Modelling Maritime SAR Effective Sweep Widths for Helicopters in VDM

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Introduction

- Search and Rescue (SAR)
- Missing person search
- Small charities (Limited time and resources)
- SAR managers need to plan effectively
- Which search asset to use?

Introduction

- Effective Sweep Width (W) from Search Theory
- Small land SAR charities are using camera drones
- They are not sure how effective they are at detecting…
- Field trials are expensive
- Is modelling a solution? (i.e. virtual trials)

Introduction

- Eventually, model camera drones and compute W
- First, model helicopters for known W

Introduction: *W* for helicopters

Table N-5 – *Sweep widths for helicopters (km (NM))*

Search object (metres (feet))	Altitude 150 metres (500 feet) Visibility (km (NM))	Altitude 300 metres (1000 feet) Visibility (km (NM))	Altitude 600 metres (2000 feet) Visibility (km (NM))
Person in water*			
Raft 1-person			
Raft 4-person			
Raft 6-person			
Raft 8-person			
Raft 10-person			
Raft 15-person			
Raft 20-person			
Raft 25-person			
Power boat < 5 (15)			
Power boat 6 (20)			
Power boat 10 (33)			
Power boat 16 (53)			
Power boat 24 (78)			
Sail boat 5 (15)			
Sail boat 8 (26)			
Sail boat 12 (39)			
Sail boat 15 (49)			
Sail boat 21 (69)			
Sail boat 25 (83)			
Ship 27–46 (90–150)			
Ship 46–91 (150–300)			
Ship > 91 (300)			

	Altitude 150 metres (500 feet)					
	Visibility (km (NM))					
Search object (metres (feet))	**1.9 (1)**	**5.6 (3)**	**9.3 (5)**	**18.5 (10)**	**27.8 (15)**	**> 37.0 (> 20)**
Person in water*	0.0 (0.0)	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)	0.2 (0.1)
Raft 1-person	0.7 (0.4)	1.7 (0.9)	2.2 (1.2)	3.0 (1.6)	3.3 (1.8)	3.3 (1.8)
Raft 4-person	0.9 (0.5)	2.2 (1.2)	3.0 (1.6)	4.1 (2.2)	4.8 (2.6)	5.2 (2.8)
Raft 6-person	0.9 (0.5)	2.6 (1.4)	3.5 (1.9)	5.0 (2.7)	5.9 (3.2)	6.5 (3.5)
Raft 8-person	1.1 (0.6)	2.8 (1.5)	3.7 (2.0)	5.2 (2.8)	6.1 (3.3)	6.9 (3.7)
Raft 10-person	1.1 (0.6)	3.0 (1.6)	4.1 (2.2)	5.7 (3.1)	6.7 (3.6)	7.4 (4.0)
Raft 15-person	1.1 (0.6)	3.1 (1.7)	4.3 (2.3)	6.1 (3.3)	7.4 (4.0)	8.1 (4.4)
Raft 20-person	1.1 (0.6)	3.3 (1.8)	4.8 (2.6)	7.0 (3.8)	8.5 (4.6)	9.4 (5.1)
Raft 25-person	1.1 (0.6)	3.5 (1.9)	5.0 (2.7)	7.6 (4.1)	9.3 (5.0)	10.4 (5.6)

* For seach altitudes of 150 metres (500 feet) only, the sweep width values for a person in water may be multiplied by 4, if it is known that the person is wearing a personal flotation device.

Background

Background: *W*

- Effective search (or sweep) width or sweep width
- Quantifies a sensor's detectability
  - Specific object
  - Specific environmental conditions
- Quantity is length

Background: W

- W derived from a Lateral Range Curve (LRC)
- $W = \int_{-\infty}^{+\infty} p(x)dx$

