



Australian Government  
Department of Defence  
Science and Technology

# Conquering Uncertainty: A Vision for HPC to Maximise the Value of Combat Simulation

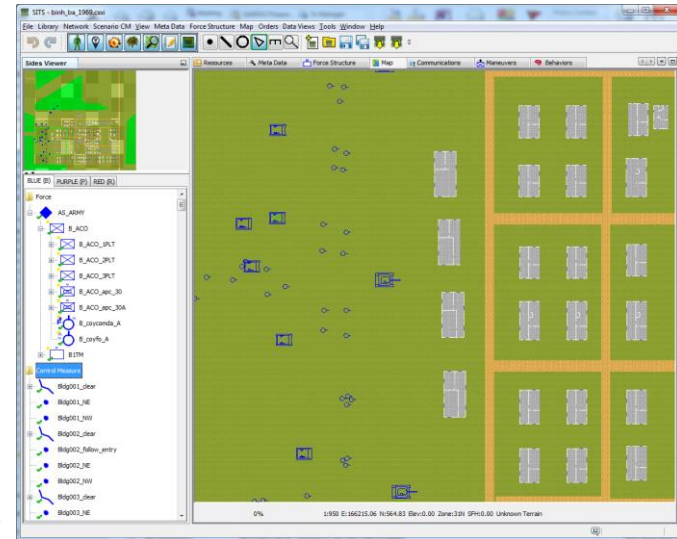
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Defence Science and Technology Group

# What is Combat Simulation?

- Supports Army decision making
  - Equipment
  - Tactics
  - Force Structuring
- Closed-loop simulation
  - All tactics/orders pre-scripted
  - Can be replicated hundreds of times
  - Resource intensive



# Parameter Spaces

- Closed-loop simulation allows for massive parameter spaces

- Schemes of Manoeuvre (the military plan)
- The options under test
- Sensitivity

Recent Studies		Study 1	Study 2	Study 3	Study 4	Study 5
Scale		Platoon	Platoon(+)	Company(+)	Company	Platoon(+)
Study Time		7-8 months	4½ months	8-9 months	6 months	6 months
SOMs		3	1 plus variations	2	1 plus variation	1
Variants	Core	27	8	92	22+	22+
	Sensitivity	272	56	0	96	96
Replications		~60,000	~13,000	~18,000	~24,000	~24,000
Runtime per replication		10min	30-100 min	120min	30min	60mins

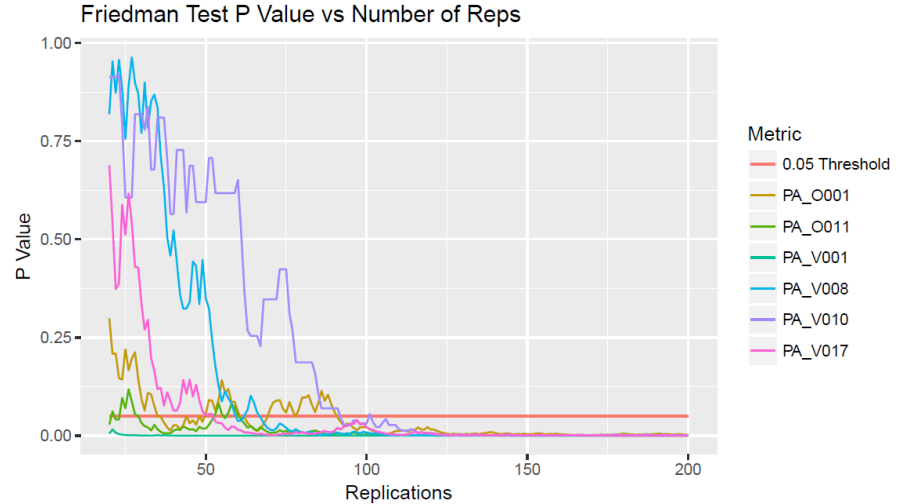
# Uncertainty

- Combat simulation is riddled with uncertainty
  - Input data – subjectivity, classification, lack of empirical data
  - Tactical data – military planning process is a human endeavour, has two sides, many “good” answers, no “right” answer
  - Scenarios – which is the right scenario? Is there a micro-aspect of the scenario that is more important than it should be?



