General Characteristics		
1	**Abstract of Model Capabilities**	TRIAD is a multiple-source, Gaussian-puff dispersion model capable of modeling the accidental release of instantaneously reactive gas to the atmosphere. Multiple moving sources can be treated, as can dry deposition and variations in elevation between sources and receptors. The wind field is determined by objective interpolation among suitably located towers, after wind speeds have been adjusted for variations in tower heights. Reactions are currently parameterized only for uranium hexafluoride. Other parameterizations may be inserted, if available.
2	**Sponsor and/or Developing Organization**	Atmospheric Turbulence and Diffusion Division National Oceanic and Atmospheric Administration NOAA/ATDD, P.O. Box 2456 Oak Ridge, TN 37831, USA (423) 576-1233 **Fax** (423) 576-1327 hosker@atdd.noaa.gov **developing organization**
3	**Last Custodian/ Point of Contact**	K. Shankar Rao NOAA/ATDD P.O. Box - 2456 Oak Ridge, TN 37831, USA (423) 576-1238 (423) 576-1327 **Fax** eao@atdd.noaa.gov **primary individual** Hosker@atdd.noaa.gov **secondary individual**
4	**Life-Cycle**	TRIAD model was developed during 1987-89 by NOAA/ATDD, Oak Ridge, for the U.S. DOE's Oak Ridge Operations (ORO) and the U.S. NRC, for modeling the dispersion of uranium hexaflouride (UF6) in the atmosphere. However, the model was widely requested and used around the world for a variety of electronic bulletin board for easy downloading. A comprehensive User's Guide is available from NTIS.
5	**Model Description Summary**	TRIAD is Gaussian puff-trajectory short-range model for dispersion of reactive or non-reactive gases and particles in atmosphere. A ______ and ______ variable wind field can be derived from observations in a moderately complex terrain. On-site turbulence data can be used for dispersion.
6	**Application Limitation**	! Wind direction is assumed constant with height. ! Puff transport is by winds at effective release height only. ! No splitting of large puffs into several smaller ones. ! No explicit treatment of chemical reactions or complex terrain dynamic effects (except those included in the observed winds). ! No building wake/cavity effects.
7	**Strengths/ Limitations**	**Strengths:** Accounts for = 1-effects release of fast ---- chemical reactions, 2-dry deposition and gravitational settling, 3- variable source emission rates, 4- on-site dispersion schemes, 5- temporarily and ______ variable windfield, 6- differences schemes, 6- differences in elevations of souces -- receptors in complex terrain. **Limitations:** No capability to address the effects of the vertical variation of wind direction shear on puff transport exists. This may be in error in cases of strong subsidence.
8	**Model References**	! Hicks, B-B-, et al., 1989 = TRIAD: A puff-Trajectory Model NOAA Tech-Memo. ERL ARL-168, available as PB89-182703/GAR from NTIS, 136 pp. ! RAO K.S., et al., 1989, J-Appl-Meteorol.28, 617-625 ! Taugirala, R.S., et al., 1991, Atmos.Environ., 26, 299-309 ! Petersen, W.B., 1986, Atmos. Environ., 20, 1341-1346
9	**Input Data/Parameter Requirements**	TRIAD requires input data on user options, grid dimensions, sources, meterology, receptors, and time scales. These data are specified on ten required and five optional card types. The optional data include the observed wind speed and direction from multiple meteorological towers within the modeling domain for determining the transport wind field.
10	**Output Summary**	TRIAD prints out all Input/Output marameters and options used in a run. For each sampling period, calculated values of surface ______ are printed at all receptors. The concentrations averaged over all sampling periods are listed at the end of the run. The output also optionally stores the interpolated gridded wind field (on Unit 21), puff coordinates, sites intermediate concentrations (on Unit 2) and concentrations for all sampling periods at each reception (on Unit 25) for analysis and plots after the run.

