



SEDRIIS 101

An Introduction to SEDRIIS Fundamentals

<http://www.sedris.org>

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SEDRI 101

An Introduction to SEDRI Fundamentals

SEDRI is a suite of technologies, standards, implementations, and tools that provide an integrated approach to the representation and interchange of environmental data.

This tutorial highlights the role and importance of standards in the representation, interchange, and reuse of environmental data, and gives an overview of the fundamental concepts and components of SEDRI. The presentation will touch on how the SEDRI technology components are used in various applications and in the interchange of environmental data, and will provide an overview of the SEDRI ISO/IEC standards and their corresponding on-line registries. A brief overview of several key SEDRI-based tools and utilities will also be included.

Prerequisites: Familiarity with environmental data and concepts, and a fundamental understanding of how models and simulations use and process environmental data.



Background: The DoD Net-Centric Strategy

- It is DoD policy for all DoD Components that all efforts to improve information-sharing capabilities will comply with the Net-Centric Data Strategy, the GIG Architecture, and the Net-Centric Operations and Warfare Reference Model.
- The DoD net-centric data strategy describes 7 major data goals as:
 - **Visible** - Discover data through catalogs, registries, ...
 - **Accessible** - Post data to “shared space.” ... stored [so] users can access it.
 - **Institutionalize** - Data approaches incorporated into [] processes & practices.
 - **Understandable** - Users can comprehend ... structurally and semantically ...
 - **Trusted** - Users can determine and assess the authority of the source ...
 - **Interoperable** - Many-to-many exchanges of data occur between systems ...
 - **Responsive to User Needs** - Perspectives of users ... incorporated into data approaches



Background: How SEDRIS relates to the DoD Net-Centric Strategy

- Uniform and integrated representation and interchange of environmental data
- Designed to enable data interchange & interoperability
- Addresses the net-centric goals (for environmental data) by providing:
 - **Visible** - *Use of registries to extend the data semantic.*
 - **Accessible** - *Standard format, interfaces, and tools for accessing the data.*
 - **Institutionalize** - *Standard practice in a number of programs/organizations.*
 - **Understandable** - *Standard structure and semantic for data representation.*
 - **Trusted** - *Provisions for identifying data sources and attributes.*
 - **Interoperable** - *Complete data representation and interchange for users/systems.*
 - **Responsive to User Needs** - *Integration of common approaches, and the necessary processes for extensions and improvements.*

 Directly addresses

 Is an enabler

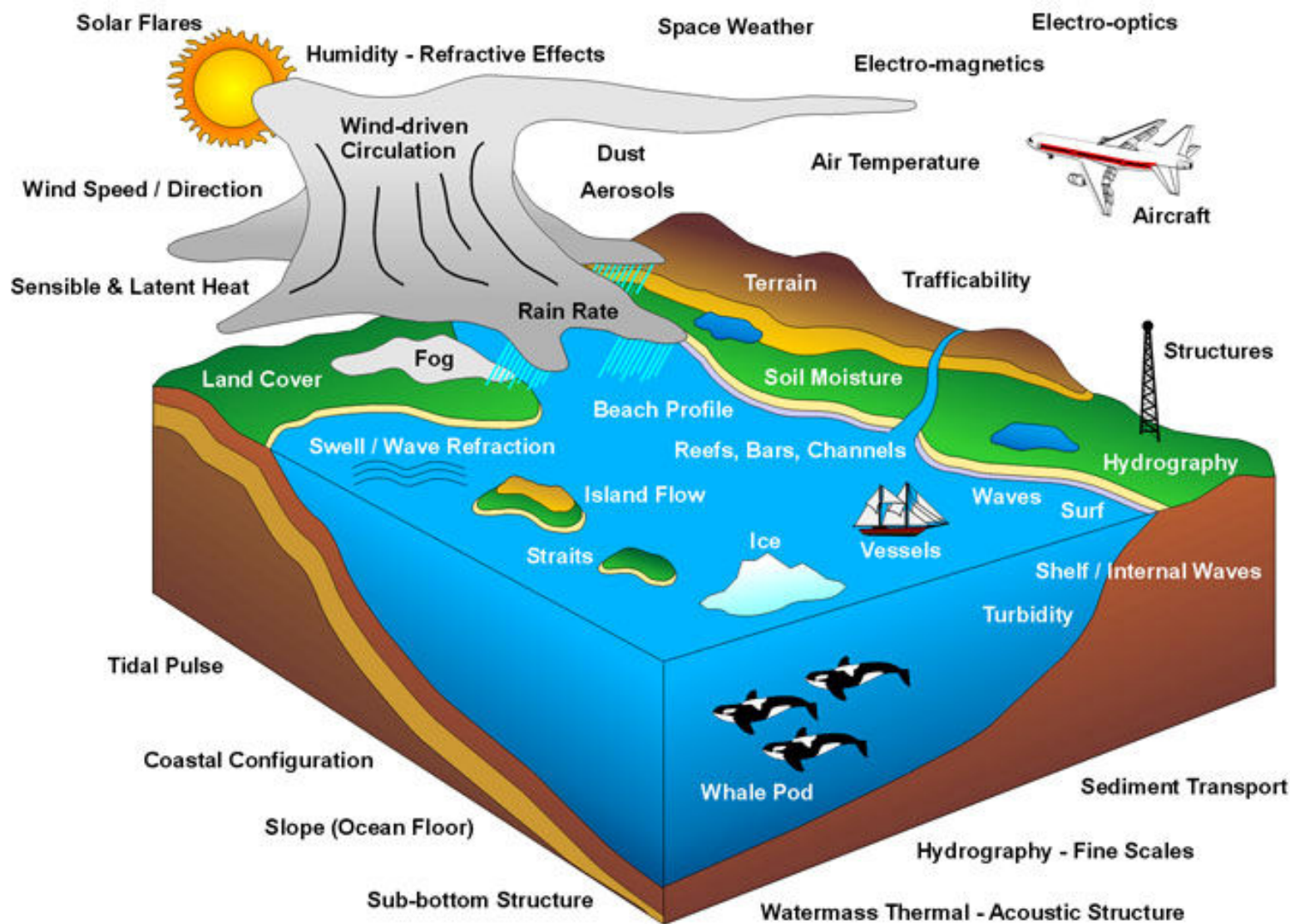


Current Environmental Data Challenges

- **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**
- **Creation, update, and tailoring for reuse of environmental data are resource-intensive and expensive (and have high recurring costs)**
- **Many systems, missions, and applications require the integration of data**
 - **from many sources**
 - **that cross domain boundaries**
- **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**



All Environmental Data



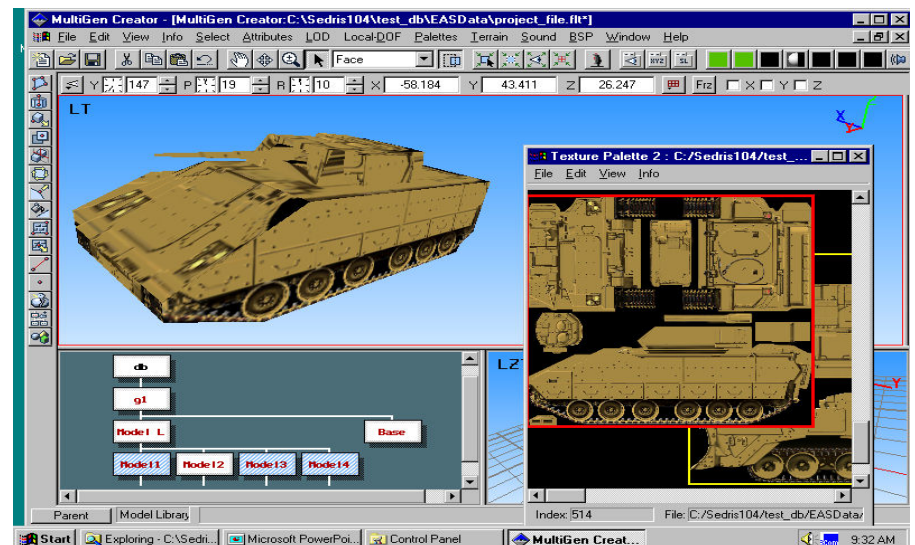
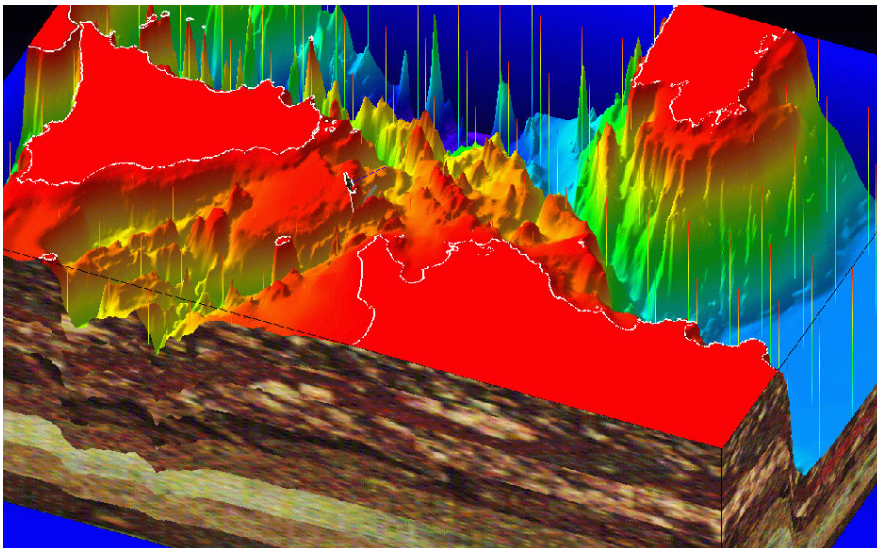


The SEDRI Solution

- SEDRI 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**
- SEDRI supports both **legacy and new** environmental data applications
- SEDRI technology use decreases both initial (development) and recurring (maintenance and update) costs. Value maximized when using **joint and networked** applications.
- SEDRI tools **improve validation quality and decrease validation time**. Without these tools, it is difficult to validate environmental data and find errors.



Interoperability: Environmental Data Used for Different Applications & Purposes





Factors to Include in Addressing the Common Environmental Model

- **Need a common set of environmental technologies for applications (Systems Approach not a single application view) with an open architecture**
- **Four (4) functions for database development and transmission**
 - **Every application needs the data to be**
 - **Uniquely labeled and defined**
 - **Geo-located**
 - **Arranged/structured**
 - **Moveable (common format)**
- **Systems Engineering**
 - **Best systems engineering has the concept separated from structure to allow for ease of maintainability (can add concepts without need for changing structure of database)**
- **DoD guidance**
 - **DoD IT Management plan lists hierarchy (International (ISO), Regional (NATO STANAGS), National (ANSI), Consortia (SISO), Military (DISR, DSP), and de facto (MS WORD))**

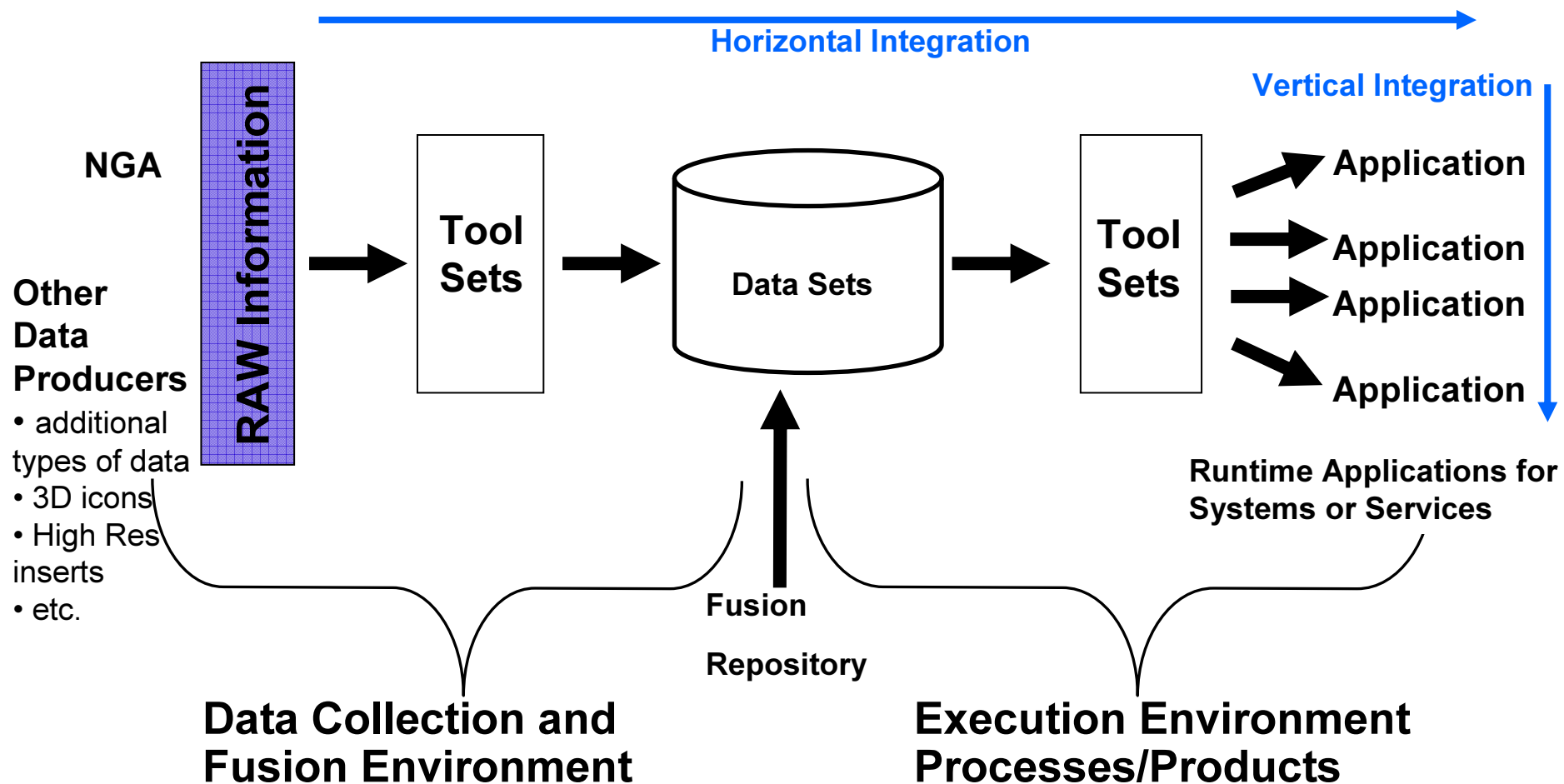


Factors to Include in Addressing the Common Environmental Model

- **SEDRI meets the “standards” listed on previous slide**
 - It provides a standard labeling system (EDCS)
 - It provides a standard geo-location system (SRM)
 - It provides a standard methodology to separate concepts from structure (DRM)
 - It provides a standard transmittal format (STF)
- **SEDRI meets the intent and letter of the DoD IT Management Plan**
 - International: SEDRI technologies are ISO standards (ISO/IEC 180xx series)
 - Regional: SEDRI technologies are NATO STANAGS (4662-4664)
 - National: As ISO standards, ANSI adopts as ANSI standards
 - Consortia: As ISO standards SISO has adopted as standards
 - Military: SEDRI standards are found in the DISR and DSP
- **SEDRI is the only known technology in the M&S community that meets the four (4) functions for database development and transmission and is an approved standard at multi-levels from International down through Military.**

