# Random Distance Parameters;

## Their Analytic Computation and Application in Airtanker System Analysis

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Two early researchers must be cited for major contributions that continue to lead to advances in location science:

## Morgan William Crofton

## 1826 - 1915

A key contribution in

Geometric probability theory

M. Crofton, "On Local Probability" written for the ninth edition of the *Encyclopaedia Britannica* of 1885. In this edition the technique of incrementing domains for the calculation of mean values is described.

# Carl Friedrich Wilhelm von Launhardt

1832-1918

A key contribution in

Applied location theory

W. Launhardt, The Theory of the Trace: Being a Discussion of the Principles of Location of 1900-02 was written in 2 parts. In this book Launhardt analyzes the cost of transporting goods uniformly distributed over a circular region to its center.

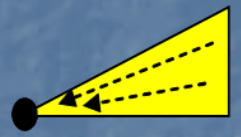
Forestry researchers who contributed notable advances of relevance to the author's current work in applied location theory include:

- **Sundberg, Ulf. (G. Almqvist) 1952-53.**

"Studier i skogsbrukets transporter." (Studies of transportation in forestry)
In two parts: SSF:s tidskrift, 1952, 50(4):341-357, and, 1953, 51(1):15-72.

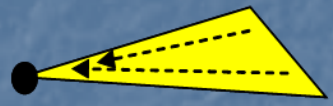
- **Suddarth, Stanley K. and Allyn M. Herrick. 1964.**

"Average skidding distance for theoretical analysis of logging costs".
Purdue Univ. Agric. Exp. Stn. Res. Bull. 789 (Dec.), LaFayette, Ind. 6 p.



- **Peters, Penn A. 1978.**

"Spacing of roads and landings to minimize timber harvest cost"
For. Sci. 24(2):209-217.

