

# **The Synthetic Environment Evaluation - Inspection Tool (SEE-IT)**

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**Bob Richbourg  
Tim Stone  
IDA Simulation Center  
rrichbou@ida.org  
tstone@ida.org**



# Tutorial Description

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## DESCRIPTION

SEE-IT is a powerful tool that provides two primary utilities for dealing with terrain databases: it checks for conditions that may be inaccurate descriptions of the physical environment, and it finds conditions that can lead to anomalous behaviors by entities operating in the simulated world. SEE-IT also provides data query and filtering mechanisms for identification, detection, and further diagnosis of environmental data. This tutorial includes examples of finding conditions such as: improper road junctions, misaligned boundaries between features, cracks in the terrain, narrow or sliver polygons, and a variety of other anomalies commonly found in terrain databases.

## WHO SHOULD ATTEND

Environmental modelers and software engineers interested in the verification and analysis of SEDRIS transmittals, and those interested in improving their SEDRIS transmittal production capabilities.

## PREREQUISITE

A basic knowledge of environmental data modeling and use, and an understanding of software development and APIs is recommended.

## WHAT TO EXPECT

At completion, the attendee has an understanding of the power of SEE-IT, and how it is used to identify and interpret various anomalies that may occur in environmental databases.



## Prerequisite

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- To get the most from this tutorial, we assume you know the following information as a prerequisite to this session:
  - Familiarity, or at least a basic knowledge, of common environmental modeling techniques, common environmental data, and data representation approaches.
  - A basic understanding of computer generated forces (CGFs) and simulation.
  - Some familiarity with EDCS.



# The Scope

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Digital representations of the environment are complex and feature interaction sometimes leads to anomalous results - these should be located and repaired well before any critical use of the data.



## Unless Appropriate!

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While SEE-IT locates erroneous terrain constructions, it should not cause alerts when the digital terrain accurately reflects real-world conditions, even though those conditions can also lead to “mobility failures” if the simulation entities accurately model the real-world.



# Outline

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## *Simulation Center*

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- Overview of SEE-IT
  - Purpose
  - Alternative Methods Available
  - Software Structure
- Anomaly Detection
  - EDCS capabilities
  - Examples of Anomalies Found
- Automatic Repair Abilities
- Using SEE-IT to identify where in the production pipeline problems were introduced
  - Shapefile export of data and conditions
- Data Query/View operations
  - EDCS



# Purpose

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## ***Synthetic Environment Evaluation - Inspection Tool***

SEE-IT has been designed to evaluate and inspect environmental data provided in SEDRIS transmittal format (STF).

### ***Verification and Validation of Environmental Data***

- Allows database *users* to assess content and quality, at any time during the database lifecycle
- Allows database *producers* to identify and repair unintended constructions before product delivery



## Alternative Methods Available

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Typical environment inspection practices are **manual operations** that rely heavily on **visual inspection**.

- Problem 1: The visual database is **not necessarily the same** as that used for simulation calculations. Thus, a visual inspection **may not even focus on appropriate data**. Ex: Road centerlines are not visible on visual databases.
- “Solution” to problem 1: Simulate use of “all” of the data, prior to an actual simulation event, by moving simulation entities repetitively across the database.
  - **Problems with “solution”:**
    - Only a small percentage of relevant data is examined in most cases
    - Cannot be used in areas where simulation entity movement is prohibited
    - Cannot describe any problem cause
    - Only locates general areas
    - May be influenced by errors in the simulation control software
    - Does not provide any guide to appropriate corrective actions
    - May not be repeatable
    - It can also be **very time consuming .....**



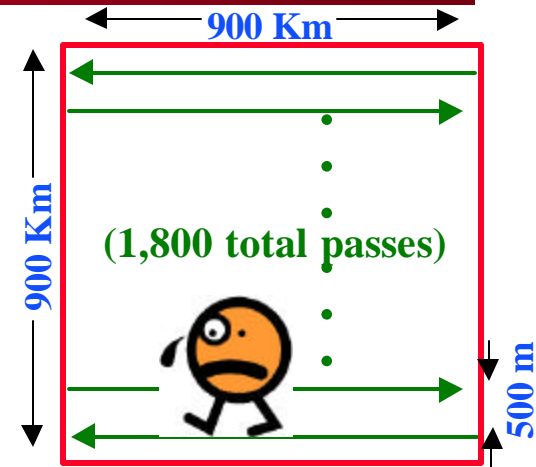


# Time Analysis & Comparison

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Concept: Send a simulation entity back and forth across a database and visually observe it's performance to locate anomalies. Assume a pass is made each 500 meters, the database is 900km square, and the simulated entity travels at 'S' KMPH. Then, the time (hours) required to examine the entire database is:

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



Entity 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 - <b>years</b>	9.25	4.6	3.1	2.3	1.8	0.92

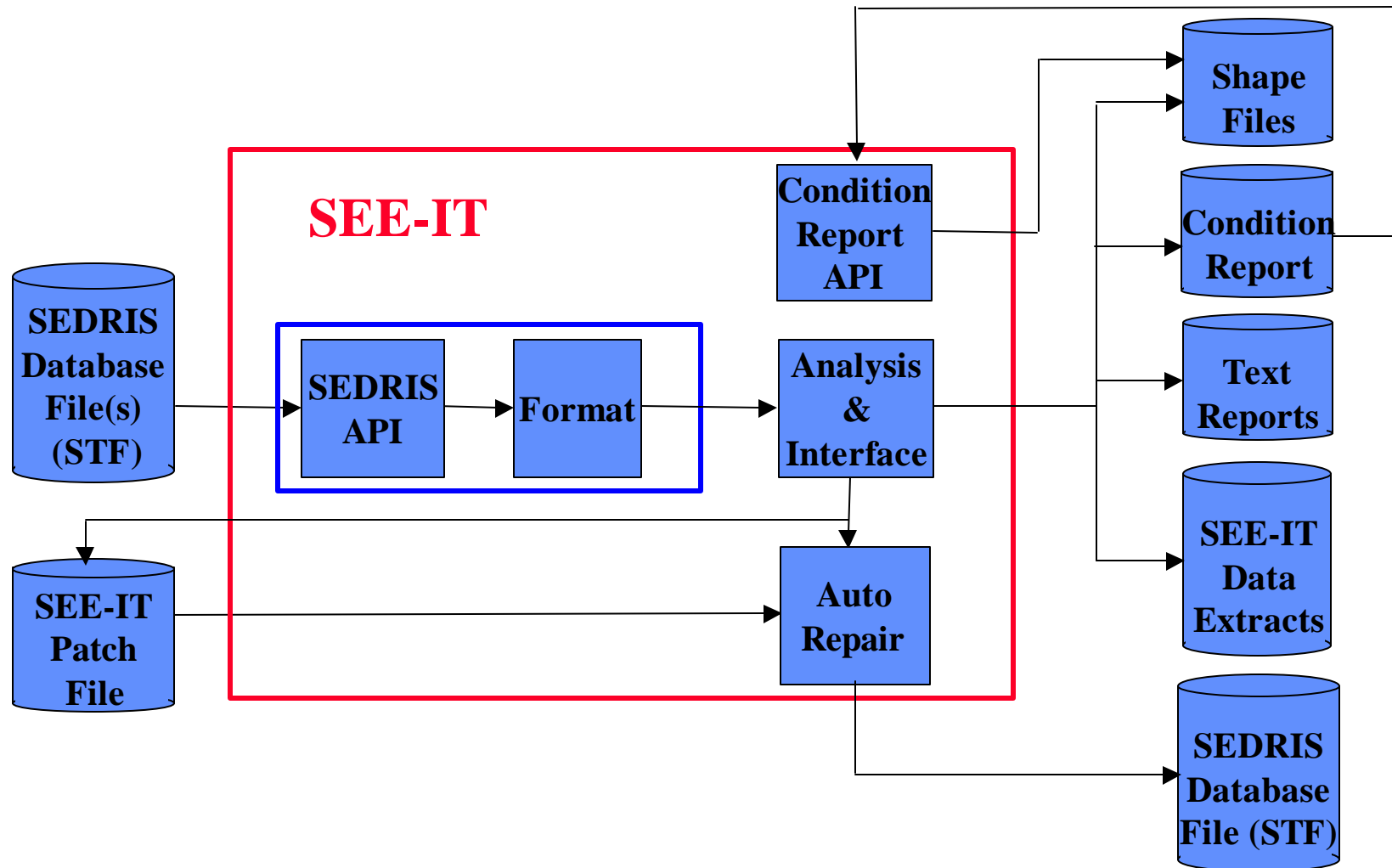
(Using multiple simulation vehicles reduces time requirements linearly, but all the other problems still remain....)

**SEE-IT required less than 5 minutes to examine a 900 x 900Km simulation database (about 2.4 million polygons inspected)**



# Software Structure

**Simulation Center**





# Anomaly Detection

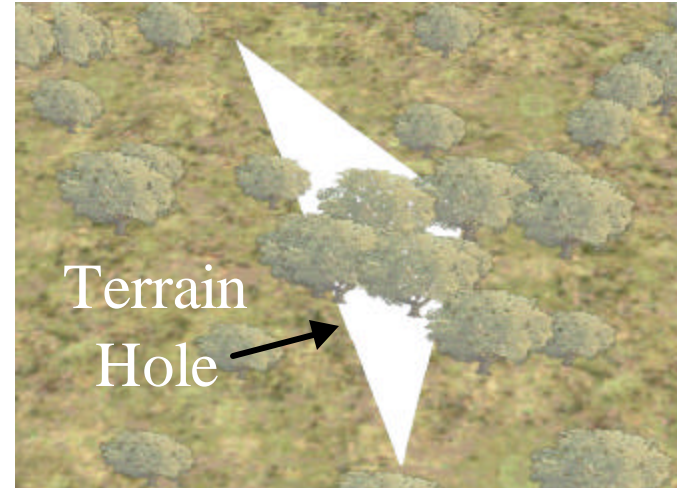
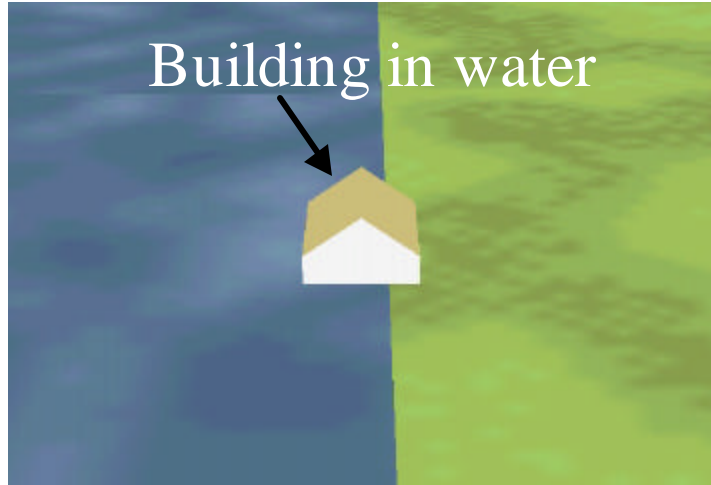
***Simulation Center***





# The Basics of Anomaly Detection

**Simulation Center**



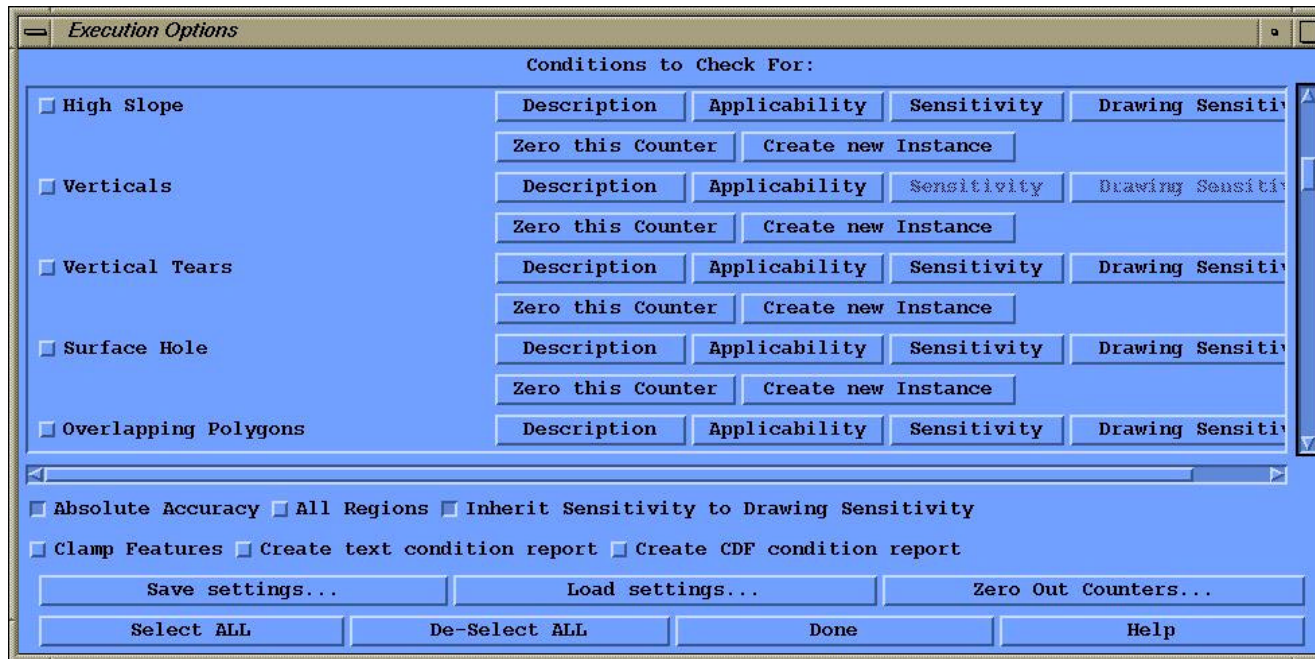
SEE-IT 1.8 provides 41 templates that can be used to locate anomalies, such as those pictured above. The templates can be configured via:

- EDCS classifications, attributes, and values
- Sensitivity thresholds
- SEE-IT domain (groupings of “similar” EDCS Classifications)
- Geometry (line/areal/polygon, etc)
- LOD(s)



# How Do I Find Those Anomalies?

## Simulation Center



- The window pictured above is used to:
  - Select which conditions to compute (via the toggle buttons at left)
  - Configure the conditions (via the buttons labeled “Sensitivity” and “Applicability”)



## “Applicability”

### Simulation Center

A screenshot of a software window titled "Selection of CSD to be checked for: Line - Slope Polygon Intersections". The window has a blue background and contains several expandable menu buttons. It is organized into two rows: "Primary" and "Secondary". Each row has three main categories: "Configuration", "Stratum", and "Domain". The "Primary" row shows "Directed Line" for Configuration, "Applique" for Stratum, and "Land Mobility" for Domain. The "Secondary" row shows "Polygon" for Configuration, "Applique" for Stratum, and "Terrain" for Domain. To the right of these are two columns of buttons labeled "EDCS exclusions..." and "EDCS additions...". A "Done" button is located at the bottom center of the window.

