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HABIT

CODE FOR ASSESSING CONTROL ROOM HABITABILITY

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Radiation Protection Branch
Office of Nuclear Regulatory Research
The United States Nuclear Regulatory Commission

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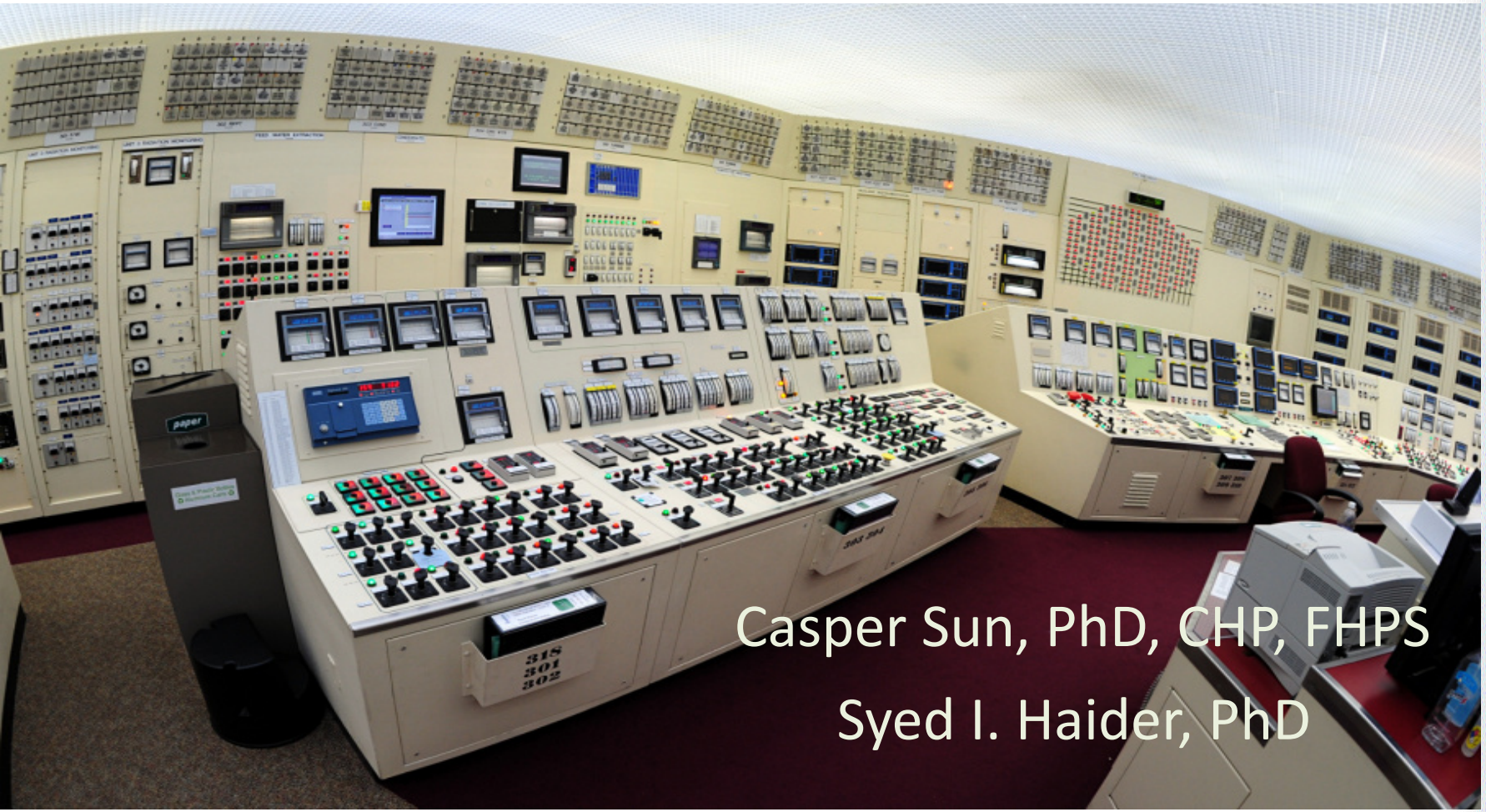
COMPUTER CODE FOR ASSESSING CONTROL ROOM HABITABILITY



Casper Sun, PhD, CHP, FHPS
Syed I. Haider, PhD

Prepared for 2015 RAMP first annual meeting,
Rockville, MD 20852: October 5th, 2015

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Real ATD Pictures

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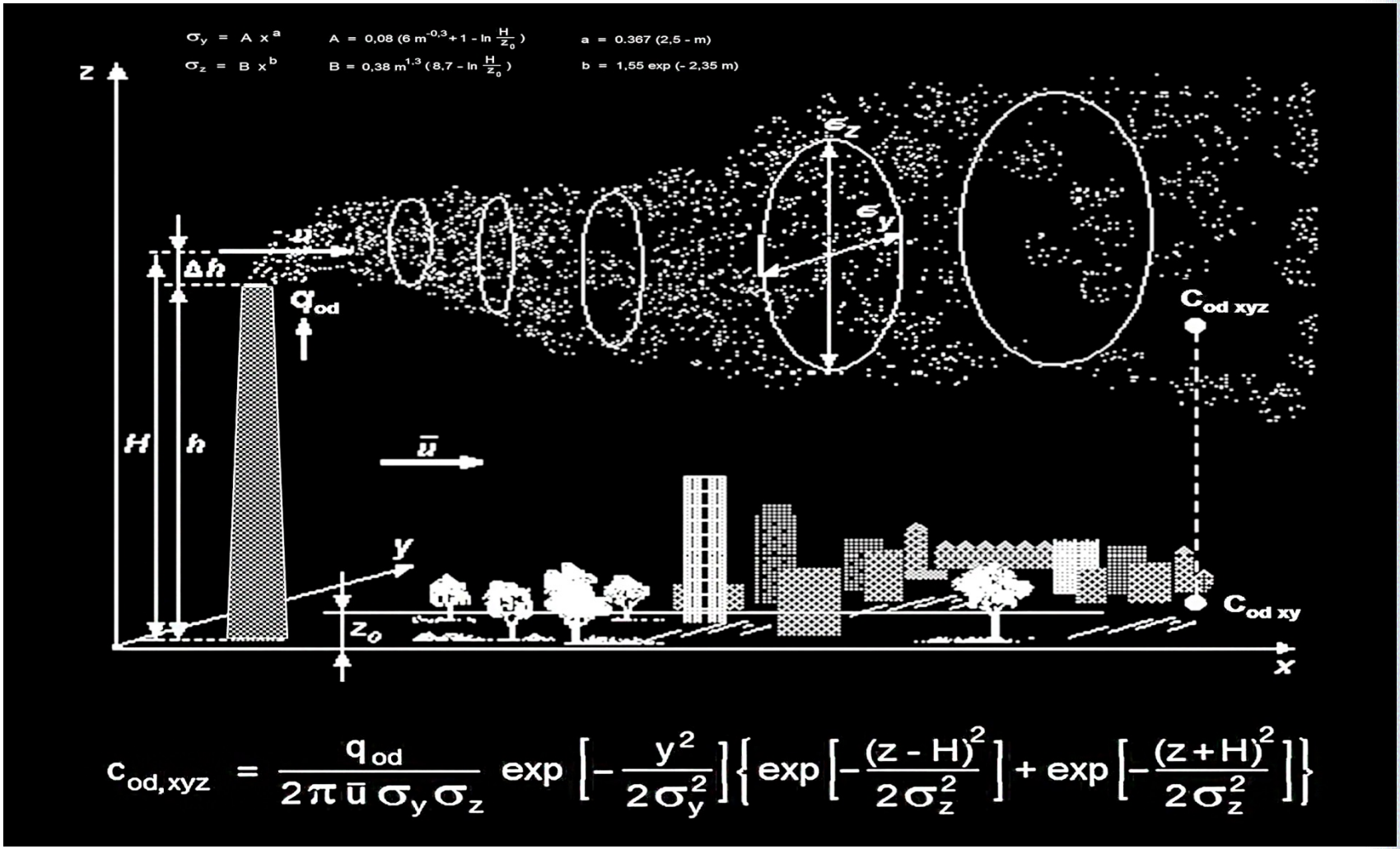
Basic Gaussian Model



