General and Specific Characteristics for Model: MACCS2 (MELCOR Accident Consequence Code System, version 2)

	General Characteristics	
1	**Abstract of Model Capabilities**	MACCS2 uses the output of MELCOR, a simulator of severe nuclear reactor accidents, as a source term for estimating the health and economic consequences of such accidents. The principal phenomena considered are atmospheric transport, diffusion, and deposition under time-variant meteorology, short- and long-term mitigation actions and exposure pathways food-chain, deposition, resuspension, etc., deterministic and stochastic health effects, and economic costs.
2	**Sponsor and/or Developing Organization**	US Nuclear Regulatory Commission (NRC) 11545 Rockville Pike Rockville, MD 20852 (301) 415-6192 (301) 415-5062 **Fax** jdr@nrc.gov **sponsoring organization** jjgrego@sandia.gov **developing organization**
3	**Last Custodian/ Point of Contact**	Janet Gregory Sandia National Laboratories (SNL) Department 6413 Accident Analysis and Consequence Assessment Sandia National Laboratories Albuquerque, NM 87185-0748 jjgrego@sandia.gov **primary individual** jdr@nrc.gov **secondary individual**
4	**Life-Cycle**	MACCS was first developed in the mid-1980's. Its basic structure with respect to simulating transport from exposed nuclear material to exposed individuals has remained unchanged. However, early simplifications regarding radionuclide decay chains and dose conversion factors have been replaced by more general models. An economic model also has been added. Uncertainties in the estimates made by MACCS are currently being evaluated in an international cooperative effort with European users of Consequence System of MAria (COSYMA), an European equivalent of MACCS. Based on this study, improvements to MACCS are expected.
5	**Model Description Summary**	The principal phenomena considered are atmospheric transport, diffusion, and deposition under time-variant meteorology, short- and long-term mitigation actions and exposure pathways food-chain, deposition, resuspension, etc., deterministic and stochastic health effects, and economic costs.
6	**Application Limitation**	MACCS' utility is currently limited to near-earth nuclear accidents and transport processes. Upper atmospheric contaminant transport (e.g. from accidents involving spacecraft carrying nuclear materials) can not be simulated reliably with MACCS.
7	**Strengths/ Limitations**	**Strengths:** MACCS integrates release, transport, environmental pathway, and dose models to allow estimates of consequences of releases of all known radionuclides that may be available in nuclear reactor accidents. **Limitations:** The weakest model in MACCS may be the straight-line Gaussian plume model of atmospheric transport and diffusion. The aforementioned cooperative uncertainty study with European counterparts is examining all models in MACCS. Improvements to MACCS are likely to be forthcoming based on that study.
8	**Model References**	! "MELCOR Accident Consequence Code System (MACCS)," Vol. 1: User's Guide; See referenced NUREG documents.Vol. 2: Model Description, NUREG/CR-4691, SAND86-1562, US Nuclear Regulatory Commission, February 1990. ! "Code Manual for MACCS2: Volume 1, User's Guide," SAND97-0594, Sandia National Laboratories, March 1997. ! "Code Manual for MACCS2: Volume 2, Preprocessor Codes COMIDA2, FGRDCF, IDCF2," SAND97-0594/2, Sandia National Laboratories, February 1998. ! "DOSFAC2 User's Guide,: SAND97-2776, NUREG/CR-6547, US Nuclear Regulatory Commission, December 1997.
9	**Input Data/Parameter Requirements**	Atmospheric data: Geometry, radionuclides, release description, wet deposition, dry deposition, dispersion parameters, plume meander, plume rise, wake effects, meteorological sampling, initial and boundary conditions. Dose data: Dose conversion factors, population data, organ definition data, shielding and exposure data, evacuation zone data. Environmental pathway data: Groundshine, resuspension, regional characteristics, food ingestion, food chain, water ingestion. Emergency response cost data.
10	**Output Summary**	Early fatality radius, population dose, average individual risk, centerline dose and risk versus distance, population-weighted risk, spatial distribution of peak dose, maximum individual food ingestion, economic cost. Risk measures are presented as cumulative complementary distribution functions (CCDF's)

11	**Applications**	MACCS is being used to estimate consequences of nuclear reactor accidents at specific US nuclear power plants. MACCS also was used extensively in the consequence estimation phase of the nuclear facilities reported in "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants," NUREG-1150, US Nuclear Regulatory Commission, December 1990. MACCS also enjoys frequent usage and application at various Department of Energy (DOE) facilities, such as Rocky Flats Environmental Technology Site, Savannah River Site, and Pantex.
12	**User-Friendliness**	Operation of MACCS is not interactive. The user has to prepare three ASCII text input files for atmospheric transport, early consequences, and late consequences. The program runs in a mainframe batch mode, i.e., once started it has to run to a specified stop time and there is no program feature for stopping it earlier.
13	**Hardware-Software Interface Constraints/ Requirements**	**Computer operating system:** MS DOS 5 or later. **Computer platform:** MACCS can be used on IBM-compatible computers with 80486 (or later) processors and 8 MB of RAM. It also could be run on a workstation, minicomputer, mainframe, or supercomputer. **Disk space requirements:** About 8 MB for MACCS2. **Run execution time** (for a typical problem)**:** On a Pentium 200 MHZ **Programming language:** FORTRAN 77 **Other computer peripheral information:** None.
14	**Operational Parameters**	**Identify whether the code has any error diagnostic messages to assist the user in troubleshooting operational problems:** There are no such features for MACCS. **Set up time for: Typical times are: *first-time user:*** .5 h ***experienced user:*** 10 min
15	**Surety Considerations**	**All quality assurance documentation:** MACCS was developed in conformance with standard software development procedures at Sandia National Laboratories. **Benchmark runs:** Summarized in "Probabilistic accident consequence assessment codes: Second international comparison," Technical Report EUR 15109 EN ISSN 1018-5593), European Commission, Brussels, Belgium, 1994. **Validation calculations:** Summarized in "MACCS2 Development and Verification Efforts," Mary Young and David Chanin, paper in *International MACCS Users Group*, Technical Report W-6139-2, Brookhaven National Laboratory, 8/29/97. **Verification with field experiments that has been performed with respect to this code:** No such experiments have been done for MACCS as a whole. Field tests of Gaussian plume models are applicable to that part of MACCS that uses such models.
16	**Runtime Characteristics**	See item 13 above.