Background: Lateral Range Curve

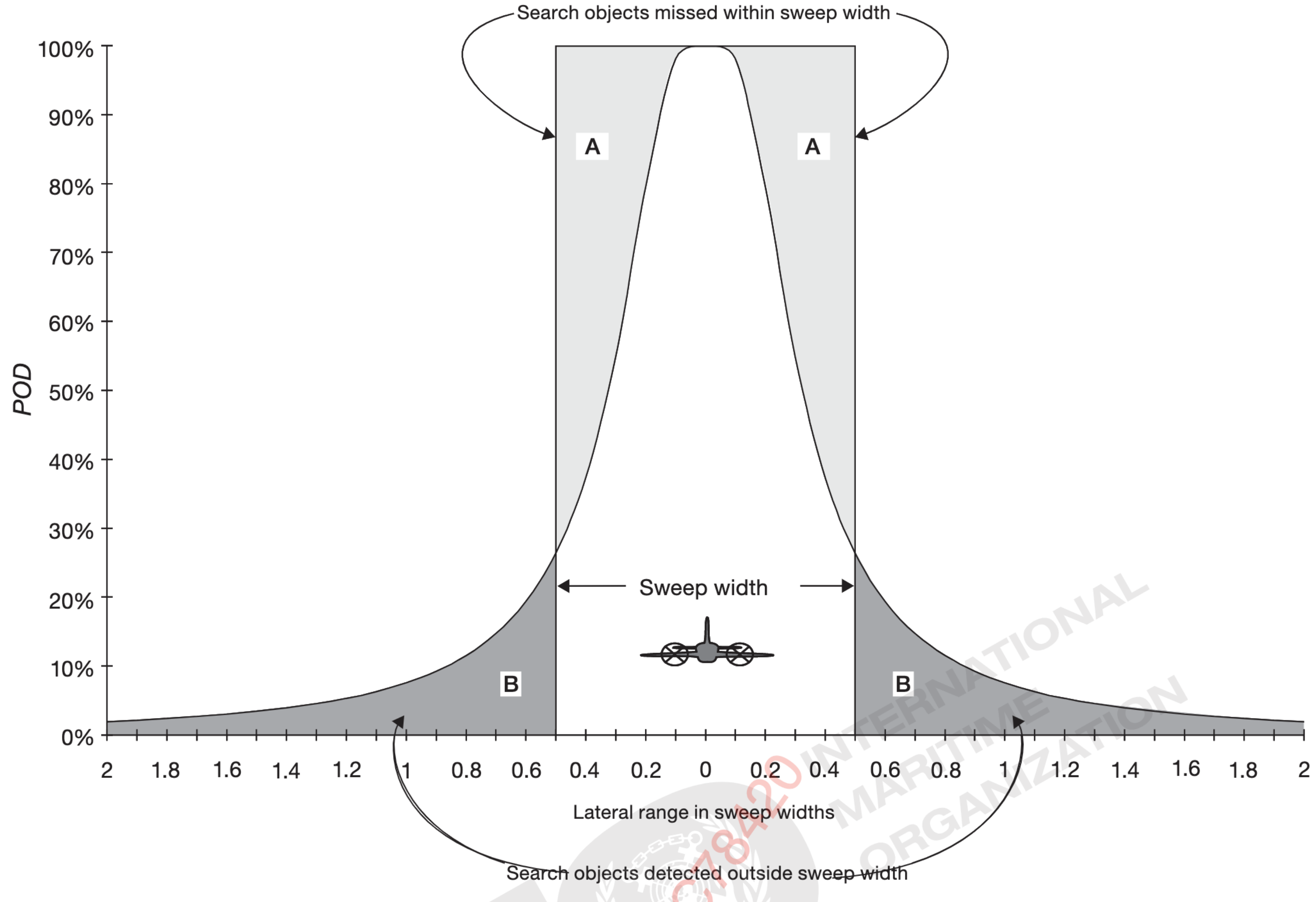
