LDTRAN/CB: A Model for the Assessment of the Impact of the Chemical/Biological Environment on Military Rotorcraft Operations

T.R. Quackenbush, R.M. McKillip, Jr.,
T.B. Curbishley, and A.Z. MacNichol

Continuum Dynamics, Inc.
Princeton, NJ

ABSTRACT

Assessing the influence of the Chemical/Biological (CB) environment on the mission effectiveness of current and projected Army rotorcraft requires the direct modeling of the rotor wake flowfield (or rotorwash) as well as wake/fuselage interaction. Rotorwash effects may have a significant influence on CB agent deposition on the fuselage, affecting both CB survivability design features as well as decontamination procedures. In generating a predictive tool to address these issues, it is desirable to use an analysis with a track record of successful application to rotor/fuselage modeling while developing a user-friendly input and a code structure suitable for taking input from the current generation of CB cloud dispersion models. The project described here constructed a coupled model of rotor wake/ airframe effects and cloud droplet transport, building on software previously developed for both U.S. Army and industry users. The general aim was to tailor this model to the requirements of CB cloud interaction problem and to implement appropriate interface software to produce a practical mission simulation tool. The work to date has led to the development of the LDTRAN/CB computer program (Lagrangian Deposition and TRajectory ANalysis/Chemical-Biological). This paper presents a technical description of LDTRAN/CB and its supporting software, an overview of its operation, and examples of its application to representative rotorcraft in typical mission operating scenarios.

NOMENCLATURE

A_k	area of the kth surface panel, m^2
C_D	droplet drag coefficient
D	droplet diameter, μm
g_i	acceleration due to gravity operating on ith particle, m/sec^2
m_k	mass deposition rate on kth panel, $kg/sec\text{-}m^2$
$\vec{n}_k$	vector normal to kth panel
$\vec{q}_k$	effective droplet velocity at kth panel, m/sec
U_i	mean free stream velocity at location of ith particle, m/sec
u_i	fluctuation in free stream velocity at location of ith particle, m/sec
V_i	mean velocity of ith particle, m/sec
v_i	fluctuation in velocity of ith particle, m/sec
X_i	mean position of ith particle, m
x_i	fluctuation in position of ith particle, m
ρ	droplet density, kg/m^3
ρ_a	density of air, kg/m^3
ρ_{mpd}	volumetric density of droplets, $droplets/m^3$
τ_p	droplet deceleration time constant, sec (eq. 3)
$\langle fg \rangle$	ensemble average of fluctuating quantities f and g

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INTRODUCTION

Recently, the U.S. Army Research Laboratory initiated an effort to directly include the effect of rotorwash on Chemical-Biological (CB) cloud deposition on helicopter fuselages as part of its ongoing work on assessment of CB challenges to be faced by current and projected Army rotorcraft. These rotorwash effects may have a significant influence on CB agent deposition on the fuselage, affecting both CB survivability design features as well as decontamination procedures.

One element of work to date has been the development of the computer program LDTRAN/CB (Lagrangian Deposition and TRajectory ANalysis/Chemical-Biological) described in this paper. The primary near-term goal of this software is to provide ARL personnel - and ultimately other interested users in the military operations community and in industry - with a flexible, user-friendly, and comprehensive tool for computing deposition of CB material on rotorcraft exterior surfaces, as well as to provide input to closely associated work on CB infiltration. LDTRAN will be a component of the CADARS (Chemical Agent Deposition Analysis for