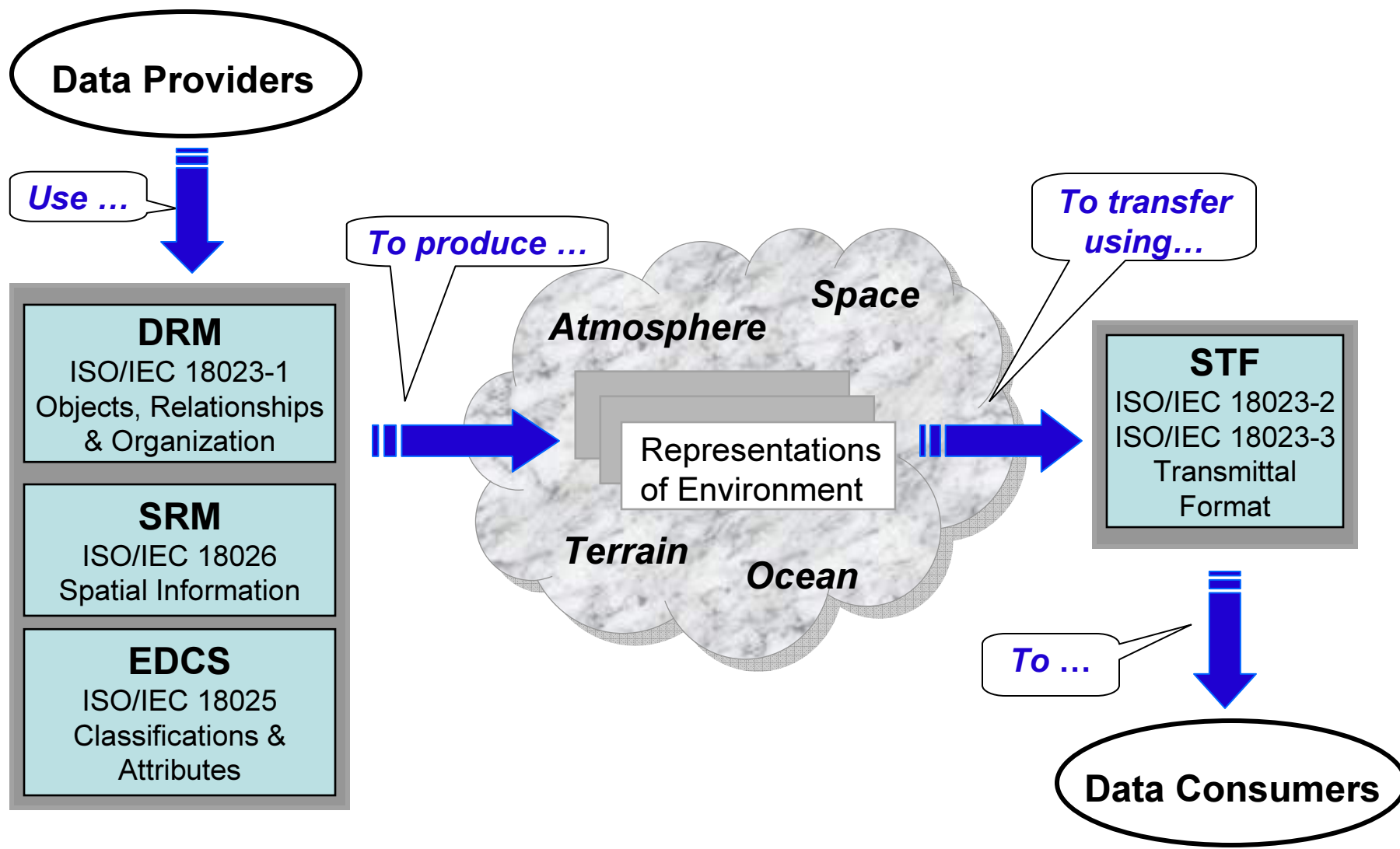


Army Guidance – from the Army (G3) Geospatial Data Integration Master Plan (AGDIMP)





How SEDRIS is used - Conceptual





Examples of Integrated Data

- Integrated environment
 - Weather effects
 - Clouds, wind, smoke
 - Moving objects
 - Terrain features
 - Lighting conditions
 - Textures
 - 3-D structures
 - Dynamic time-varying effects
 - Autonomous navigation
 - Line of sight calculations
 - Material attributes





Examples of Integrated Data- urban/interior

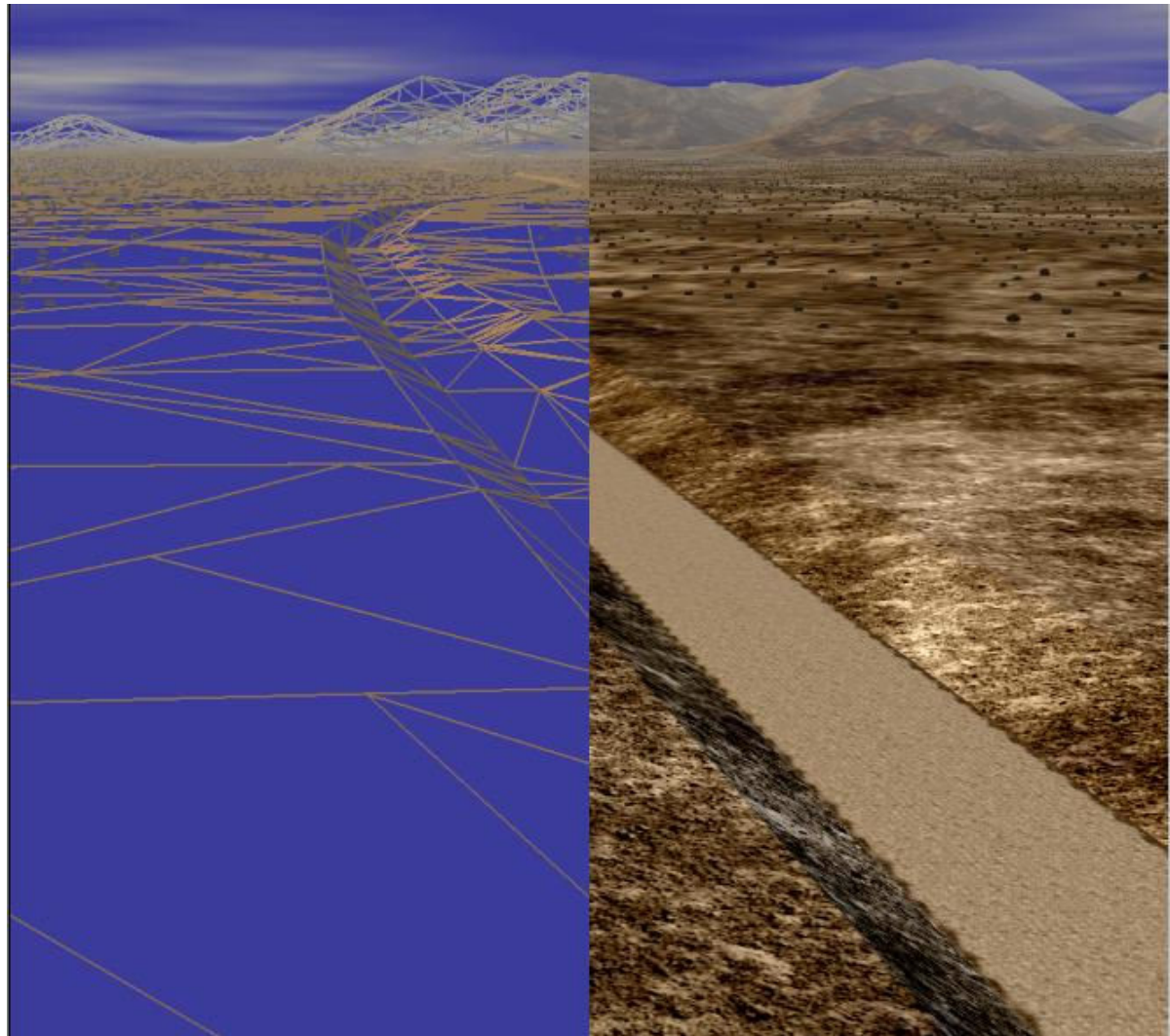
- Integrated environment
- Urban applications
 - Building interiors
 - Lighting effects
 - Material attributes
 - Multi-level structures
 - Textures and imagery
 - Sound & light reflection
 - Dynamic effects





Examples of Integrated Data - inspection

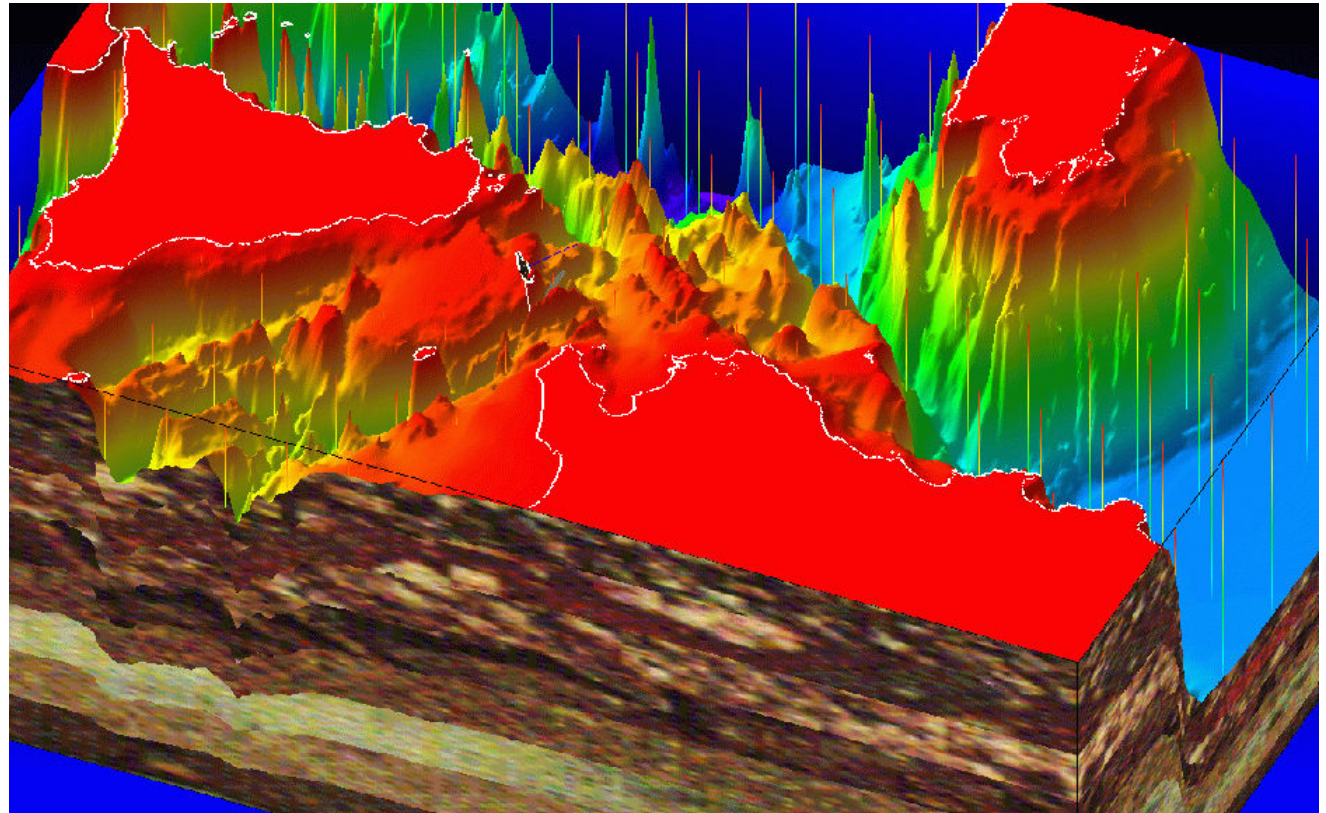
- Data content analysis
 - Data comparison
 - Terrain surface representations
 - Imagery
 - Features
 - Surface attributions
 - Sensory impacts





Examples of Integrated Data - undersea

- Integrated environment
 - Bathymetry
 - Ocean volume
 - Salinity
 - Temperature
 - Pressure
 - 4-D grid data
 - Ocean features
 - Littoral features
 - Tide effects





Examples of Integrated Data - urban

- Integrated environment
- Driving applications
 - Signage
 - Collision detection
 - Cultural data
 - Weather effects
 - Surface attributions
 - Autonomous vehicle navigation





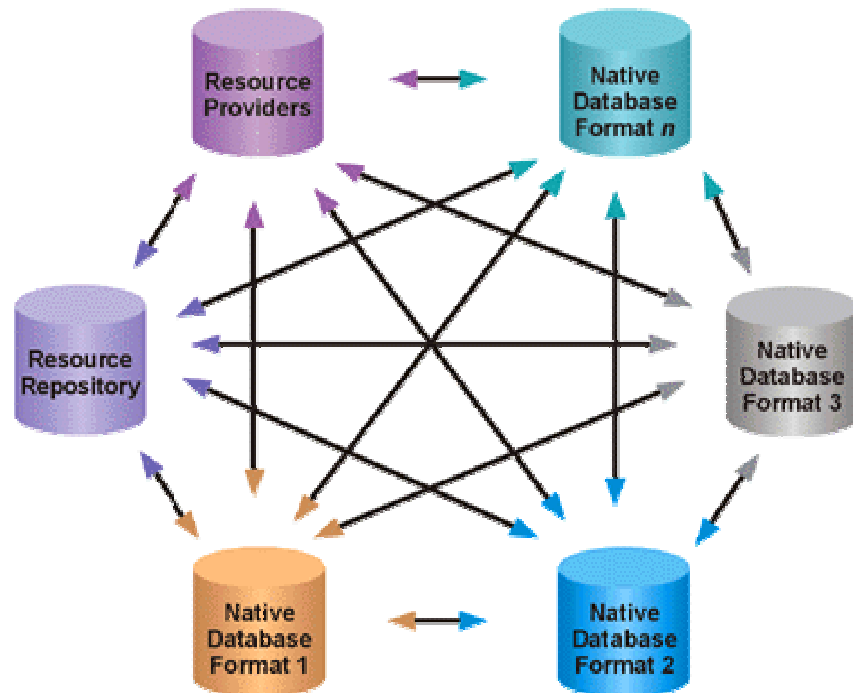
Examples of Integrated Data - weather effects

- Integrated environment
 - Weather, local fog
 - Material attributes
 - Lighting effects
 - Local illumination

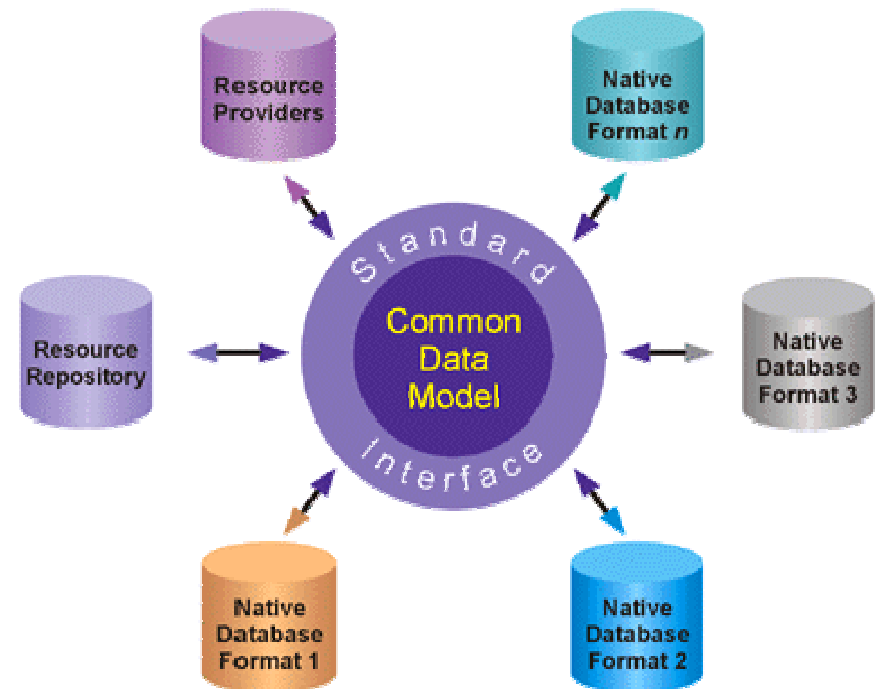




Data Sharing Using a Standards-based Middleware Approach



- 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



SEDRI Is...

