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(71) Applicant (for all designated States except US): **THE UNITED STATES OF AMERICA, as represented by THE SECRETARY OF THE NAVY** [US/US]; Naval Research Laboratory, 4555 Overlook Avenue, SW, Washington, DC 20375-5325 (US).

(72) Inventors: **BORIS, Jay, P.**; 3516 Duff Drive, Falls Church, VA 22041 (US). **OBENSCHAIN, Keith, S.**; 7520 Hamlet Street, Springfield, VA 22151 (US). **YOUNG, Theodore, R., Jr.**; 6104 Lee Brooke Place, Springfield, VA 22152 (US). **PATNAIK, Gopal**; 12904 Hawkshead Terrace, Silver Spring, 20904 (US). **SCOTT, Robert, J.**; 215 Ridge Road, Jupiter, FL 33477 (US).

(74) Agent: **KARASEK, John, J.**; Associate Counsel (Patents), Code 1008.2, Naval Research Laboratory, 4555 Overlook Avenue, SW, Washington, DC 20375-5325 (US).

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(54) Title: CT-ANALYST: A SOFTWARE SYSTEM FOR ZERO LATENCY, HIGH FIDELITY EMERGENCY ASSESSMENT OF AIRBORNE CHEMICAL, BIOLOGICAL, RADIOLOGICAL (CBR) THREATS

(57) Abstract: CT-Analyst (100, 101) provides accurate graphical predictions of Chemical Biological Radiological (CBR) threats in urban settings. CT-Analyst uses the best 3D computations possible or ground truth data prepared well ahead of time, capturing their salient results in a highly compressed database to be manipulated, and displayed. All internal calculations and results from CT-Analyst are produced and displayed virtually instantaneously. This capability is then immediately available to first-responders and emergency managers in a visual interactive, easy-to-comprehend form. CT-Analyst can support emergency response to both civilian and military CBR threats as well as the control and integration of sensor networks. On site and headquarters staff would use this tool for data fusion to give a minute-by-minute situation assessment including projected escape paths. It could also be used for war games, virtual reality training, site defense planning, and sensor network optimization. Sensor readings (301) can be used to backtrack (303) upwind and locate an unknown source and the downwind "Footprint" of the expanding plume can be determined. The implementation also has sensor fusion capabilities with a "point-and-click" controller (100) to select, morph, and manipulate user-constructed or sensor-driven CBR scenarios directly.



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**CT-Analyst: A Software System for Zero Latency , High Fidelity Emergency
Assessment of Airborne Chemical, Biological, Radiological (CBR) Threats**

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention is concerned with a first responder, and planning system for predictively modeling contaminant transport during an environmental threat or a Chemical, Biological, or Radiological (CBR) Attack and for effective response after the threat.

2. Description of the Prior Art

The effective defense of cities, large bases, and military forces against chemical, biological, or radiological (CBR) incidents or attack requires new prediction/assessment technology to be successful. The existing plume prediction technology in use throughout the nation is based on Gaussian similarity solutions (“puffs” or “plumes”), an extended Lagrangian approximation that only really applies for large regions and flat terrain where large-scale vortex shedding from buildings, cliffs, or mountains is absent. These current plume methods are also not designed for terrorist situations where the input data about the source (or sources) is very scant and the spatial scales are so small that problem set-up, analysis and situation assessment must take place in seconds to be maximally effective. Both greater speed and greater accuracy are required.

The CBR defense of a fixed site or region has a number of important features that make it different from the predictive simulation of a contaminant plume from a known set of initial conditions. The biggest difference is that very little may be known about the source, perhaps not even its location. Therefore any analysis methods for real-time response cannot require this information. It is a crucial requirement to be able to use anecdotal information, qualitative data, and any quantitative sensor data we may be lucky enough to have and instantly build a situation assessment suitable for immediate action.

A software emergency assessment tool should be effectively instantaneous and easy to use because we require immediate assessment of new data, instantaneous computation of exposed and soon-to-be exposed regions, and the zero-delay evaluations of options for future actions. The software should also be capable of projecting optimal evacuation paths based on the current evolving situation assessment.

To meet these requirements, a new tool is required that is much faster than current “common use” models with accuracy comparable to three-dimensional, physics-based flow simulations for scenarios involving complex and urban landscapes. The focus is on situation assessment through sensor fusion of qualitative and incomplete data.

Common-use hazard prediction and consequence assessment systems have at their heart a plume simulation model based on a Gaussian plume/puff model. These systems typically employ Gaussian plume simulation models. The Gaussian plume method, while relatively fast, tends to be inaccurate, especially for urban areas. The setup for all these

systems tends to be complicated, and require a-priori knowledge of the source characteristics.

Some examples of common-use hazard prediction and assessment systems are as follows:

CATS (Consequences Assessment Tool Set) is a consequence management tool package, developed by the U.S. Defense Threat Reduction Agency, U.S. Federal Emergency management Agency, and Science Applications International Corp, that integrates hazard prediction, consequence assessment, emergency management tools, including the Hazard Prediction and Assessment Capability (HPAC) system, and critical population and infrastructure data within a commercial Geographical Information System. (CATS: Consequences Assessment Tool Set, U.S. Defense Threat Reduction Agency, U.S. Federal Emergency management Agency, and Science Applications International Corp.)

CAMEO® (Computer Aided Management of Emergency Operations) is a system of software applications used to plan for and respond to chemical emergencies. It is one of the tools developed by EPA's Chemical Emergency Preparedness and Prevention Office (CEPPO) and the National Oceanic and Atmospheric Administration Office of Response and Restoration (NOAA), to assist front-line chemical emergency planners and responders. (CAMEO®: Computer Aided Management of Emergency Operations, EPA's Chemical Emergency Preparedness and Prevention Office (CEPPO) and NOAA.

MIDAS-AT™ (Meteorological Information and Dispersion Assessment System – Anti-Terrorism), a product of ABS Consulting Inc. is a software technology that models dispersion of releases of industrial chemicals, chemical and biological agents, and radiological isotopes caused by accidents or intentional acts. MIDAS-AT is designed for use during emergencies and for planning emergency response drills. Its Graphical User Interface (GUI) is designed for simple entry of information required to define a terrorist scenario. (MIDAS-AT™: Meteorological Information and Dispersion Assessment System – Anti-Terrorism: ABS Consulting)

HPAC (Hazard Prediction and Assessment Capability), developed by Defense Threat Reduction Agency, is a forward-deployable, counter proliferation-counterforce collateral assessment tool. It provides a means to predict the effects of hazardous material releases into the atmosphere and its impact on civilian and military populations. The HPAC system also predicts approximate downwind hazard areas resulting from a nuclear weapon strike or reactor accident and has the capability to model nuclear, chemical and biological weapon strikes or accidental releases. (HPAC: Hazard Prediction and Assessment Capability, DTRA, HPAC Version 2.0 and HASCAL/SCIPUFF Users Guide, Defense Special Weapons Agency, July 1996)

VLSTRACK (Vapor, Liquid, and Solid Tracking), developed by Naval Surface Warfare Center, provides approximate downwind hazard predictions for a wide range of chemical and biological agents and munitions of military interest. The program features

smart input windows that check input parameter combinations to ensure that a reasonable attack is being defined, and simple and informative output graphics that display the hazard footprint for agent deposition, dosage, or concentration. The model also features variable meteorology, allowing for interfacing the attack with a meteorological forecast. (VLSTRACK: Vapor, Liquid, and Solid Tracking, [US Patent 5,648,914] Naval Surface Warfare Center, Bauer, T.J. and R.L. Gibbs, 1998, NSWCDD/TR-98/62, "Software User's Manual for the Chemical/Biological Agent Vapor, Liquid, and Solid Tracking (VLSTRACK) Computer Model, Version 3.0," Dahlgren, VA: Systems Research and Technology Department, Naval Surface Warfare Center.)

