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# Using VFT and Optimization to Create the Acquisition Portfolio for the Marines Infantry Optics

MORSS June 2008



## Background

- ▶ Since 2003 the USMC Program Manager for Optics has invested considerable resources to meet Urgent Universal Needs Statements from the Operating Forces for enhanced optics. Since the needs identified were urgent, there was not time to fully understand how these different systems would work together.
- ▶ **Bottom Line:** How useful is our current optics portfolio, and what are some cost effective solutions to improve it?
- ▶ **Study Objectives:**
  - Identify capability gaps and technological shortcomings of current and near-term optics systems, and
  - Provide recommendations and courses of action on a suite of systems to resolve those capability gaps and technological shortcomings.



## Study Characterization

- ▶ There are four “Buckets” of capability as defined by ICDs that are highly **interrelated**.
  - Hand Held, Helmet Mounted, Weapon Mounted, Crew Served
- ▶ Capability value is **dependent** on the Five Scenarios and who is using the system.
- ▶ Value of a system is dependent on what others in the unit have.
- ▶ Data:
  - Initial metrics had been determined but little data had been gathered against the alternatives.
  - Some testing had been done
    - A lot of system level data gaps
  - Like many situations where there was rapid fielding to meet urgent needs, there was no comprehensive knowledge of who had what equipment and what equipment was being used.

