General Characteristics		
1	**Abstract of Model Capabilities**	The VLSTRACK Computer Model, version 1.6, provides approximate downwind hazard predictions for a wide range of chemical and biological agents and munitions of military interest. The program was developed to be user-friendly and very portable as FORTRAN code to either a high-speed workstation or a 386/486 or equivalent microprocessor-based personal computer. VLSTRACK features smart input windows which check input parameter combinations to ensure that a reasonable attack is being defined, and simple and informative output graphics which display the hazard footprint for agent deposition, dosage, or concentration. Selection sets are used for entering and changing parameters with minimal keystrokes. Output can be obtained either as a cumulative hazard from the time of the attack or as a periodic hazard for each time period. The model also features variable meteorology, allowing for interfacing the attack with a meteorological forecast; this feature is very important for biological and secondary evaporation computations. A vertical wind profile meteorology forecast can also be used for high-altitude releases. Although the model normally runs quickly, the rigorous computations can take an hour or more for biological plumes, large numbers of munitions, and secondary evaporation. For quick estimates, the model features a rapid approximations option for each of the attack situations which can be used for preliminary hazard evaluation; the rigorous computations can then be done if a more accurate hazard estimate is required and time permits.
2	**Sponsor and/or Developing Organization**	Department of the Navy Naval Surface Warfare Center Dahlgren Division 17320 Dahlgren Road Dahlgren, Virginia 22448-5100
3	**Last Custodian/ Point of Contact**	Timothy J. Bauer and Roger L. Gibbs Systems Research and Technology Department (above address) (703) 663-8621 or DSN 249-8621 (R.L. Gibbs)
4	**Life-Cycle**	The VLSTRACK model (version 1.0) was developed in response to Navy requirements during Operation Desert Shield. Version 1.2 was a further development of version 1.0. Based on comments by users, version 1.3 was developed and distributed. In response to requirements from the Space and Naval Warfare Systems Command, U.S. Marine Corps, U.S. Army Space and Strategic Defense Command, U.S. Army Nuclear and Chemical Agency and Defense Nuclear Agency, a major revision and enhancement to version 1.3 was undertaken. VLSTRACK 1.5 included all of the features of previous versions and added the capability to address many of the situations resulting from high-altitude intercepts of chemical or biological warheads. VLSTRACK 1.6 has been developed in response to an Independent Technical Review (ITR) performed by the National Oceanic and Atmospheric Administration (NOAA). The ITR found significant theoretical errors in the methodology developed for VLSTRACK. VLSTRACK 1.6 corrects these theoretical errors and integrates the features of all of the specialized versions and adds some of the additional capabilities developed for these versions. Version 1.6.1 was issued during this study but was not received in time to be included.
5	**Model Description Summary**	The model incorporates a trivariate Gaussian puff model with varying meteorological inputs. A complex terrain version (2.1) is available but was not evaluated in this study. The model is adapted for high-altitude releases and takes the density of the plume(s) into account, although the classical slumping treatment of heavy gas near the ground is not considered to be appropriate for military applications. A bivariate Gaussian distribution equation is used to determine deposition. A calculation grid with dynamic grid spacing is used to accumulate dose from many source locations representing multiple munitions.
6	**Application Limitation**	Source configuration is limited to munitions and there is no library of chemicals of interest to DOE. Output is not easily compared with toxic limits expressed as ppm or concentrations.
7	**Strengths/ Limitations**	**Strengths:** Strengths are in applications for munitions. In its present form, it is very difficult to apply to common chemical spills of the type generally evaluated by DOE.
8	**Model References**	**!** Bauer, Timothy J. and Roger L. Gibbs, “Software User’s Manual for the Chemical/Biological Agent Vapor, Liquid, and Solid Tracking (VLSTRACK) Computer Model, Version 1.6 (DOS-PC),” NSWCDD/MP-95/56, February 1995, Naval Surface Warfare Center, Dahlgren, VA. **!** Bauer, T., “Operator’s Instruction Manual for VLSTRACK, Version 1.2,” NAVSWC TR 91-801, February 1992, Naval Surface Warfare Center, Dahlgren, VA. **!** Kamada, R., C. Skupneiwicz and S. Drake, Preliminary Evaluation and Upgrade of the Airborne Toxic Dispersion Model, VLSTRACK, NPS-PH-91-008, February 1991, Naval Postgraduate School, Monterey, CA.