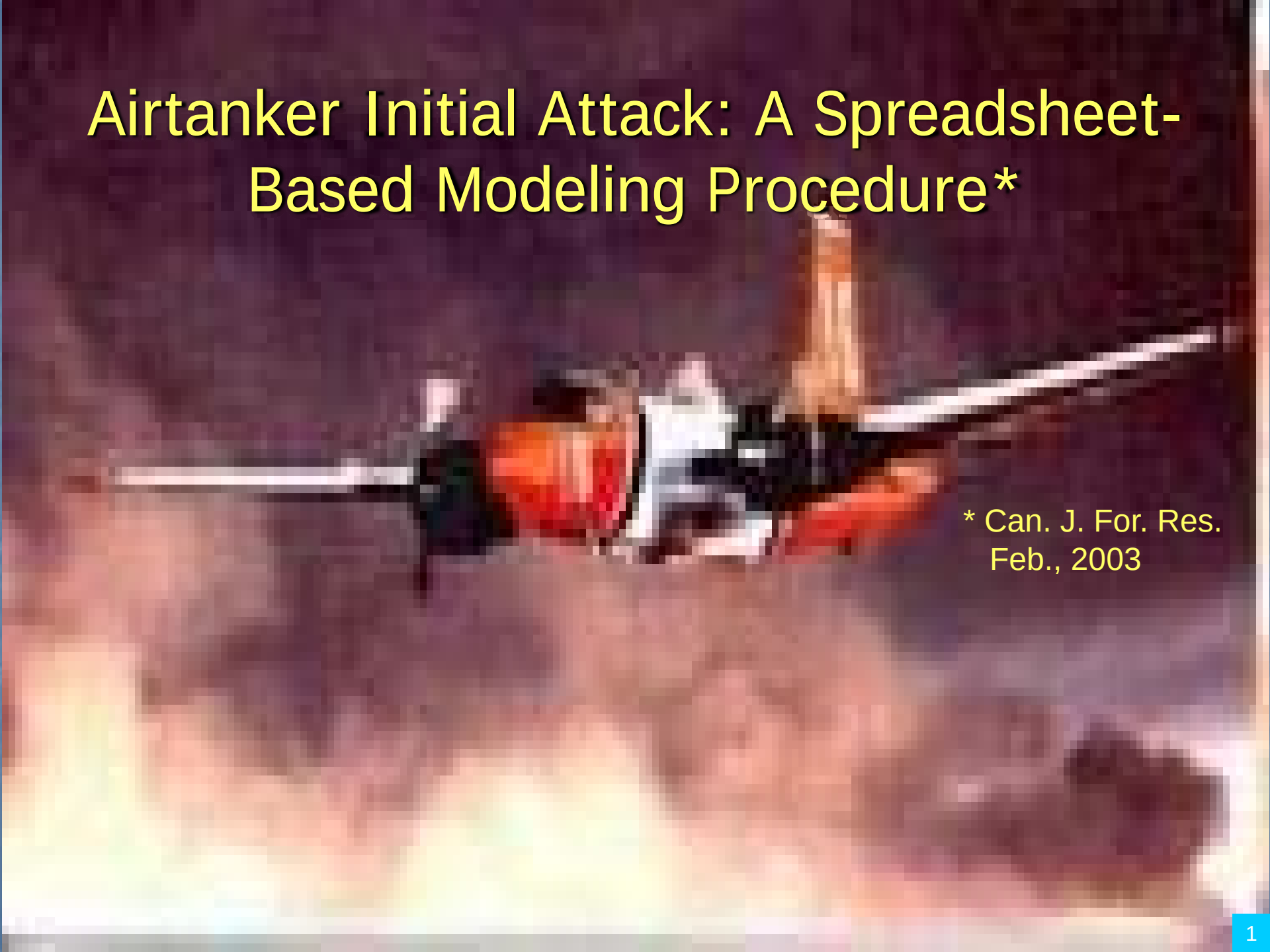


- **Donnelly, Dennis M. 1978.**

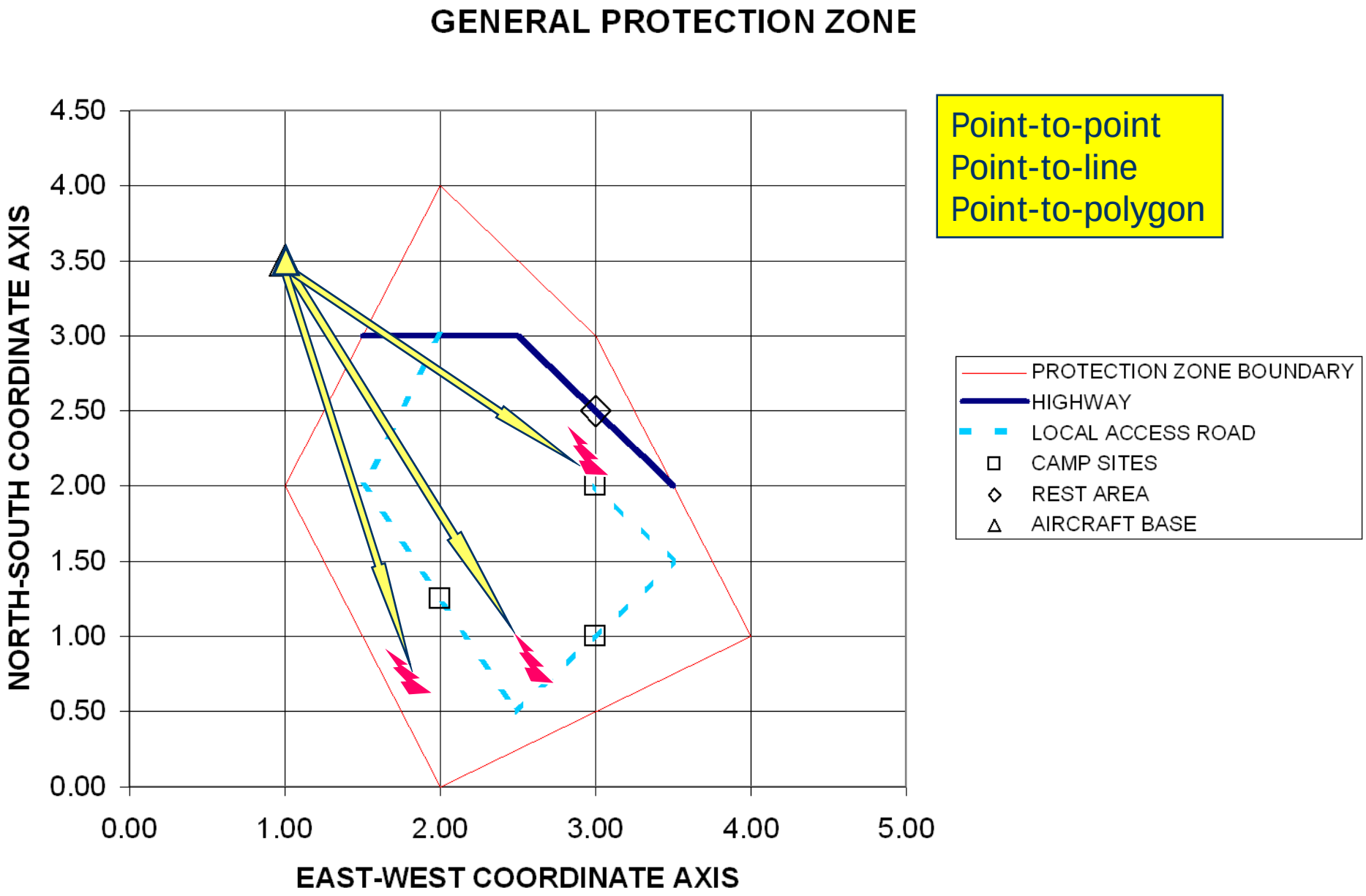
"Computing average skidding distance for logging areas with irregular boundaries and variable log density"
USDA Forest Service General Technical Report RM-58. 10 p.