- The window pictured above is the “Applicability” window for one particular check, in this case “Line - Slope Polygon Intersections”
- There are 2 rows, representing the concept that there are 2 “participants” involved in this check, the “Line” and the “Slope Polygon”
- All items shown in this window are expandable menus, allowing complete selection of all applicable items
  - Selection of the “Primary Domain” pull-down menu would result in a list of all SEE-IT domains that the user could then select or de-select *for this check*.
  - Selection of “EDCS additions...” or “EDCS exclusions” would result in a mechanism to select or de-select database items *for use in this check* via their assigned EDCS values.





# SEE-IT Classificatory System

**Simulation Center**

3 Axes:

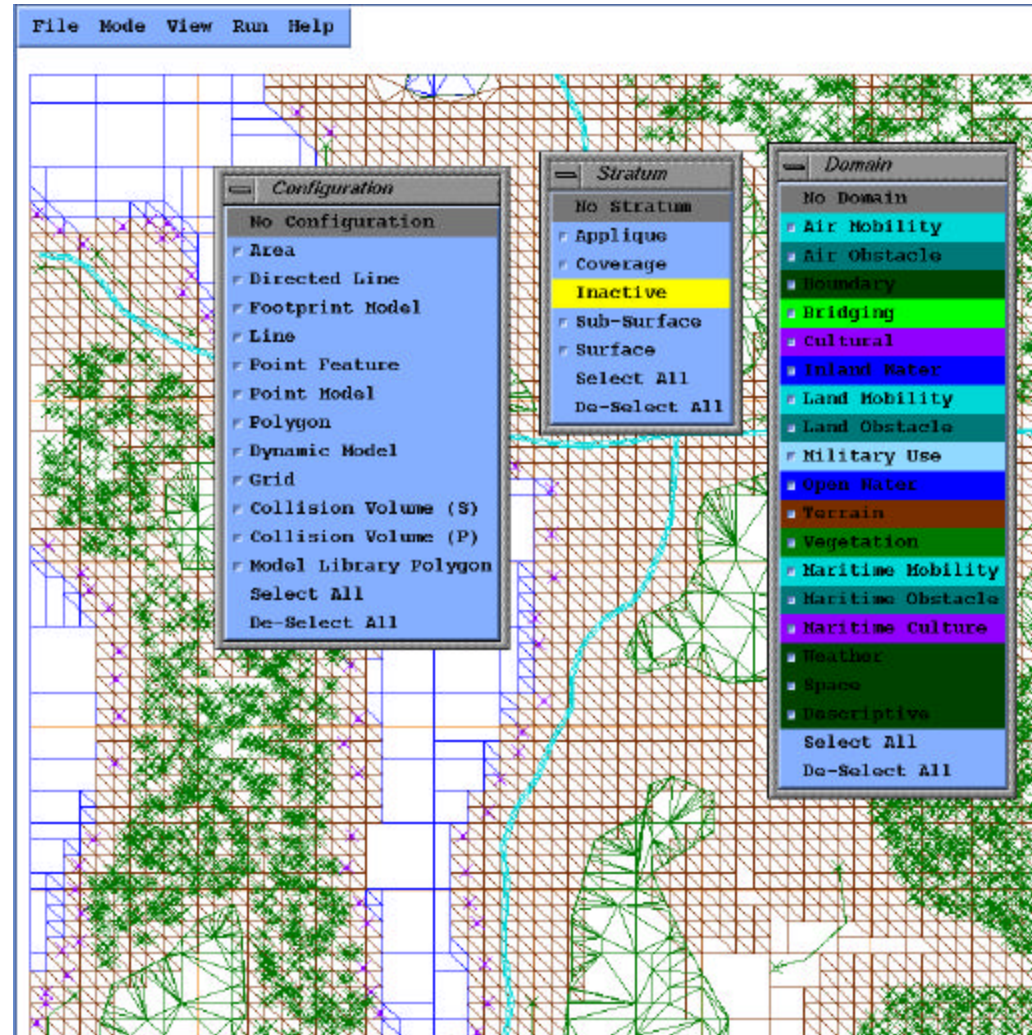
Configuration

Stratum

Domain

Assignments based on  
STF data (EDCS)  
and user input

Used to filter data  
elements for display,  
analysis, and query





# EDCS Based Specification for Analysis and Query

## Simulation Center

The window shown at right is used to specify objects in the database using their EDCS Classifications, Attributes, and values.

This window is used for condition specification and data query.

This window can aid in answering queries such as: “Display all the BUILDINGs with a HEIGHT of 3.0-5.0”, or use these objects in particular inspections.

**Attribution Highlighting Window**

Classification identifiers  
(32 Definitions)

Selected classification items:

ROAD (691)

TERRAIN (10128)

TREED\_TRACT (9621)

TREED\_TRACT bush\_short\_a (1788)

TREED\_TRACT bush\_short\_b (1785)

TREED\_TRACT bush\_tall\_a (1815)

TREED\_TRACT bush\_tall\_b (1860)

TREED\_TRACT tree\_fir\_a (16815)

TREED\_TRACT tree\_large\_a (1713)

TREED\_TRACT tree\_small\_a (1902)

Attributes found in DB  
(11 definitions in this DB):

Values for SELECTED attribute  
(4 definitions):

Selected attribute items:

BRUSH\_DENSITY

HEIGHT\_ABOVE\_SURFACE\_LEVEL

PREDOMINANT\_HEIGHT\_WITHIN\_O

ROAD\_MINIMUM\_WIDTH

SUMMER\_CANOPY\_COVER\_FRACTION

SURFACE\_THERMAL\_INDEX

SURFACE\_THERMAL\_MODEL

TERRAIN\_ELEVATION

TERRAIN\_TRAFFICABILITY\_COAR

TREE\_CANOPY\_BOTTOM\_HEIGHT

Value: DEEP\_WATER (266)

Value: DEFAULT (24662)

Value: RCI\_250 (10128)

Value: ROAD (689)

EA TERRAIN\_TRAFFICABILITY\_COAR

☐ Locate COMBINATIONS of classification and attributes

De-Select highlighted classification items

De-Select ALL classification items

De-Select highlighted attribution items

De-Select ALL attribution items

Help

Done / Apply



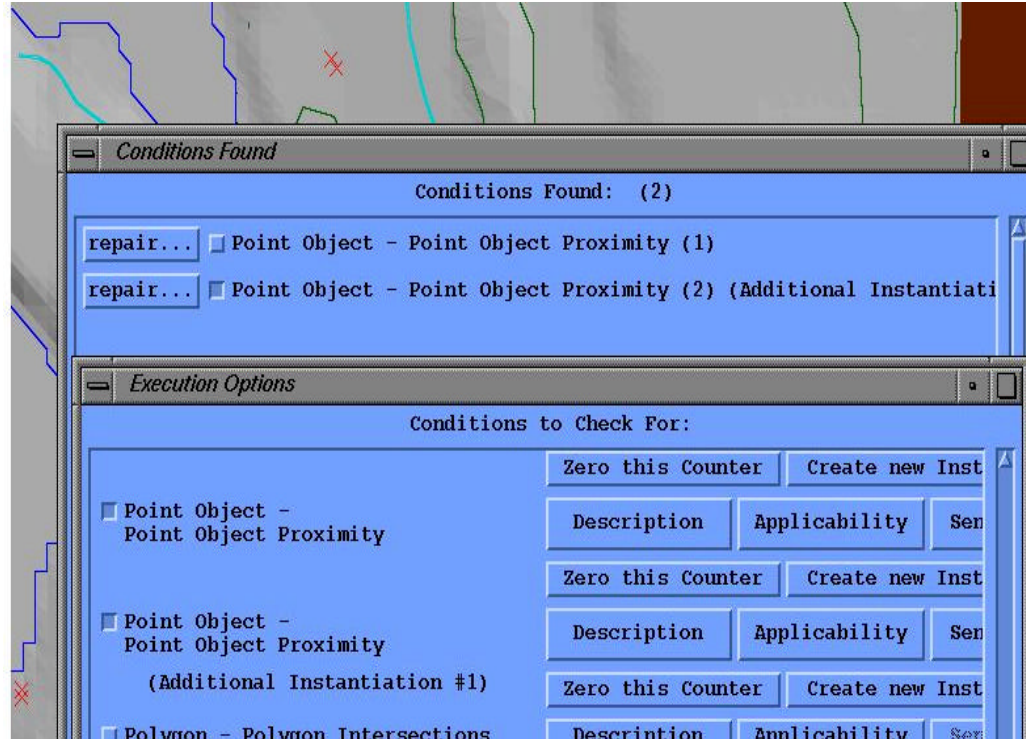


# Multiple Check Instantiation

## Simulation Center

In SEE-IT 1.8, it is possible to create multiple instances of a single check type (with different Applicability and/or Sensitivity) during a single run.

The snapshot to the right shows 2 instances of the “Point Object - Point Object Proximity” check created, and 1 condition found for the first instance, and 2 conditions found for the second instance.



The first instance of the check looked for Vegetation (SEE-IT Domain) point features within 1 meter of other Vegetation point features, while the second instance looks for BUILDING (EDCS classification) point features within 100 meters of other BUILDING point features. Any number of additional instantiations may be created.



## Examples of Anomalies Located Using SEE-IT

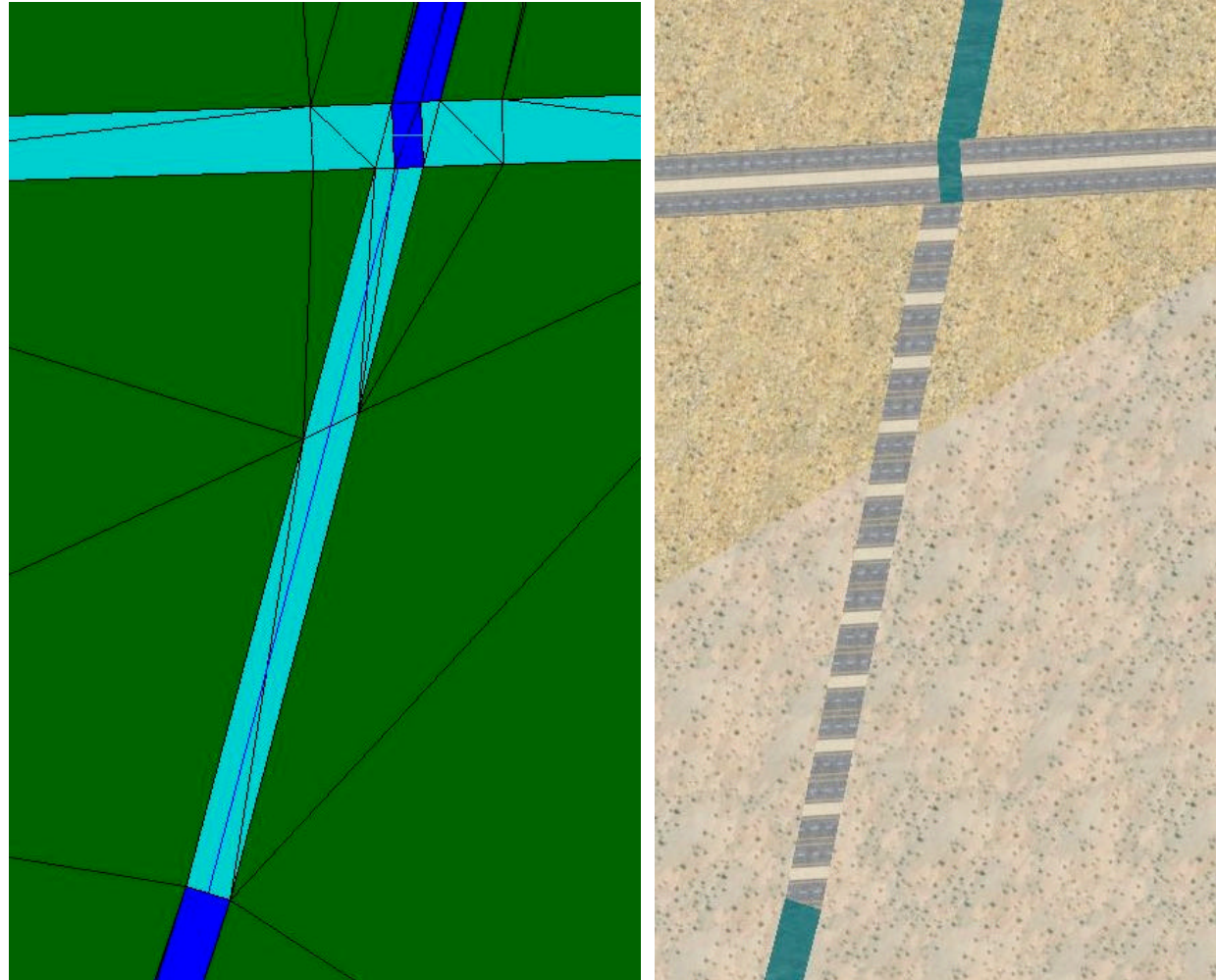


## Unusual River (Or is it a Road?)

**Simulation Center**

**Left:** SEE-IT locates an anomalous river/road crossing.

**Right:** The same anomaly viewed using an out-the-window-viewer



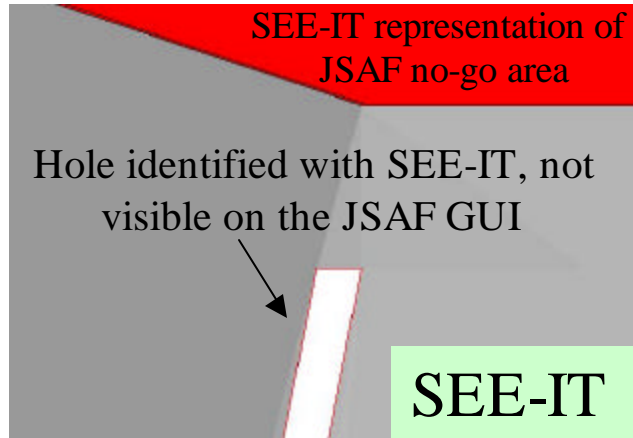
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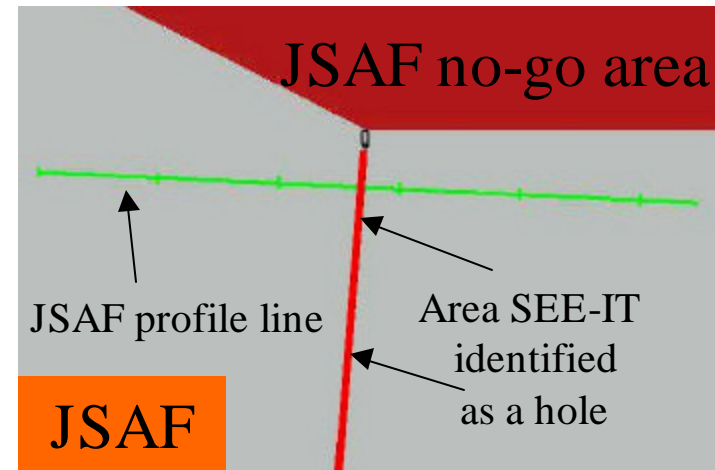