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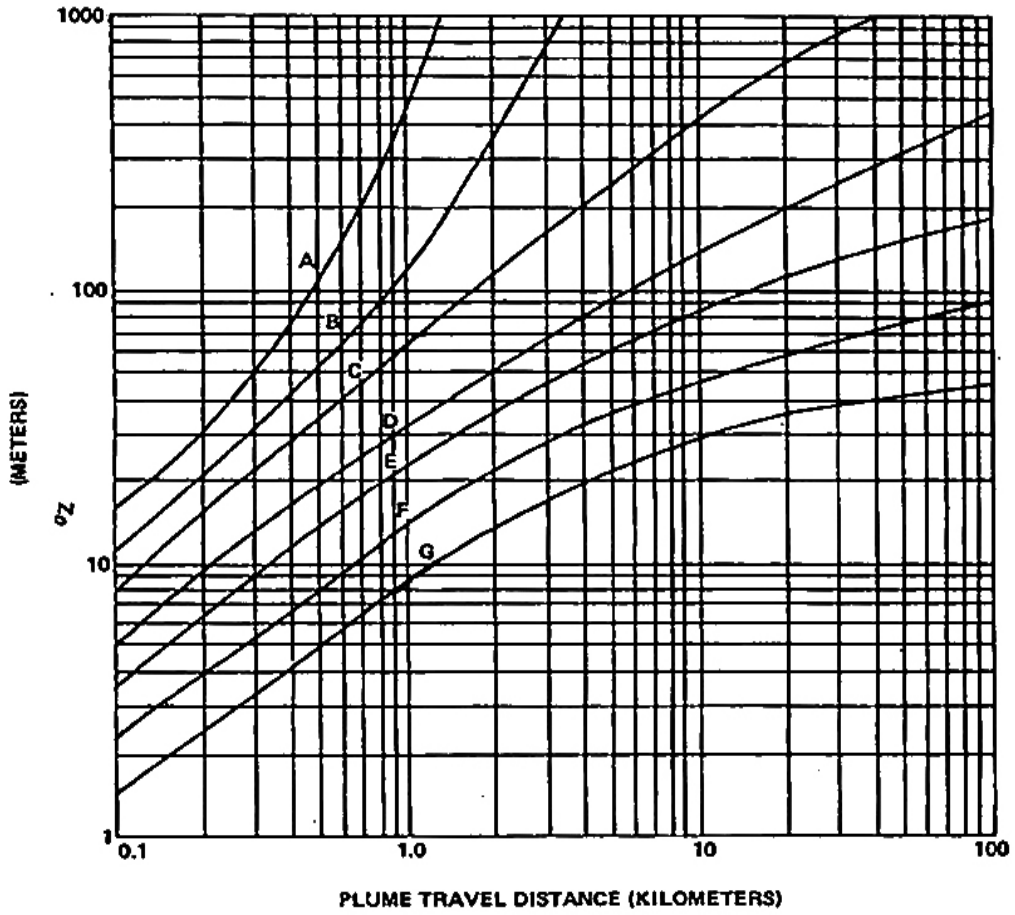
Height (σ_z) Vs. Distance



Concentration in σ_z direction:

- Decreases with stability classes (A>F)
- Increases with downwind distance

RG 1.145: Atmospheric dispersion models for potential accident consequence assessment at nuclear power plants (1982)

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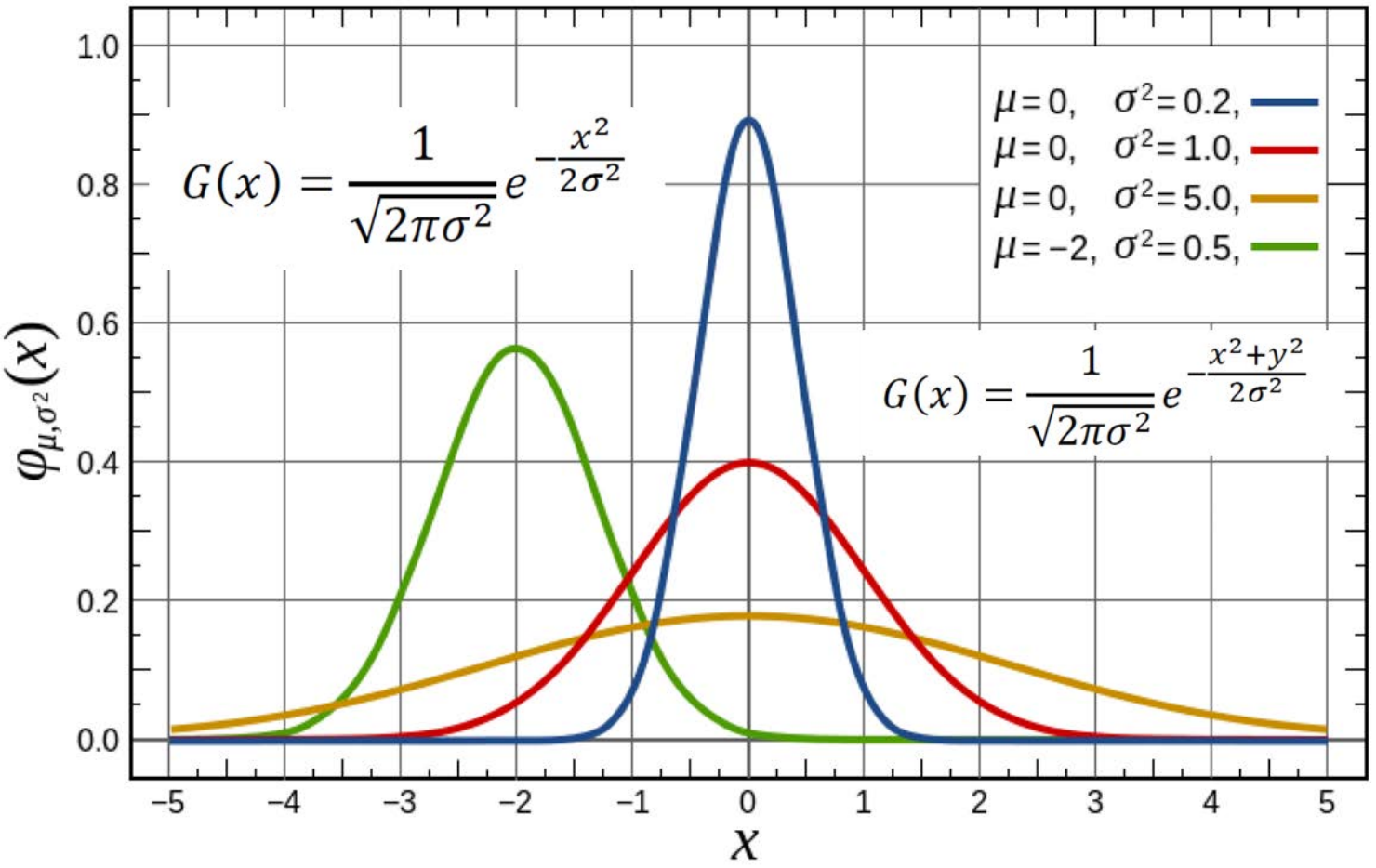
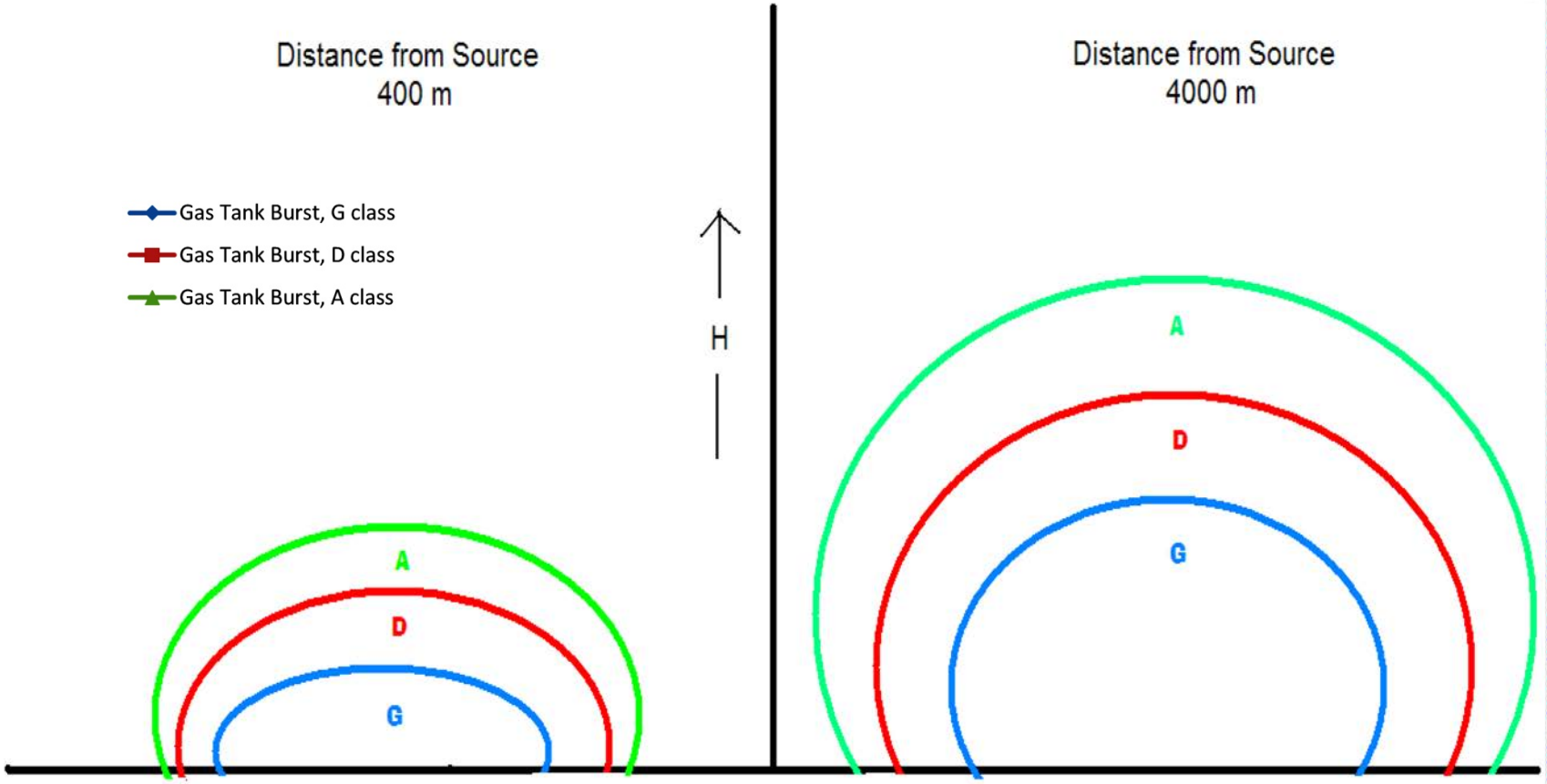
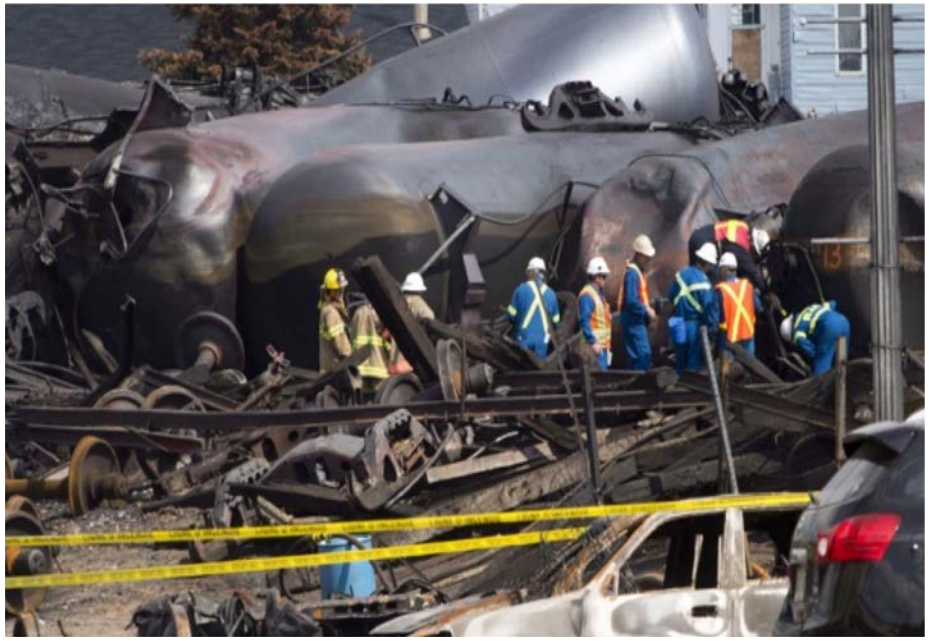
Gaussian, Normal Function