Specific Characteristics

Part A: Source Term Submodel Type

A1	**Source Term Algorithm?**	__YES ✔ NO
A3	**For Radiological Consequence Assessment Models**	**Gaseous releases:** ✔ **noble gases** ✔ **iodines** ✔ **other non-reactive gases** **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

C2	**Deterministic**	MACCS is generally deterministic, except as noted below.
C3	**Stochastic**	The stochastic nature of MACCS' predictions is attributable to parameter uncertainty. Evaluation of that uncertainty requires many runs of MACCS using a Monte-Carlo or Latin Hypercube parameter-selection scheme. The meteorological model implemented in MACCS is stochastic.
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:** NA
F2	**For Radiological Consequence Assessment Models**	**Cloudshine:** __ finite cloud __ semi-finite cloud ✔ other **Groundshine:** ✔ short-term ✔ long-term **Inhalation:** ✔ short-term ✔ long-term ✔ Total effective dose equivalent __ Uptake of respirable fraction of particle spectra **Resuspension:** ✔ short-term ✔ long-term __ Anspaugh **Food/Water Ingestion:** __ dynamic __ static **Skin dose:** ✔ absorption __ other **Dose assessment:** ✔ ICRP-60 criteria ✔ organs ✔ pathways **Health effects:** ✔ early ✔ latent
Part G: Effects and Countermeasures Submodel Type		
G1	**For Chemical Consequence Assessment Models**	**Evacuation:** NA **Sheltering:** **Interdiction:** **Spray/Foam:** **Victim Treatment/Treatment Measures:**
G2	**Radiological Consequence Assessment Models**	**Land contamination:** Yes **Economic costs:** __ decontamination __ interdiction __ foodstuff losses __ denial of facility access __ victim treatment **Evacuation:** Yes **Sheltering:** Yes **Interdiction:** Yes **Decontamination:** Yes
G3	**For Weapons Consequence Assessment Models**	**Land contamination:**Yes **Economic costs:** Yes **Evacuation:**Yes **Sheltering:** Yes **Interdiction:** Yes
Part H: Physical Features of Model		
H1	**Stability Classification Turbulence Typing**	**Pasquill-Gilfford-Turner:** Yes **STAR:** Yes **Irwin:** No **Sigma theta:** No **Richardson number:** No **Monin-Obukhov length:** No **TKE-driven:** No **Split sigma:** No
H2	**Release Elevation**	✔ ground ✔ roof
H4	**Horizontal Plume Meander**	Yes
H5	**Horizontal/Vertical Wind Shear:**	No
H6	**Mixing Layer**	✔ trapping ✔ lofting ✔ reflection __ penetration __ inversion breakup fumigation __ temporal variability

H8	**Cloud Liquid Droplet Formation/ Aerosolization**	No
H9	**(Radio)chemical Transformation and In-Cloud Conversion Processes**	No
H10	**Deposition**	**_✔_ gravitational setting _✔_ dry deposition __ precipitation scavenging __ resistance theory deposition __ simple deposition velocity __ liquid deposition __ plateout and re-evaporation**
H11	**Resuspension**	Yes
H12	**Radionuclide Ingrowth and Decay**	Yes
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** See above. **Dew point temperature: _ single point __ single tower/multiple point _ multiple towers** See above. The actual measurement is of humidity from which the dew point can be calculated. **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		
J1	**Hazard Zone**	Yes
J2	**Graphic Contours and Resolution**	No
J3	**Concentration Versus Time Plots**	No (Time-integrated concentration only)
J4	**Tabular at Fixed Downwind Locations**	Yes
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?**	**_✔_ block __ block group _✔_ country** (16 angular sectors are used.)
J7	**Graphic Contours of Probability of Exceeding Concentration**	Not part of MACCS. These contours could be prepared from MACCs outputs by other software.

J8	**F-N Probability Distribution Curves**	See item 7.
J9	**Commercial Off-the-Shelf (COTS) Geographic Information System (GIS) Used**	Not applicable.
J10	**Other**	Printed output.
Part K: Model Usage Considerations		
K1	**Ease of Model Use**	**Training required to run the model: _4_ background (years of education)** **_1_ training time needed on the model to be able to exercise all model capabilities** **Training required to continue development of the model:** **_4_ background (years of education)** **__ training time needed on the model to be able to exercise all model capabilities**
K2	**Time to Process From Notification of Release (including data acquisition) to Production of Product Listed in #K1, Listed for Platforms for Which the Program is Already Compiled**	PC-executable versions of MACCS are available when a new modification of it is released. For all other platforms, the FORTRAN source code is available, but the user has to compile it. The time to process would be the same as the time needed to create an executable program for the platform in question.
K3	**Ease of Use of Output, Evaluated as the Time Needed to Train a College Graduate in the Use of the Output**	One month.