ALOHA (Areal Locations of Hazardous Atmospheres), from EPA/NOAA and a component of CAMEO, is an atmospheric dispersion model used for evaluating releases of hazardous chemical vapors. ALOHA allows the user to estimate the downwind dispersion of a chemical cloud based on the toxicological/physical characteristics of the released chemical, atmospheric conditions, and specific circumstances of the release. Graphical outputs include a "cloud footprint" that can be plotted on maps to display the location of other facilities storing hazardous materials and vulnerable locations, such as hospitals and schools. (ALOHA® - Areal Locations of Hazardous Atmospheres, EPA/NOAA)

FASTD-CT (FAST3D – Contaminant Transport) is a time-accurate, high-resolution, complex geometry CFD model developed by the Naval Research Laboratory

in the Laboratory for Computational Physics and Fluid Dynamics. The fluid dynamics is performed with a fourth-order accurate implementation of a low-dissipation algorithm that sheds vortices from obstacles as small one cell in size. Particular care has been paid to the turbulence treatments since the turbulence in the urban canyons lofts ground-level contaminant up to where the faster horizontal airflow can transport it downward. FAST3D-CT has a number of physical processes specific to contaminant transport in urban areas such as solar chemical degradation, evaporation of airborne droplets, re-lofting of particles and ground evaporation of liquids. (FAST3D-CT: FAST3D – Contaminant Transport, LCP & FD, NRL Boris, J. “The Threat of Chemical and Biological Terrorism: Preparing a Response,” *Computing in Science & Engineering*, pp. 22-32, March/April 2002.)

NARAC (National Atmospheric Release Advisory Center) maintains a sophisticated Emergency Response System at its facility at Lawrence Livermore National Laboratory. The NARAC emergency response central modeling system consists of a coupled suite of meteorological and dispersion models. Users access this system using a wide variety of tools, also supplied by NARAC. Users must initiate a problem through a phone call to their operations staff or interactively via computer. NARAC will then execute sophisticated 3-D models to generate the requested products that depict the size and location of the plume, affected population, health risks, and proposed emergency responses. (ARAC: Atmospheric Release Advisory Capability, Lawrence Livermore

National Laboratory, DOE. Wilt, G "Forewarnings of Coming Hazards," Science & Technology Review, pp. 4-11, June 1999, Lawrence Livermore National Laboratory.)

State-of-the-art, engineering-quality 3D predictions such as FAST3D-CT or the NARAC Emergency Response System that one might be more inclined to believe can take hours or days to set up, run, and analyze.

All of the above-mentioned systems take several minutes, hours, or even days to return results. Simplified systems such as PEAC® (Palmtop Emergency Action for Chemicals [US Patent 5,724,255] originally developed by Western Research Institute provide the necessary emergency response information to make quick and informed decisions to protect response personnel and the public. PEAC-WMD 2002 provides in hand information compiled from a number of references with very fast recall. PEAC provides emergency responders with instant access to information from a number of sources and evacuation distances based on several sets of guidelines. This system, can return results within seconds, requires less detailed knowledge of the source, but the resulting fixed-shape plume does not take into account any effect of complex terrain or buildings.

Waiting even one or two-minutes for each approximate scenario computation can be far too long for timely situation assessment as in the current common-use hazard prediction systems. Overly simplified results can result in inaccurate results. The answer to this dilemma is to do the best computations possible from state-of-the-art 3D

simulations well ahead of time and capture their salient results in a way that can be recalled, manipulated, and displayed instantly.

SUMMARY OF THE INVENTION

Greater accuracy and much greater speed are possible at the same time in an emergency assessment system for an environmental threat or airborne chemical biological and radiological (CBR) threats. CT-Analyst is a portable, entirely graphical hazard prediction software tool that exploits the new dispersion nomograph technology in order to achieve its speed and accuracy. The use of the dispersion nomograph representation and processing algorithms also allow some new features not available in existing systems. Multiple sensor fusion for instantaneous situation assessment is an automatic consequence of the nomograph technology. Reports from sensors about a contaminant can be used to determine the affected area downwind. Using three or four appropriate sensor readings, CT-Analyst can also backtrack and locate an unknown source graphically with zero computational delay. CT-Analyst can accept qualitative and anecdotal input and does not require knowledge of a source location or a source amount.

CT-Analyst provides an easy to use graphical user interface(GUI) to manipulate sensor, source, or site properties (i.e. location) and immediately provides an updated display of potential CBR hazards from a contaminant plume. The implementation has fast forward and fast reverse for the plume envelope displays, direct sensor fusion, and the ability to vary environmental properties in mid scenario. CT-Analyst also plots evacuation routes automatically. The capability appears to the user as an infinite library

of scenarios with a graphical controller to select, morph, and manipulate the CBR scenarios directly.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram showing the overall structure, and main components of CT-Analyst.

Figure 2 is an Event Flow diagram illustrating how the components of CT-Analyst respond to events generated internally, and externally.

Figure 3 is a diagram representing the components of the CT-Analyst graphical user interface.

Figure 4 is a diagram showing the presentation of Nomograph displays generated by the Nomograph library.

Figure 5 is a detailed scenario using CT-Analyst

Figure 6 is a block diagram of the various events generated externally, and internally in CT-Analyst.

Figure 7 shows a block diagram representing the main event loop, a component of CT-Analyst to Nomograph Interface

Figure 8 is a functional block diagram of the interface used to communicate with the Nomograph libraries, a component of the CT-Analyst to Nomograph Interface.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Refer to Figure 1 for the overall data flow of the invention. There are two main components to CT-Analyst (CT-A), the CT-Analyst Graphical User Interface (CT-A GUI) **100**, and the CT-Analyst to Nomograph Interface (CT-A Interface) **101**. This modular configuration allows manipulation either from CT-A, or the External Interface **107**. This flexibility enables CT-A as a stand-alone system or as a component of larger command and control system. This modular approach is used throughout CT-A, which allows it to be flexible, robust, and easily extendable.

The CT-A Interface **101** translates from the data format used in the CT-Analyst GUI, and the External Interface **107** to the data format used by the Nomograph Library **102**. Within CT-A, the properties of each sensor, source, and site (SSS) are represented as an object. An object is defined as the set of properties that comprise a sensor, source or site. The number of properties for each sensor, source, or site object may vary, depending on what type of sensor, source, or site the object represents. Each sensor, source, and site is represented as a state vector in the Nomograph Library. A state vector is defined as the properties the Nomograph Library **102** uses for a sensor, source, or site to calculate the Nomograph display **106**. An object will always have a corresponding state vector. The sensor, source, and site objects will include at a minimum the properties represented by its corresponding state vector. An object may be modified by: 1) user of CT-A GUI, 2) by an outside program, script, network, or other connection via the External Interface, or 3) by the reconciliation of the properties between an object and its

state vector counterpart after a new set of Nomograph displays has been generated. Similarly, an environment object exists that contains the overall properties used by the Nomograph Library. Any changes to a property of any object, made by the External Interface **107**, or the CT-A GUI **103-105** are reported to the CT-A Nomograph Interface. Depending on the object property changed, the Nomograph Library **102** would be called, and new displays **106** would be generated. The change of a property of an object will send out a notification that the object has been changed to the CT-A GUI, and to the External Interface.

