An Introduction to SEDRIS

DMSO

Industry Days

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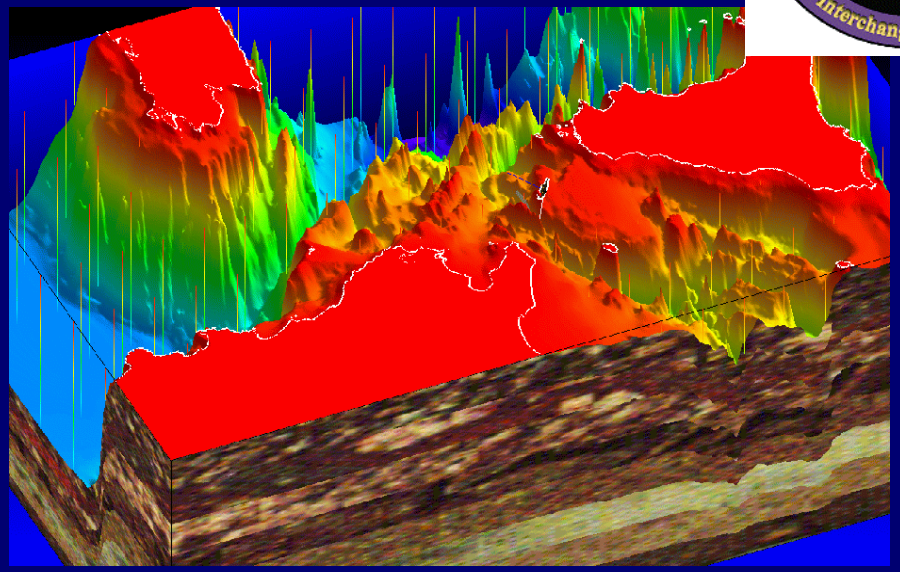
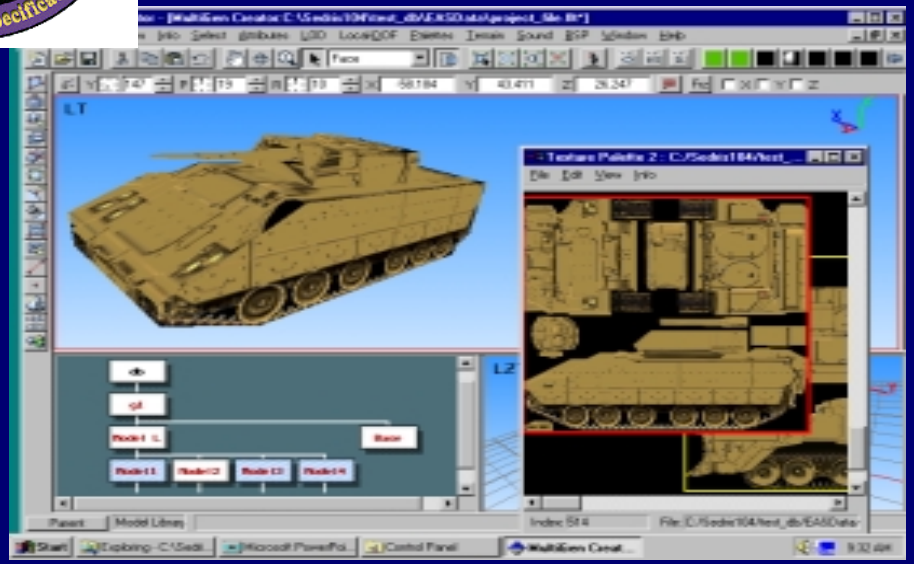
Presentation Outline

- *Introduction:*
  - A Quick Glance at SEDRIS
  - The Need for SEDRIS: Background, Problem Space & Rationale
  - A Few Applications
  - Atmospheric and Oceanographic Data
- *Standards Development*
- *Environmental Data, Interoperability and Interchange*
- *Database Generation:* Sources, Processes and Requirements
- *SEDRIS: Technology Components*
  - What is A Data Representation Model ?
  - What is an Environmental Data Coding Specification ?
  - What is the Spatial Reference Model ?
  - The SEDRIS Interface Specification
  - SEDRIS Transmittal Format
- *SEDRIS: Applications*
- *Summary*

SEDRIS

Interchange Supporting Interoperability





Introduction:

A Quick Glance at SEDRIS

SEDRIS Is Not …

- 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*

…But you can use SEDRIS to do all of these!

SEDRIS Is...

- A *method (language)* for unambiguously describing the environment (independent of whether it is geo-specific or geo-typical)
- A *mechanism to share and interchange* the described environment
- An *infrastructure technology*

Primary Aspects of SEDRIS

- ***Unambiguous representation of environmental data***
  - **Semantics and relationships of data elements**
  - **All environmental domains**
  - **Expressed in a data representation model**
- ***Efficient interchange of environmental data***
  - **Sharing and re-use**
  - **Ease of access and software development (API)**
  - **Tools and applications**

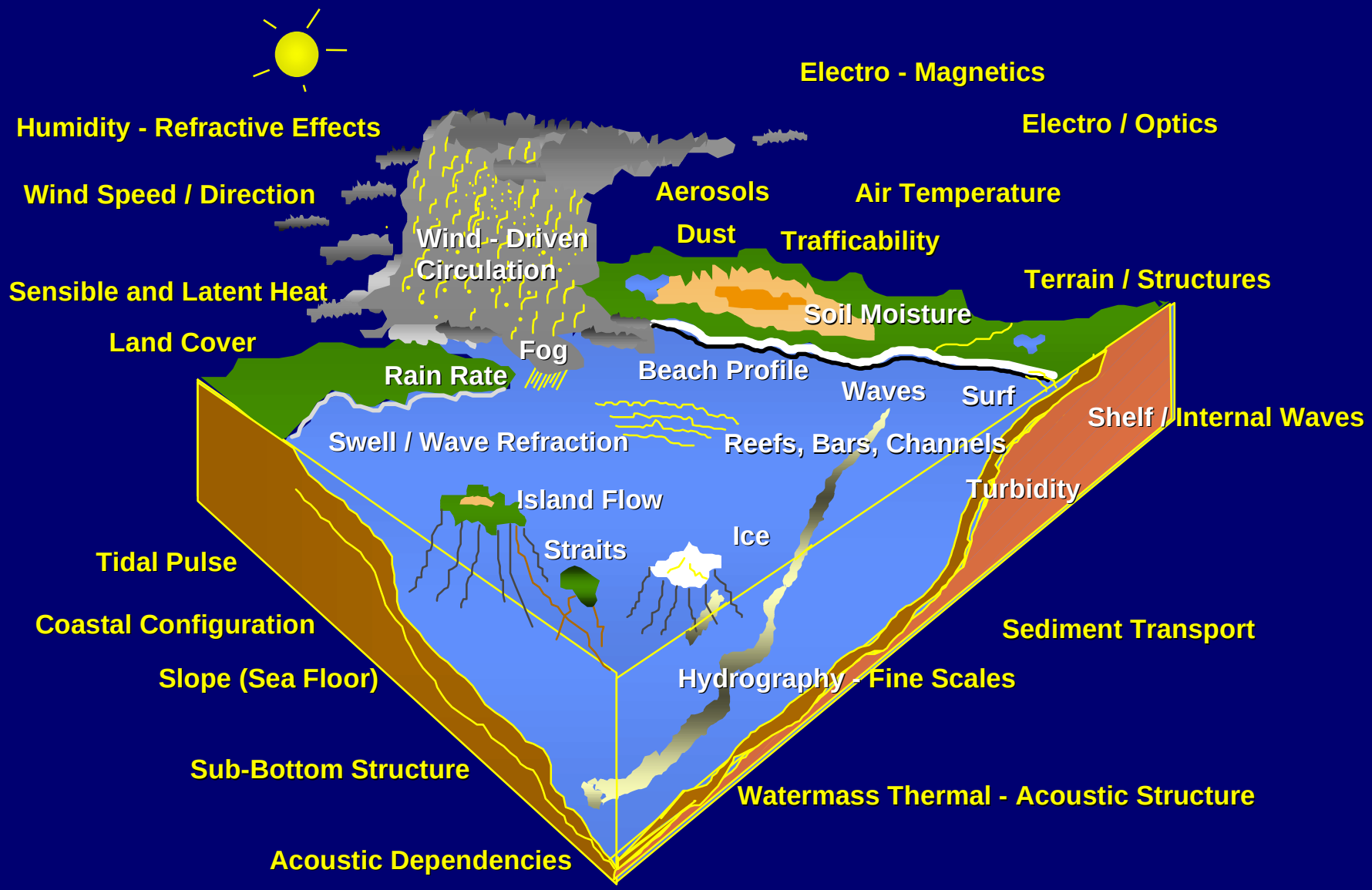
SEDRIS Objectives

- **Articulate and capture the complete set of data elements and associated relationships needed to fully represent environmental data:**
  - ***Data Representation Model (DRM)***
  - ***Environmental Data Coding Specification (EDCS)***
  - ***Spatial Reference Model (SRM)***
- **Provide a standard interchange mechanism to pre-distribute environmental data and promote database reuse among heterogeneous applications**
- **Support the full range of applications across all environmental domains (terrain, ocean, atmosphere, and space)**

Technology Components of SEDRIS

- ***Data Representation Model (DRM):*** **Provides syntax and structural semantics for representing environmental data and databases**
- ***Spatial Reference Model (SRM):*** **Unified and robust description of the coordinate systems, along with an accurate, efficient, and fast software implementation**
- ***Environmental Data Coding Specification (EDCS):*** **Provides "thing" level semantics (classify/attribute scheme)**
- ***Software Interface Specification*** **(Read and Write Application Programmer Interfaces (APIs))**
  - **Allows ease of access**
  - **Lowers the barrier-to-entry in software development**
- ***SEDRIS Transmittal Format (STF)*****: Platform independent storage and transmission of data**

A Potentially Complex Environment



What Constitutes a Database?

- An *integrated set of data elements*, each describing some aspect of the same geographical region and the elements or events expected there, referred to as an environmental database
- *Typical data elements used in a database:*
  - Terrain surface, ocean bottom digital elevation models
  - Terrain features
  - 3-D models/icons; blueprints, Computer Aided Design data
  - Textures, images, colors; sources such as photos
  - Attributes; such as Infra-Red signatures, surface material
  - Environmental data; haze, fog, smoke, weather
  - Other; animations, system specific data, names, tables, etc.

An Integrated Model of the Environment

- **Must preserve *real world* properties critical to predicting player and equipment performance**
- **Must be *realistic* and be…**
  - **A best-approximation of a specific or typical place and time**
  - **Physically consistent:**
    - **Rivers: flow downhill**
    - **Terrain, atmosphere, ocean, and space: content agree**
    - **Roads: connected and consistently attributed**
    - **Cuts, fills, obstacles: appropriate to engineering practices**
    - **Structures: attached and appropriately aligned**

Note: Maps are also approximations of the real world, but requirements are different because…

- ***Inaccuracies are accounted for through visual interpretation***
- ***Synthetic Forces can't adjust ... inconsistent representation causes errors***

The need for SEDRIS

Background, Problem Space, and Rationale

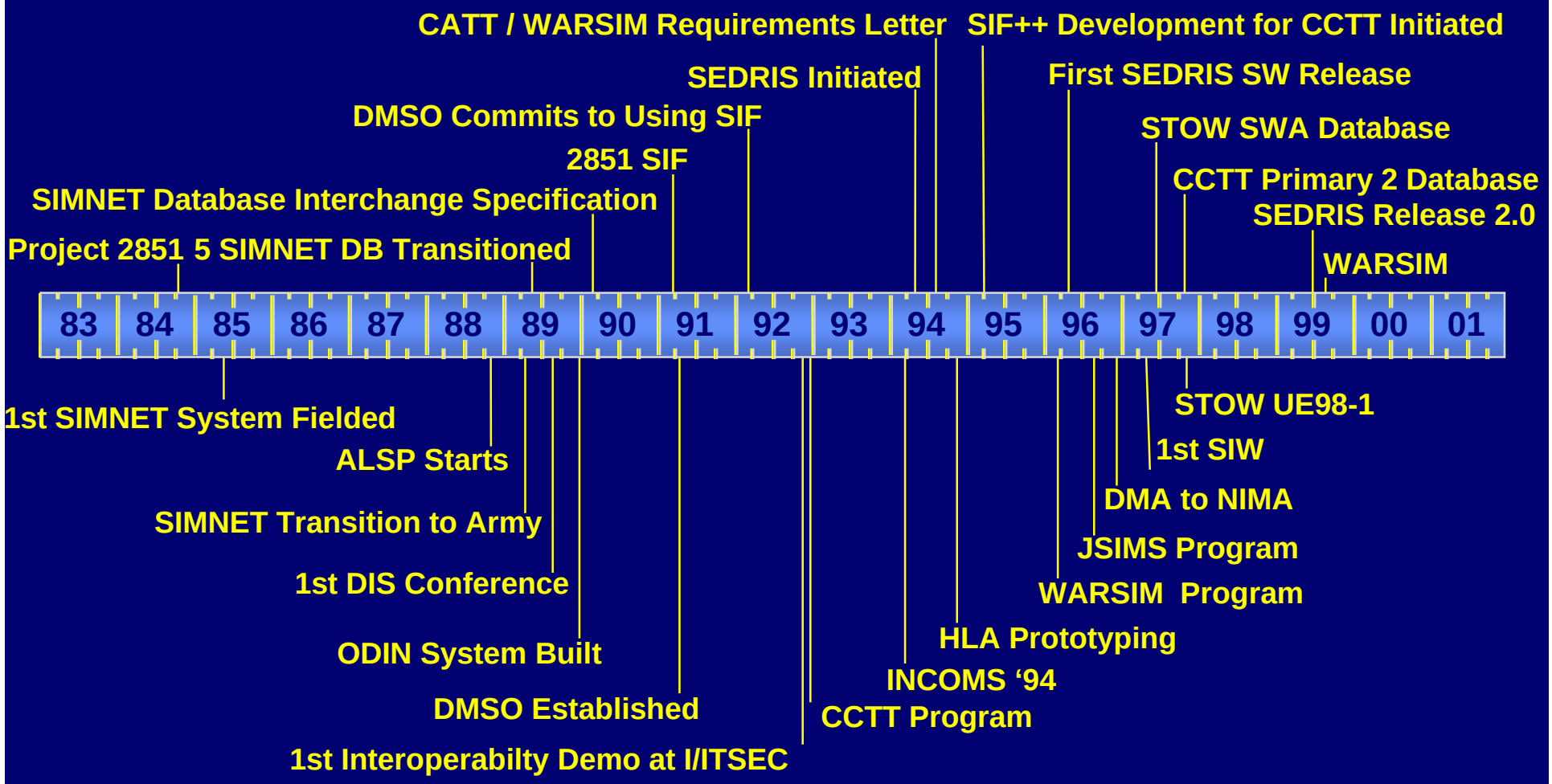
Trends Impacting Environmental Data

Impact of:

- Distributed interoperable systems, applications, and simulations - from standalone to networked
- Joint environmental applications
- Multiple domains - use of common architecture
- Multiple applications - Virtual, Computer Generated Forces, Analysis Systems, Plan View Displays, etc.