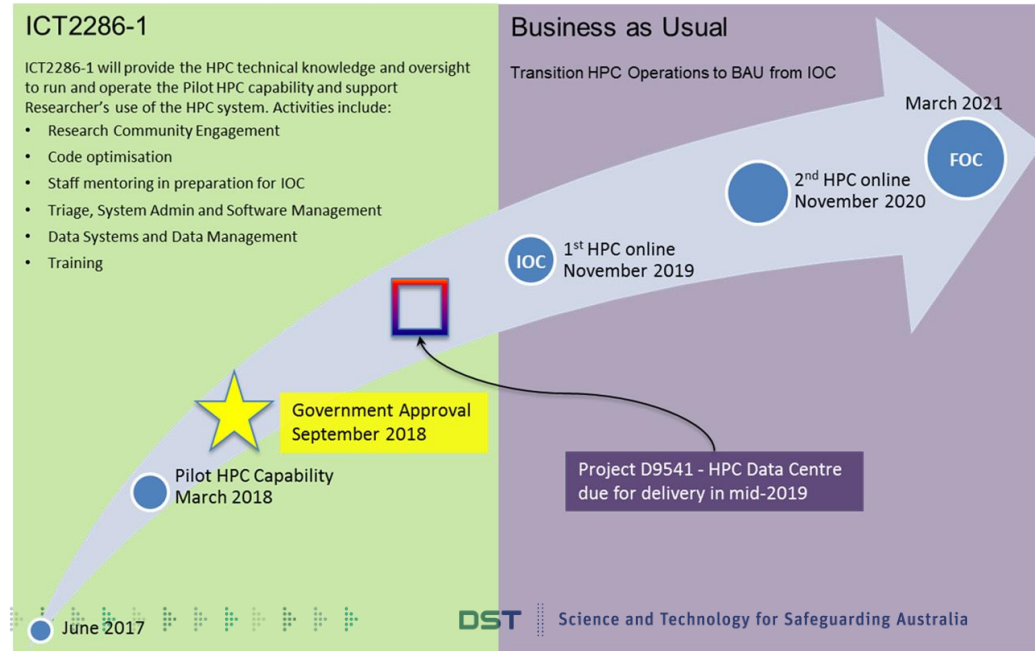
# Uncertainty

- Output data
  - Combat outcomes are highly uncertain
  - Prone to rare but important events; we are often more interested in the outliers than the mean
  - Uncertain about how many runs are required



# The HPC Opportunity

- DST Group is acquiring a HPC capability
- At the same time we are dipping into the cloud computing space
- How do we exploit?
  - Evolutionary
  - Revolutionary



# Exploitation – Evolutionary Approaches

- Expand Sensitivity Analysis
  - Input data – what if our assumptions are wrong?
  - Tactics – what if different tactical solutions were attempted?

	A	B	C	D	E	F					
1	Component	Parameter	Value	Units	Confidence	Data/Working					
2		Aperture Diameter	25.5mm (Wide FOV)/46mm (Narrow FOV)	cm	Medium	Based on SME advice.					
3		Average Optical Transmission	0.8		No Effect	Used the default value for a staring array					
	Optical System	Effective Focal Length	51mm (Wide FOV)/ 92mm (Narrow FOV)	mm	Low	Made a number of assumptions to reach this conclusion					
4											
5							Optics Temperature	300	Kelvin	No Effect	Used a default value. This is probably alright though
6		Horizontal Detector Pitch	20	um	High	Detector pitch is 40um. This is a microscanning detector, therefore the array itself is half the detector pitch.					
7	Staring Array	Vertical Detector Pitch	20	um	High	Detector pitch is 40um. This is a microscanning detector, therefore the array itself is half the detector pitch.					
8		Horizontal Detector Count	640		High	Value stated in Janes & other documentation					
9		Vertical Detector Count	480		High	Value stated in Janes & other documentation					
10		Frame Rate	30	Hz	Low	Unknown value, making assumption					
11		Read Time	0	ms	No Effect	Used the default value for a staring array from NVThermIP					
12	Detector	Horizontal Detector Dimension	40	um	High	Value stated in Janes & other documentation					
13		Vertical Detector Dimension	40	um	High	Value stated in Janes & other documentation					