All sensor, source, and site objects have the following properties, position of the object, and a property, which includes, or excludes the object from the generation of a Nomograph display.

Sensor objects typically represent external sensors **203** (sensor in external mode). A sensor object in external mode will have most of its properties determined by a connection to a real sensor via the External Interface **107**. The sensor state can be either hot or cold. A sensor in a hot state is defined as a sensor that has detected a contaminant at its location, while a sensor in a cold state has not. Sensor objects have all of the general properties of an object, along with additional properties depending on the type of sensor represented. This includes sensor modes, its current state, the timestamp of its last state change, the concentration, mass, type and other relevant properties of the contaminant detected. The additional sensor modes include manual, and simulation modes. A sensor object in manual mode has all of its properties determined by the user

and are typically used for anecdotal reports entered by the user in the CT-A GUI. In the simulation mode, a sensor's state is determined by the contaminant plume as determined by the Nomograph Library. For example, sensors in simulation mode within the contaminant footprint will change its state from cold to hot, while a sensor in manual or external mode would not. Depending on the information provided by the external, or manual sensor, additional sensor states showing intermediate states between hot and cold might be represented by the sensor object. However, the additional sensor states would be translated into hot and cold states in the corresponding state vector depending on the sensitivity of the sensor network, and user preference. Multiple sensor objects could represent one real sensor. An example would be a mobile sensor taking sensor readings at fixed interval in time. Sensor objects can be grouped together. Examples of sensor groups include a sensor group for a fixed sensor network, and a sensor group for mobile sensors.

Source objects represent a contaminant release at a location. The number of properties can vary in a Source object. At a minimum, it has the general properties of a standard object. Additional properties can include the concentration, mass, type, and other relevant properties of the contaminant. These additional properties would increase the level of detail provided by the Nomograph displays, but are not required. Multiple source objects can be grouped together to form other types of contaminant releases. This includes line sources.

Site objects represent a region, or area of interest. A site object is used to provide detailed properties about that area. They are typically used to generate additional Nomograph displays specifically pertaining to that site. A site object has the general properties of a standard object. Additional properties could include building parameters, or other relevant information used to protect that site.

An environmental object exists for CT-A. The properties in an environmental object consist of temperature, time, season, wind speed, and direction, and other meteorological properties. These properties may be set by the user manually, or updated automatically via the External Interface.

The Nomograph Library **102** takes the sensors, sources, and sites state vectors, and the environmental vector as input and outputs Nomograph displays. These state vectors only include the properties used to generate a Nomograph display. Properties common to sensor, sources, and sites state vectors are its position, and a flag that allows the vector to be excluded from the calculation of the Nomograph displays.

The sensor state vectors **109** consist of the its current state, the timestamp of its last state change, its mode, the concentration, mass, type, and other relevant properties of the contaminant detected. Source state vector properties include the amount of contaminant released, timestamp of release, mass, type, and other relevant properties of the contaminant. Site state vectors contain the special properties pertaining to that site. The environmental state vector **108** consists of the time of day, season, current temperature, wind direction, and speed, and other meteorological properties.

The Nomograph Options **110** passed to the Nomograph Library include the requested size of the Nomograph display, the selected area of the Nomograph, and which set of Nomograph tables to be used in the generation of a Nomograph display.

A more detailed description of the invention is found in Figure 2 which depicts the event flow between the CT-A GUI **100**, the External Interface **107**, and the CT-A Interface **101**. An event is defined as a notice communicated to a component of CT-A that an object, or a component of CT-A has been modified. Upon receipt of an event, the recipient will take the appropriate action. For example, if a user changes a manual sensor's state from cold to hot, the sensor object would post a SSS Altered event (**Figure 6 602**). This is received by the CT-A Interface, which calls the Nomograph Library to generate an updated Nomograph display. The CT-A Interface would then post an event notifying the CT-A GUI that an updated Nomograph display is available. If necessary, this change will be shown to a user. The use of events in CT-A allow for uniform handling of internal and external changes. This allows objects, and components of CT-A to be synchronized regardless of the source of the change, internal or external.

The CT-A Interface receives events from the components of CT-A, and from all the objects in CT-A. A change in a property of an object from any component of CT-A would be sent to the CT-A Interface. From this component, other objects and components would be notified of the change via events. Examples of actions from the CT-A Interface that post events are: 1) a modification of an SSS object, or the environmental object by the External Interface or the CT-A GUI, 2) modification of a

SSS object, or the Environmental object after a reconciliation of an object with its corresponding state vector after the generation of an updated Nomograph display.

Depending on the type of event received, the CT-A Interface will call the Nomograph Library to generate a new Nomograph Display, or will wait some period of time for more events to arrive before updating the Nomograph Display.

The CT-A GUI posts events through actions of the user, and reacts to events from the CT-A Interface. Examples of user actions that generate events through the CT-A GUI are: 1) the addition or removal of SSS objects, 2) A modification of a property of an SSS object, 3) modification of properties in the Environment object, 4) saving/loading of SSS objects and the Environmental object from a storage device, 5) a change in how the Nomograph displays are presented, 6) changing the set of nomograph tables used to generate Nomograph displays. The events that the CT-A GUI reacts to are changes in the properties of SSS objects, changes to properties in the environment object, and updates to Nomograph displays.

The External Interface posts events through changes to SSS objects, and the environment object via connections 203 to the External Interface. Connections to the External Interface typically include sensors, meteorological information, an external program, or network connections. The External Interface reacts to events from the CT-A Interface. Examples of actions from the External Interface that generate events are: 1) modifying a property of a SSS objects, 2) modifying a property of the environmental object, 3) a generation of updated Nomograph Displays.

As shown in Figure 3, the user and monitor of Chemical, Biological or Radiological Attacks interacts with CT-Analyst through a graphical user interface. The CT-A Graphical User Interface (CT-A GUI) displays the sensor, source, and site (SSS) objects as graphical elements in the GUI. The CT-A GUI (Figure 1, 100) is one of the key components of CT-A, through which the user (Figure 2, 200) interacts with CT-A. The simplicity, and ease of use of CT-A GUI is in stark contrast to other emergency response systems. The user has to merely point and click to manipulate properties of sensor, source, and site objects, or environmental properties. The user is not required to input detailed information about the contaminant prior to obtaining a useful result. Additional information can be added as it becomes available. Because of its simplicity of use, training in the use of CT-A is minimal.

Using the CT-A GUI, the user can add, remove, or modify the properties of the sensor, source, and site objects. The various environmental properties can also be modified **302**. The user may also load, and save scenarios, run simulations, and change how the Nomograph displays are presented **303**. The CT-A GUI translates the Nomograph displays into a display format **300**, which is viewable by the user. This includes translating the Nomograph displays into the required coordinate system, adding maps, or other graphical layers (Figure 1, 111) representing buildings, terrain features, or other relevant geographical information about the area (Figure 1, 111), and merging the selected Nomograph displays into an image, or images.