- A set of international **standards** 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



What Does SEDRI 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



SEDRI 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**



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**



SEDRI Technology Components

Data Representation Model (DRM)

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

Gives the constructs to express and "shape" environmental data

Spatial Reference Model (SRM)

Makes the environmental description readable in other coordinates

Application Program Interface (API)

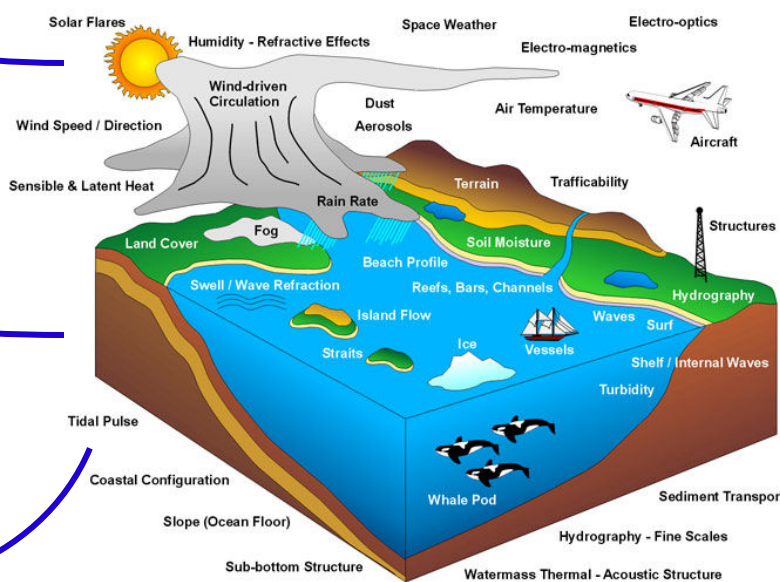
Provides software access to individual elements of environmental data

Environmental Data Coding Specification (EDCS)

Names and identifies types of objects in an environmental description

SEDRI Transmittal Format (STF)

Transfers complete "chunks" of environmental data



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



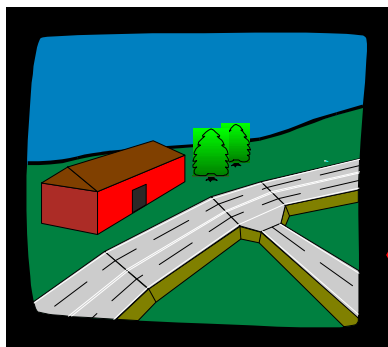
Same Object - Differing Views

- **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**
- **SEDRI is designed to support multiple independent or integrated views**

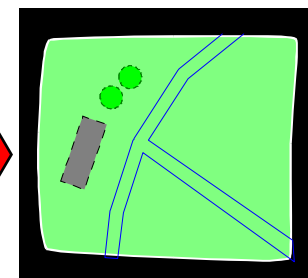


Different Representations of the Same Environment

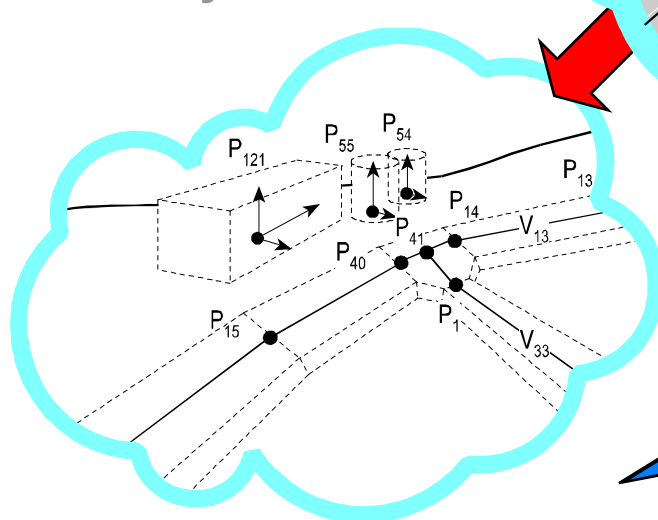
Visual Database



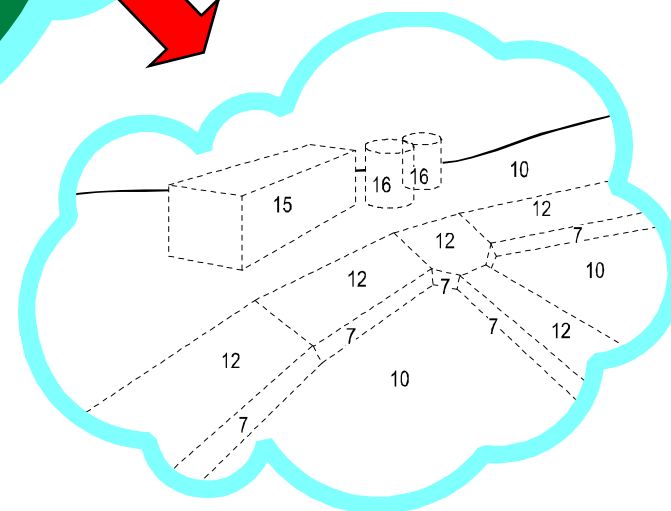
Electronic Maps



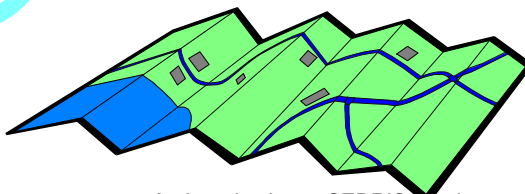
Mobility Database



CGF Database



Paper Maps





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



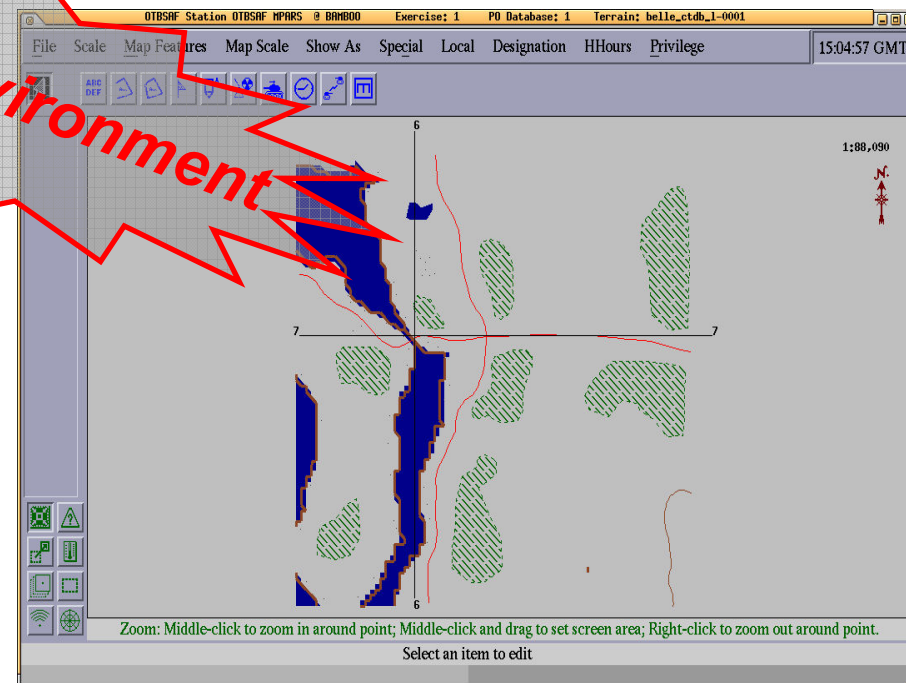
From DMs of the Environment ... to a DRM for the Environment



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

- **SEDRE 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





SEDRI Family of ISO / IEC Standards

Eight International Standards first published in 2005-2006:

Environmental Data Coding Specification (EDCS)* - ISO/IEC 18025:2005
EDCS C Language Binding - ISO/IEC 18041-4:2008

SEDRI Functional Specification (DRM and API)* - ISO/IEC 18023-1:2006
SEDRI Abstract Transmittal Format - ISO/IEC 18023-2:2006
STF Binary Encoding* - ISO/IEC 18023-3:2006
SEDRI C Language Binding* - ISO/IEC 18024-4:2006

Spatial Reference Model (SRM)* - ISO/IEC 18026:2009
SRM C Language Binding - ISO/IEC 18042-4:2011

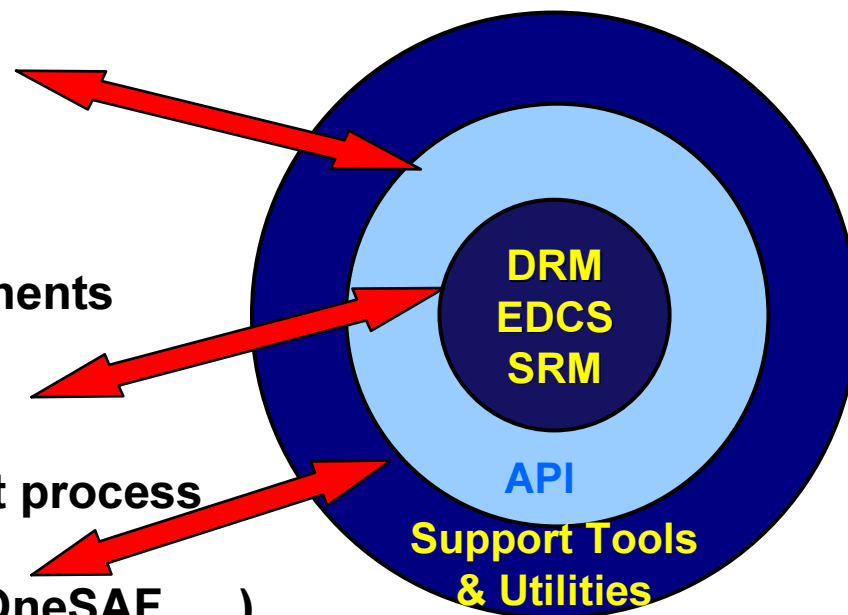
The EDCS, DRM, and SRM standards are supported by three online registries: <http://www.iso.org/jtc1/sc24/register>

** New edition or an amendment to the standard is in process*



A Team-based Open Development Approach

- **SEDRE 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
- Programs using the technology (e.g. TENA, FCS, SE-CORE, CATT, OneSAF, ...)
- 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



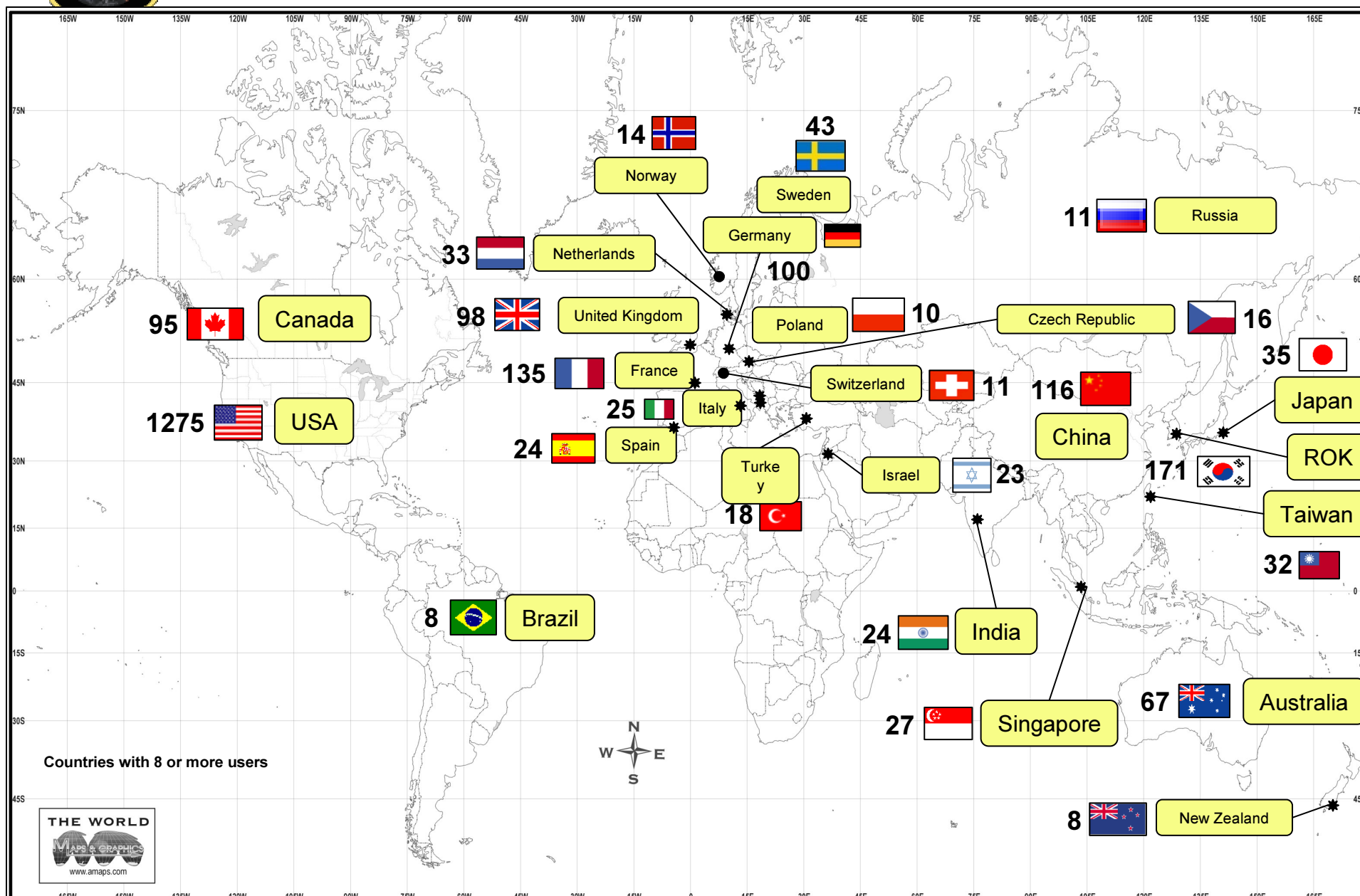


International Participation

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



Registered Users (2002-2010)