Not a New Problem in Simulation Field

Environment Representation Timeline



Networked Modeling and Simulation Timeline

The Tough Problems

Business

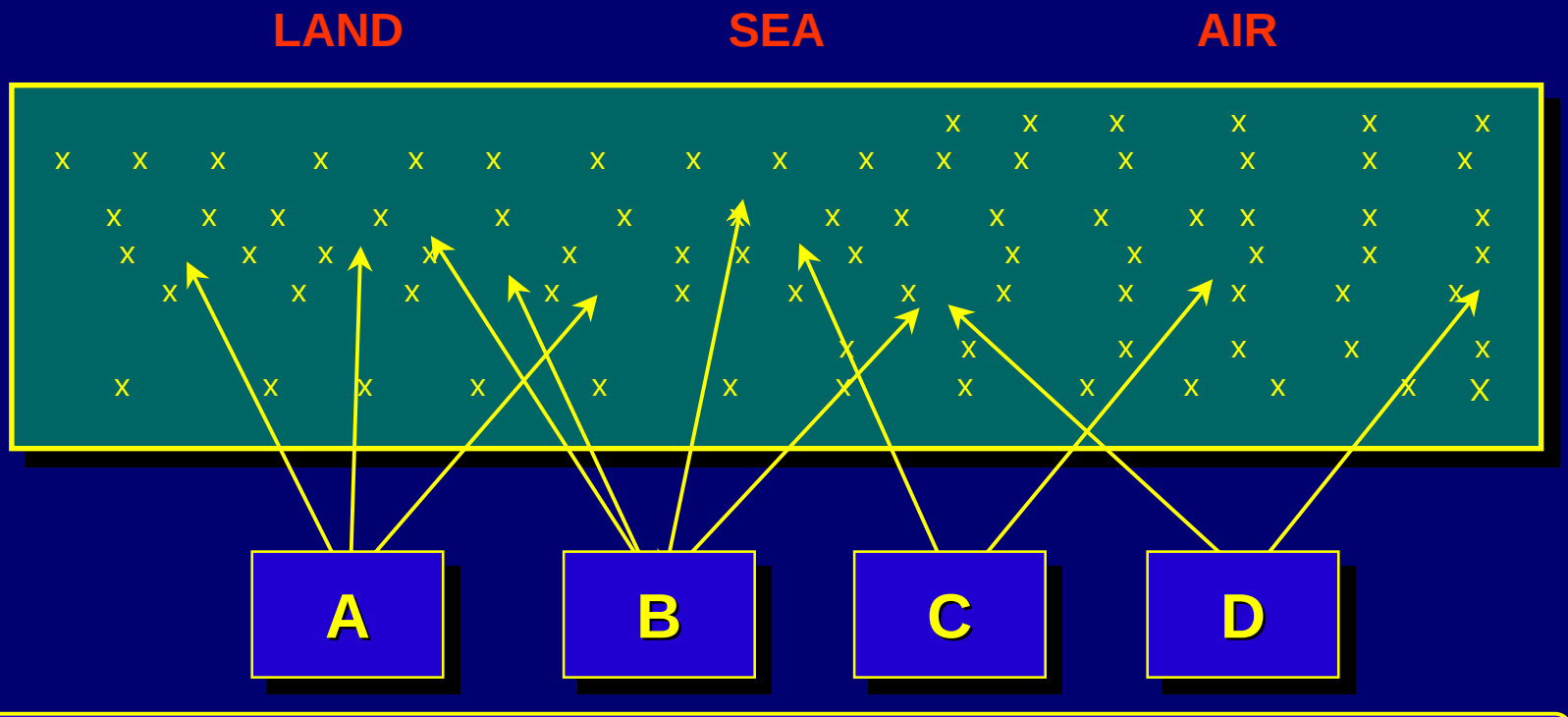
- Get a total set of requirements
- Keep commercial processes and proprietary products involved but maintain an open exchange mechanism

Technical

- Different views of the environment
  - Air, land, sea, space
  - Spatial location and orientation (coordinate system and datum)
- Lack of underlying environmental framework
  - No integrated reference model available
    - Representation
    - Naming/semantics
  - Existing Data Models are conceptual, future models which are non-integrated and don't address current data repositories and data interchange requirements

Tackling the Requirements Problem

Very large number of users with both common & unique requirements



Agencies or companies that produce environmental databases

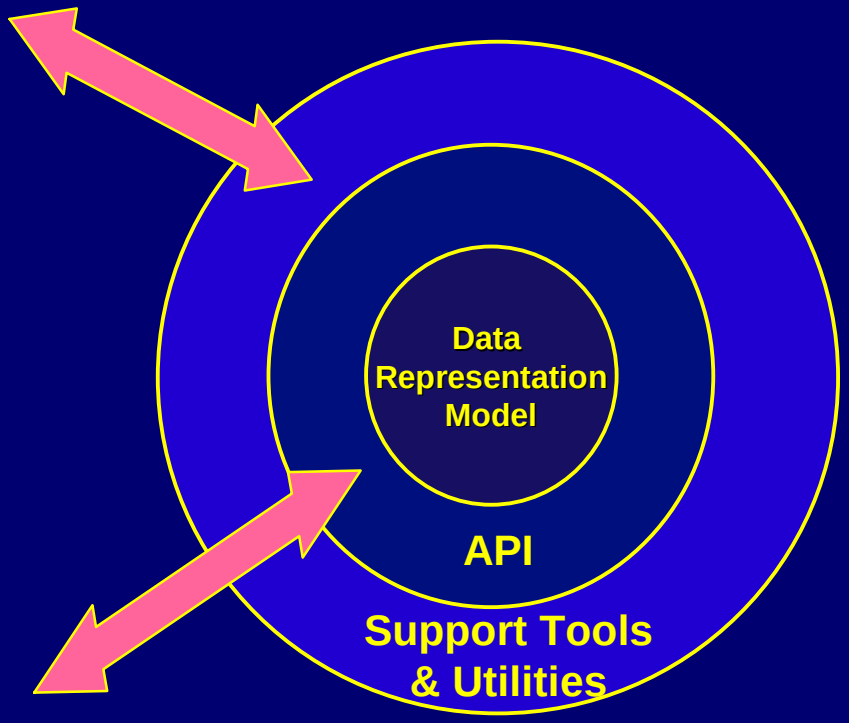
The Key: ***Small number of environmental database builders (in contrast to environmental data users)***

Commercial Process Issues

- Proprietary products
- Open exchange (same place): Required for interoperability
- Value-added tools and utilities for small product volume

How SEDRIS has been Developed

- *SEDRIS Associates* (key environmental database developers/users)
  - Review and feedback
    - Data Representation Model
    - Interface Specification (API)
  - Native-model mapping
  - Interchange experiments
  - Value-added tools/utilities
- *Core Team*
  - Managed evolution
    - Data Representation Model
    - Interface Specification (API)
  - Reference implementation(s)
  - Transmittal Format



Associates

- AcuSoft, Inc.
- Analysis and Technology, Incorporated (A&T)
- Boeing
- Centric (formerly Coryphaeus) Software, Incorporated (CSI)
- Cybernet Systems Corporation
- Evans and Sutherland (E&S)
- JRM Enterprises, Inc.
- Litton-TASC
- Lockheed Martin Information Systems (LMIS)
- Lockheed Martin Tactical Defense Systems (LMTDS)
- MultiGen - Paradigm Inc. (MPI)
- PAR Government Systems Corporation
- Raytheon Systems Company
- Raytheon Training Systems
- Reality By Design Government Systems, LLC (RBD)
- Science Applications International Corporation (SAIC)
- Silicon Graphics Inc. (SGI)
- TerraSim
- Thomson Training and Simulation (TT&S)

What Associates Do...

- Learn to *speak SEDRIS*: enhanced Rumbaugh & Unified Modeling Language (UML) notation
- Generate *mapping documents*
  - For native format(s) or assigned government format(s)
  - To ensure the data representation model and coding standard can handle all data requirements
- Develop software: to *convert native data* into SEDRIS and back to check completeness of the interchange
- *Participate* in SEDRIS Associate Meetings (SAMs) and associated experiments
  - Exchange ideas
  - Cooperatively define and develop SEDRIS technology
  - Share non-proprietary (native format) utilities and applications that support SEDRIS interchange

International Participation & Interest

- **Industry**
  - Thomson Training and Simulation *(United Kingdom, France)*
  - STN ATLAS Elektronik GmbH *(Germany)*
  - BVR Systems Ltd. *(Israel)*
  - SOGITEC *(France)*
  - OKTAL *(France)*
- **Government**
  - Defence Evaluation and Research Agency *(DERA) (United Kingdom)*
  - Defense Science and Technology Organization *(DSTO) (Australia)*
- **Other International Interest**
  - ISO Committees, OGC, DGIWG, SISO
  - NATO M&S Master Plan
  - International Conferences (e.g., I/ITSEC, ITEC, and ITEA)

Other Participating Organizations

- Air Force Weather Agency (AFWA)
- Armed Forces Training Systems, Incorporated (AFTS)
- Defense Advanced Research Projects Agency (DARPA)
- Defense Information Systems Agency (DISA)
- Defense Modeling and Simulation Office (DMSO)
- Defense Threat Reduction Agency (DTRA)
- Dismounted Warrior Network (DWN)
- Distributed Simulation Technology, Incorporated (DiSTI)
- Institute for Defense Analyses (IDA)
- Joint Simulation System, Joint Program Office (JSIMS/JPO)
- Joint Warfare System, Joint Program Office (JWARS/JPO)
- The MITRE Corporation
- National Imagery and Mapping Agency (NIMA)
- Naval Air Warfare Center Training Systems Division (NAWC/TSD)
- Naval Oceanographic Office (NAVOCEANO)
- Naval Research Laboratory (NRL)
- Quantum Research International
- SRI International
- U.S. Army Topographic Engineering Center (USATEC)
- U.S. Army Simulation Training & Instrumentation Command (STRICOM)

A Few Applications

Entertainment Applications

- ***Entertainment simulations:***
  - **No standard way of interchanging data**
  - **No standard method of networking**
- **Military spending roughly $1 B U.S. on training technology**
- **Commercial revenues of $1.2 B U.S. on arcade games and $540 M U.S. on online games**
- ***Solution:***
  - ***Establish standards as viable commercial alternatives***
    - **SEDRIS technologies can be used for representation and exchange of data across a wide variety of available formats**
    - **Use existing or emerging standards in networking**
  - ***What's in it for the commercial market?***
    - **Access to more complex data**
    - **Lower costs for developing such data**
    - **Lure of actual military simulation data and 'players'**

Distributed Gaming Simulation

- Develop simulation for the entertainment market
- Make publicly available synthetic environments accessible through SEDRIS (U.S. Geological Survey (USGS) and Commercial Flight Simulator databases)
- Establish a nationwide gaming network based on the High Level Architecture (HLA)
- Extend access to commercial formats (OpenSkies design tools)
- Add more extensive training capabilities
- Chat and speech recognition
- Intelligent Agents

UK-CATT

- LMIS will procure their CIG based on a competitive bid
- In order to isolate program risk and dependency, UK- CATT has adopted SEDRIS as their database interface and interchange mechanism
- To evaluate potential bidders SEDRIS databases have been provided (CCTT P1 I9, and later P1 AE) to vendors, and expects them to consume the data and demonstrate on their system
- A new database is being built and provided to bidders to ensure prior knowledge of CCTT is eliminated as an initial factor. This new database will be delivered in SEDRIS
- UK-CATT has committed to using SEDRIS

Current Status

- Initial content specification completed 1 July 1999
- Initial SEDRIS transmittal (10% sample) delivered on schedule
  - 1 September 1999: Correlated database (feature data) SEDRIS delivered to SAIC
  - 8 September 1999: Visual (geometry data) delivered to E&S
- Content Specification update in October ‘99 and March ‘00 as a mid point correction to transmittal content.
- Final (100%) SEDRIS database will be delivered to E&S and SAIC January 2001

Simulation Database Facility Study

- Sponsored by UK Ministry of Defence
- Contractors: Lockheed Martin / Thomson Training & Simulation (TT&S)
- Study has shown facility to be financially viable and technically feasible
- Database interchange identified as enabling factor
- SEDRIS a core technology
- Conversion experiments

DERA

UK SEDRIS Pathfinder Project

- Two Year Collaborative Research Contract
  - "Improved Inter-Operability and Representation of a Synthetic Environment"
  - April 1998 - March 2000, Joint funding (TT&S / DERA)
- Analysis of mapping between BDD3 and SEDRIS
- Develop SEDRIS interface software for native TT&S BDD3 format
- Interchange Data with other SEDRIS Associates
- Deliverables
  - Presentations, demonstrations, documentation
  - Study reports on SEDRIS specification and implementation

DERA

Pathfinder Project Benefits

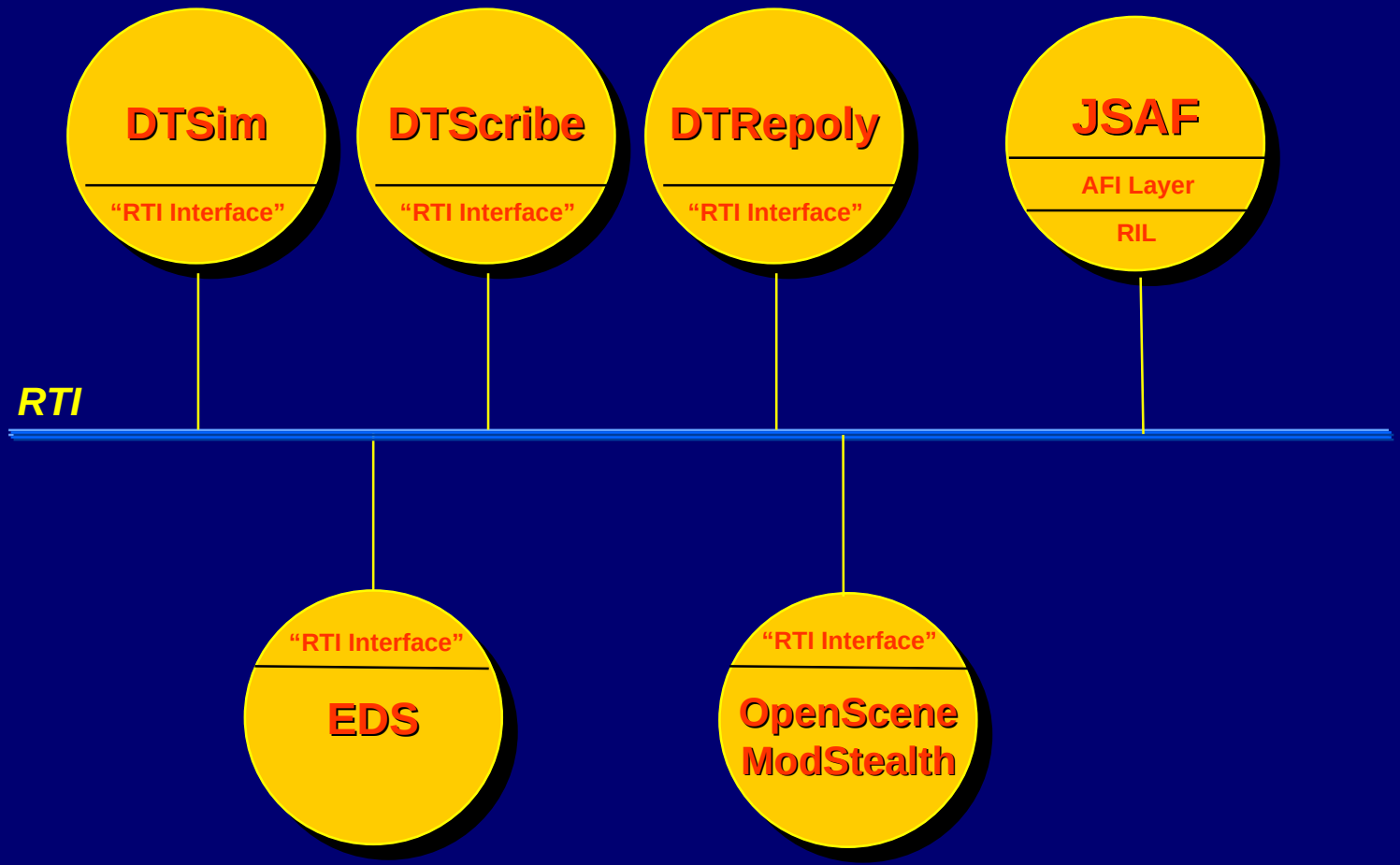
Benefits to:

- ***MOD / DERA:*** **Early SEDRIS awareness, through direct involvement in US DoD program, and its potential application to UK training systems, e.g., database re-use, simulation interoperability**
- ***TT&S:***
  - **Experience, shared with DERA, gained from implementation of SEDRIS interface software for the Company's visual product**
  - **The opportunity of being able to offer an improved database interchange capability to customer community**
- ***SEDRIS development effort:***
  - **Fresh (Non-U.S.) perspective brought to the program, at no cost to U.S. DoD**
  - **TT&S technical involvement in SEDRIS development**
  - **Foster standardization through the British Standards Institute**

DERA

Environment Federation

Applying the SEDRIS Data Representation Model and Environmental Data Coding Specification ...



SEDRIS at Runtime

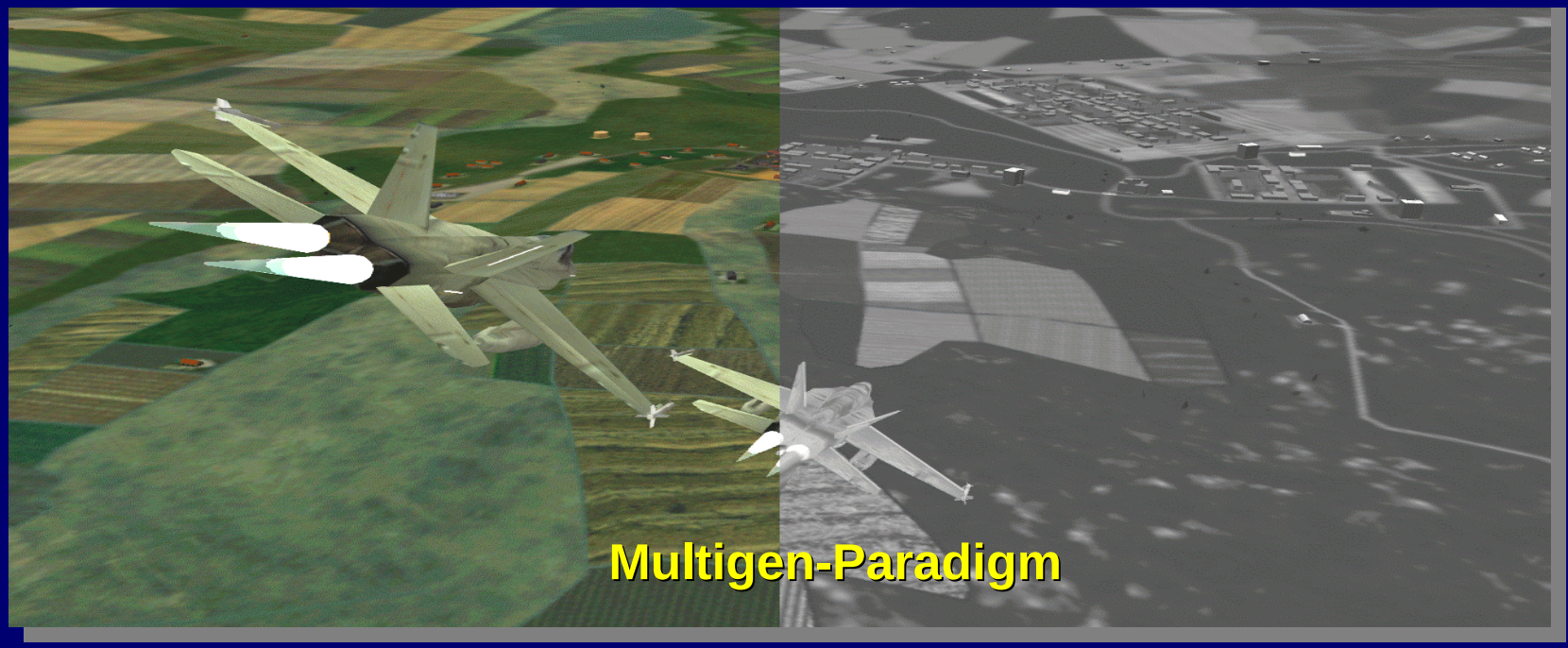
- **Unambiguous representation of environmental data**
  - ***Data Representation Model:*** **Complex data elements in object-based model**
  - ***Data Coding Standard:*** **Well-specified data element definitions / semantics**
  - ***Spatial Reference Model:*** **Completeness, accuracy, performance**
- **Efficient interchange of environmental data (pre-simulation runtime)**
  - ***Interface Specification:*** **Platform and language independent APIs, with reference implementation**
  - ***Transmittal Format:*** **Assures architecture neutral data exchange, when required**
  - **Tools and applications: Inspect, evaluate, verify, transform, ...**

