



*Complex Adaptive System of Systems
(CASoS) Engineering Initiative*
<http://www.sandia.gov/CasosEngineering/>

The Crossover Point: Comparing Policies to Mitigate Disruptions

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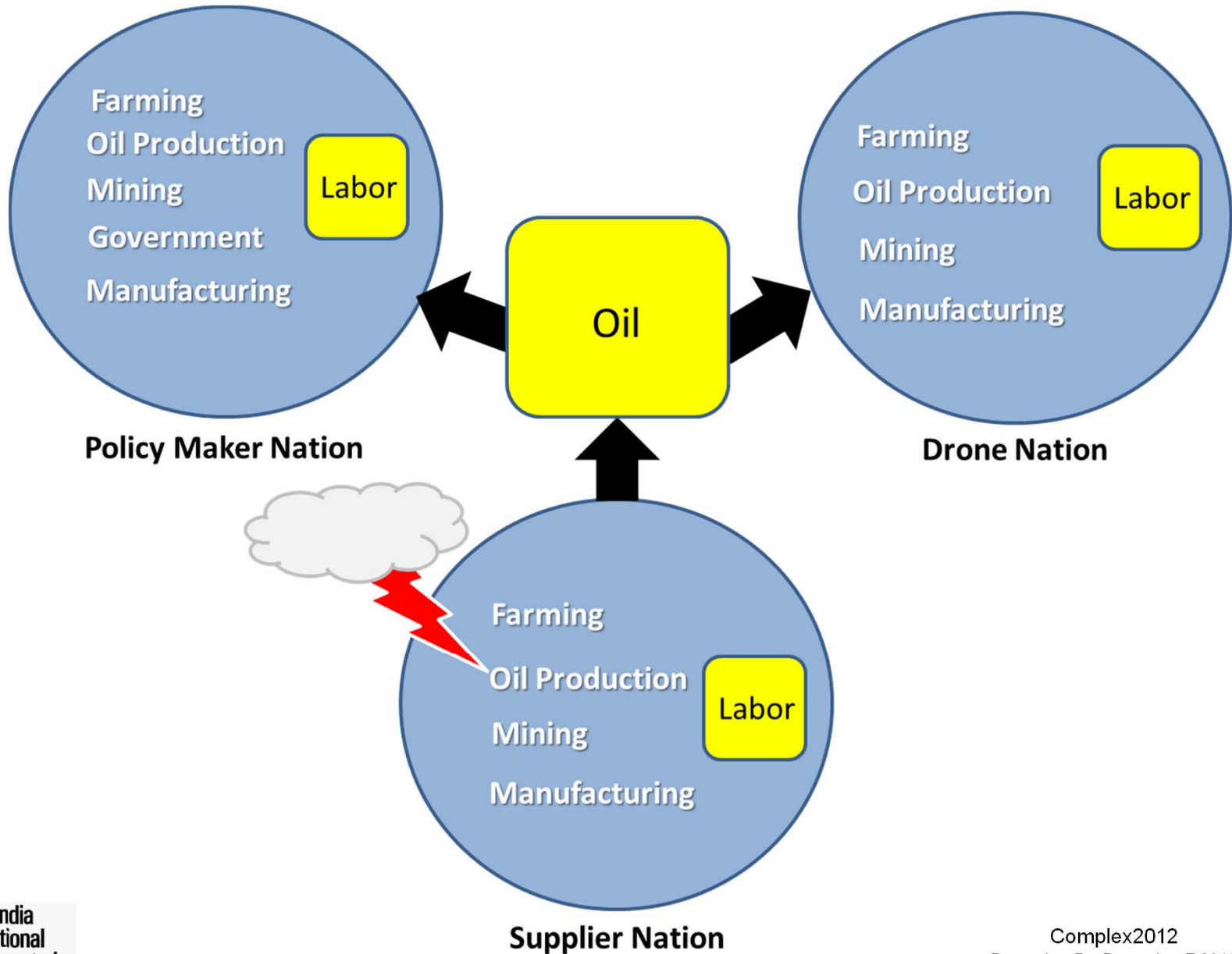
Sandia National Laboratories