The graphical representation of each object is dependant on some or all of its properties **304-307**. For example, a source object that is included in the Nomograph generation is depicted as a star **304**. Sensor objects are depicted using different colors and shapes, depending on their properties. Examples of sensor depictions are shown **305-307**. For instance, a simulation sensor **305**, in a hot state, which is included in the generation of a Nomograph display, is easily identified from a manual sensor **306**, whose state is cold, which is also used in the generation of a Nomograph display.

The CT-A GUI can provide multiple views of SSS objects, or the environment object. For example, a sensor object **306** is depicted in two graphical displays **300** and **301**. The main graphical user interface (main GUI) **300** is used to display some information about all of the objects on the screen, as well as a presentation of the Nomograph displays. The auxiliary graphical display (auxiliary GUI) **301** is used to present the properties in an object in a different, or expanded format. The auxiliary GUI may display the same information as the Main GUI interface, but typically shows more detail about one or more SSS objects, the Environment object, or the Nomograph Options. Multiple auxiliary GUI's may be used depending on user preference. In this figure, two other auxiliary displays are shown, a GUI to control the environment object's properties **302**, and an auxiliary GUI to control the Nomograph Options **303**.

Figure 4 shows diagrams of the main Nomograph displays generated by the Nomograph Library **102**. This figure shows some of the unique diagnostic capabilities of CT-A. For example, the Backtrack display **401** is unique to CT-A due to the use of the

Nomograph Library. The speed with which the displays are generated contribute to the usefulness of CT-A.

The Nomograph tables used to generate the Nomograph displays are typically selected based on the properties of the state vector, and the area of interest. The main types of Nomograph tables generated are 1) the consequence display **400**, 2) the backtrack display **401**, 3) the footprint display **402**, 4) the simulation display **403**, 5) escape display **404**, 6) danger zone display **405**, and 7) the leakage display **406**. The Nomograph library may generate specialized displays for a particular state vector, if requested.

Sensor vector states are used to generate two types of Nomograph displays, consequence and backtrack displays. The consequence display **401** consists of a region downwind, with an upwind safety radius from a sensor that could potentially be exposed to a contaminant. This is dependant on the whether the sensors states are hot or cold. The Backtrack display **402** shows the probability of a contaminant source location for different regions. The Backtrack display will display regions by different values, depending on the probability that a source originated from that area.

Source vector states are used to generate simulation **403**, footprint **402**, and escape route **404** displays. The footprint display shows the area downwind, with an upwind safety radius that could become exposed to the contaminant from the source. The simulation display shows a time evolution of a plume. The escape display shows the optimal escape routes, based on the footprint display from the source.

Site vector states are used to generate danger zone **405**, and leakage **406** displays. The danger zone display shows the area upwind from a site where a contaminant placed in that area could reach the site. The leakage display shows the area downwind of the site that could potentially be exposed to a contaminant if the site itself was exposed.

Figure 5 is a block diagram detailing a user's response to information displayed by CT-A. In this scenario, a chemical agent has been released in an urban environment **500**. A fixed sensor net has been deployed in the urban area, and several of the sensors alarm **501** indicating that a chemical release has occurred in the area. The sensors are connected to the External interface, and their change in status is received **502**. A Nomograph display **503** is generated, which is displayed by the CT-A GUI, which also shows the change in status of the effected sensors. The user sees the change in state, and selects the backtrack display from the CT-A GUI (**figure 3 303**). Sensor readings can also be obtained from mobile sensors, or other sources like first responder radio reports, or people becoming ill from the chemical release. If this information exists **505**, it can be entered into CT-A as a manual sensor reading **510**.

If any manual sensors, or automatic sensors are hindering the ability of CT-A to limit an area where the chemical release has occurred, the user can exclude **506** the sensor readings from the backtrack. The user can now determine if they have enough information to determine where the source is located **507**. If the backtrack area displayed by CT-A is not narrowed to a small region, the user has several options. They can wait for more information to come in via the fixed sensor network, or by manual sensor input

508. They can also send mobile sensors to the potential chemical source area displayed by the backtrack **509**, with the goal of finding the edges of the chemical plume.

When the backtrack display from CT-A has narrowed the location of the chemical release to a small region, a source object can be placed in the backtrack region **511**. With the source object displayed in CT-A, the area downwind that could be contaminated by the chemical release is known. The user can now setup escape routes based on the source object **512**, and send out this information out to areas downwind of the source **513**. The escape route information can be sent out to remote sites via CT-A's External Interface, or through other methods external to CT-A.

Figure 6 is a functional block diagram showing the creation of events typically created in CT-Analyst. These events are routed through the CT-Analyst to Nomograph Interface to other components in CT-Analyst. An event may affect multiple components of CT-A, or none at all.

Environmental Objects usually generate events by changing environmental parameters **600**, or changing the Nomograph tables used **601**. Changing the environment parameters generates a metEvent **606**. The environment parameters that are most frequently altered are the wind direction, and velocity **604**. Other miscellaneous parameters **605** that would generate a metEvent include time of day, season, and weather conditions, and other meteorological parameters. Changing the nomograph tables used or a change in the location viewed CT-A **608**, will generate an areaEvent.

The two types of events that occur with Sensor, Source, or Site objects are a change in the properties of an SSS object **602**, and the addition/removal of an SSS object **603**. Changing a property of an SSS object **609** will generate an SSS Object Event **610**. The properties that typically create an SSS Object Event include altering the objects location, the type of object it represents, whether it is included in the calculation of the nomograph displays, and its state. Adding or removing an SSS Object **611** will generate an SSS Add/Remove Object Event **612**.

Figure 7 is a functional block diagram of the CT-Analyst Event Loop (CT-A Event Loop). This is an internal component of the CT-A to Nomograph Interface **101**. The CT-A Event Loops is started **700** when the CT-A Interface is initialized. It first checks see if any SSS events have occurred **701**. If an SSS event was generated, it is checked to determined what type of event it is **706-707**, and sets the updateFlag to true if the event is valid. If an environment object event has occurred **702**, a new nomograph table will be loaded depending of the parameters of the Environmental object **709**, and the updateFlag will be set. If the updateFlag has been set **703**, the NG Interface will be called **711**, which will update the Nomograph displays. If the program hasn't finished, it will continuously process this loop **704**, otherwise the loop will exit **705**.

Figure 8 is a functional block diagram of the NG Interface. This is an internal component of the CT-A to Nomograph Interface **101**, which translates the SSS objects, and Environmental objects into the format that the Nomograph Library can use, and outputs updated SSS objects, and updated Nomograph displays.

First, the SSS objects, and the Environmental object are converted into their state vector equivalent **800-801**. Next, the Nomograph Library is called, and new Nomograph displays are generated **802**. Since the Nomograph Library can potentially alter the state vectors, each vector is checked to see if it has been altered **803-805**. If it has been altered, the SSS object and SSS vector are reconciled by updating the properties of the SSS object using the properties from the state vector **807**. The new Nomograph displays are sent out to the other components of CT-A **806**, and the NG Interface returns.

Although this invention has been described in relation to an exemplary embodiment thereof, it will be understood by those skilled in the art that still other variations and modifications can be affected in the preferred embodiment without detracting from the scope and spirit of the invention as described in the claims.