Experimental Application (at runtime)

Replaced by RTI (at runtime)

Simulation Based Acquisition

- Developed to complement constructive analysis
- Visual database design with intent to transition from constructive analysis to virtual
- Designed to provide correlated views of RADAR, Infra-Red and out the window (OTW) visuals in that order of priority



Environmental Representation for Multi-Player Networked-based Systems

- Provide a complete and consistent representation of the natural and physical environment
- Generate an appropriate integrated database
- Interchange environmental representations unambiguously without data loss
- Support interoperability of simulations

Standards Development

Standards Development Objectives

- Document technologies as recognized standards
- Obtain review, and feedback, from the broader international community
- Establish international standards
- Promote software implementations:
  - Software library for the Spatial Reference Model (SRM)
  - Data dictionary database for the Environmental Data Coding Specification (EDCS)

ISO/IEC Standards

- ISO/IEC (International Organization for Standardization and the International Electrotechnical Commission) selected
- Four standards are in development:
  - SEDRIS
  - SEDRIS Language Bindings
  - Environmental Data Coding Specification (EDCS)
  - Spatial Reference Model (SRM)
- Two additional standards to be nominated:
  - EDCS Language Bindings
  - SRM Language Bindings

Four ISO/IEC Standards

- ***WD 18023: SEDRIS*** **– a multi-part standard, initial parts are:**
  - ***Part 1: SEDRIS Functional Specification*** **(includes the Data Representation Model and the Interface Specification)**
  - ***Part 2: SEDRIS Transmittal Format***
  - ***Part 3: SEDRIS Transmittal Format Binary Encoding***

- ***WD 18024: SEDRIS Language Bindings*** **– a multi-part standard, initially:** ***Part 4: SEDRIS Language Binding to C***

- ***WD 18025: Environmental Data Coding Specification (EDCS)***

- ***WD 18026: Spatial Reference Model (SRM)***

Additional ISO/IEC Standards

Two new standards to be nominated as:

- ***WD xxxxx: EDCS Language Bindings*** **– a multi-part standard, initially:** ***Part 4: EDCS Language Binding to C***

- ***WD xxxxx: SRM Language Bindings*** **– a multi-part standard, initially:** ***Part 4: SRM Language Binding to C***

Participating in ISO/IEC Standards

- **SEDRIS standards work assigned to *Joint Technical Committee 1 Sub-Committee 24 (JTC1 SC 24)***
- **SC 24 established *Working Group 8 (WG 8)* (Environmental Representation): SEDRIS work started October 1999**
- **ISO/IEC standards development steps: *Working Draft (WD), Committee Draft (CD), Final Committee Draft (FCD), Draft International Standard (DIS), International Standard (IS)***
- **National standards development organizations represent member countries in the ISO/IEC standards development, review, and voting process**
- **One vote per member country**
- **For more information see the following web sites:**

  http://www.iso.ch

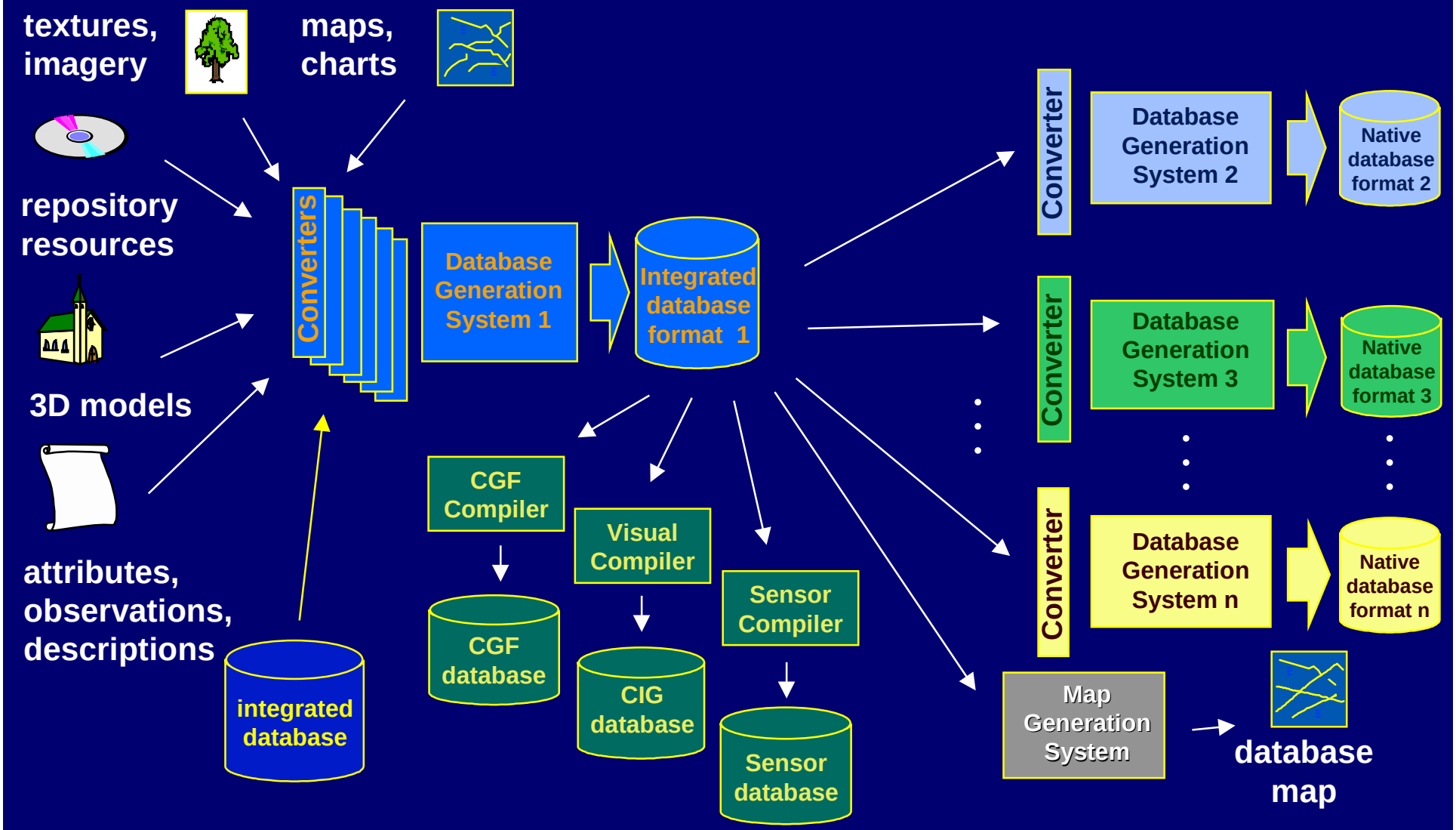
  http://www.jtc1.org

  http://www.bsi.org.uk/sc24

  http://www.sedris.org/wg8home

Database Generation Process

Database Generation & Sharing Today

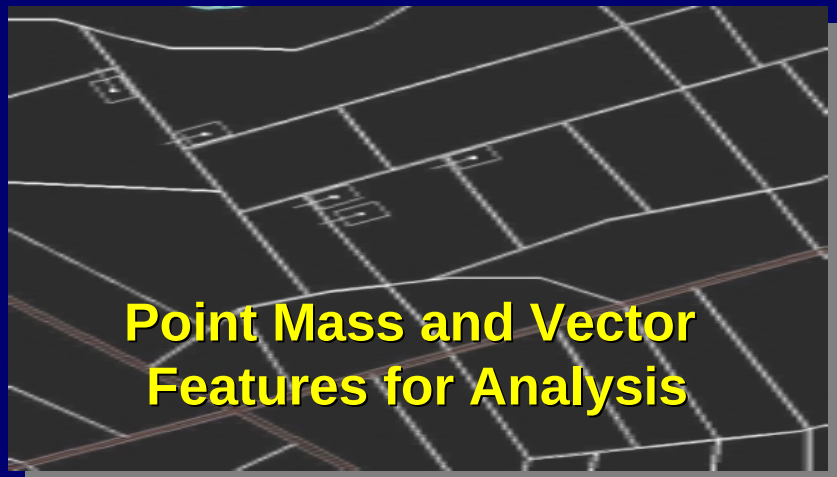


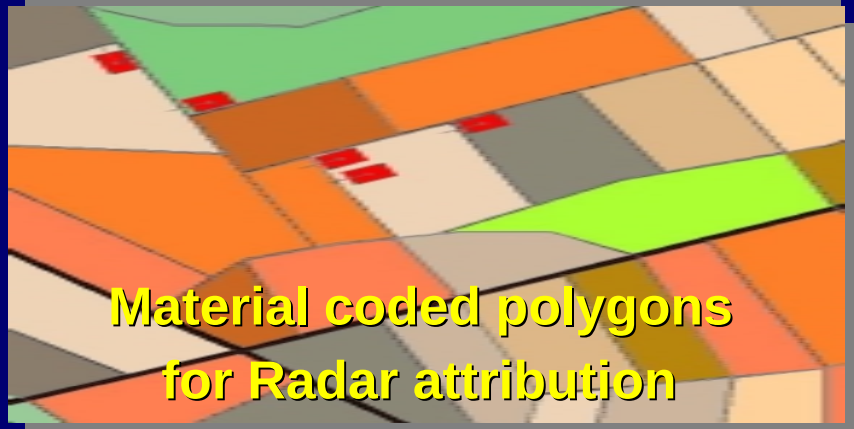
Integration of Source Data is Complex

- ❑ Various Elevation Data Grids
- ❑ Various Bathymetric Data Grids
- ❑ Terrain Analysis Products
- ❑ Multi-Spectral Data
- ❑ Image Products
- ❑ Various Nautical Chart Libraries
- ❑ Shoreline Data
- ❑ DCW — Digital Chart of the World
- ❑ Various Feature Databases
- ❑ Raster Graphics
- ❑ Coastline Profiles
- ❑ Regional Image Analyses
- ❑ Legacy M&S Databases

Feature Integration into Imagery

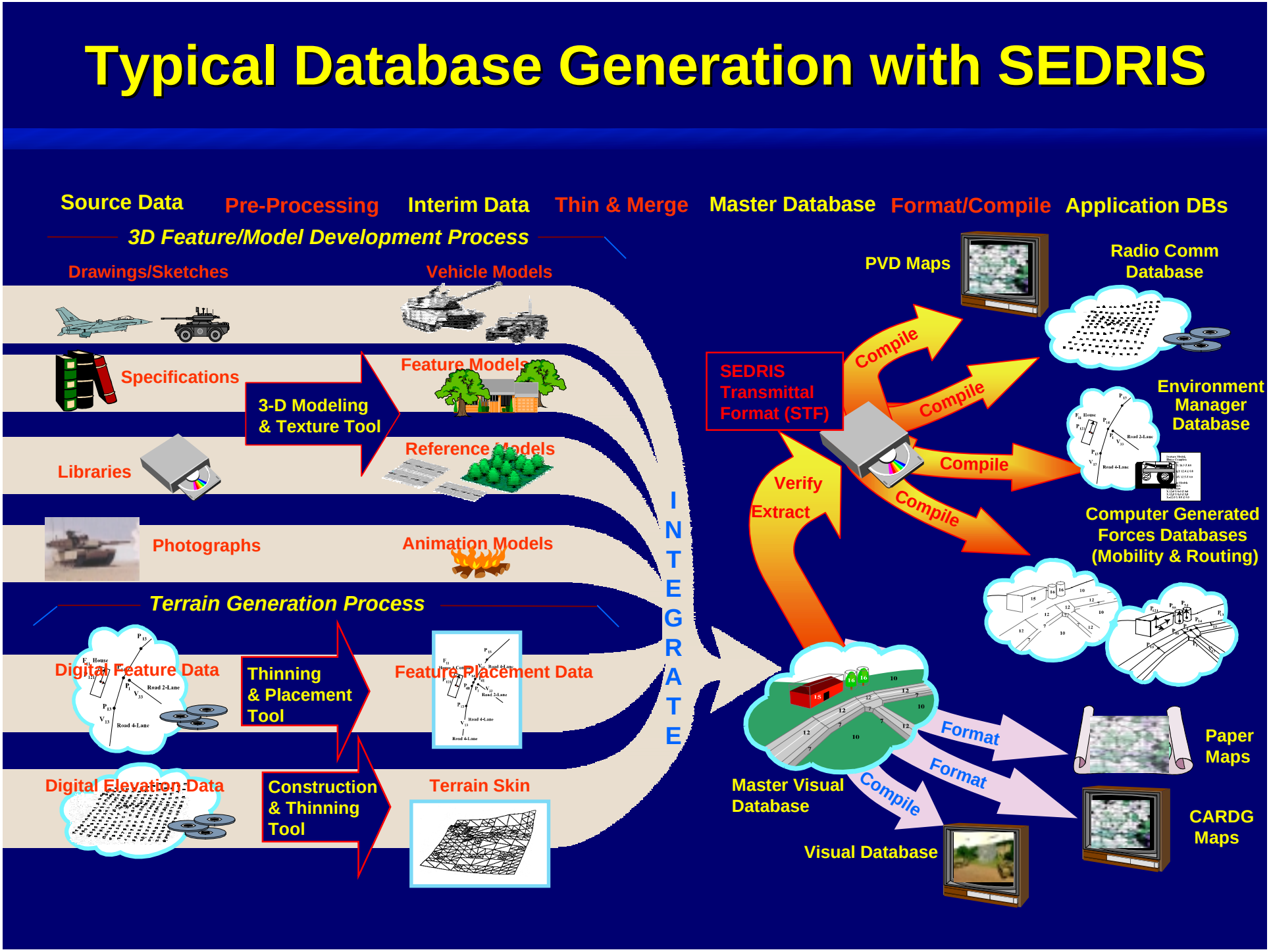
Multiple Representations, Multiple Uses



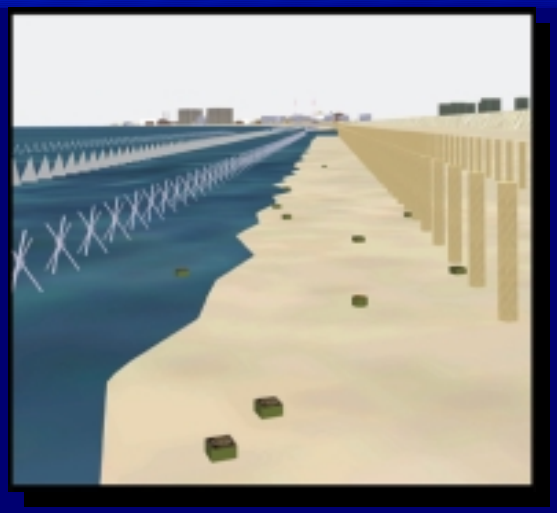


Multigen-Paradigm Database

Typical Database Generation with SEDRIS

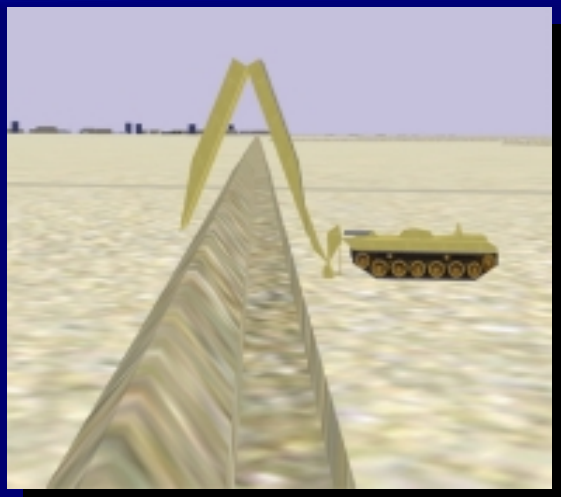


...Dynamic Environments...



