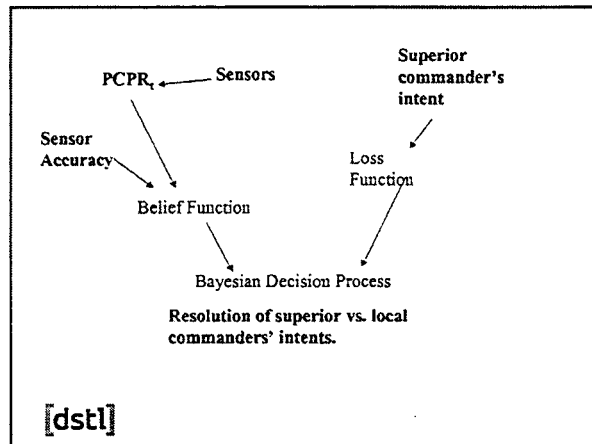


# Notes

**ISMOR 2001  
Bayesian Decision Making and Military  
Command and Control**

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**[dstl]**



**Belief Function**

$V$  - sensor accuracy  
 $c$  - PCPR<sub>i</sub> value from sensors

**[dstl]**

**Loss Function**

$\mu$  - superior commander's preferred value of PCPR<sub>i</sub>  
 $k$  - measure of 'width' of loss function  
(how much error is tolerated by the superior commander)

**[dstl]**

**Expected Loss**

$$E(\delta) = \int_{\theta} L(\theta) f(\theta | \delta) d\theta = h \left[ 1 - \sqrt{\frac{k}{k+V}} \exp\left(\frac{-(\delta-d)^2}{2(k+V)}\right) \right]$$

**[dstl]**

**Normal Belief Function**  
 $f(\theta|\delta) = \frac{1}{\sqrt{2\pi V}} \exp\left[-\frac{(\theta-(c+\delta))^2}{2V}\right]$

**Conjugate Normal Loss Function**  
 $L(\theta) = h \left[ 1 - \exp\left[-\frac{(\theta-\mu)^2}{2k}\right] \right]$

**Bayesian Decision Process**  
 $E(\delta) = h \left[ 1 - \sqrt{\frac{k}{k+V}} \exp\left[-\frac{(\delta-\mu+c)^2}{2(k+V)}\right] \right]$

$\delta^* = \mu$

**[dstl]**

# Notes

## Bigger decisions have bigger risks

$$k = (\eta^2 + \rho^2 \delta^2)^{-1/2}$$

$\eta$  - command style of force (measure of 'top-down/bottom up-ness').

$\rho$  - measure of tolerance e.g. public opinion.

$\delta$  - decision.

[dstl]

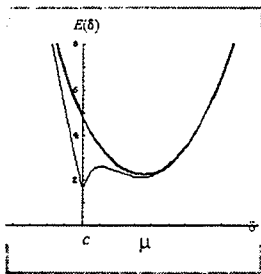
## Conflict of local and superior commanders' intents

Output of Catastrophe model - the local commander accepts

- EITHER
  - his own value of  $PCPR_1 (\delta^* \approx c)$
- OR
  - the superior commander's desired value of  $PCPR_1 (\delta^* \approx \mu)$

[dstl]

## Effect of increasing $\eta$



Bold plot - high value of  $\eta$  i.e. top down style of command

$\mu$  preferable

Light plot - low value of  $\eta$  i.e. bottom up style of command

$c$  preferable

[dstl]

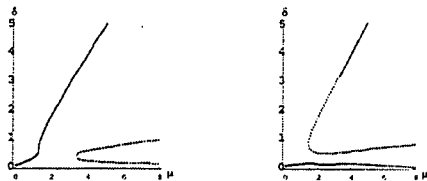
## Effect of increasing $\rho$

$\rho$  is a measure of tolerance to error ('blame culture').  
 high  $\rho$ , intolerance  
 low  $\rho$ , relative tolerance

Relationship between  $\rho$  and  $\eta$  appears to be more important than absolute values.