Case	Variation	Rank									
1	50%										
	75%										
	Baseline										
	150%										
2	200%										
	50%										
	75%										
	Baseline										
6	150%										
	200%										
	50%										
	75%										
7	Baseline										
	150%										
	200%										
	50%										
8	75%										
	Baseline										
	150%										
	200%										
9	50%										
	75%										
	Baseline										
	150%										
	200%										

# Exploitation – Evolutionary Approaches

- Options Exploration
  - Always more options than we can explore
  - Can we say yes to the client more?

Protection	Weapon	Ammo Load	Sight	Section Configuration
Standard	Steyr 5.56mm	210 rds, 2 grenades	1.5x sight	8 person sections
Enhanced Level 1	SA80	180 rds, 3 grenades	No optics	10 person sections
Enhanced Level 2	M16	210 rds, 2 breaching charges	Comp M4	12 person sections
Enhanced Level 3	C7	300 rds		
Enhanced Level 4				



# Exploitation – Revolutionary Approaches

## ■ “Smart” Meta Models

- Exploring that vast input data space with a bit more nuance than brute force dimensional iteration
- Algorithmically explore vast parameter spaces to determine what is important

P1a	P2a	P3a	P4a	P5a	P6a	P7a	P8a	P9a
P1b	P2b	P3b	P4b	P5b	P6b	P7b	P8b	P9b
P1c	P2c	P3c	P4c	P5c	P6c	P7c	P8c	P9c
P1d	P2d	P3d	P4d	P5d	P6d	P7d	P8d	P9d
P1e	P2e	P3e	P4e	P5e	P6e	P7e	P8e	P9e
P1f	P2f	P3f	P4f	P5f	P6f	P7f	P8f	P9f
P1g	P2g	P3g	P4g	P5g	P6g	P7g	P8g	P9g

Parameter Type	Parameter	Effect
Firepower	Squad Rifle Accuracy	
	Grenade Launcher Accuracy	
	Grenade Launcher Lethality	
Sensors	Weapon Sight Acquisition Range	
	Weapon Sight Acquisition Time	
	Vegetation Density	
Mobility	Soldier Maximum Speed	
	Vehicle Maximum Horizontal Gap	
	Vehicle Acceleration	
Protection	Body Armour Protection Rating	
	Vehicle Armour Protection	
	Defensive Aid Suites	
	Soldier Helmet Protection Rating	

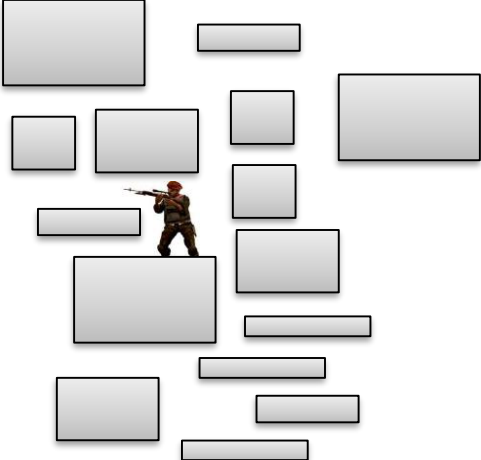
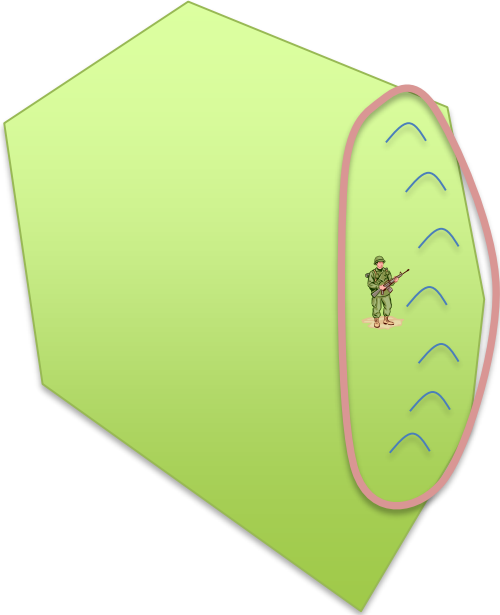