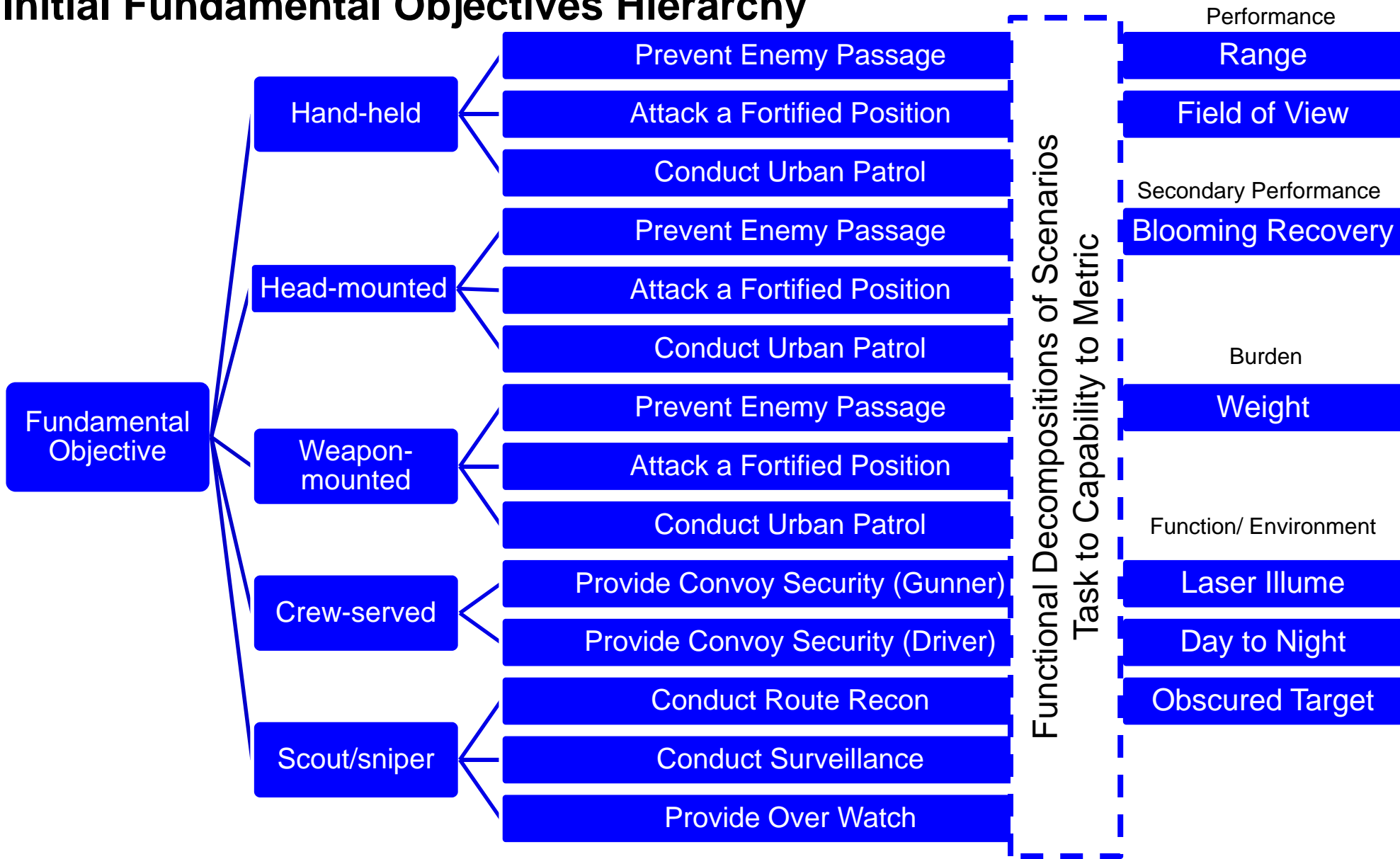


# Accomplishments

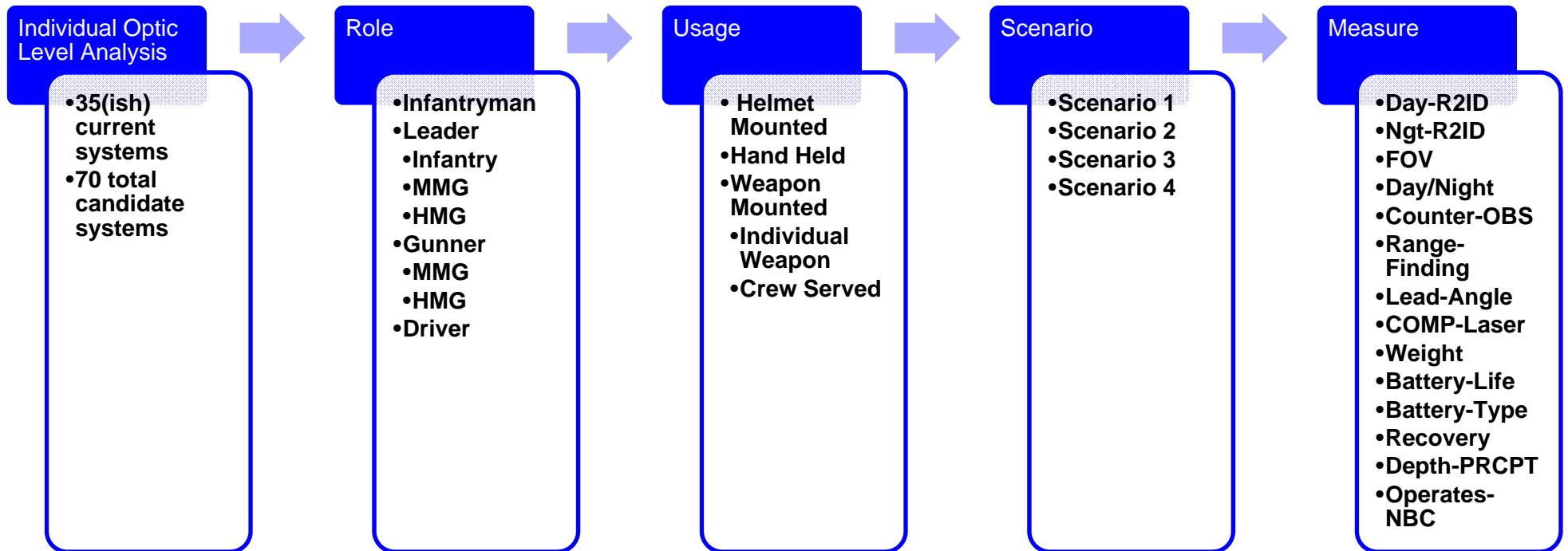
- ▶ Two level analysis
  - System Level Analysis: The analysis helped determine the “best” system within each role and usage, such as Infantryman Head-Mounted.
  - Portfolio Level Analysis: The analysis gave insight into portfolio level trade to ensure that the optics systems were true treated as a family of systems.
- ▶ Unique use of linear programming to ensure capability gaps were fulfilled and addressing competing objectives.