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- Sector
 - Division of a nation based on consumption and production of particular resources
- Health
 - A measure of how much a sector can consume
- Perturbation
 - Shock to a sector, taking away all stored produced resources

Exchange Model Entities and Components



Supplier Consumption Terms

Oil	Food	Goods	Labor	RawMa	
1	1	1	0	1	Household
1	1	0	1	1	Manufacturing
1	0	1	1	1	Farming
0	1	1	1	1	Oil Production
1	1	1	1	0	Mining

Supplier Production Terms

Oil	Food	Goods	Labor	RawMa	
0	0	0	4	0	Household
0	0	4	0	0	Manufacturing
0	4	0	0	0	Farming
X	0	0	0	0	Oil Production
0	0	0	0	4	Mining

Drone Consumption Terms

Oil	Food	Goods	Labor	RawMa	
1	1	1	0	1	Household
1	1	0	1	1	Manufacturing
1	0	1	1	1	Farming
0	1	1	1	1	Oil Production
1	1	1	1	0	Mining

Drone Production Terms

Oil	Food	Goods	Labor	RawMa	
0	0	0	4	0	Household
0	0	4	0	0	Manufacturing
0	4	0	0	0	Farming
3	0	0	0	0	Oil Production
0	0	0	0	4	Mining

Policy Maker Consumption Terms

Oil	Food	Goods	Labor	RawMa	Tech	
1	1	1	0	1	0	Household
1	1	0	1	1	0	Manufacturing
1	0	1	1	1	0	Farming
0	1	1	1	1	.1	Oil Production
1	1	1	1	0	0	Mining
0	0	0	.1	0	0	Government

Policy Maker Production Terms

Oil	Food	Goods	Labor	RawMa	Mil	Tch
0	0	0	4	0	0	0
0	0	4	0	0	0	0
0	4	0	0	0	0	0
Y	0	0	0	0	0	0
0	0	0	0	4	0	0
0	0	0	0	0	.1-R	R

* R = [0.0 , 0.1]

3-Dimensional Sweep

- Perturbation Frequency
 - {extremely high, high, medium, low}
- Effectiveness of Military
 - {91% max, 56% max, 20% max}
- Technology : Military Production Ratio
 - {40%:60%, 60%:40%, 80%:20%, 100%:0%}

Varying Dependency for 10 Sweeps

- Policy Maker's Dependence on Supplier Nation (surplus oil producer)

{Low , ... , High}

Oil Production	Supplier	Policy Maker	Drone
Rate(Sweep 1)	5.4	4.1	3.0
Rate(Sweep 2)	5.6	3.9	3.0
Rate(Sweep 3)	5.8	3.7	3.0
...			
Rate(Sweep 10)	7.4	2.1	3.0

Abundance:

Oil Production	Supplier	Policy Maker	Drone	Total Surplus
Rate(Sweep 1)	5.4	4.1	3.0	+5
Rate(Sweep 2)	5.6	3.9	3.0	+5
...				
Rate(Sweep 10)	7.4	2.1	3.0	+5

.2 Units from Supplier:

Oil Production	Supplier	Policy Maker	Drone	Total Surplus
Rate(Sweep 1)	5.2	4.1	3.0	+3
...				
Rate(Sweep 10)	7.2	2.1	3.0	+3

.2 Units from Policy Maker:

Oil Production	Supplier	Policy Maker	Drone	Total Surplus
Rate(Sweep 1)	5.4	3.9	3.0	+3
...				
Rate(Sweep 10)	7.4	1.9	3.0	+3

Varying Stability & Military Effectiveness of Oil Supplier Nation State (1st scenario)