Recent work by the author dealing with analytical modeling of airtanker systems based on the application of continuous location theory includes the following:

# Airtanker Initial Attack: A Spreadsheet-Based Modeling Procedure*



* Can. J. For. Res. Feb., 2003


GENERAL PROTECTION ZONE
NORTH-SOUTH COORDINATE AXIS
4.50
4.00
3.50
3.00
2.50
2.00
1.50
1.00
0.50
0.00
0.00
1.00
2.00
3.00
4.00
5.00
EAST-WEST COORDINATE AXIS
Point-to-point
Point-to-line
Point-to-polygon
PROTECTION ZONE BOUNDARY
HIGHWAY
LOCAL ACCESS ROAD
CAMP SITES
REST AREA
AIRCRAFT BASE

# MODELING RESULTS

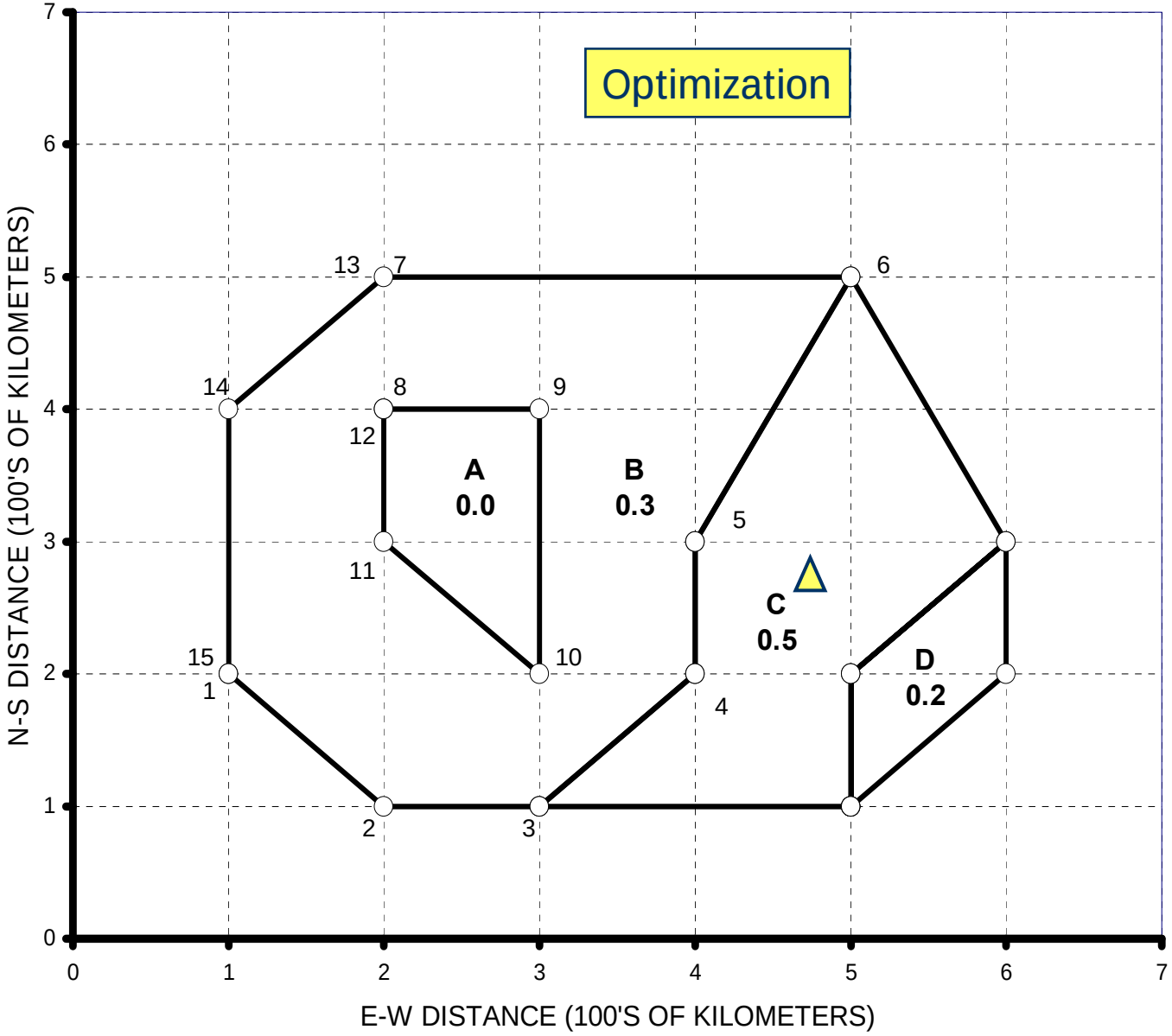
| FEATURE | WEIGHT | E{D} | $E\{D^2\}$ |
|---|---|---|---|
| GENERAL AREA | 0.40 | 2.2722 | 5.8141 |
| HIGHWAY | 0.25 | 1.7787 | 3.5788 |
| ACCESS ROAD | 0.10 | 3.1016 | 9.6667 |
| CAMP SITES | 0.20 | 2.7213 | 7.5208 |
| REST AREA | 0.05 | 2.2361 | 5.0000 |
| **TOTAL ZONE** | **1.00** | **2.3197** | **5.9412** |

$E\{Cost\} = 1.15 + 0.0891\ E\{Dist\} + 0.0449\ E\{Dist^2\}$

$E\{Cost\} = 1.15 + 0.0891\ (2.3197) + 0.0449\ (5.9412)$

$E\{Cost\} = 1.62$ (cents per liter of water dropped)