# Exploitation – Revolutionary Approaches

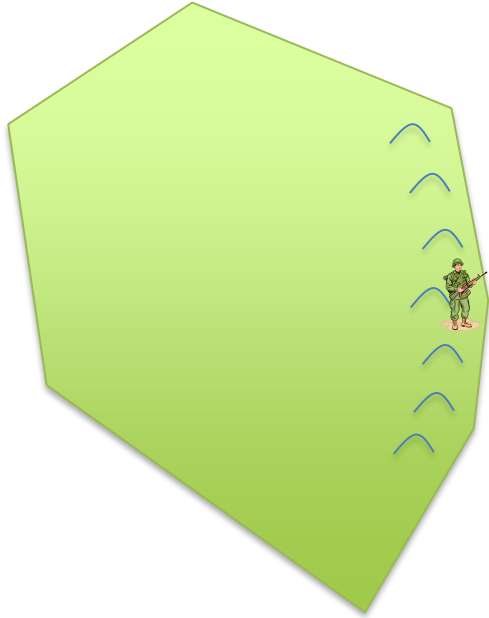
- Co-Evolution of Soldier Tactics
  - Example of uncertainty – where on this hill should my soldier position themselves? How should the section array themselves?
  - Military SME will have an idea, but this is based on imperfect information – hard to survey digital ground
  - We can use the simulation to assess potential positions
  - Expand this to other areas of a combat simulation
  - Expand this to the enemy – what is the best response?
  - Does this relationship settle down? We don't really know!

# Co-Evolution of Soldier Tactics

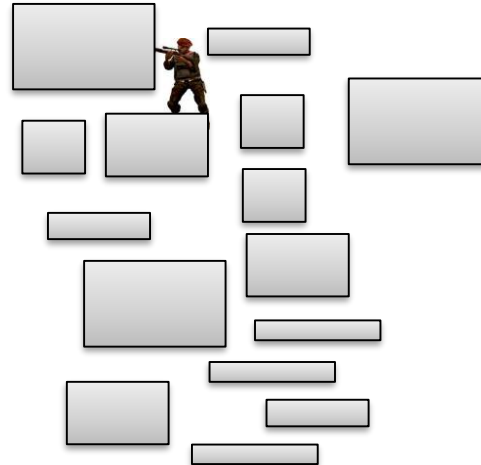
Where do we position the soldier on the  
ridgeline?



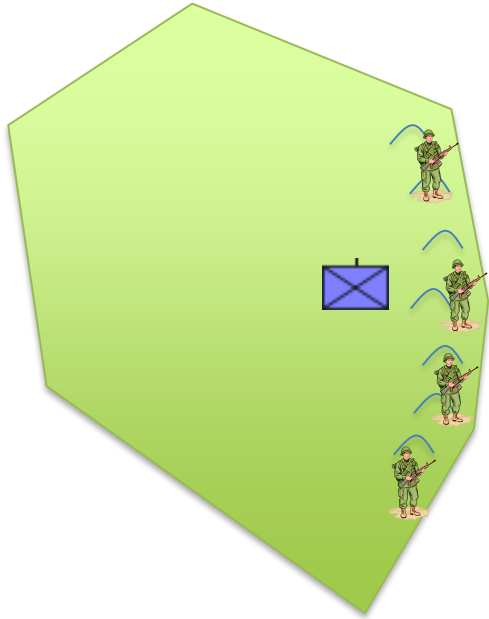
# Co-Evolution of Soldier Tactics



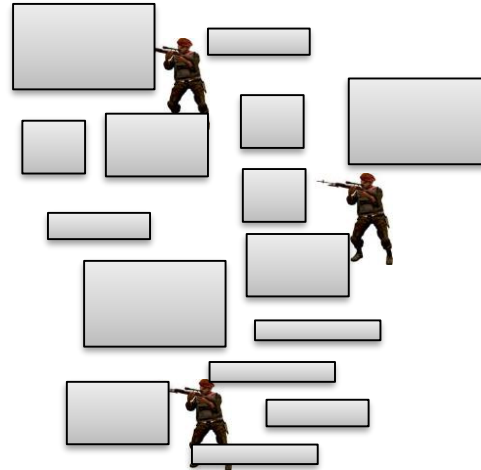
Based on this, where is the best enemy location?



