmittal Format** - ***ISO / IEC 18023-2***
- **STF Binary Encoding** - ***ISO / IEC 18023-3***
- **SEDRIS C Binding** - ***ISO / IEC 18024-4***

- **Spatial Reference Model (SRM)** - ***ISO / IEC 18026***
- **SRM C Binding** - ***ISO / IEC 18042-4***

SEDRIS in the Future…

- **SEDRIS will remain under DMSO development sponsorship until ISO/IEC standards are completed**
- **Upon completion of development, technologies will transition to another organization**
- **After transition, it is anticipated that the new organization will work with existing and emerging customers and associates to:**
  - ***configuration manage SEDRIS technologies***
  - ***solve technical interchange problems collectively***
  - ***protect the interests of current "value-added" developers***
  - ***facilitate continued and expanded business interest in the SEDRIS technologies***
- **DMSO looks to SEDRIS customers and associates to expand SEDRIS technology use in other areas, such as:**
  - ***GIS marketplaces (expanded by the SEDRIS broad domain of use)***
  - ***Telecommunications - wireless, web-based, …***
  - ***Homeland Security (Cooperative Defense, Civil, Industry)***
  - ***Academia***

… Continuing Current Goals

- **Promote better business solutions through SEDRIS technologies, as well as tools and utilities built on those technologies**
- **Expand the customer base**
- **Collaborate with other standards groups in areas of common interest to promote shared objectives. For example:**
  - **Other ISO, ISO/IEC Technical Committees and Sub-Committees**
  - **Digital Geographic Information Working Group (DGIWG)**
  - **World Meteorological Organization (WMO)**
  - **International Hydrographic Organization (IHO)**
  - **International Astronomic Union (IAU)**
  - **International Civil Aviation Organization (ICAO)**
  - **Simulation Interoperability Standards Organization (SISO)**
  - **Consortia, academia, . . .**
- **Stay focused on practical solutions that support our customers (Associates, industry, government, programs, and projects)**

Summary - SEDRIS:

- Is an infrastructure technology with proven components
  - Complete and powerful language for environmental representation (DRM, EDCS, SRM)
  - Mechanism to communicate and evaluate environmental data (API, STF)
  - Tools - practical applications, converters, and utilities
  - TCRS - emerging technologies to specify and evaluate content and interface-level requirements
- Consists of eight international standards (ISO/IEC)
- Is used worldwide in information technology applications by a wide range of organizations and projects
- Provides the concepts to represent all environmental domains (terrain, ocean, atmosphere, and space) in an integrated manner, to include urban and littoral areas
- Provides users with the capability to correlate and integrate data from multiple sources
- Reduces cost and promotes environmental database reuse

More information

- **Open source software SDK releases, videos of tutorials, papers**
- **SEDRIS technology components (EDCS, SRM, DRM, API)**
- **Proceedings from past conferences**

  Available at http://www.sedris.org
- **Free tools & utilities, and pointers to commercial tools**

  Available at http://tools.sedris.org
- **Data samples**

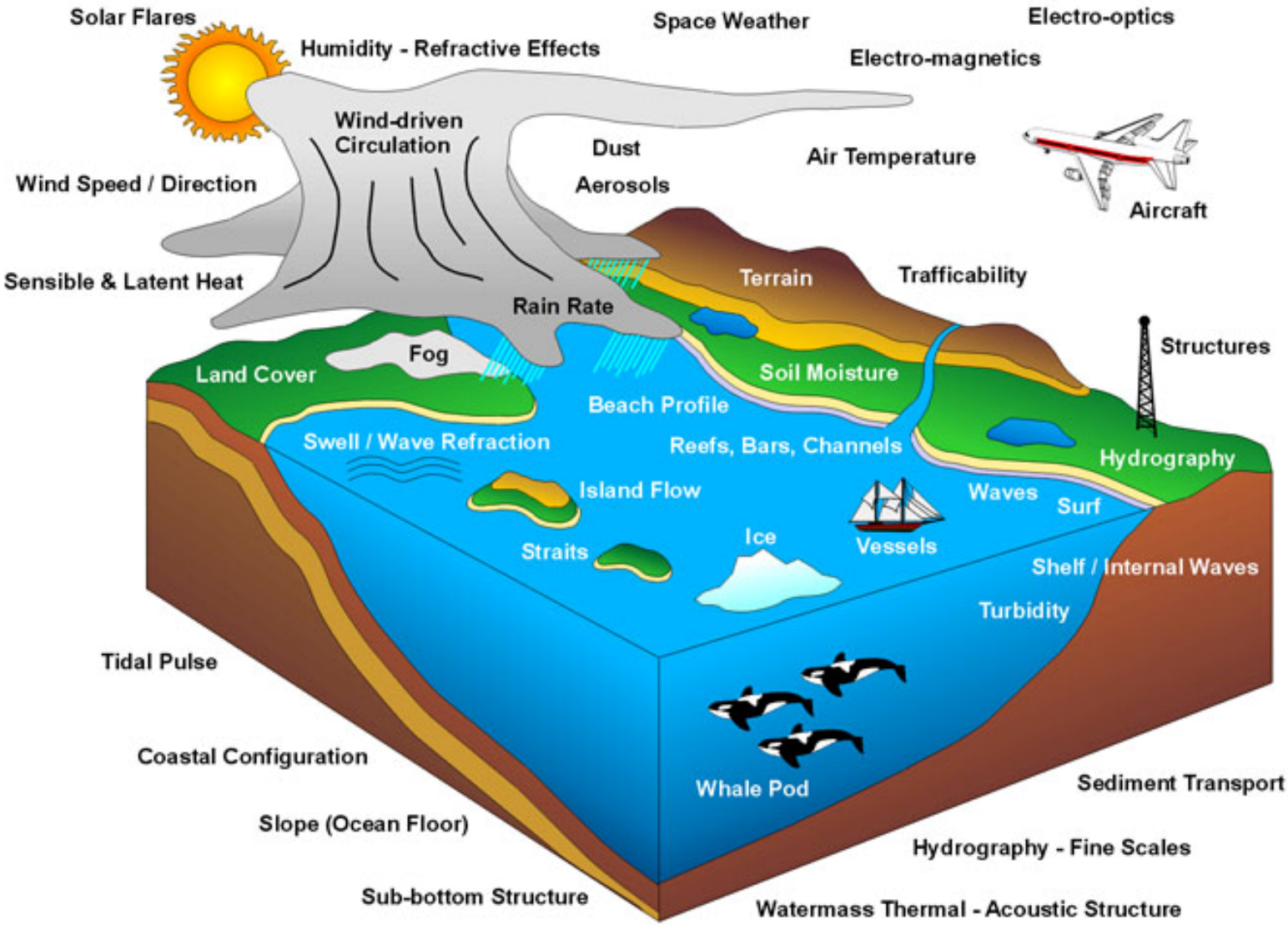
  Available at http://data.sedris.org
- **Questions**

  Can be sent to help@sedris.org
- **ISO/IEC standards activities**

  Information at http://wg8.sedris.org

Environmental Data Challenges

All Environmental Data



Environmental Data Challenges

- **Regardless of what format(s) or product(s) are utilized, users need to represent all of their environmental data in a unified manner such that changes, updates, modifications, or additions (to systems or sub-systems) can be handled in an efficient and methodical manner**
- **Some critical issues are:**
  - **How individual data items (objects) relate to each other**
  - **How new objects/capabilities/features can be added without fundamentally changing the underlying schema**
  - **How formats will be isolated from object-level representations or interfaces**

Environmental Data Challenges (cont'd)

- **Representation of location for the various coordinate systems (spatial reference frames), local or global, that will be "natural" for individual systems or sub-systems**
- **Accurate, efficient, and fast conversion of location data between different spatial reference frames**
- **Comprehensive dictionary of terms that not only deals with terrain data, but also atmosphere, ocean, littoral, and space data. And is also extensible in a predictable and supported manner**
- **A representation schema that can handle any resolution, type, organization, and extent of environmental data through a uniform approach for all domains of the environment**

Environmental Data Challenges (cont'd)

- A mechanism to access and interact with any of the previous items through a robust software interface
- Capture and communicate the resulting data in a persistent, efficient, and platform independent format designed to handle large and distributed data sets
- Tools to manipulate, evaluate, visualize, or analyze the data
- Automatically evaluate and validate data sets against stated requirements

Using SEDRIS Products

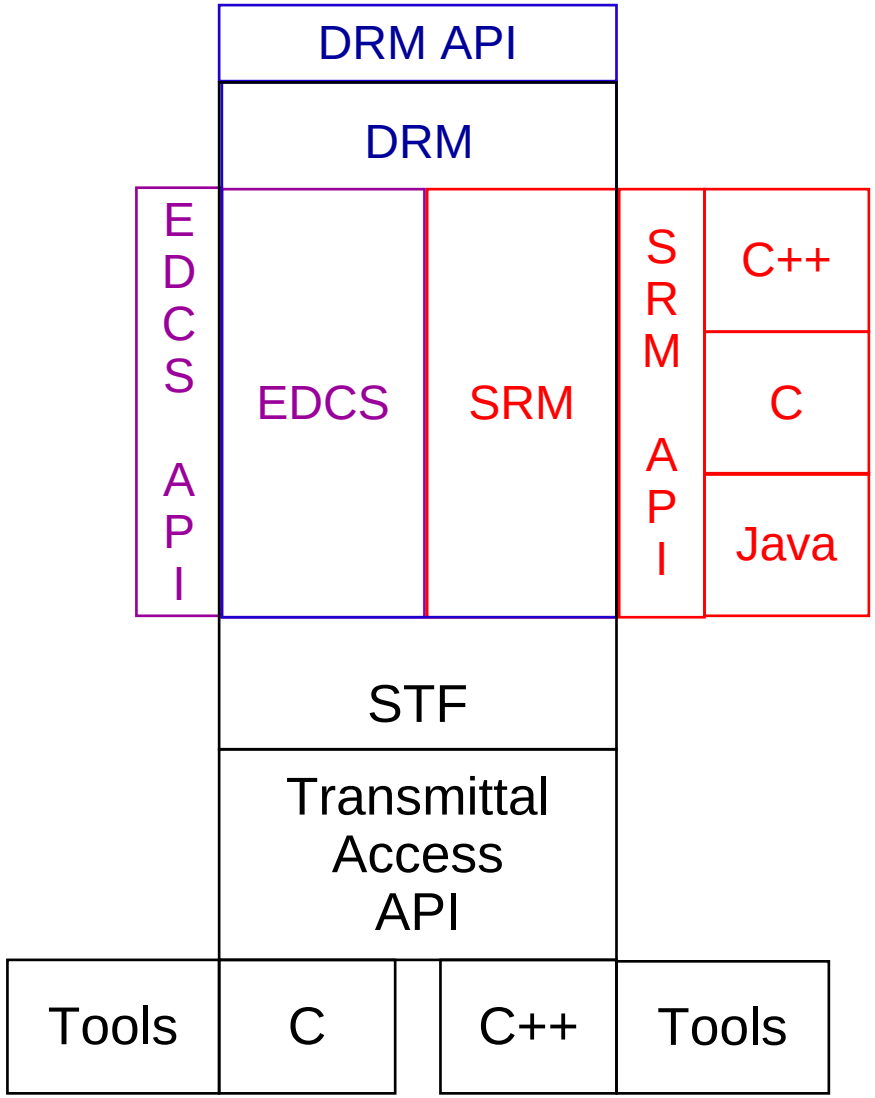
Key SEDRIS Concepts

- **Separate format and data representation**
- **Separate environmental object semantics from representation**
- **Separate science and the mathematics of location specification and conversion techniques from location data representation**
- **Provide a mechanism for reconciling different spatial reference frames (coordinate conversions and transformations)**
- **Provide a standard interface and data representation schema**
- **Provide tools to make users' job easier**

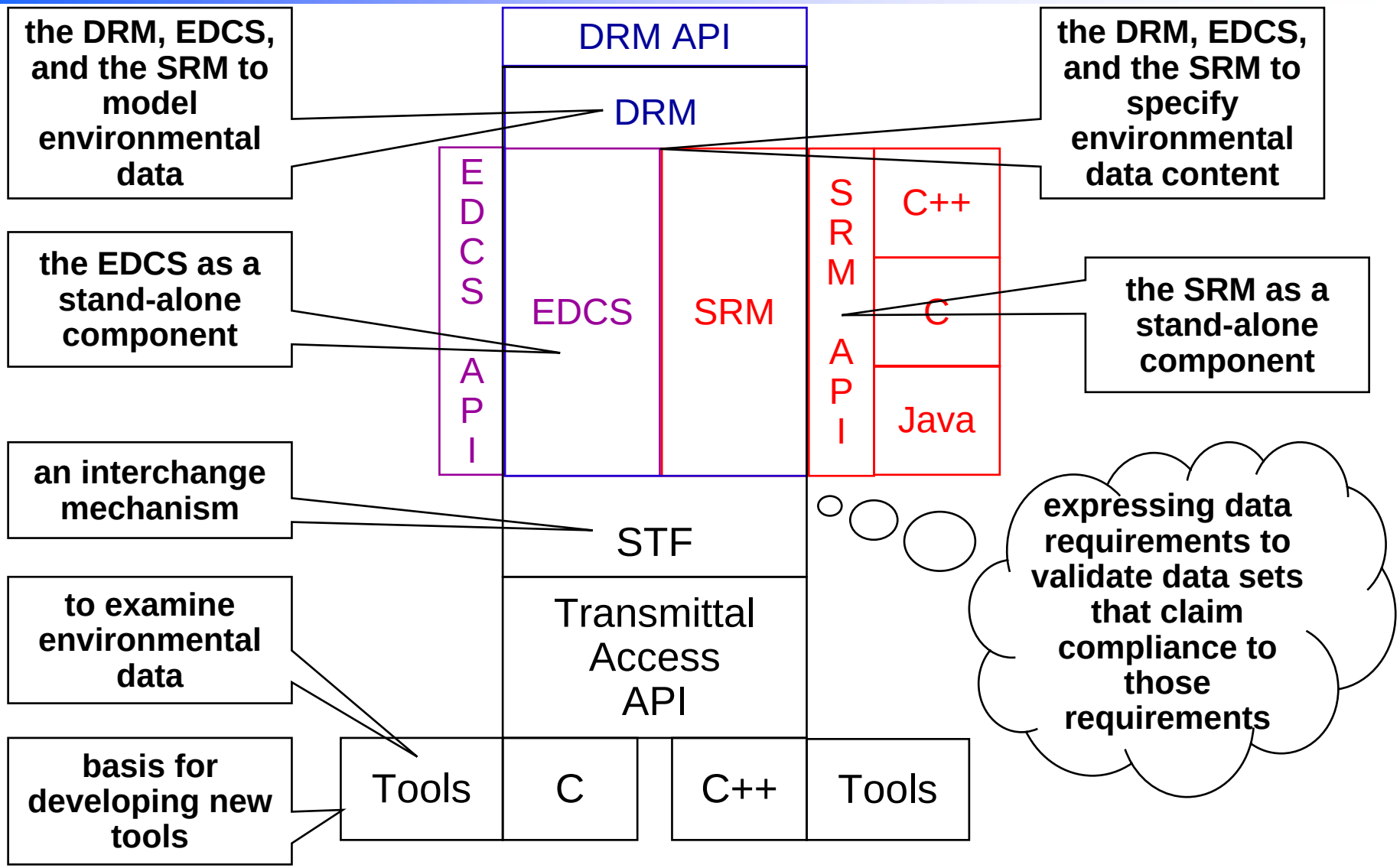
SEDRIS can be used to build…

- A repository or a library system for environmental data
- An authoring tool or an environmental database generation system
- A specific environmental database
- An archiving or data discovery mechanism
- A scenario generation system
- An application that converts databases