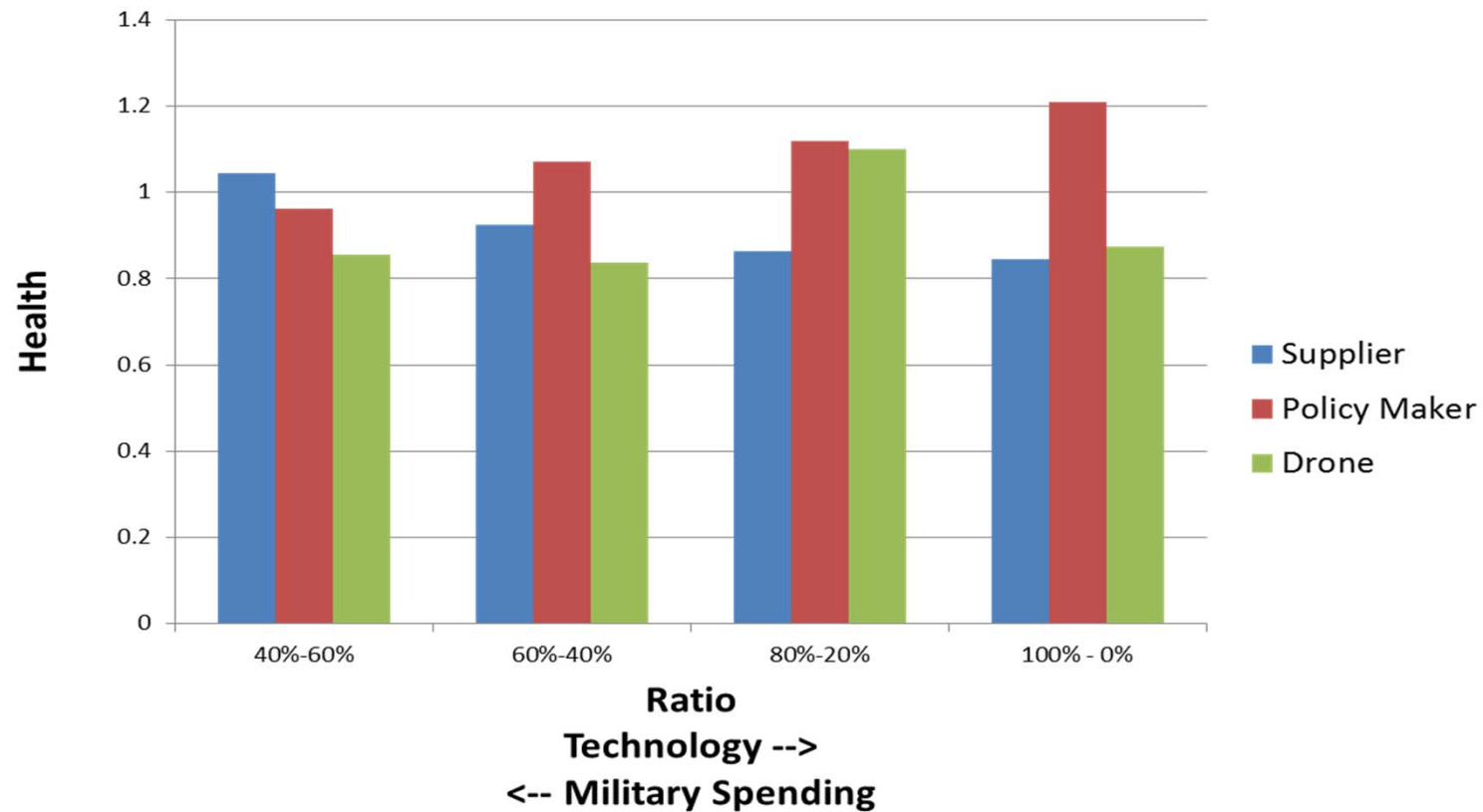
• Low Dependence

- Supplier produces Oil at rate = 5.4 (ideally)
- Supplier consumes Oil at rate = 4.0
- Policy Maker produces Oil at rate 4.1 (ideally)
- Policy Maker consumes Oil at rate 4.0
- Drone produces Oil at rate 3.0
- Drone consumes Oil at rate 4.0

• High Abundance

- Global Surplus Rate = +.5

- Varying Military Effectiveness and Stability
 - Low Dependence, High Abundance



Varying Stability & Military Effectiveness of Supplier Nation (2nd scenario)