# Initial Fundamental Objectives Hierarchy



# New Structure for Individual Optic Evaluation



## ▶ Twenty-three R-U-S level paths

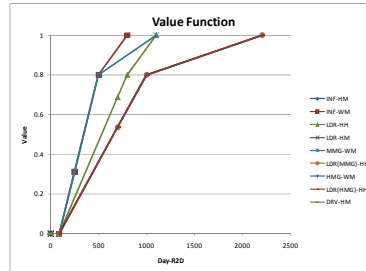
– Example: Infantry Leader- Helmet Mounted - Scenario 1



# Value Focused Thinking approach was taken for initial Individual Optic analysis

R-U-S	Measure	Min	Current	Threshold	Objective	Min	Current	Threshold	Objective
LDR-HH-scn1	Nat-R2ID	0	60	250	800	0	0.2	0.8	1
LDR-HH-scn1	Nat-R2ID	0	60	250	300	0	0.25	0.8	1
LDR-HH-scn2	Nat-R2ID	0	60	250	800	0	0.2	0.8	1
LDR-HH-scn2	Nat-R2ID	0	60	200	300	0	0.24	0.8	1
LDR-HH-scn3	Nat-R2ID	0	60	250	800	0	0.2	0.8	1
LDR-HH-scn3	Nat-R2ID	0	60	200	300	0	0.24	0.8	1
Nat-HM-scn1	Nat-R2ID	0	60	200	300	0	0.24	0.8	1
Nat-HM-scn1	Nat-R2ID	0	120	250	500	0	0.38	0.8	1
Nat-HM-scn2	Nat-R2ID	0	60	200	300	0	0.24	0.8	1
Nat-HM-scn2	Nat-R2ID	0	120	250	500	0	0.38	0.8	1
Nat-HM-scn3	Nat-R2ID	0	60	200	300	0	0.24	0.8	1
Nat-HM-scn3	Nat-R2ID	0	120	250	500	0	0.38	0.8	1
LDR(MMG)-HH-scn1	Nat-R2ID	0	150	250	800	0	0.48	0.8	1
LDR(MMG)-HH-scn2	Nat-R2ID	0	150	250	800	0	0.48	0.8	1
LDR(MMG)-HH-scn3	Nat-R2ID	0	150	250	800	0	0.48	0.8	1
MMG-WM-scn1	Nat-R2ID	0	150	250	800	0	0.48	0.8	1
MMG-WM-scn2	Nat-R2ID	0	150	250	800	0	0.48	0.8	1
MMG-WM-scn3	Nat-R2ID	0	150	250	800	0	0.48	0.8	1
LDR(HMG)-HH-scn1	Nat-R2ID	0	60	250	1100	0	0.19	0.8	1
LDR(HMG)-HH-scn2	Nat-R2ID	0	60	250	1100	0	0.19	0.8	1
LDR(HMG)-HH-scn3	Nat-R2ID	0	60	250	1100	0	0.19	0.8	1
DRV-HM-scn4	Nat-R2ID	0	60	150	200	0	0.32	0.8	1
HMG-WM-scn4	Nat-R2ID	0	310	350	1100	0	0.71	0.8	1

Swing for each measure was define (refined several times)

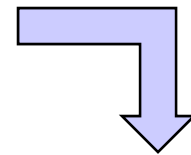


Value Functions (refined several times)

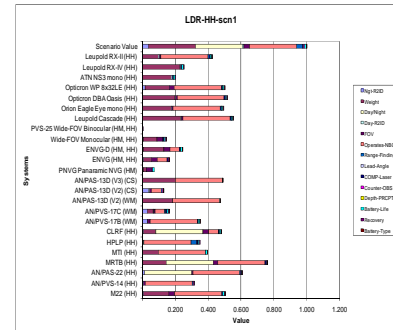
	Nice to Have	Low	Moderate	High
Large Variance			Nat-R2ID FOV	Day/Night Range-Finding Weight Operates-NBC
Moderate Variance		COMP-Laser	Day-R2ID	Battery-Life
Little Variance	Battery-Type	Recovery	Counter-OBS	

Swing Weight (One for each R-U-S)

Alternative Development and System Applicability

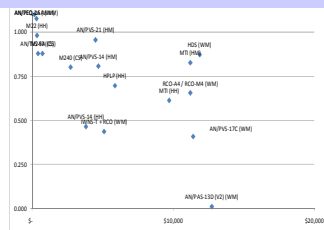


- ▶ Example of Value Based Alternatives added
  - Integrated laser into optics: Already bore sited, one less optic, total is lighter weight
  - Monocular with LRF: Lose depth percentage but gain active range finding, decreased weight and cost.
- ▶ Good at evaluating individual systems
- ▶ But from a Pf level, misses relationship between Roles and also between alternatives

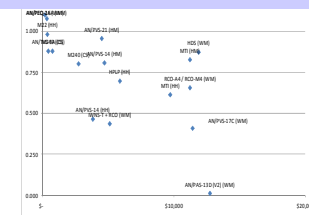


Evaluated the Alternatives (for each R-U-S)

New Cost Benefit (Aggregated to R-U Level)



Evaluated Cost Benefit (Aggregated to R-U Level)