# Co-Evolution of Soldier Tactics

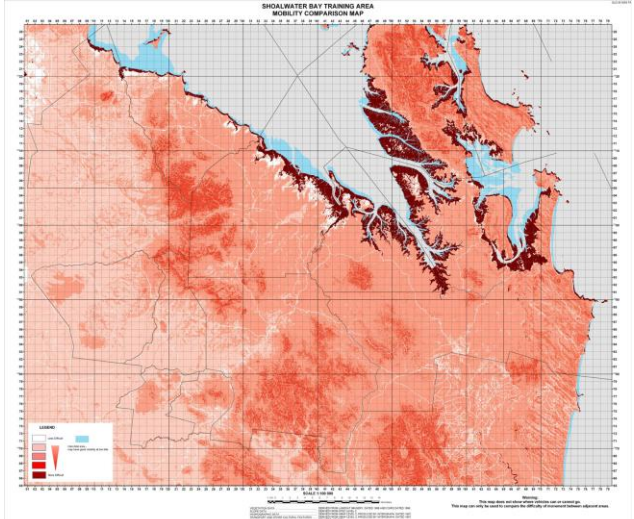
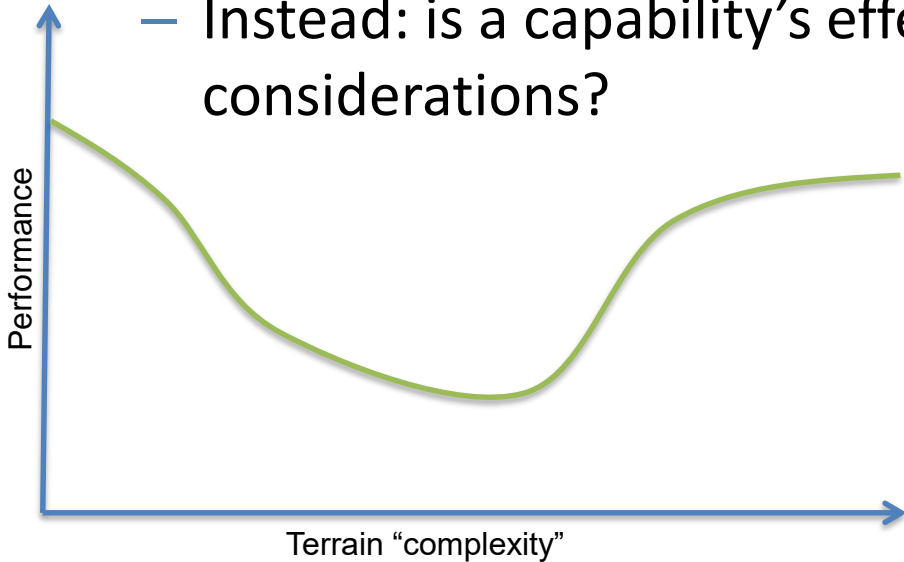


Expand the problem to teams instead of individuals



# Exploitation – Revolutionary Approaches

- Introduce Terrain as a Variable
  - Typically, we pick terrain(s) to simulate our options against
  - Instead: is a capability's effectiveness bounded by terrain considerations?



## Summary

- LCA uses combat simulation
  - Supports the Army modernisation program
  - Uncertainty is a major issue
- We plan to exploit HPC
  - Both by exploiting the wider highway, but thinking more expansively too
- Happy to talk
  - We have ongoing collaborations with Deakin, UniSA and RMIT

# Questions?