8	**Model References (Cont.)**	! Bauer, T., "Characterization and Bounding of Heavier-Than-Air Gas (HTAG) Effects," NSWCTR 89-347, November 1989, Naval Surface Warfare Center, Dahlgren, VA. ! Bauer, Timothy J. and Roger L. Gibbs, "Software User's Manual for the Chemical/Biological Agent Vapor, Liquid, and Solid Tracking (VLSTRACK) Computer Model, Versions 1.5.1 and 2.0," NSWCDD/MP-94/111, April 1994, Naval Surface Warfare Center, Dahlgren, VA
9	**Input Data/Parameter Requirements**	Input data is entered on the screen and through predefined input files. Screen 1 — Main Attack Window Munitions (type of munitions from file VLSMUN.PAR; other munitions can be added by editing the file or "undefined" can be selected), Chem/Bio Agent (agent from the file VLSAGN.PAR; other agents can be added by editing the file), date, time, attack location; (latitude/longitude, degrees and minutes or UTM coordinates can be entered), trajectory angle, ground surface type (list of ground cover types; used for time variable meteorological conditions to estimate surface roughness), output type (deposition (mg/m2), dosage (LCtx), and droplet/particle concentration (part/m3) output is available), output mode, output file prefix, map scale (five ratios available to use as map overlays, or the output can fill the screen), range, record input file. Screen 2 — Meteorology Options Wind measurement height, wind direction sensitivity, met condition duration, transition times (for dawn, day, dusk, and night), met mode, number of vertical levels, detonation coordinates (methods used for generating or entering detonation coordinates for multiple munitions; random coordinates can be generated using a Gaussian or normal distribution about the target or using a uniform distribution within a rectangular or elliptical region defined around the target), munitions density, target size, input file names, agent mass percent, detector alarm mode. Screen 3 — Output/Comp Opt Window Number of points (used in the grid for representing the downwind hazard footprint), grid sizing mode (self-adjusting or fixed), map corner locations for fixed grid sizing, four contour values, output time step, secondary evaporation mode, Gaussian plume mode for rapid approximations, sprayer duration, biological decay rate, random number seed, wind meander seed, grid output mode. Screen 4 — Munitions Properties Window Number of munitions, rate of fire, height of release, fill weight, initial lateral and vertical sigma, plume or line length, munition fall angle, down and cross range target sigma, mass-median droplet diameter, distribution sigma, and dissemination efficiency. Screen 5 — Meteorology Window Select met file or enter met parameters if height-time variable data is not to be used, wind bearing (four cardinal points), wind speed, stability class, air temperature, cloud cover. Screen 6 — Detector Data Detector locations, number, flow rates, duration, thresholds.
10	**Output Summary**	Input summary, initialization values, detector alarm messages, deposition concentration and accumulated mass, graphics plot of hazard area, and maximum hazard value and area coverages. Files of plot data and information on the individual puffs being tracked for airborne and deposited clouds.
11	**Applications**	Designed for use in estimating effects from chemical/biological warheads. Not used in the public sector; considered to be Critical Technology. Applications are not well publicized, but document does mention Operation Desert Shield with respect to an earlier version.
12	**User-Friendliness**	Interface consists of data entry windows, which respond to either mouse or keyboard commands. There are separate windows for each type of input. Online help is available.

13	**Hardware-Software Interface Constraints/ Requirements**	**Computer operating system:** Model can operate on the following systems: 1.) Tektronix, Sun, Silicon Graphics, and Hewlett-Packard workstations; 2) Digital VMS MicroVAXs; and 3) PCs with 80386 or 80486 (DOS 5.0 or higher) microprocessor, a math coprocessor, 2 MB or more of RAM or Apple Macintosh IIs. **Computer platform:** FORTRAN-77 code makes code portable to most modern platforms with FORTRAN
13	**Hardware-Software Interface Constraints/ Requirements (Cont.)**	**Disk space requirements:** Minimum of 16 MB. **Run execution time** (for a typical problem)**:** Long problems can take over an hour. **Programming language:** FORTRAN 77 **Other computer peripheral information:** No information provided.
14	**Operational Parameters**	**Identify whether the code has any error diagnostic messages to assist the user in troubleshooting operational problems:** The manual provides a section on error messages. There are seven data entry errors, and three error conditions that are non-recoverable. Some system errors are also identified. Instructions for running in batch mode in either DOS or UNIX environments are included in the manual.
15	**Surety Considerations**	**All quality assurance documentation:** VLSTRACK 1.6 is being verified, documented, and validated against experimental data in a similar manner to VLSTRACK 1.2 and 1.5.1. Details were not provided. **Benchmark runs:** Not discussed in documentation provided. **Validation calculations:** No informatin provided. **Verification with field experiments that has been performed with respect to this code:** Mentioned but not discussed in documentation.
16	**Runtime Characteristics**	The manual provides a section on error messages. There are seven data entry errors, and three error conditions that are non-recoverable. Some system errors are also identified. Batch Mode Capability (several cases at once) Instructions for running in batch mode in either DOS or UNIX environments are included in the manual.