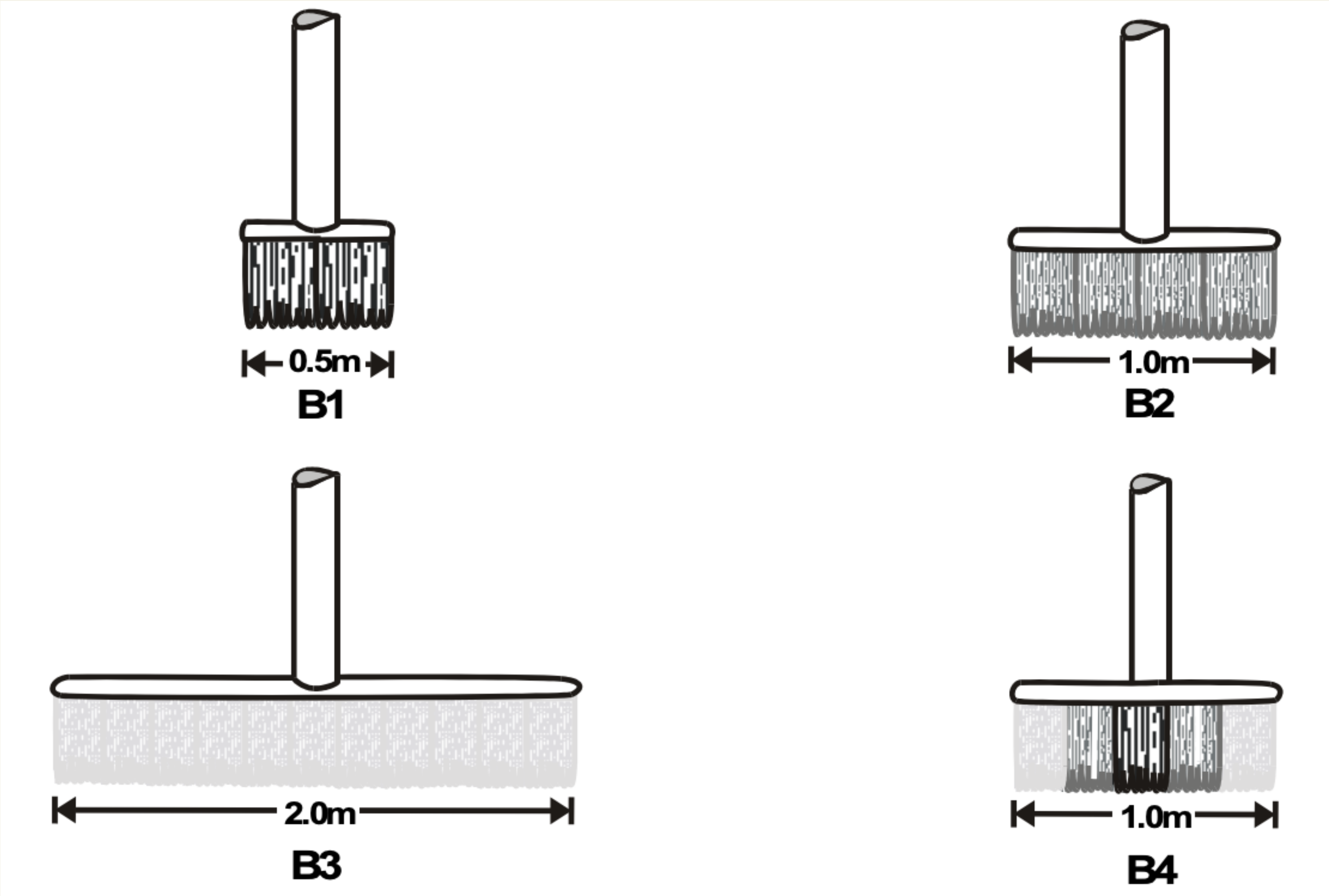
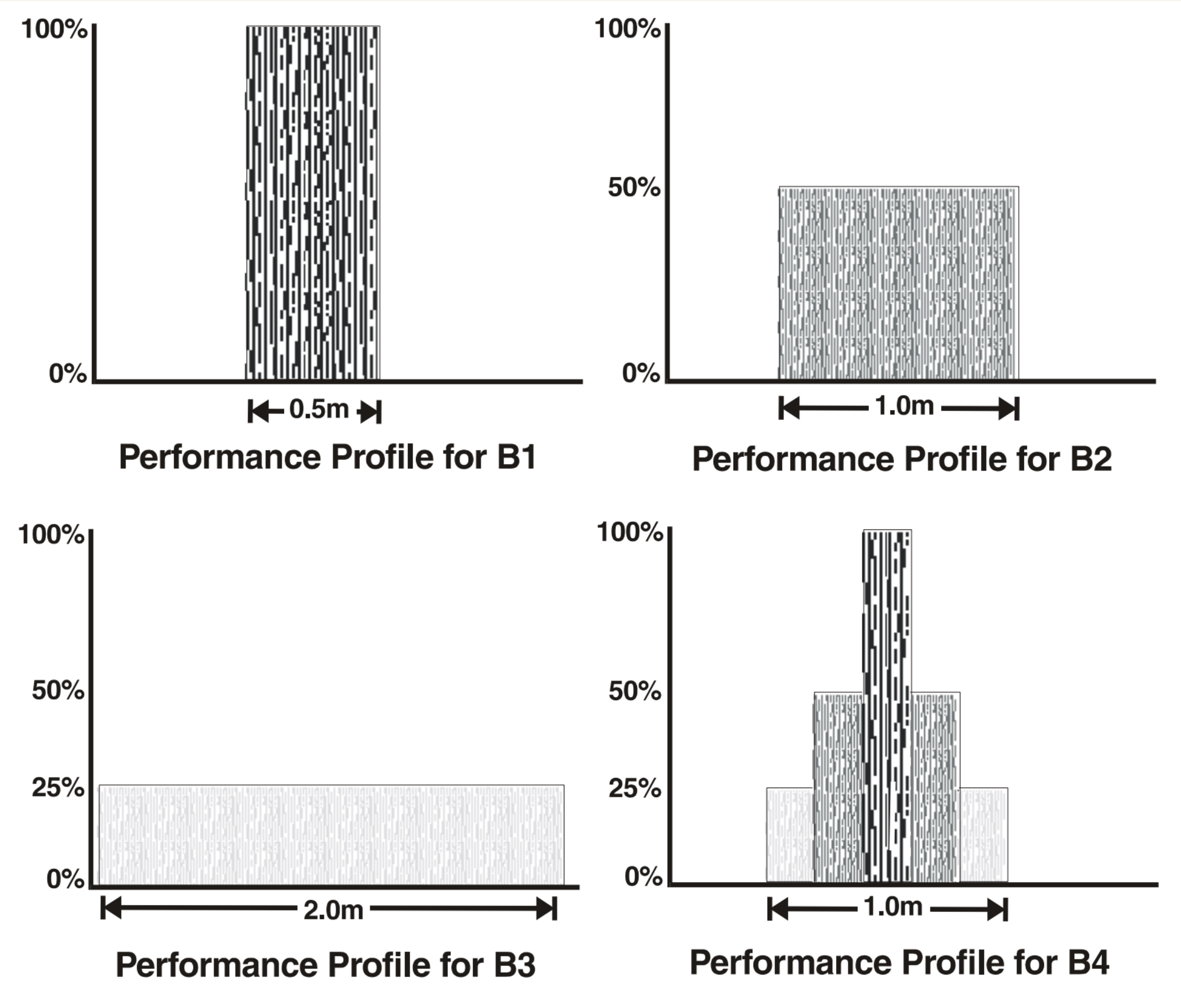