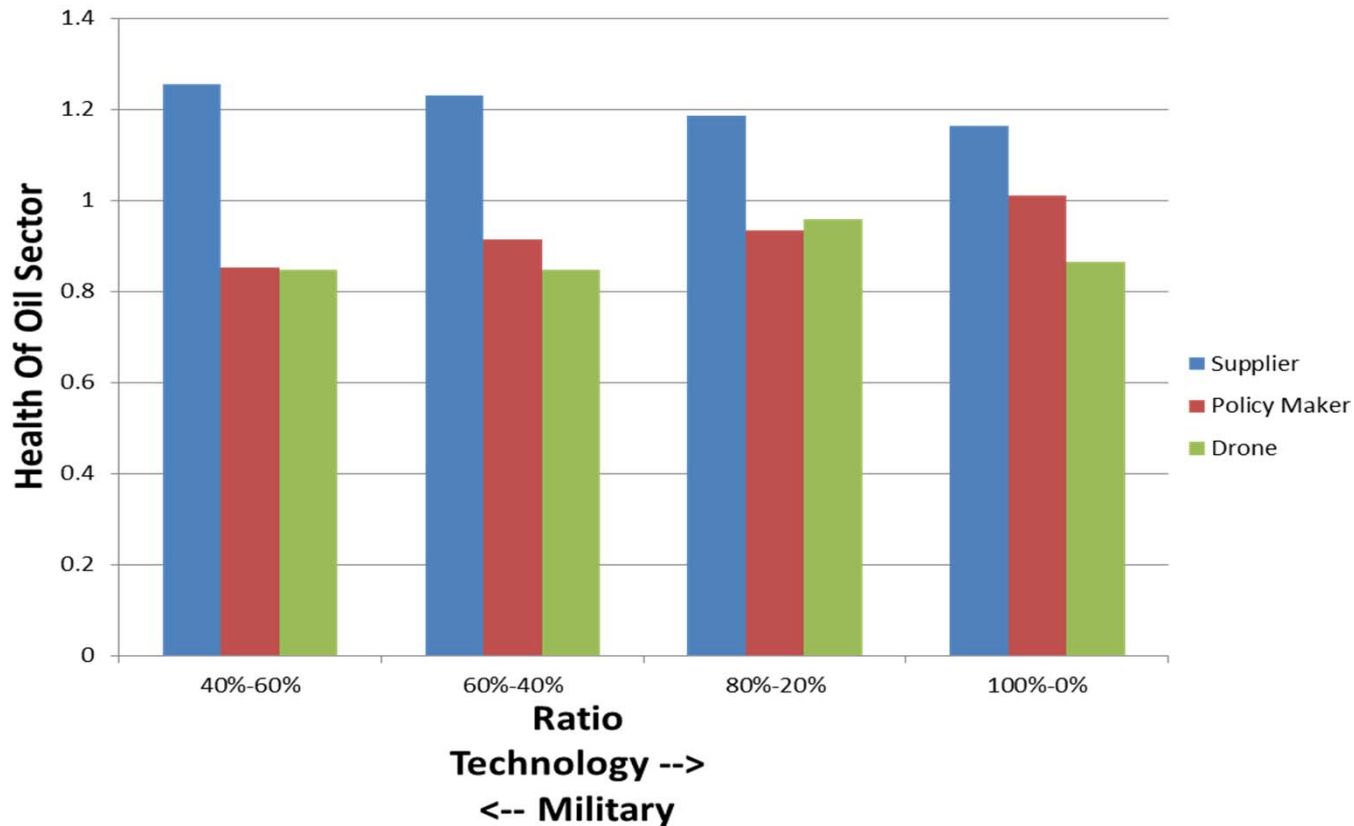
• Medium Dependence

- Supplier produces Oil at rate = 6.0 (ideally)
- Supplier consumes Oil at rate = 4.0
- Policy Maker produces Oil at rate 3.3 (ideally)
- Policy Maker consumes Oil at rate 4.0
- Drone produces at rate 3.0
- Drone consumes at rate 4.0