Specific Characteristics

Part A: Source Term Submodel Type		
A1	**Source Term Algorithm?**	✔ YES __ NO
A2	**For Chemical Consequence Assessment Models**	**Liquid spill: ✔ pool evaporation __ particulate resuspension** **Pressurized releases: __ two-phase jets __ flashing __ entrainment ✔ aerosol formation** **Solid spills: __ resuspension __ sublimation**
A4	**For Weapons Consequence Assessment Models**	Can address biological agent source term components.
Part B: Dispersion Submodel Type		
B1	**Gaussian**	**✔ Straight-line plume ✔ Segmented plume __ Statistical plume ✔ Statistical puff**
B9	**Multiple Capabilities**	Version 2.1 has the capability of allowing plumes to follow terrain changes.
Part C: Transport Submodel Type		
C1	**Prognostic**	Includes forecast based on expected meteorology.
C2	**Deterministic**	Yes
C4	**Frame of Reference**	**✔ Eulerian __ Lagrangian __ Hybrid __ Eulerian-Lagrangian**
Part D: Fire Submodel Type (Not Applicable)		
Part E: Energetic Events Submodel Type (Not Applicable)		

Part F: Health Consequence Submodel Type		
F1	**For Chemical Consequence Assessment Models**	**Health effects: ✔ fatalities __ cancers __ latent cancers __ symptom onset** **Health criteria** **__ IDLH __ STEL __ TLV __ TWA** **__ ERPG __ TEEL __ AEGL __ WHO** **Zones with flammable limits: __ UFL __ LFL** **Blast overpressure regions:** **Fire radiant energy zones:** **Risk qualification:** **Concentration: ✔ single value ✔ time-history ✔ integrated dose** **Probits:**
F3	**For Weapons Consequence Assessment Models**	**Health effects: ✔ fatalities __ cancers __ latent cancers __ symptom onset** **Health criteria** **__ IDLH __ STEL __ TLV __ TWA** **__ ERPG __ TEEL __ AEGL** **Risk quantification:** **Concentration: ✔ single value ✔ time-history ✔ integrated dose** **Probits:**
Part G: Effects and Countermeasures Submodel Type (Not Available)		
Part H: Physical Features of Model		
H2	**Release Elevation**	**✔ ground ✔ roof**
H6	**Mixing Layer**	**__ trapping __ lofting ✔ reflection __ penetration** **✔ inversion breakup fumigation __ temporal variability**
H7	**Cloud Buoyancy**	**✔ neutral [passive] __ dense [negative] __ plume rise [positive]**
H8	**Cloud Liquid Droplet Formulation/ Aerosolization**	Suspended droplets are evaporated based on NUSSE transfer equations.
H10	**Deposition**	**__ gravitational setting ✔ dry deposition __ precipitation scavenging** **__ resistance theory deposition ___ simple deposition velocity __ liquid deposition** **__ plateout and re-evaporation**
H13	**Temporally and Spatially Variant Mesoscale Processes**	**Urban heat island:** **Canopies:** **Complex terrain (land) effects: ✔ mountain-valley wind reversals** **___ anabatic winds ___ katabaic winds** **Complex terrain (land-water) effects: ___ seabreeze airflow trajectory reversals** **___ Thermally Induced Boundary Layer definition ___ seabreeze fumigation** **___ landbreeze fumigation** **Thunderstorm outflow:** **Temporally variant winds:** **High velocity wind phenomena: __ tornado __ hurricane __ supercane __ microburst**
Part I: Model Input Requirements		
I1	**Radio(chemical) and Weapon Release Parameters**	**Release rate: ✔ Continuous ✔ Time dependent ✔ Instantaneous** **Release container characteristics: __ vapor temperature __ tank diameter** **__ tank height __ tank temperature __ tank pressure __ nozzle diameter** **__ pipe length** **Jet release: __ initial size __ shape** **__ concentration profile at end of jet affected zone** **Release dimensions: ✔ point ✔ line __ area** **Release elevation: ✔ ground ___ roof ___ stack ✔ airplane**

I2	**Meteorological Parameters**	**Wind speed and wind direction: ✔ single point __ single tower/multiple point __ multiple towers** **Temperature: ✔ single point __ single tower/multiple point __ multiple towers** **Dew point temperature: __ single point __ single tower/multiple point __ multiple towers** **Precipitation: __ single point __ single tower/multiple point __ multiple towers** **Turbulence typing parameters: __ temperature difference __ sigma theta __ sigma phi ✔ Monin-Obukhov length __ roughness length ✔ cloud cover __ incoming solar radiation __ user-specified** **Four dimensional meteorological fields from prognostic model:**
Part J: Model Output Capabilities		
J2	**Graphic Contours and Resolution**	Lethality isopleths.
J5	**Health Effects**	**__ toxicity indices [e.g., ERPG's, PAG's] ✔ potential fatalities __ cancers ✔ other adverse effects**
J6	**Number of People Affected, Calculated at What Resolution?**	Plots area where 95%, 50%, 20%, and 5% lethality is exceeded.
Part K: Model Usage Considerations (See Items 5 - 7.)		