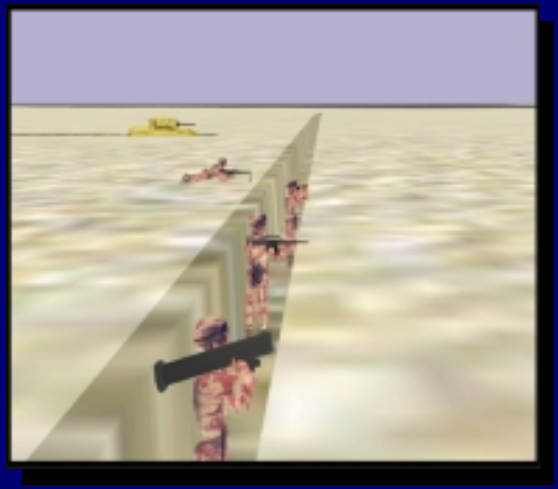
Obstacles

Survivability Positions



Anti-Tank Ditch Breaching

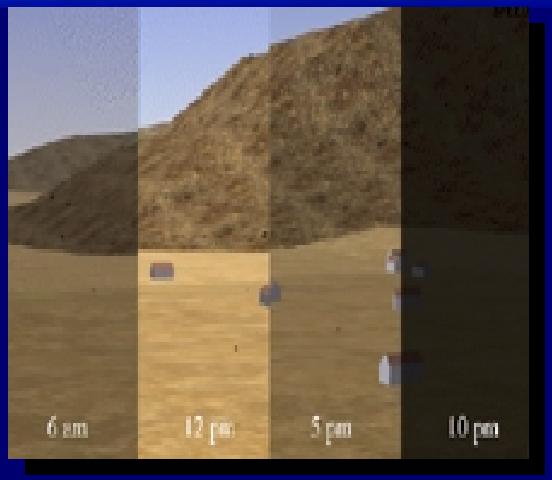
Minefield Breaching - Blade



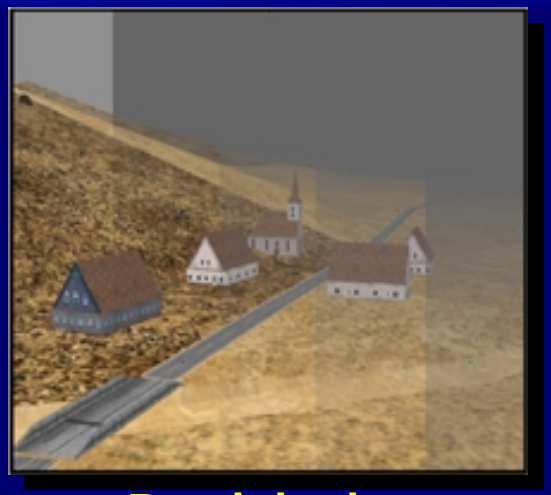
Infantry Trench

Dynamic Cratering

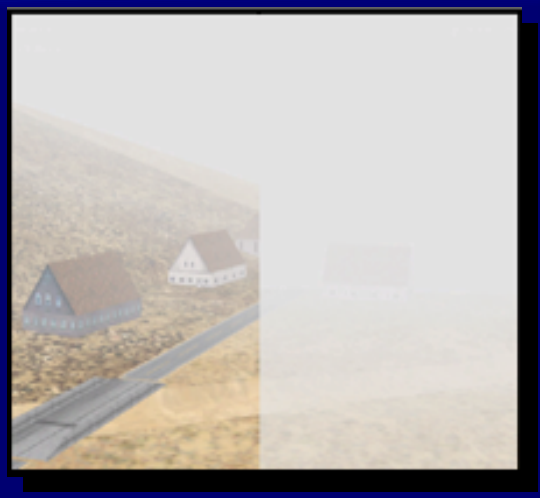
...and Environmental Effects...



Time-of-Day

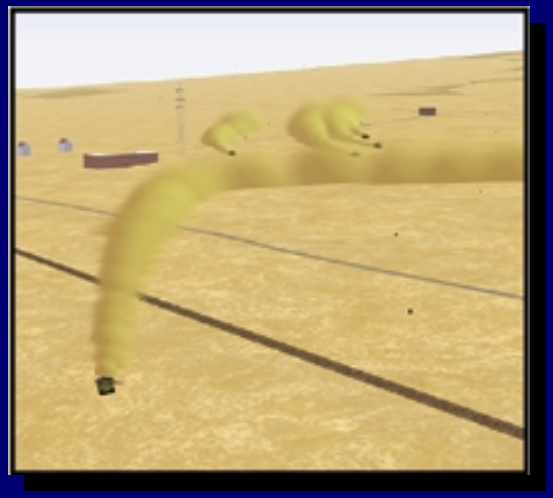


Precipitation

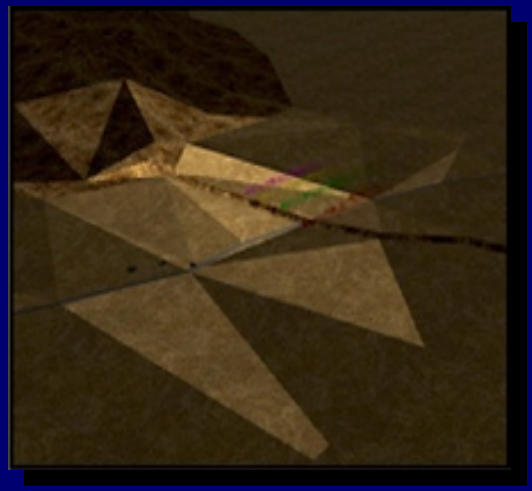


Haze

Clouds



Vehicular Dust



Signal / Illumination Flares

Atmospheric & Oceanographic Data

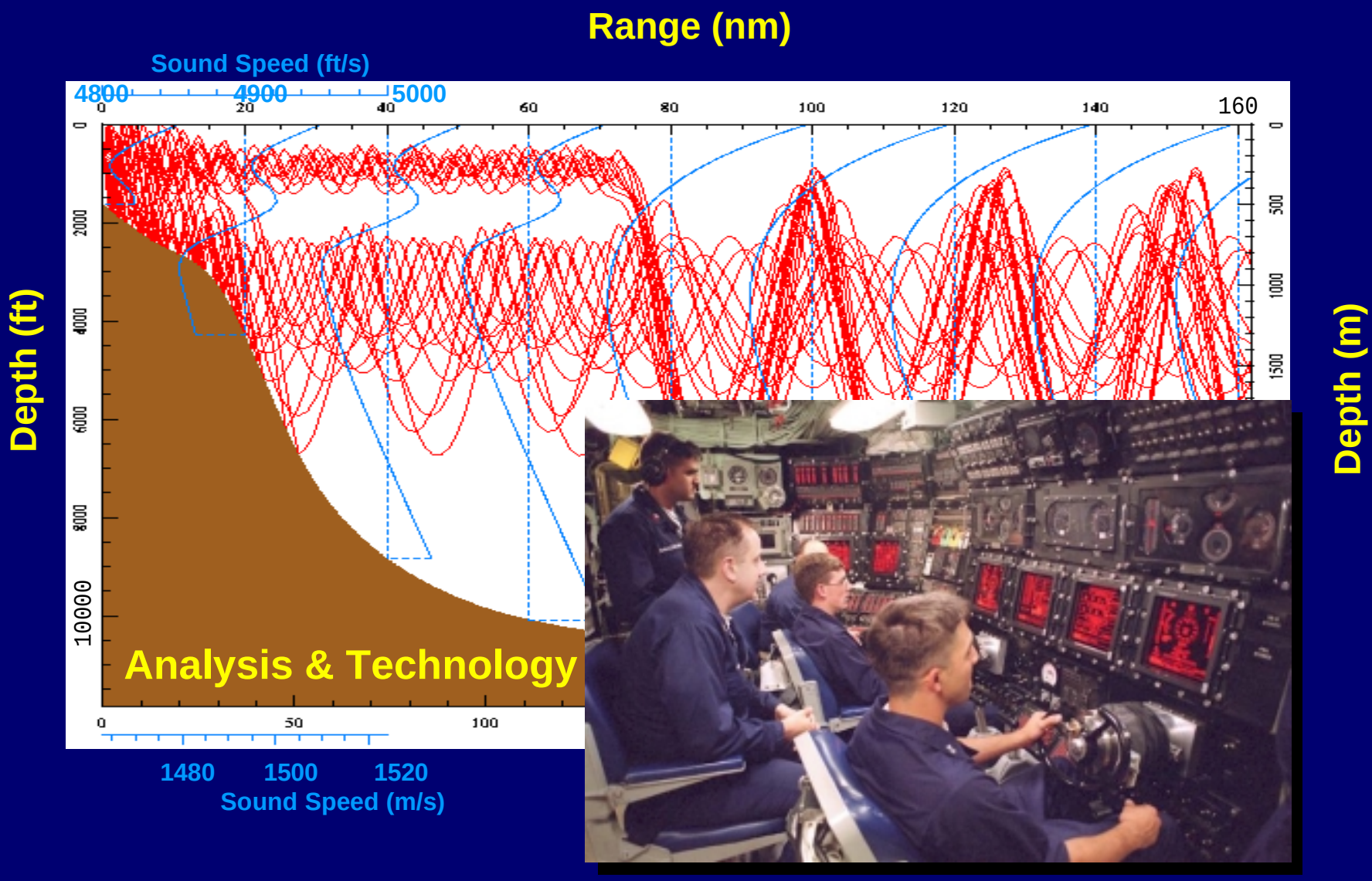
Characteristics of METOC Data

- Sampled values representing a continuous phenomenon
  - Gridded data, linear profiles, regional observations
  - Uniformly spaced time samples
- Complete representation usually requires assembling data from multiple sources and multiple files
  - 3-D, multi-quantity grids often disassembled into 2-D, one - quantity files
  - Observations, analysis, forecasts, scientific models
- Each source may use a different format
  - Ad-hoc based on sensor, numeric application, textual report, …
  - International standards: World Meteorological Organization (WMO)

METOC Data Sets

- Atmospheric Forecast Data
- Atmospheric Observations
- Ocean Forecast Data
- Ocean Observations
- Climatology
- Bathymetry
- Marginal Ice Zone
- Space Observations

Underwater Acoustic Ray Trace



Meteorology, Oceanography & Space Data

We need technologies to:

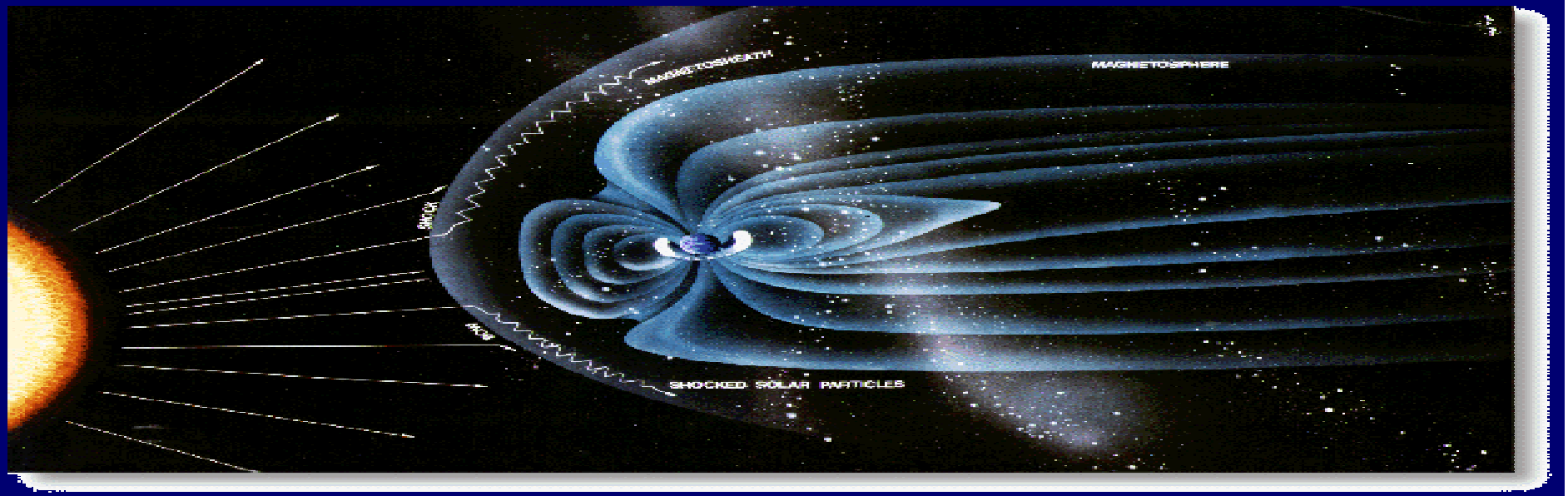
- Provide stronger and more explicit structuring of complex data formats, especially for data integration
- Eliminate consumer dependency on data format
- Provide more than one way to represent data

Atmosphere-Ocean Variables...

- Temperature
- Dewpoint
- Relative Humidity
- Wind U, V
- Precipitation Rate
- Precipitation Type
- Extinction Coefficient
- Extinction Amount
- Extinction Type
- Cloud Height (Base)
- Cloud Top
- Cloud Cover
- Cloud Type
- Surface Duct Height
- Evaporation Duct Height
- Surface Duct Intensity
- Evaporation Duct Intensity
- Ducting K
- Time of day (for ephemeris)
- Sea State
- Salinity
- Gulf Spectra
- Surf zone spectra
- Number of Waves
- Number of Frequencies
- Breaker Type
- Breaker Angle
- Sea Surface Temperature
- Wave Direction
- Wave period
- Wave Height
- Current Velocity
- Tide Level

Space Data Sets

- Ionospheric Scintillation
- Electron Density Profile
- Solar Energetic Particles
- Solar Electromagnetic Emissions
- Magnetospheric Plasma
- Geomagnetic Fields
- Solar Wind
- Auroral Emissions
- Interplanetary Magnetic Fields
- Auroral Precipitating Particles
- Cosmic Rays
- Auroral Electrojet
- Total Electron Count (Vertical)
- Neutral Density
- Trapped Energetic Particles

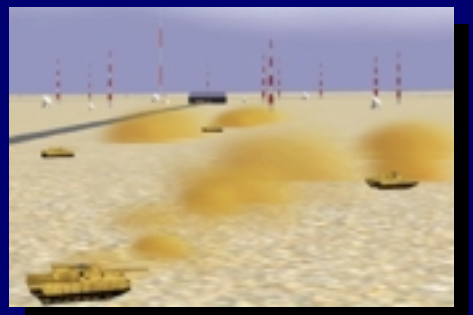


...Environmental Effects and Impacts

Gridded Weather

MICLIC Explosion

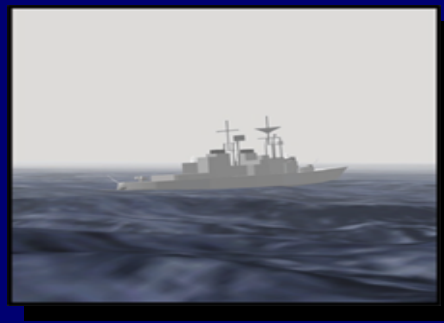
Natural Illumination (Haze / Horizon Glow)



Muzzle Dust

LCAC Spray

Deep Water Mine



Sea State

DARPA, Lockheed-Martin Databases

Critical Areas: Database Generation

- ***Source data:*** **good correlation and integration; quality data; timely access; low cost; standard access interface**
- ***Tools:*** **integrated and robust suite of tools**
- ***Sharing and reuse:*** **enables value-adding; requires standards for representation of information and interchange of data**

Some Key Things to Remember

- Database generation is a significant cost to information technology systems
- Creating good database content depends on many parameters, is non-trivial, and expensive
- Limited access to source data *(this will change!)*
- Efficient, well-integrated, and inexpensive tools needed to reduce database creation cost & time
- Sharing and reuse requires development of standards, and will promote value-adding

SEDRIS:

Technology Components

SEDRIS is about ...

- **Unambiguous representation of environmental data**
  - ***Data Representation Model:*** **Complex data elements in object-based model using Rumbaugh and Unified Modeling Language (UML) notation**
  - ***Environmental Data Coding Specification:*** **Well-specified data element definitions/semantics**
  - ***Spatial Reference Model:*** **Completeness, accuracy, performance**
- **Efficient interchange of environmental data**
  - ***Interface Specification:*** **Platform and language independent APIs, with reference implementation**
  - ***Transmittal Format:*** **Assures architecture neutral data exchange, when required**
  - ***Tools and applications:*** **Inspect, evaluate, verify, transform, ...**

What is a Data Representation Model?