# Hole Visualized in SEE-IT and JSAF

## Simulation Center

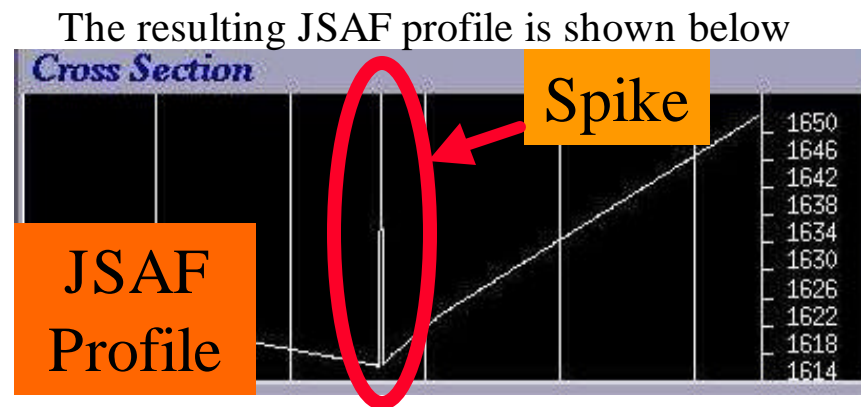


SEE-IT locates a topological hole in  
the CTDB data (white)



JSAF is used to draw a terrain cross section  
through the suspect area

- **SEE-IT was used to locate an anomaly in the CTDB data (top left)**
- **The anomaly is not visible on the JSAF GUI due to zoom limitations (top right)**
- **The anomaly confuses even JSAF's own profile tool, resulting in a large spike in the elevation profile that does not exist (right)**

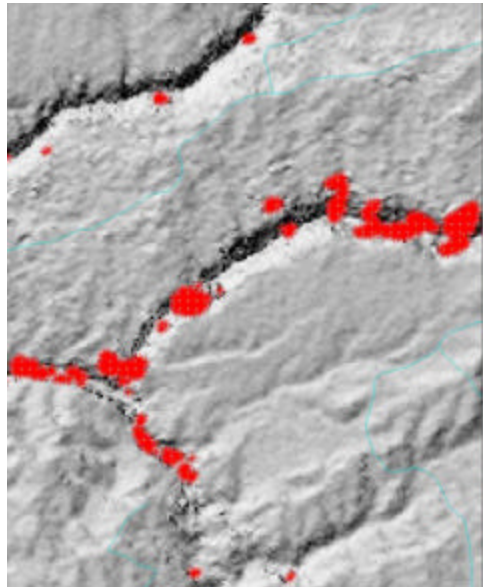




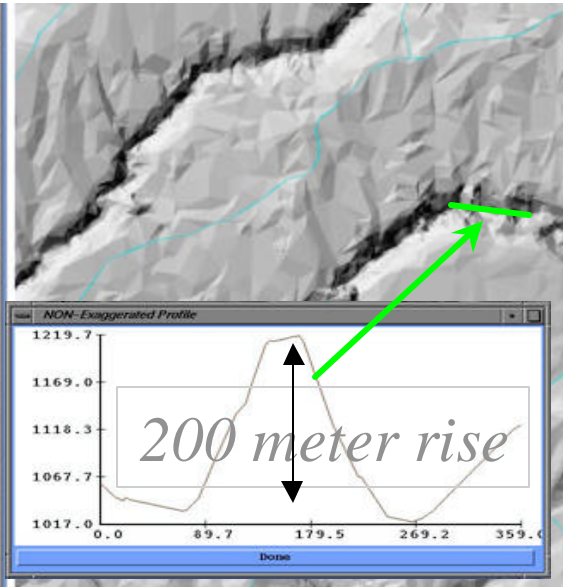


# Enduring Freedom Reconstruction: Constructing the Simulation DBs

## Simulation Center



SEE-IT displaying a shaded relief of source data, and identifying data dropouts (red).



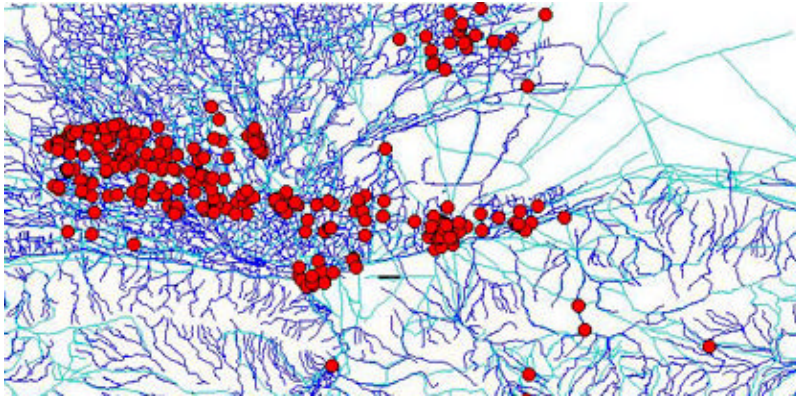
SEE-IT displaying a shaded relief of the simulation database, and an elevation profile through a river valley. Note that a “land-bridge” representing a 200 meter rise has been created in the river valley.

- The high resolution source data that was available contained missing data (dropouts).
- The dropouts were filled in with lower resolution DTED 1 data.
- The simulation database that resulted contained anomalies in the areas that were filled with the lower resolution data.
- SEE-IT was used to identify problem areas in the source data and the simulation database.

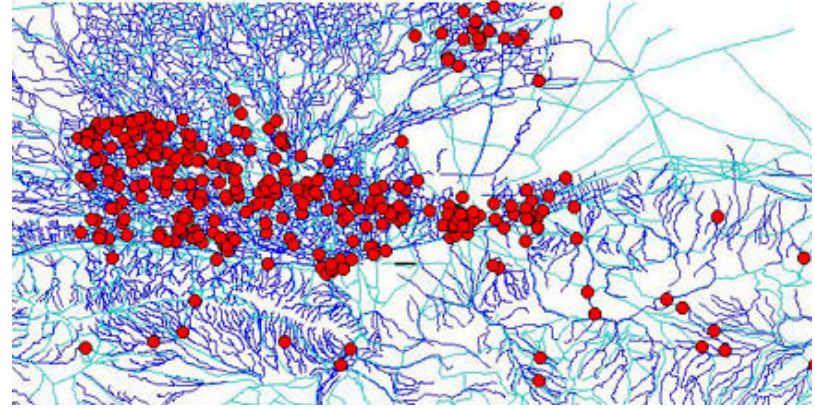


# Intensification Can Also Intensify Error Counts

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Initial data set - (December 2001):  
300 disconnected linear end nodes



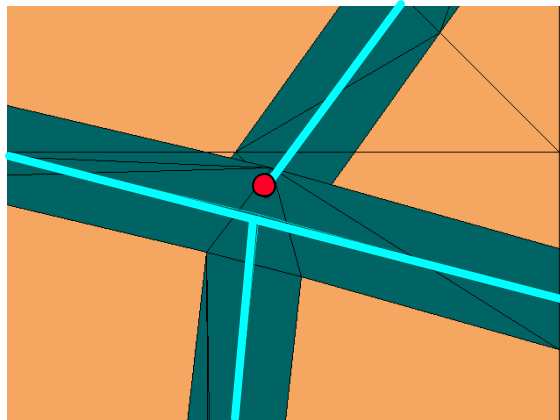
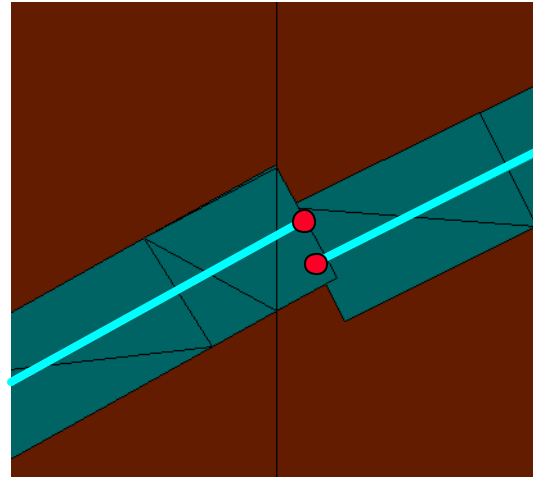
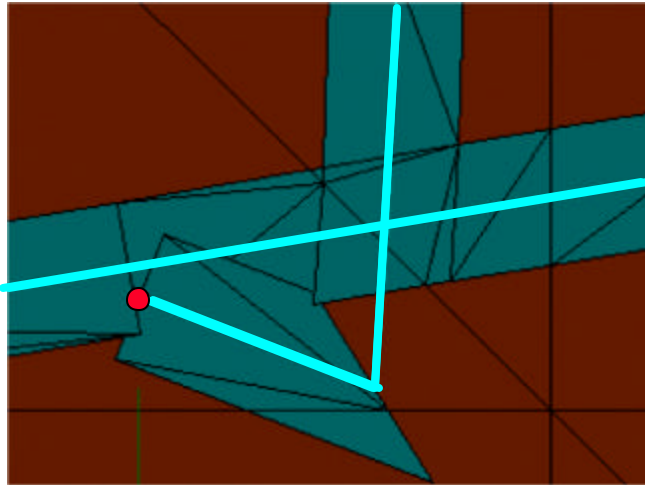
*Intensified* data set - (January 2002):  
428 disconnected linear end nodes

- This data was created in 2 passes:
  - An initial data set was produced quickly for immediate use
  - An *intensified* data set was created later, with more data added
- SEE-IT was used to identify instances of Hydrological and Transportation linear end node discontinuities. The results are shown above.
- SEE-IT was used to identify anomalies in the data sets after both were produced. SEE-IT was not used during the production process.



# Road Problems

**Simulation Center**



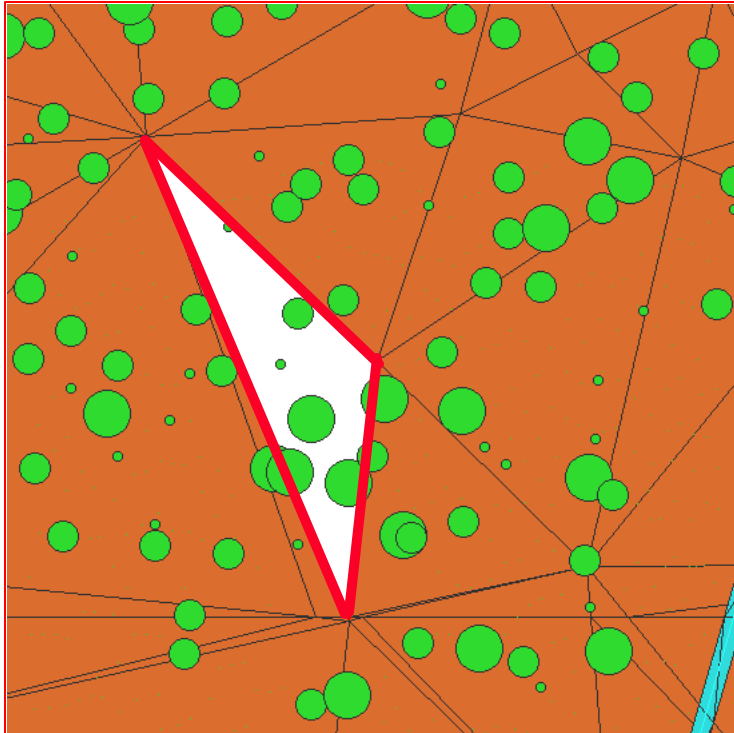
These images show different types of (road) linear disconnects. Dark cyan polygons are road polygons. Light cyan lines are road centerlines. Brown/Tan polygons represent terrain.

It is important to note that the top two problems would be visible if one was inspecting the terrain manually, the third would not!

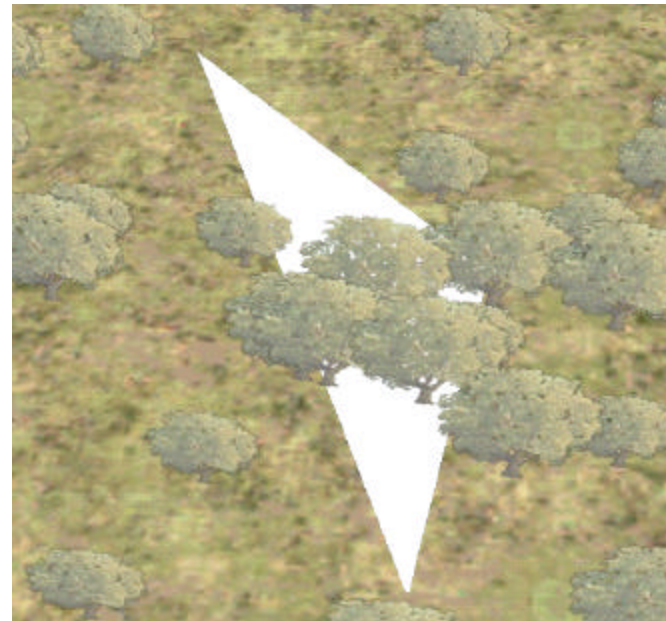


# Topological Hole

**Simulation Center**



SEE-IT locates a topological hole in the terrain surface ...



