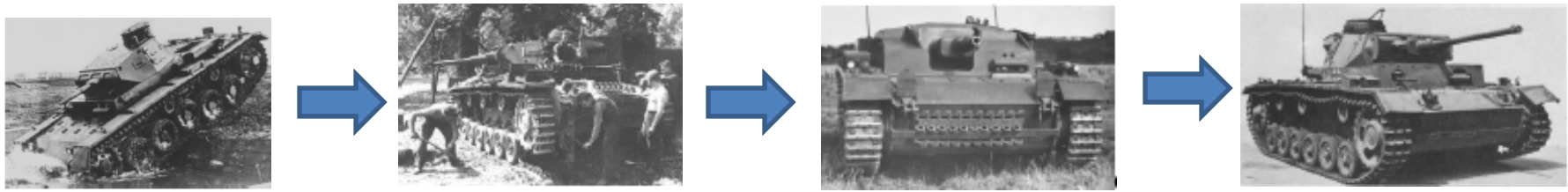




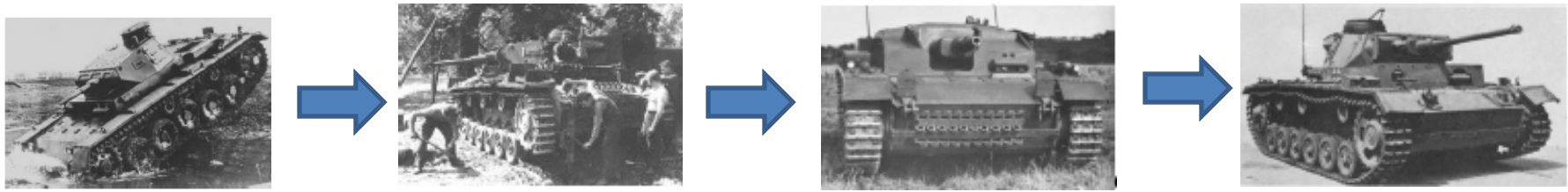
# Design of a Replacement German Main Battle Tank in 1941

Andrew Alan Rader  
ESD 1.71 Final Project



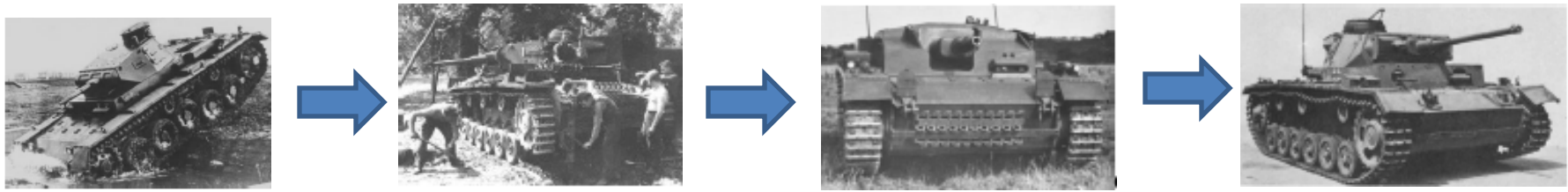
# Presentation Outline

- Introduction
- System description
- Decision analysis
- Lattice analysis
- Conclusions



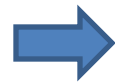
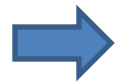
# Introduction

- Problems:
  - German tanks (panzers) not adequately armed to combat emerging Soviet models during early stages of Operation Barbarossa: (surprise to generals!)
  - Future trend of Soviet tank armor protection unclear
  - Need both immediate and long-term solutions, and facing uncertainty
  - Should the current panzers be upgraded or a new one designed?