Stylized Representation of Changing Puff Volume Limits with Stability Class

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Conservation Equation

$$\frac{\partial \Phi}{\partial t} + \nabla \cdot (\mathbf{F} + \Phi \mathbf{V}) - H = 0$$

$$C(x,y,z,t) = \frac{Q}{2\pi u \sigma_y \sigma_z} \cdot \exp\left(-\frac{y^2}{2\sigma_y^2}\right)\left[\exp\left(-\frac{(z-H_{eff})^2}{2\sigma_z^2}\right)\right] + \exp\left(-\frac{(z+H_{eff})^2}{2\sigma_z^2}\right)$$

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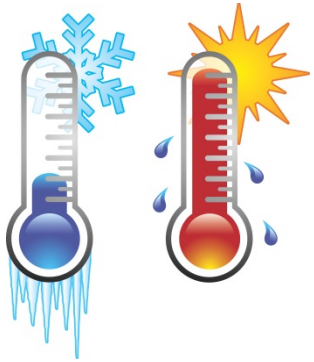
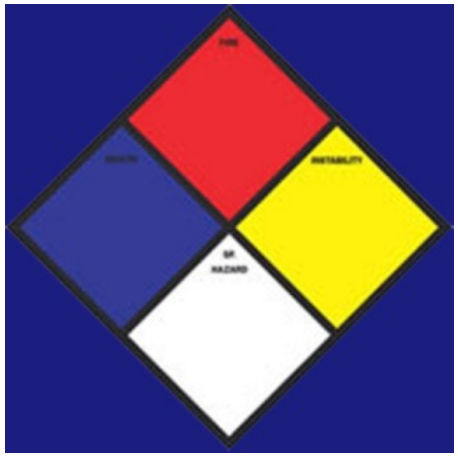
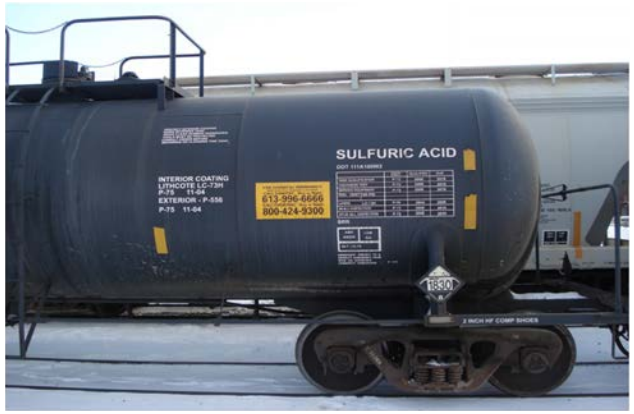
Habitability Issues at NRC

Radiological



Non-radiological





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Request for Additional Information (RAI) No. 6158

"…the staff posits that since chlorine and sulfuric acid clearly fit the definition of a heavy gas that **ALOHA modeling is the more appropriate program (i.e. as opposed to HABIT) to use for determining main control room habitability.** More specifically, the use of the HABIT Gaussian model may be producing non-conservative results for these two heavy gases. The staff requests that the applicant re-evaluate their findings of FSAR 6.4.4.2 and address the fact that chlorine and sulfuric acid are heavy gases and provide **a comprehensive justification for why the results are appropriate and conservative.**" (November 2011)

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User-Need Request: NRO-2011-007

HABIT Code Evaluation and Update

ACTION ITEMS

Phase 1: Re-hosting HABIT to Windows 7 (64-bit)

- Upgrade FORTRAN and modernize GUI
- Build-in tooltips and develop “User’s Manual”

Phase 2: Adding Dense-Gas Functions

- Integrate DEGADIS and SLAB to HABIT
- Update TBDs

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Project Overview

- **Phase I** (June 2014 – Feb. 2015):
  - Repair **HABIT v1.1** FORTRAN source code
  - Develop User Manual and interactive pop-up help screens.
  - Comply Section 508 requirements
  - TRM for **HABIT v1.2** (download and install)
- **Phase II** (April 2015 – Sept. 2016):
  - Integrate DEGADIS and SLAB (D&S) dense gas models
  - GUI and programing completed by April 2016
  - **HABIT v2.0** and revise NUREG/CR-6210 (9/30/16)
  - ATD benchmark and revise RG 1.78 (on the horizon)

RG 1.78: Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release (2001)

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HABIT PHASE-I

June 1, 2014 – February 14, 2015

Legacy Portfolio Analysis

FUNCTIONAL VALUE ↑	Application Portfolio Decision Analysis	
	REFACTOR REBUILD	RETAIN REHOST
	REPLACE RETIRE	REVISE

TECHNICAL VALUE →

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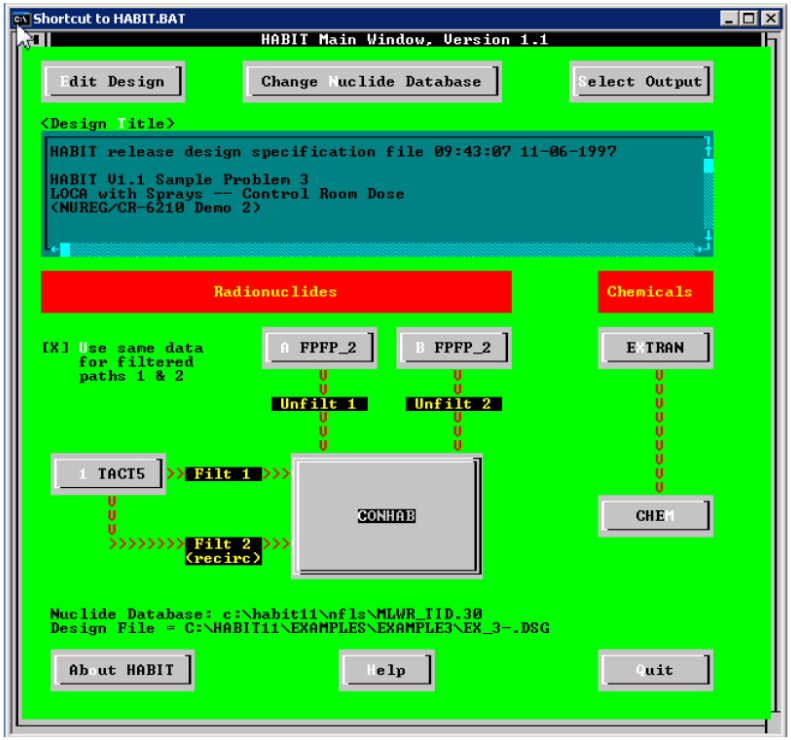
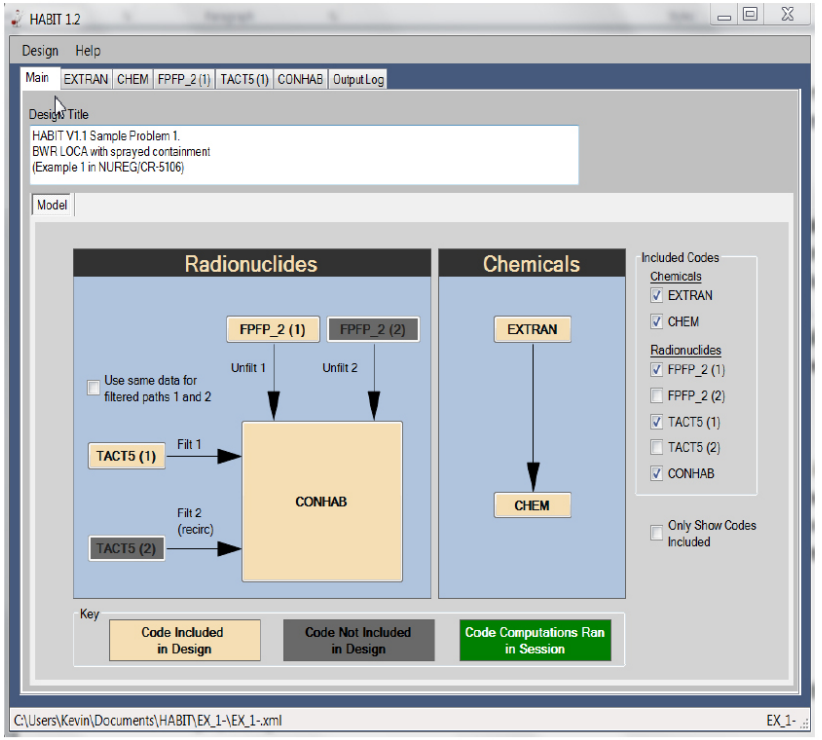
HABIT MAKEOVER