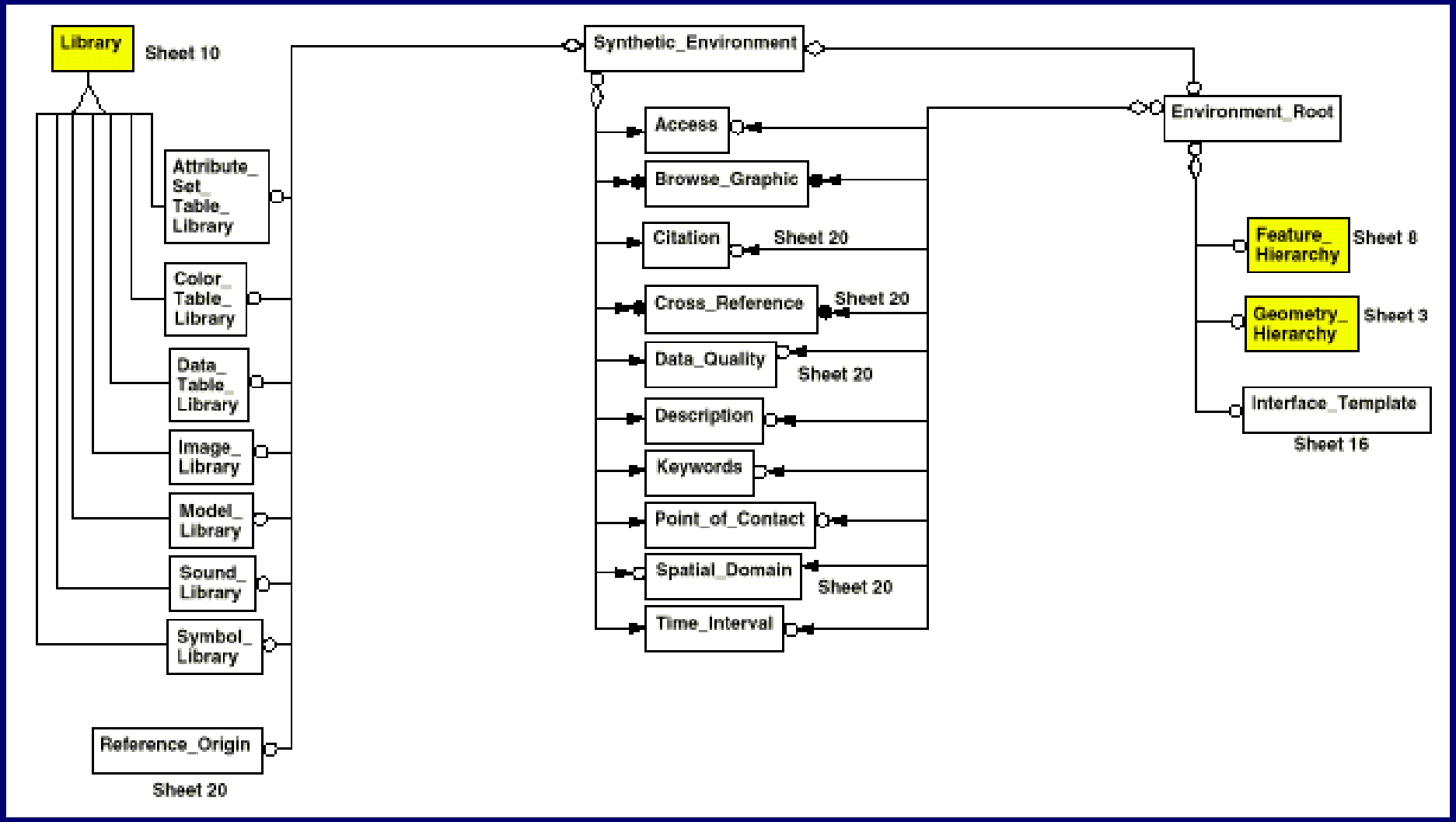
Data Representation Model

- Augmented Rumbaugh Object Modeling Technique & UML Notation
  - Abstract classes are shaded
  - Arrows are used on one-way relationships
- 340 Classes:
  - *Geometry* (surfaces: Point, Polygon, ...)
  - *Features* (abstractions: Point, Linear, Areal)
  - *Data Tables* (Property Table, Property Grid)
  - *Topology* (Feature/Geometry connectivity)
  - *Attributes/Components* (Colors, Locations)
  - *Organizers/Containers:*
    - Hierarchies (organize spatially, temporally, …)
    - Libraries (collections of reusable objects, including Sounds, Images, and Map Symbols)
- Associated Data Dictionary:
  - Machine parsed
  - Automatically derives HTML and various software files

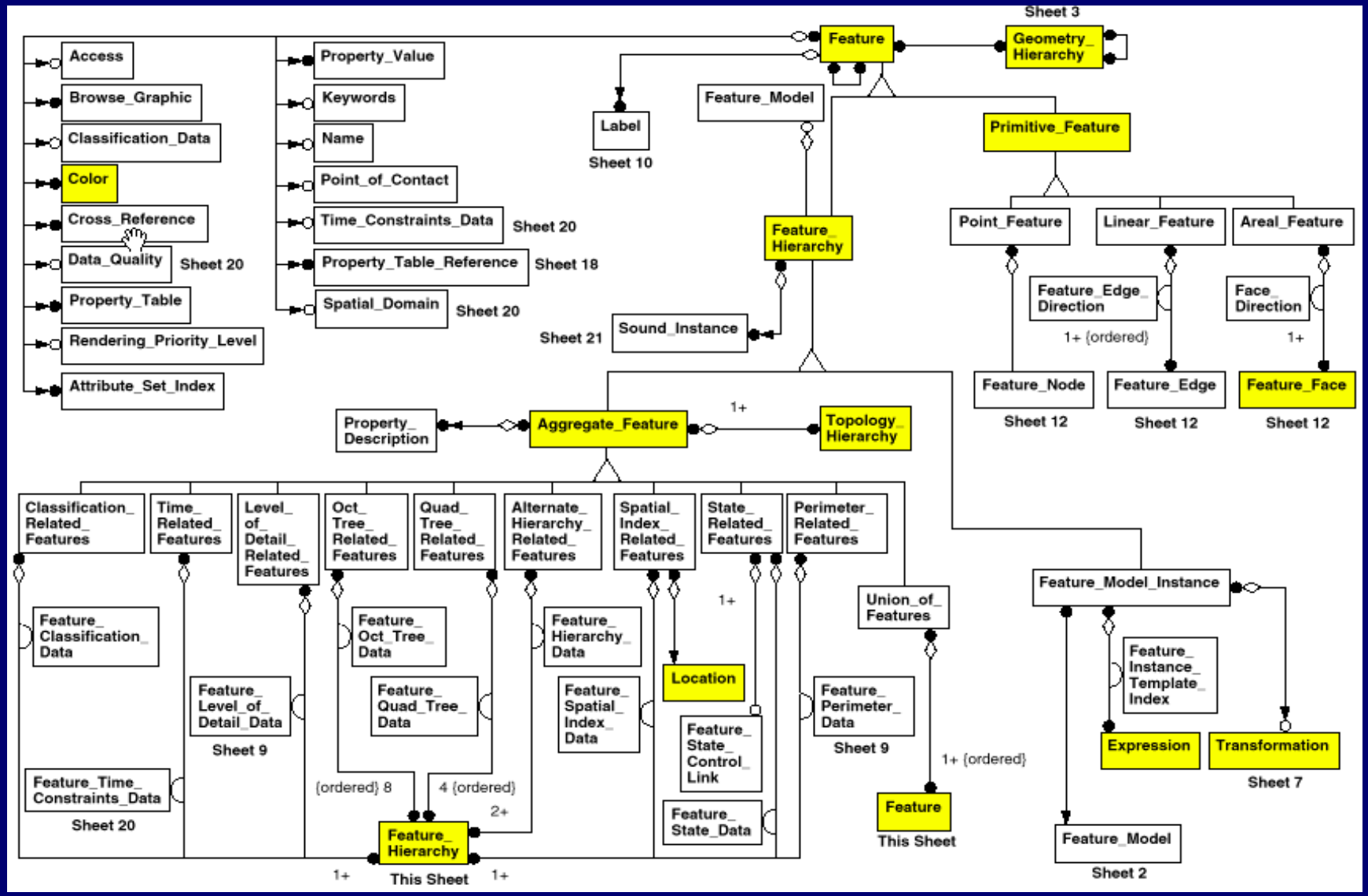
The DRM is Composed of ...

- ***Geometry type objects*** **Physical/surface representations of real world objects (ie: 3D polygons, patches, lines, and points)**
- ***Feature type objects*** **Represent higher level abstraction of real world objects (ie: areal, linear, and point features)**
- ***Topology*** **Concise, mathematical definition of inter-Feature or inter-Geometry object relationships**
- ***Attributes*** **(ie: location, time, color, sound, width, etc.)**
- ***Libraries*** **Store copies of any instanceable object**
- ***Explicit relationships*** **Among feature objects, geometry objects, or between feature and geometry objects**
- ***Organizational schemes*** **Allows for well-described hierarchical configuration of geometry and feature objects**

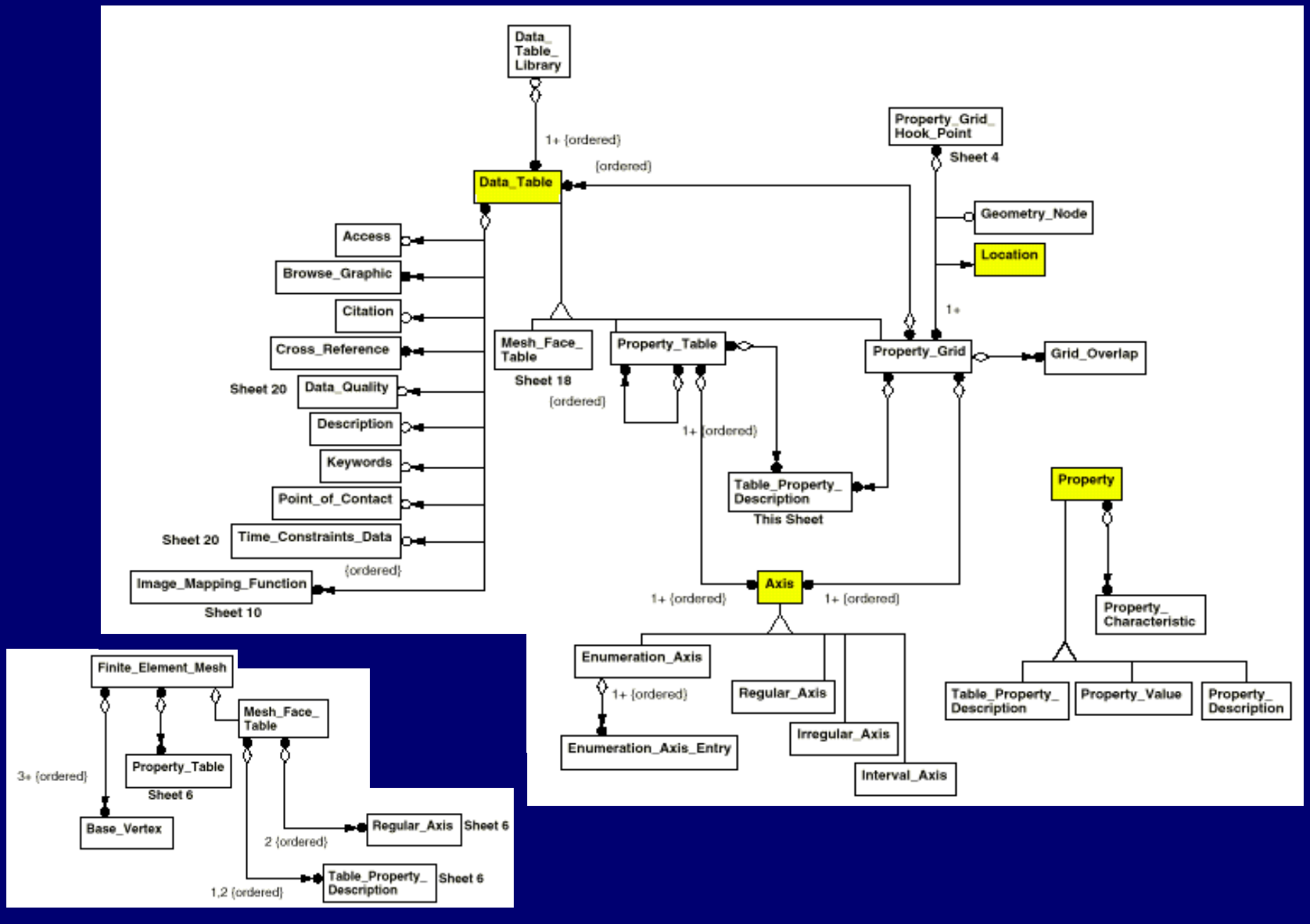
Synthetic Environment (example)



Features (example)



Data Table & Finite Element Mesh (example)



What is an Environmental Data Coding Specification?

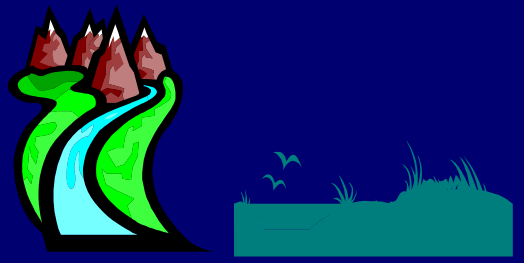
Data Coding Specification

- **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:**
  1. ***What is it?***
     → **EDCS Classification Code (ECC)**
  2. ***What are its additional clarifying characteristics?***
     → **EDCS Attribute Code (EAC)**
  3. ***What are its characteristic measures?***
     → **EDCS Unit Code (EUC)**

ECC: Classifications (and Features)

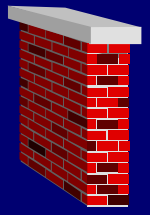
What is it?

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

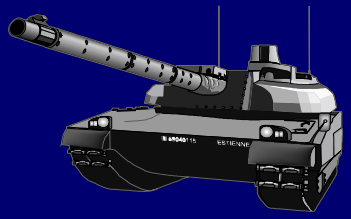


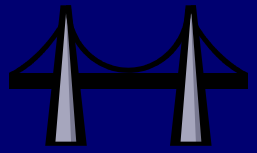
Weather?

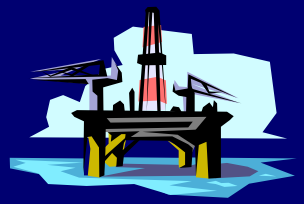
Landscape?



Water?







Vehicle?

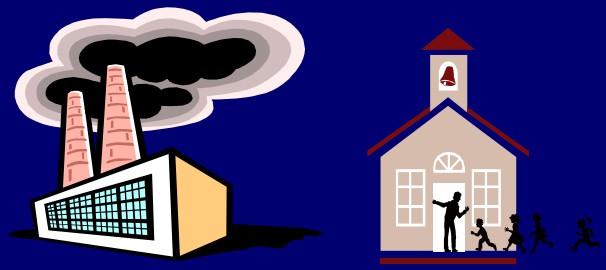
Structure?

Celestial?

EAC: Attributes (and Values)

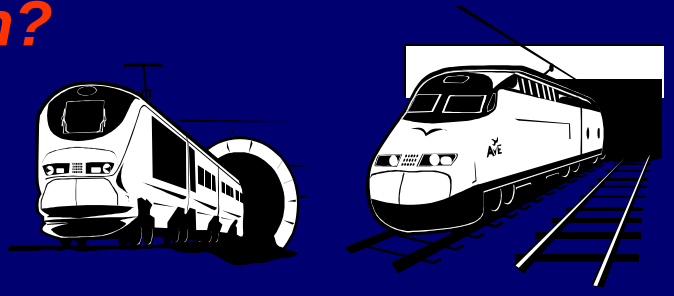
What are its additional clarifying characteristics?

lighthouse, 1.5m, red, coral



Building Function?

Vegetation Type?

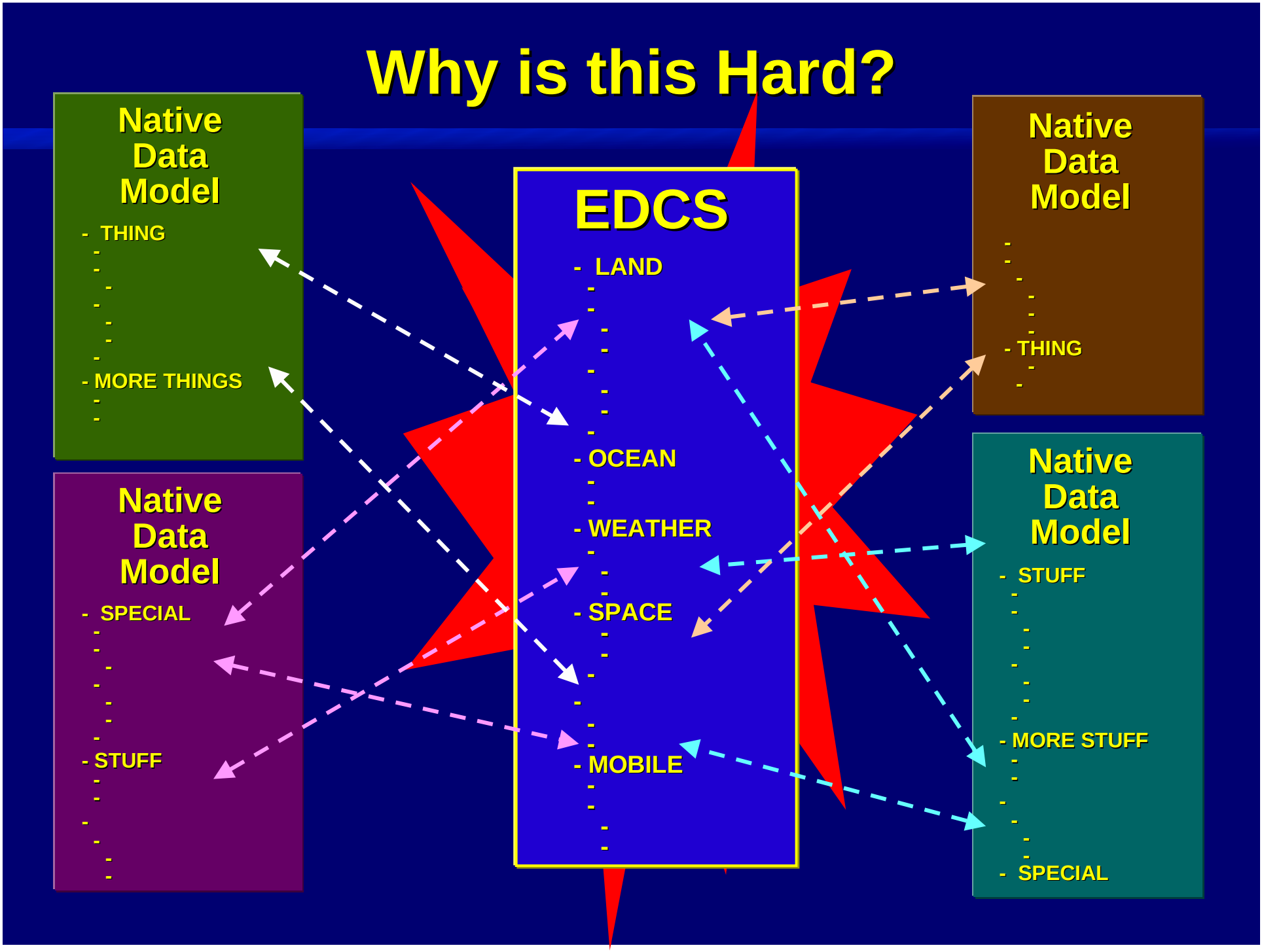


Overhead Clearance?