WHAT IS CLAIMED:

1. A computer system for predictively modeling environmental threats, comprising:
 - a computer for processing environmental data and interfacing with a user;
 - a graphical user interface connected to said computer for displaying data concerning environmental threats;
 - an external interface connected to said computer and connected to environmental sensors to detect environmental threats; and
 - an interface connected to said computer and to a library of regional geographic data for enabling the display of environmental data together with data concerning environmental threats.
2. The computer system of claim 1, wherein said environmental threats comprise Chemical, Biological, Radiological or obscurants threats.
3. The computer system of claim 1, wherein said graphical user interface displays the location of sensors, sites, and sources of environmental threats in a selected region.
4. The computer system of claim 1, wherein said graphical user interface displays regions affected by environmental threats and maps regions to be affected by said environmental threats.
5. The computer system of claim 1, wherein said graphical user interface is enabled to provide virtually instantaneous real time displays of regions affected by environmental threats by using the library of regional geographic data.

6. The computer system of claim 1, wherein said external interface is connected to environmental objects which measure temperature, time, season, wind speed, wind direction and other meteorological properties.
7. The computer system of claim 1, wherein said external interface is connected to a network or to a larger command and control system.
8. The computer system of claim 1, wherein the interface connected to a library of regional data takes input from sensors, sources, and sites and outputs a current regional display map.
9. The computer system of claim 8, wherein said current regional display map is a Nomograph display.
10. The computer system of claim 8, wherein said current regional display map is a geographic display.
11. The computer system of claim 9, wherein said interface connected to said computer receives updated sensor data and based on said updated data generates an updated Nomograph display.
12. The computer system of claim 11, wherein an updated Nomograph display is produced if a relevant event is generated.
13. The computer system of claim 1, wherein the graphical user interface permits the user to generate events that will generate an updated display.

14. The computer system of claim 13, wherein said events comprise modification of a sensor, source, or site, changing nomograph data to be displayed, or modifying an environmental object.

15. A method of using a computer to display an environmental threat to a given region, comprising the steps of:

- using environmental sensors to determine whether an environmental threat has occurred in a given geographical region;

- polling said environmental sensors to determine their current status;

- generating a regional map based on data from said sensors displaying an affected region as determined by said sensors;

- determining whether said sensors have provided relevant environmental data;

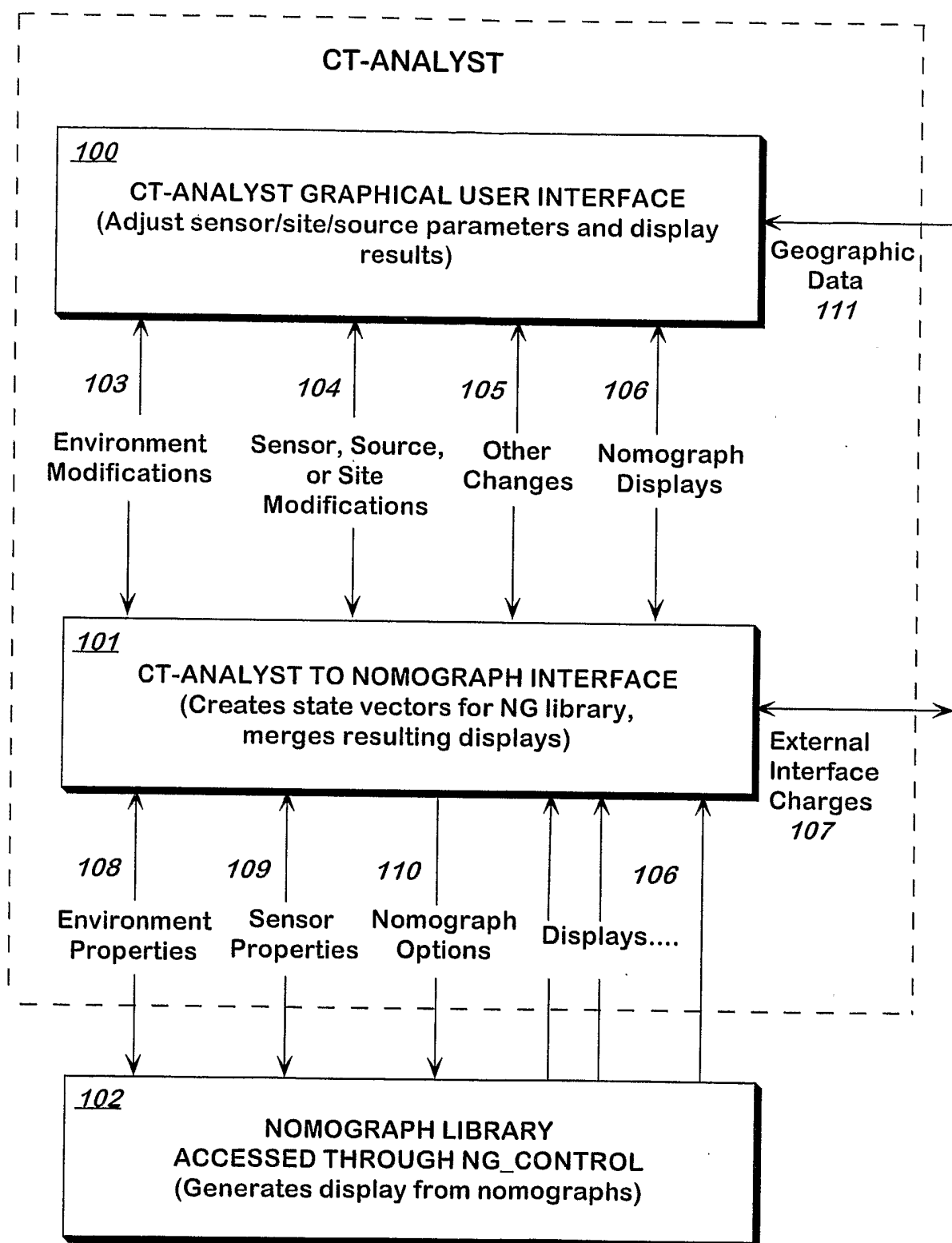
- excluding sensor data which is not relevant;

- detecting a source object in the affected region;

- displaying a plume generated by said source object;

- displaying escape routes based on said source object; and

- sending out warnings to areas downwind from said source which are known to be affected.