SEDRIS Components



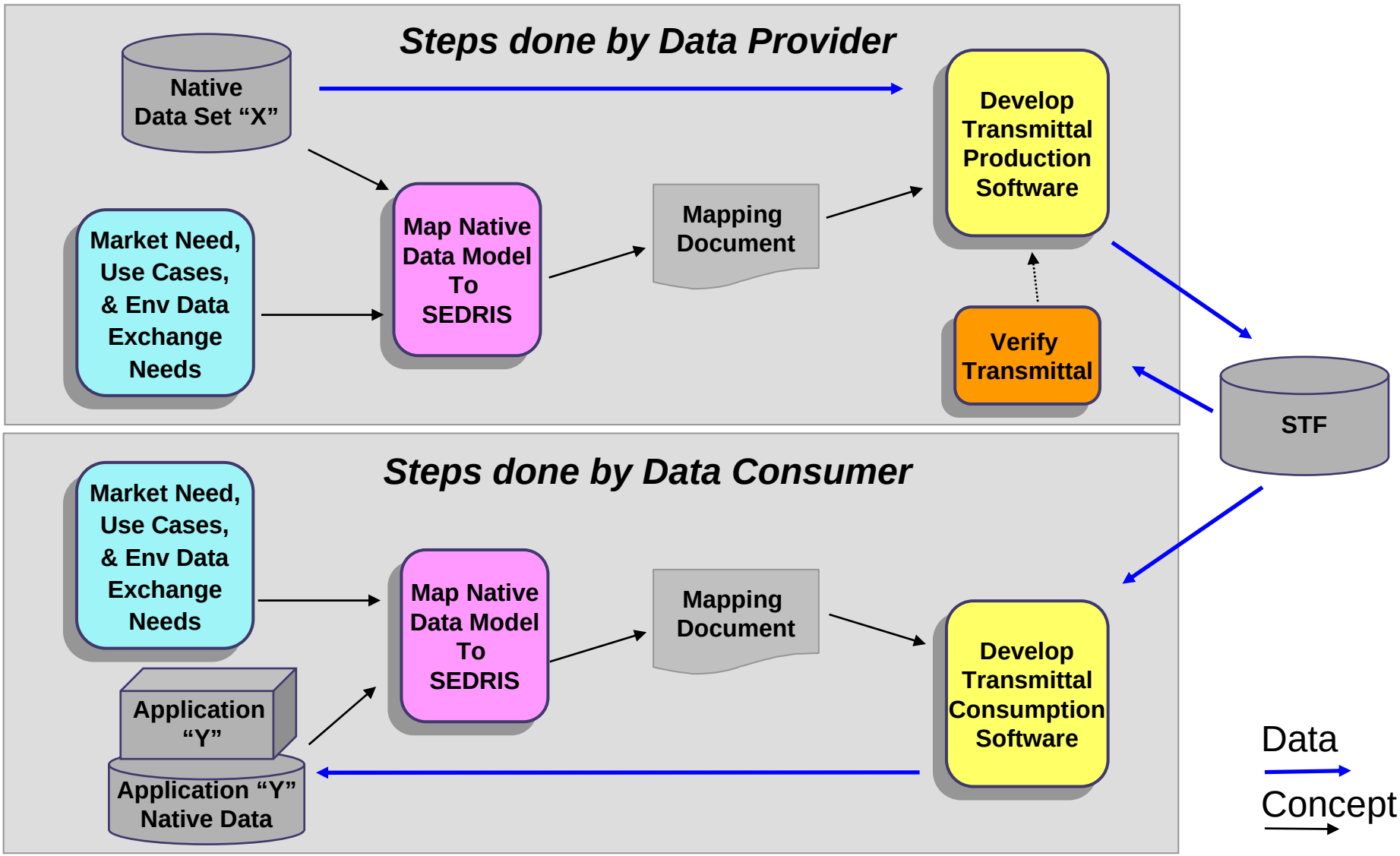
Using the SEDRIS Components



How to Develop SEDRIS Expertise

- **Learn to speak SEDRIS: learn the DRM**
- **Generate mapping documents**
  - **For native format(s) or assigned government format(s)**
  - **To ensure the DRM and EDCS can handle all data requirements**
- **Develop software: to convert native data into SEDRIS and back to check completeness of the interchange**
- **Become a SEDRIS Associate and participate in SEDRIS Associates Meetings (SAMs) and interchange experiments**
  - **Exchange ideas**
  - **Cooperatively define and develop SEDRIS technology**
  - **Share non-proprietary (native format) utilities and applications that support SEDRIS interchange**

Steps in the SEDRIS Production and Consumption Processes

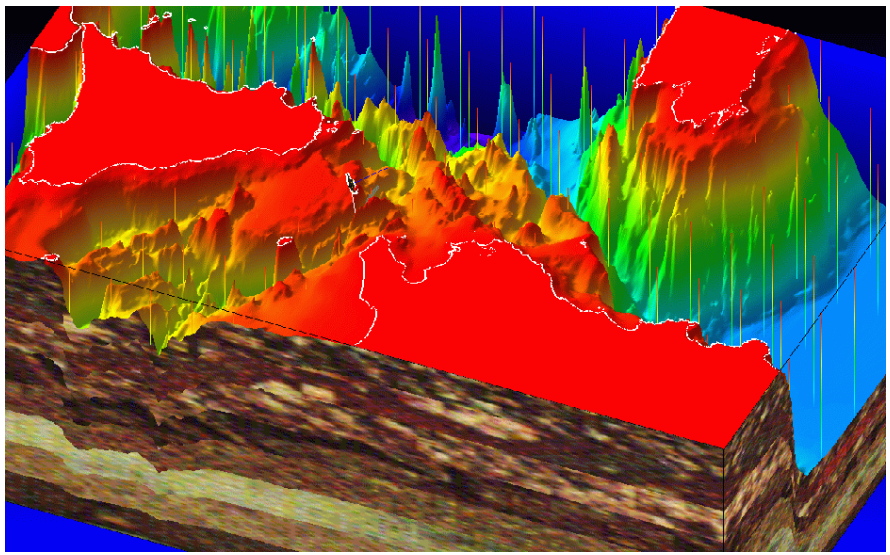


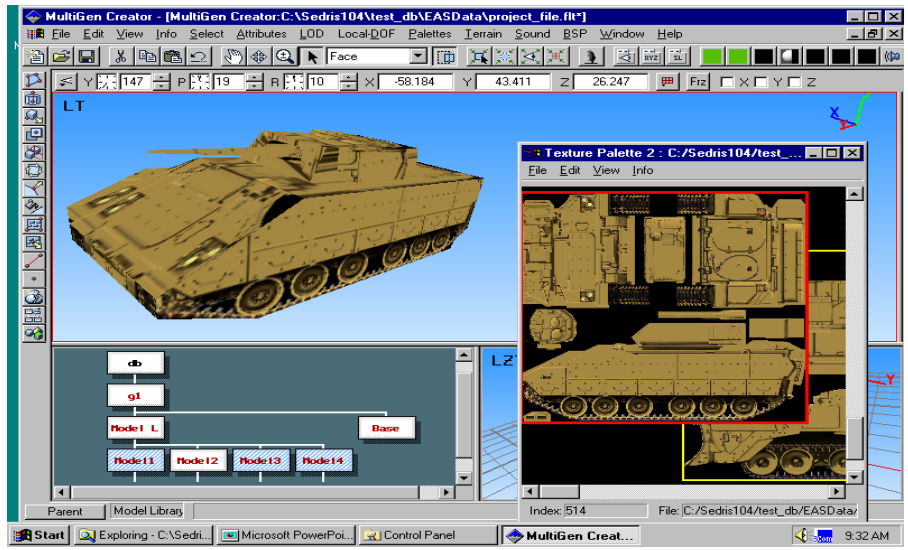
Data Models vs.
a Data Representation Model

Application Data Models

- **Every environmental application has a "native" data model.**
  - **Native to the domain or application scope**
  - **Optimized for the application**
  - **Limited to only the data elements used within its abstraction of the environment**
  - **Has a specific representation of environmental elements**
- **Application data models are derived based on the purpose of the application such as:**
  - **To drive down the road**
  - **To simulate an aircraft**
  - **To find closest fishing spot**
  - **To design a vehicle**

Application Data Model Views

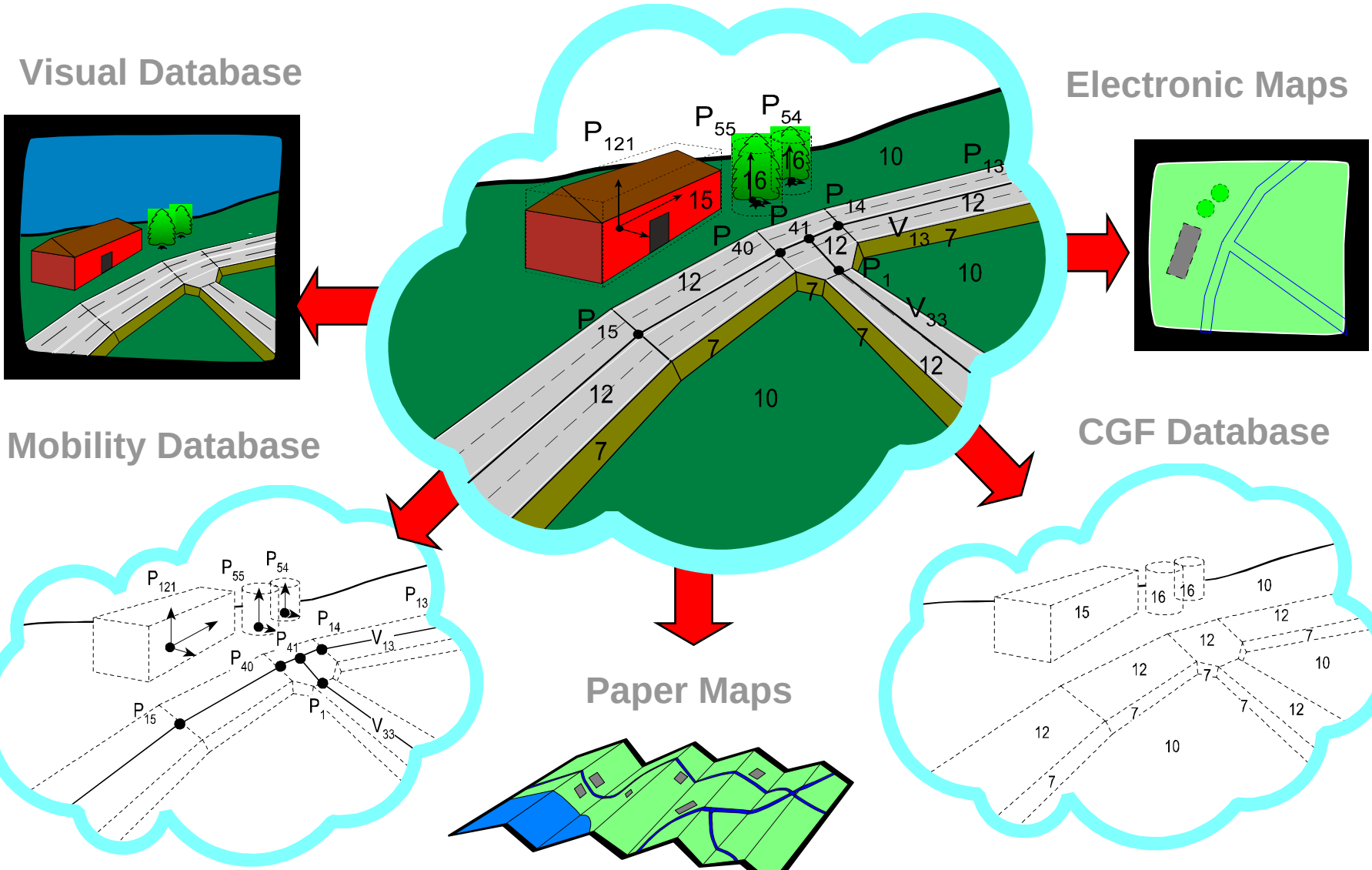




Same Object - Differing Views

- What we think of an object depends on our use, interaction, and perception of that object … our concept
- For example, a bridge is
  - an obstacle to sailboats with long masts
  - a connector in road networks
  - a target during warfare
  - a load-bearing structure to an engineer
- These differing views are also reflected in the way applications process environmental data about the same object
- SEDRIS is designed to support multiple independent or integrated views

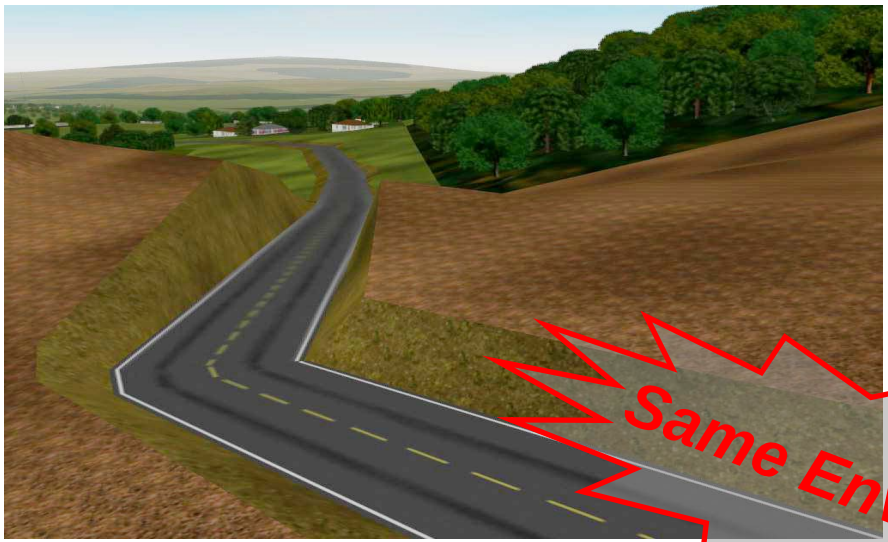
Different Representations of the Same Environment



A DRM for the Environment

- How do you provide a mechanism for all environmental data; i.e., take into account all native data models?
- One approach: Capture all elements into one Data Model
  - Hard to agree on
  - Hard to determine all possible applications or combinations
  - Impossible to capture all possible data models (never ending task)
- Another: Use the SEDRIS DRM approach to
  - Decompose known environmental data models into components
  - Generalize and extrapolate variations
  - Unify common components
  - Verify completeness by forward and reverse mappings to known data models
  - Use the DRM as the building blocks for common representation
  - Plan for change

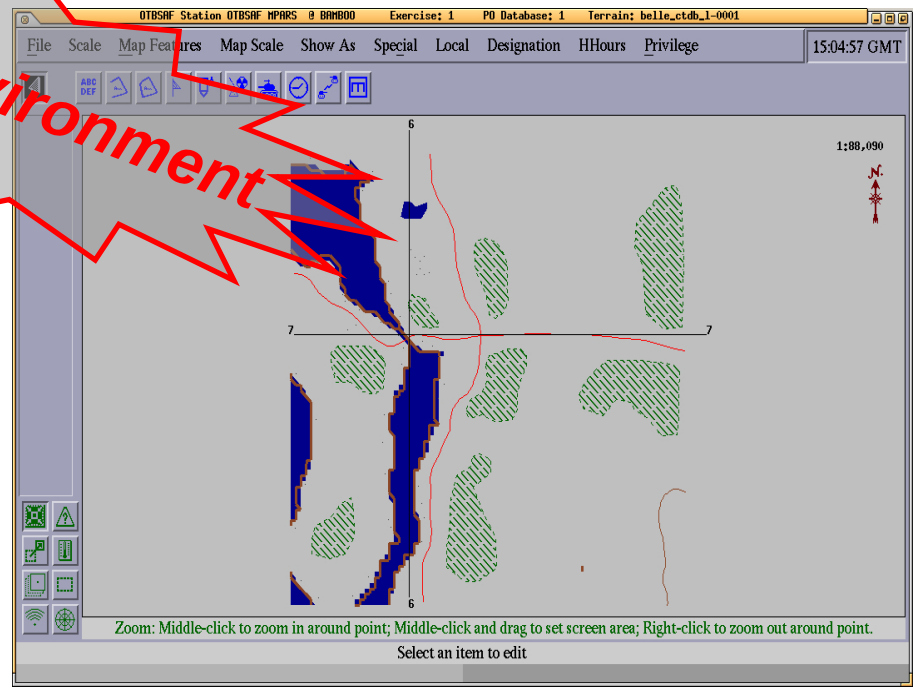
From DMs of the Environment … to a DRM *for* the Environment



- **Usual DM Based Approach**
  - Different native data models
  - Difficult to map between them
  - “Value added” data needed for interchange is external to both models

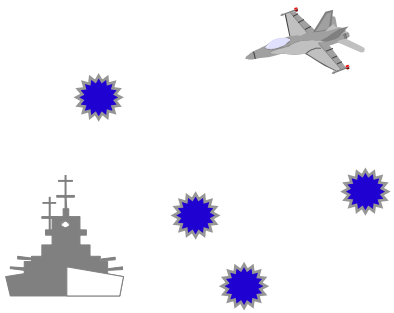
Same Environment

- **SEDRIS DRM Based Approach:**
  - One DRM supports representations of both views
  - Unambiguous representation aids in mapping between a native DM and the DRM
  - “Value added” data may be fully integrated with both views



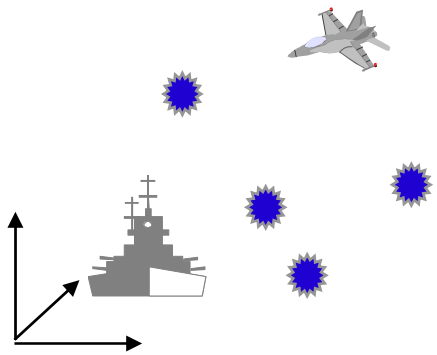
Spatial Reference Model (SRM)

Representation begins with Location ...



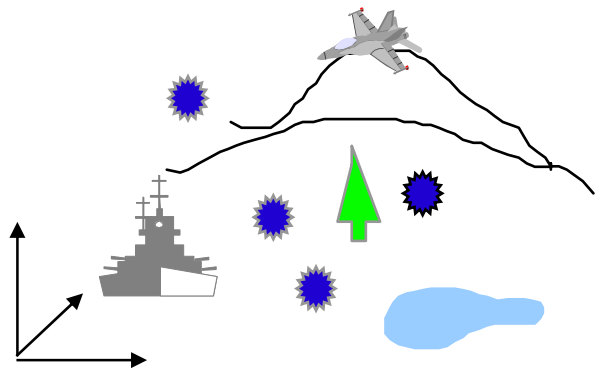
Systems

The void ...



Systems, *where?*

Start with locating your systems--sometimes that's about all you could afford in legacy simulations.



Systems, *and what else?*

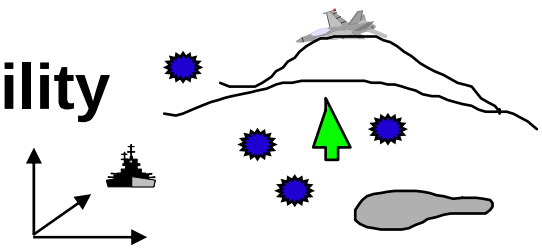
Define the context within which systems engage--and that context can help or hinder, ...

Defining and using a consistent spatial reference framework are critical for interoperability

- **System models (men, material, …)**
- **Environmental data, models, phenomena**

... but Location is Not Enough

- **The key in interoperability is not so much where you are, but *what you can interact with* …**
  - **Remembering that "what" includes both systems and components of the environment itself**
- **A complete SRM must address:**
  - **Direction (azimuth and elevation angle)**
  - **Range**
  - **(support for) Geometric intervisibility**



Systems, and what else?

Location interconversions between common spatial reference frames do not necessarily preserve these

The environmental representation continues with defining the context within which systems *interact*–and that context can help or hinder them ...

