DEPARTMENT OF DEFENSE
UNITED STATES AFRICA COMMAND
OPERATION UNITED ASSISTANCE (MA205 PROJECT)
MONROVIA, LIBERIA

REPLY TO ATTENTION OF

AFRICOM-J35 20 NOV 2014

MEMORANDUM FOR Operations Officer, J3, Operation United Assistance

SUBJECT: Uncertainty Analysis for Course of Action Three

1. Tasked with assisting the Liberian government in combating the Ebola virus, the J-35 conducted extensive analysis to determine three courses of action (COA) for how a grant of $50 million should be allocated in order to minimize the death toll of the virus.

a. Specifically analyzed in this portion, COA 3 calls for an allotment plan of:

1) $26.00 million to Protection and Awareness, $11.50 million to Contact Tracing, and $12.50 million to Treatment Units

b. Of the three COA created, there is reasonable doubt in the accuracy of the data (coefficients τ, $\bar{c}$, and f) which the model utilizes. For the three coefficients, there is a three percent margin of error.

2. In order to determine whether or not the course of action development needs to be rethought, the existing Excel model for Euler's Method was adjusted to provide upper and lower limits of the coefficients due to the 3.0 % uncertainty. This allowed for a side by side comparison of death proportions after five months, as well as the opportunity to implement the Solver device to minimize the amount of death occurring at each extreme.

3. The three percent uncertainty present in the values of τ, $\bar{c}$, and f result a difference of 14% between the percentage of dead population after five months (8.87% lower limit, and 23.58% upper limit). Like in the previous analysis, optimizing the uncertainty models with Mathematica excludes any money from being allocated to treatment units. However, when the allocation to Treatment Units was set constant to $12.5 million again, the death proportions again reflected a slight increase. Still, the lowest limit, at 8.87%, is almost half of what COA 3 originally yielded.

4. The presence of uncertainty in the coefficients for the SEIR Model of this system yields death percentages both higher and lower than COA 2 currently produces. However, the course of action development does not need to be changed as it stands. Minimizing the percentage of death at five months again resulted in no money being supplied towards Treatment Units. In this case, the course of action development need not be changed; like in COA 2, a fixed amount of $12.5 was allotted to treatment units and the model reoptimized.

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Appendix A

Epidemiology Model

S(t) = The proportion of the population Susceptible to the Ebola virus at time t

E(t) = The proportion of the population Exposed and incubating the Ebola virus at time t

I(t) = The proportion of the population Infected and contagious with the Ebola virus at time t

R(t) = The proportion of the population Recovered from the Ebola virus at time t

t = Time, measured in days

m = Money, in millions of dollars, allocated to different counter-Ebola programs

β = The transmission rate of the Ebola virus between Susceptible and Infected people. B is a function of two variables: b = t ¯

τ = The probability of transmission after contact between an Infected person and a Susceptible person

$\bar{c}$ = The average daily number of contacts that an Infected person has with Susceptible people

σ = The daily proportion of Exposed people who become Infected ($\frac{1}{\sigma}$ = average incubation duration)

v = The daily proportion of Infected people who exit the Infected state ($\frac{1}{V}$ = average infection duration)

f = The fatality rate for the virus

$$\frac{dS(t)}{dt} = -\beta S(t)I(t)$$

$$\frac{dE(t)}{dt} = \beta S(t)I(t) - \sigma E(t)$$

$$\frac{dI(t)}{dt} - \sigma E(t) - vI(t)$$

$$\frac{dR(t)}{dt} = v(1-f)I(t)$$

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Part III

No Change to COA 3

Money Allocation	
Protection and Awareness	$26M
Contact Tracing	$11.5M
Treatment Units	$12.5M

Coefficients	
β	0.343
τ	0.179
$\bar{c}$	1.914
σ	0.1
v	0.2
f	0.714

Proportions after 5 months	
Suseptible	0.6963646
Exposed	0.0634349
Infected	0.0295518
Recovered	0.0607264
DEAD	0.149922

Lower Limit Unconstrained

Money Allocation	
Protection and Awareness	$35.47M
Contact Tracing	$14.53M
Treatment Units	$0M

Coefficients	
β	0.319
τ	0.172
$\bar{c}$	1.857
σ	0.1
v	0.2
f	0.698

Proportions after 5 months	
Suseptible	83.02%
Exposed	3.67%
Infected	1.66%
Recovered	3.56%
DEAD	8.10%

Upper Limit Unconstrained

Money Allocation	
Protection and Awareness	$35.47M
Contact Tracing	$14.53M
Treatment Units	$0M

Coefficients	
β	0.3597
τ	0.1825
$\bar{c}$	1.9714
σ	0.1
v	0.2
f	0.7416

Proportions after 5 months	
Suseptible	58.55%
Exposed	7.92%
Infected	3.83%
Recovered	7.72%
DEAD	21.98%

Lower Limit Constrained

Money Allocation	
Protection and Awareness	$25.90M
Contact Tracing	$11.60M
Treatment Units	$12.5M

Coefficients	
β	0.323
τ	0.174
$\bar{c}$	1.856
σ	0.1
v	0.2
f	0.692

Proportions after 5 months	
Suseptible	81.22%
Exposed	4.06%
Infected	1.84%
Recovered	4.00%
DEAD	8.871%

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Upper Limit Constrained

Money Allocation	
Protection and Awareness	$25.90M
Contact Tracing	$11.60M
Treatment Units	$12.5M

Coefficients	
β	0.364
τ	0.185
$\bar{c}$	1.971
σ	0.1
v	0.2
f	0.735

Proportions after 5 months	
Suseptible	55.65%
Exposed	8.20%
Infected	4.02%
Recovered	8.55%
DEAD	23.578%

Graphical Comparison of Death Proportion Upper vs. Lower Limits