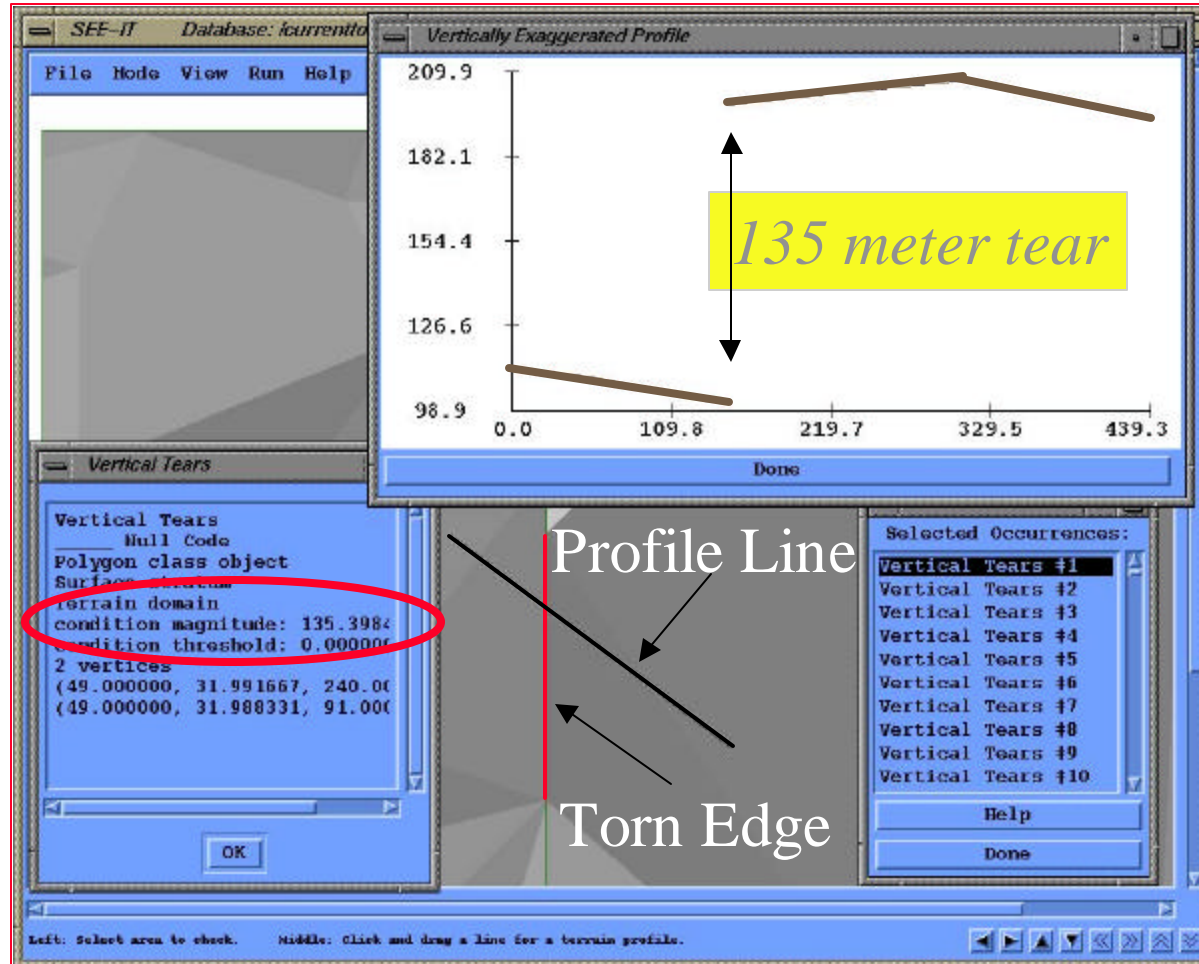
which also appears in the out-the-window view in that area





# Vertical Tears

## Simulation Center



The images to the left show SEE-IT locating and sorting a list of vertical tears.

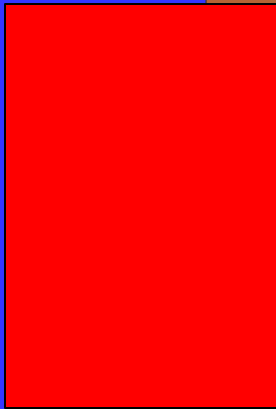
The most extreme tear, of magnitude **135m**, is described, and a terrain profile through the area containing it is shown.



# Building Placed in Water

**Simulation Center**

SEE-IT representation



SEE-IT locates a building that is placed on both land and water ...

Out-The-Window representation

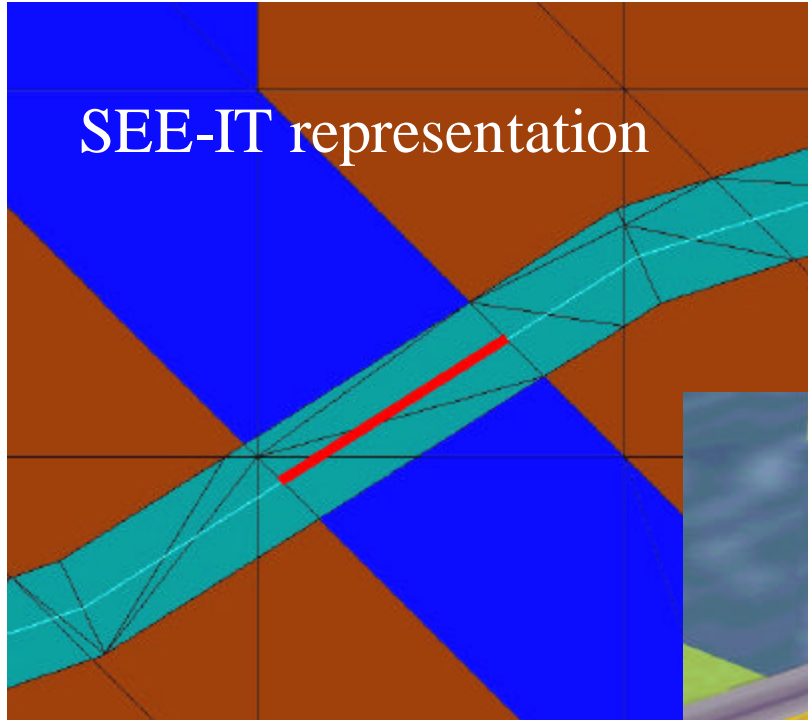


which also appears in the out-the-window view in that area



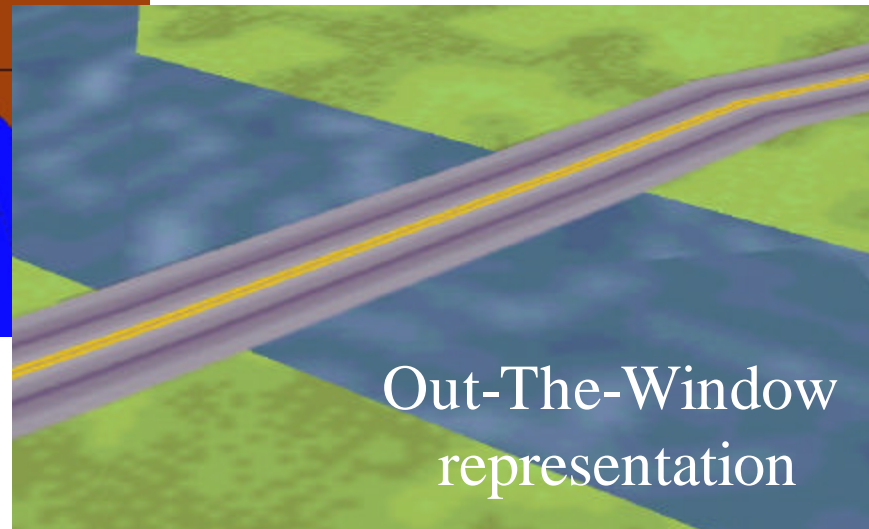
# Road/River Intersection Without Bridge

**Simulation Center**



SEE-IT locates a road  
crossing a river  
without a bridge...

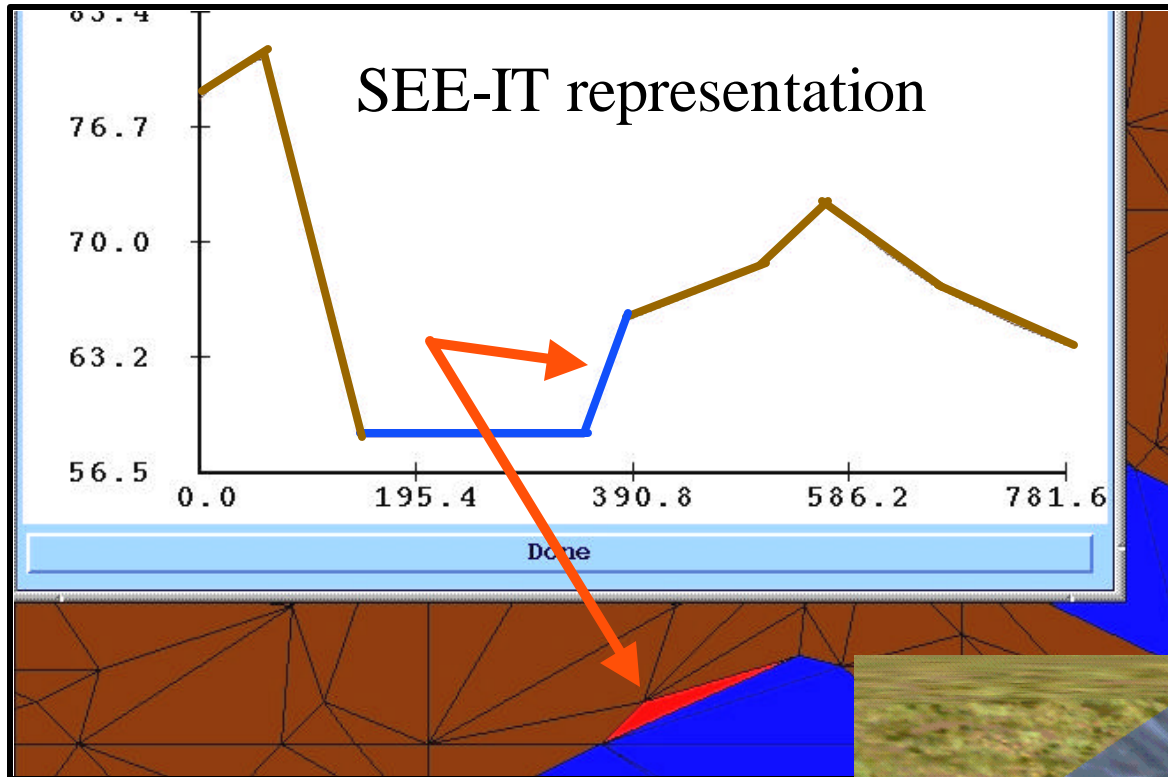
which also appears in the  
out-the-window view in  
that area





# Steep Water Polygon

Simulation Center



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

which also appears in the out-  
the-window view in that area

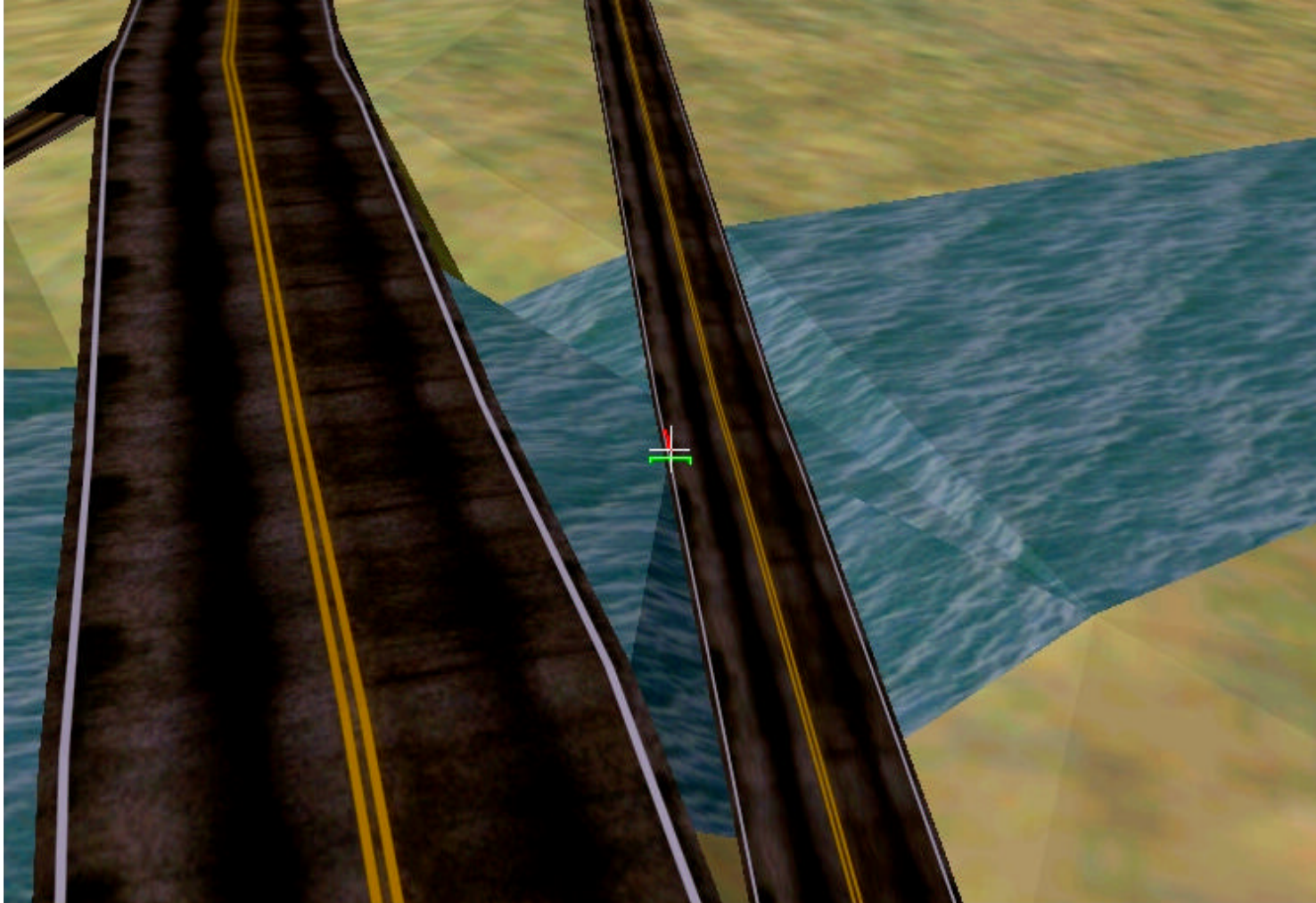
Out-The-Window representation





## Road - River Intersection Without Bridge

**Simulation Center**



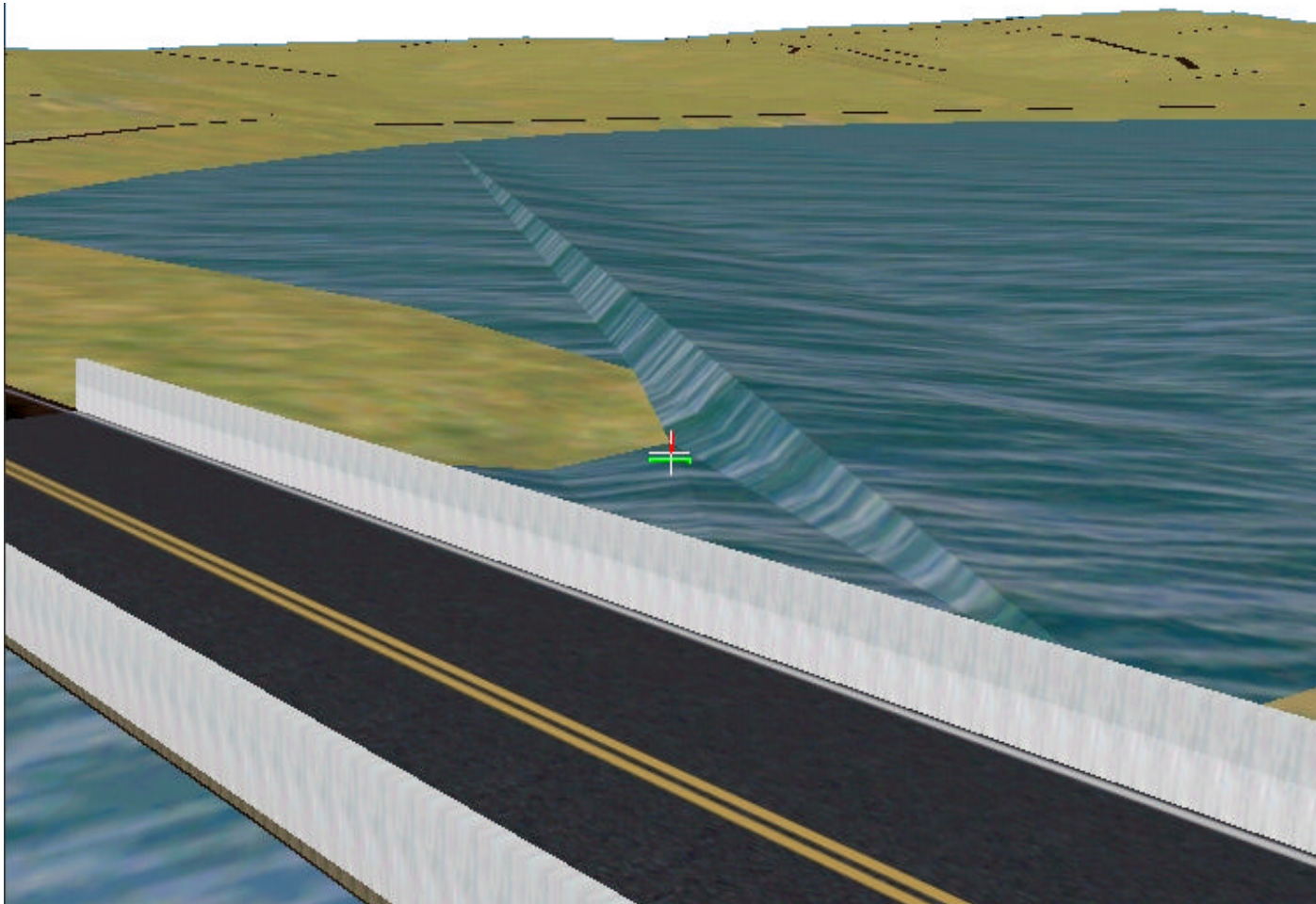
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# High Slope Water Polygon