## Main Options

1. Upgrade current anti-tank forces
2. Upgrade and up-gun current panzers
3. Design minimal new panzer (barely adequate now)
4. Design maximal new panzer (able to counter any foreseeable threat)
5. Design flexible new panzer that can be upgraded as it becomes necessary



# Options: Panzer III Lifecycle



A



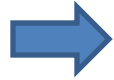
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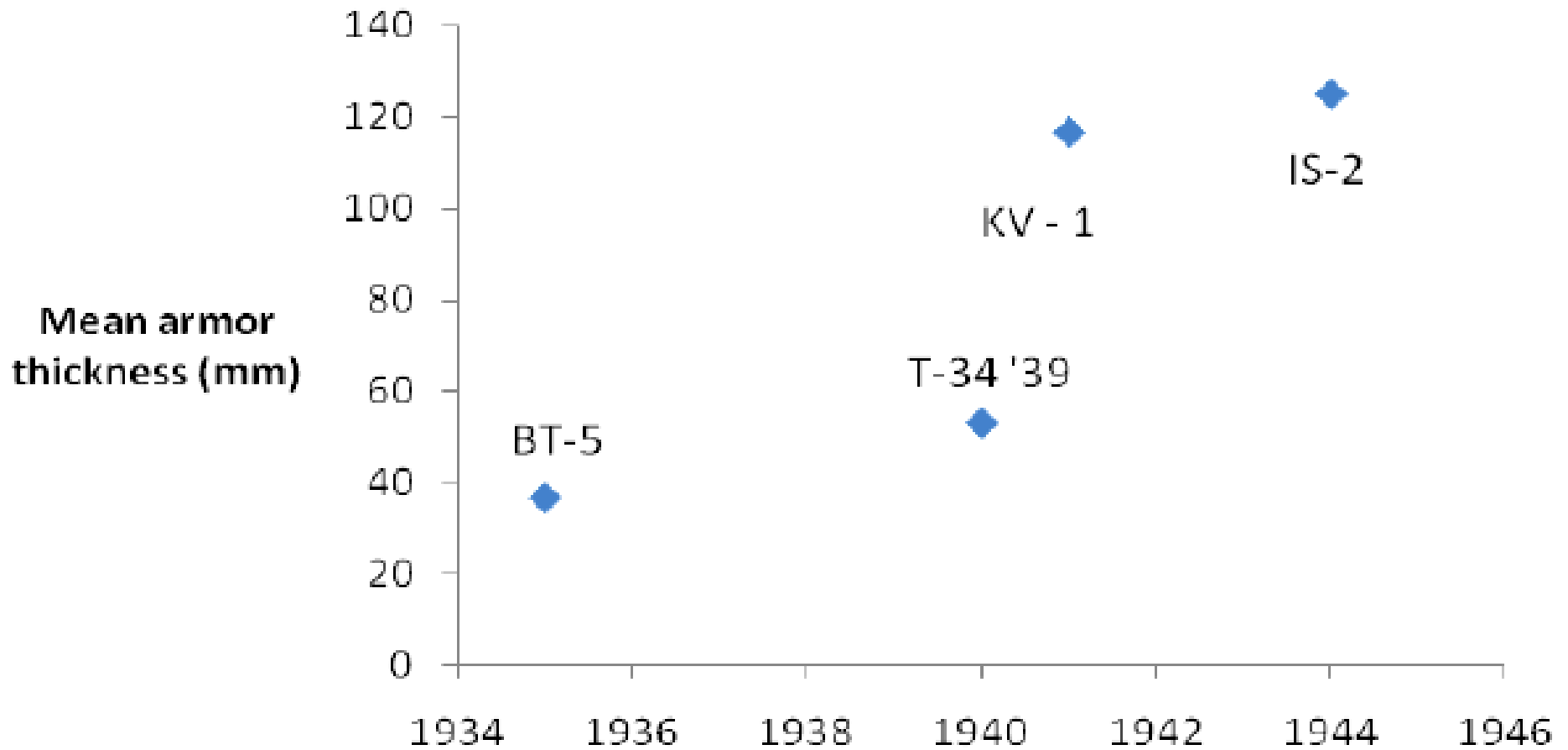
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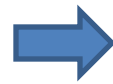
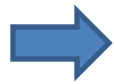