from v1.1 to v1.2

Original	New
	

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What's New in HABIT v1.2

- Used Intel Visual FORTRAN compiler for compatibility with Windows 7 (64-bit)
  - I/O are identical as HABIT v1.1
  - Backwards compatible for old designed (.DSG) files and FORTRAN input (.INP) files
- Used new Microsoft .NET technology for graphical user interface (GUI) development
  - Consistent module interface design (tabs)
  - Section 508 Compliance (e.g., color blinder or muted use of color, JAWS accessibility)

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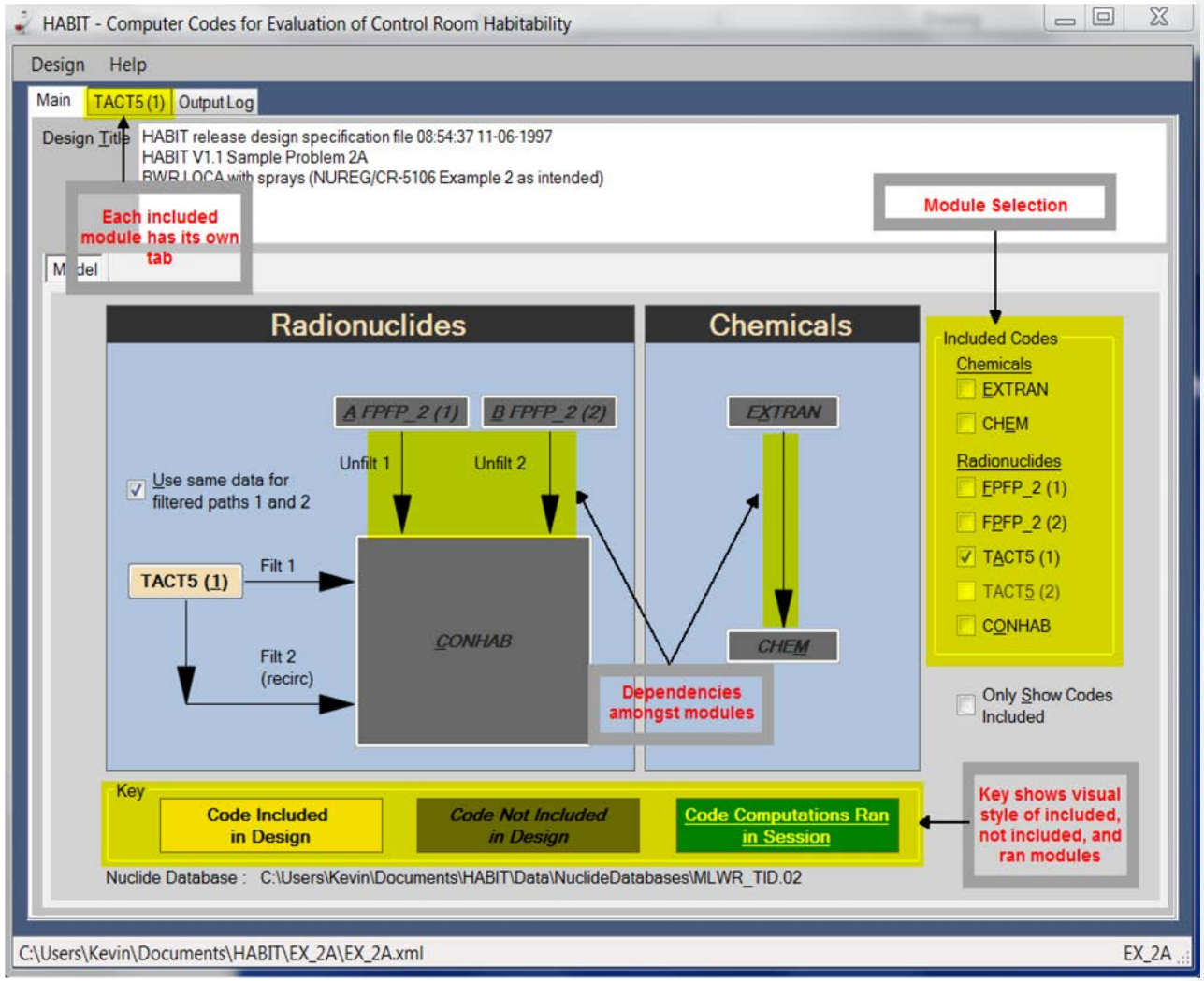
GUI Capabilities

The GUI:

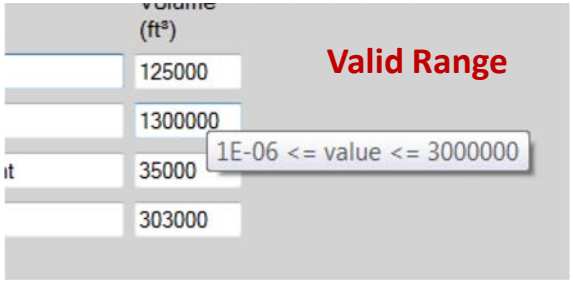
(1) Depict the relationships between the modules and

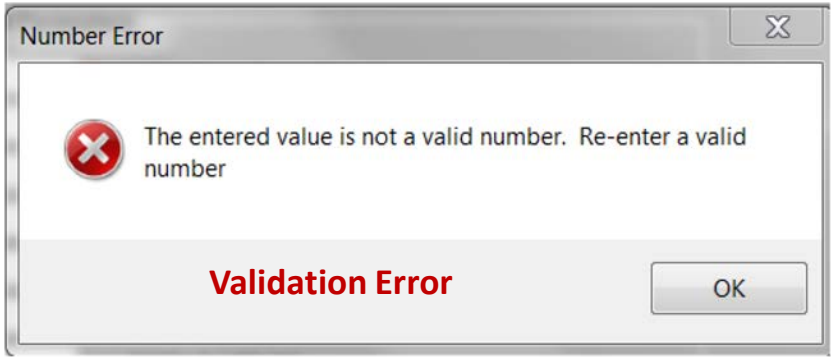
(2) Show modules in the current calculation.

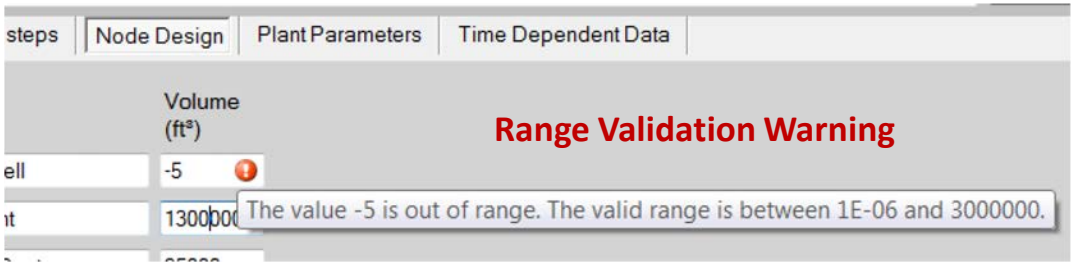


HABIT v1.2: Tooltips

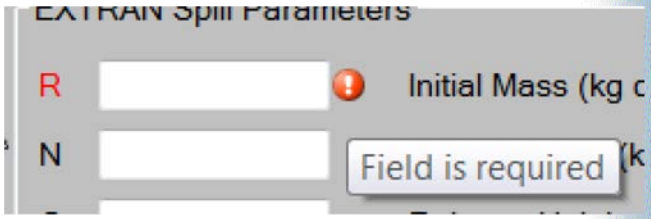
Tooltips provide a convenient way to see the expected range for fields and provide validations to prevent entering bad data.