# AIRTANKER INITIAL-ATTACK ZONE

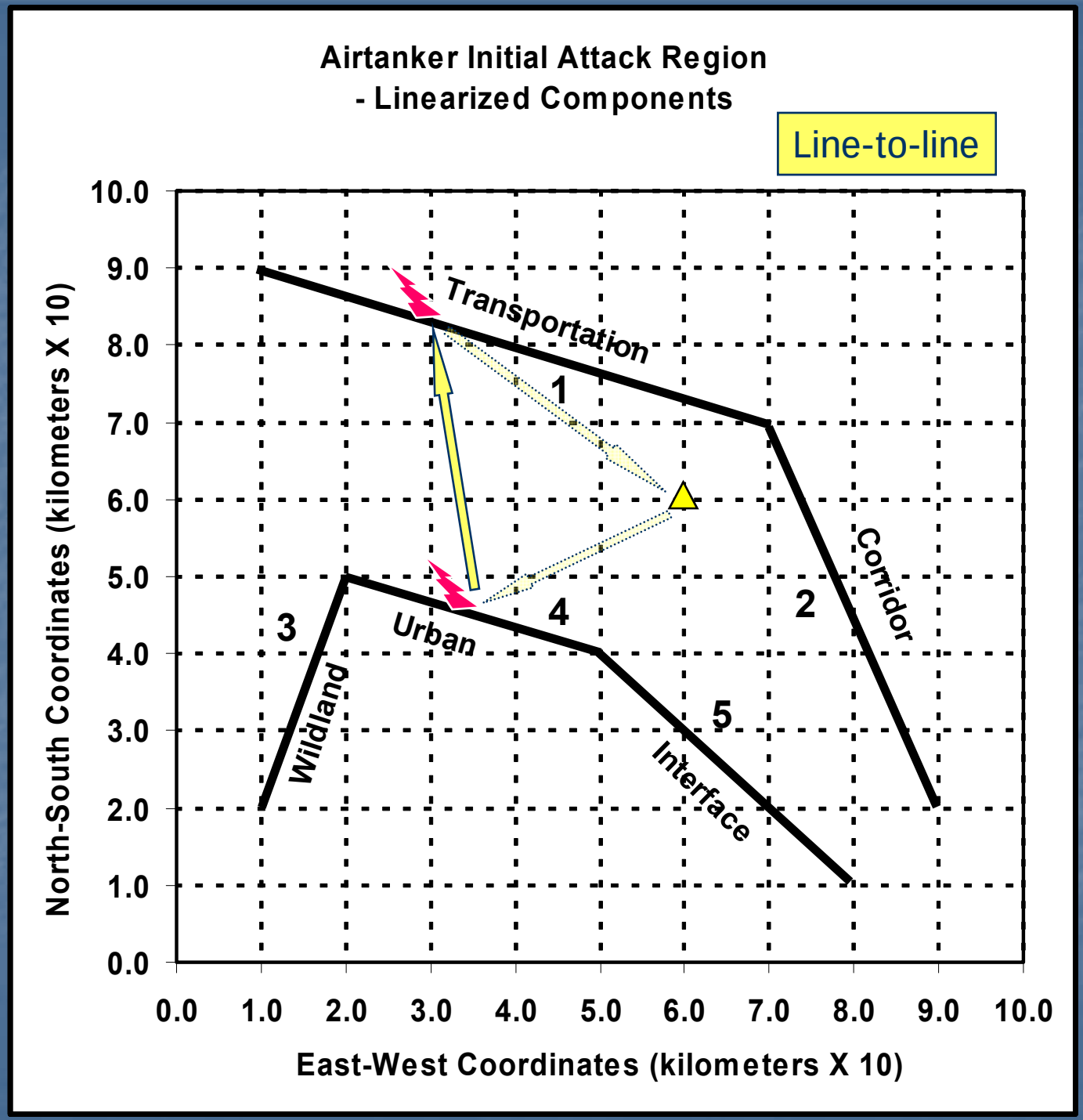


# MODELING RESULTS

| AIRBASE LOCATION | COORDINATES | PARTITION | WEIGHT | E{D} | E{$D^2$} | EXPECTED COST |
|---|---|---|---|---|---|---|
| ARBITRARY POINT | (4.00, 4.00) | B | 0.3 | 1.9057 | 4.5333 | 1.5233 |
| | | C | 0.5 | 1.7628 | 3.5667 | 1.4672 |
| | | D | 0.2 | 2.5385 | 6.5000 | 1.6680 |
| | | | AGG.: | 1.9608 | 4.4433 | 1.5242 |
| ARBITRARY POINT | (5.00, 3.00) | B | 0.3 | 2.5905 | 7.4333 | 1.7146 |
| | | C | 0.5 | 1.0746 | 1.5000 | 1.3131 |
| | | D | 0.2 | 1.1942 | 1.5000 | 1.3238 |
| | | | AGG.: | 1.5533 | 3.2800 | 1.4357 |
| MIN{$DIST^1$} | (4.55, 2.59) | B | 0.3 | 2.3011 | 5.9143 | 1.6206 |
| | | C | 0.5 | 1.0416 | 1.3273 | 1.3024 |
| | | D | 0.2 | 1.2090 | 1.5006 | 1.3251 |
| | | | AGG.: | 1.4529 | 2.7381 | 1.4024 |
| MIN{$DIST^2$} | (4.27, 2.69) | B | 0.3 | 2.0687 | 4.8667 | 1.5528 |
| | | C | 0.5 | 1.1175 | 1.4843 | 1.3162 |
| | | D | 0.2 | 1.4839 | 2.2390 | 1.3827 |
| | | | AGG.: | 1.4761 | 2.6500 | 1.4005 |
| MIN{COST FUNCTION} | (4.37, 2.66) | B | 0.3 | 2.1482 | 5.2145 | 1.5755 |
| | | C | 0.5 | 1.0817 | 1.4078 | 1.3096 |
| | | D | 0.2 | 1.3874 | 1.9625 | 1.3617 |
| | | | AGG.: | 1.4628 | 2.6608 | 1.3998 |