**FIG. 1**

EVENT FLOW IN CT-ANALYST

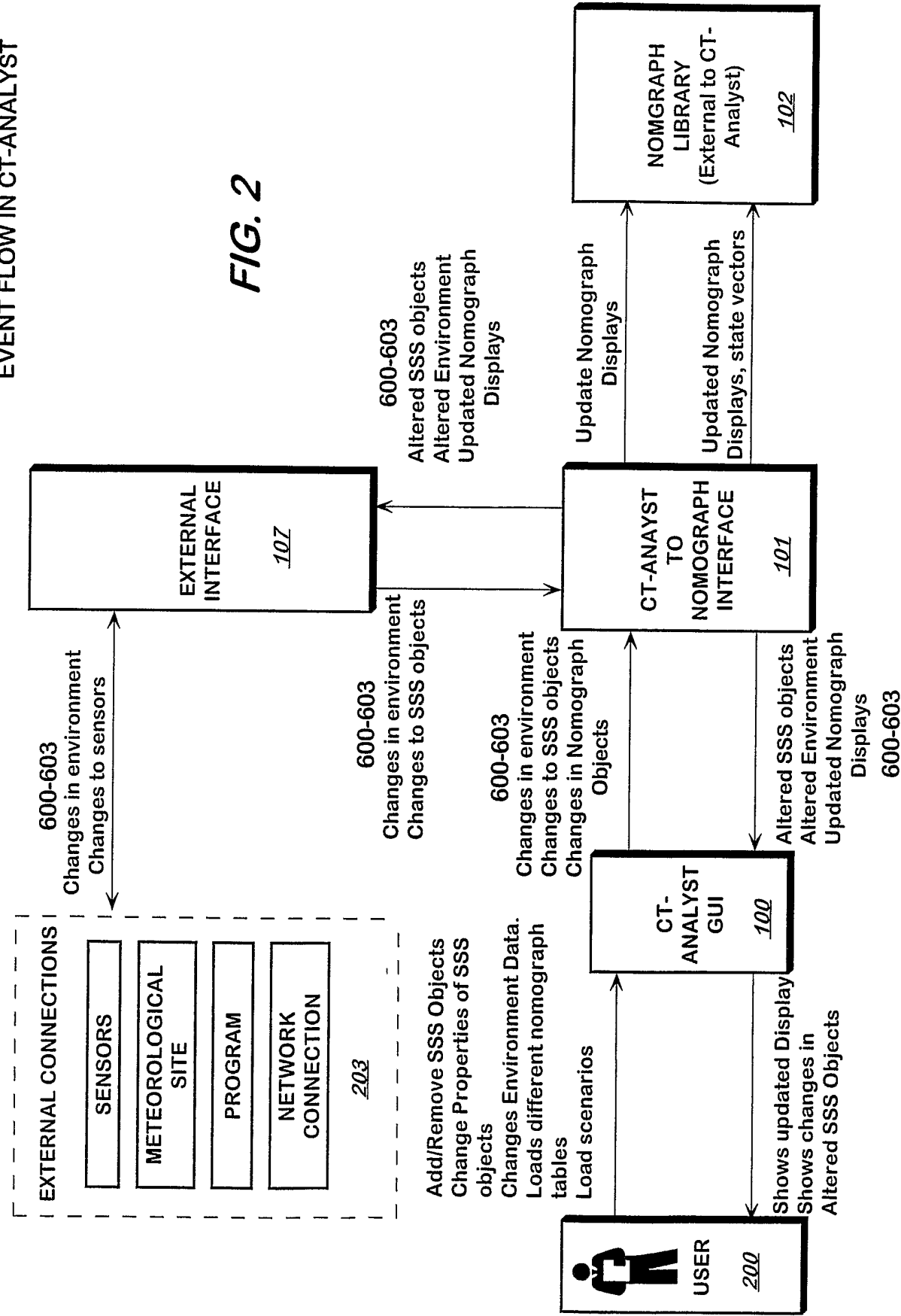
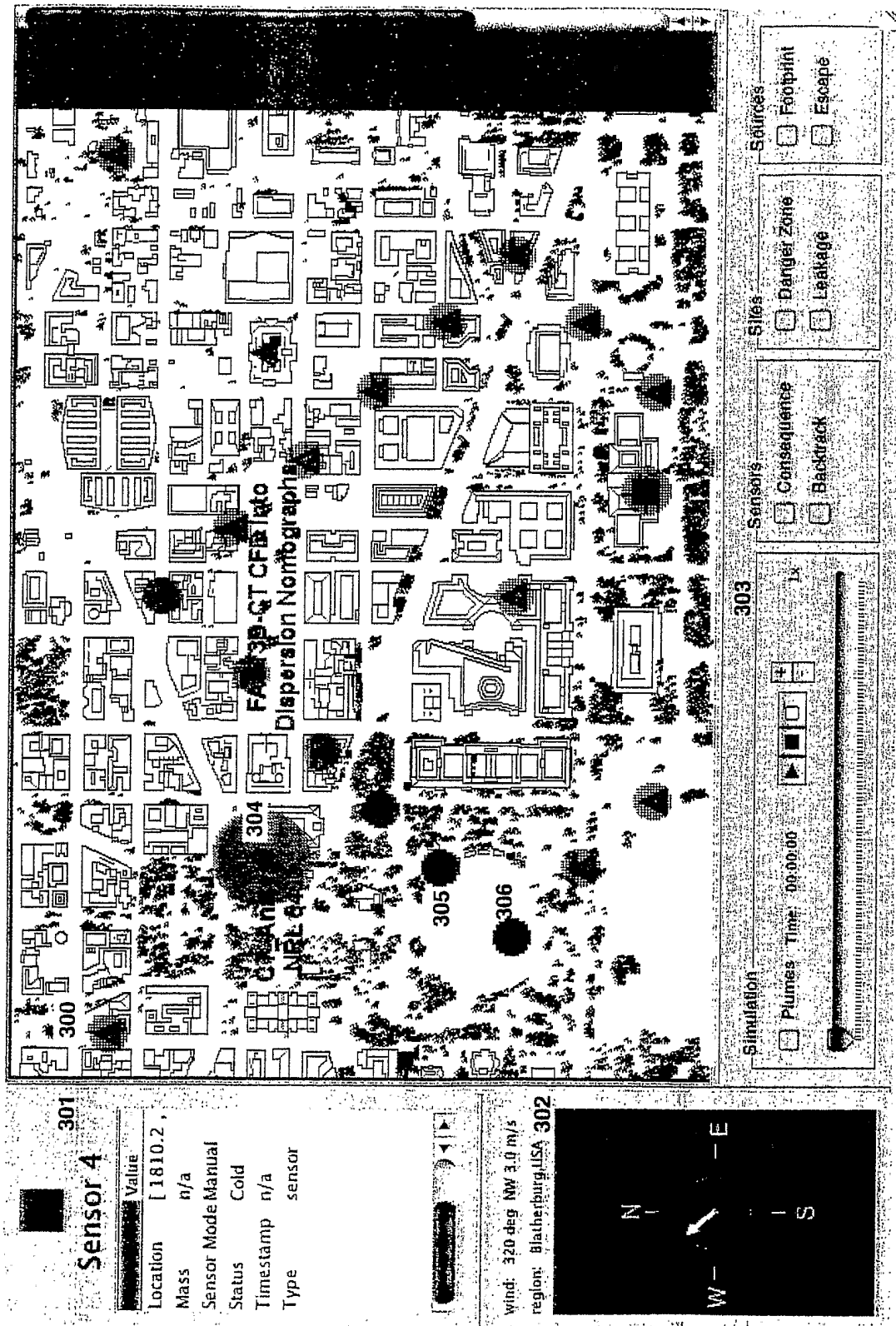