Required Field Warning



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HABIT v 1.2

- **Design File**
  - DSG (Input) file can be created from scratch or imported from HABIT v1.1 Design Packages
  - DSG files are auto-saved when running a module
  - Previously saved DSG file is auto-loaded the next time HABIT v1.2 is opened

- **Running Modules**
  - Output Log-Tab displays FORTRAN I/O data
  - Alerts user when a dependency exists between modules i.e., EXTRAN & CHEM
  - "TOOLTIPs" added to interactive check the expected data range and prevent entering bad input

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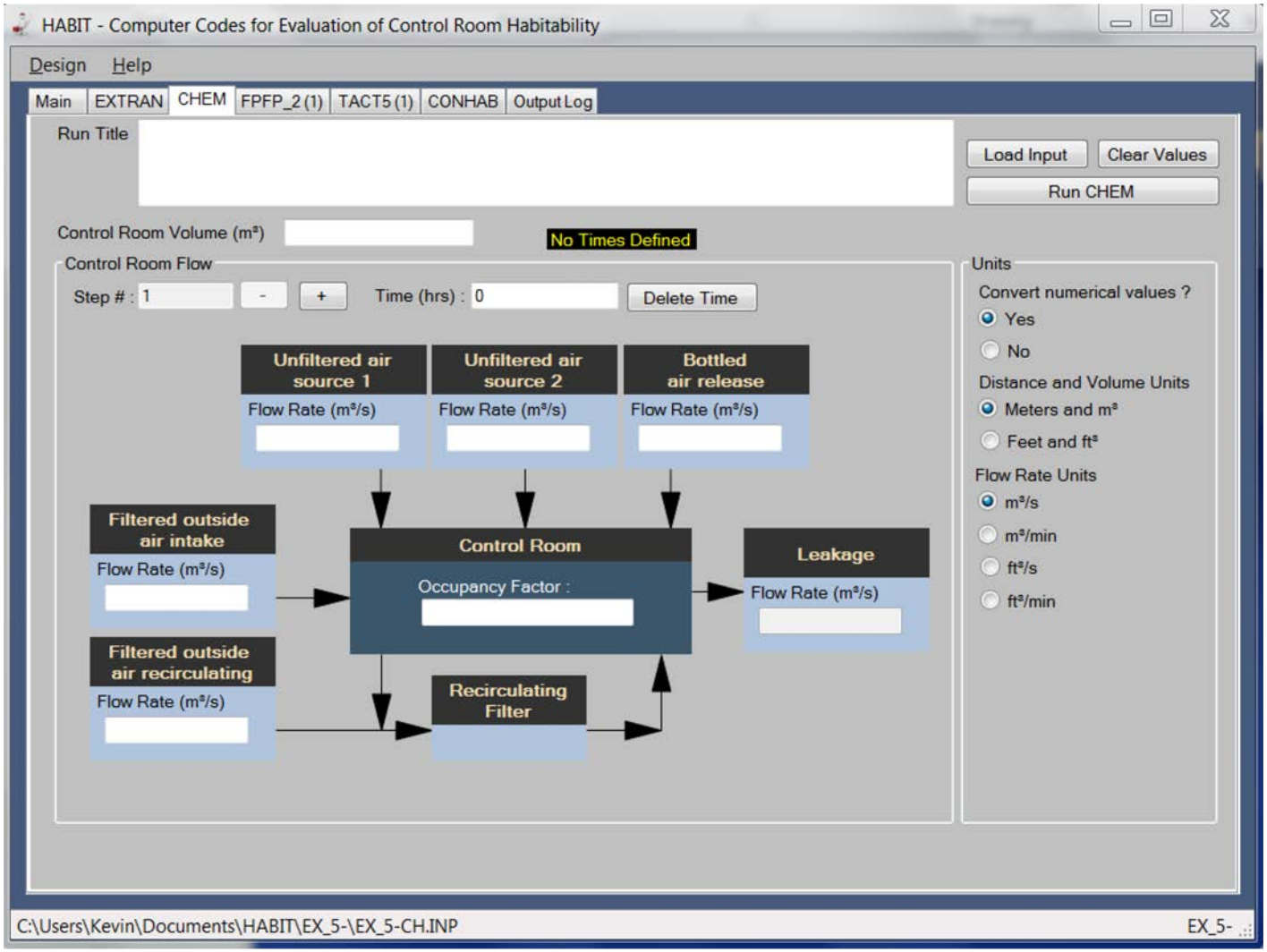
CHEMical Module



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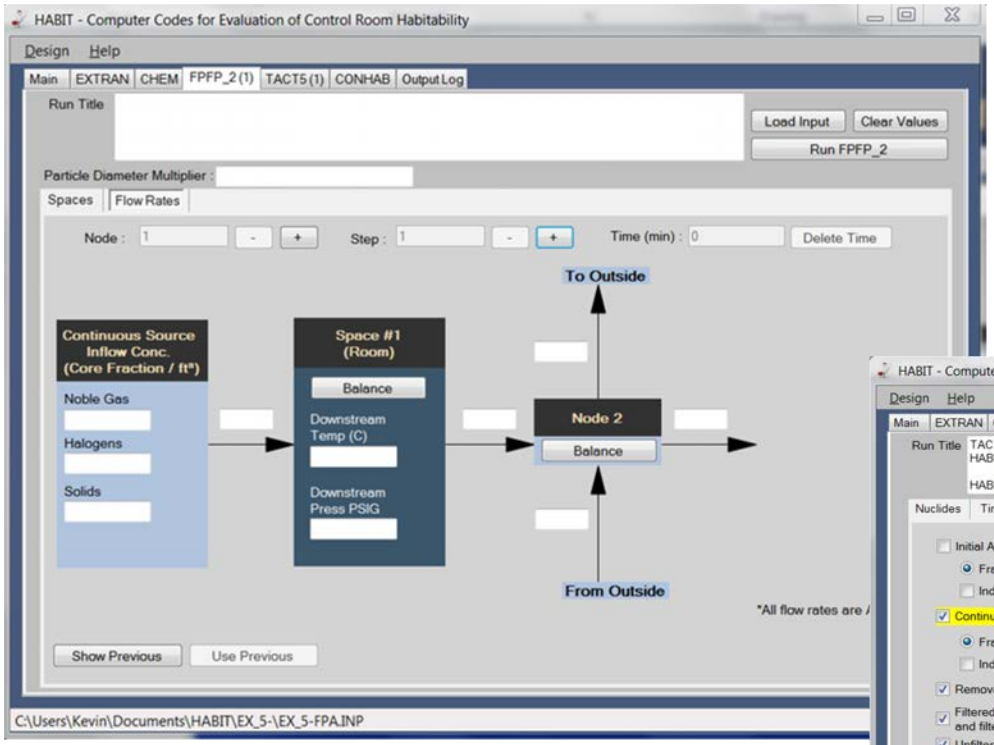
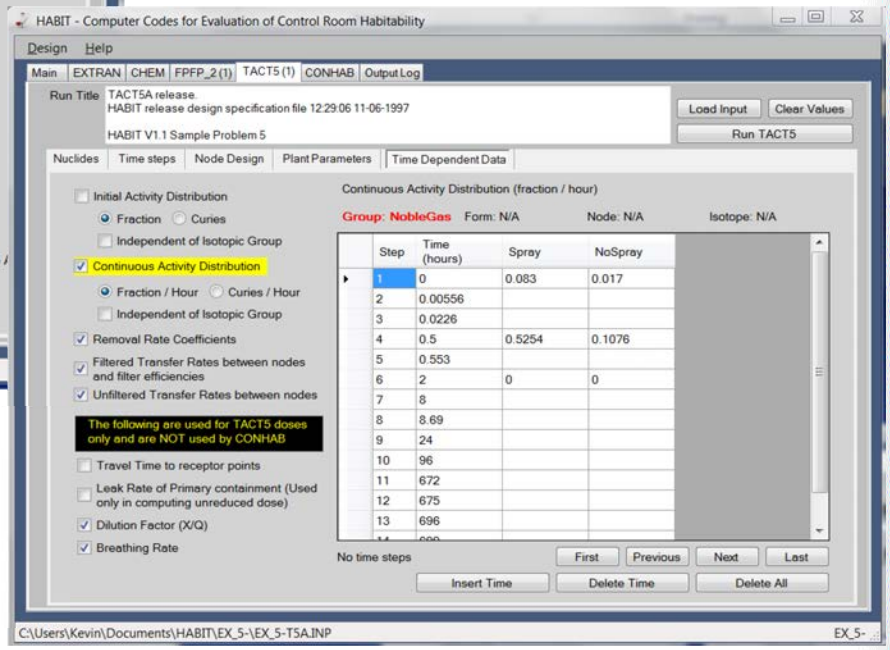
Radiological Modules



FPFP Module

TACT Module



Have we built the software right?

Verification and Validation

Have we built the right software?