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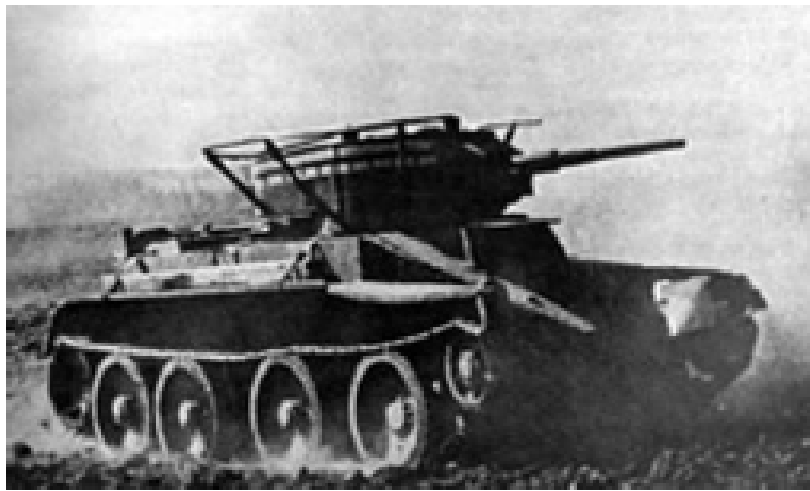


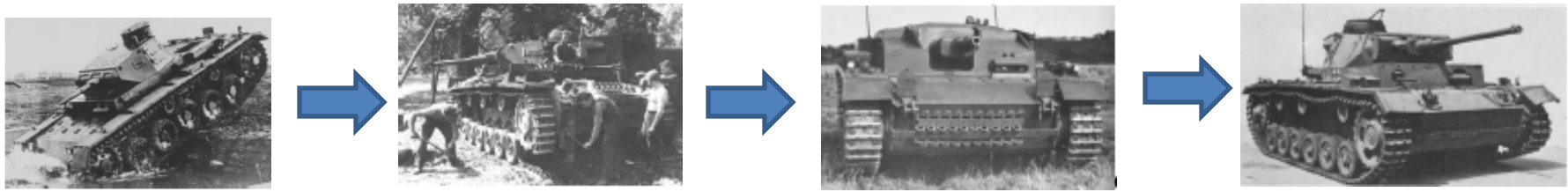
# The Armor/Gun Race...





# The "Competition"



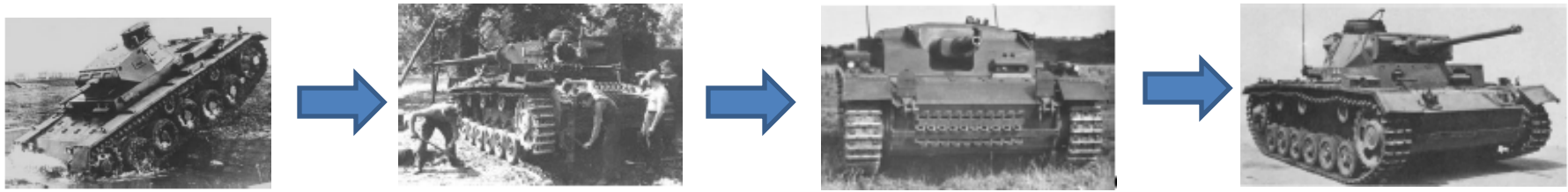


# Gun "Benefits"

- High Explosive (HE) vs. Armor Piercing (AP)
- Combat ranges
- Force composition

Gun	Shell weight (kg)	Normalized HE ability	Penetration at close range	Penetration at	
				1000 yrds (mm)	Penetration at 2000 yrds (mm)
50 mm L/43	4	0.14	all	50	30
128mm L/55	28	1	all	180	140
75 mm L/43	6	0.2	all	80	60
75 mm L/48	6	0.2	all	95	60
88 mm L/56	10.2	0.36	all	130	100
88 mm L/71	10.2	0.36	all	150	110

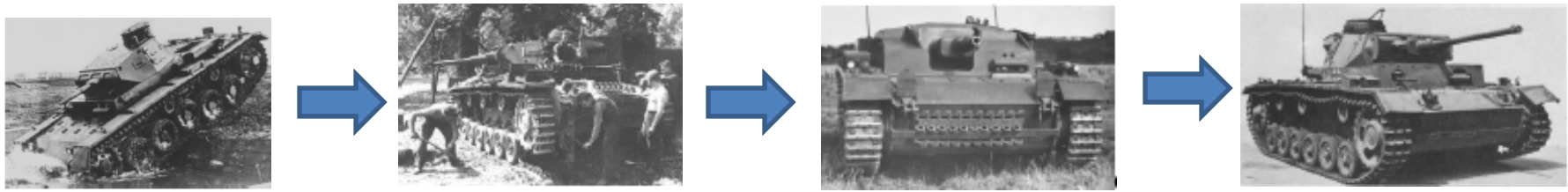




## Gun "Costs"

- Weight – chassis, turret
- Fixed design vs. upgrade
- Historical trends

Vehicle	Weight (tons)	Gun Type
Panzer IVF	24	75 mm L/43
Panther	45	75 mm L/48
Tiger	55	88 mm L/56
Tiger II	70	88 mm L/71
Maus	188	128 mm L/55