**Simulation Center**

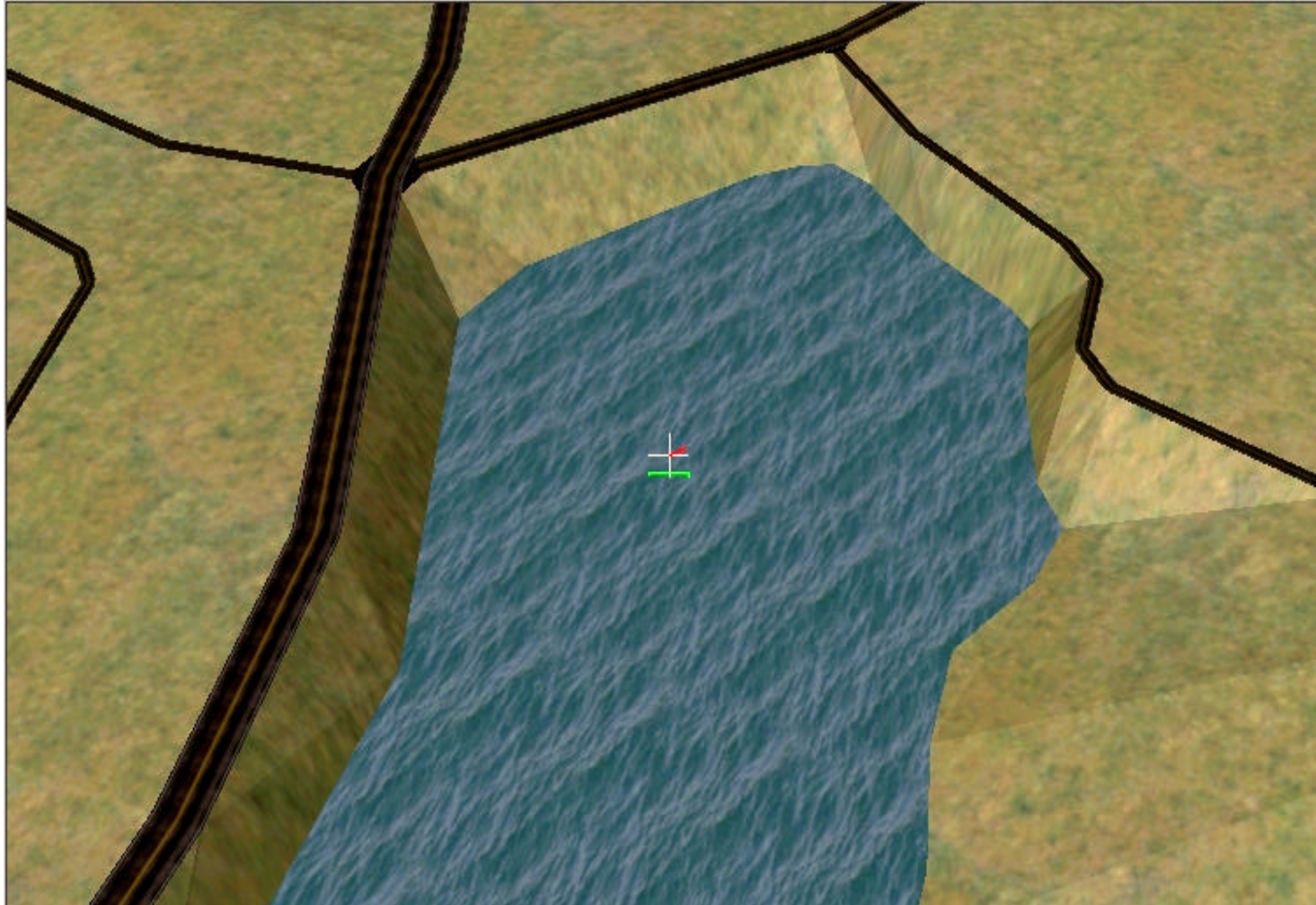






# High Slope Terrain Polygons

**Simulation Center**



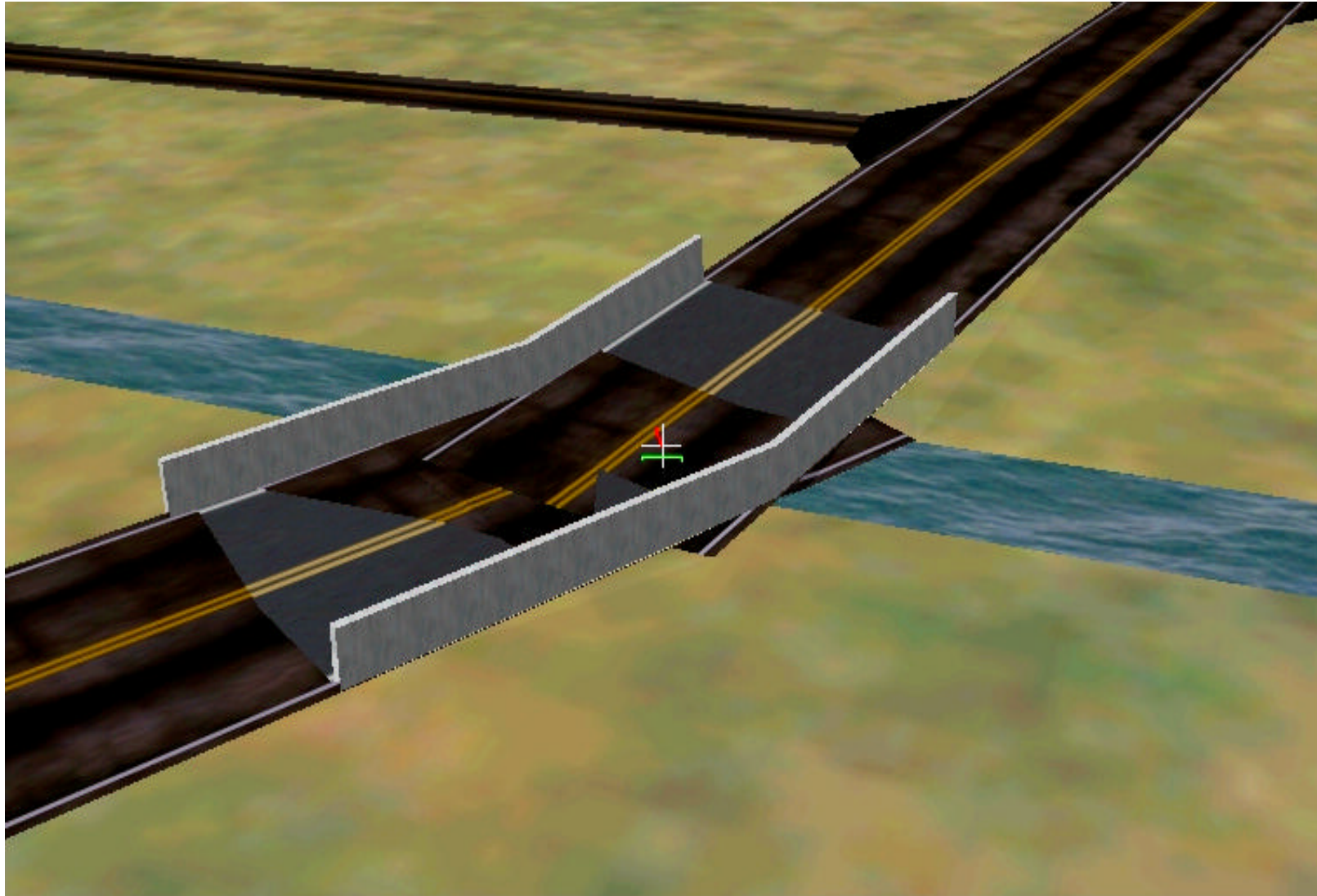
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## Disconnected Road Network



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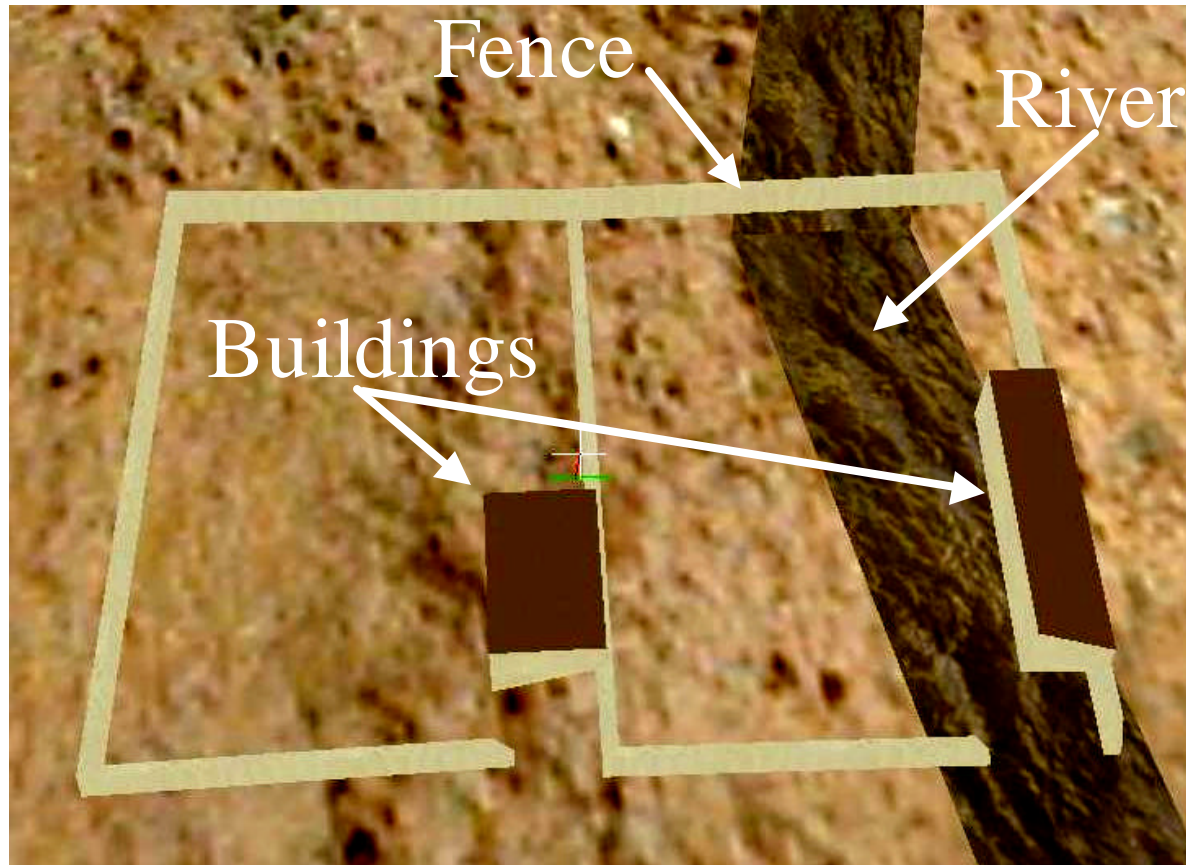
SEE-IT tutorial -- STC 2004, Lake Buena Vista, Florida