FORTRAN modules and I/O data

- Impacts from identified "BUGS" and modifications made in HABIT 1.2
- Precision of reproduced identical results

Compilation and operational steps in the new "User Manual"

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HABIT PHASE-II

April 2015 - Sept 2016

- **Version 2.0 (2016):** Built-in with two most popular DEGADIS and SLAB (D&S) dense gas models
- Align and update TBD documents

RADIATION PROTECTION CODE
RAMP
ANALYSIS AND MAINTENANCE PROGRAM

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Vertical Dispersion Coefficients (σ_z)

Differences between σ_z used in HABIT and ALOHA codes

Stability Class	A (very unstable)			D (neutral)			G (very stable)		
Wind Speed (m/s)	1	3	5	1	3	5	1	3	5
HABIT σ_z									
Distance = 400 m	87	97	156	30	52	133	26	50	133
Distance = 4,000 m	1000	1000	1000	86	226	590	40	213	585
ALOHA σ_z									
Distance = 400 m	83	83	83	15	15	15	4	4	4
Distance = 4,000 m	1000	1000	1000	78	78	78	19	19	19

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Comparison HABIT vs. ALOHA for a Spilled Chlorine Pool Release

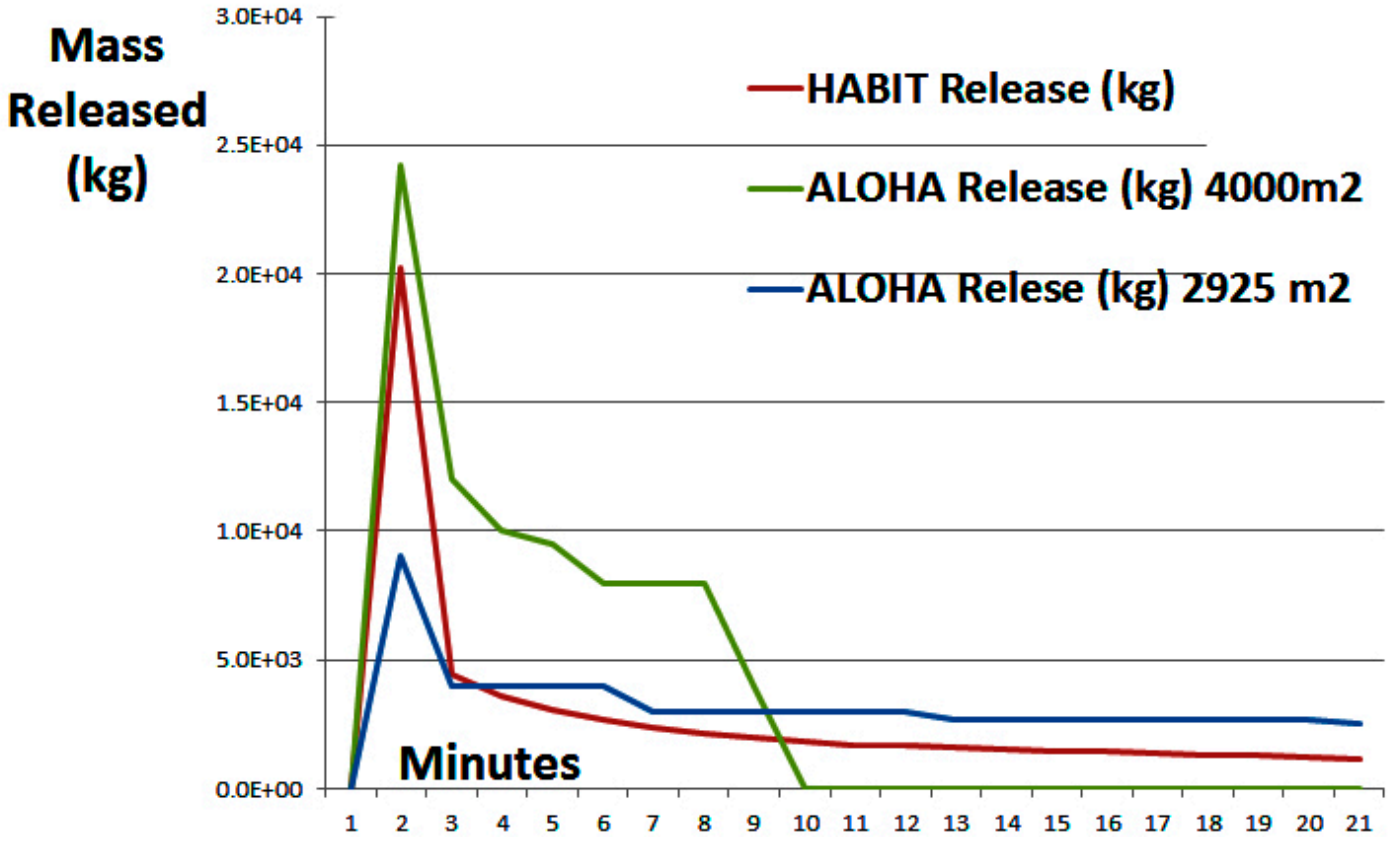

Figure 2. Source: A Spilled Chlorine Pool of 81,650 kg

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Dense Gases Models Validation

Model	Developer	Purpose	Scenarios	Type
ALOHA 5.4.3	EPA/NOAA	Dense gas and neutrally buoyant gas dispersions	Leak from pipeline or tank, evaporating puddle, direct open source	Source-term model
DEGADIS 2.1	University of Arkansas	Dense gas and neutrally buoyant gas dispersions	Elevated or ground-level area source, vertical jet leak	Non-source-term model
HABIT 1.1	**PNNL**	**Neutrally buoyant gas dispersions**	**Liquid or gas tank burst and leak**	**Source-term model**
SCIPUFF 2.2	Titan Research and Technology	Dense gas and neutrally buoyant gas dispersions	Moving and stack sources, gaseous and particulate materials	Non-source-term model
SLAB	LLNL	Dense gas and neutrally buoyant gas dispersions	Open evaporating pool, horizontal and vertical jet/stack, instantaneous volume liqiud sources	Non-source-term model

Table E.1: Performed by ANL (ANL/EVS/TM-13.3: April 2013)

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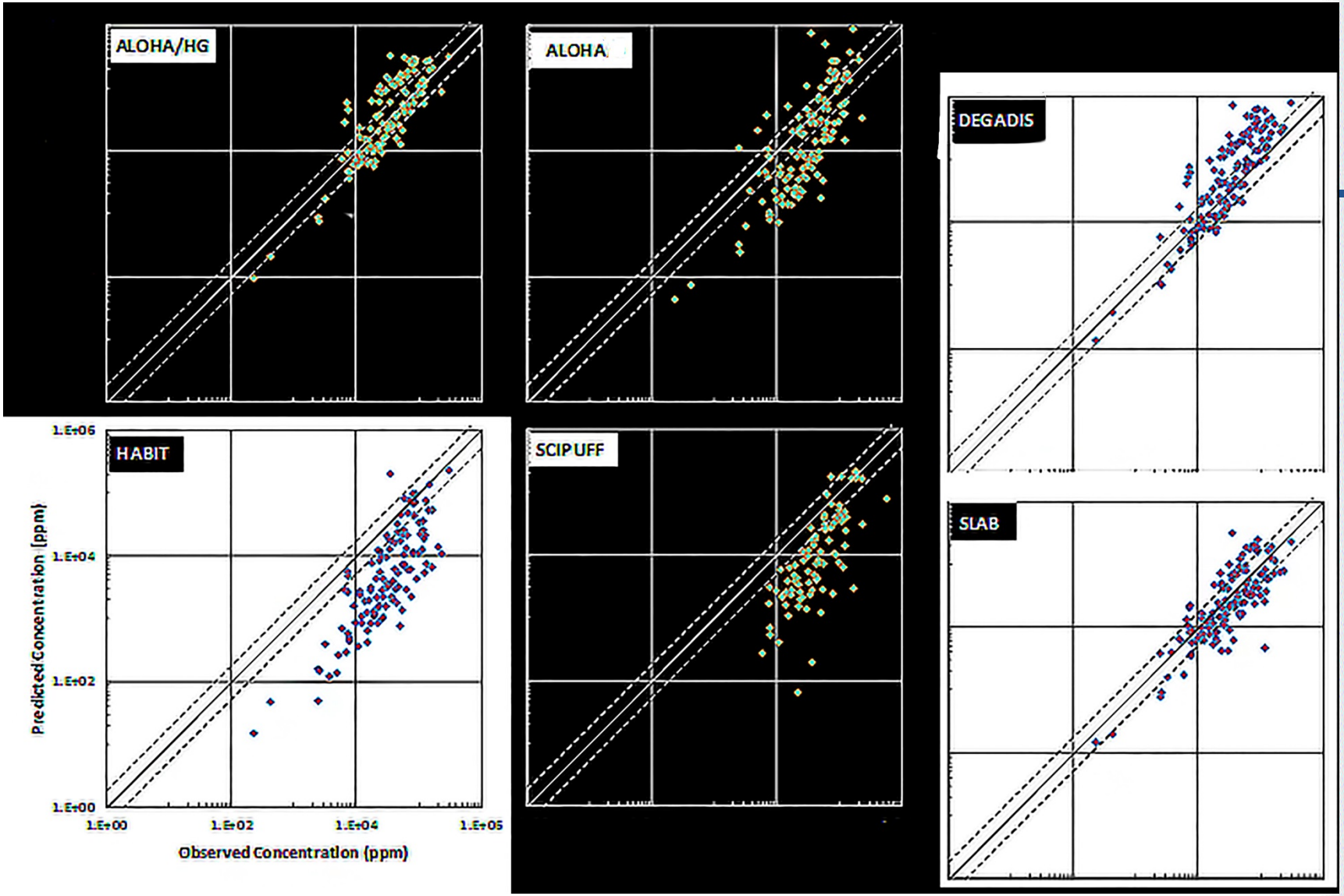
Experimental Data (Hanna et al.1991)