SRM Requirements

- ***Completeness* must:**
  - **include coordinate systems in wide usage.**
  - **tie those systems together into a common framework.**
  - **educate the system developer.**
    - ***e.g., What's a ORM, a vertical offset surface, a geoid?***
- ***Accuracy***
  - **Generally higher than required for C4ISR systems.**
    - ***e.g., typically better than 1 cm. up past geosynchronous orbit (nominally 1 mm near the ERM surface).***
  - **Computation of operations in spatial frames must not impact application validity.**
- ***Performance***
  - **Never fast enough!**
  - **Many environmental data sets dominated by location data**
  - **Federate costs for distributed systems using heterogeneous coordinate systems can be substantial (*e.g.*, 20% or more).**

SEDRIS algorithms and implementations are very accurate and 2-10x faster than algorithms/implementations reported in the literature.

Spatial Reference Frames

Spatial Reference Frames (SRF) **serve to locate coordinates in a multi-dimensional space (generally either two- or three-dimensional). Specified in two parts:**

A geometric description (model) of a reference object embedded in (and serving to orient) that frame -- referred to as an *Object Reference Model (ORM)* an Earth Reference Model (ERM) is a special case of an ORM.

A *Coordinate System (CS)* specifying how a tuple of values uniquely determine a location with respect to the origin of that frame. By extension, that tuple also specifies a location with respect to the reference object.

SRF = ORM + CS

There are no "naked" coordinate systems

SEDRIS Spatial Reference Frames

Today SEDRIS Supports 151 SRFs

Arbitrary ORM	**Local Space Rectangular**	LSR2	2D	
		LSR	3D	
Earth-Centered, Earth-Fixed	**Geocentric**	GC	3D	
Earth-Surface, Global	**Geodetic**	GD2	2D	
		GD	3D	
Earth-Surface, Local (Topocentric)	**Local Tangent Plane**	LTP2	2D	
		LTP	3D	
	GCS	GCS	3D	
Earth-Surface, Projection-Based	**Mercator**	M	2D	
		AM	3D	
	Oblique Mercator	OM	2D	*Spherical ERM Only*
		AOM	3D	
	Transverse Mercator	TM	2D	
		ATM	3D	
	Universal Transverse Mercator (60)	UTM	2D	
		AUTM	3D	
	Lambert Conformal Conic	LCC	2D	
		ALCC	3D	
	Polar Stereographic	PS	2D	
		APS	3D	
	Universal Polar Stereographic (2)	UPS	2D	
		AUPS	3D	
	Equidistant Cylindrical	EC	2D	*Spherical ERM Only*
		AEC	3D	
Earth-Centered, Rotating (Inertial & Quasi-Inertial)	**Geomagnetic**	GM	3D	
	Geocentric Equatorial Inertial	GEI	3D	
	Geocentric Solar Ecliptic	GSE	3D	
	Geocentric Solar Magnetospheric	GSM	3D	
	Solar Magnetic	SM	3D	

SRM Summary

- **Unambiguously specifying location**
  - **Common SRF provided in implementation**
  - **Used within the DRM to store location information**
  - **Used within the DRM to store SRF information**

SRM

- **Efficient conversion of location data**
  - **Platform and language independent implementations to change from one SRF to another**
  - **Provides a framework to inter-convert between standard SRFs as well as new SRFs**

Environmental Data Coding Specification (EDCS)

Environmental Data Coding Specification

Unifies characterizations of environmental "things"

Regardless of how represented:
Feature or Geometry or Data Table or Model or ...

Whether individual primitives or structured collections of primitives:
Furniture *vs*. Room *vs*. Building *vs*. Facility *vs*. Region

Separates enumerations from Data Representation Models

Evolve at different rates for different reasons

It's a big world to capture ...

Answers three types of questions:

What is it? **Classifications and Features**

What are its additional clarifying characteristics? **Attributes and Values**

What are its characteristic measures? **Units of Measure and Scale**

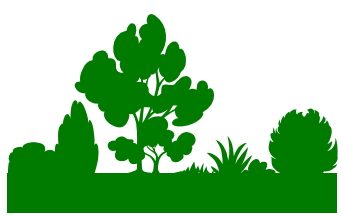
Classifications (and Features)

1. What is it?

building, river/stream, air warning light, ocean floor

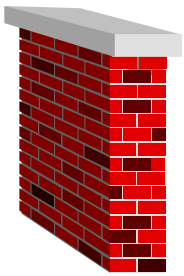
Animal?

Water?

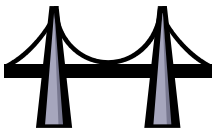


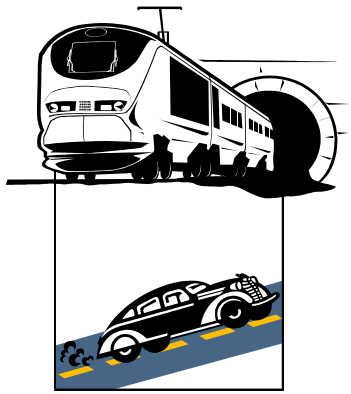
Vegetable?

Weather?

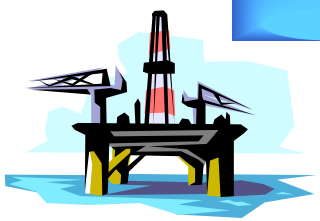


Mineral?





Vehicle?



Structure?

Celestial?

Attributes (and Values)

1. *What is it?*

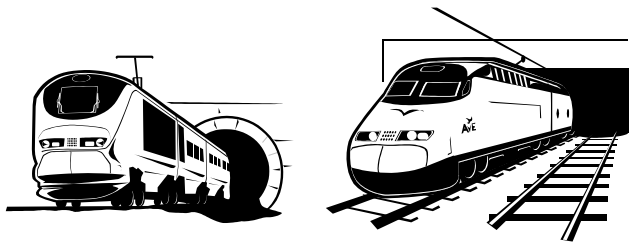
   building, river/stream, air warning light, ocean floor

2. ***Additional clarifying characteristics?***

   lighthouse, 1.5, red, coral

Vegetation Type?

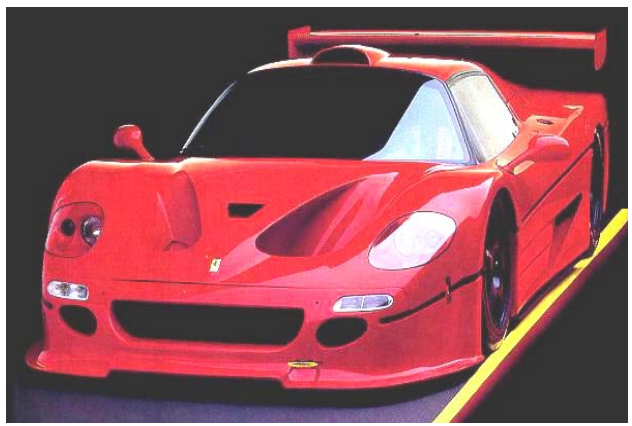
Building Function?



Overhead Clearance?

Units of Measure and Scales

1. *What is it?*
   building, river/stream, air warning light, ocean floor
2. *Additional clarifying characteristics?*
   lighthouse, 1.5, red, coral
3. ***What are its characteristic measures and scales?***
   kelvin, decametre, kilometre/hour; micro, tera, deci

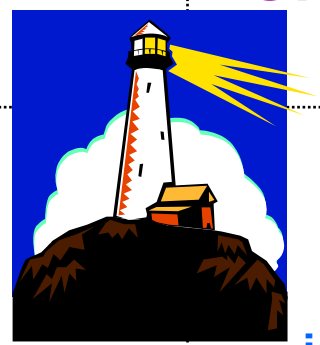


How fast?
kilometres per hour

How warm?
kilokelvin

How tall?
decametres

Putting EDCS Entries Together Clarify the Object's Description

What is it?	*How is the object characterized ?*	*How is the object measured?*
Classifications	**Attributes**	**Units of Measure & Scales**
Building	With the function of a *Lighthouse* Whose height	 is 3.05 *deca*metres
River Stream	Whose speed	is 1.5 metres per second
Ocean Floor	Which is composed of *Coral* Whose density	 is 0.97 kilograms per cubic *deci*metre

http://physics.nist.gov/cuu/Units/index.html

EDCS Basics (1)

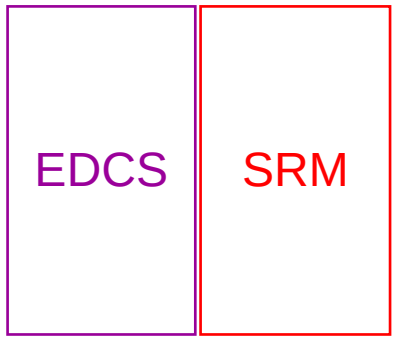
- **The EDCS provides mechanisms to unambiguously specify objects used to model environmental concepts.**
  - The EDCS supports the encoding and communication of qualitative and quantitative information associated with natural and artificial environments
- **The EDCS specifies a collection of nine dictionaries of environmental concepts, as well as:**
  - Guidelines for expanding these dictionaries through registration,
  - Conventions for applying the encodings in information processing applications,
  - A functional interface to convert between numeric values given in different units of measure and scales, and
  - Organizational Schema and Groups to aid in searching specific dictionaries

EDCS Basics (2)

- **An EDCS Dictionary Entry for a given environmental concept minimally includes:**
  - A Definition which is a precise statement of the nature, properties, scope or essential qualities of a concept embodied in the entry
  - A Label which is a compact and human-readable designator that is used to denote a concept; this is represented as a character string
  - A Code which is a compact, and not necessarily human-readable, designator that is used to denote a concept; this is represented as an integer
  - Each entry is unique and defines one concept
- **EDCS is not a Data Model or a Taxonomy**
  - Allows a definition to reference other concepts in order to make best definition

EDCS Summary

- **Answers**
  - ***What is it?***
  - ***What are its additional clarifying characteristics?***
  - ***What are its characteristic measures?***
- **Provides a data dictionary**
- **Expandable**
- **Separates representation from semantics**



Data Representation Model (DRM)

The DRM in relation to SRM, EDCS

- The DRM provides the syntax and the structural semantics for the expression of environmental data
- It relies on the SRM for specifying location of environmental data, and
- It relies on the EDCS to capture the semantics of the environmental data
- In analogy to natural languages, the DRM can be thought of as the grammar, and the EDCS as the dictionary of words
- Semantics of the data depend on both the grammar and the dictionary

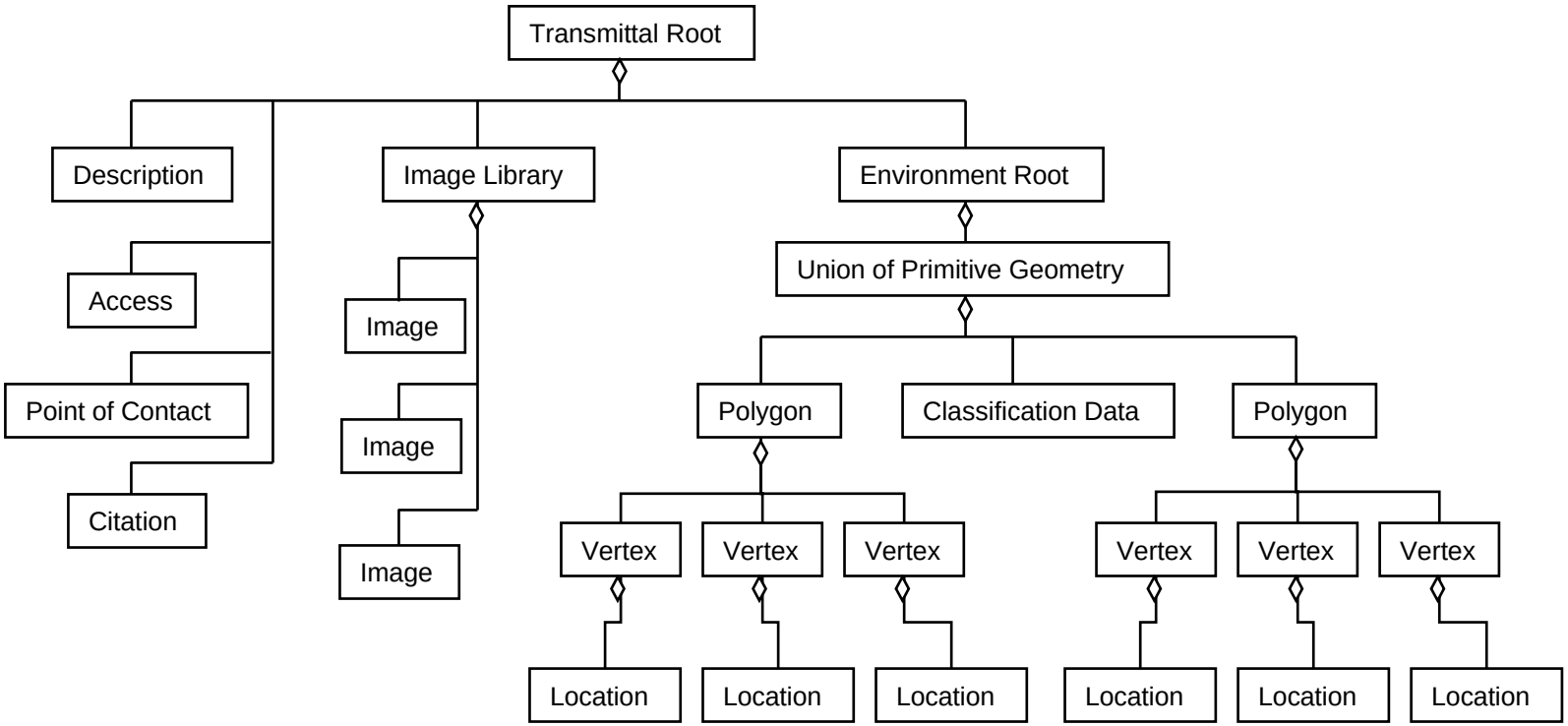
DRM Basics

- **The DRM is a set of classes and the data types used to specify their data elements**
- **The DRM defines formal relationships between these classes**
- **The DRM specifies a set constraints or requirements on instances of classes**
- **Actual data sets contain object instances of DRM classes**

DRM Basics

- **The formal relationships between classes specify what relationships are allowed to exist between instances of those classes and what those relationships mean**
- **The constraints further refine requirements for objects in specific contexts**
- **A SEDRIS data set or database is called a *transmittal***
- **The objects contained within a transmittal are organized as a tree in terms of aggregate/ component (whole vs. part) relationships between objects.**

DRM Basics



A sample transmittal provided as a DRM class instance

An Example of a DRM Class Definition

Class	**<Transmittal Root>**
Super Class	SEDRIS Abstract Base
Sub Class	None
Description	The hierarchical root of all objects in a single SEDRIS transmittal.
Field Elements	name, major_DRM_version,minor_DRM_version, interim_DRM_version,major_EDCS_version, minor_EDCS_version,interim_EDCS_version[2]
Possible Components	<*Base Time Data*> <Data Table Library> <Image Library> <Property Set Table Library> <Sound Library> <Transmittal Summary> <Citation> <Data Quality> <Colour Table Library> <Environment Root> <Model Library> <Reference Origin> <Symbol Library> <Access> <Cross Reference> <Description>
Constraint	Objects of this class cannot be published.

The DRM is Composed of ...

- **Organizer and container classes**
  - **Classes used to organize other classes**
  - **Examples**

    <Transmittal Root>, <Library>, <Environment Root>, <Feature Hierarchy>, <Geometry Hierarchy>
- **Primitive representation element classes**
  - **Geometry classes**

    Physical/surface representations of real-world objects (e.g., 3D polygons, images, lighting, etc.)
  - **Feature classes**

    Higher level abstraction of real-world objects (i.e., area, line, and point representations)
  - **Topology**

    Concise, mathematical definition of inter-Feature or inter-Geometry object relationships
- **Properties**
  - **Classes which describe the representation elements in a transmittal**
  - **Examples**

    <Classification Data>, <Property Value>, <Colour>, & metadata classes

Organizing Principles

- **Union**
  - Organize primitives that need to be grouped together but for which no other organizer is more suitable.
  - A “bag of” points, polygons, etc
- **Alternate Hierarchy**
  - To provide two or more representations of the same underlying data
  - Organized as separate branches of hierarchy tree
  - The <Hierarchy Data> associated with each branch describes that particular representation
- **Spatial Index**
  - Organizes data into a spatial grid
  - Each branch of the hierarchy contains one grid

Organizing Principles

- **Quadrant**
  - Divides the representation into four spatial regions
  - Each branch contains one of the quadrants
- **Octant**
  - Divides the representation into eight volumes
  - Each branch contains one of the octants
- **Perimeter**
  - Organizes data into irregularly shaped partitions
  - Each branch of the hierarchy specifies the perimeter of the region
  - Each branch contains primitives that fall within the specified perimeter

Organizing Principles

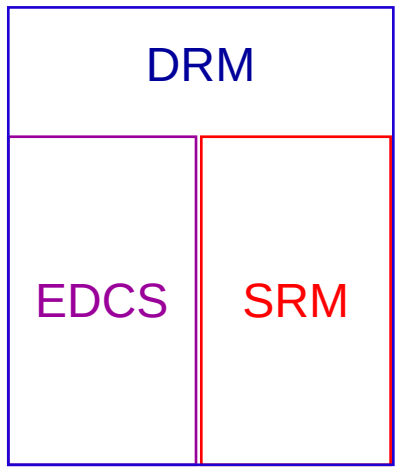
- **Classification**
  - Organizes data according to its EDCS Classification.
- **Level Of Detail**
  - Organizes different representations of the same underlying data that differ in level of detail.
  - Each branch contains one of the octants
- **Continuous Level Of Detail**
  - Is specific to primitive geometric representations, such as polygonal representations
  - Provides a mechanism for specifying an arbitrary number of levels of finer and finer detail
  - Allows the consumer to decide under what conditions the end application should switch from a coarse representation to a more detailed one, or vice versa.