Figure 4-12 – *Visual search detection profile for a single sweep under ideal search conditions*

Background: Lateral Range Curve: Four Brooms



Background: Lateral Range Curve: Broom performance profiles

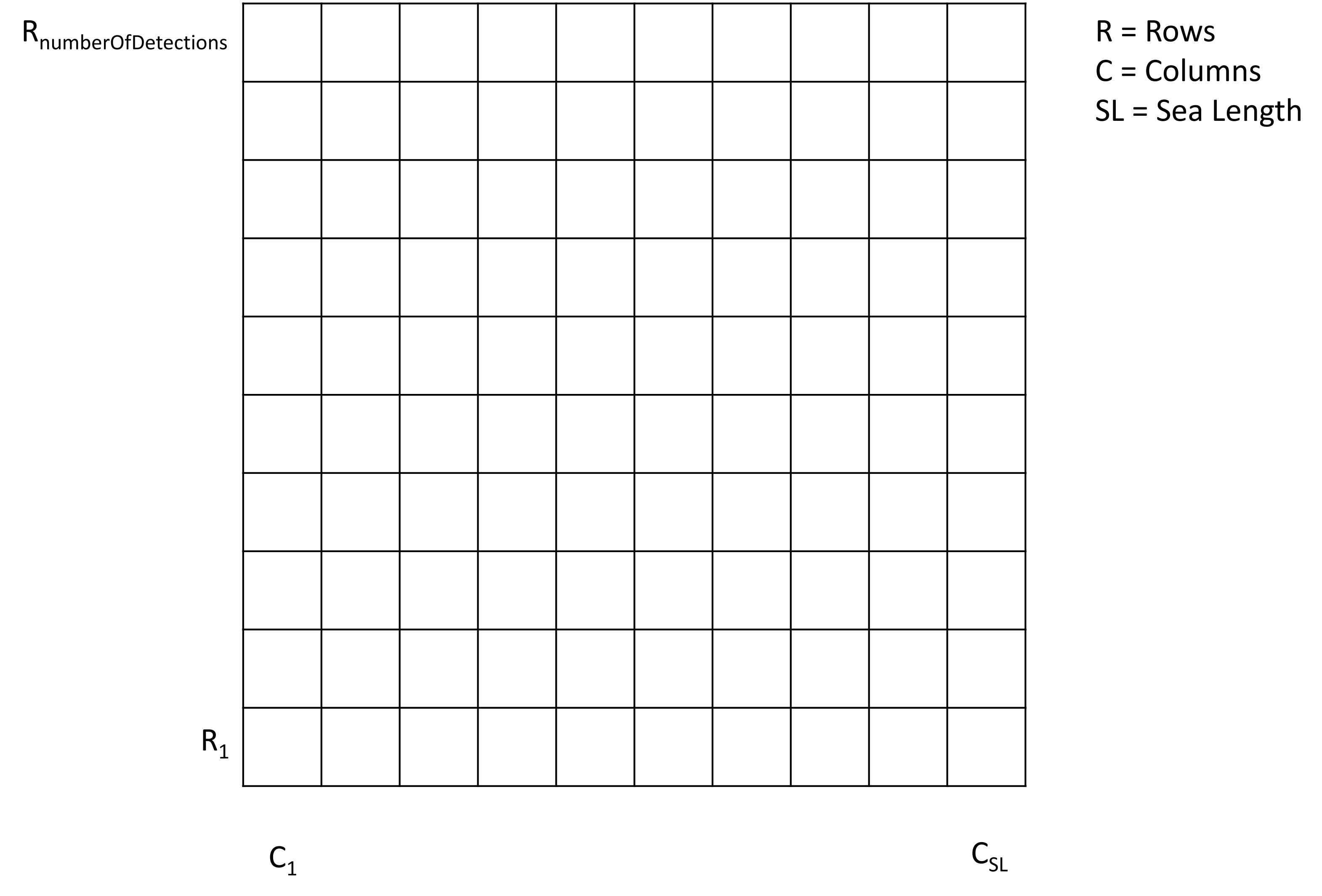


Background: Lateral Range Curve: Broom experimental results

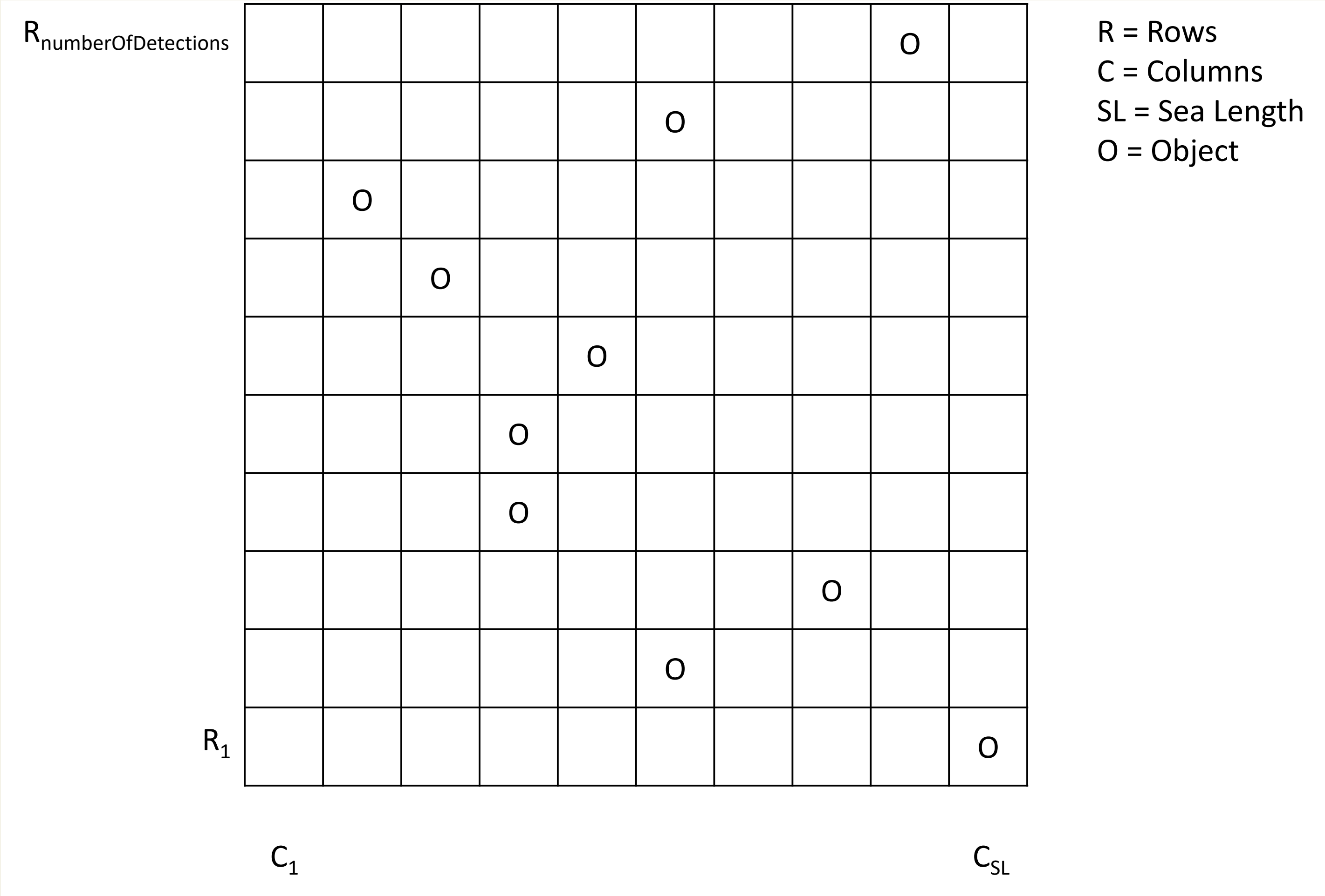
	Broom B1	Broom B2	Broom B3	Broom B4
Broom Width	0.5 m	1.0 m	2.0 m	1.0 m
Maximum Lateral Range	0.25 m	0.5 m	1.0 m	0.5 m
Bristle Density	Dense	Less dense	Much less dense	Composite
Broom Effectiveness (avg.)	100 %	50 %	25 %	50%
Sand "Density"	10 g/m^2	10 g/m^2	10 g/m^2	10 g/m^2
Sweeping Speed	0.5 m/sec	0.5 m/sec	0.5 m/sec	0.5 m/sec
Time	20 sec	20 sec	20 sec	20 sec
Distance Moved	10 m	10 m	10 m	10 m
Area Swept	0.5 m x 10 m	1.0 m x 10 m	2.0 m x 10 m	1.0 m x 10 m
Amount of Sand Swept Up	50 g	50 g	50 g	50 g
Average Sand Removal Rate	2.5 g/sec	2.5 g/sec	2.5 g/sec	2.5 g/sec
Effective Sweep Width	0.5 m	0.5 m	0.5 m	0.5 m
Area Effectively Swept	0.5 m x 10 m	0.5 m x 10 m	0.5 m x 10 m	0.5 m x 10 m
Effective Sweep Rate	0.25 m^2/sec	0.25 m^2/sec	0.25 m^2/sec	0.25 m^2/sec