# Buildings and Fences in River

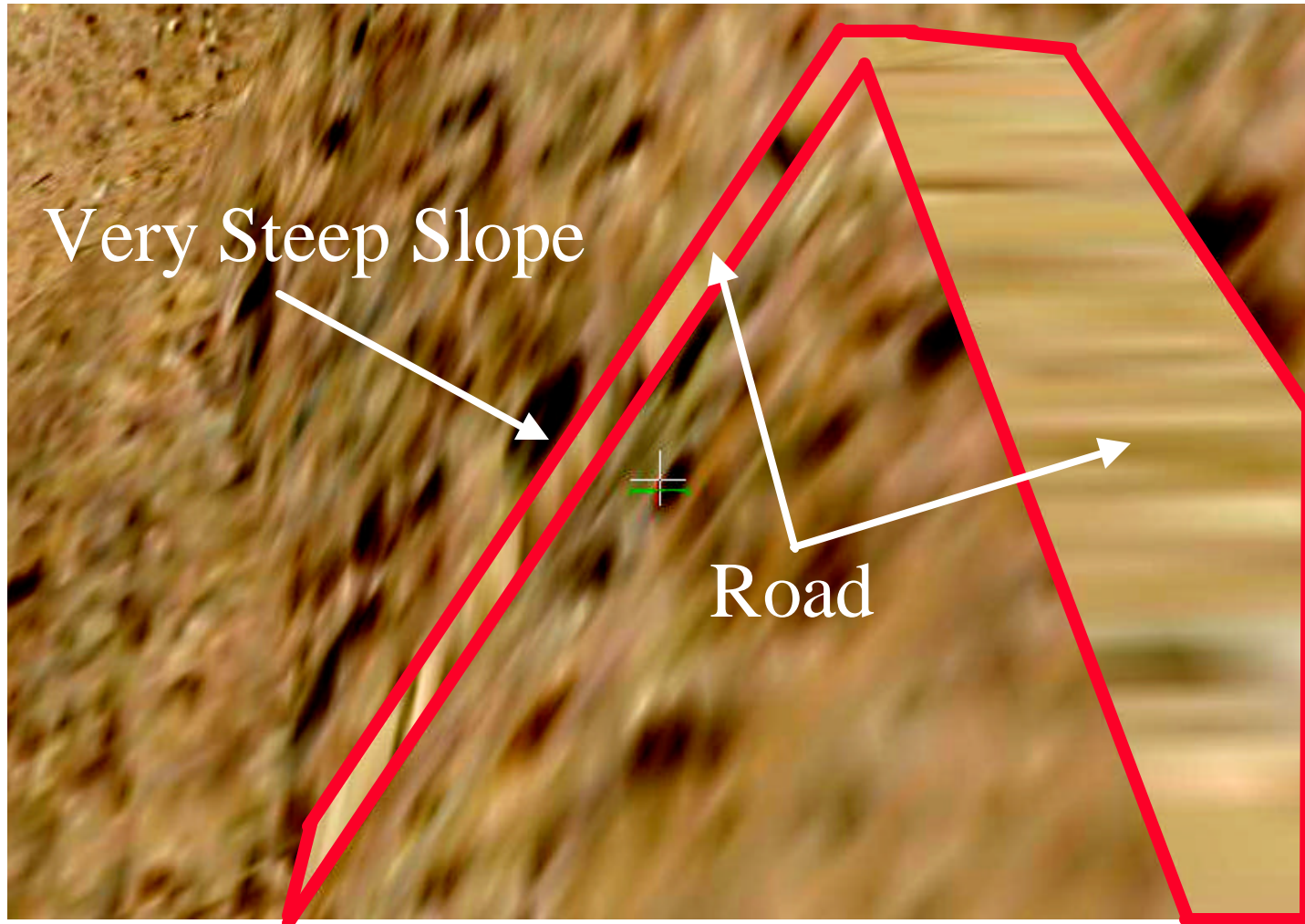
**Simulation Center**





# Road With Very Steep Slope

**Simulation Center**





***Simulation Center***

# Repairs



## Data Correction using SEE-IT

*Simulation Center*

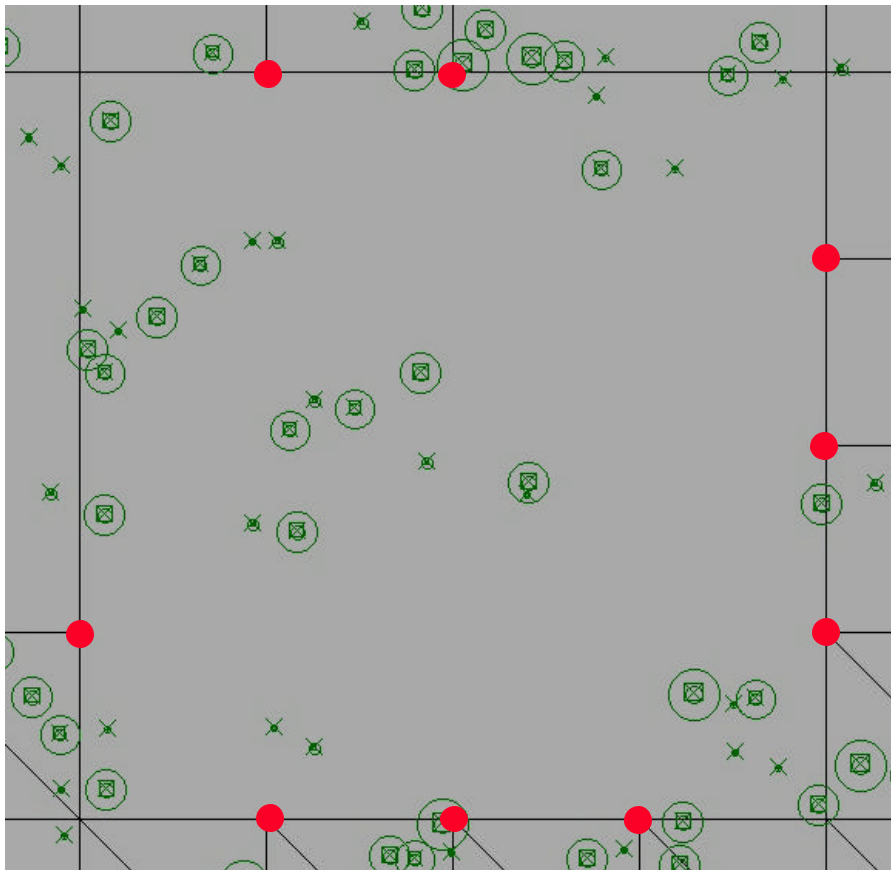
- In addition to condition identification and location, SEE-IT has the ability to **automatically** correct some conditions that do not require adjudication by human editors
- These kinds of conditions include:
  - Repair of “T” vertex surface polygon topologies
  - Removal of duplicate objects
  - Repair of nearby linear features that are not coincident
  - Repair of vertical tears in polygonal surface topology
  - Adjustment of outlier elevations
  - And others to come...
- Current SEE-IT implementation relies on SEDRIS format as both input and output for corrections



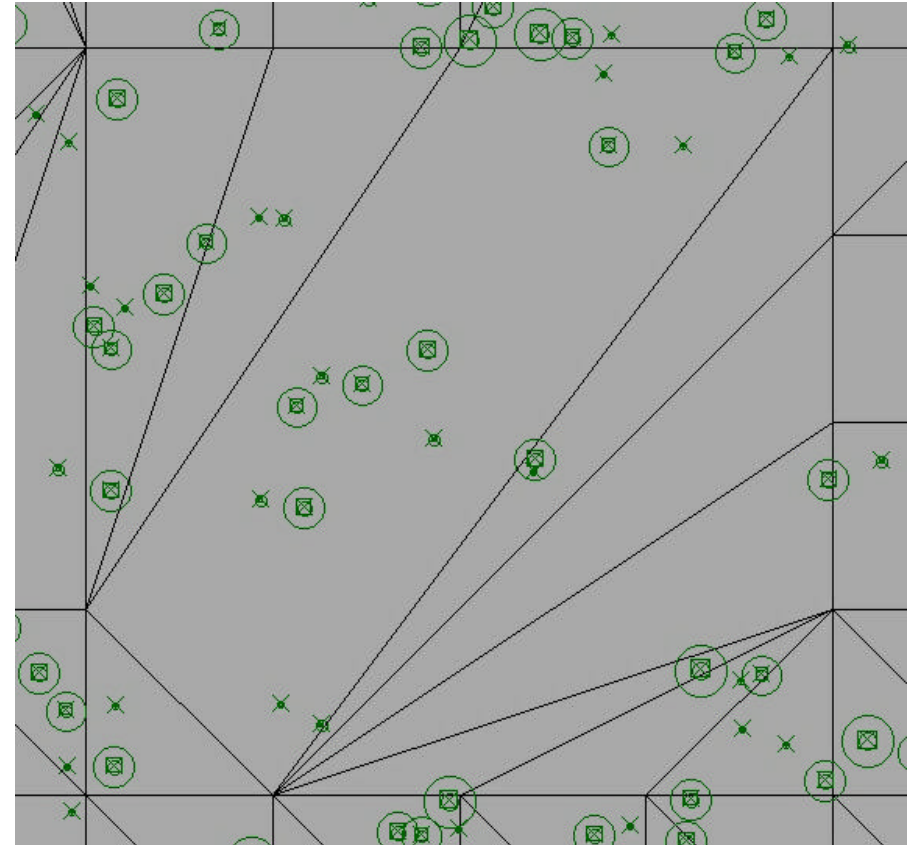
## Example of T-Vertex Repair (Bellevue)

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



Jan 6, 2004



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



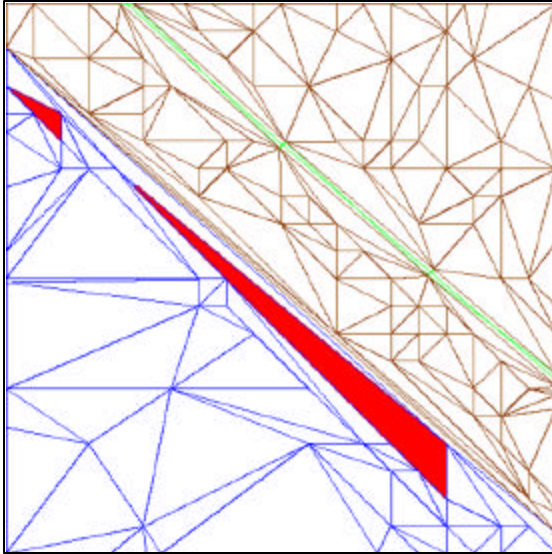


# Identifying problem point-of-origin in the production process



# The Flying Vehicle Picture Again

**Simulation Center**



**Polygons with “T” vertex constructions highlighted in SEE-IT**



**A visualization of SAF vehicle behaviors after encountering topological construction featuring “T” vertices along adjacent polygons**

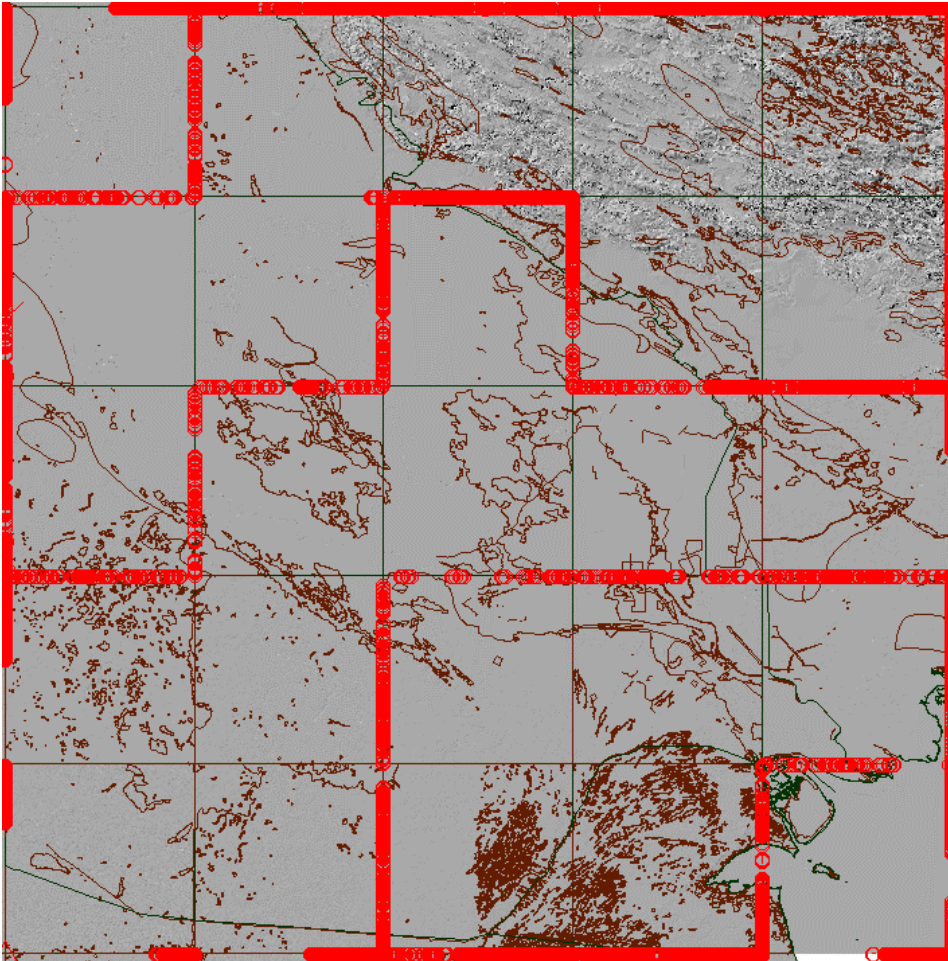
An example of an early SEE-IT success story:

- SEE-IT was used to identify anomalies existing in this database.
- The locations of anomalies were sent to the database producer, who ran vehicles over the suspect areas.
- The visualization image was produced during this process.



# Piecing Together the Story

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- This 5x5° square area was actually built as 25 separate (1° square) databases
- SEE-IT provided the first integration of these into a single database...
- Top level view of vertical tears in surface topology found in an **early**-build version of a database
- Note that the problems occur at the 1° cell boundaries
- **Early** identification of this systematic problem **allowed** an **engineering solution** that **avoided** delivery of an unacceptable database





## A JSAF Operator Speaks ... And SEE-IT is put to work

### *Simulation Center*

“... there are **big holes and canyons** out in water and lots of 'em. And the **ships fall into them**. Ships that are down in the holes **can't get intervis** with the ones up on top and visa-versa.

...

It looks like all the north-south running cell boundaries have such a **canyon about 3 miles wide and there's lots of big ones out in the cells too**

...

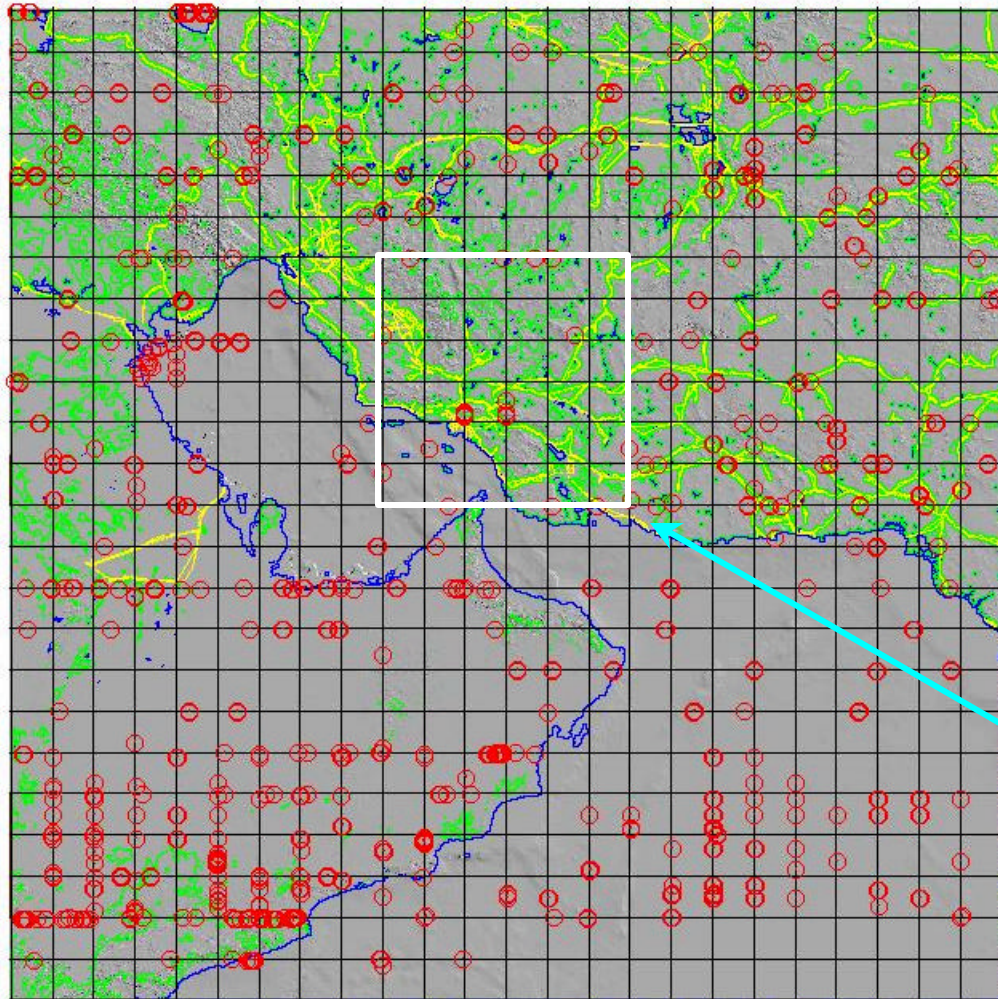
Given the size and number of the holes, I'd say we'll likely have **a whole bunch of ships in various holes at any one time**. So until its fixed, I don't see any alternative other than to turn off the intervis checks on the radars.