Sample of SEDRI Web Site Statistics

<http://www.sedris.org/>

Month	Daily Average		Monthly Totals	
	Visits	Pages	Visits	Pages
July 2010	1,227	12,235	38,052	379,289
June 2010	1,361	10,237	40,852	307,134
May 2010	1,804	11,290	46,906	293,549



SEDRI in Use - Recent significant activities

- ❑ Since 2006, the FCS program (BCTM) has **invested and contributed an estimated \$400K in updating the SEDRI tools and implementations** to support the changes they have required. The updated tools have been provided back to the SEDRI baseline and are available for all users. This investment does not include their internal expenditures in using the SEDRI technologies in their data modeling and database development efforts.
- ❑ The EDCS Registry has been very active since its inception in 2005. Since then, more than 1470 items have been proposed for registration. A significant subset of these proposed additions have been received from the following projects:
 - ❑ OneSAF
 - ❑ SE-CORE
 - ❑ FCS (BCTM)
 - ❑ Institute for Creative Technologies (ICT)



SEDRI in Use - Past and present

- ❑ U.S. Army Combined Arms Tactical Trainer: using SEDRI has **saved at least \$25M** due to streamlined database generation (**avoided dependence on proprietary formats for re-compete of CCTT image generator system**)
- ❑ U.S. Army WARSIM (in 1999): **saved over \$500K** for IOC GOTS tools development and **over \$350K** for coordinate conversion services
- ❑ To date, WARSIM, CCTT, and OneSAF, which all use the same SEDRI Spatial Reference Model coordinate conversion and transformation package, have **saved an estimated \$2.4 to \$7.2M** in development cost
- ❑ U.S. DoD Test and Training Enabling Architecture (TENA): has **saved \$3.5M** by using the SEDRI Spatial Reference Model for **all coordinate and orientation transformations**. This is taking into account more than \$100K of TENA funds that supported the development of SRM Orientation capabilities
- ❑ U.S. Navy Tactical Environmental Data Services (TEDServices): “**significant development cost savings**” and “**anxious for JAVA implementation of SRM**”
- ❑ Joint Strike Fighter: used SEDRI to **integrate Government and proprietary formats** for open systems use
- ❑ Virtual Cities: **SEDRI facilitated security planning** for Salt Lake City Olympics



Examples - SEDRIS in Use - past & present

- 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: 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** in ballot
- 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

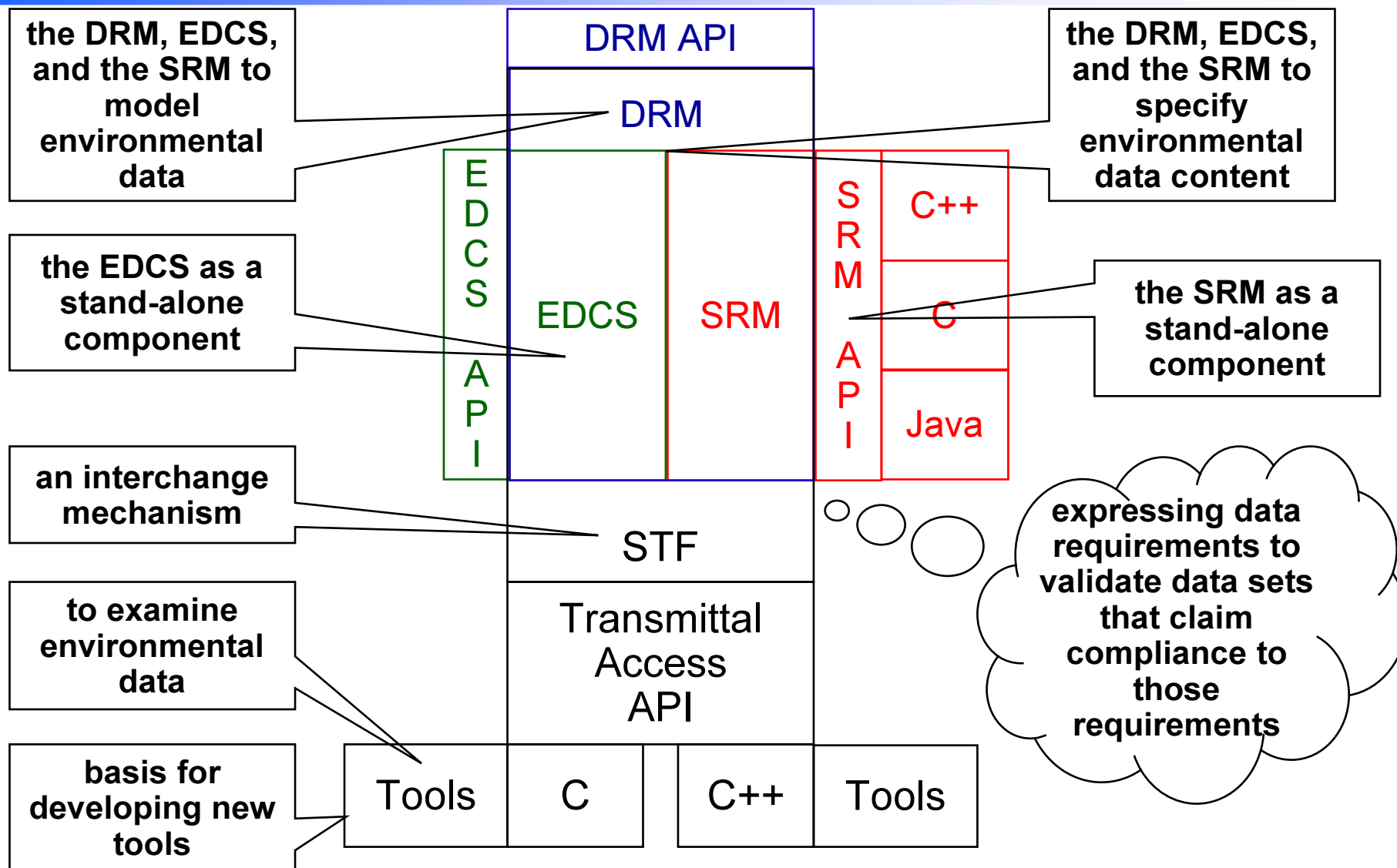


Continuing Goals

- **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)**



Using the SEDRIS Components





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**



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)**



Related Standards, Efforts, & Projects

- **ISO TC211 191xx series of standards**
 - Mainly traditional GIS/2D terrain standards; Define many higher level (more abstract) methodology/process; Complementary to SEDRIS
- **OpenFlight - File Format for exchange of visual system data**
 - Widely used with loaders/converters for visual systems; Supports several reference frames; Mainly graphics systems (no SAF, weather, or features representation); No explicit data model or dictionary
- **Common Database (CDB) - Visual database generation process**
 - Process for generation of common visual system runtime databases (with some support for SAF); Relies on multiple file formats; Complementary to SEDRIS; Uses concepts from SEDRIS; Implied data model
- **Navy Portable Source Initiative (PSI) - VisSim DB generation support**
 - Provides support for sharing of visual/sensor simulation databases; Uses several industry de-facto file format standards; Complementary to SEDRIS; No explicit data model or dictionary
- **SE-CORE - Army simulation database generation project and process**
 - Supports visual and SAF systems; Uses an internal unified model; Support for runtime formats; Uses SEDRIS standards (EDCS, SRM, and other concepts); Complementary to SEDRIS; Can output multiple formats, including STF



Resources - Where to find the standards and registries

- **All SEDRIS standards can be found online at:**
<http://standards.sedris.org>
 - ISO/IEC 18023-1:2006(E), SEDRIS -- Part 1: Functional specification
 - ISO/IEC 18025:2005(E), Environmental Data Coding Specification (EDCS)
 - ISO/IEC 18026:2009(E), Spatial Reference Model (SRM)
- **All ISO/IEC JTC 1/SC 24 registries can be accessed at:**
<http://www.iso.org/jtc1/sc24/register>
- **There are many registries hosted at this site that correspond to other (non-SEDRIS) standards**



Registerable Items for SEDRIS Standards

- **ISO/IEC 18023, SEDRIS - Part 1**
 - The following DRM data types may be registered:
 - Selection item data type selectors, and
 - Set data type members

- **ISO/IEC 18025 - EDCS**
 - New concepts for any of the following EDCS dictionaries may be registered:
 - Classification (EC)
 - Attribute (EA)
 - Attribute enumerant (EE)
 - Attribute value characteristic (EV)
 - Unit (EU)
 - Unit equivalence class (EQ)
 - Organizational schema (EO)
 - Group (EG)
 - Profiles



Registerable Items for SEDRIS Standards (cont')

- **ISO/IEC 18026 - SRM**
 - **New instances of the following SRM concepts may be registered:**
 - Abstract coordinate systems
 - Temporal coordinate systems
 - Reference datums
 - Object reference model templates
 - Object reference models
 - Reference transformations
 - Object binding rule sets
 - Spatial reference frame templates
 - Spatial reference frames
 - Spatial reference frame sets and their members
 - Designated spatial surfaces
 - **Profiles**



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



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
 - STF and SDK validation utilities
 - Syntax Checker
 - Depth
 - Rules Checker
 - Focus (STF browser and manipulation)
 - Model Viewer
 - XTCRS Checker (data content requirement validation)
 - VPF to STF converter
 - Shape to STF converter
 - STF to Shape converter
 - Grids (gridded raster) to STF converter
 - GRIB to STF converter
 - CTDB to STF converter
 - STF to CTDB converter
 - STF to DTED converter
 - GeoTIFF to STF converter
 - STF (previous version) to STF (current version) converter
 - SEE-IT
 - Side-by-Side (a CAE (formerly AcuSoft Inc.) product)



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

- Software Development Kits (SDK) releases, Tutorial videos, Papers
- SEDRIS technology components -- EDCS, SRM, DRM, APIs
- Proceedings from past SEDRIS Technology 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>

<http://standards.sedris.org>

Technology Components Overview

Spatial Reference Model (SRM)



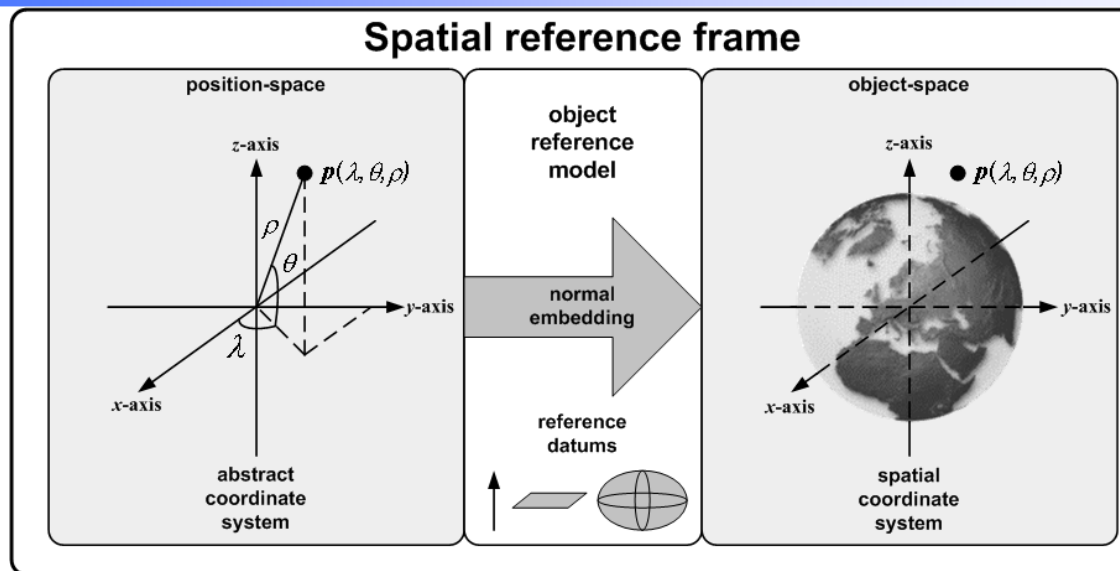
SRM Requirements

- **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).

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



SRM Conceptual Relationships



- **Object independent aspect:**
 - An abstract coordinate system (CS) is based on the underlying Euclidean structure of position-space.
- **Object empirical measurement/model dependent aspect:**
 - The reference datums bound to an object determine how position-space relates to object-space.
 - The relationship may be mathematically expressed by a normal embedding.
 - The relationship is specified as an object reference model (ORM).
- **Combined as a spatial reference frame (SRF)**
 - An SRF combines an abstract CS with an ORM to specify a spatial coordinate system.



Spatial Reference Frame

- A ***spatial reference frame*** specifies a spatial coordinate system by combining an abstract coordinate system with an object reference model.
- An abstract coordinate system may be combined with many different object reference models. Thus, a geodetic coordinate tied to the Earth object reference model **WGS_1984** does not identify the same place as when tied to the Earth object reference model **EUROPEAN_1950**, or when tied to an object reference model for Mars.
- A spatial reference frame specification includes:
 - ***Object Reference Model (ORM)*** -- A geometric description (model) of a reference object embedded in (and serving to orient) that frame. An Earth Reference Model (ERM) is a special case of an ORM.
 - A ***Abstract 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.
 - (optionally) a valid region description or specification to limit the region of applicability.

$$SRF = ORM + CS$$



Spatial Reference Frame Templates (SRFT)

An SRF template is an abstraction of a collection of spatial reference frames that share the same abstract coordinate system, coordinate system parameter binding rules, and similar ORM types that model the same spatial object type.