Organizing Principles

- **Separating Plane & Animation**
  - **Specific to geometric primitives**
  - **Organize by planes that partition the geometry into volumes to assist the rendering process**
- **Animation**
  - **Specific to geometric primitives**
  - **Organize by creating an animation sequence**
- **Time**
  - **Organizes data temporally**
  - **Each branch specifies a different time period.**
- **State**
  - **Organizes based on the state being represented**

DRM Summary

- Set of class definitions and constraints
- Set of defined relationships between classes, specified in UML
- Instanced as a transmittal
- <Feature> and <Geometry> primitives
- Uses SRM and EDCS
- Metadata at transmittal and object level
- Organizational capabilities provide flexibility



SEDRIS Transmittal Format (STF)

SEDRIS Transmittal Format (STF)

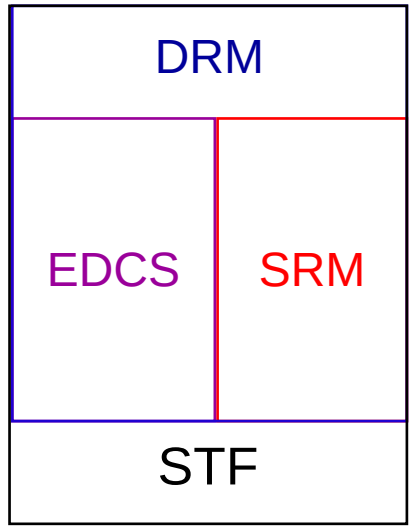
- ***A file format developed to store SEDRIS data***
- ***The data organization is derived directly from the DRM.*** **Objects are stored and retrieved in direct 1-to-1 relationship with the data created by the producer**
- ***A binary format which is machine architecture and word order independent***
- **STF transmittals consist of multiple files but are named by one main 'root' file**
- **The SEDRIS API Implementation provides the functionality of extraction and insertion DRM objects from the STF**

Transmittal Format - Requirements

- ***Platform Independence:***
  - **Both software and files**
  - **Adapts to platform's word order**
- ***Fully Support the SEDRIS Data Representation Model:***
  - **Full expressive power of the DRM**
  - **Data driven via DRM support functions**
  - **Completely loss-less with respect to objects instantiated by the data provider**
- ***Space Efficient Media Storage:***
  - **Minimal overhead with respect to the size of the SEDRIS objects stored**
- ***Run-time Efficiency:***
  - **Efficient with respect to both memory and processing time**
  - **Heavier emphasis on extraction performance than on insertion**
- ***Insulate Developers from Implementation Details:***
  - **Format and software can evolve independently from applications**
- ***SW Implementation abstracts system services to simplify portability:***
  - **Marshals system resources**
  - **Supports platform specific tuning to enhance performance**

STF Design Features

- ***File based storage on media:***
  - **Structure of data on physical media is the responsibility of the platform operating system, not the STF**
  - **STF transmittals use hierarchical directory structure to organize files**
- ***In essence, implements a simple persistent object database system:***
  - **STF is intentionally *not* a full object-oriented database management system**



- ***SW Implementation abstracts system services to simplify portability:***
  - **Marshals system resources**
  - **Supports platform specific tuning to enhance performance**

SEDRIS Application Program Interfaces (APIs)

Definitions

- ***API (Application Program Interface):*** **An encapsulation of functionalities common to many applications into reusable modules.**
- ***API Implementation:*** **The instantiation of an API's functionality in software that is bound to one or more software language.**
- ***Transmittal:*** **Environmental data realized as a collection of DRM-compliant instances conveyed using the SEDRIS API and/or STF.**

The SEDRIS API

- **The SEDRIS API is an encapsulation of functionality which provides applications the ability to access DRM objects.**
  - **Data Extraction - provides searching methods to access DRM objects in a SEDRIS transmittal.**
  - **Data Insertion - provides ability to create DRM objects in new or existing SEDRIS transmittals.**
  - **Data Representation Model - provides access to meta-data about DRM classes, data types, and their allowable relationships.**
- **A set of function definitions (bindings).**
- **Why an API (not just a format specification) ?**
  - **It provides a consistent interface between a user's software application and SEDRIS transmittals.**
  - **It decouples the user's application from the transmittal's format, allowing the DRM, the transmittal format, and the user's application to evolve relatively independently of each other.**
  - **It provides functions to simplify the navigation of complex transmittals.**

The APIs

- The Transmittal Access API is used to insert and extract data into a Transmittal
- The DRM API is used to query information about the DRM such as:
  - Date elements, DRM classes, relationships, etc
- The SRM API provides coordinate conversion of data from one SRF to another
- The EDCS API provides access to the EDCS dictionaries of integer codes, labels and definitions
- The Transmittal Access API implementation relies on the DRM, SRM, and EDCS APIs
- The SRM and EDCS implementations are independent and can be used “stand alone”

Basic Extraction Steps

Logic	Function Calls
• Open a Transmittal	• SE_OpenTransmittalByFile
• Get the Root Object	• SE_GetRootObject
• Create a Search Boundary	• SE_CreateSpatialSearch Boundary
– Create a Search Filter	– SE_CreateSearchFilter
– Create an Iterator	– SE_InitializeComponentIterator
• Retrieve an object	• SE_GetNextObject
• Get the fields	• SE_GetFields
• Process the Object	
• Free the Object	• SE_FreeObject
– Free the Iterator	– SE_FreeIterator
– Free the Search Filter	– SE_FreeSearchFilter
• Free the Search Boundary	• SE_FreeSpatialSearchBoundary
• Free the Root Object	• SE_FreeObject
• Close the Transmittal	• SE_CloseTransmittal

Basic Insertion Steps

Logic

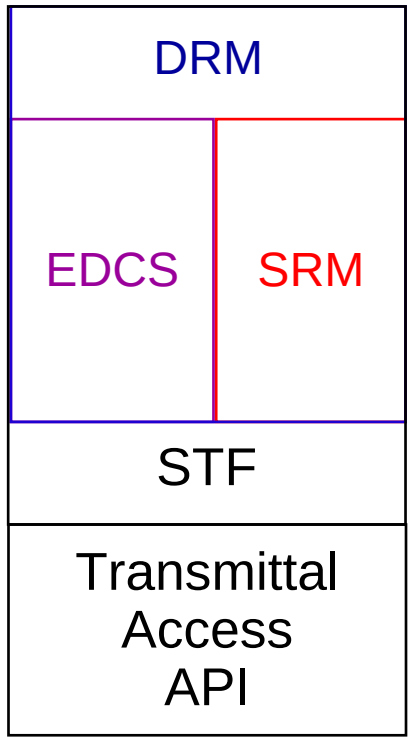
- Open a Transmittal
- Create the Root Object
- Set the Root Object Fields
- Set the Root Object for the Transmittal
- Create an Object
  - Set the Object Fields
  - Add as Component of Root
    - Create an Object
    - Set the Object Fields
    - Add as Component
    - Free the Object
  - Free the Object
- Free the Root Object
- Close the Transmittal

Function Calls

- SE_OpenTransmittalByFile
- SE_CreateObject
- SE_SetFields
- SE_SetRootObject
- SE_CreateObject
  - SE_SetFields
  - SE_AddComponentRelationship
    - SE_CreateObject
    - SE_SetFields
    - SE_AddComponentRelationship
    - SE_FreeObject
  - SE_FreeObject
- SE_FreeObject
- SE_CloseTransmittal

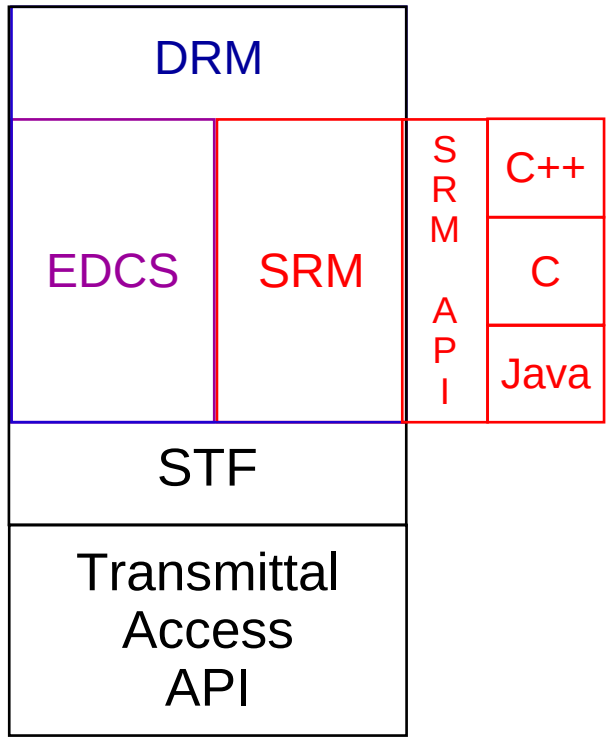
Transmittal Access API Summary

- **A handful of concepts**
  - **Transmittal**
  - **Objects**
  - **Object Ids**
  - **Traversal**
  - **Iterators**
- **Provides all functionality necessary to retrieve the data in a transmittal**
- **Provides all functionality necessary to create a transmittal as well as modify it**
- **Provides helper functions such as enumerations to string**



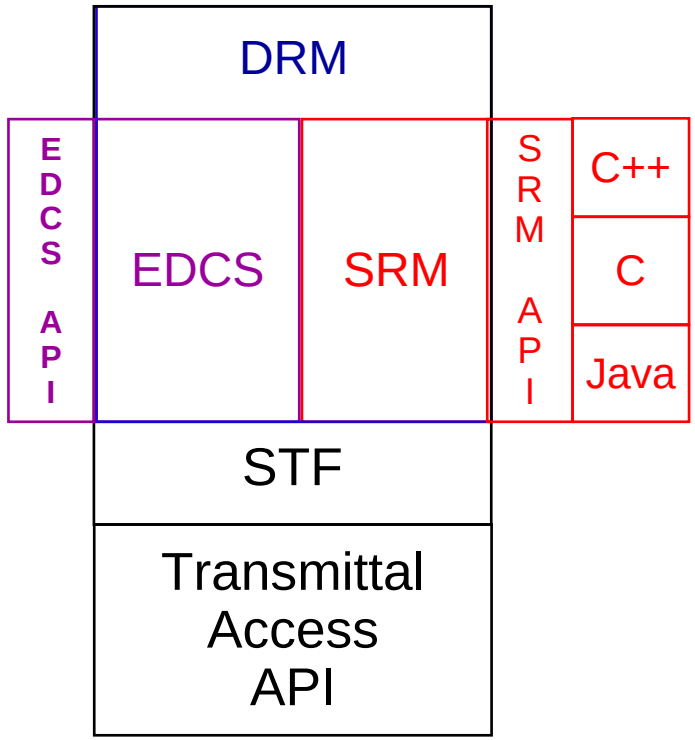
The SRM API

- The SRM API deals with SRFs, coordinates, directions, and orientations constructs
- Data structures are defined for the instantiation of each concept
- SRF constructs for managing coordinates, direction, and orientation
- Functionality provided for:
  - SRF, coordinates, direction, & orientation construct creation
  - Inter-SRF conversion for coordinates, direction, & orientation constructs
  - Specific calculations
    - ConvergenceOfTheMeridian
    - GeodesicDistance
    - EuclideanDistance
- Multiple language implementations
  - C, C++, & Java



The EDCS API

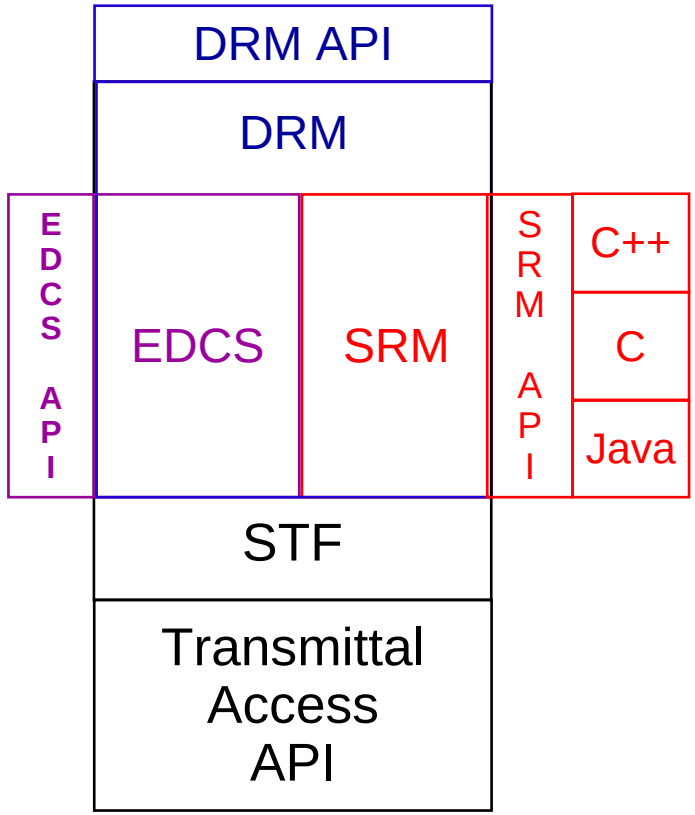
- **Functions for converting character strings to enumerated types**
- **Functions for converting simple and structured types to character strings**
- **Functions for validating simple and structured types**
- **Functions for comparing data structures (qsort compatible)**
- **Function for converting quantity values between units**



- **27 Functions for interacting with the 9 EDCS Dictionaries (3 each)**
  - **For retrieving the EDCS dictionary entry by code**
  - **For converting EDCS labels to codes**
  - **For converting C binding “Symbolic Constants” (mnemonics)**

The DRM API

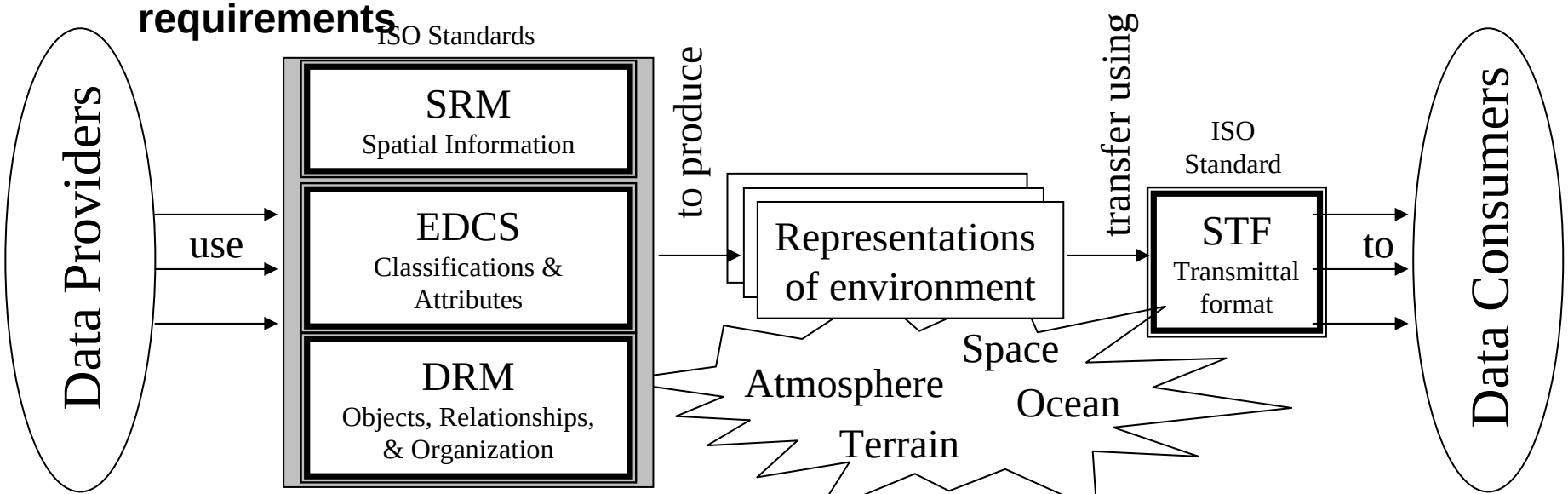
- **Functionality to query:**
  - **DRM types**
  - **DRM classes**
  - **DRM inheritance**
  - **Allowable relationships between DRM Classes**
  - **Fields and field elements**
- **Functionality for converting data types to character strings**
- **Functionality for validating simple and structured types**



- **Allows software to query for DRM definitions**
- **Also provides functionality for converting between color models**

How the Five Components Relate

- **Complete and powerful language for environmental representation:**
  1. ***DRM* - syntax and the structural semantics**
  2. ***EDCS* - vocabulary for object semantics**
  3. ***SRM* - unified methodology for location specification & conversion**
- **Mechanism to communicate and evaluate environmental data:**
  4. ***API* - standard interface and implementation**
  5. ***STF* - platform-independent, transparent, and persistent format**
- **Value-added Tools**
  - **practical applications, converters, and utilities (such as SEE-IT)**
  - **TCRS-- technologies to specify and evaluate content and interface-level requirements**



How to Apply SEDRIS Technologies

Use:

- DRM, EDCS, and SRM to model environmental data
- DRM, EDCS, and SRM to specify environmental database content
- EDCS as a stand-alone component as a common environmental dictionary of concepts
- SRM as a stand-alone component for coordinate conversion
- all SEDRIS components as an interchange mechanism
- SEDRIS tools to examine, convert, or manipulate environmental data
- SEDRIS Technologies as the basis to develop new tools
- TCRS (Transmittal Content Requirements Specification) methodology and syntax to express data requirements (using DRM, EDCS, and SRM)
- TCRS to validate data sets for requirements compliance