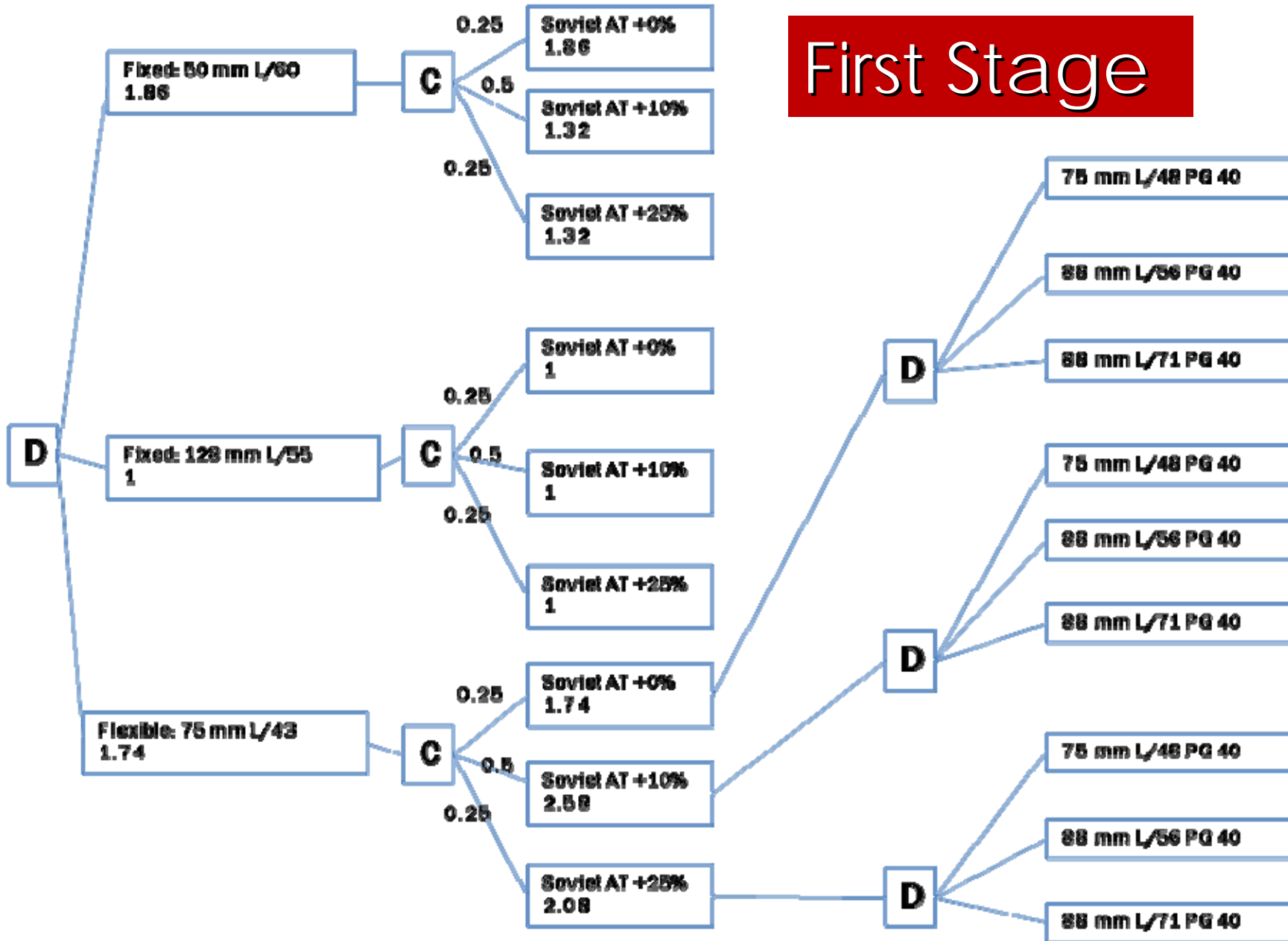
# Decision Analysis (DA)