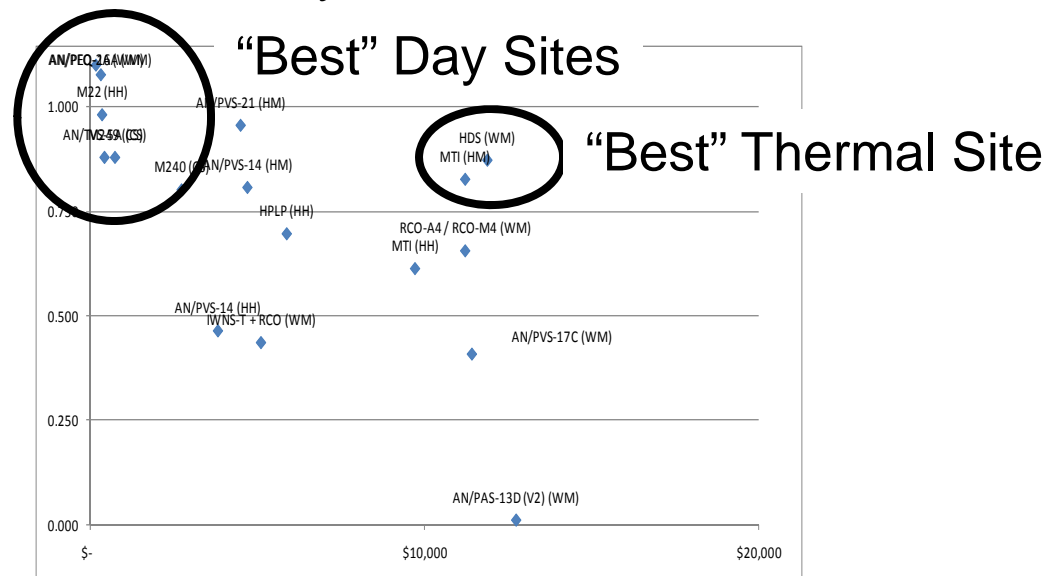


Identified New Value Based Alternatives



# Evaluating the **Family** of Individual Optics study

- ▶ We had the Individual Optics (system level) analysis pretty good
- ▶ Now we have to deal with the family. Some system “types” were not selected because of cost but they provide capability.
- ▶ We need to define Family (portfolio) level capability.
  - This is more difficult because they hadn’t been defined before.



## Pf Level Issue 1: Relationship between Roles

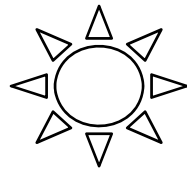
- ▶ Infantry Leader and Infantry can leverage capability. Leader has to have the same or greater capability --- Sometimes
  - Taking into account three factors should allow for MECE evaluation
    - Day
    - Night
    - Obscurants



# Pf Level Issue 1: Relationship between Roles

## Examples of Leveraging and Satisfying

Ldr: Can you ID that bad guy?  
Inf: Yes!  
Ldr: Okay, shoot him.



Day Time/ XX Meters  
(No need to leverage)



Ldr: Can you ID that bad guy?  
Inf: No.  
Ldr: I can, can you see my laser?  
Inf: Yes!  
Ldr: Okay, shoot him.



Night Time/ XX Meters  
(Opportunity to leverage)



Ldr: Can you ID that bad guy?  
Inf: No.  
Ldr: I can, can you see my laser?  
Inf: No.  
Ldr: Okay, I'll shoot him.



Obscurants / XX Meters  
Leverage is more difficult



## Pf Level Issue 2: Relationship between Usage

- ▶ Infantryman can use one (or more) device to accomplish a mission.
  - Helmet Mounted 1x I<sup>2</sup> optic to maneuver at night (base capability)
    - They use a head mounted eyeball during the day
  - Plus an 4x I<sup>2</sup> clip on to increase range and a 4x IR handheld to see through obscurants.
    - Downside: Greater range potential but more systems to worry about, more total weight
  - A 4x helmet mounted fused I<sup>2</sup> plus IR optic to increase range and see through obscurants.
    - Downside: Fewer systems and less total weight BUT lower performance and more weight on your head

***All ounces are not equal***



## Pf Level Issue 3: Different Tasks for Different Roles

- ▶ Leaders need to sense and detect, as well as Identify.
- ▶ Infantrymen need to sense to maneuver but identify to engage



# One Pf Level Solution Identify a Domain

- ▶ Establish a Domain level required capability
  - Domains determined by how Marines fight.

Capability for each Role and Usage:  
 Completing a **Task** in a **Condition** to a **Standard**.