# Airtanker Flight-Distance between Fires: Random Fire-Starts on Line Segments*

* For. Sci. Oct., 2005


Airtanker Initial Attack Region
- Linearized Components
Line-to-line
Transportation
1
2
Corridor
3
Wildland
Urban
4
5
Interface
North-South Coordinates (kilometers X 10)
East-West Coordinates (kilometers X 10)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0

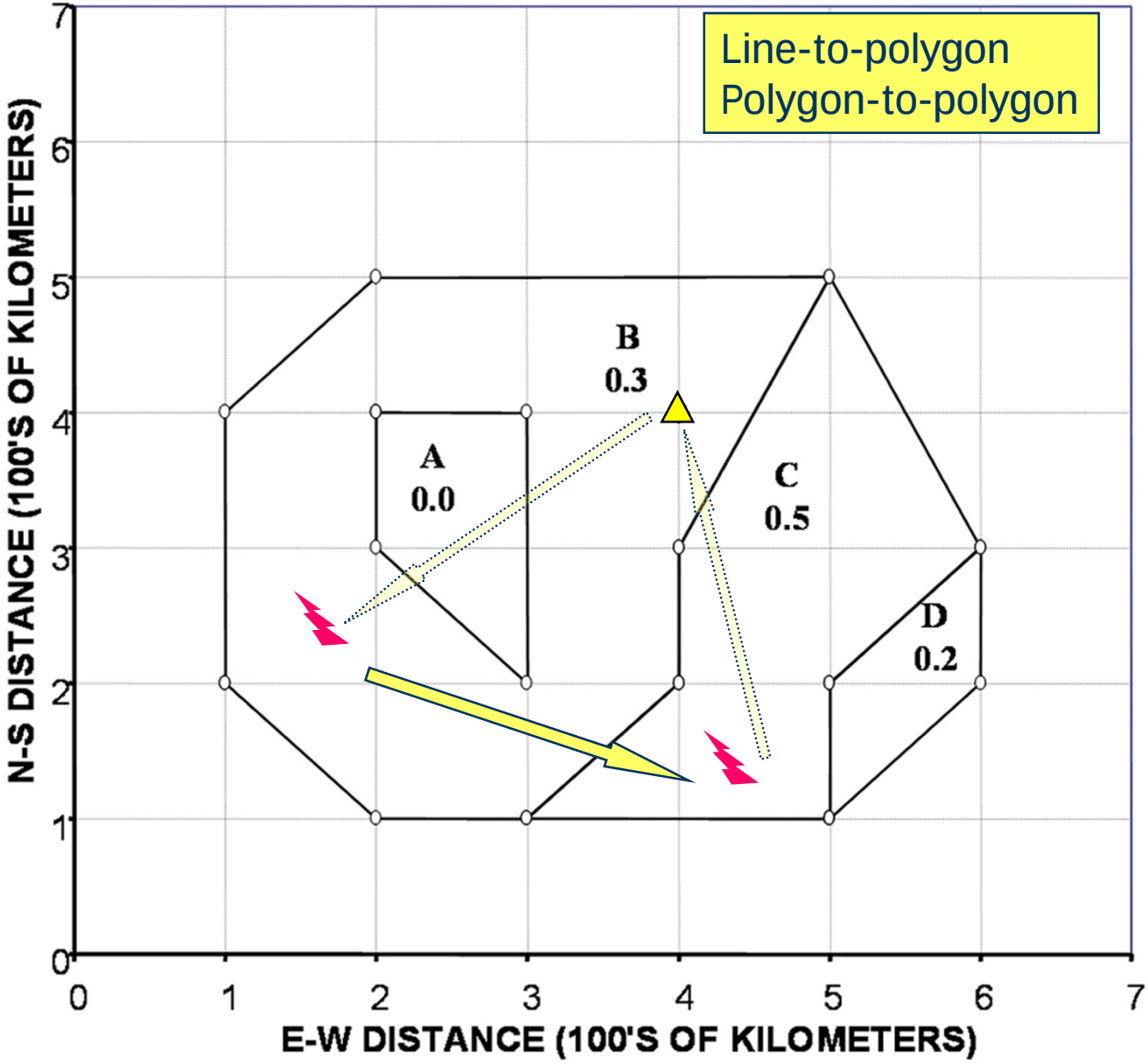
# Computed population parameters for the random one-way transfer distance between line segments