SEDRIS Software Development Kits (SDKs)

Component SDKs

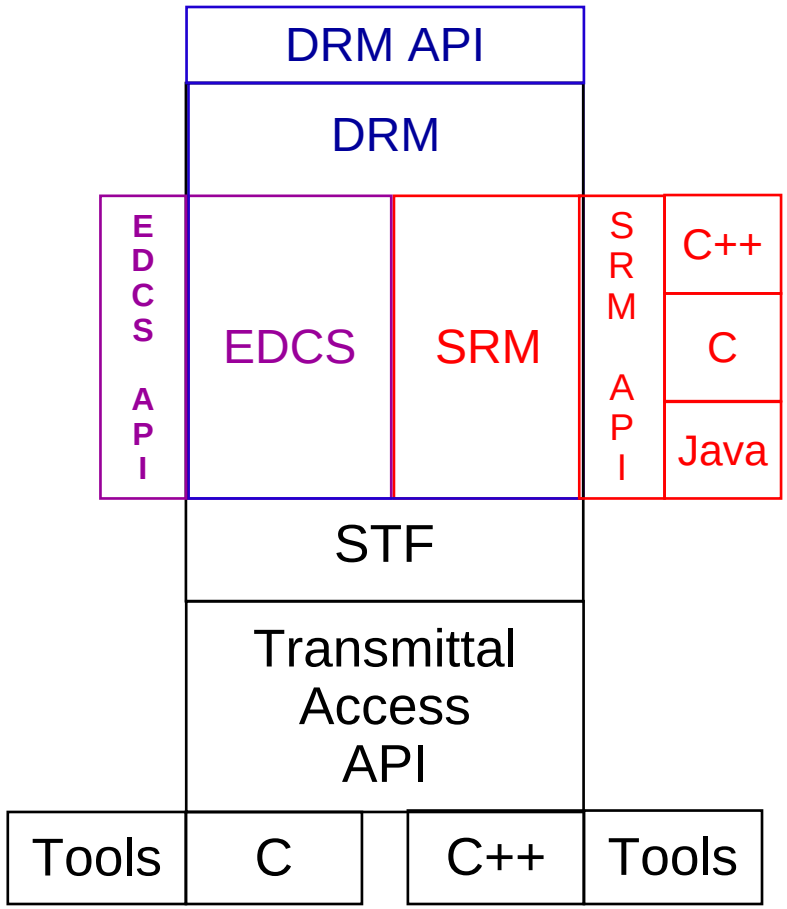
- EDCS SDK
  - Standalone EDCS implementation
  - Build environment to compile and link included software
  - Utilities to test executables following builds
  - HTML Documentation:
    - Reference Manual
    - Migration Guide for upgrading from previous releases
    - Mapping utilities from other standards e.g. FACC 2.1
- SRM SDKs
  - Standalone SRM implementation
  - Build environment to compile and link included software
  - Utilities to test executables following builds
  - HTML Documentation:
    - Reference Manual
    - Migration Guide for upgrading from previous releases
  - Individual SDK for Java, C, and C++

SEDRIS SDK

- Source Code to Reference Implementation of:
  - EDCS API
  - SRM API
  - DRM API
  - Transmittal Access API implemented over STF
- Standard Tools
  - Depth – Traverses an STF transmittal and produce an ASCII dump
  - Model Viewer – OpenGL based viewer for Model Geometry
  - Syntax Checker - Traverses a transmittal and validates object relationships against DRM
  - Rules Checker – Traverses transmittal and validates content against DRM constraints
- Build environment to compile and link included software
- Utilities to test executables following builds
- Sample transmittals
- HTML Documentation:
  - Build Kit: build & install
  - Reference Manuals for: EDCS, SRM, DRM, All APIs
  - Migration Guide for upgrading from previous releases
  - Technical Guides for Special Topics
  - User Guides for Standard Tools

SEDRIS SDK

- **Current version is SEDRIS SDK Release 4.0**
  - **C++ SRM**
  - **Java SRM**
  - **C++ Transmittal Access API**
- **Release numbering includes major, minor, and maintenance version**
- **Releases with major and minor versions are compatible**
- **Release 4.0.1 is currently in testing and scheduled to be released in May**



SEDRIS Reference Implementation

- 400K+ Lines of open source software: C, C++, and Java
- Available as source and precompiled binary
- Supported Platforms (with various compilers):
  - Sun OS (5.6, 5.7)
  - Linux (Red Hat 2.4.7-10)
  - Windows (98 / ME / NT / 2000)
  - Mac OS X
  - Irix 6.5

SEDRIS-based Tools and Applications

Many SEDRIS-based tools, utilities, and applications exist

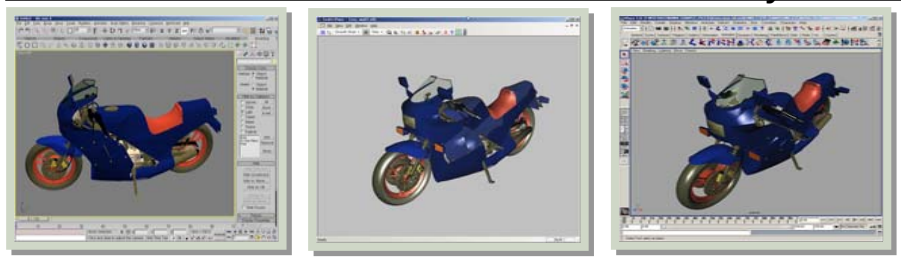
- **The following tools (for a number of platforms) are freely available from the SEDRIS web site:**
  - **EDCS Query Tool**
  - **Transmittal Browser**
  - **STF utilities**
  - **Syntax Checker**
  - **Depth**
  - **Rules Checker**
  - **Model Viewer**
  - **VPF to STF converter**
  - **DTED to STF converter**
  - **CTDB to STF converter**
  - **STF to CTDB converter**
  - **GeoTIFF to STF converter**
  - **STF (previous version) to STF (current version) converter**
  - **Focus**
  - **SEE-IT**
  - **Side-by-Side (an AcuSoft Inc. product)**

SEDRIS in Korean applications

Data conversion

- Support 3D Formats – Max, Maya, CAD etc.
- Keep data hierarchy structure

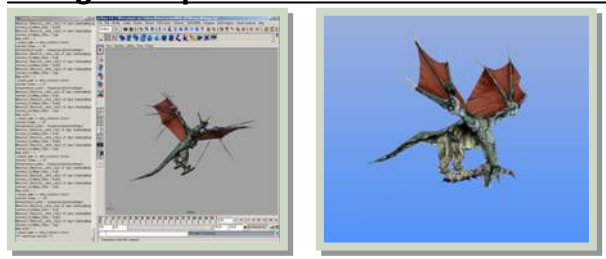
3ds Max ⇢ SEDRIS ⇠⇢ Maya



Animation data conversion

- Support Geometry Entities
  - Polygon Geometry
  - Undeformed NURBS geometry (converted to polygons on export)
  - Rigid and Soft body object
  - Texture Maps and Lights

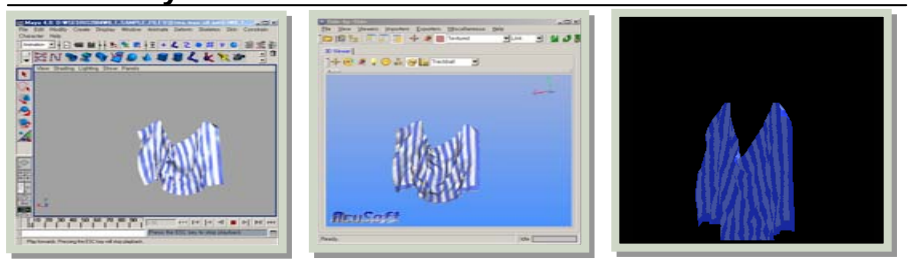
Plug-in Exporter SEDRIS



Cloth Animation

- Use Self-developed Algorithm
- Instable Self Collision Detection
- Support Aerodynamic Effects
- Support Polygon Reduction

Maya SEDRIS Mobile



Synthetic Environment Evaluation - Inspection Tool (SEE-IT)

Topology: **Holes, elevation mismatches, "T" vertices, incorrect 2-D surface area**

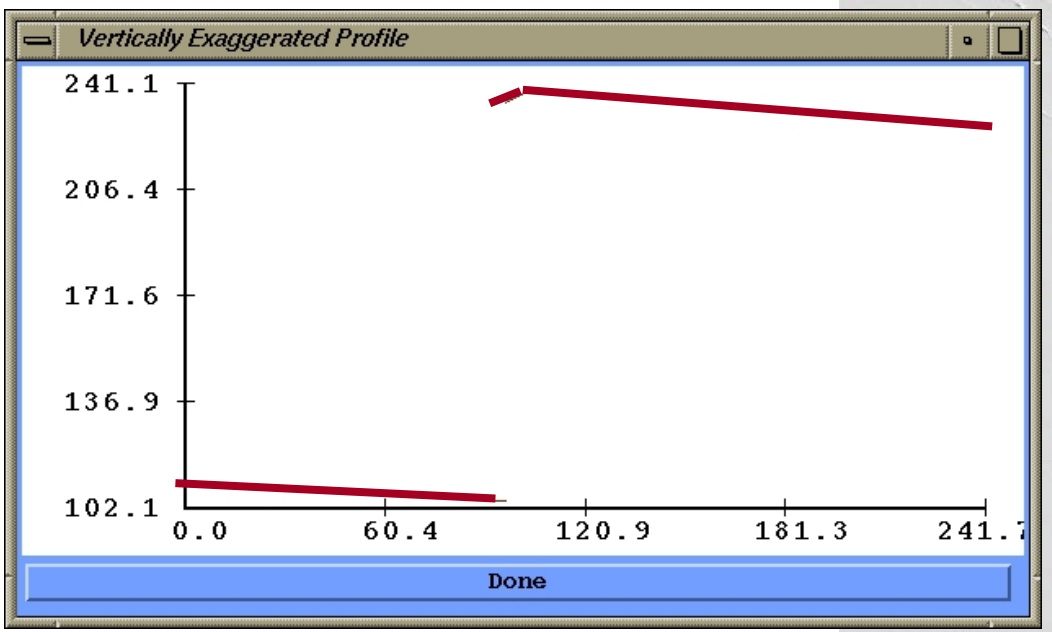
Polygons: **Duplicate, highly sloped, narrow, small area, or sliver polygons**

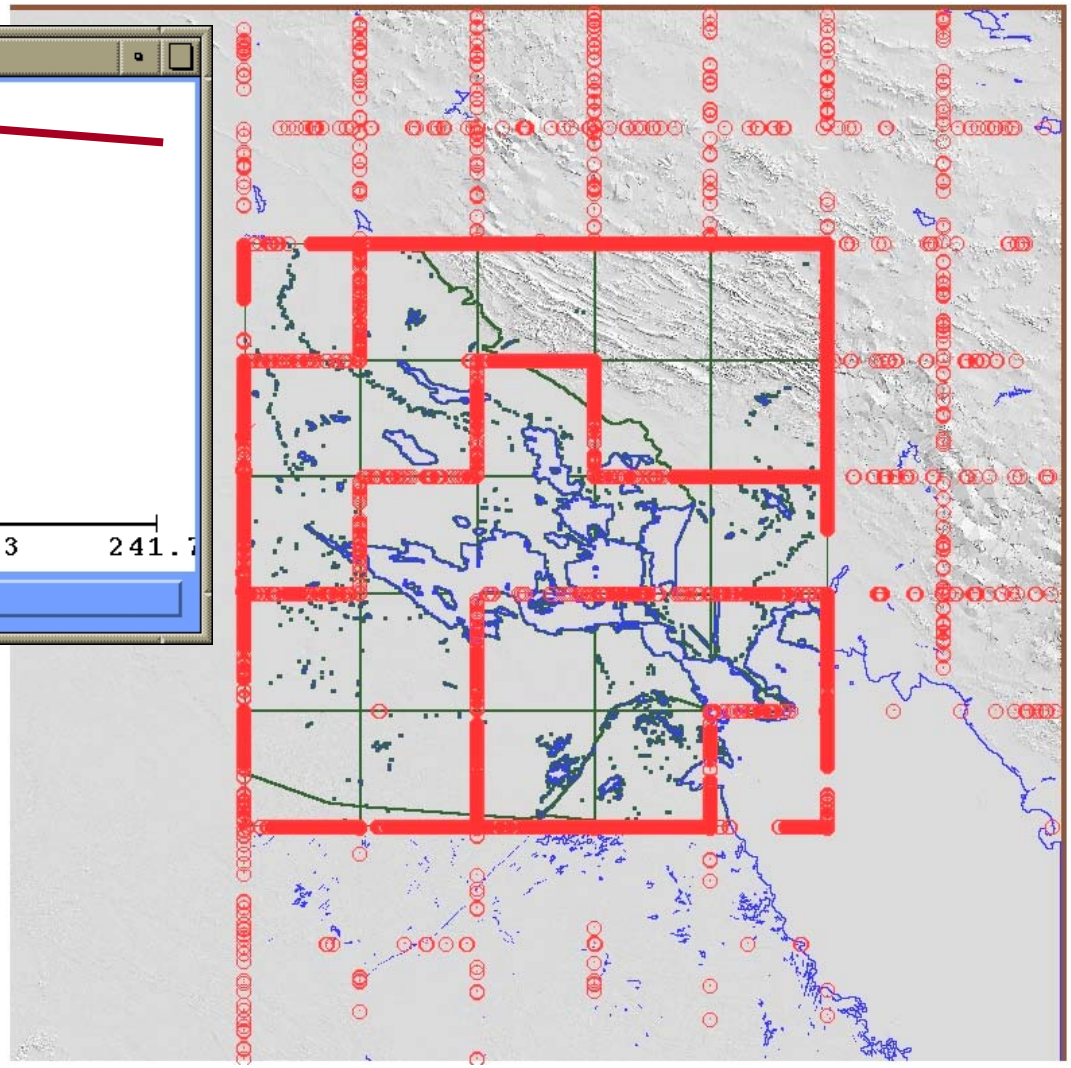
Networks: **Disconnects - Road segments with excessive slope, sharp turns, incorrect elevations, width changes, or that intersect NO-GO areas**

Models:

- **Gaps and skews between bridge segments**
- **Bridge segments without associated road networks or that include road network ends, intersections, or width changes**
- **Static models placed on high slope surface polygons or on a collection of polygons that have high slope variance**
- **Static models, other than bridges, that have bounding volumes which intersect or otherwise overlap road network locations**