- Defining the minimum, maximum, and flexible case



# First Stage

First Stage (1 year): Benefit/Cost shown below outcome

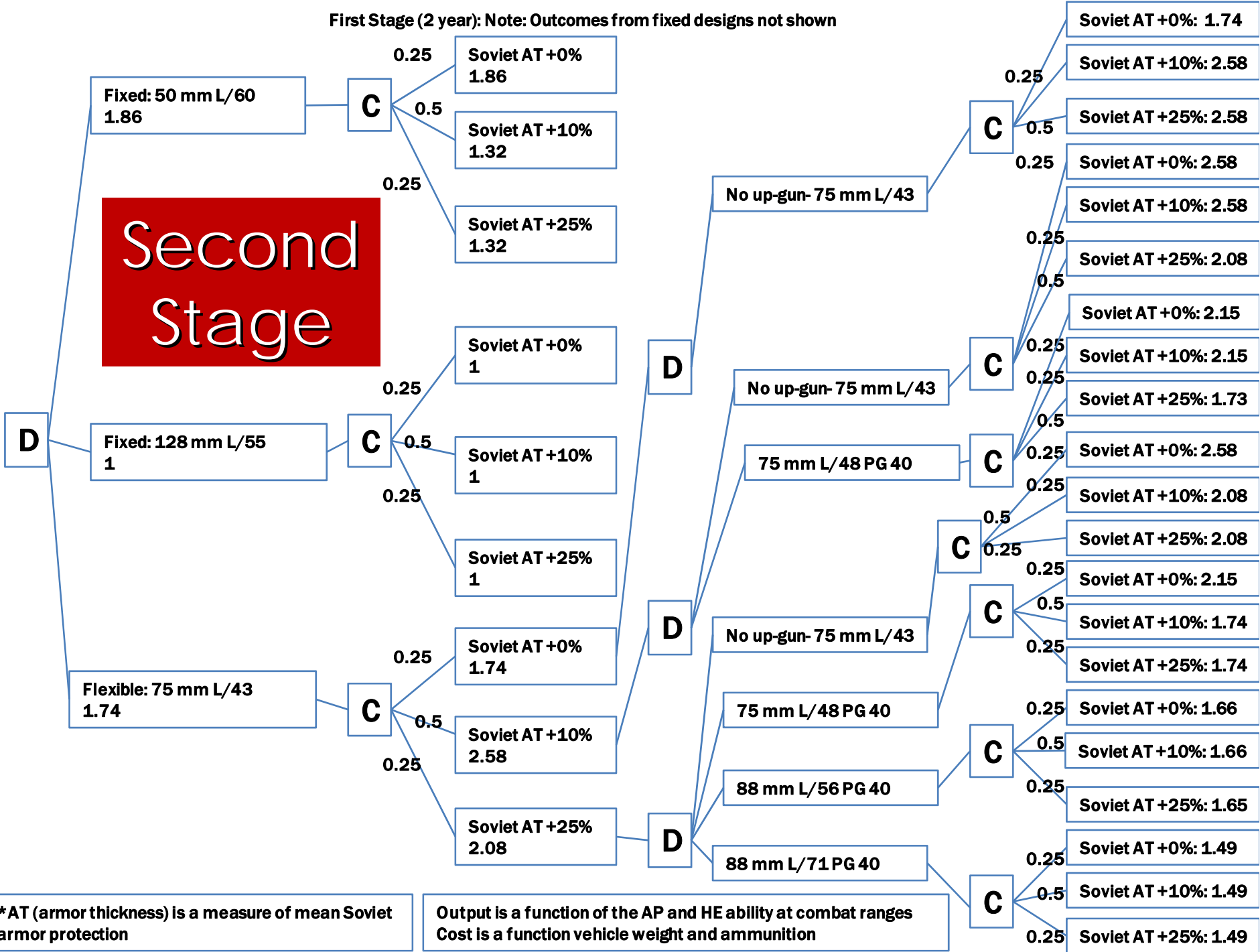


\*AT (armor thickness) is a measure of mean Soviet armor protection

Output is a function of the AP and HE ability at combat ranges  
Cost is a function vehicle weight and ammunition