SEE-IT was used to identify the problem source,  
as described in the next 2 slides



# SEE-IT CTDB Spiral 2 Analysis (Modified SW USA TDB)

**Simulation Center**



Analysis of the 24x24 degree CTDB revealed many holes in the terrain surface - these were being injected into the data during the compile process.  
(The black grid shows 1 degree cell boundaries.)

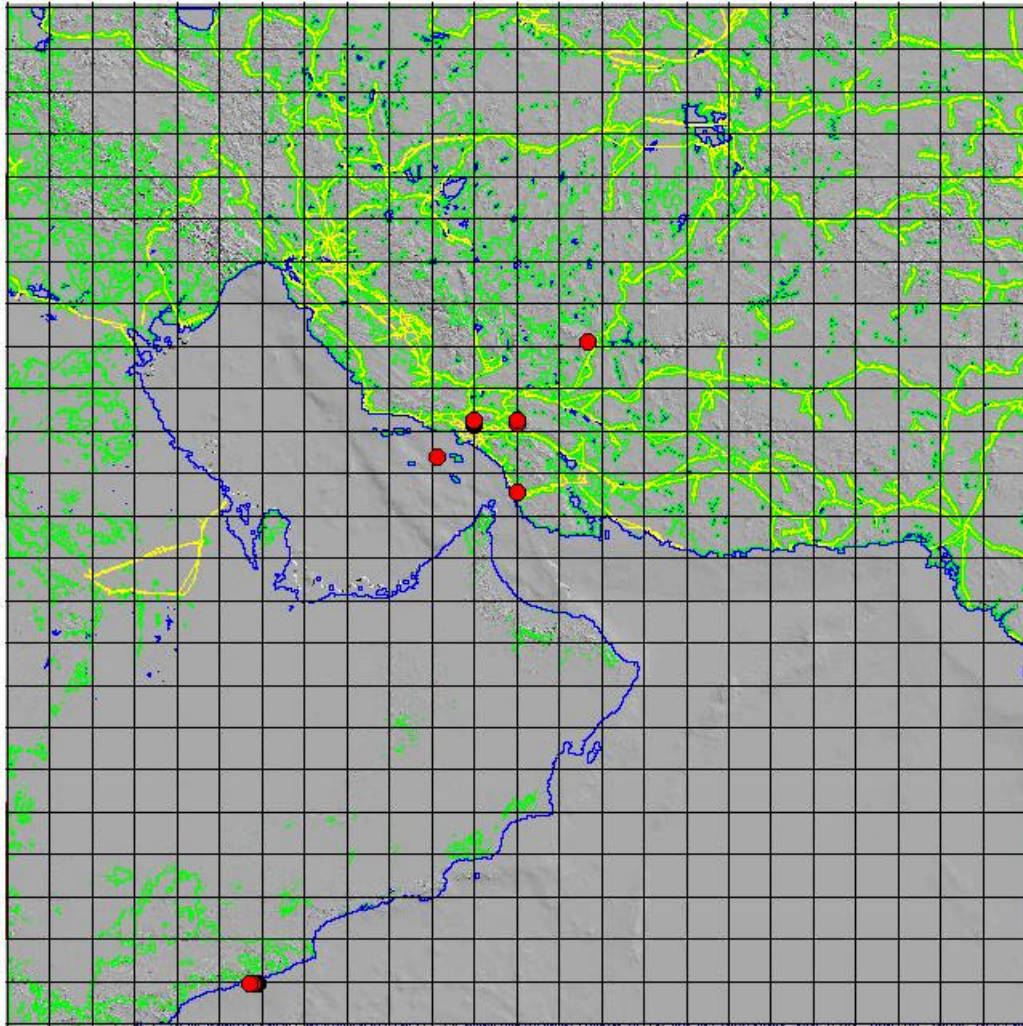
6 degree square high-importance operations area





# SEE-IT CTDB Spiral 3 Analysis (24 degree square area)

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The database builder used the SEE-IT analyses to improve their compiler, resulting in much fewer errors.

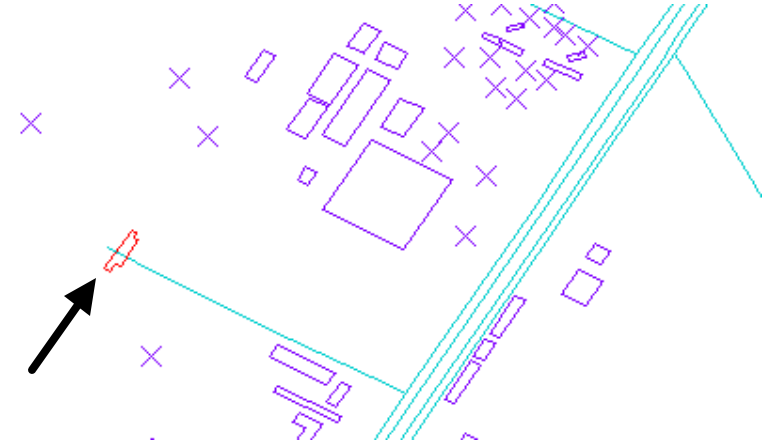
Not all issues have been resolved, but there is obviously significant progress.



# IRAQ analyses

## Simulation Center

Below: FORDs (blue X-marks) within 100m of RIVERs,  
and FORDs (red X-marks) not within 100m of any RIVERs



Above: BUILDINGs (purple) and ROADs (cyan)  
The red BUILDING has been identified by SEE-IT

- NGA recently provided IDA feature data for the country of IRAQ.
- IDA used SEE-IT to do an initial pass over the following subset of the data:
  - CART TRACKS, ROADs, RIVERs, AQUEDUCTs, LAKEs, FORDs, BUILDINGs
- SEE-IT analyses rapidly located:
  - Disconnected ROADs, RIVERs, CART TRACKs, and AQUEDUCTs (957/254464)
  - FORDs more than 10m from RIVERs (379/1858)    More than 100m (219/1858)
  - Areal BUILDINGs intersecting ROADs (528/70087)
  - Areal BUILDINGs intersecting RIVERs (37/70087)
  - Point BUILDINGs inside LAKEs (67/413038)





# Shapefile Export

**Simulation Center**

- Shapefiles are a common format for source data.
- SEE-IT 1.8 has the ability to export Shapefiles:
  - Shapefiles can be created from SEE-IT condition reports.
  - Shapefiles can be created from the data itself.
- In cases where Shapefiles are used as source data:
  - In tracking where in the production pipeline a problem was introduced, it is useful to export conditions found as Shapefiles so that these conditions may be loaded into the “native system” simultaneously with the source data.



# Shapefile Export Capability

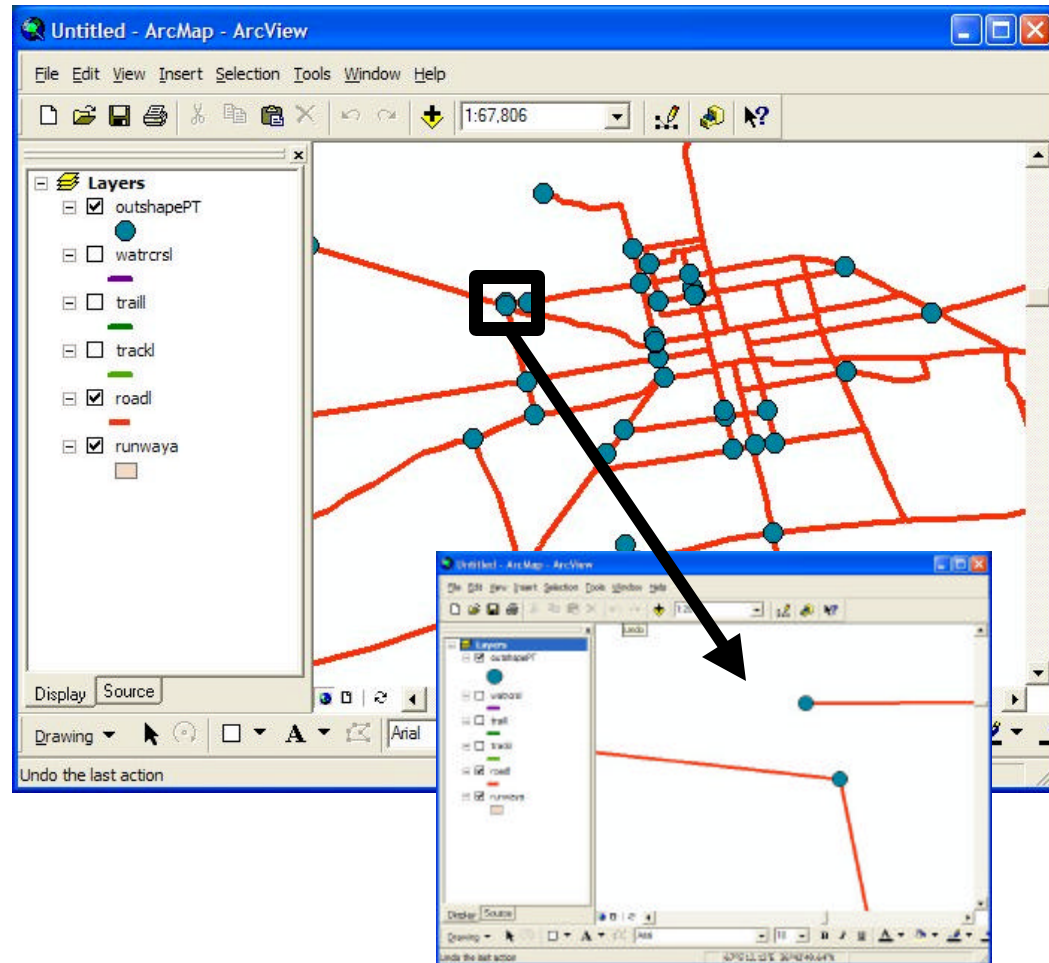
## Identifying Source Data Problem

### Simulation Center

The large image to the right shows ArcMap displaying “outshapePT”, a shapefile of disconnected road conditions exported by SEE-IT.

The cyan circles represent SEE-IT exported conditions. The red lines represent source data (roads). The black box represents the zoom in area.

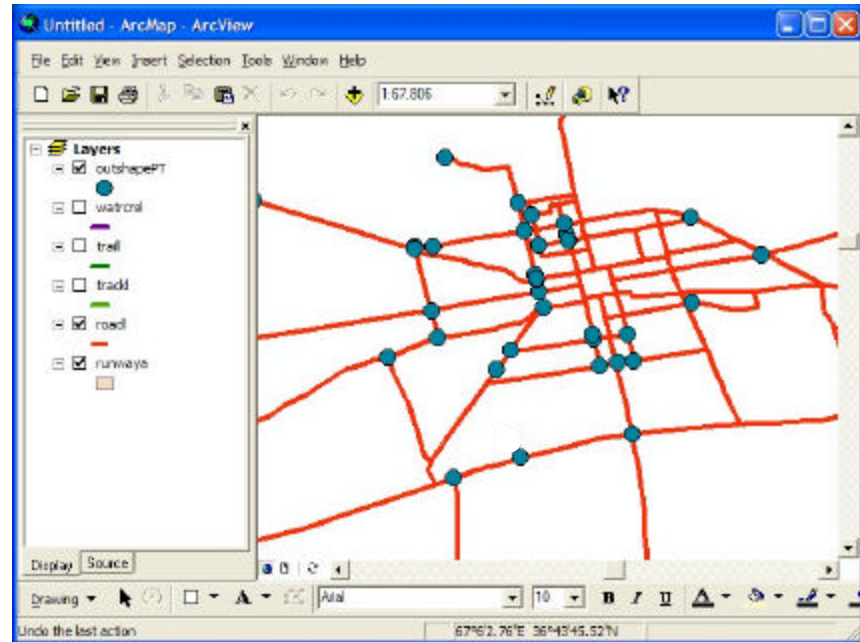
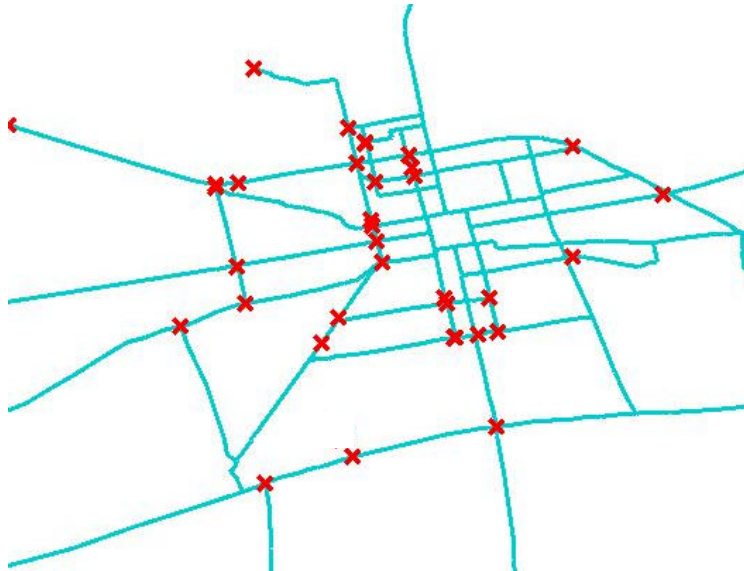
The smaller image to the lower right shows a zoom in on one specific location, showing a typical road segment disconnect of .5m.