FIG. 3



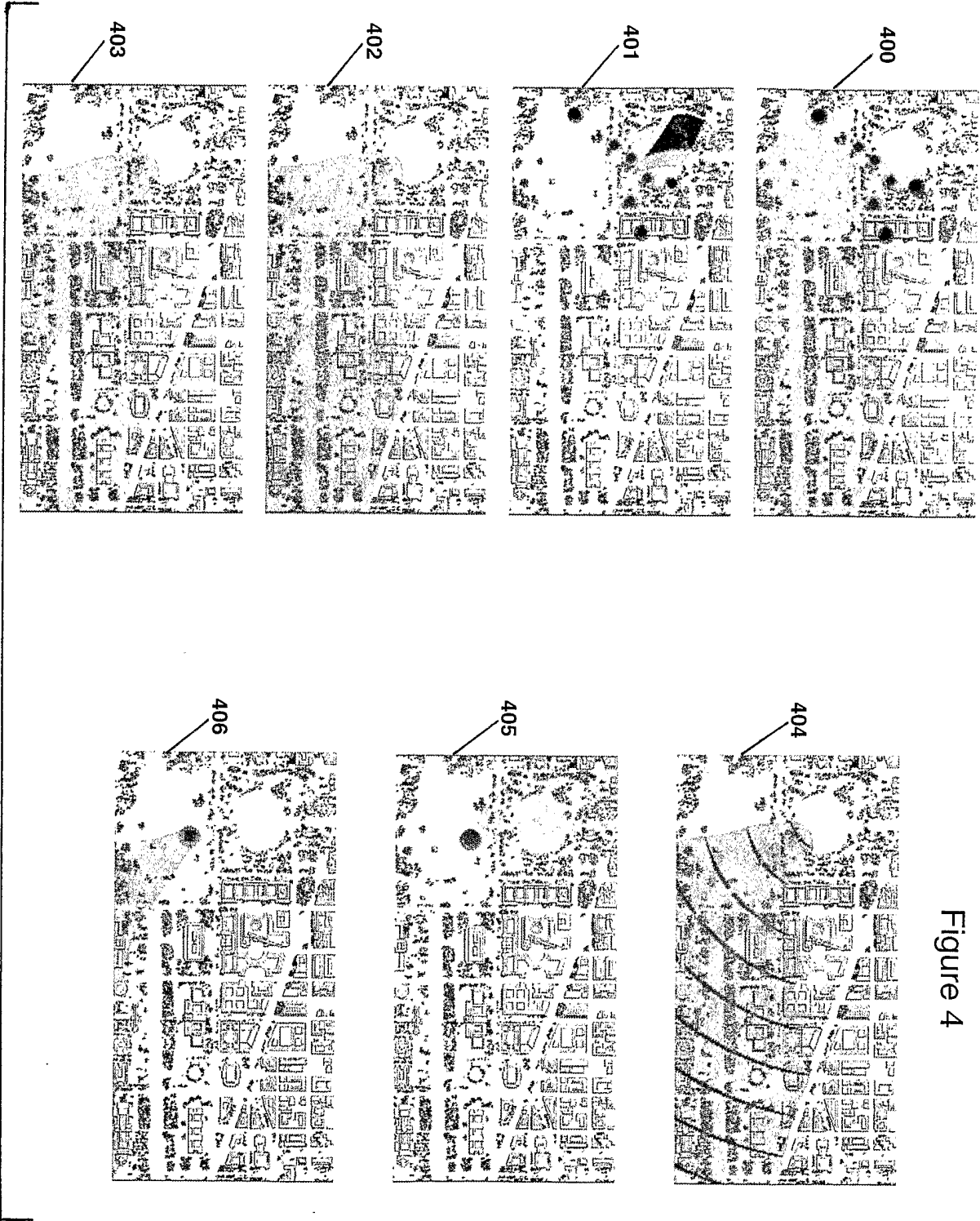
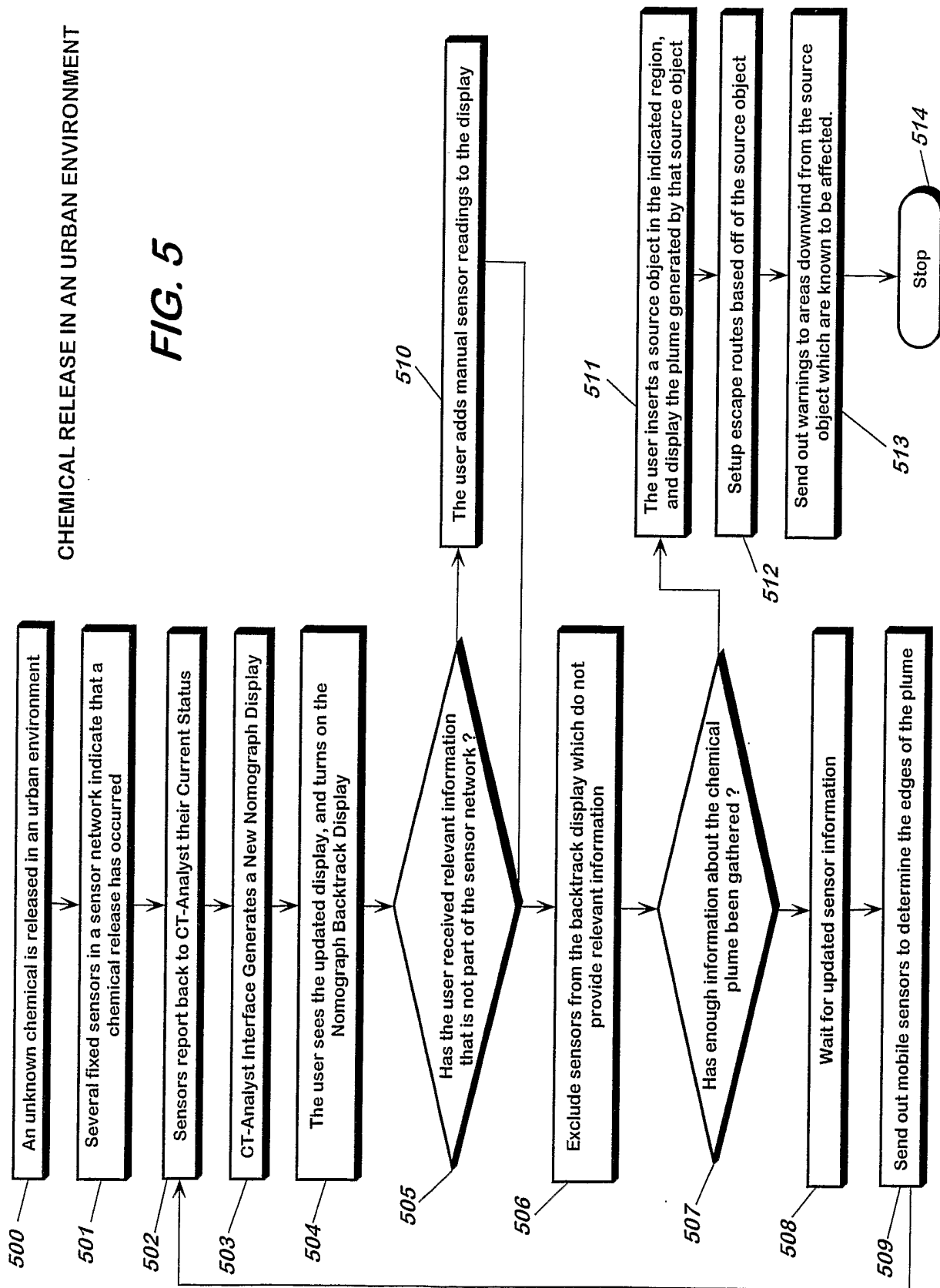