Units

- **Observed problem in related specifications (e.g., DIGEST)**
  - **Unit specification gets "bound" into attribute code**
  - **Leads to alternative codes for the "same thing"**
    - **LEN_ Length/Diameter meter 32 bit integer**
    - **YLN_ Length of Greater Precision decimeter 32 bit floating point**
- **EDCS adopts the ISO International System of Units (SI)**
  - **Reference: *http://physics.nist.gov/cuu/Units/index.html***
  - **Defines:**
    - **Seven *SI base* units**
    - ***SI derived* units**
    - ***SI supplemental* units (radian and steradian)**
    - ***SI scaled* units based on standard prefixes**
    - ***SI associated* units outside the SI, but are important and widely used**
    - ***Temporary* units outside the SI but currently accepted for use with the SI by NIST. Their continued use is not encouraged.**
- **EDCS is completing migration to full SI compliance in this area**
  - **Will allow only units of the correct "type" to apply to each EAC (e.g., measures of length vs. mass**

Why is this Hard?



Consumer: Finding Desired Objects

The EDCS includes a classification code for Dam/Weir which seems the most natural classification for this object instance …
but ...

… a closer look reveals

A major roadway travels across the top of the Dam: Therefore, should:

This dam be classified along with bridges or roadways?

All dams be grouped with bridges?

Dams have a bridge attribute?

Context ...

One system's error ...

... is another system's design

An Expressway Overpass

Bridge or Overpass

JFK Airport

But…the overpass is also a taxiway

Which usage is most important?

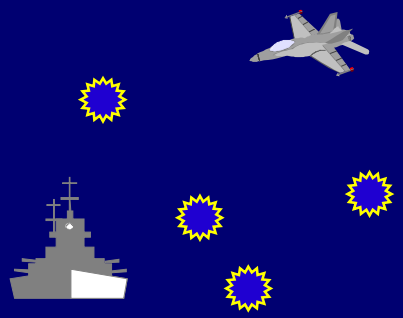
How should it be classified?

EDCS Summary

- **Addresses methodology and content - *covers full range of environmental data***
- **Methodology separates meaning (semantics) from representation (syntax) - result is applicable to *any* representation**
- ***Fully defined* - no optional items**
- **Full methodology for handling *units* builds on ISO SI compliance**
- **Provides *organizational* mechanism (e.g., feature and attribute groups)**
- **Mechanisms for incremental extension (e.g., *Registration of new items*)**
- **Reference implementation and functionality**

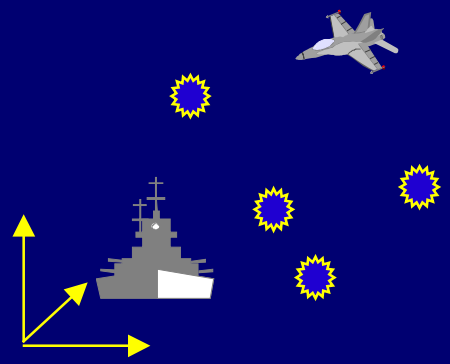
What is the Spatial Reference Model? (SRM)

Representation begins with Location ..



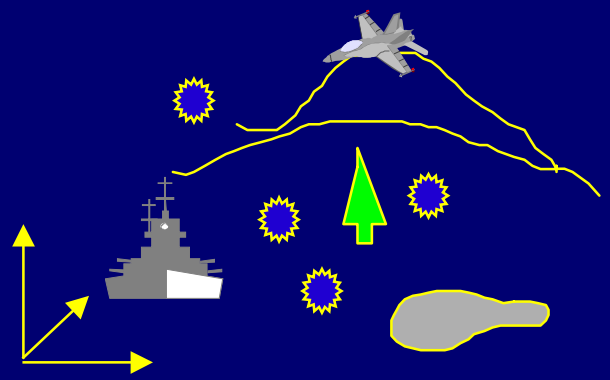
Systems

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 advantage, or disadvantage, ...

Defining and using a consistent spatial reference framework is critical for M&S interoperability

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

Spatial Reference Model Requirements

- ***Completeness:***
  - **Include coordinate systems in common usage**
  - **Tie those systems together into a common framework**
  - **Educate the system developer** (e.g., What's a horizontal datum? A vertical datum?)
- ***Accuracy:***
  - **Generally higher than required for C4ISR systems**
  - **Typically better than 1 cm up past geo-synchronous orbit**
- ***Performance:***
  - **Computation speed - Never fast enough!**
  - **Support environmental data sets dominated by location data**
  - **Reduce costs for simulation using heterogeneous coordinate systems (spatial reference frames)**

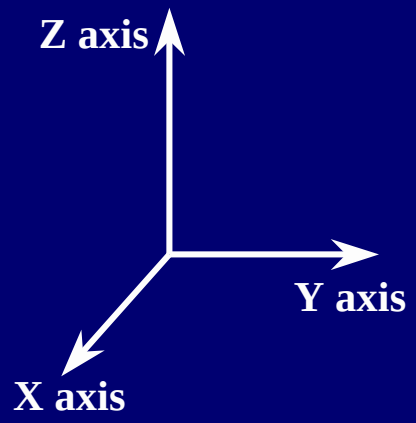
Spatial Reference Frames

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

SEDRIS Spatial Reference Frames



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	

The SEDRIS Interface Specification

Interface Specification

- **An encapsulation of the functionality required to produce and/or consume SEDRIS Transmittals**
  - **Provides a consistent interface between a user's (either data provider or data consumer) software application and SEDRIS transmittals**
  - **Decouples user's application from transmittal data structures**
  - **Allows:**
    - the Data Representation Model,
    - transmittal mechanism-specific data structures, and
    - user's applications – to evolve relatively independently
- **Bound using ANSI C**
  - **Reference implementation(s) in C++**
  - **Other bindings (e.g. Java, Ada95) are straightforward**
- **Multi-platform: Win9x/NT (Intel), Unix (Sun, SGI, IBM RS6000)**

Interface Functional Organization

Four categories of functionality:

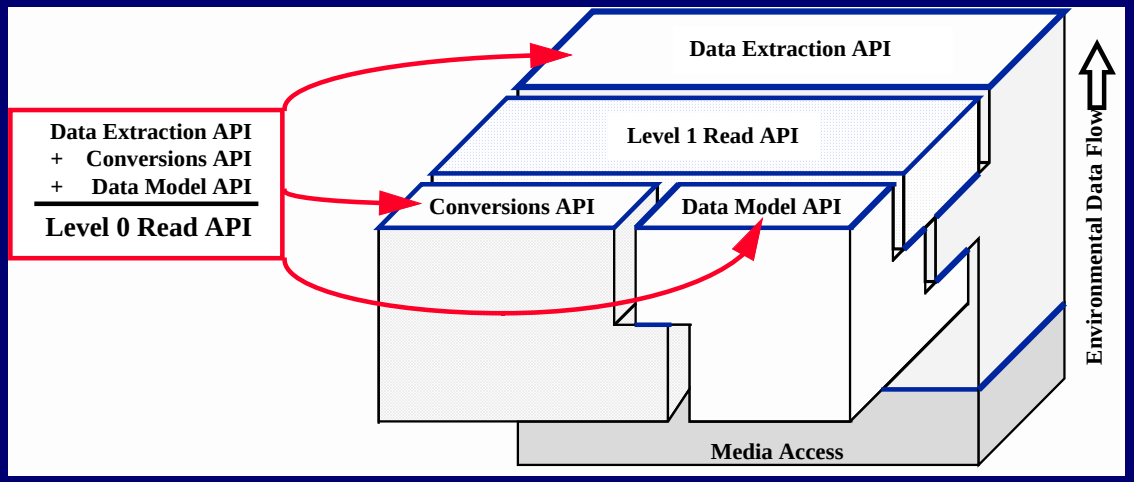
- ***Data Conversion*: Conversion of data from one representation to another (coordinates, colors, and units of measure)**
- ***Data Representation Model*: Access to meta-data describing the DRM including all its data types, object classes, and object relationships.**
- ***Data Extraction*: Access to DRM objects and data contained in a SEDRIS transmittal**
- ***Data Insertion*: Create and modify DRM objects in both new and existing SEDRIS transmittals**

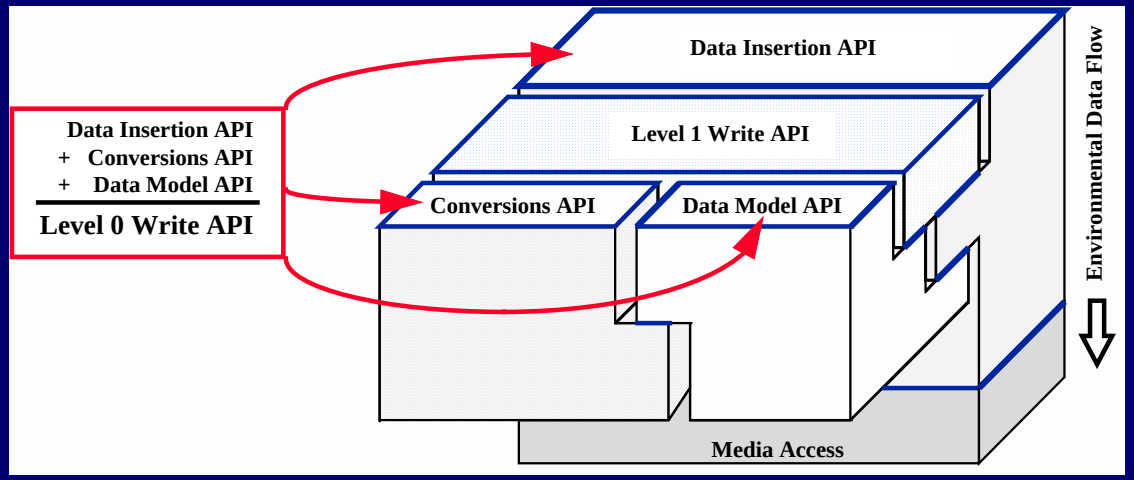
Design intentionally uses common access methods across almost all data representation model classes

Interface Structural Organization

For extraction and insertion, there are two levels of encapsulation:

- ***Level 0:*** provides data access / transfer with no derivation of data
- ***Level 1:*** a collection of functions that provides data that is derived or abstracted from information provided by level 0 functions





SEDRIS Transmittal Format (STF)

Transmittal Format

- Platform independent mechanism for interchanging SEDRIS transmittals via file-based media
  - Specification: the layout and interpretation of bytes on media
  - Software: a reference implementation of the SEDRIS API which extracts and inserts data into STF transmittals
- STF is *not* a library or repository of environment data
  - It merely facilitates the creation/management of such a repository
- Evolution synchronized with the SEDRIS DRM and API
- Useful when the interchange process precludes the use of producer-specific software during transmittal consumption owing to:
  - Platform incompatibilities
  - Need for independent legacy support
  - Run-time performance & resource requirements

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**
- ***Leverage Existing Format Standards where it makes sense:*** **Images and Data Tables**

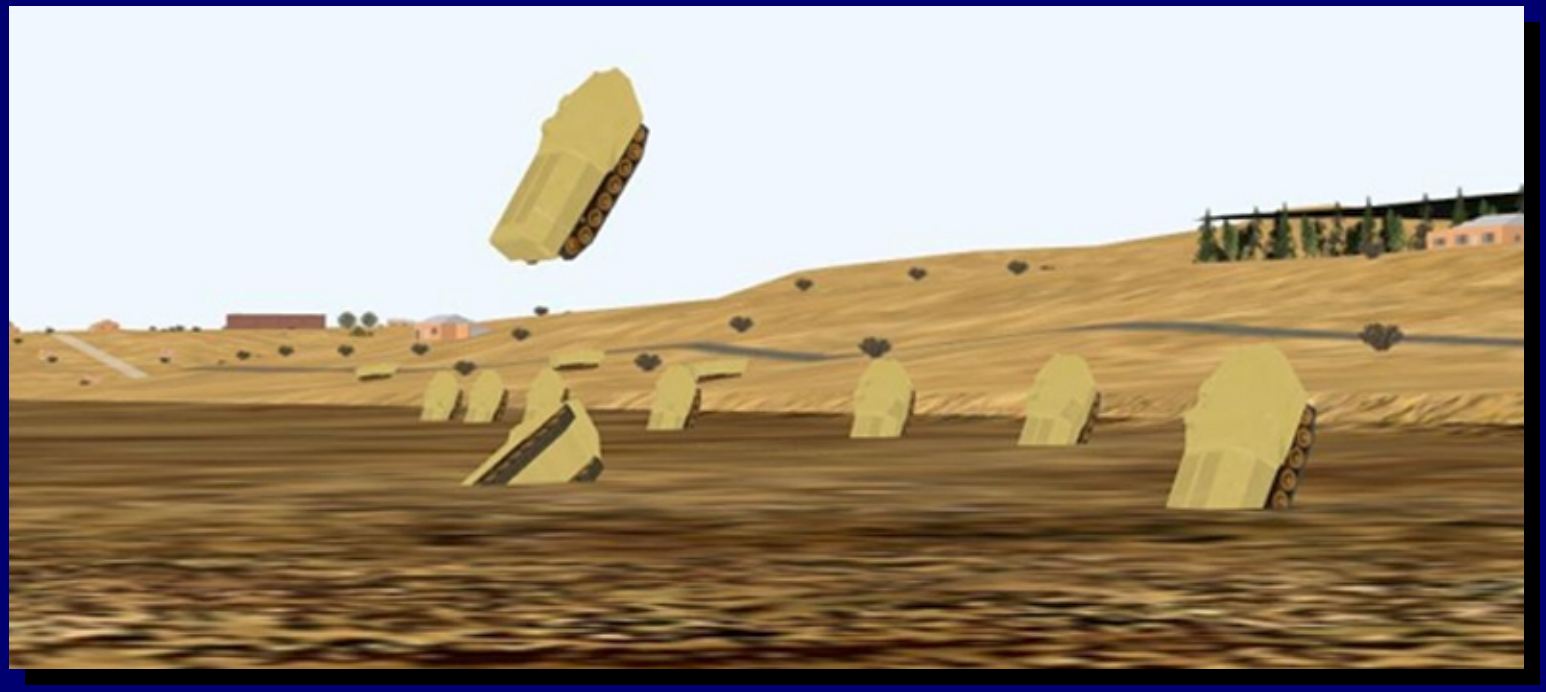
STF Design Features

- ***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 can 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**
- ***Abstracts system services to simplify portability:***
  - **Marshals system resources**
  - **Supports platform specific tuning to enhance performance**
- ***Supports "composite" objects to reduce overhead***
- ***Supports quick culling when search filters include rules specifying the object type***

SEDRIS:

Applications

Synthetic Environment Evaluation - Inspection Tool



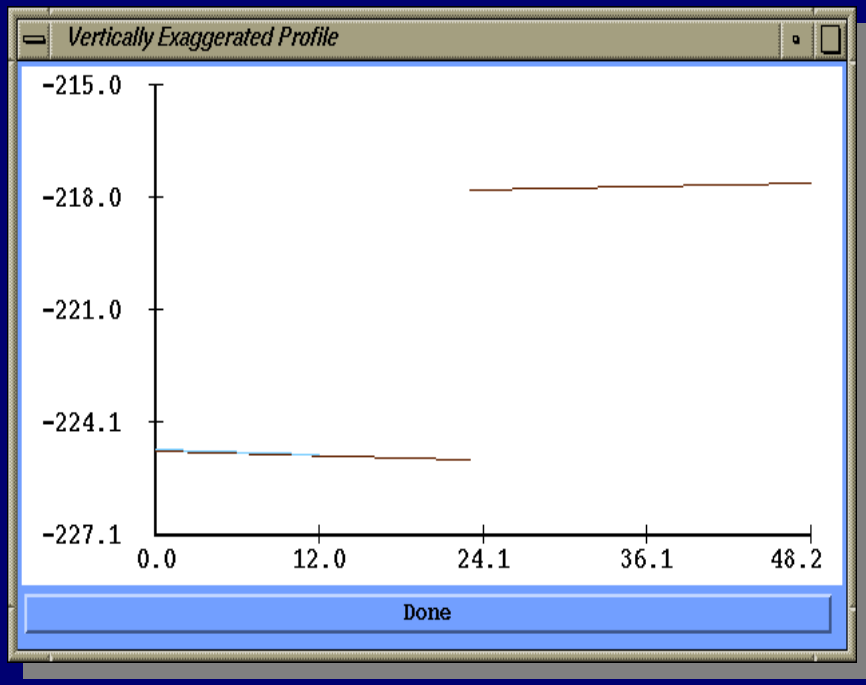
Why care about Environment Database correctness?