VDM

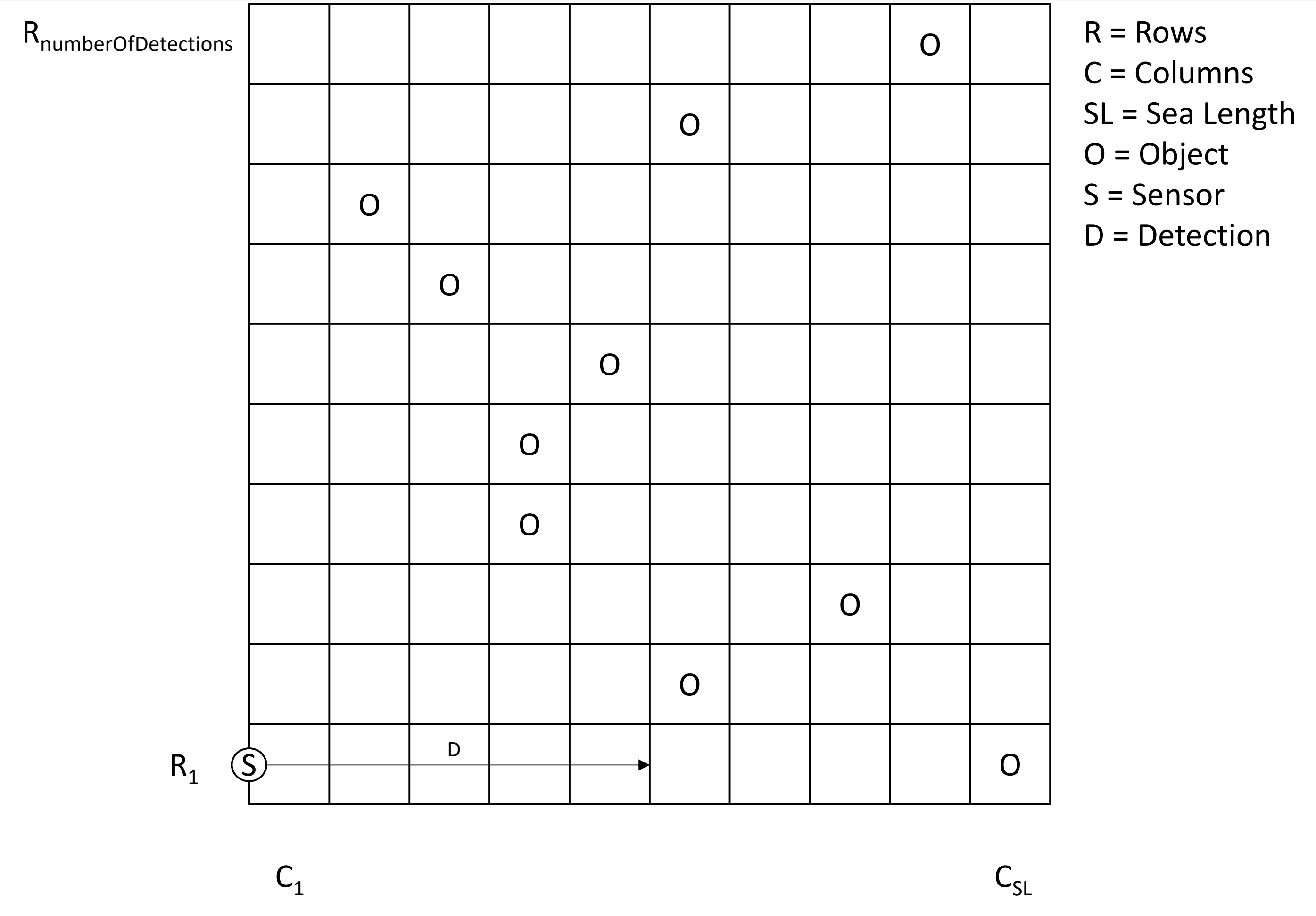
VDM: Lateral range experiment grid setup