Vertical Tear Locations

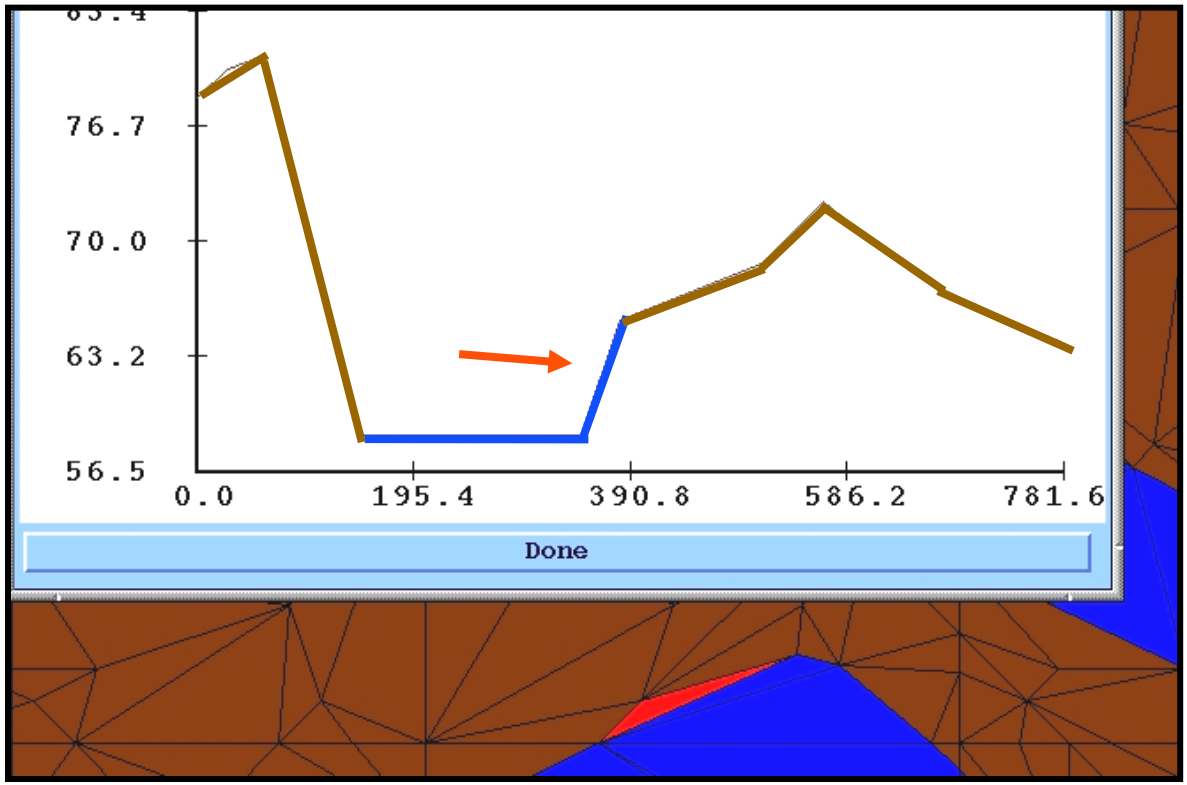




Cross section of a single tear instance with a magnitude of 135m

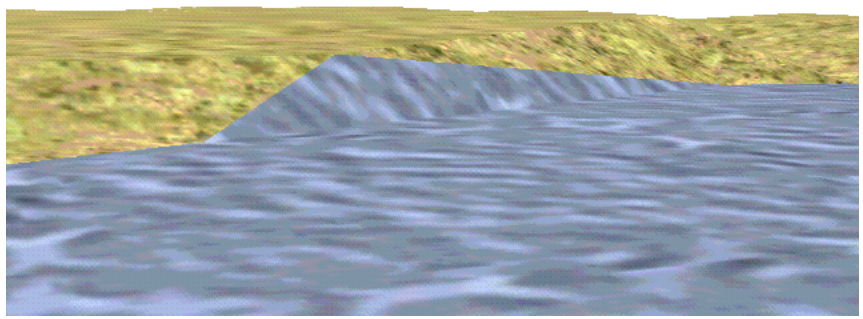
900Km X 900Km terrain skin

Water Surface Polygon with High Slope

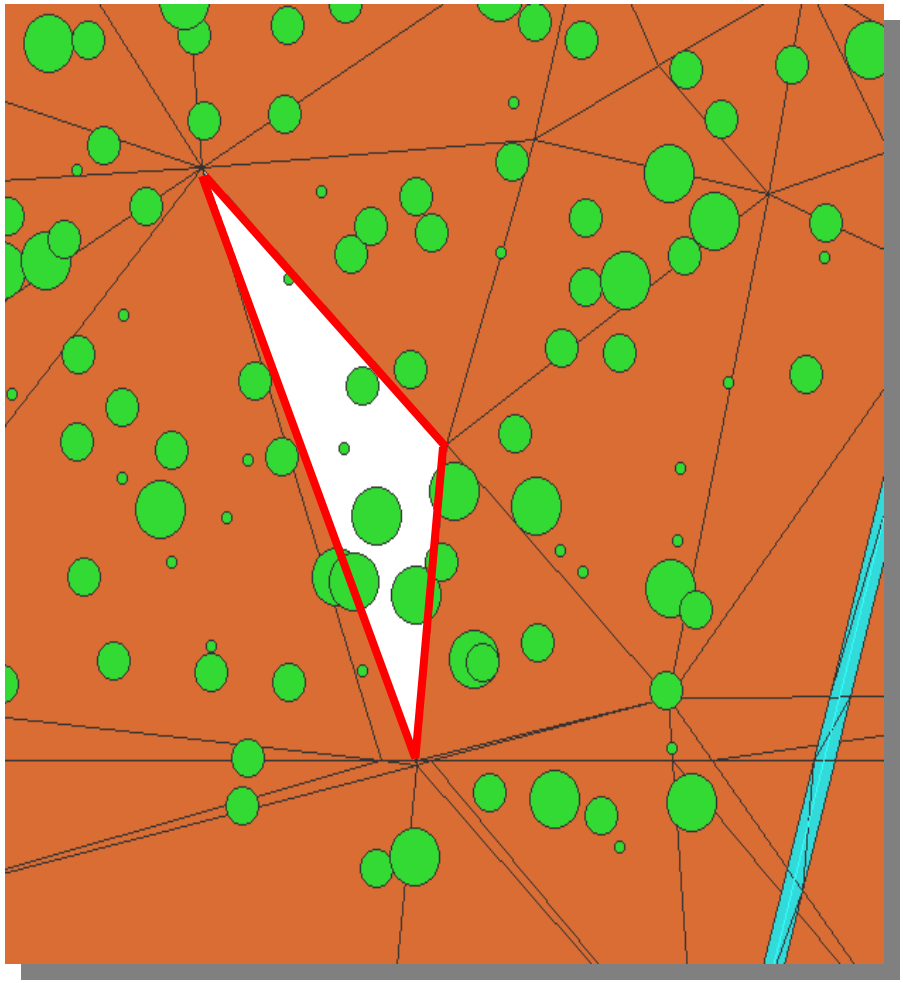


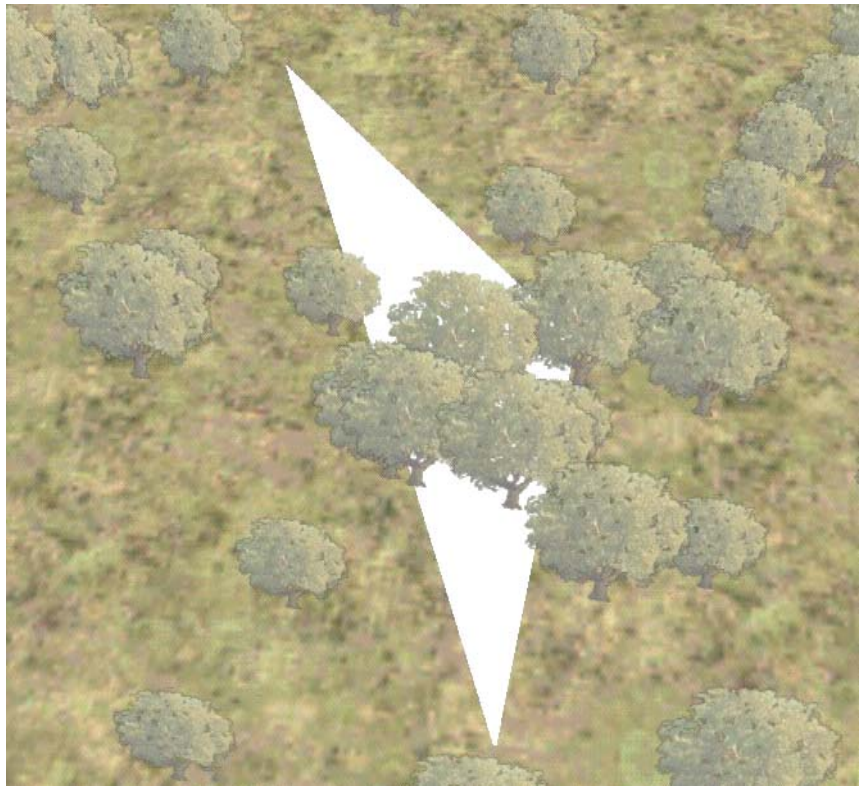
SEE-IT locates a water surface polygon with very high slope ...