Example: Observed ModSAF landing craft behaviors in an area identified by SEE-IT as having undesirable topology constructions

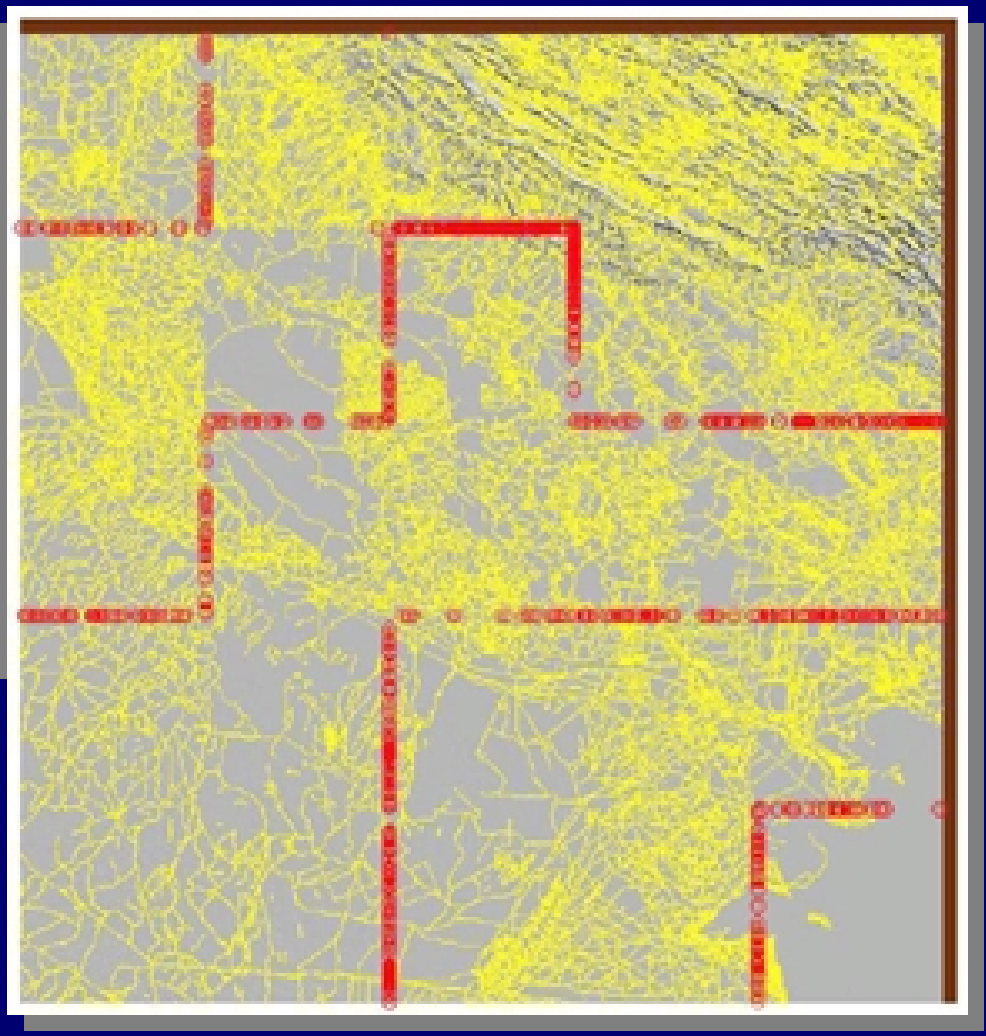
Automated Inspections Must Check?

- ***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

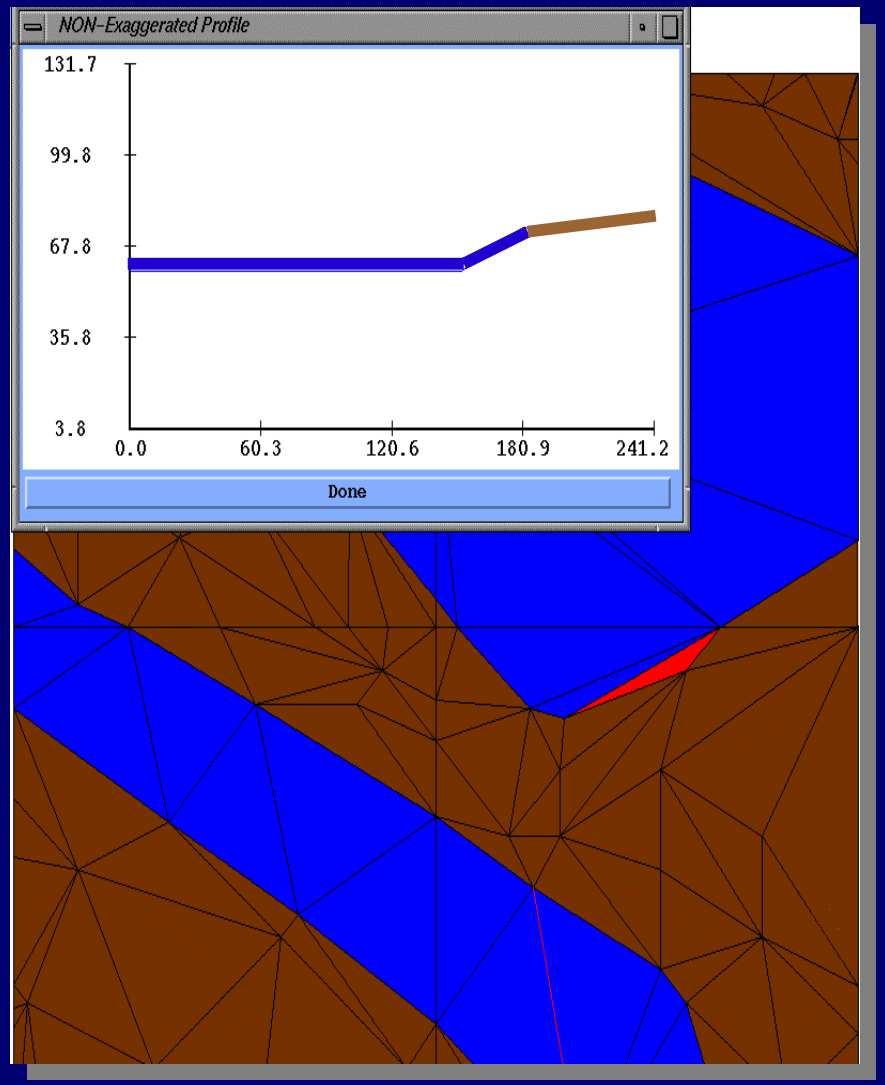


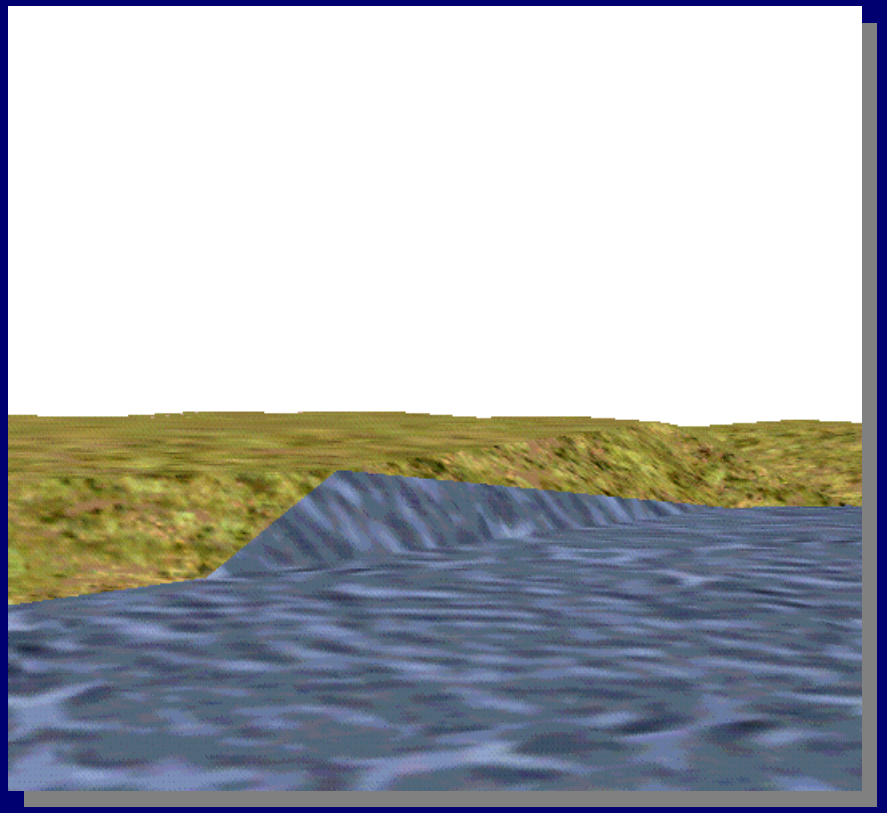
Cross section of a single tear instance; some tears reached 140m in magnitude