CS type	ORM Type		SRFT names	
3D	3D ORM		Celestiocentric	Local space rectangular 3D
			Lococentric Euclidean 3D	
	Oblate ellipsoid ORM		Celestiodetic	Planetodetic
			Local tangent space Euclidean	
Surface and 3D (augmented map projection)	Special binding rules	Planet	Solar ecliptic	Solar equatorial
			Solar magnetic	Solar magnetic ecliptic
		Sun	Heliospheric Aries ecliptic	
			Heliospheric Earth ecliptic	
2D			Heliospheric Earth equatorial	
	Oblate ellipsoid ORM		Mercator	Oblique Mercator spherical
			Transverse Mercator	Lambert conformal conic
			Polar stereographic	Equidistant cylindrical
	2D ORM		Local space rectangular	
			2D Local space azimuthal	
			Local space polar	



SRM registerable concepts

- **Abstract coordinate systems**
- **Temporal coordinate systems**
- **Reference datums**
- **Object reference models**
 - object reference model templates
 - reference transformations
 - object binding rule sets
- **Spatial reference frames**
 - spatial reference frame templates
 - spatial reference frame sets and their members
- **Designated spatial surfaces**
 - Vertical offset surfaces
- **SRM profiles**



SEDRI Spatial Reference Frames

**SEDRI
Supports
a Large
Number
of 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	

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



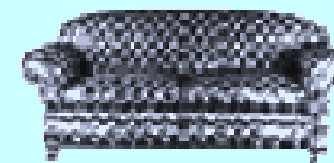
EDCS Overview

- Adds value by:
 - Reducing ambiguity by factoring out concepts into separate dictionaries
 - Providing a unified cover of the complete environment, including urban, terrain, ocean, atmosphere and space
- Has 9 dictionaries populated with over 11,000 entries
- Each entry references existing dictionaries, catalogues, or external sources, where used
- Provides support for an integrated view of environment, such as:
 - Atmospheric column
 - Subsurface-terrestrial
 - Water column
 - Space
 - Three-dimensional objects
- Has an API that allows the EDCS dictionaries to be accessed
- Supported by a registry that allows new entries to be submitted

Vehicles (and Life forms)



Furniture, Openings, Equipment



Rooms / Compositions





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



Required Content for EDCS Concepts Registration

Required Information	EDCS CONCEPT							
	Classification	Attribute	Enumeration	Characteristic Value	Unit	Unit Equivalence	Organization	Group
Label	X	X	X	X	X	X	X	X
Definition	X	X	X	X	X	X	X	X
Attribute Value Type		X						
Symbol					X			
EA Label			X					X
EC Labels								X
EQ Label					X			
EO Label	X	X						X
EG Labels	X	X					X	
EU Labels						X		
Reference Type	X	X	X	X	X		X	X
Reference	X	X	X	X	X		X	X
Supplemental Reference(s)	X	X	X	X	X		X	X
Applicability				X				
Justification	X	X	X	X	X	X	X	X
Comments	X	X	X	X	X	X	X	X



Related Standards

- **ISO TC211 19110**
 - Defines a methodology for creating geographic object, attribute and relationship catalogues; an abstract (higher-level) standard; ISO/IEC 18025 is complementary to, and used many of the methodologies of ISO 19110
- **Feature Attribute Coding Catalog (FACC)**
 - A catalog and coding scheme for geographic (GIS) features and attributes; Developed by Defence Geospatial Information Working Group (DGIWG); Many digital feature and/or map products use FACC; As applied to M&S, shortcomings in FACC gave birth to EDCS; FACC only supported GIS/terrain features, difficult to extend, mixed concepts (such as multiple concepts or units in one item); Retired a few years ago
- **DGIWG Feature Data Dictionary (DFDD)**
 - Replaces for FACC; Supports mainly GIS/terrain features; Extensible through registration; Contains many entries and concepts from EDCS; Some digital data products based on DFDD (more is anticipated)
- **NSG Feature Data Dictionary (NFDD)**
 - The US NGA profile of DFDD (NFDD is unique to US); Uses a subset of DFDD and extends with other concepts; Contains product support constructs (including a mix of data model; not just a dictionary); Data production based on NFDD anticipated
- **Joint METOC Broker Language (JMBL, related to Joint METOC Conceptual Data Model (JMCDM))**
 - Designed for negotiating and exchange of meteorological and oceanographic (METOC) data and constructs; Supports observation, derived, and climatological data

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**

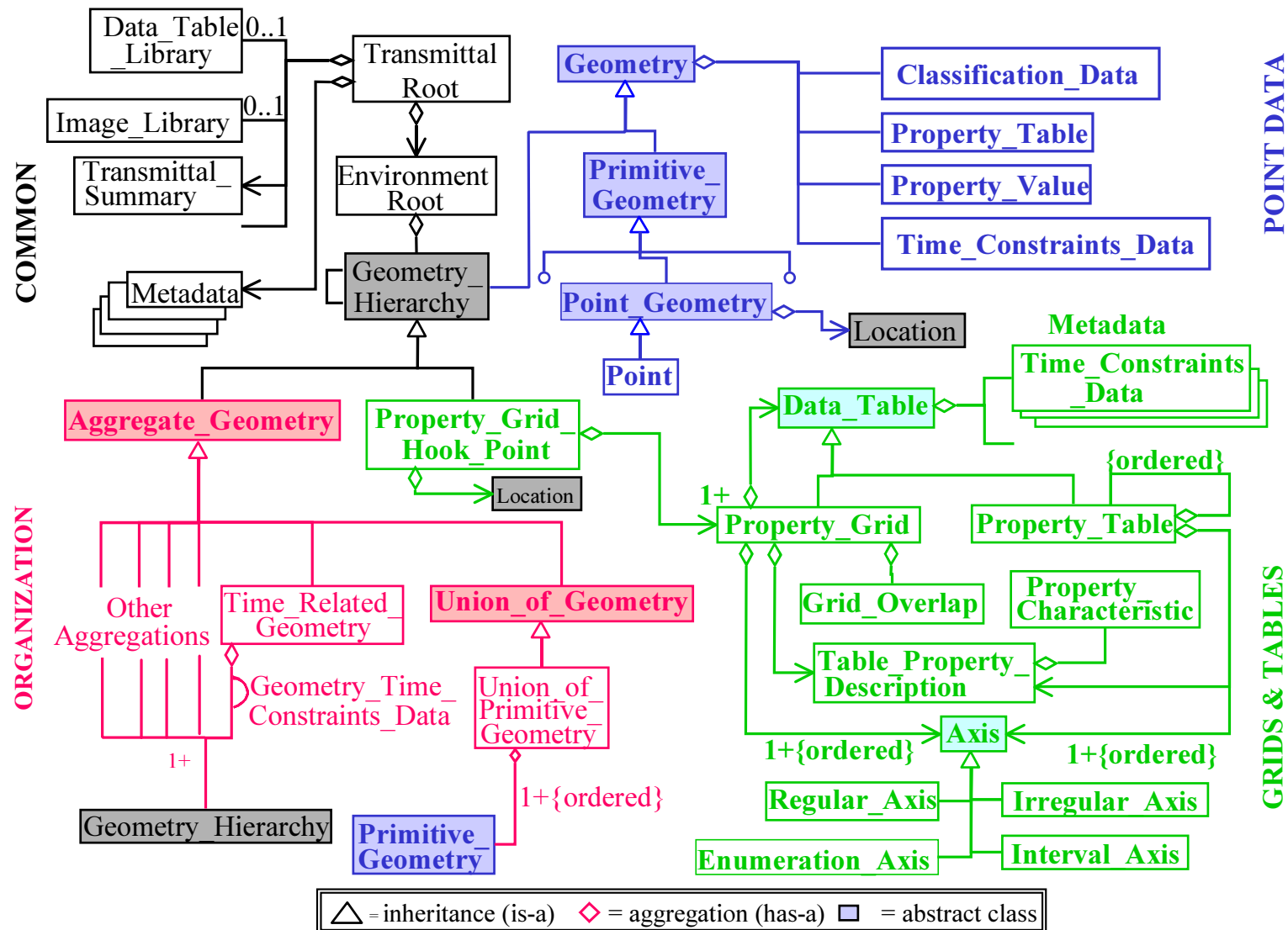


DRM Basics

- 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.



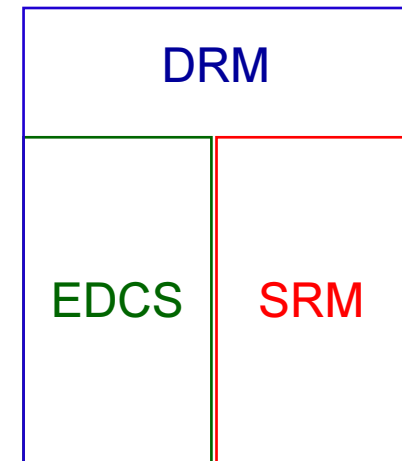
An Overview of a Subset of the SEDRIS DRM





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)



SEDRI Transmittal Format (STF)

- *A file format developed to store SEDRI 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 SEDRI 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



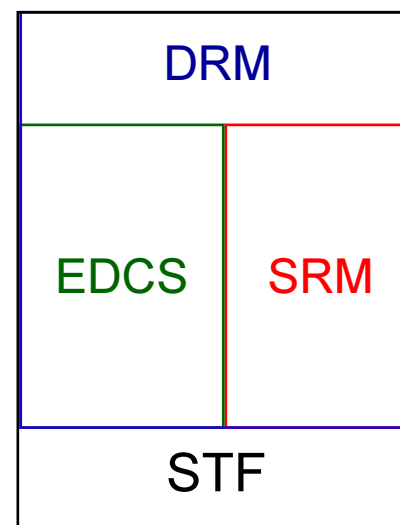
STF Design Features

- ***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)



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.



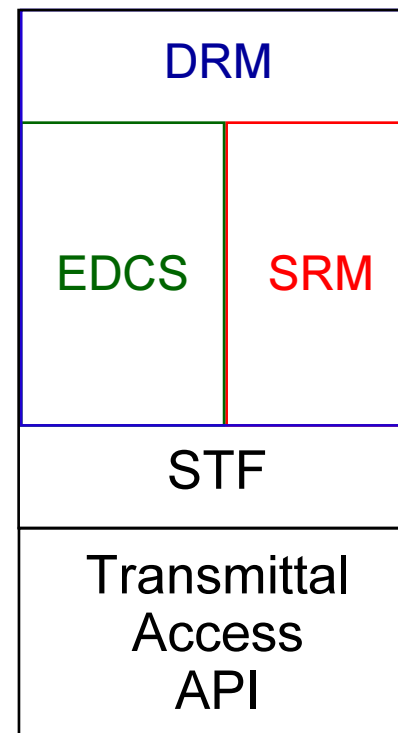
The APIs

- **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”**



Transmittal Access API Summary

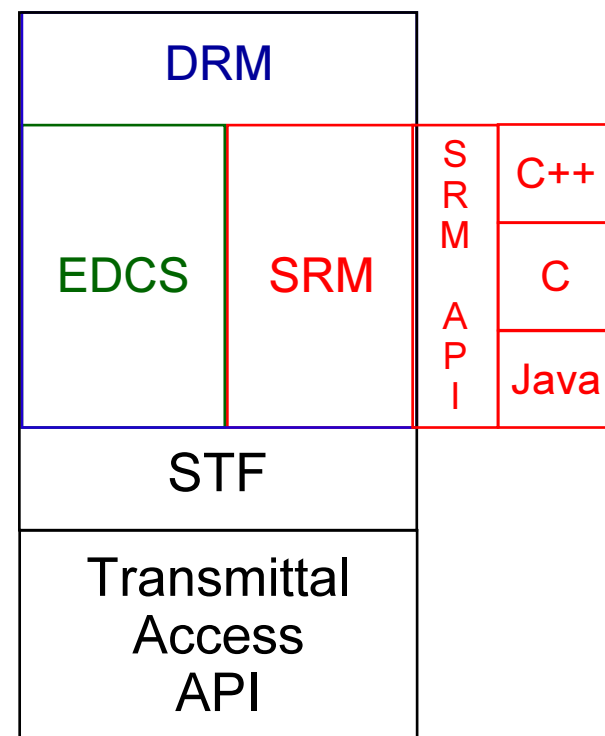
- **A handful of concepts**
 - Transmittal
 - Objects
 - Object Ids
 - Traversal
 - Iterators
- **Provides all functionality necessary to retrieve the data in a transmittal**
- **Provides all functionality necessary to create a transmittal as well as modify it**
- **Provides helper functions such as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





The SRM API

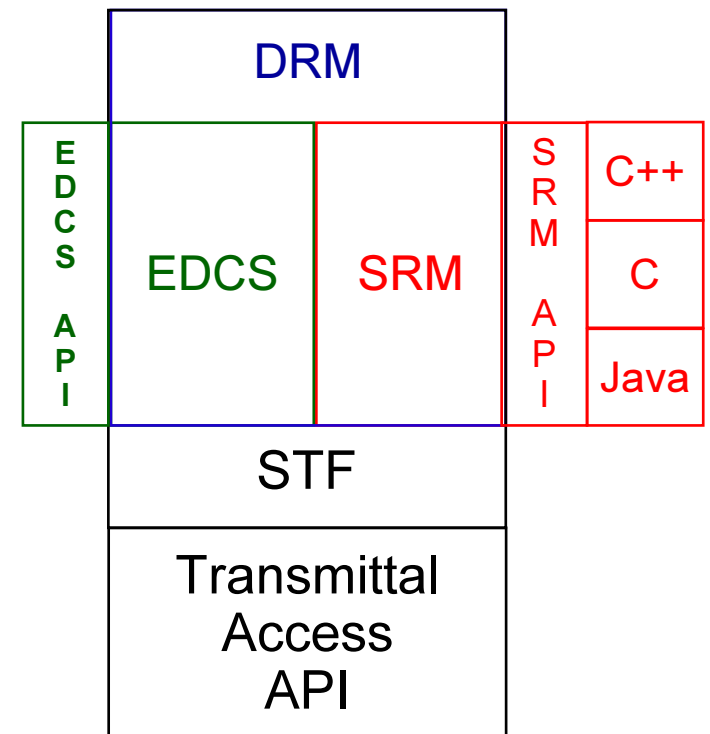
- The SRM API deals with SRFs, coordinates, directions, and orientations constructs
- Data structures are defined for the instantiation of each concept
- SRF constructs for managing coordinates, direction, and orientation
- Functionality provided for:
 - SRF, coordinates, direction, & orientation construct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





The EDCS API

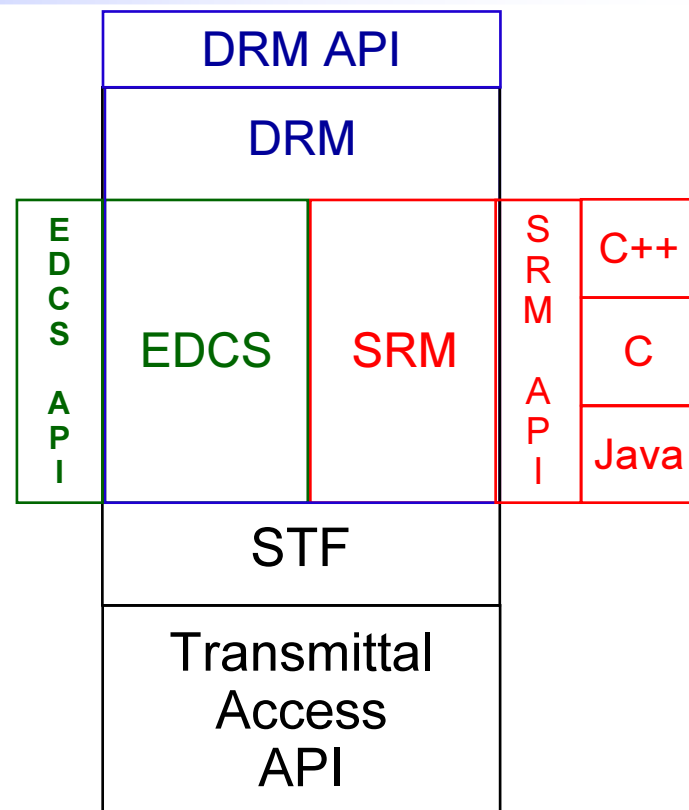
- Functions for converting character strings to enumerated types
 - Functions for converting simple and structured types to character strings
 - Functions for validating simple and structured types
 - Functions for comparing data structures (qsort compatible)
 - Function for converting quantity values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