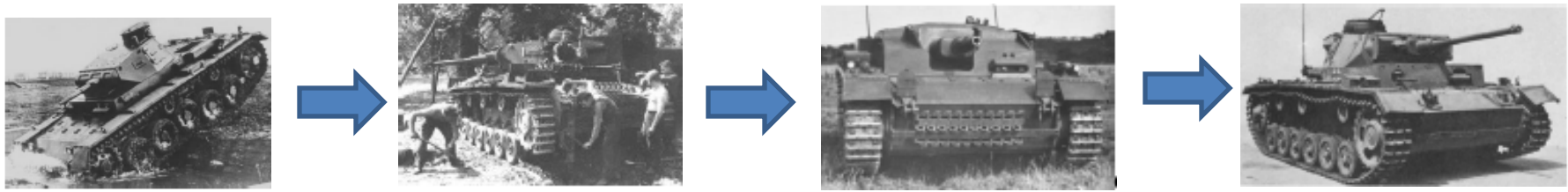
First Stage (2 year): Note: Outcomes from fixed designs not shown

# Second Stage



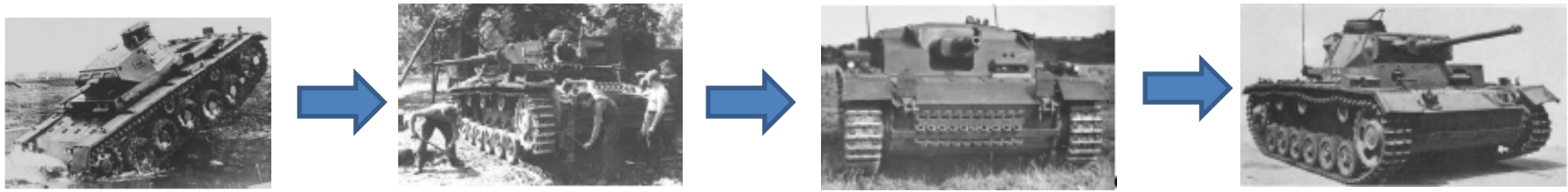
\*AT (armor thickness) is a measure of mean Soviet armor protection

Output is a function of the AP and HE ability at combat ranges  
Cost is a function vehicle weight and ammunition



## DA: Summary

- Optimal strategy:
  - select the flexible design (panzer mounting a 75 mm L/43 gun with provision for upgrading)
  - upgrade to the 75 mm L/48 gun after the first period (in 1942) only if Soviet armor protection increases beyond 10%
  - 88mm gun would not likely be necessary until the next period
- Remarkably historical outcome!