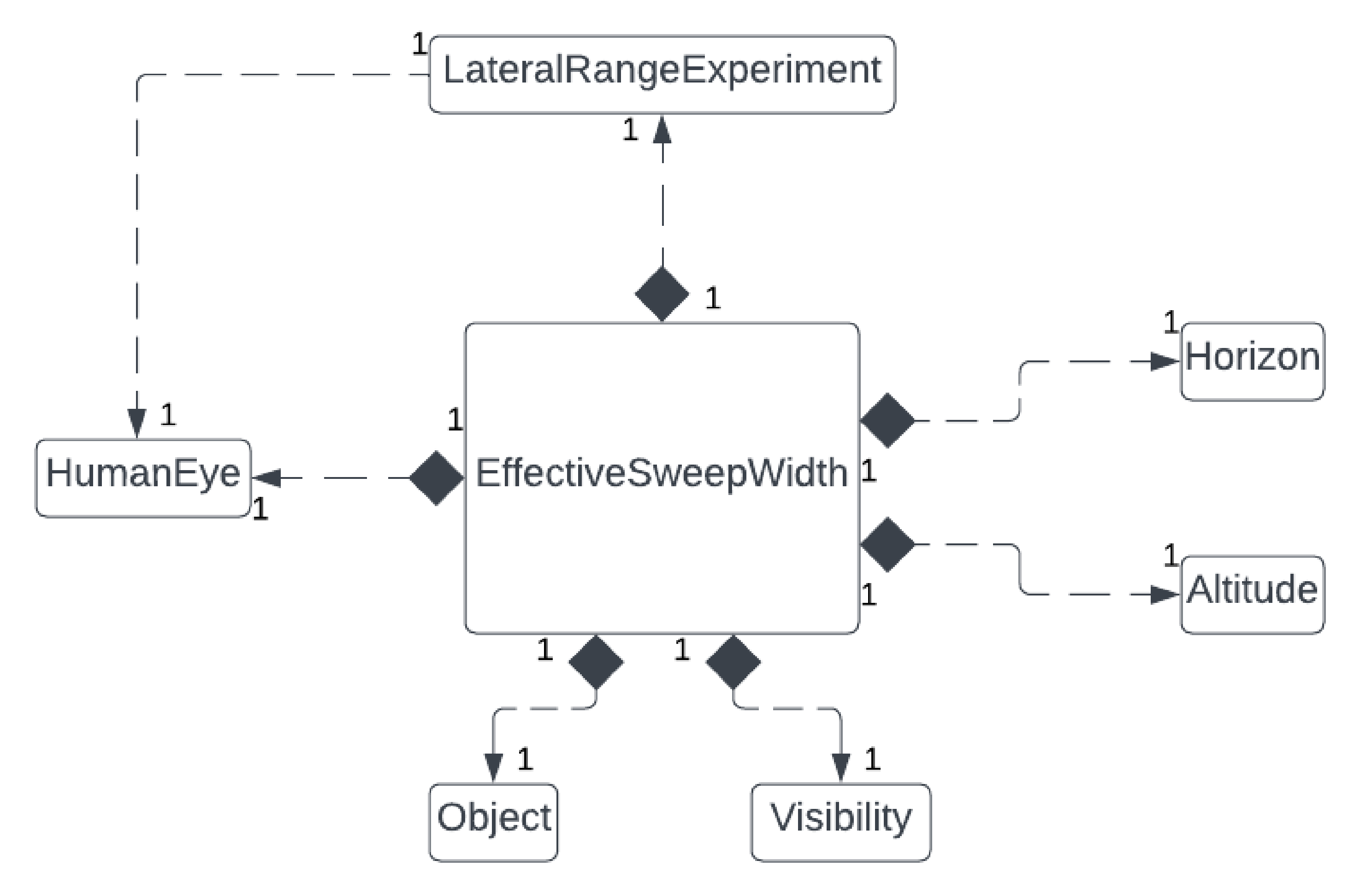
VDM: Lateral range experiment randomly place objects



VDM: Lateral range experiment detection



VDM: Class diagram



VDM: Detection data

Column index

Detections

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objDetnD : map nat1 to (nat * nat * real)
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Detected