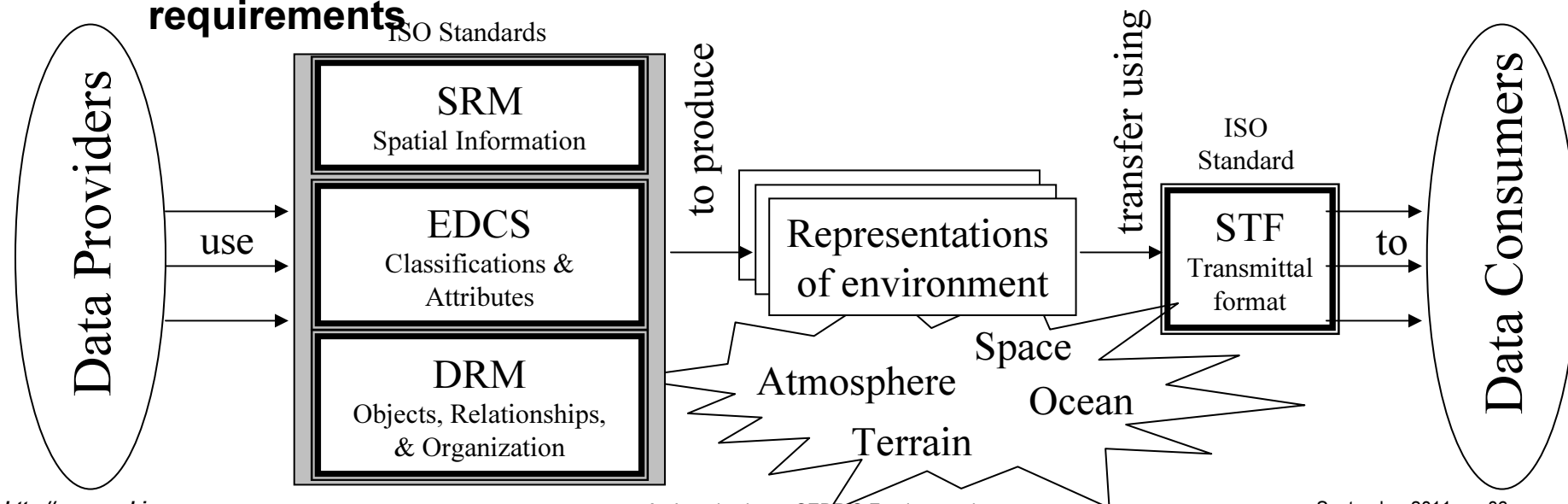


- **Allows software to query for DRM definitions**
- **Also provides functionality for converting between color models**



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, Focus)
 - 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-based Tools and Applications



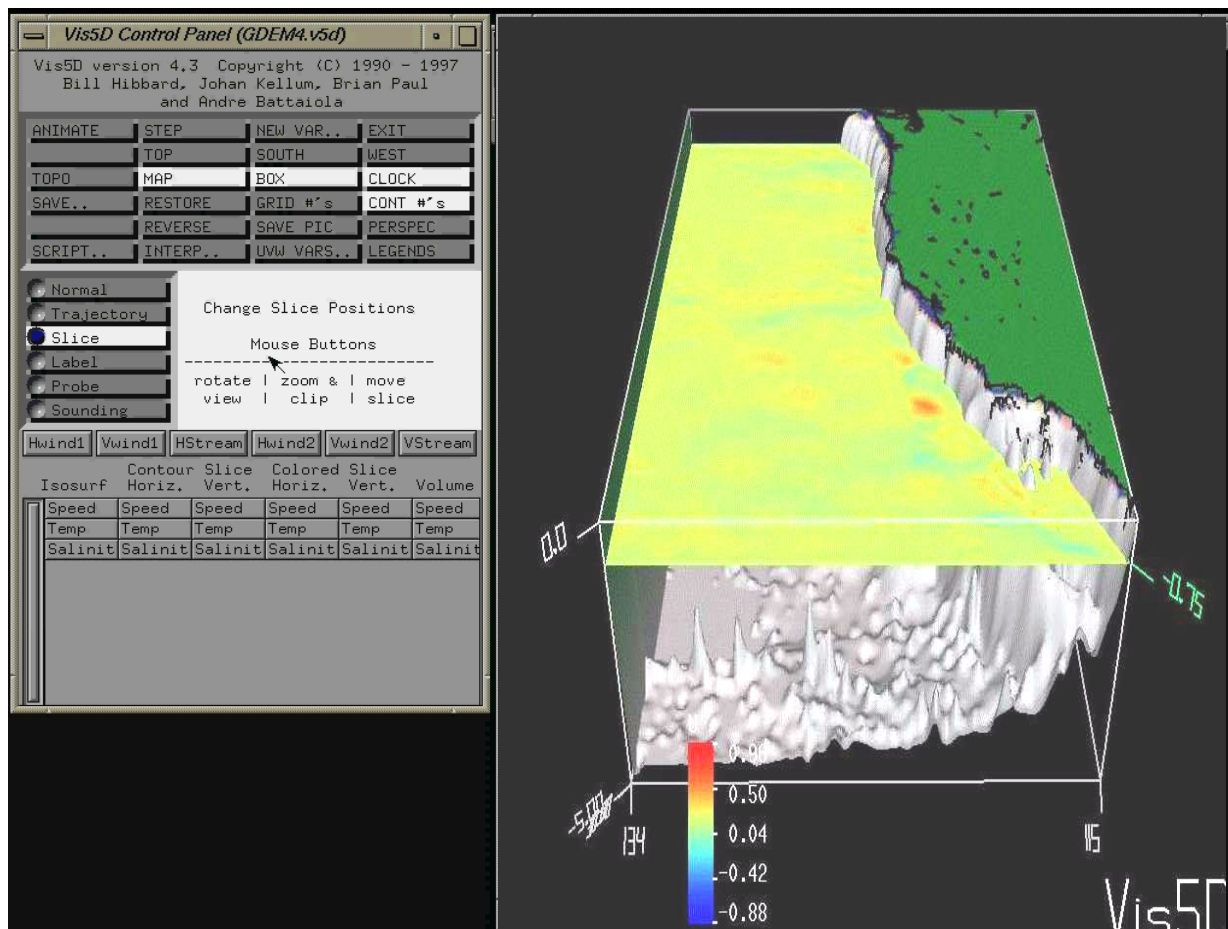
Many SEDRIS-based tools, utilities, and applications exist

- 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 (a CAE (formerly AcuSoft Inc.) product)



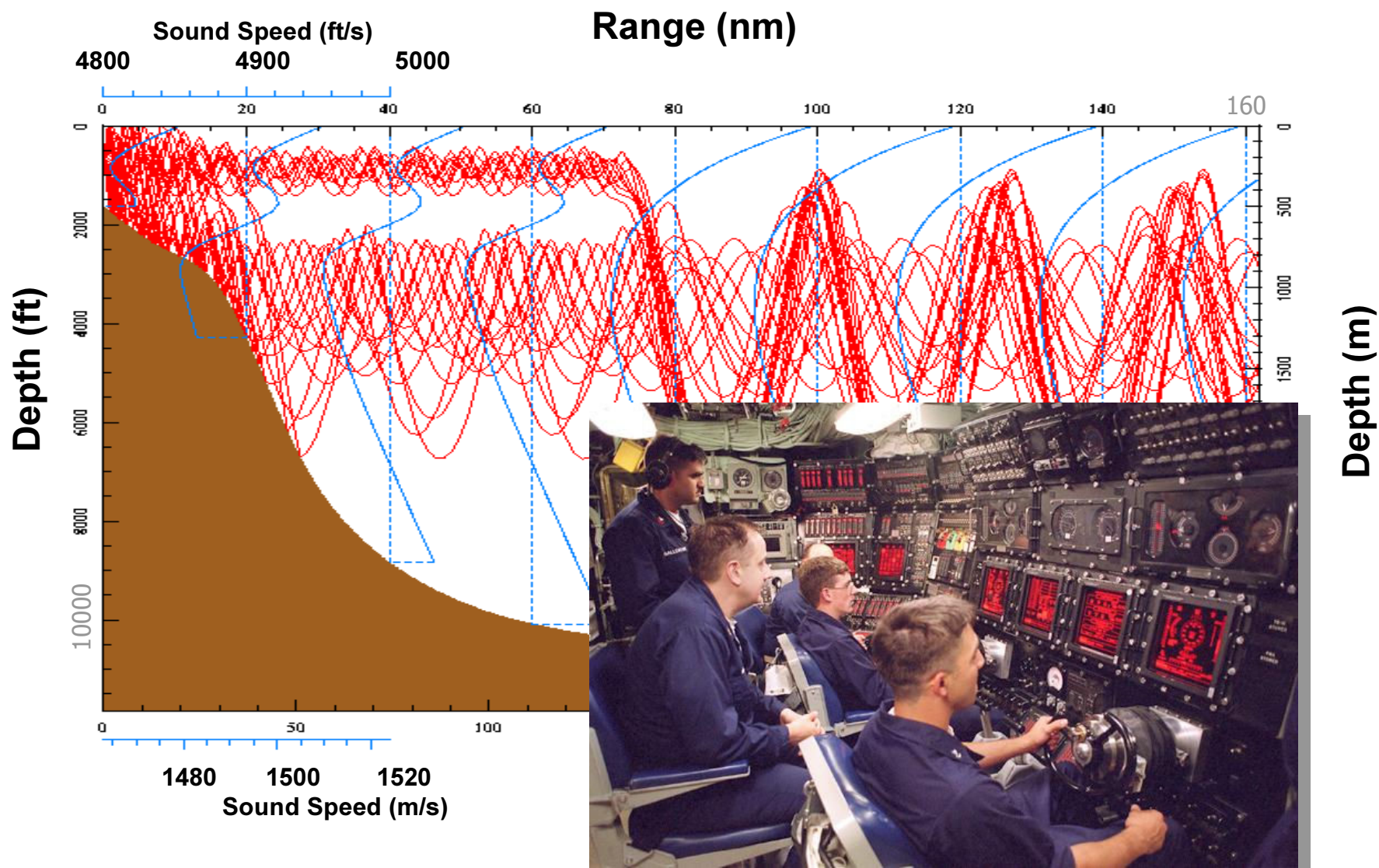
Ocean Profile viewer

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





SEDRI in Korean applications



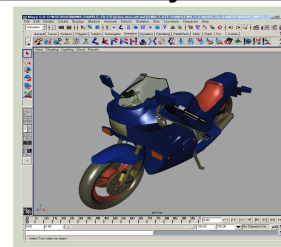
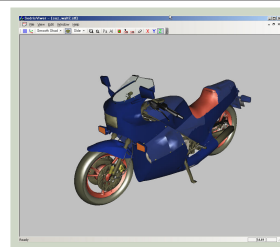
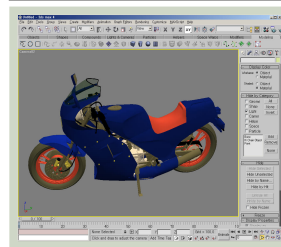
Data conversion

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

3ds Max

SEDRI

Maya

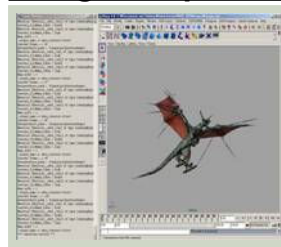


Animation data conversion

- 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

SEDRI



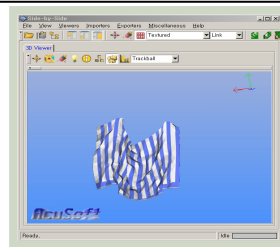
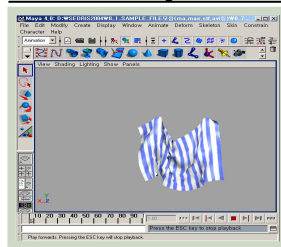
Cloth Animation

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

Maya

SEDRI

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

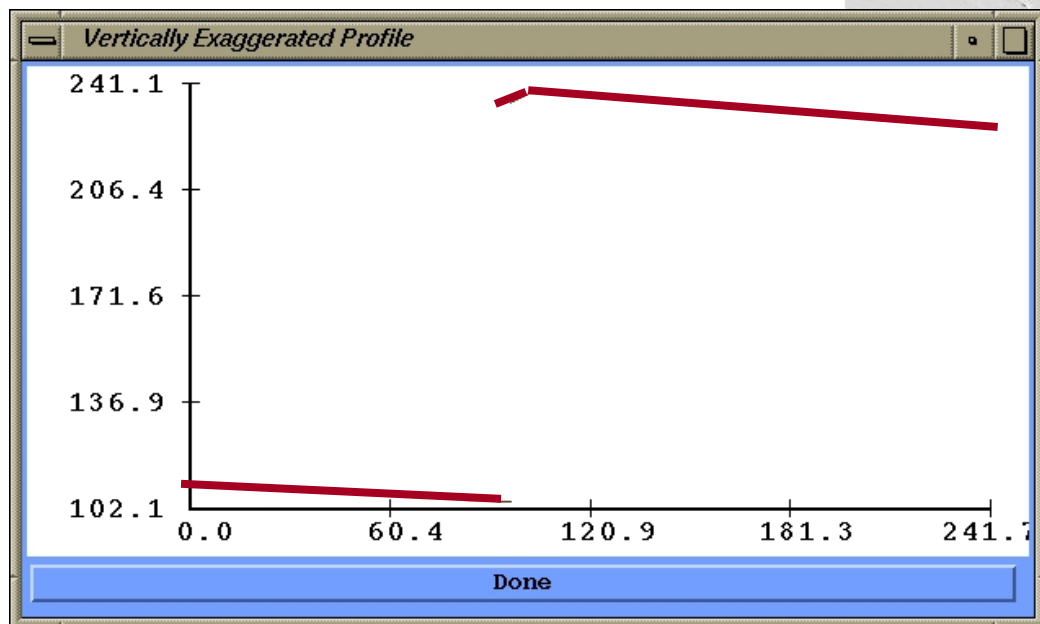
- Bridge segments without associated road networks or that include road network ends, intersections, or width changes

- Static models placed on high slope surface polygons or on a collection of polygons that have high slope variance