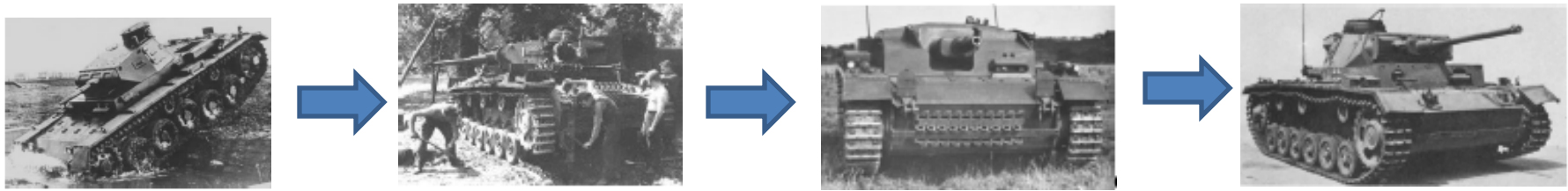


# Lattice Analysis

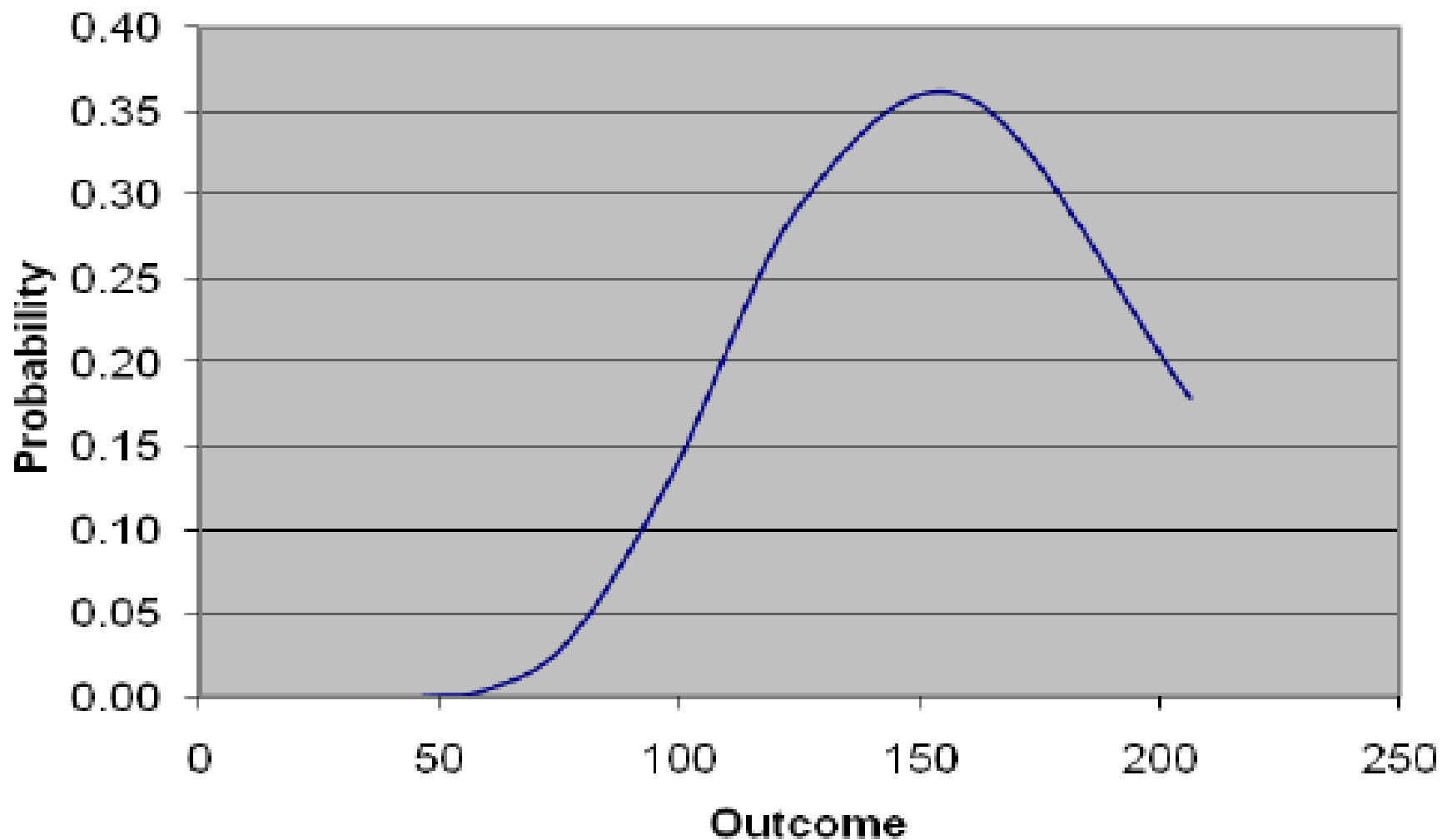
- Choosing the parameters:

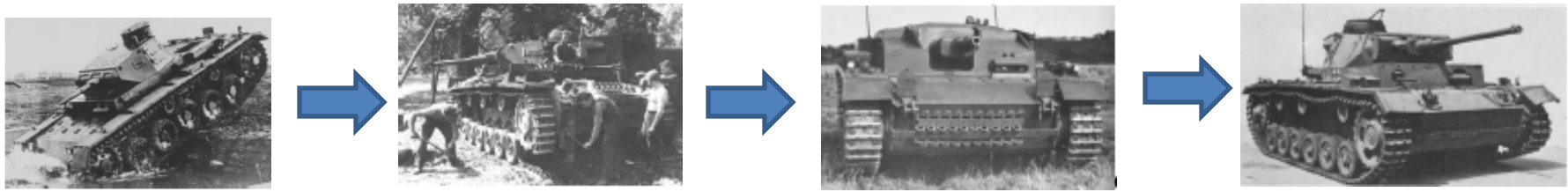
$$p = 0.5 + 0.5 (v/s)(Dt)^{0.5} = 0.5 + 0.5 (0.25/0.50) = 0.75$$