| $E\{D\}$ | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 2.1082 | 5.4152 | 5.4563 | 4.0399 | 6.2260 |
| 2 | — | 1.7951 | 6.7940 | 4.7462 | 3.0657 |
| 3 | — | — | 1.0541 | 2.4198 | 5.2262 |
| 4 | — | — | — | 1.0541 | 3.6231 |
| 5 | — | — | — | — | 1.4142 |
| $E\{D^2\}$ | 1 | 2 | 3 | 4 | 5 |
| 1 | 6.6667 | 34.0000 | 30.6667 | 16.6667 | 41.3333 |
| 2 | — | 4.8333 | 46.5000 | 23.5000 | 10.1667 |
| 3 | — | — | 1.6667 | 6.6667 | 28.3333 |
| 4 | — | — | — | 1.6667 | 15.3333 |
| 5 | — | — | — | — | 3.0000 |
| $\sigma$ | 1 | 2 | 3 | 4 | 5 |
| 1 | 1.4907 | 2.1623 | 0.9460 | 0.5884 | 1.6031 |
| 2 | — | 1.2693 | 0.5847 | 0.9868 | 0.8766 |
| 3 | — | — | 0.7454 | 0.9008 | 1.0102 |
| 4 | — | — | — | 0.7454 | 1.4855 |
| 5 | — | — | — | — | 1.0000 |

# Modeling Airtanker Flight Distance between Concurrent Fires; The Development and Use of Statistical Distribution Parameters*

*For. Sci.
Feb.(?), 2008

# AIRTANKER INITIAL-ATTACK ZONE



| All Permissible | Ab/B/B/Ab | Ab/C/B/Ab | Ab/D/B/Ab |
|---|---|---|---|
| Flight Patterns [a] | Ab/B/C/Ab | Ab/C/C/Ab | Ab/D/C/Ab |
| | Ab/B/D/Ab | Ab/C/D/Ab | Ab/D/D/Ab |
| | Ab/B/Ab | Ab/C/Ab | Ab/D/Ab |
| | | X | |
| P{X} [b] | B | C | D |
| | 0.3 | 0.5 | 0.2 |
| | | | |
| P{Y \| X} [c] | B | C | D |
| B | 0.120 | 0.040 | 0.020 |
| Y: C | 0.040 | 0.080 | 0.050 |
| D | 0.010 | 0.020 | 0.050 |
| Ab | 0.830 | 0.860 | 0.880 |
| | | | |
| P{Pattern} [d] | 0.036 | 0.020 | 0.004 |
| | 0.012 | 0.040 | 0.010 |
| | 0.003 | 0.010 | 0.010 |
| | 0.249 | 0.430 | 0.176 |
| | | | |
| E{Dist; X→Y} [e] | B | C | D |
| B | 191.1 | 260.2 | 329.2 |
| Y: C | 260.2 | 139.8 | 150.7 |
| D | 329.2 | 150.7 | 61.2 |
| Ab | 190.6 | 176.3 | 253.9 |
| | | | |
| E{Dist \| Pattern} [f] | 572.2 | 627.1 | 773.6 |
| | 627.1 | 492.4 | 580.8 |
| | 773.6 | 580.8 | 568.9 |
| | 381.1 | 352.6 | 507.7 |
| | | | |
| E{Dist} | 418.9 | | |

Multiply

Sum

Advantageous characteristics of these collective analytical procedures:

1. Closed-form solutions are provided for the first two moments of the distance distribution.
2. Values to machine accuracy are provided in exceptionally short execution times.
3. Both data entry and user-controlled modification are very easily done.

Future research opportunities:

1. Development of implementing software for the general GIS user.
2. Development of closed-form equations for higher moments of the distance distribution.
3. Development of closed-form equations for calculating the covariance.
4. Other distance metrics; e.g., the rectilinear distance measure.
5. Higher dimensions; e.g., three dimensions.

That completes the presentation

and

Thank you