Parameter	Burro	Coyote	Desert Tortoise	Goldfish	Hanford (continuous)	Hanford (Instantaneous)	Maplin Sands	Prairie Grass	Thorney Island (continuous)	Thorney Is. (instantaneous)
Number of trials	8	3	4	3	5	6	4, 8[a]	44	2	9
Location	China Lake, Calif.	China Lake, Calif.	Nevada Test Site, Nev.	Nevada Test Site, Nev.	Richland, Wash.	Richland, Wash.	Maplin Sands, U.K.	Near O'Neill, Neb.	Thorney Island, U.K.	Thorney Island, U.K.
Period	Jun.-Sep. 1980	Sep.-Oct. 1981	Aug.-Sep. 1983	Aug. 1986	Sep.-Nov. 1967	Sep.-Nov. 1967	Sep. 1980, Sep.-Oct. 1980	Jul.-Aug. 1956	Jun. 1984	Aug. 1982-Jun. 1983
Material	LNG	LNG	NH_3	HF	Krypton-85	Krypton-85	LNG, LPG	SO_2	Freon-12, N_2	Freon-12, N_2
Type of release	Boiling liquid (dense gas)	Boiling liquid (dense gas)	2-phase jet (dense gas)	2-phase jet (dense gas)	Gas (non-buoyant)	Gas (non-buoyant)	Boiling liquid (dense gas)	Gas jet (non-buoyant)	Gas (dense gas)	Gas (dense gas)
Total mass (kg)	10,700-17,300	6,500-12,700	10,000 - 36,800	3,500-3,800	11-24[b]	10[b]	2,000-6,600, 1,500-8,400	23-63	4,800	3,150-8,700
Release duration (s)	79-190	65-98	126-381	125-360	598-1,191	(instantaneous)	100-230, 90-360	600	460	(instantaneous)
Surface	Water	Water	Soil	Soil	Soil	Soil	Water	Soil	Soil	Soil
Surface roughness (m)	0.0002	0.0002	0.003	0.003	0.03	0.03	0.0003	0.006	0.01	0.005-0.018
P-G stability class	C-E	C-D	D-E	D	C-F	C-F	D, C-D	A-F	E-F	D-F
Max. distance (m)	140-800	300-400	800	1,000-3,000	800	800	180-650, 250-650	800	472	410-580
Min. averaging time (s)	1	1	1	66.6-88.3	38.4	4.8	3	(dosage)	30	0.6
Max. averaging time (s)	40-140	50-90	80-300	66.6-88.3	269-845	4.8	3	600	30	0.6

[a] The first and second values denote LNG and LPG, respectively, if any.

[b] Curies, rather than kg, are used as a measure of the amount of this radioactive tracer released.



Comparison between the "Observed" and "Predicted" Concentrations (ppm)

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Modules Selected

- **DEGADIS (Thomas Spicer)** solves the gas concentrations by gravity-driven, over flat terrain, then into the entrainment layers.
- **SLAB (Donald Ermak)** solves gas concentrations by mass, energy, and momentum balances at downwind locations.

Both Models can perform for release from:

pool evaporation, jets, and explosion scenarios.

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HABIT Phase-II Milestone & Schedule

Program Schedule: April 20, 2015 – April 04, 2016

Kickoff: April 20, 2015

Task	Main Objective	Duration (days)	Finish Date
1	Re-host D&S	109	June 22
2	Integrate D&S	113	Oct. 16
3	V&V HABIT v 2.0	73	Jan. 26, 16
4	Update NUREG/CR-6210	85	April 4, 16

D&S: DEGADIS and SLAB

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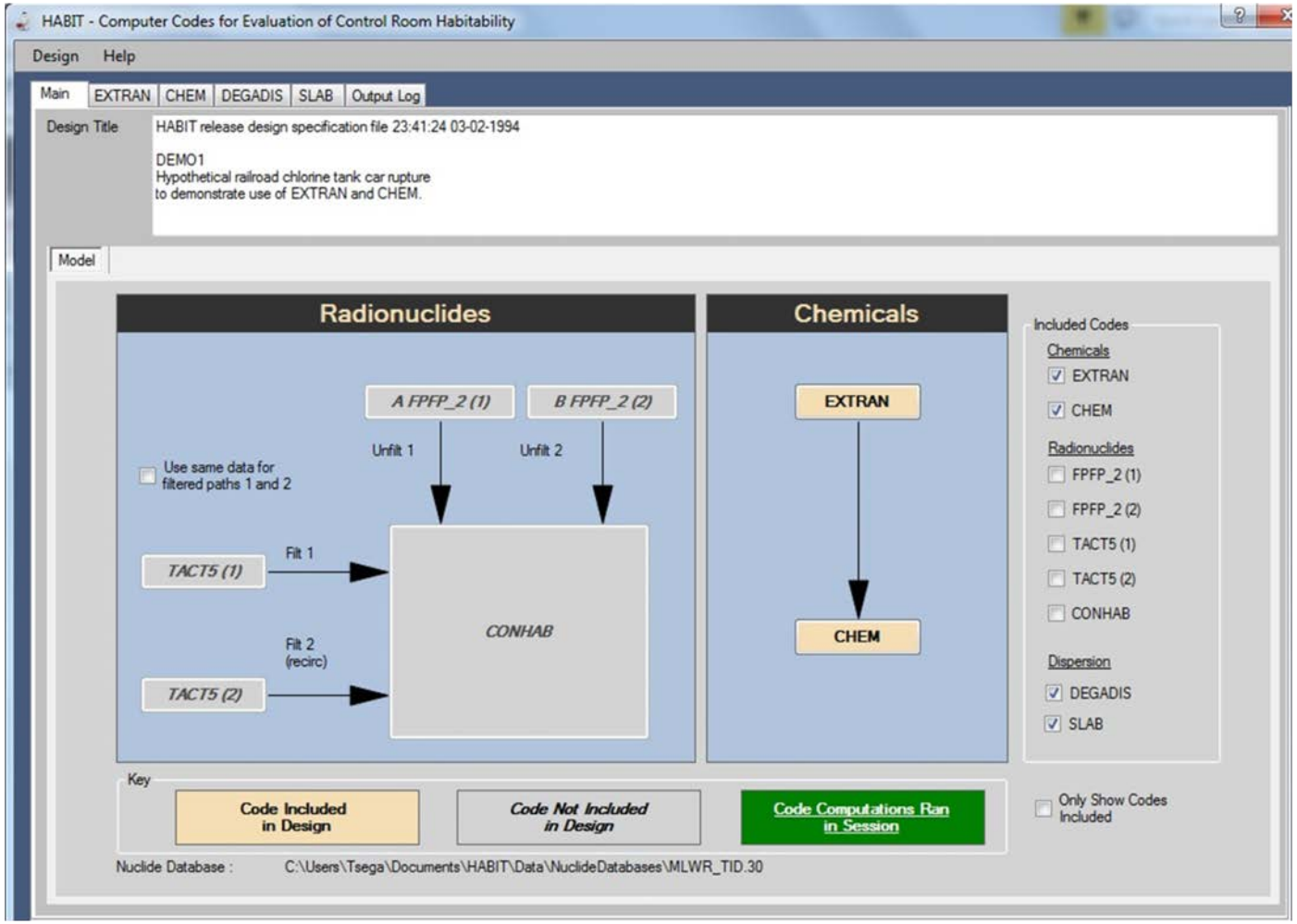
HABIT v2.0 Main Screen



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DEGADIS' 4 Modules

GTI-04/0049 - DEGADIS 2.1: Dense Gas Dispersion Model for LNG...

DEGADIS 2.1: Dense Gas Dispersion Model for LNG Vapor Dispersion

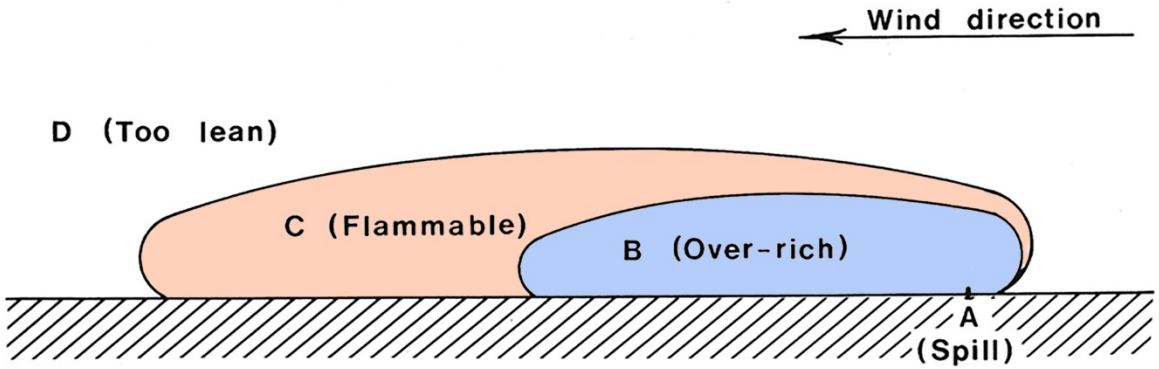
Federal regulations governing LNG dispersion protection (49 CFR 193.2059) specify DEGADIS as an acceptable means of determining flammable vapor-gas dispersion distances.