Percentage detected

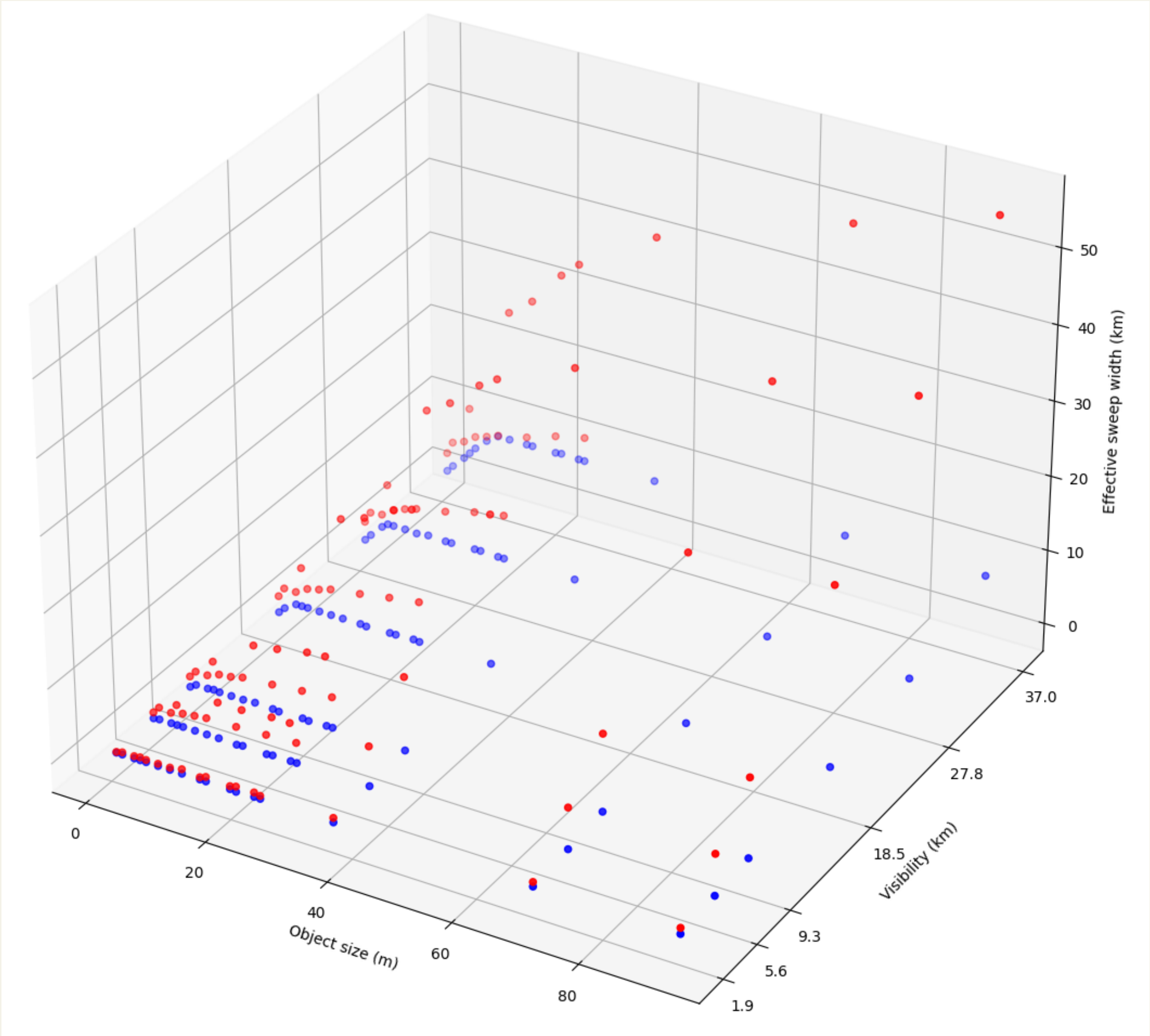
VDM: Detection factors

- Altitude
- Visibility
- Object size
- Angular resolution

Results

Results: Actual vs expected

- 600-metre altitude case
- Red = Expected
- Blue = Actual
- Limitations
  - 4000 detections for each object



Conclusions

Conclusions

- Initial model built (helicopter detection case)
- The number of detections is a key factor for W
- Derive W for any sensor using a lateral range experiment

Future work

Future work

- Apply to drone camera detection case
- Sensor
  - Camera angular resolution
  - Human factors (E.g. detection fatigue and flying experience)
  - Real-time motion

Future Work

- Object
  - Real-time motion
  - Physical characteristics (E.g. colour)
- Environmental conditions
  - Weather
  - Lighting
  - Obstacles (E.g. waves or vegetation)

Thank you for listening!