which also appears in the out-the-window view



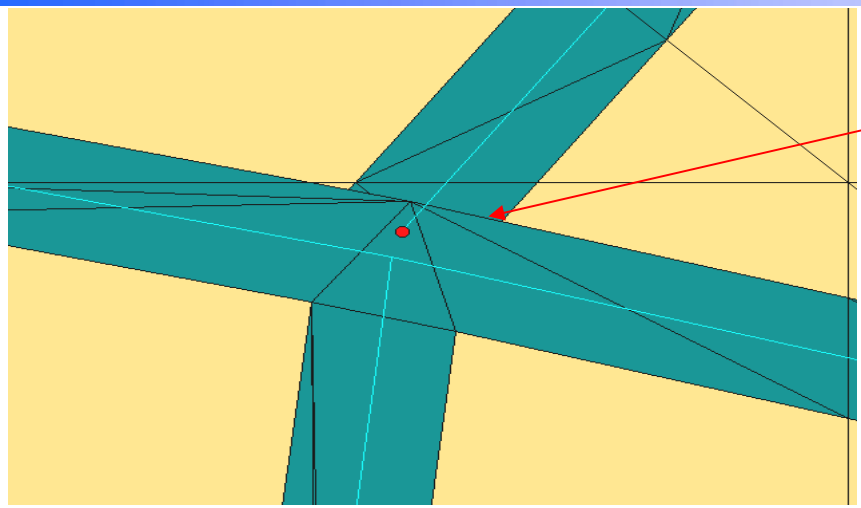
Topological Hole in the Terrain Surface

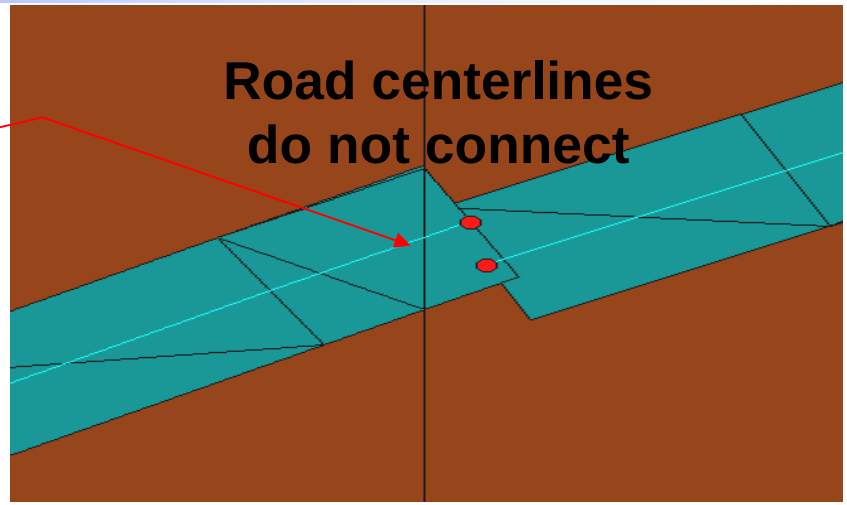


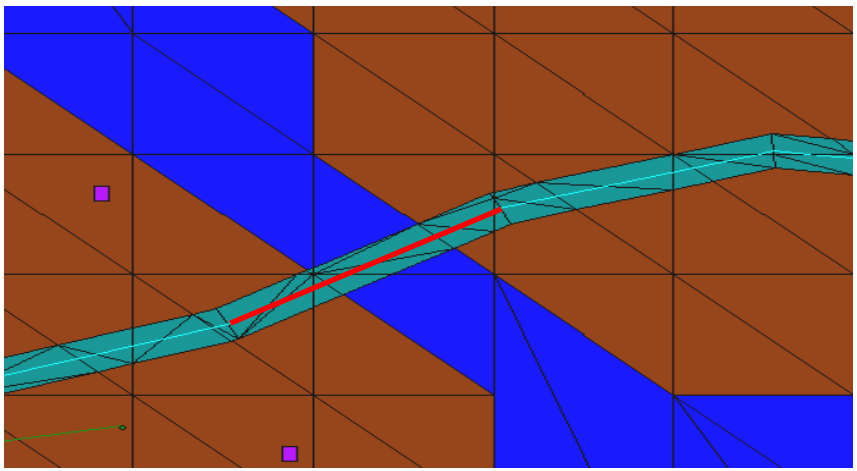


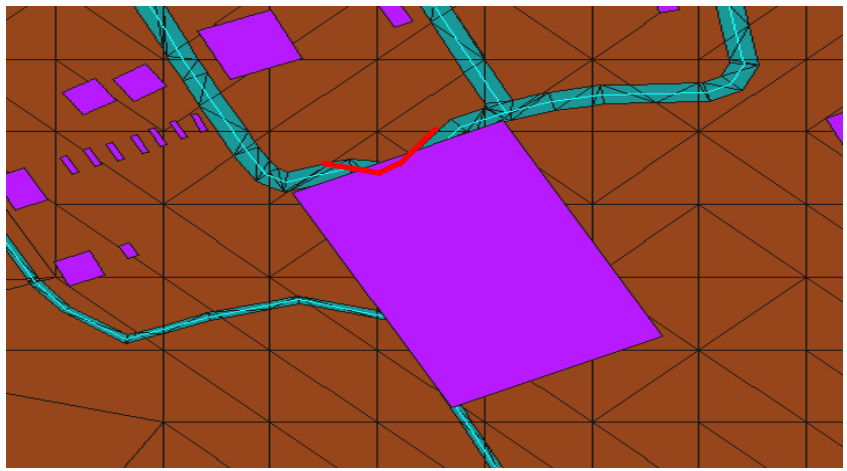
Also appears in the out-the-window view

Connectivity Problems





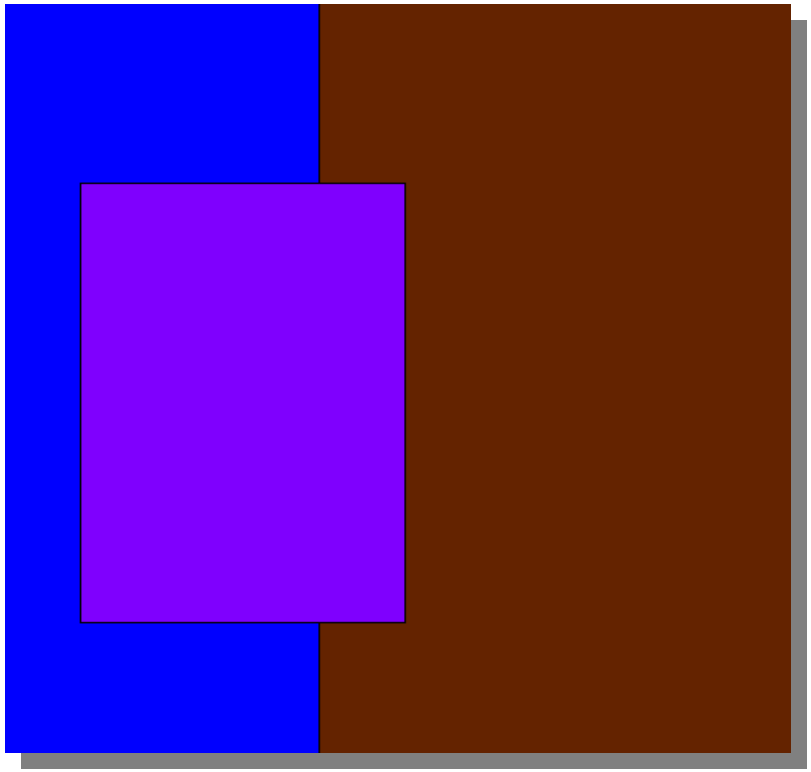


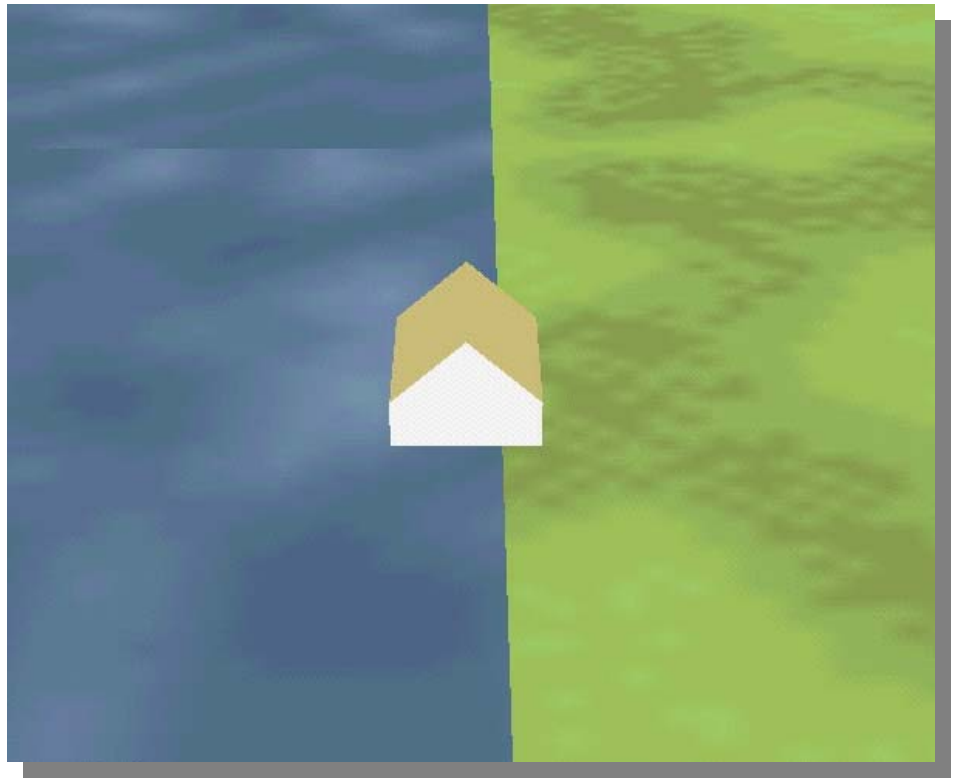


Road intersects water feature without a bridge

Road intersects a model bounding volume

Model Placed on both Land and Water

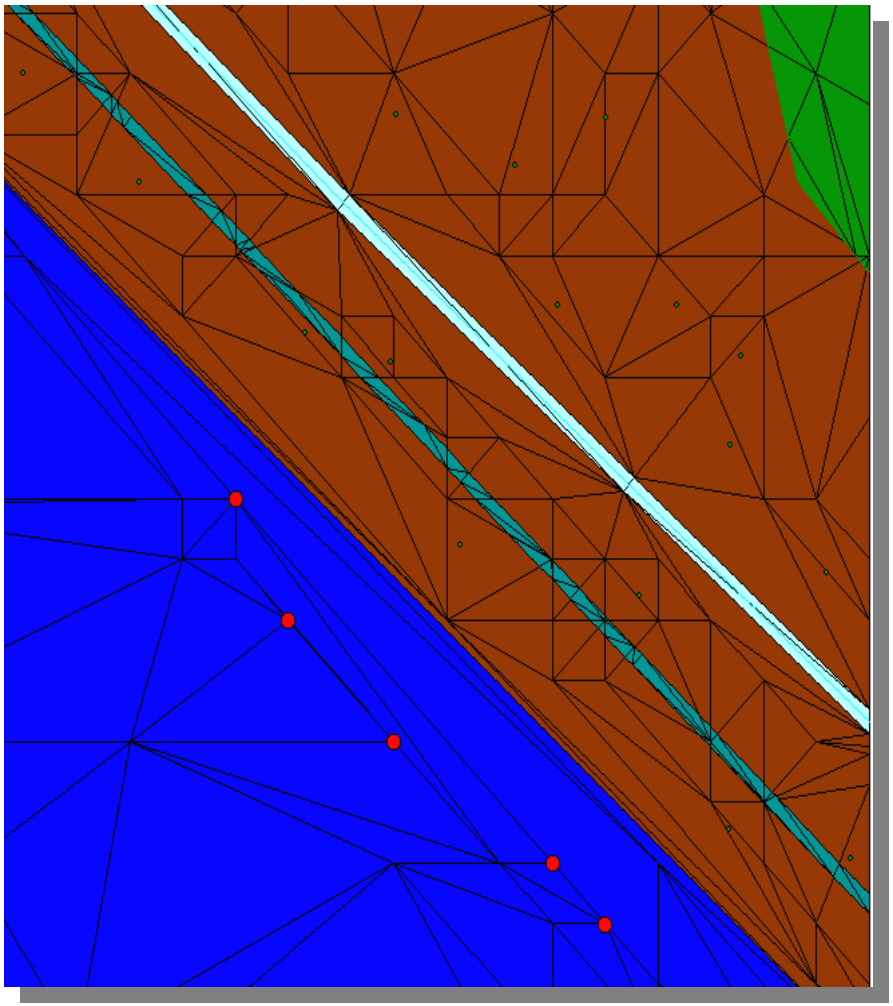


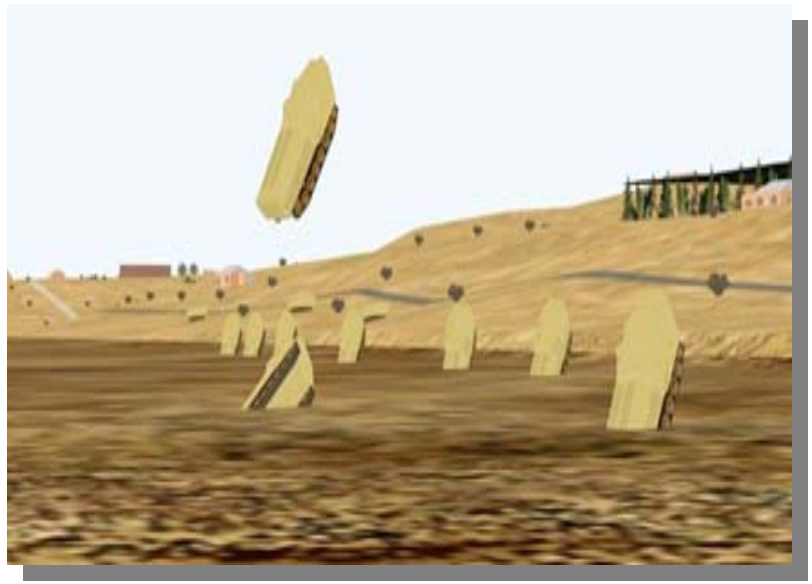


Also appears in the out-the-window view

‘T’ Vertex Topology

Bathymetric Data Surface



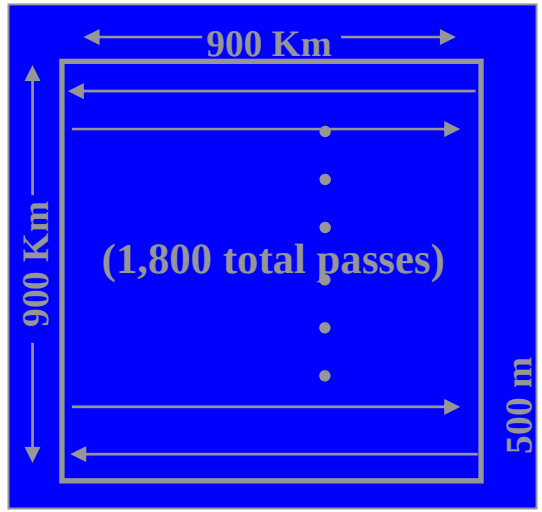


Resulting ModSAF Behavior

Comparison with Current Practice

Current Practice:

- Send a vehicle back & forth across the database to locate vehicle-specific problem areas
- Parameters:
  - One pass each 500 meters
  - 900Km x 900Km database
  - Vehicle speed is 'S' KMPH
- Time required to traverse the database:
  (1,800 passes * 900Km / pass) / "S" KMPH



SAF Speed (KMPH)	20	40	60	80	100	200
Time - hours	81,000	40,500	26,973	20,250	16,200	8,100
Time - days	3,375	1,688	1,124	844	675	338
Time - years	9.25	4.6	3.1	2.3	1.8	0.92

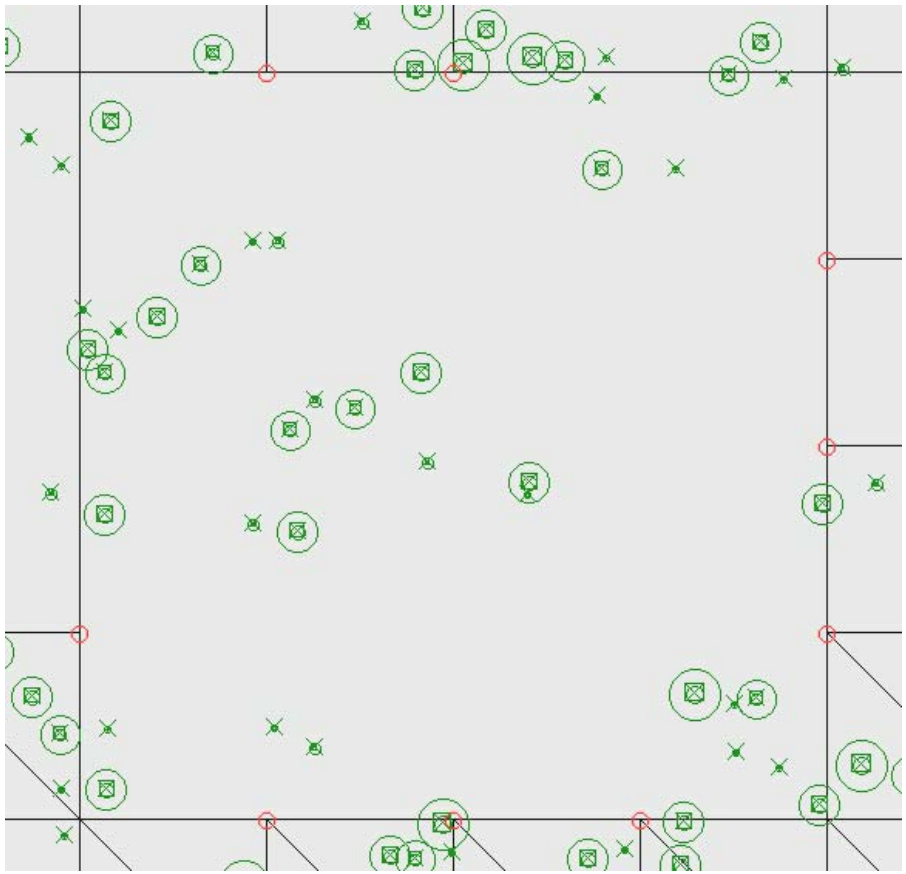
(Using multiple vehicles reduces time requirements linearly, but many other problems remain …)

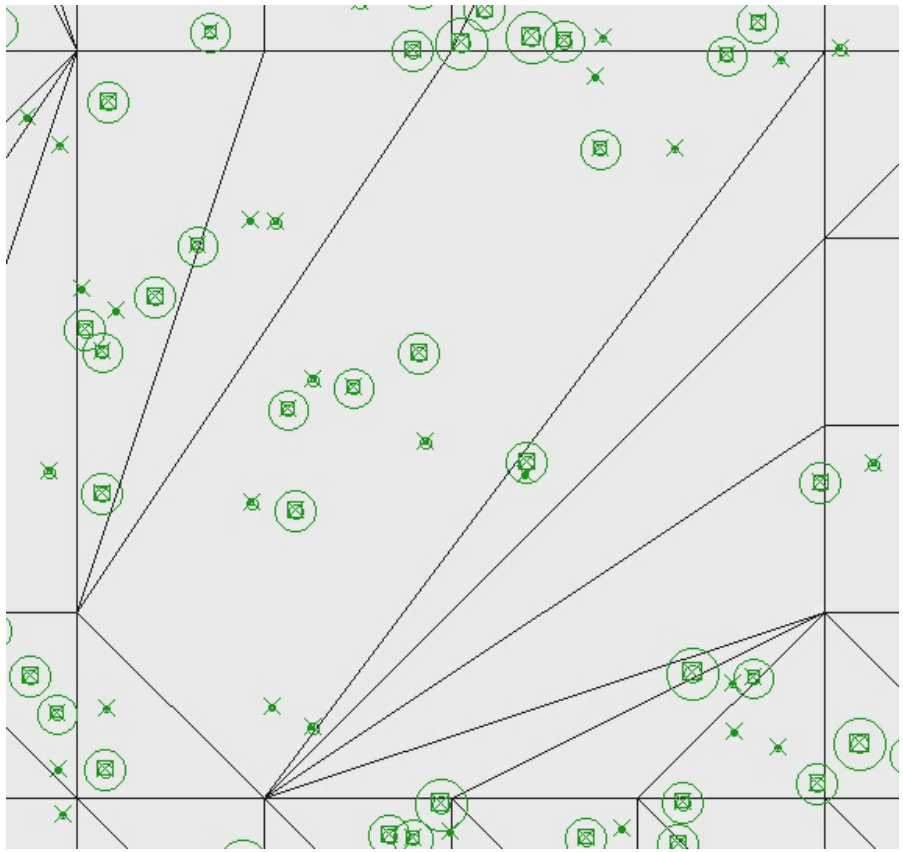
SEE-IT: Required 45 minutes to examine the entire 810,000Km² database (about 2.5 million polygons plus numerous non-polygonal features inspected)

A factor of over 100,000X improvement!

Repairs ...

SEE-IT locates a polygon with 9 T-Vertices ...





… and applies *automatic* repairs,creating a new STF

Model Viewer

Allows visual examination of 3-D icon (models) in SEDRIS transmittals

3-D models are often used in visual system applications

Provides the means to review levels of detail, states, and animation of special effects

Allows for display of textures in a transmittal

Demonstration of Focus tool

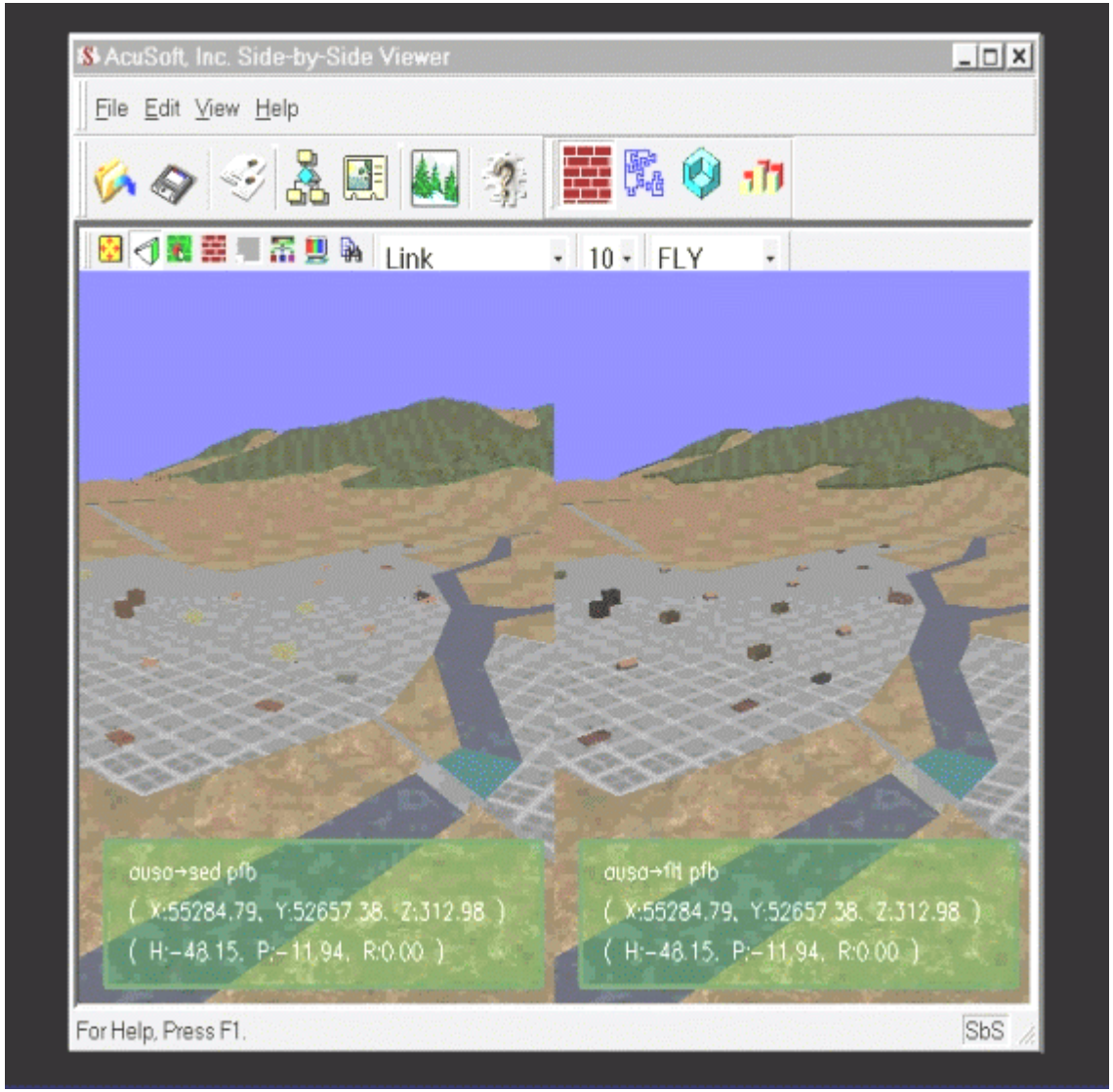
Sample 1

Sample 2

Sample 3

Side-by-Side viewer

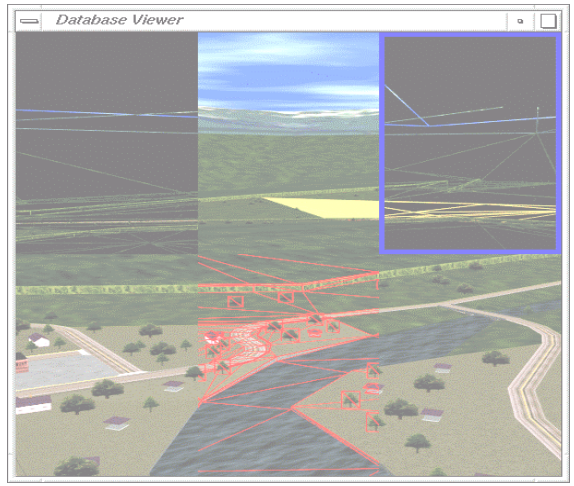
- Simultaneous viewing of multiple databases, up to hardware limit
- Independent or synchronized navigation modes
- Designed for database comparison
- Modular design to accepting user specific processing plug-in

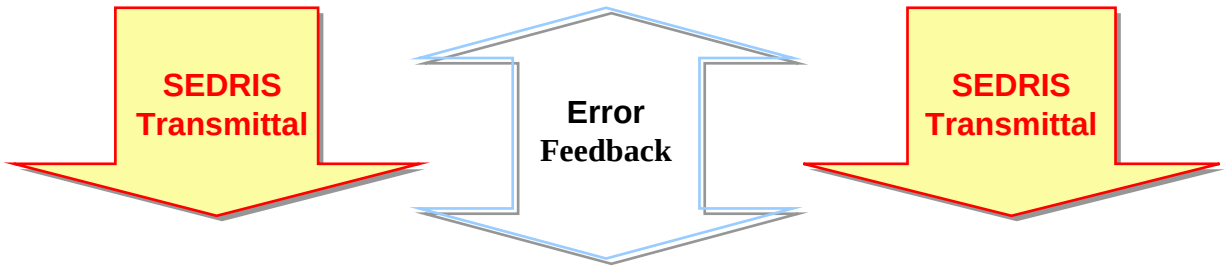


Coupling SEDRIS diagnostics & DBGS

DBGS

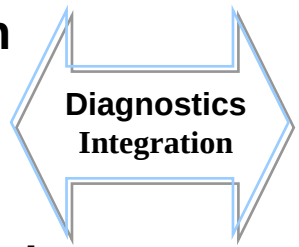
- Database generation using process Flowgraph GUI
- Inspection and editing of source geospatial data
- Rapid incremental recompilation
- “Just enough GIS” automatic processing





- Terrain skin error detection
- Geometry and attribution errors
- Identify SAF terrain anomalies
- User customizable analysis

SEE-IT



- Innovative visualization tool to compare multiple databases
- Visually highlighting of database errors
- Automated database structure analysis
- End-to-end database verification and validation

Side-by-Side viewer

Demonstration of Side-by-Side tool

Geometry Compare

Geometry Feature Compare

STF Browse

Examples of Formerly Demonstrated Applications

SEDRIS Navigator

A client-server based application **that allows viewing of databases across the Internet (or local intranets)**

Runs in conjunction with standard Internet browsers or as a stand-alone application

Supported on PC (Win98 / NT), SUN, Linux, SGI

Viewing modes:

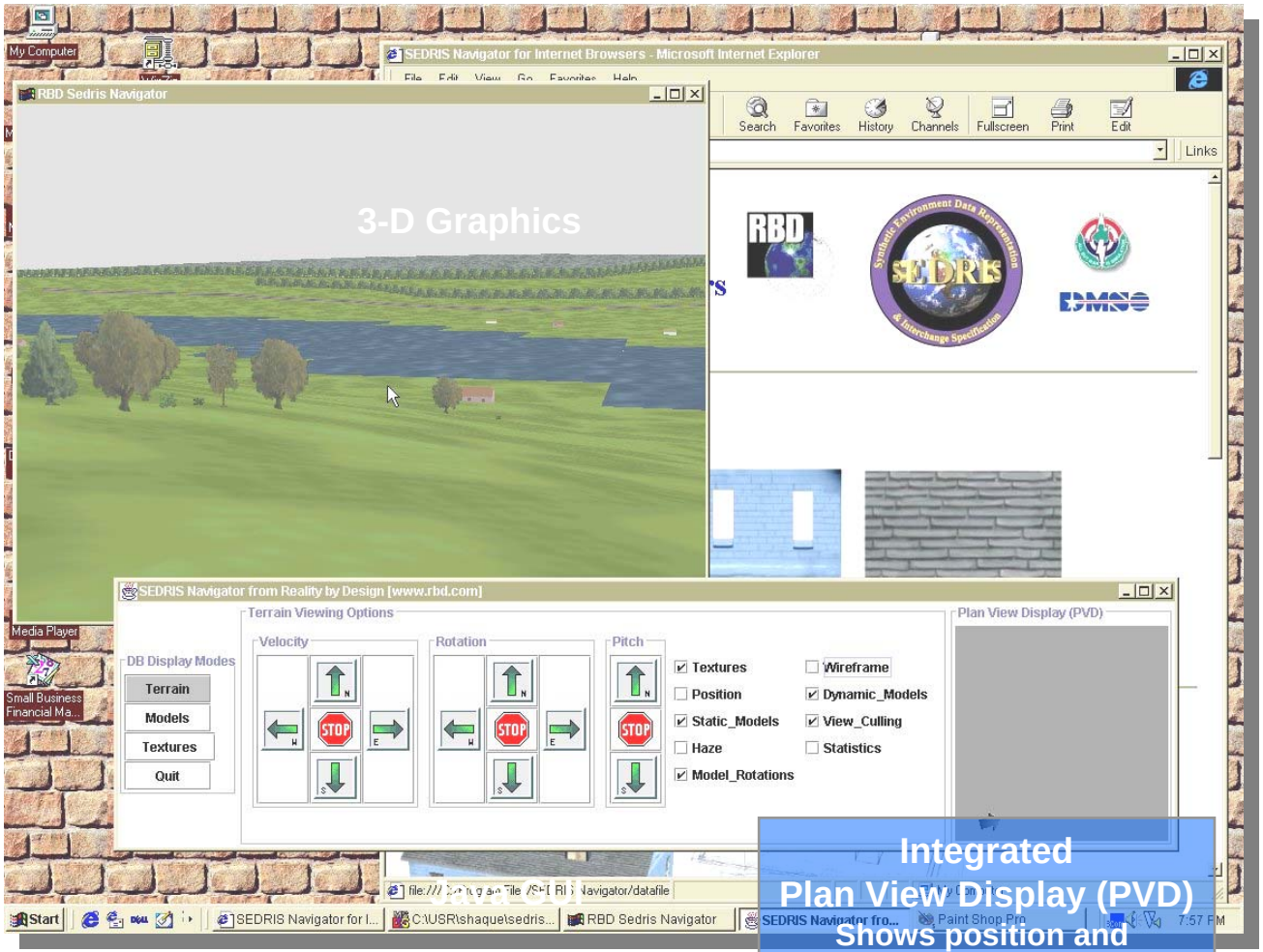
- **Items in a SEDRIS Model Library**
- **Entries from a SEDRIS Texture Library**
- **Terrain skin and Geometry Model Instances**

Display options:

- **Cross platform: OpenGL (Win32, SGI, Linux)**
- **Textured, wire frame, shaded (averaged texture)**

Java-based Graphical User Interface

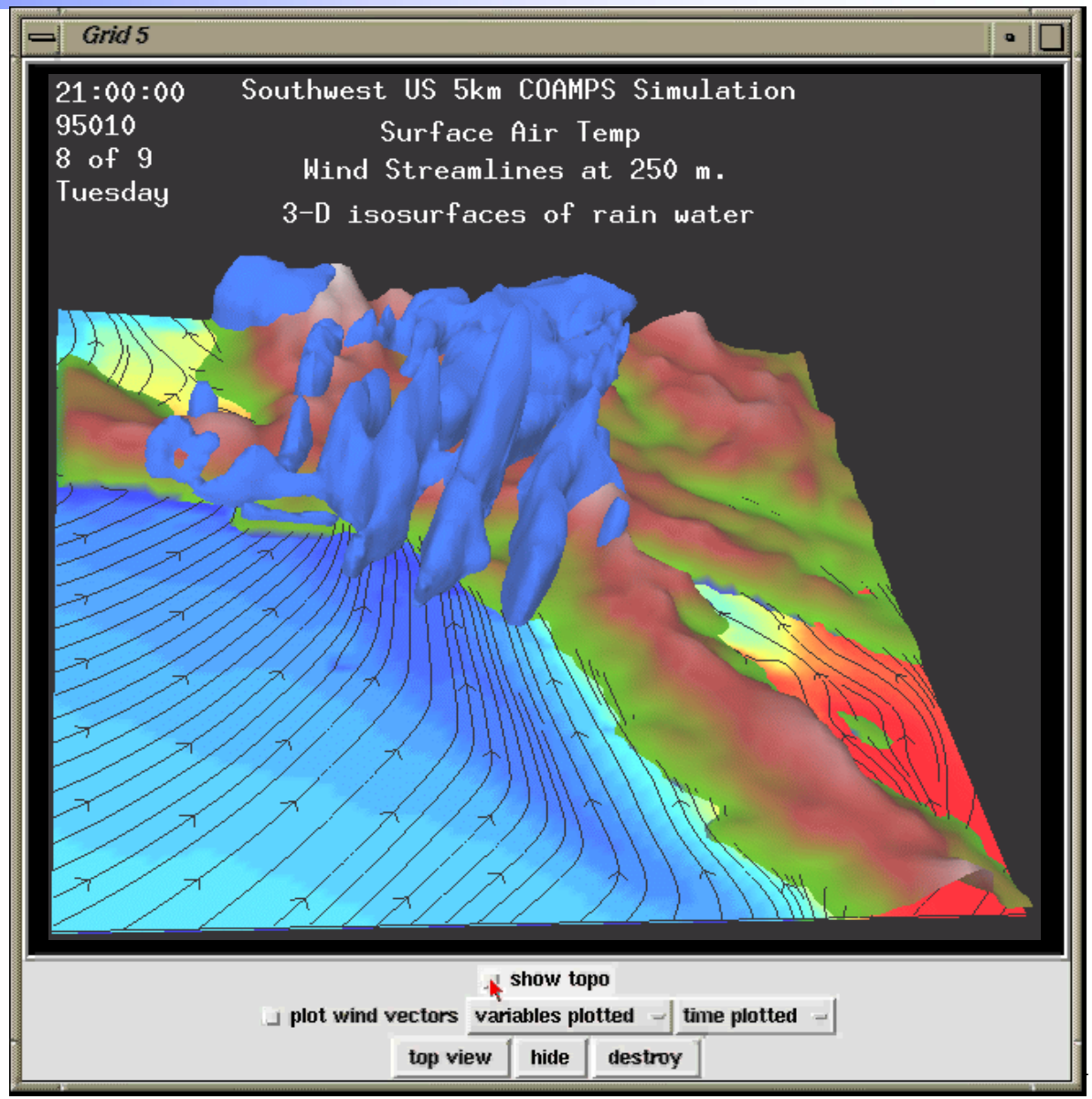
Display Components



Integrated Plan View Display (PVD)
Shows position and orientation with respect to SEDRIS Spatial Domain

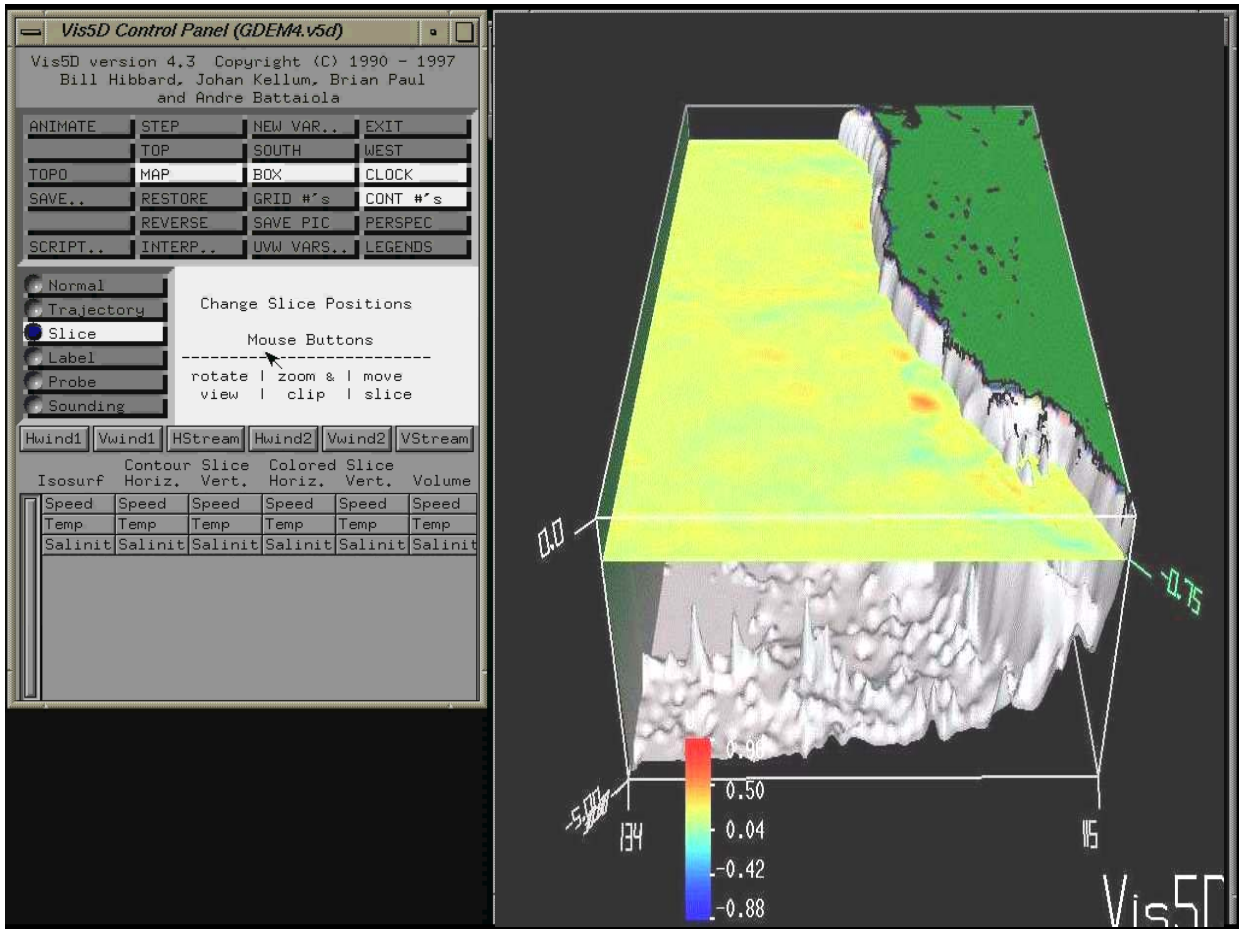
Wind Map

SEDRIS Transmittal Format can carry the content of various meteorological databases. The wind map program reads multiple data from a SEDRIS transmittal, via the SEDRIS API, for display using a graphics viewer.

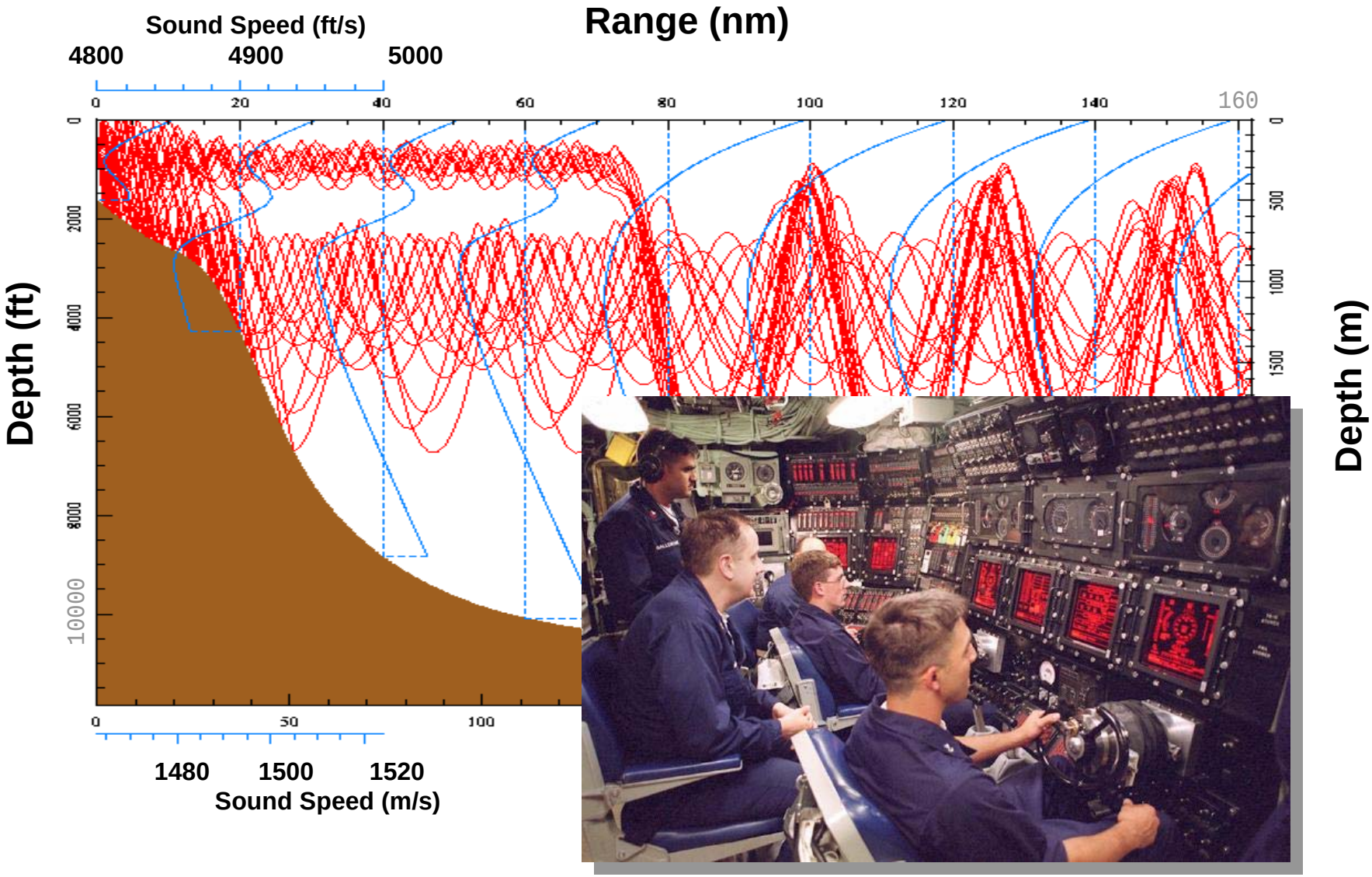


Ocean Profile viewer

The SEDRIS API can be used to extract data from a transmittal to drive applications. The user selects a rectangular ocean surface area from the transmittal. The application uses the API to extract bathymetry, sound speed, temperature, and salinity in the selected ocean volume for visualization.



Acoustic Ray Trace viewer



Conclusion

Solving Environmental Data Challenges

- Representation of location for the various coordinate systems (spatial reference frames), local or global, that will be “natural” for individual systems or sub-systems
- Accurate, efficient, and fast conversion of location data between different spatial reference frames
- Comprehensive dictionary of terms that not only deals with terrain data, but also atmosphere, ocean, littoral, and space data. And is also extensible in a predictable and supported manner
- A representation schema that can handle any resolution, type, organization, and extent of environmental data through a uniform approach for all domains of the environment

- The SRM is designed for this
- The SRM implementation does this
- The EDCS is designed for this
- The DRM is designed for this

Solving Environmental Data Challenges

- **A mechanism to access and interact with any data sets or data collectors through a robust software interface**
- **Capture and communicate the resulting data in a persistent, efficient, and platform independent format designed to handle large and distributed data sets**
- **Tools to manipulate, evaluate, visualize, or analyze the data**
- **Automatically evaluate and validate data sets against stated requirements**

- **The API implementations do this**
- **The STF is designed for this**
- **Use the array of powerful tools and utilities**
- **Use the Transmittal Content Requirements Specification (TCRS)**

Summary - SEDRIS:

- Is an infrastructure technology with proven components
  - Complete and powerful language for environmental representation (DRM, EDCS, SRM)
  - Mechanism to communicate and evaluate environmental data (API, STF)
  - Tools - practical applications, converters, and utilities
  - TCRS - emerging technologies to specify and evaluate content and interface-level requirements
- Consists of eight international standards (ISO/IEC)
- Is used worldwide in information technology applications by a wide range of organizations and projects
- Provides the concepts to represent all environmental domains (terrain, ocean, atmosphere, and space) in an integrated manner, to include urban and littoral areas
- Provides users with the capability to correlate and integrate data from multiple sources
- Reduces cost and promotes environmental database reuse

More information

- **Open source software SDK releases, videos of tutorials, papers**
- **SEDRIS technology components (EDCS, SRM, DRM, API)**
- **Proceedings from past conferences**

  Available at http://www.sedris.org
- **Free tools & utilities, and pointers to commercial tools**

  Available at http://tools.sedris.org
- **Data samples**

  Available at http://data.sedris.org
- **Questions**

  Can be sent to help@sedris.org
- **ISO/IEC standards activities**

  Information at http://wg8.sedris.org