Parameter	Value
$\Delta t$	1 year
$v$	0.25
$\sigma$	50%
$u$	1.28
$d$	1.00
$p$	0.75



# Probability Density Function





## Lattice: Option Analysis

- Start with 75 mm L/48
- Option to upgrade to 88 mm L/56

Benefit/cost for 75 mm gun lattice

=

[benefit/cost of 75 mm]/[minimum of  
benefit/cost of 75 mm or 88 mm gun  
(whichever is lower for that AT value)]



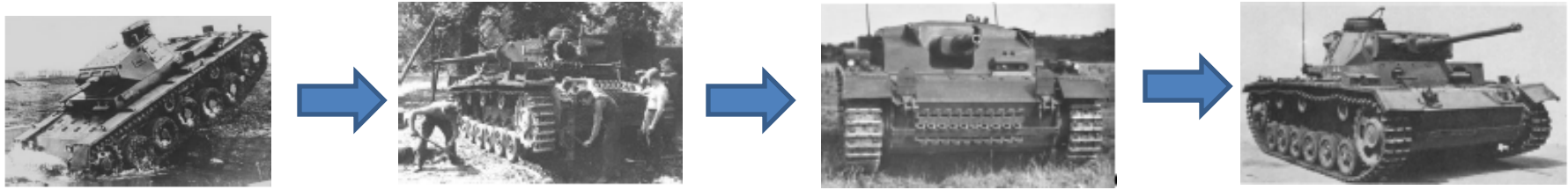


**Expected values of upgrade for lattice points**

Period	0	1	2	3	4	5
	-0.300	-0.040	0.598	0.618	0.206	0.094
		-0.300	-0.040	0.598	0.618	0.206
			-0.0300	-0.040	0.598	0.618
				-0.300	-0.040	0.598
					-0.300	-0.040
						-0.300

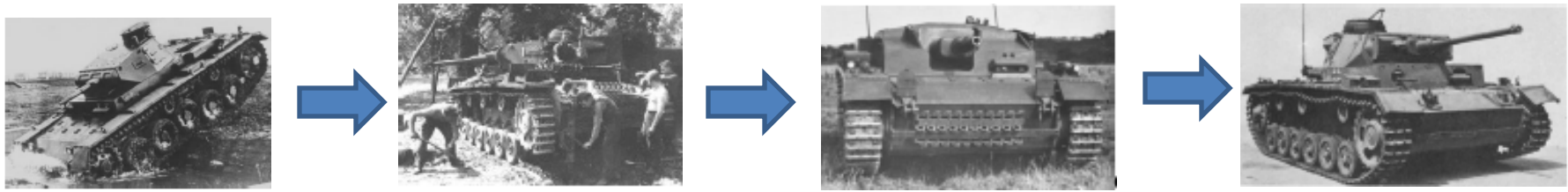
**Upgrade choice; "Y" = upgrade, "N" = no upgrade**

Period	0	1	2	3	4	5
	N	N	Y	Y	Y	Y
		N	N	Y	Y	Y
			N	N	Y	Y
				N	N	Y
					N	N
						N



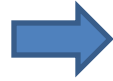
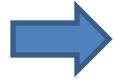
# Lattice: Option Value

Table 20: Positive upgrade value contribution							OVERALL SUM
Period	0	1	2	3	4	5	
			0.34	0.51	0.45	0.32	
				0.25	0.39	0.30	
					0.27	0.29	
						0.25	
<b>SUM</b>			0.34	0.76	1.11	1.15	



## Conclusions

- Both decision and lattice analysis produced similar (and remarkably historical!) results
- Gun should be upgraded as the situation develops, but unnecessary upgrades squander scarce resources
- Flexible design is much better than fixed model due to uncertainty of future Soviet armor thickness (which is in fact iterative)



Questions?

Thanks for your attention!