$500.00

1 Add to Cart

Availability: In Stock

- Simulation Processes
- Atmospheric Processes
- Chemical Specifications
- Release Specifications



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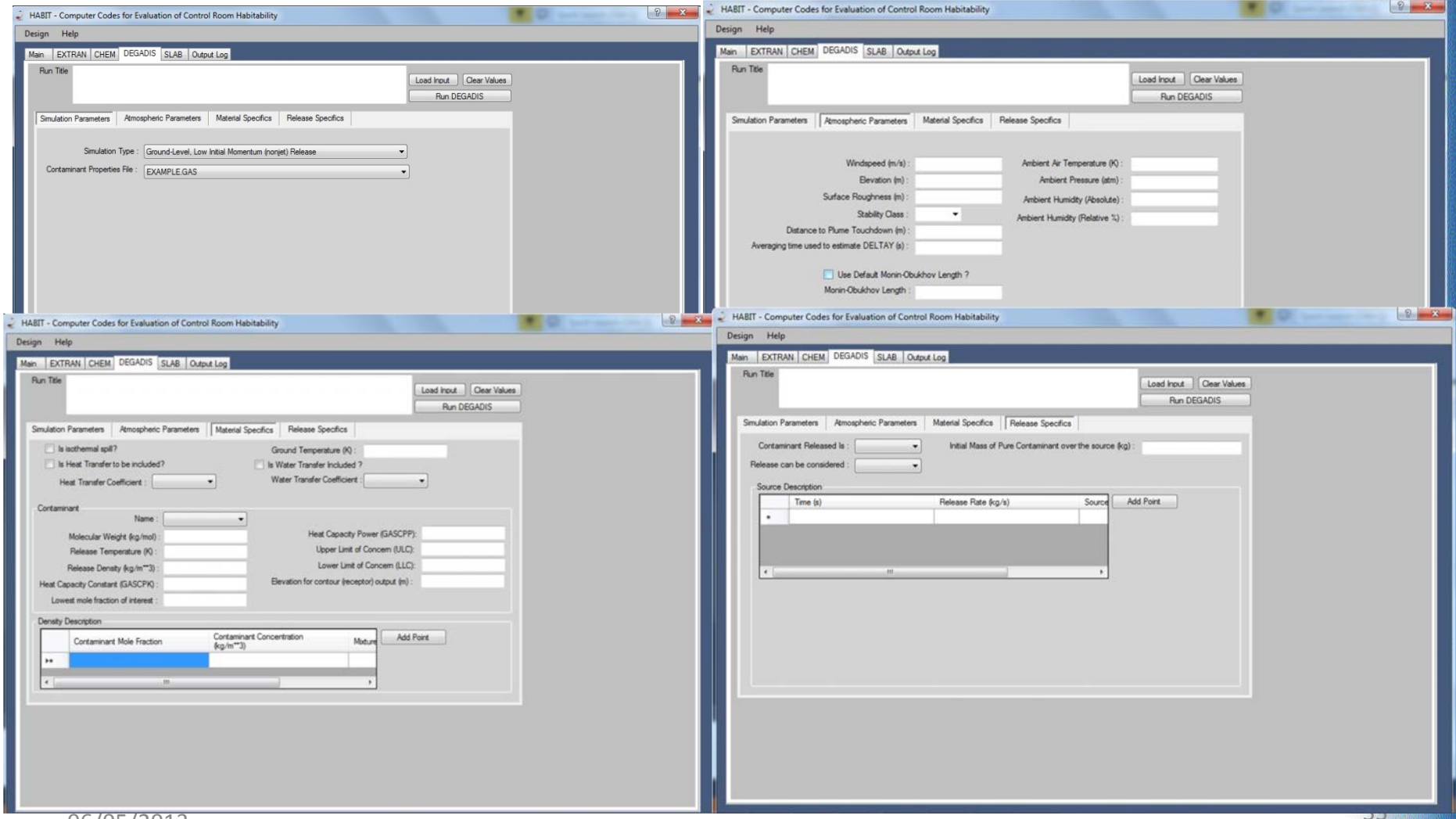
DEDAGIS: GUI



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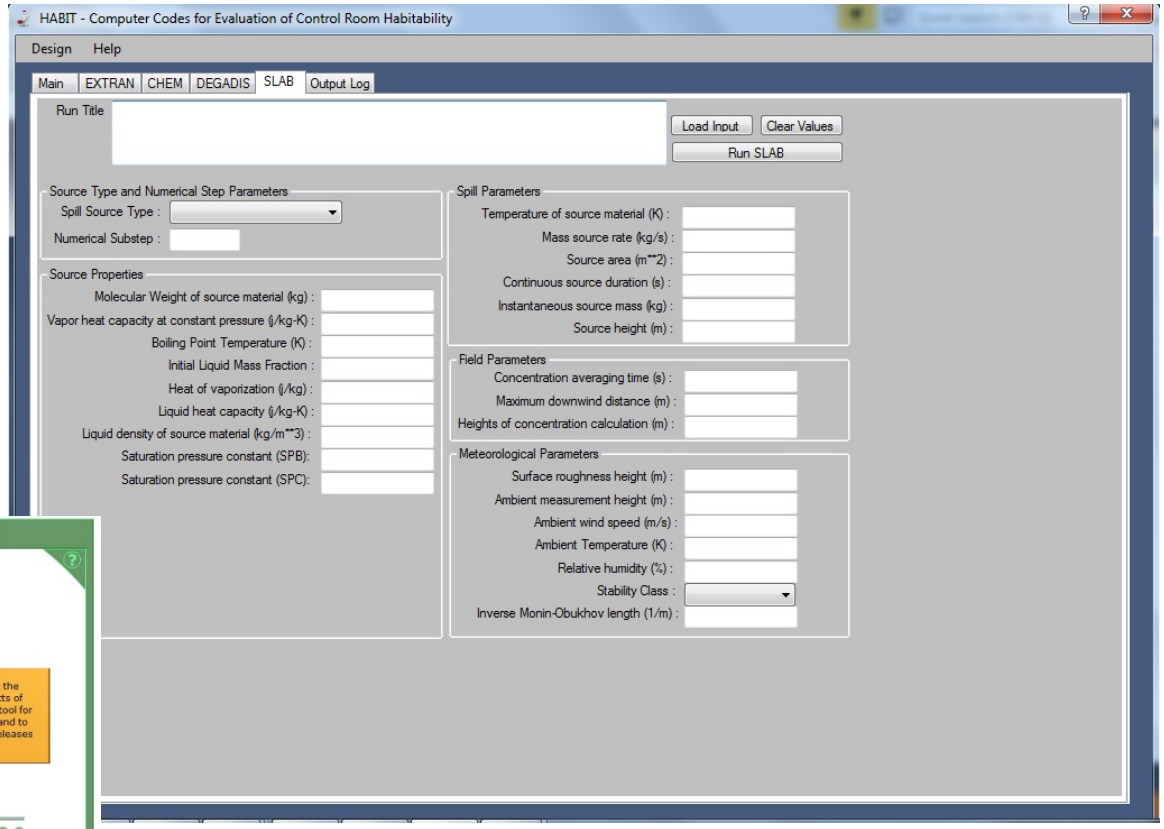
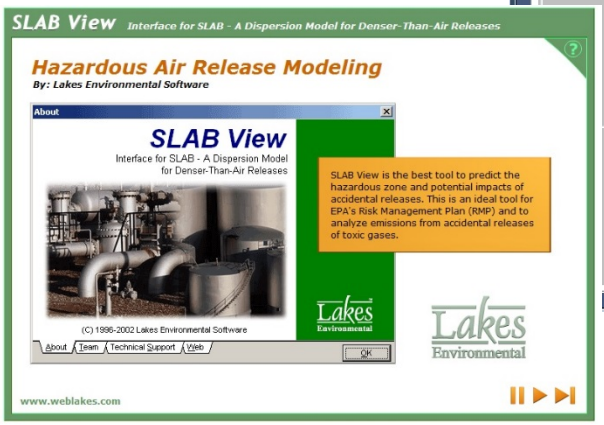
SLAB (1-1)





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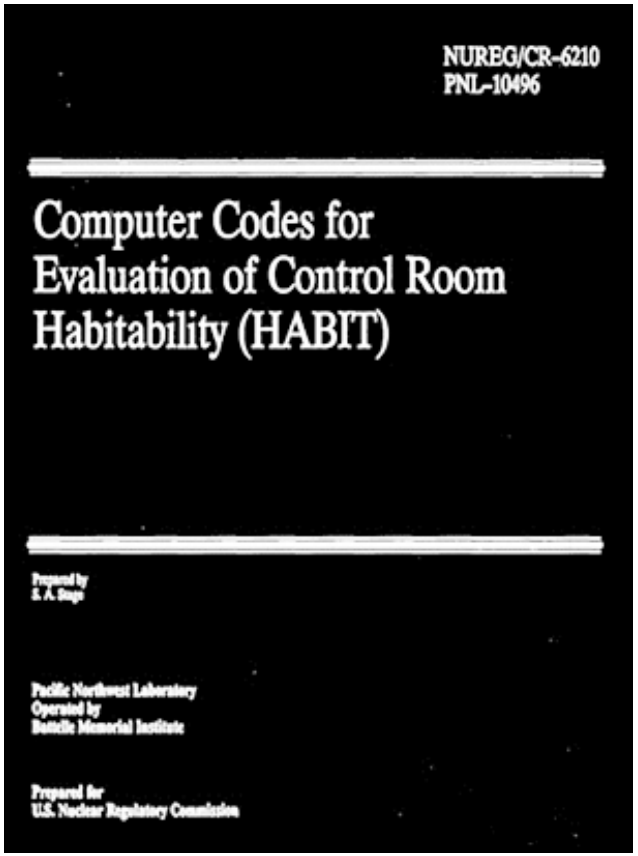
Work-in-Progress



- Analyze and integrate D&S
- V&V HABIT v2.0 I/O data
- Update TBDs

Targeted completion date: 9/30/2016

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On-Going Enhancements

- Adding chemicals
- Adding graphic analysis
- Adding ICRP 60/103 dose coefficients
- Supporting RAMP
- Benchmark ATD Models

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The 6 have 7 Brains

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