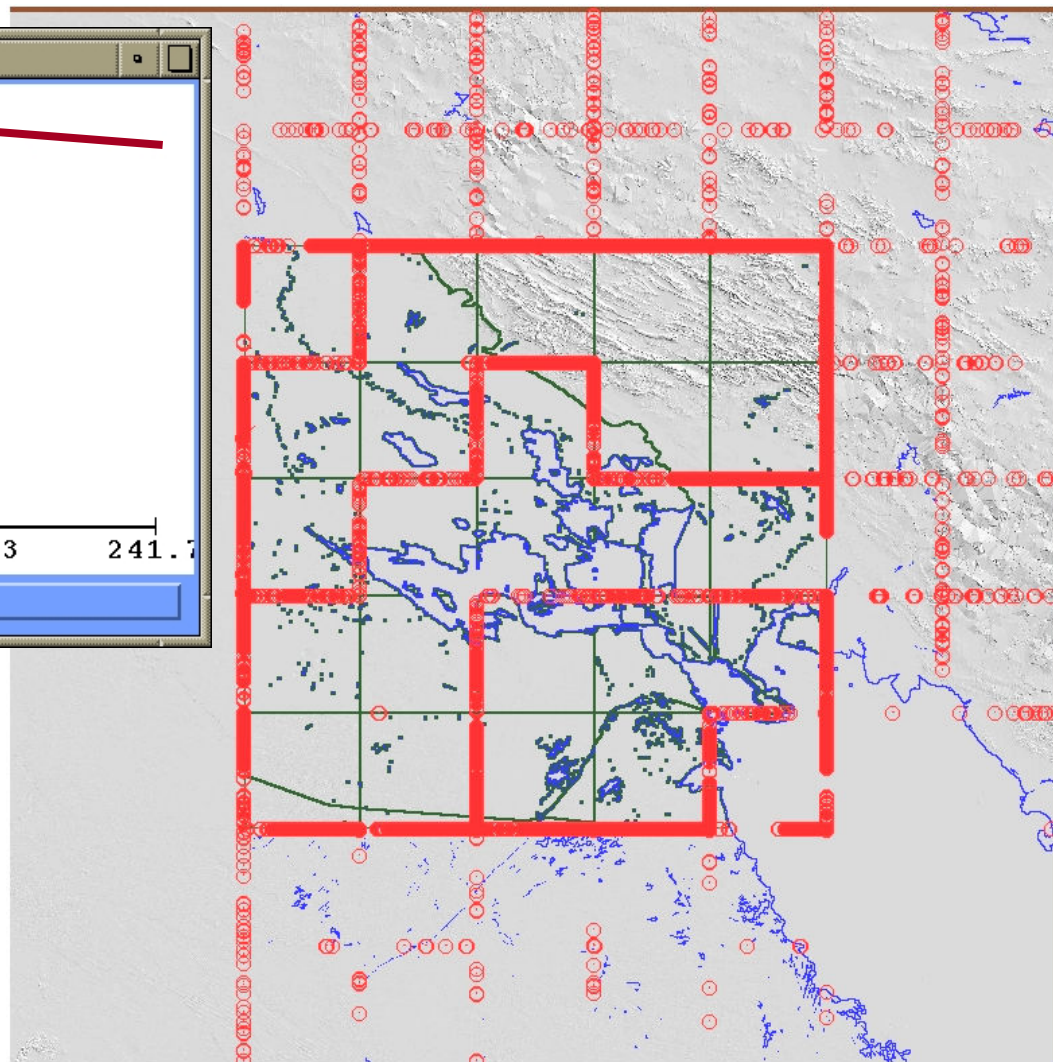
- Static models, other than bridges, that have bounding volumes which intersect or otherwise overlap road network locations



Vertical Tear Locations



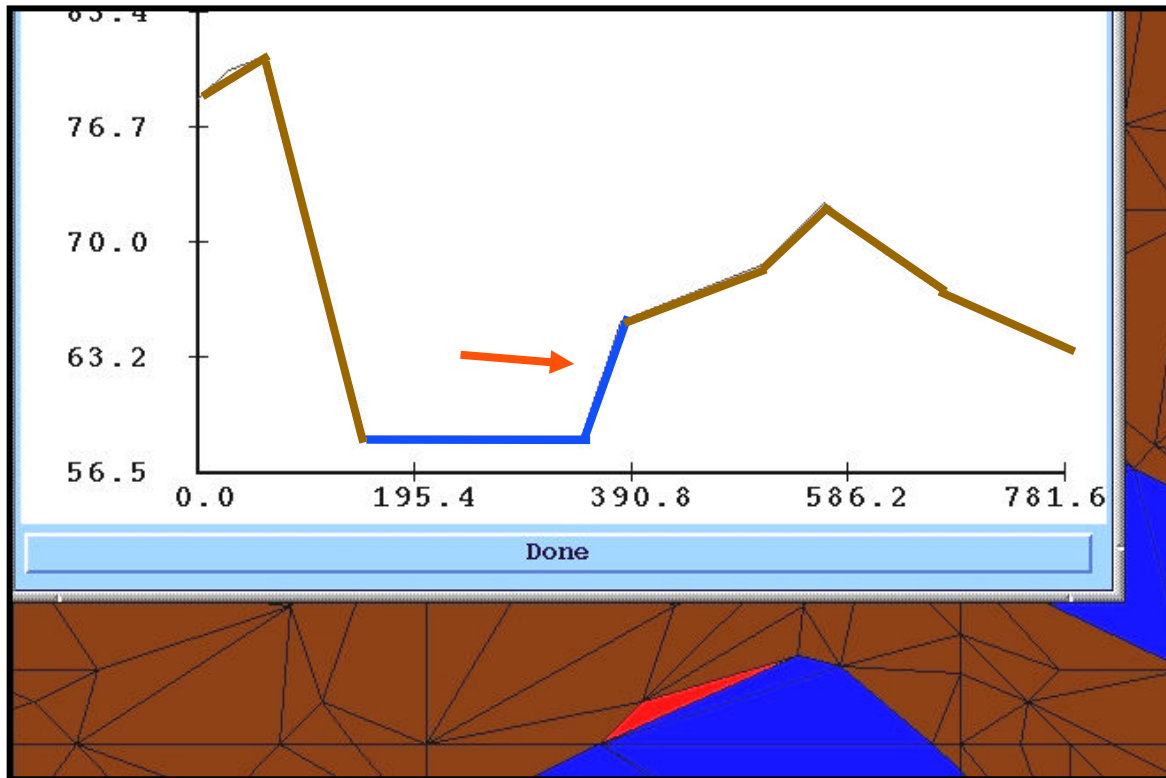
**Cross section of a
single tear instance
with a magnitude of
135m**



900Km X 900Km terrain skin



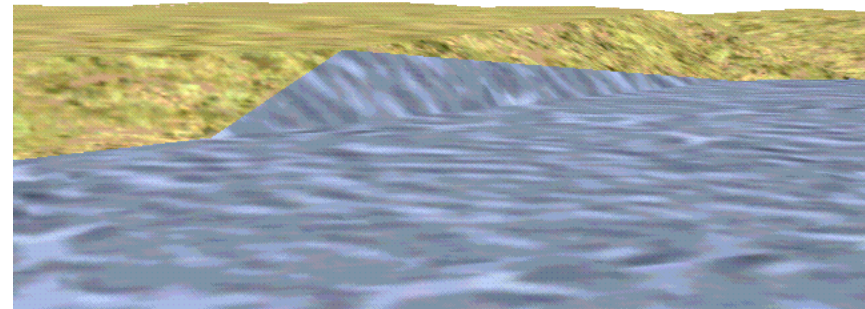
Water Surface Polygon with High Slope



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

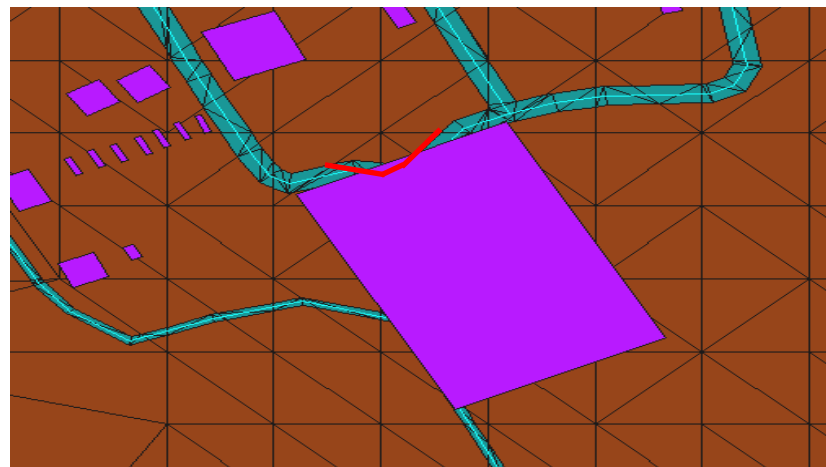
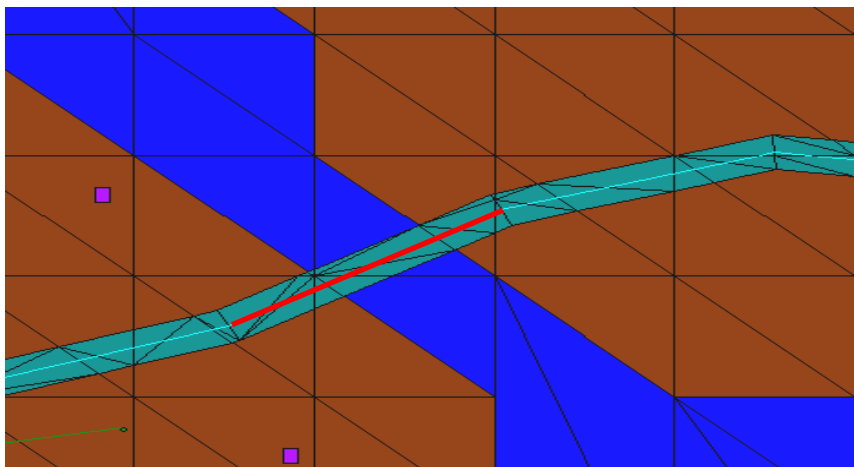
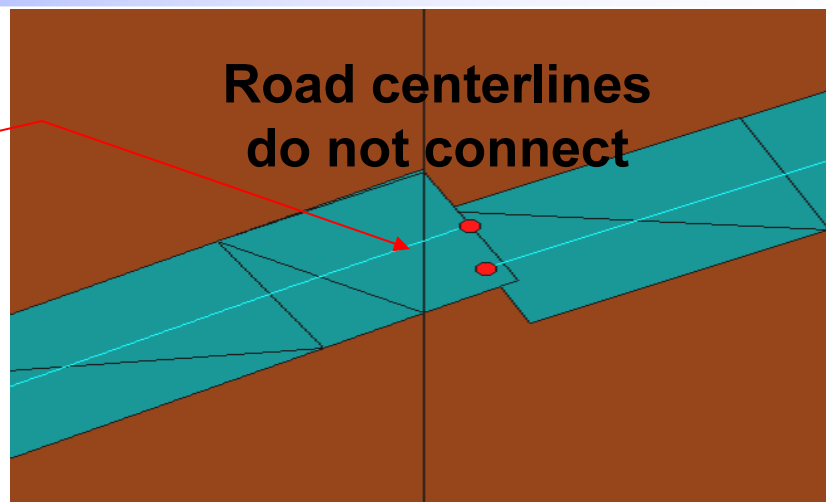
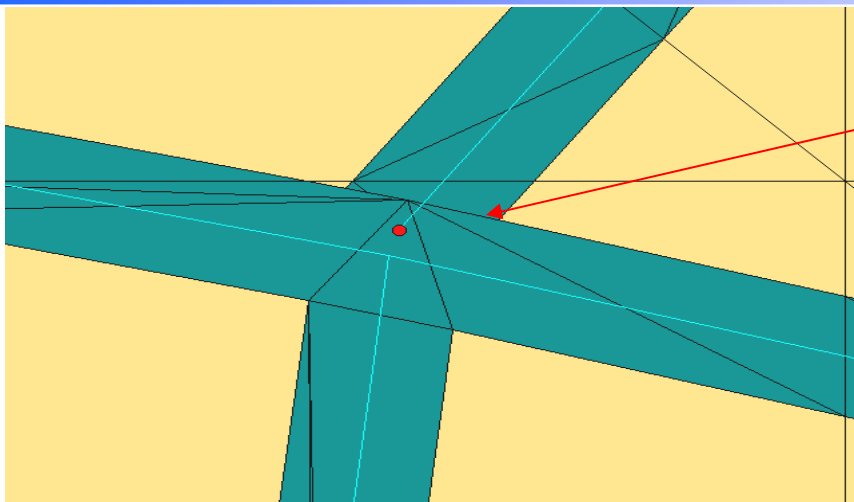
...

**which also appears in the
out-the-window view**





Connectivity Problems



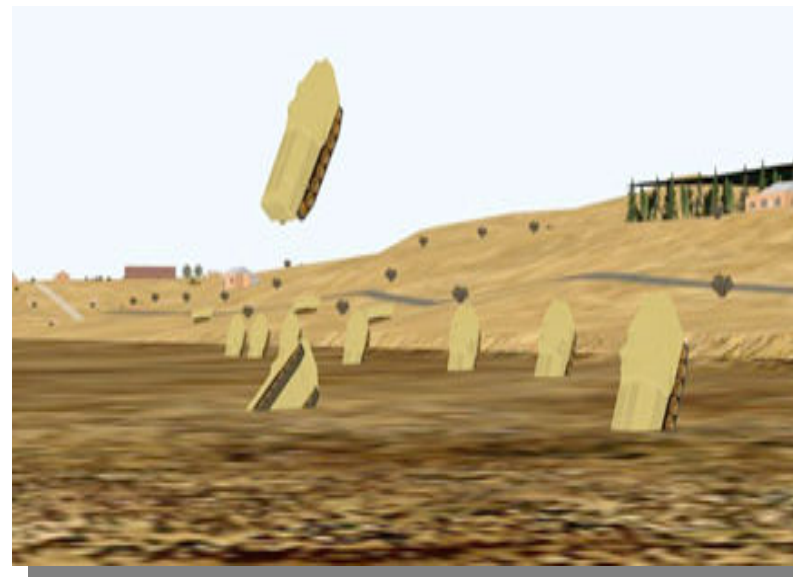
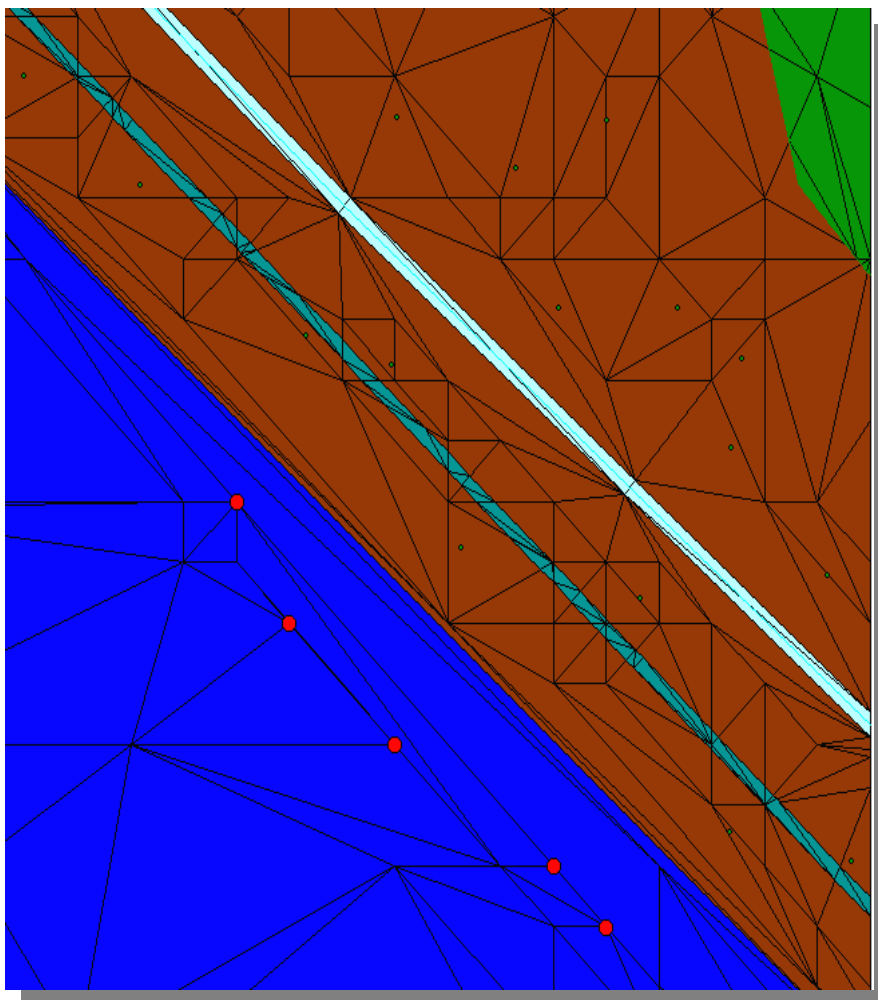
**Road intersects water
feature without a bridge**