500Km X 500Km terrain skin

Water Surface Polygon with High Slope

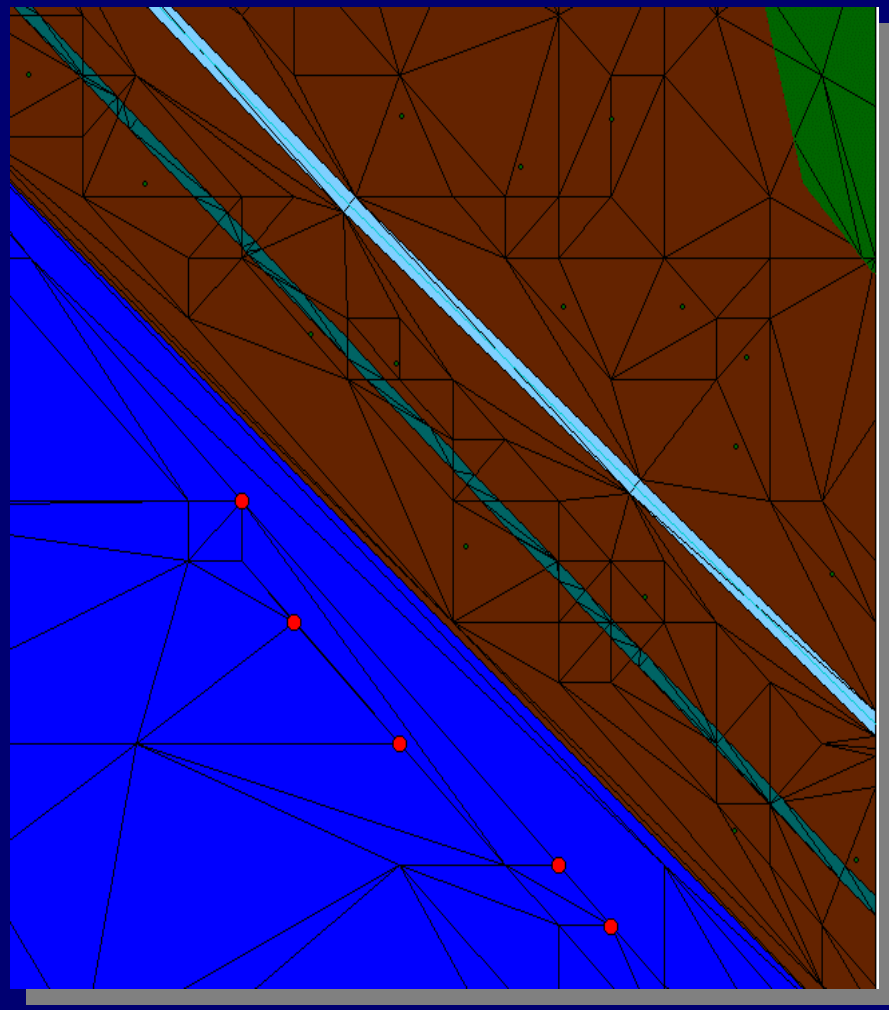




Also appears in the out-the-window view

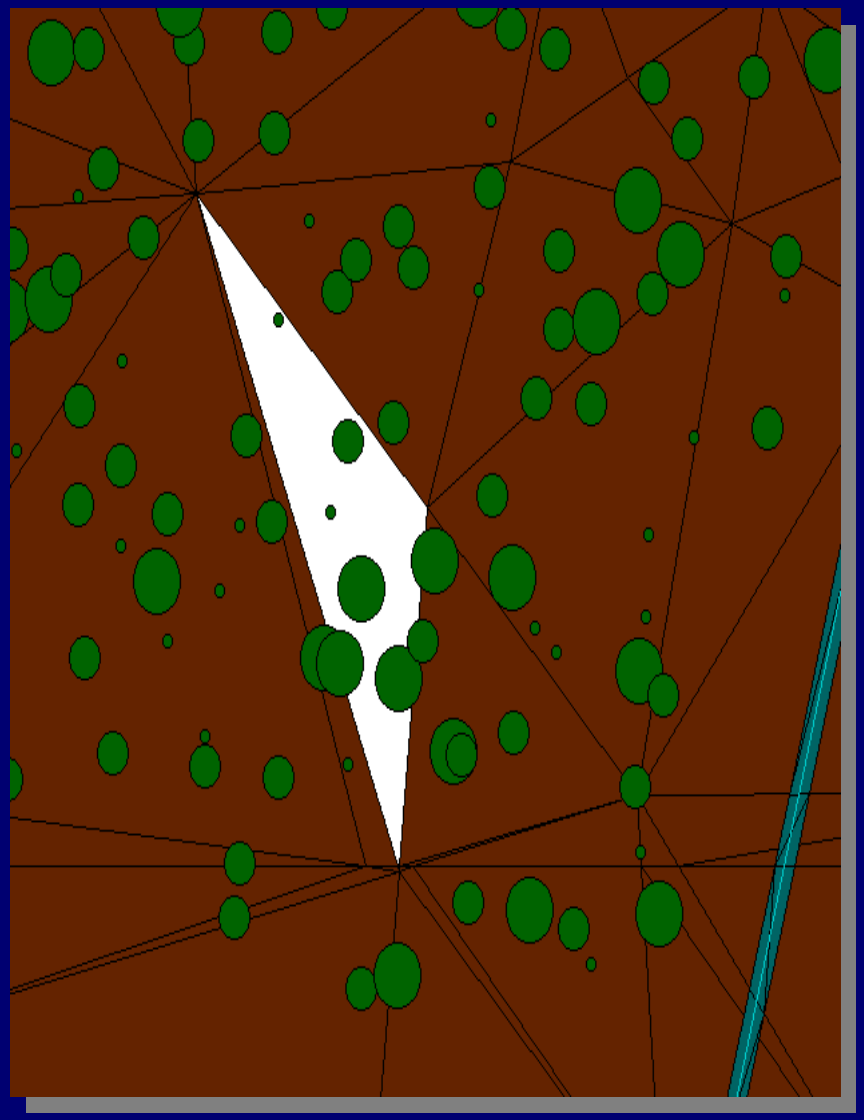
‘T’ Vertex Topology

Bathymetric Data Surface



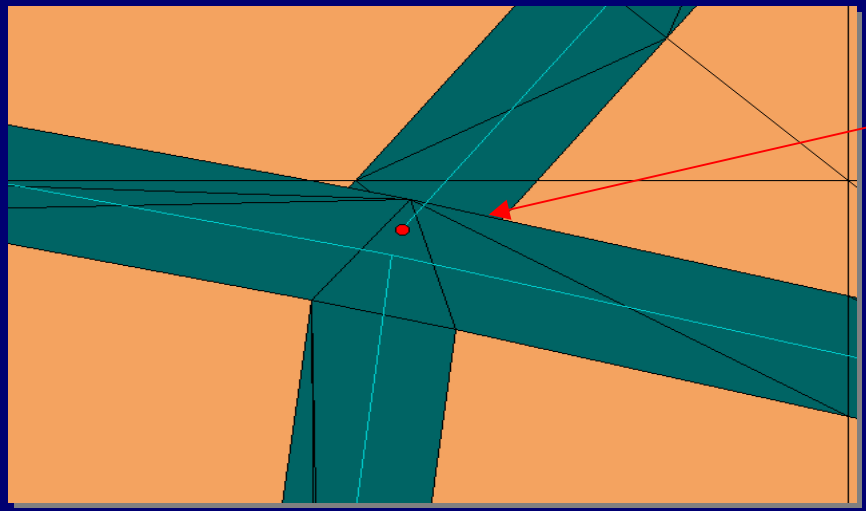
Resulting ModSAF Behavior

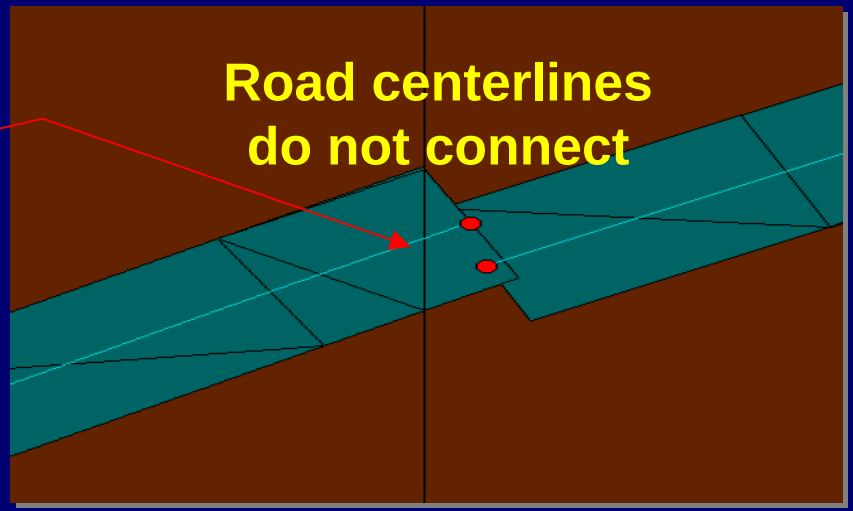
Topological Hole in the Terrain Surface

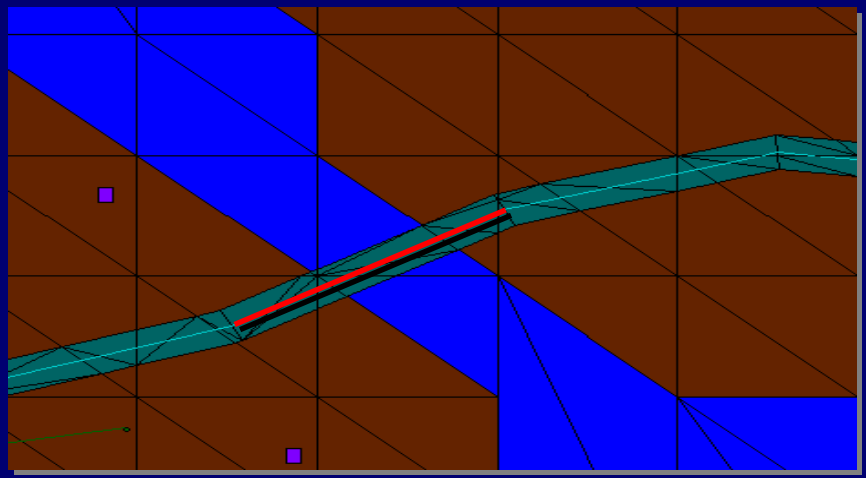


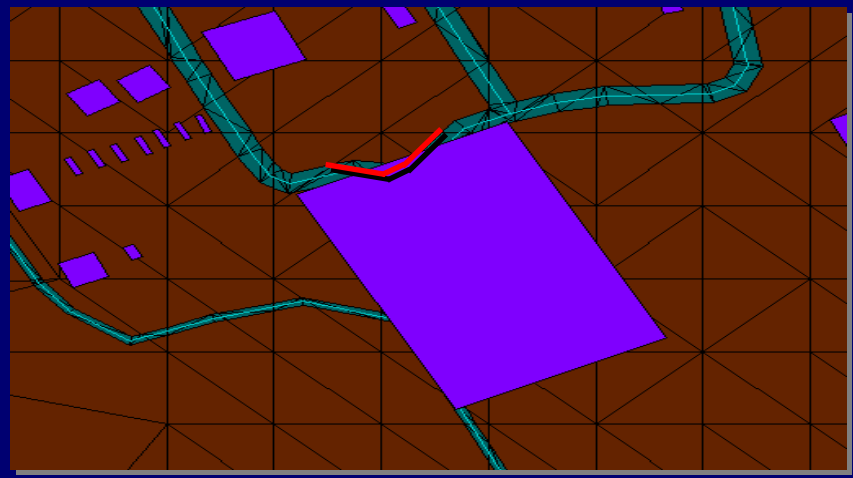
Also appears in the out-the-window view

Connectivity Problems





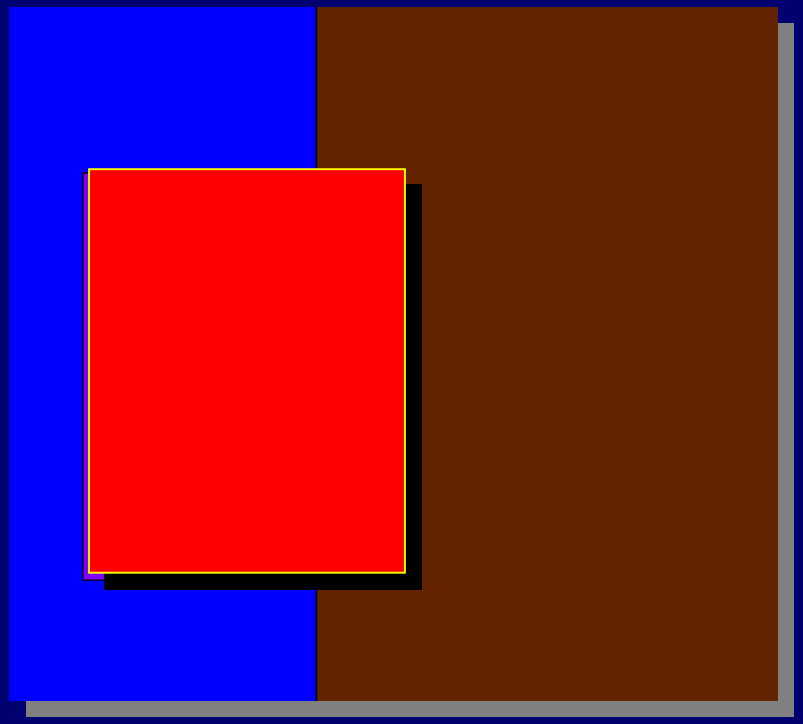


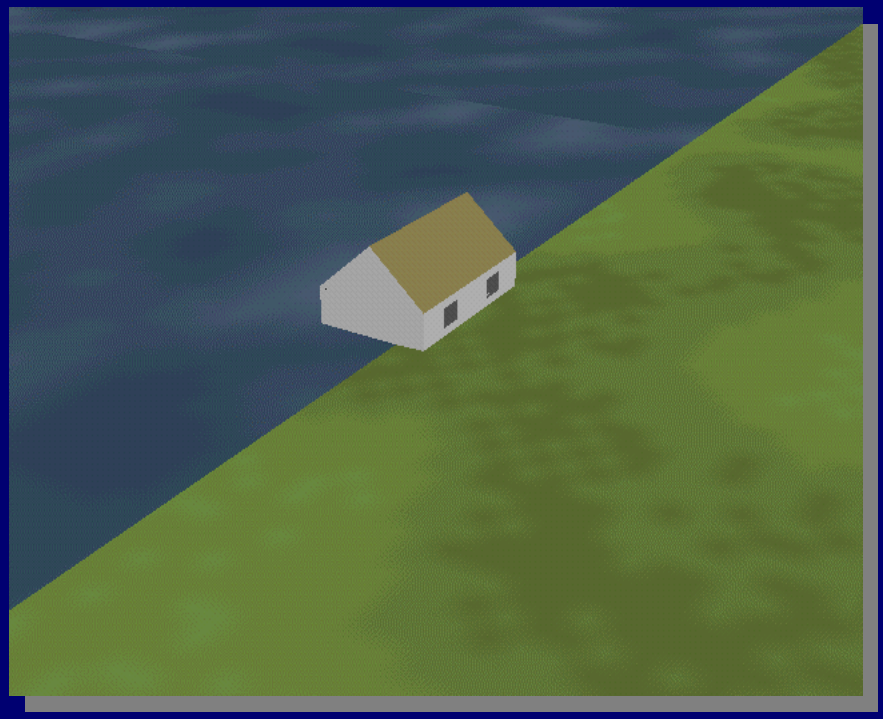


Road intersects water feature without a bridge

Road intersects a model bounding volume

Model Placed on both Land and Water



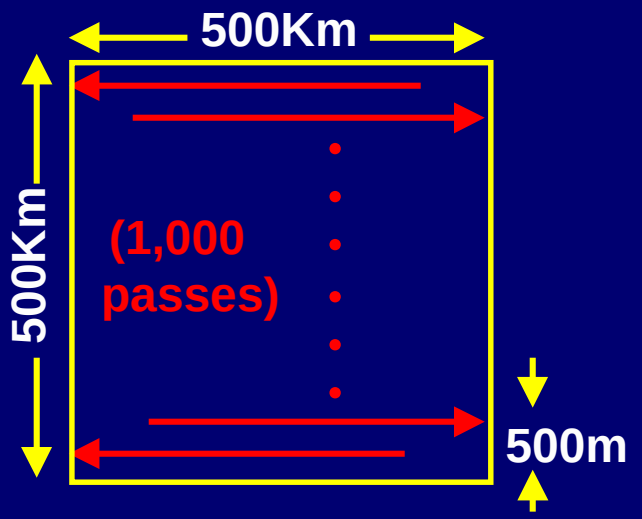


Also appears in the out-the-window view

Comparison with Current Practice

Current Practice:

- Send a vehicle back and forth across the database to locate vehicle - specific problem areas
- Parameters: **One pass each 500m**
  500Km x 500Km database
  Vehicle speed - 'S' KMPH
- Time required to traverse the database:
  (1,000 passes X 500Km / pass) / 'S' KMPH



Vehicle Speed (KMPH)	20	40	60	80	100	200
Time (hours)	25,000	12,500	8,325	6,250	5,000	2,500
Time (days)	1,050	525	350	250	200	100

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

SEE-IT: 45 minutes to examine the entire 250,000Km² database
(inspected ~2.5M polygons plus numerous non-polygonal features)

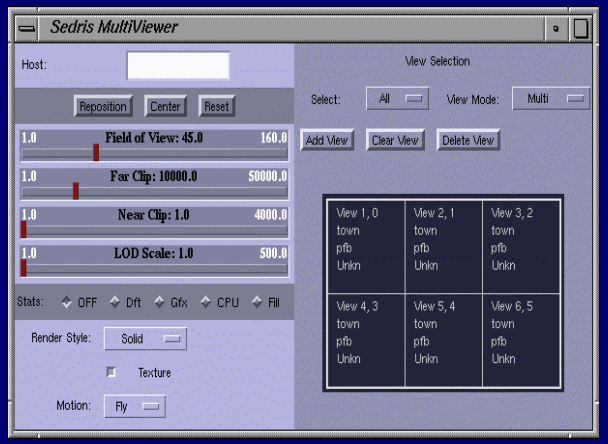
A factor of 25,000X improvement!

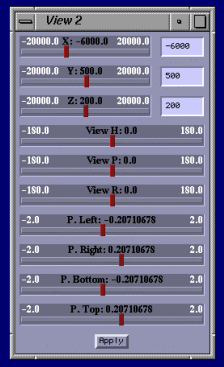
SEDRIS Model Viewer

- 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

SEDRIS Side-By-Side Viewer

- Database Comparison
- Database Correlation
- SEDRIS Validation
- Configuration Control





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, wireframe, shaded (averaged texture)
- Java-based Graphical User Interface

Sample Screen Shots

Model View

Silicon Graphics Inc. (SGI) O2
CCTT M1A2, E&S GDF format

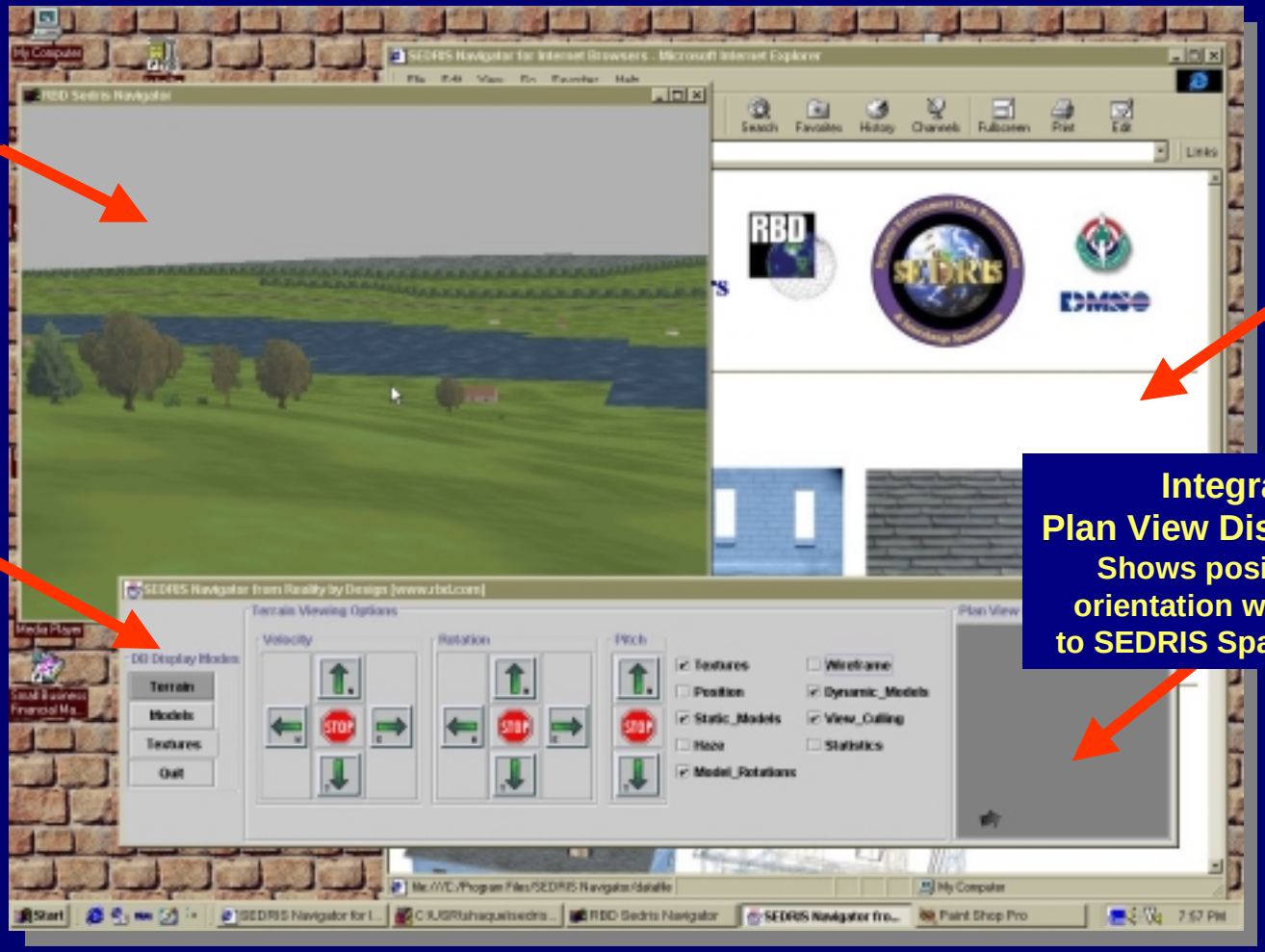
Texture View

NT 400MHz PII, FireGL 1000Pro/AGP
Ft. Benning MOBA database (S1000)

Terrain View

Windows ’95, 3Dfx chipset (Quantum 3D)
AUSA95 (SEDRIS Transmittal Format)

Sample Screen Shots



METOC Data Demonstration

SEDRIS Wind Map

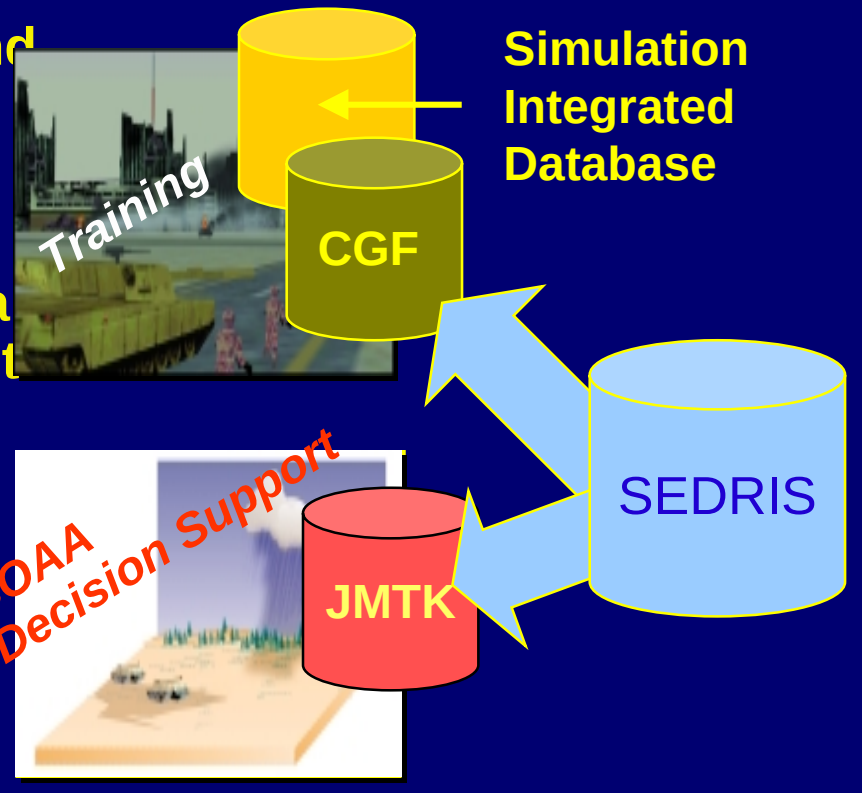
Demonstrates the ability of the SEDRIS Transmittal Format to accept and manipulate the atmospheric data content carried by the international GRIB meteorological standard distribution format. The wind map program reads data from a SEDRIS transmittal, via the SEDRIS Read API, for display using a graphics viewer.

Ocean Profile Viewer

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

SEDRIS Today is ...

- A key component of the Integrated Natural Environment Authoritative Representation Process (INEARP)
- Cited in the DISA Joint Technical Architecture
- Targeted by M&S Offices for Military Department adoption *(AMSO (already STRICOM policy) and NAVMSMO - AF-XOC / AFAMS investigating)*
- Developing a Global Command and Control System (GCCS) Joint Mapping Toolkit (JMTK) interface
- Developing formal standards
- Cited in the NATO M&S Master Pla targeted for STANAG development *(Armaments Group)*
- Targeted for ABCA QSTAG development *(Australia)*



Summary

SEDRIS is:

- An integrated collection of tightly coupled technologies that allow complete and unambiguous representation of environmental data
- An infrastructure technology that can be used in many applications
- An open development process and has benefited greatly from the significant contributions of practitioners from all environmental domains
- In use and rigorously tested, and its foundational concepts have not changed in more than two years

To get More Information...

- Visit the SEDRIS web site: *www.sedris.org*
- Request SEDRIS Development Team Resources:
  - Proceedings from the SEDRIS Technology Conferences (STCs), February 11 - 12 and September 28 - 30, 1999
  - Next STC: August 22 - 24, 2000 - Snowbird, Utah
  - Various video tapes, tutorials and presentations
- Attend Commercial Courses

A realistic environment obtained and reused through SEDRIS