11	**Applications**	! Successful evaluation with research grade tracer data sets in DOE's ASCOT experiments in Brush Creek and Rocky Flats Plant, CO. ! Simulation of Richmond, CA, oleum release consequences, and comparison with sophisticated models. ! Widely used in other countries (e.g., India, Bulgaria, etc.) for safety assessments
12	**User-Friendliness**	Error messages will be printed. Comment cards inserted in all subroutines with suitable explanations.
13	**Hardware-Software Interface Constraints/ Requirements**	**Computer operating system:** DOS **Computer platform:** IBM-PC or equivalent **Disk space requirements:** 283 KB **Run execution time** (for a typical problem)**:** 20-40 seconds **Programming language:** FORTRAN **Other computer peripheral information:** I/O storage capability on tapes and other media for analysis and plots
14	**Operational Parameters**	**Identify whether the code has any error diagnostic messages to assist the user in troubleshooting operational problems:** Explanatory comments in code; well-written User's Guide with extensive notes. **Set up time for: Typical times are: *first-time user:*** 6 hours ***experienced user:*** 1 hr or less
15	**Surety Considerations**	**All quality assurance documentation:** Peer-reviewed documentation**.** **Benchmark runs:** included in User's Manual **Validation calculations:** Yes. Applied in different climatic conditions. **Verification with field experiments that has been performed with respect to this code:** Yes. This is documented in peer-reviewed journal publications**.**
16	**Runtime Characteristics**	Run times depend on the number of meteorological periods. Sources and receptors to be modeled. For a Single point source with 9 meteorological periods and 25 receptors, the typical run time is of the order of a few minutes on a IBM 486/DX2 PC. TRIAD is designed for short-term (<24 hr) and short-range (~30 km or less) assessments.

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** Into plume Momentum (jet and buoyancy (plume) releases
A3	**For Radiological Consequence Assessment Models**	**Gaseous releases:** _✔_ **noble gases** _✔_ **iodines** _✔_ **other non-reactive gases** Uranium hexaflouride (UF6) (Other fast-reaction gaseous release can be modeled with suitable modifications) **Aerosol releases:** Yes **Particulate releases:** Yes _✔_ **Chemistry** __ **Isotopic exchange** ___ **Physical properties capability**

Part B: Dispersion Submodel Type

B1	**Gaussian**	_✔_**Straight-line plume** __**Segmented plume** __ **Statistical plume** _✔_ **Statistical puff**

Part C: Transport Submodel Type

C1	**Prognostic**	No prognostic capability
C2	**Deterministic**	Model is deterministic in nature
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 (No Information Provided.)

Part G: Effects and Countermeasures Submodel Type (Not Applicable)

Part H: Physical Features of Model		
H1	**Stability Classification Turbulence Typing**	**Pasquill-Gifford-Turner: ✔** **STAR:** **Irwin:✔** **Sigma theta: ✔** **Richardson number:** **Monin-Obukhov length:** **TKE-driven:** **Split sigma:**
H2	**Release Elevation**	**_✔_ ground _✔_ roof**
H4	**Horizontal Plume Meander**	Only through observed Sigma Theta in the dispersion scheme.
H5	**Horizontal/Vertical Wind Shear:**	Vertical wind speed shear is accounted through power-law adjustments. Horizontal wind direction shear is accounted through the wind data from mulitple towers. Vertical variation of this direction shear cannot be accounted.
H6	**Mixing Layer**	**_✔_ trapping __ lofting _✔_ reflection __ penetration** **__ inversion breakup fumigation __ temporal variability**
H7	**Cloud Buoyancy**	**_✔_ neutral [passive] __ dense [negative] _✔_ plume rise [positive]**
H9	**(Radio)chemical Transformation and In-Cloud Conversion Processes**	Effects of fast chemical reactions are parameterized at source.
H10	**Deposition**	**_✔_ gravitational setting _✔_ dry deposition __ precipitation scavenging** **__ resistance theory deposition _✔_ simple deposition velocity __ liquid deposition** **__ plateout and re-evaporation**
H12	**Radionuclide Ingrowth and Decay**	Simple, __________ decay included.
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**
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 (See Item 10.)		

Part K: Model Usage Considerations		
K1	**Ease of Model Use**	**Training required to run the model:** ✔ **background (years of education)** B.S. in meteorology/engineering ✔ **training time needed on the model to be able to exercise all model capabilities** or equivalent experience working with air quality dispersion models. **Training required to continue development of the model:** ✔ **background (years of education)** M.S. in meteorology/engineering with some dispersion modeling experience. ✔ **training time needed on the model to be able to exercise all model capabilities** . 1 year