• Medium Abundance

- World Surplus Oil Rate = +.3
- -.2 Rate From Supplier

- Varying Military Effectiveness and Stability
 - Medium Dependence, Medium Abundance



Varying Stability & Military Effectiveness of Supplier Nation (3rd scenario)

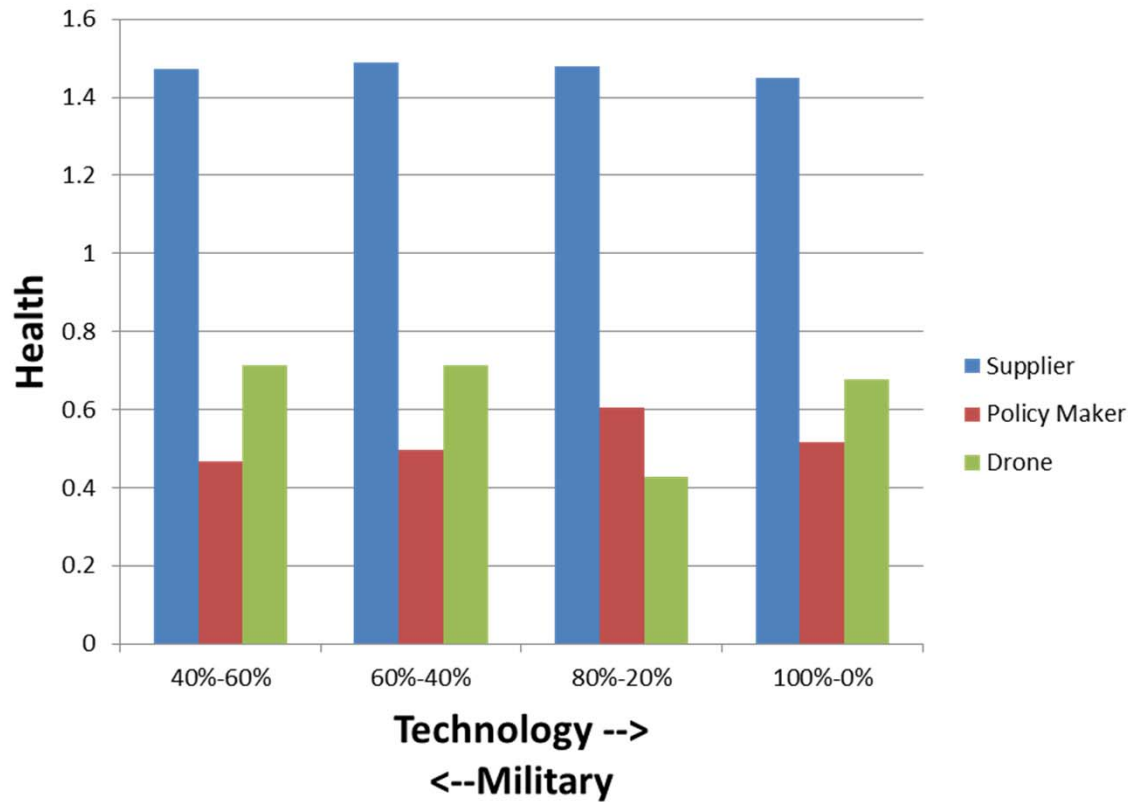
- **High Dependence**

- Supplier produces Oil at rate = 7.4 (ideally)
- Supplier consumes Oil at rate = 4.0
- Policy Maker produces Oil at rate 1.9 (ideally)
- Policy Maker consumes Oil at rate 4.0
- Drone produces at rate 3.0
- Drone consumes at rate 4.0

- **Medium Abundance**

- World Surplus Oil Rate = $+0.3$
- -0.2 Rate From Policy Maker

- Varying Military Effectiveness and Stability
 - High Dependence, Medium Abundance



Effects of Dependency: Health of Oil Sector

- Varying Military Effectiveness, Stability, and Perturbation Frequency in conditions of High Abundance