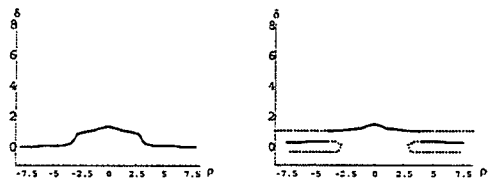
[dstl]

## Effect of increasing $\rho$



[dstl]

## Effect of increasing $d$



[dstl]

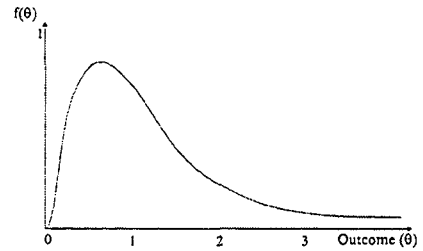
# Notes

## Posture Transition

- Transition between missions is through user-input values of  $m$  and  $n$  (proven useful approach).
  - local commander can deviate from ordered mission for  $n$  C2 cycles
  - local commander must then return to his ordered mission for  $m$  C2 cycles
- The Catastrophe model potentially gives the transition points based on the situation parameters, sensor information and human behaviour effects.
- Best solution may be a combination of both of these

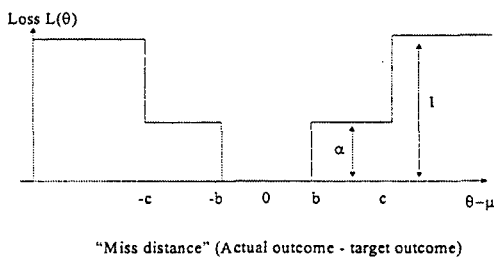
[dstl]

## Lognormal belief function, shape parameter $V$



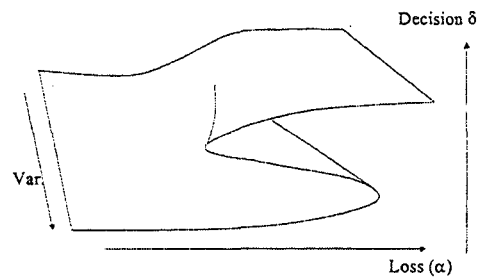
[dstl]

## Double step loss function, shape parameter $\alpha$



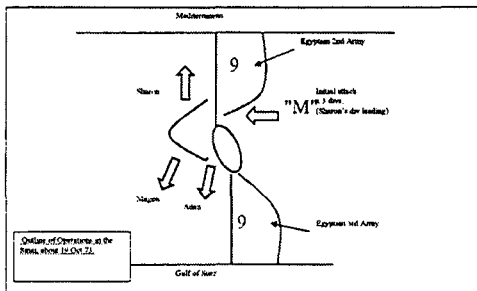
[dstl]

## Bayesian decision surface



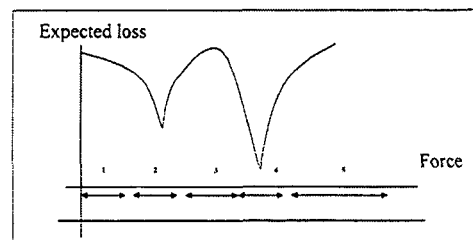
[dstl]

## Arab/Israeli War of 1973 - Israeli Counterattack



[dstl]

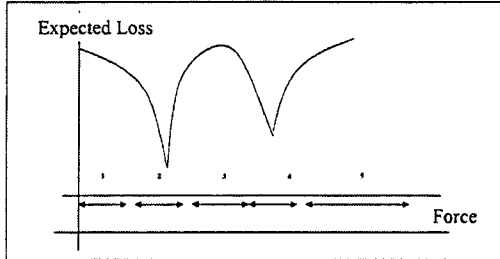
## Operational Aspects



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# Notes

## Tactical aspects



[dstl]

## Conclusion

- Mathematics of Bayesian Decision firmly established
- Relevance of Catastrophe Theory established
- Some promising applications and insights developed

[dstl]