# Comparison of SEE-IT data with Source data

**Simulation Center**



- Above left: Snapshot from SEE-IT after locating some disconnected roads. Disconnects are red X-marks, road linears are cyan lines.
- Above right: Snapshot from ArcMap showing original source data road linears (red) and SEE-IT exported shapefile of conditions SEE-IT found (cyan circles).
- The pictures are geometrically identical



# Data Processing Problem Creating Disconnected Road Network

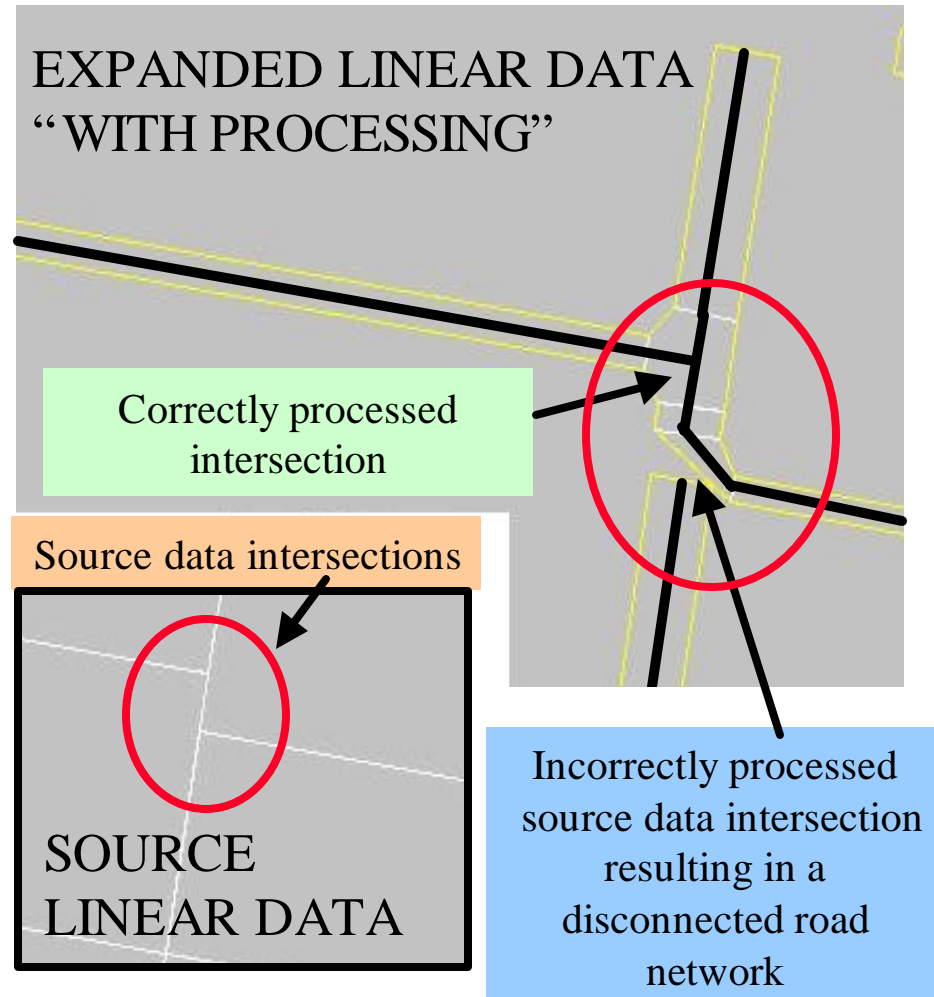
## Simulation Center

The lower left picture shows source linear (road) data as white line segments. These segments will be “expanded” using their WIDTH attribute to create road areas of the proper width.

The larger image shows the result of this processing. Yellow outlined areas represent expanded source linear data.

Heavy black lines represent centerlines of expanded roads.

Note the 2 intersections in the smaller oval area and their post-processing representations in the larger oval: one of them has been correctly processed, the other has not.







# Data Query / View Operations



# Viewing Data with SEE-IT

Simulation Center

SEE-IT provides many ways to “look at” the data from an STF:

- Shaded relief of surface polygons or elevation grids
- Wire-frame view of all polygons
- Cross-sections
- Single or multiple Level-of-detail (LOD)
- Zoom-in or Zoom-out
- Line-of-Sight (LOS) fans or rays
- Superimpose contour lines, coordinate grids, bookmarks, ...
- View by configuration class, stratum, or domain
- View by any EDCS specification:

*“Show me all the airports (with Attribute A, value V)”*

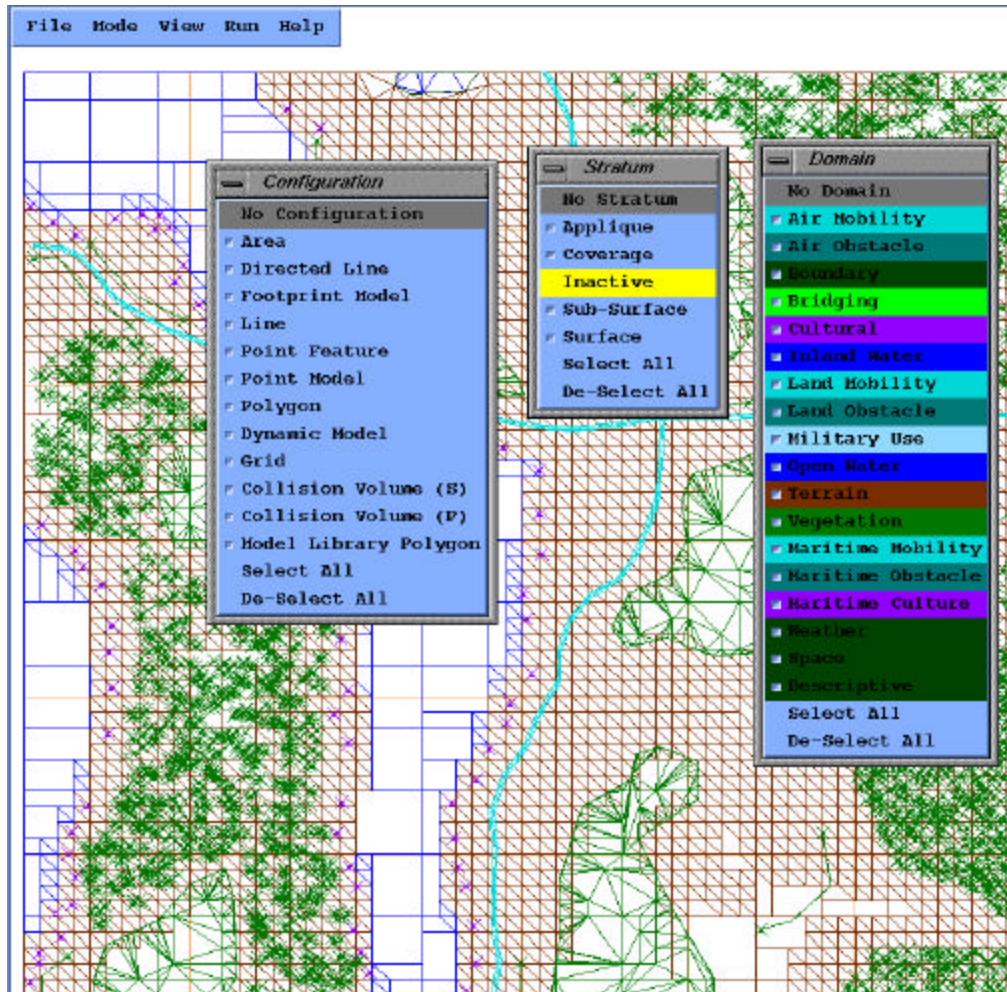
Summary of content

And more ....



# Data Filter Via Configuration, Stratum, domain

## Simulation Center



The window at left provides the ability to *select* any database elements using their Configuration, Stratum, and Domain assignments.

*Selected* database elements are drawn.

Using this functionality, it is trivial to accomplish tasks such as:

“Show me only the cultural areal features and the vegetation point features.”

“Show me only the items representing the surface (not the items resting on top of the surface or below it)”



# Data Filter Via EDCS Specifications

## Simulation Center

Attribution Highlighting Window

Classification identifiers  
(32 Definitions)

Selected classification items:

ROAD (691)

Attributes found in DB  
(11 definitions in this DB):

Values for SELECTED attribute  
(4 definitions):

Selected attribute items:

EA TERRAIN\_TRAFFICABILITY\_COAR

☐ Locate COMBINATIONS of classification and attributes

De-Select highlighted classification items      De-Select ALL classification items

De-Select highlighted attribution items      De-Select ALL attribution items

Help      Done / Apply

The window at left provides the ability to *select* any database elements using their EDCS classification, attributes, and values.

*Selected* database elements are then highlighted.

Using these tool, it is **trivial** to accomplish tasks such as:

“Show me all the ROADS and tell me how many there are in the database”

“Show me all of the ROADS with WIDTH greater than 6.0m”

“How many database items have attribute TERRAIN\_TRAFFICABILITY\_COARSE?  
How many of those have a value of DEEP\_WATER? ROAD?

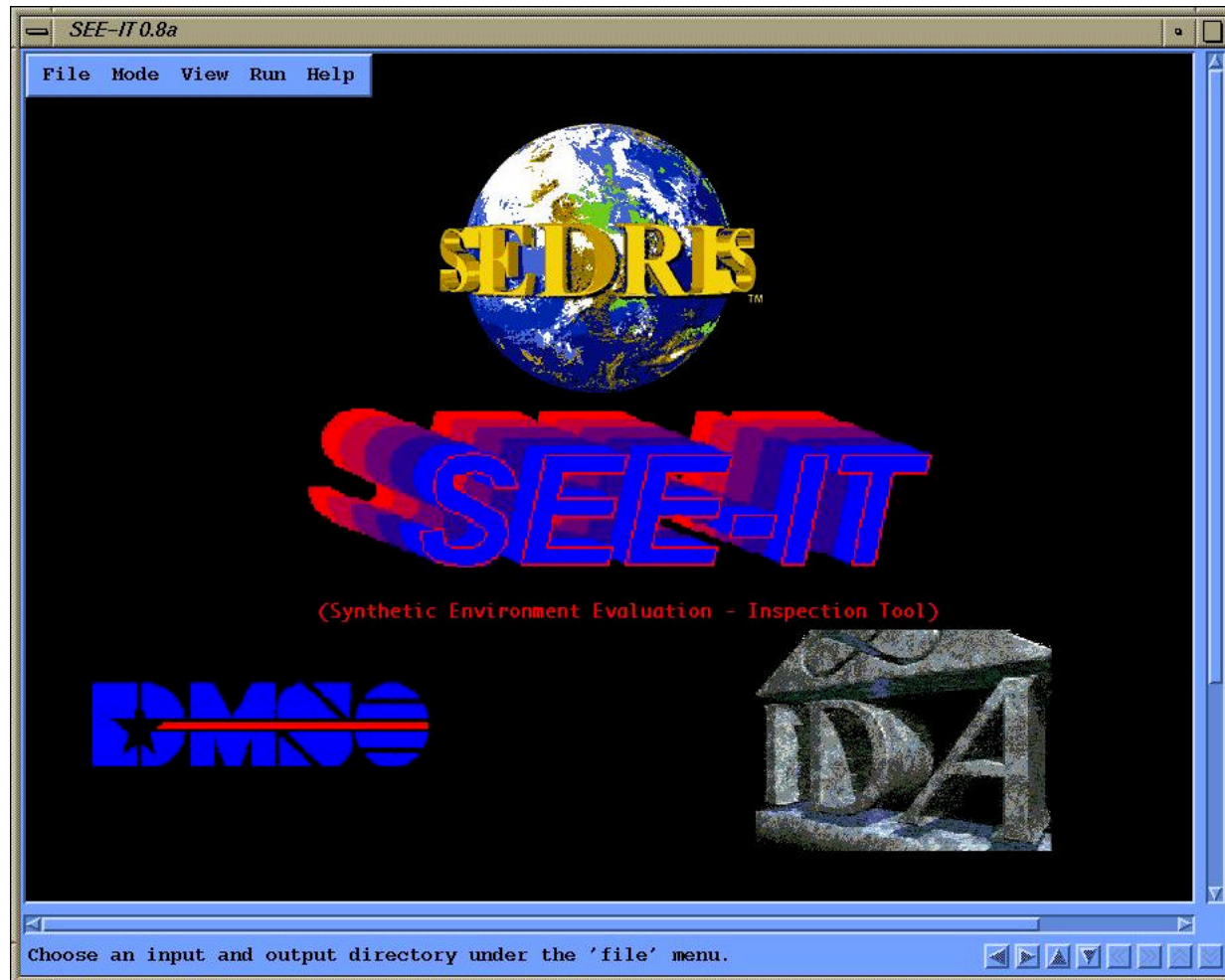
Where are they?





# System Demonstration

**Simulation Center**





## Notes: Import a Single STF

**Simulation Center**

- “Input Type” is “STF (SEDRIS Transmittal File)”
- Search for “extractable” objects
- Collect classification data and other meta-data
- Assign a default SEE-IT classification to each object
- Create intermediate files



## Notes: CSD Modification Window

**Simulation Center**

- CSD is “configuration, stratum, domain”
- SEE-IT classification system
- Data elements partitioned by EDCS Classification Label and associated EDCS Attribution Labels
- Default mappings may not be correct! User must intervene here



## Notes: Format Extracted Database

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### *Simulation Center*

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- Conversion of input STF to internal SEE-IT format creates an optimized SEE-IT database for subsequent analyses
- On completion, the “Great! Let’s SEE-IT” button offers a short-cut to the “Input Source” operation
- This formatted database can now be selected as the “Input Source” at any time





## Notes: Output Source

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*Simulation Center*

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- Used for output files
- Must be selected before many operations will be allowed
- Contents will be overwritten next time this same directory is used as output source



## Notes: Mode Menu

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### ***Simulation Center***

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- Zoom
- Information
- Profiles (and parameters)
- LOS Fan (and parameters)
- Distance
- Mouse button operations described at bottom of the screen



## Notes:View Menu

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### *Simulation Center*

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- Fill Style
- View by Configuration, Stratum, Domain
- Background, Foreground (and parameters)
- Attribution
- LOD
- Areas of Interest
- Summary Information
- Refresh View
- Screen Grab
- Shading Parameters



## Notes: Run Menu

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### ***Simulation Center***

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- Execution Options
- Load/Save Condition Report
- Examination of many saved conditions
- Repair Operations
- Shift buttons
- Graphs
- Modify Current Mappings
- Data Export Options



## Notes: Help Menu

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### *Simulation Center*

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- EDCS Classifications and attributes help window
- EDCS search capability
- Interpret left button as middle





## Future Work

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### *Simulation Center*

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- Continue to improve the STF import capability
- Provide more analyses for other interactions
- Improve the attribution analyses
- Import data directly from other formats
- Continue expansion and improvement of the edit and save capability (using the SEDRIS write API)
- Utilize future inter-application interface
- Continue to expand the ‘family’ of SEDRIS analytical tools ...



# The User Guide

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***Simulation Center***

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SEE-IT comes complete with an extensive user's guide. This document describes the design and use of the system in great detail. It also provides examples of each included utility and inspection.



## Where to go from here

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### ***Simulation Center***

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- Learn about *Fundamentals for Accessing Transmittals* Tuesday 1:30 - 6 pm
- Learn *Advanced Use of the SEDRIS SDK* Wednesday 8:30 am - 12 pm
- Learn about the *Side-by-Side (SbS)* Thursday 11:00 - 11:30 am
- Learn *How to Produce and Consume Transmittals* Friday 8:30 am-12 pm
- Obtain SEE-IT from tools.sedris.org
- Obtain various converters to create STFs from tools.sedris.org
- Obtain visualization software for STF from tools.sedris.org