**Road intersects a model
bounding volume**



'T' Vertex Topology

Bathymetric Data Surface



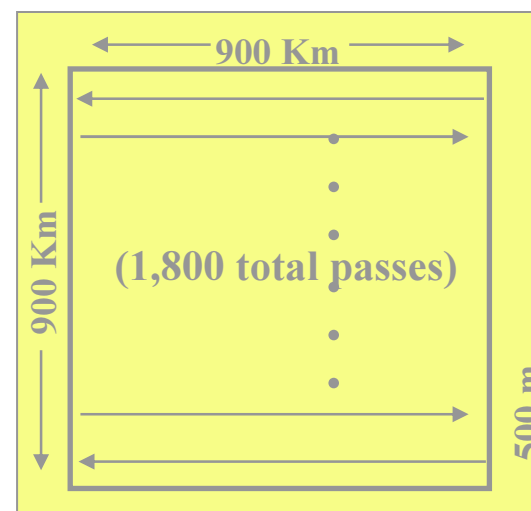
Resulting ModSAF Behavior



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:
 $(1,800 \text{ passes} * 900\text{Km} / \text{pass}) / \text{"S" KMPH}$



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 ...)

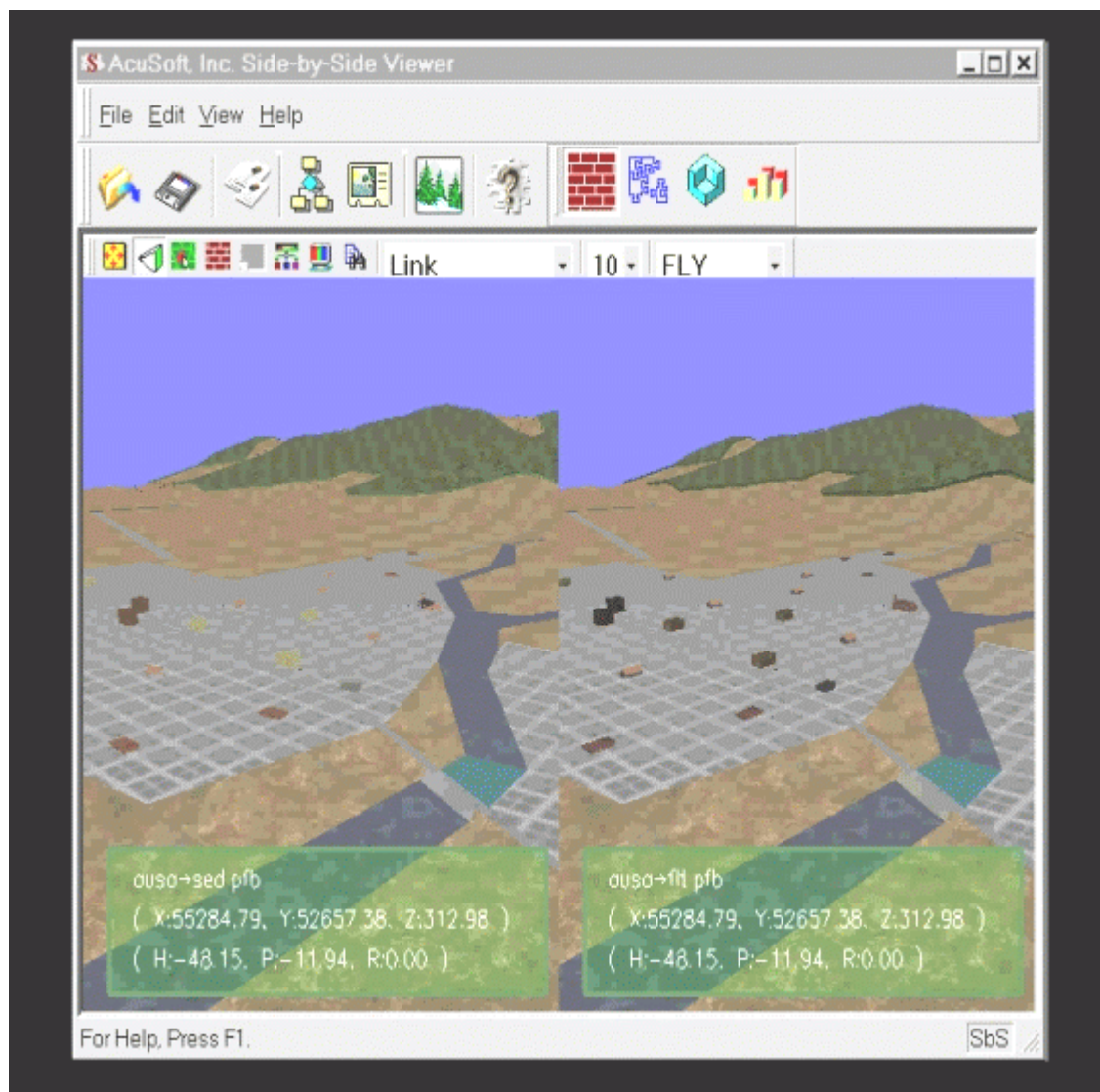
SEE-IT: Required 45 minutes to examine the entire 810,000Km² database (about 2.5 million polygons plus numerous non-polygonal features inspected)

A factor of over 100,000X improvement!



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**





SEDRI 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 SEDRI Model Library

Entries from a SEDRI Texture Library

Terrain skin and Geometry Model Instances

Display options:

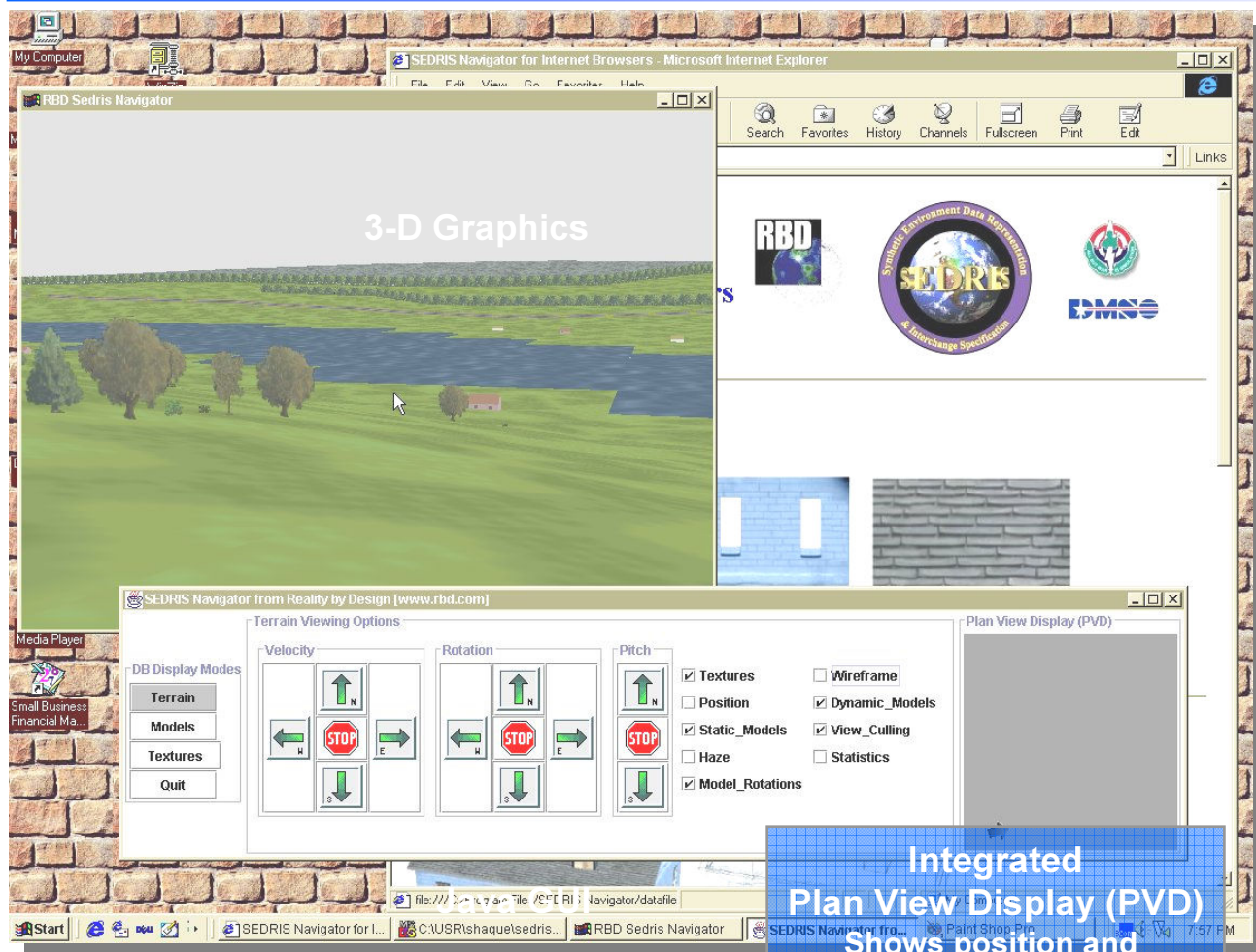
Cross platform: OpenGL (Win32, SGI, Linux)

Textured, wire frame, shaded (averaged texture)

Java-based Graphical User Interface



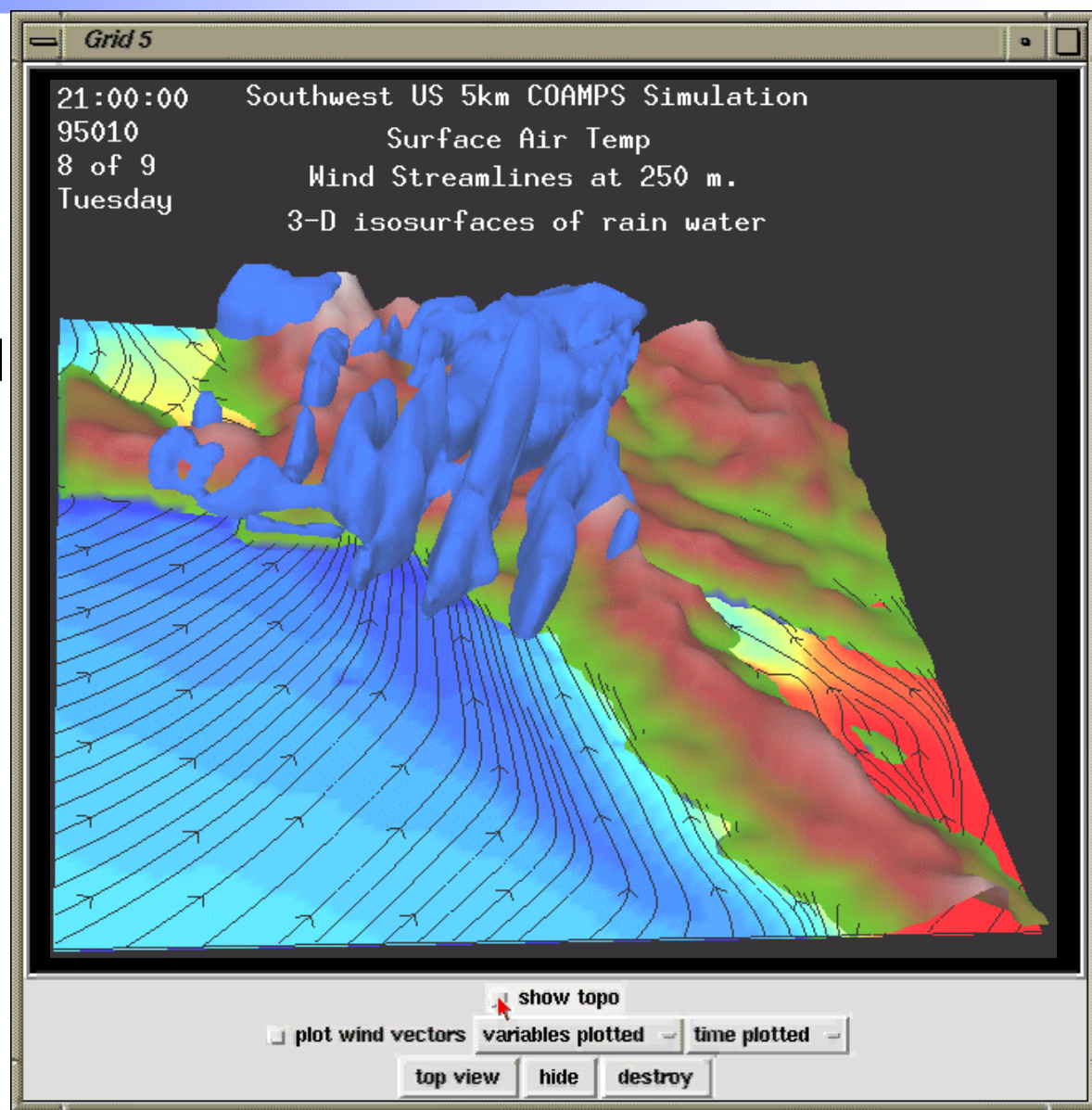
Display Components





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.





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

- Software Development Kit (SDK) releases, Tutorial videos, Papers
- SEDRIS technology components -- EDCS, SRM, DRM, APIs
- Proceedings from past SEDRIS Technology 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>

<http://standards.sedris.org>