Figure 4

CHEMICAL RELEASE IN AN URBAN ENVIRONMENT

FIG. 5



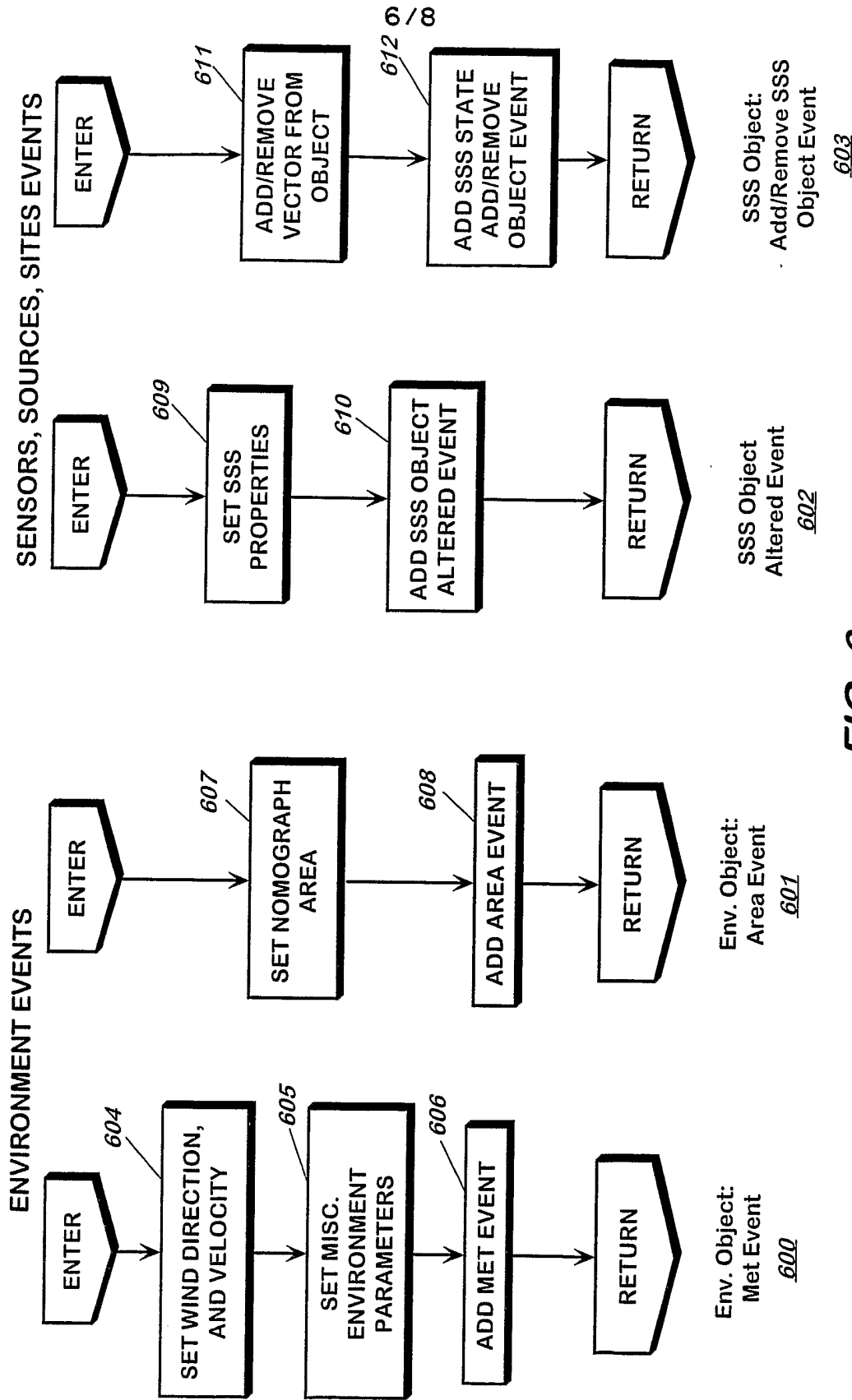
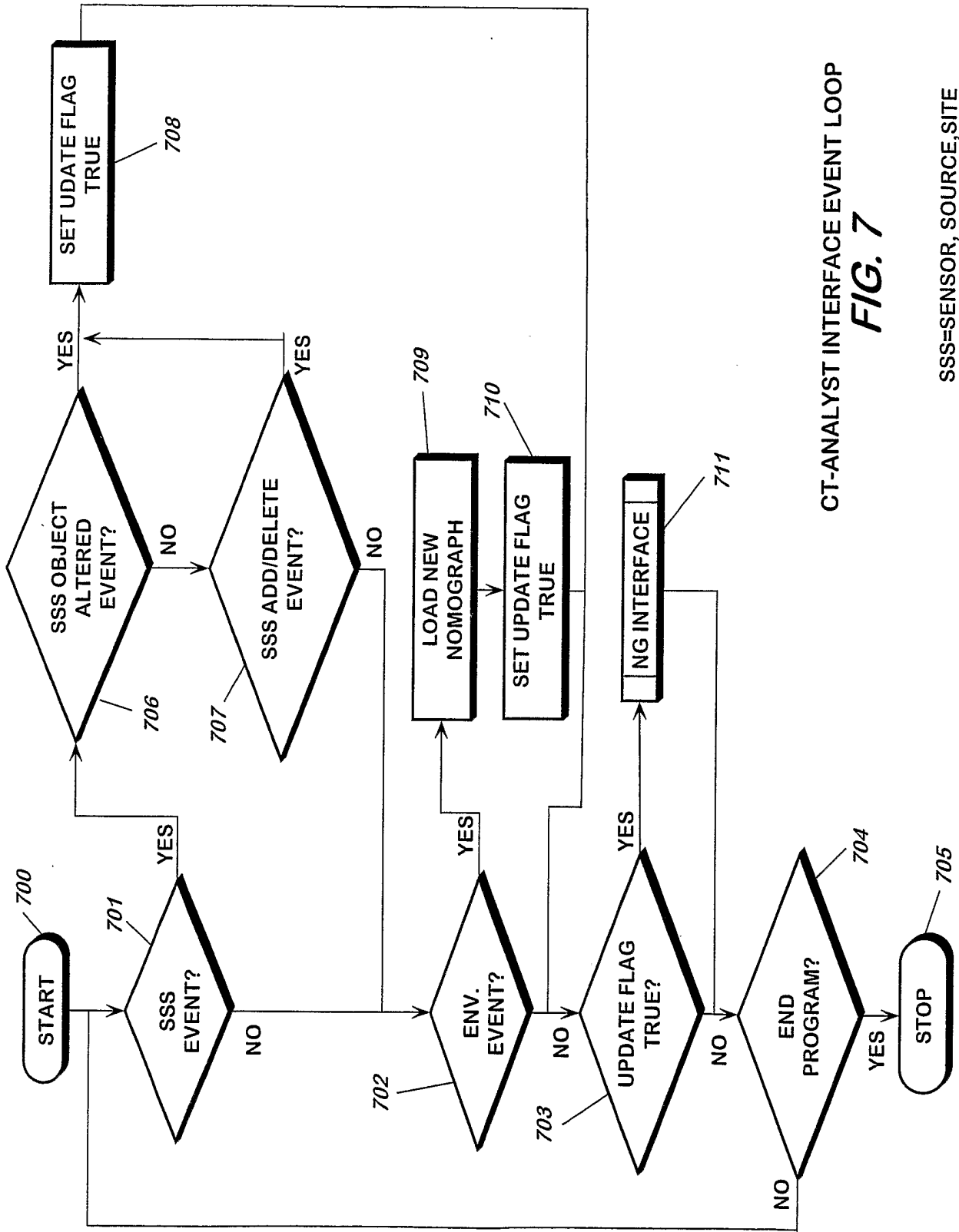


FIG. 6



CT-ANALYST INTERFACE EVENT LOOP
FIG. 7

SSS=SENSOR, SOURCE, SITE