The standard were defined as the value measures within the context of the Marines Role and how the optics would be used.

Task	Condition	Infantry		Leader (ft, sgd, plt)		
		HM	WM	HH	HM	WM
Sense	Day	Required		Required	Required	Required
	Night	Required		Optional		
	Obs	Leverage		Required ( HH or HM)		
Engage	Day	Required		Optional	Required	
	Night	Required ( HM or WM)		Required (HH, HM or WM)		
	Obs	Leverage		Required (HH, HM or WM)		

Whether a capability was required (leverage or optional) was determined by the study team and verified by an operator panel



# Domains allow for identifying building blocks within the Pf

► This construct allows for identification of capability gaps.

2007 Pf		Infantry			
		HM	System(s)	WM	System(s)
Sense	Day	Required	AN/PVS-14 (HM)		
	Night	Leverage			
	Obs				
Engage	Day			Required	RCO-A4 / RCO-M4 (WM)
	Night	Req'd w/in Role	AN/PVS-14 (HM)	Req'd w/in Role	AN/PEQ-2A (WM)
	Obs			Leverage	

2010 Pf		Inf			
		HM		WM	
Sense	Day	Required	AN/PVS-14 (HM)		
	Night	Leverage			
	Obs				
Engage	Day			Required	RCO-A4 / RCO-M4 (WM)
	Night	Req'd w/in Role	AN/PVS-14 (HM)	Req'd w/in Role	AN/PEQ-16A (WM)
	Obs			Leverage	

LDR (Section)					
HH		HM		WM	
Required	M22 (HH)	Required	AN/PVS-14 (HM)		
Optional		Required	AN/PVS-14 (HM)		
Req'd w/in Role					
Optional				Required	RCO-A4 / RCO-M4 (WM)
Req'd w/in Role		Req'd w/in Role	AN/PVS-14 (HM)	Req'd w/in Role	AN/PEQ-2A (WM)
Req'd w/in Role					

LDR (Section)					
HH		HM		WM	
Required	M22 (HH)				
Optional		Required	AN/PVS-14 (HM)		
Req'd w/in Role	MRTB (HH)	Req'd w/in Role			
Optional (range finding)				Required	RCO-A4 / RCO-M4 (WM)
Req'd w/in Role	Leverage WM	Req'd w/in Role	Leverage WM	Req'd w/in Role	IWNS-I2 (WM)
Req'd w/in Role	Leverage WM	Req'd w/in Role	Leverage WM	Req'd w/in Role	IWNS-T (WM)



## Building blocks can be put together to identify Pf metrics

- ▶ Unit of analysis is the Infantry Company with Heavy Machine Gun platoon.
  - It addresses the needs of the most demanding users and gives a basis for identifying Pf level metrics
    - Total Pf Value, Total Weight, Total Number of Systems (Human Factors), Total Number of Unique systems (sustainability measure)

Putting the Building blocks together will get 90% there

Infantry	WM	HM	Leader (Lt. Sp4, Plt)	WM
Required	Required	Optional	Required	Required
Leverage	Required	Optional	Req'd with Role	Required
Req'd with Role	Required	Optional	Req'd with Role	Required
Leverage	Required	Optional	Req'd with Role	Required
Infantry	WM <td>HM<td>Leader (Lt. Sp4, Plt)<td>WM</td></td></td>	HM <td>Leader (Lt. Sp4, Plt)<td>WM</td></td>	Leader (Lt. Sp4, Plt) <td>WM</td>	WM
Required	Required	Optional	Required	Required
Leverage	Required	Optional	Req'd with Role	Required
Req'd with Role	Required	Optional	Req'd with Role	Required
Leverage	Required	Optional	Req'd with Role	Required
Infantry	WM <td>HM<td>Leader (Lt. Sp4, Plt)<td>WM</td></td></td>	HM <td>Leader (Lt. Sp4, Plt)<td>WM</td></td>	Leader (Lt. Sp4, Plt) <td>WM</td>	WM
Required	Required	Optional	Required	Required
Leverage	Required	Optional	Req'd with Role	Required
Req'd with Role	Required	Optional	Req'd with Role	Required
Leverage	Required	Optional	Req'd with Role	Required
Infantry	WM <td>HM<td>Leader (Lt. Sp4, Plt)<td>WM</td></td></td>	HM <td>Leader (Lt. Sp4, Plt)<td>WM</td></td>	Leader (Lt. Sp4, Plt) <td>WM</td>	WM
Required	Required	Optional	Required	Required
Leverage	Required	Optional	Req'd with Role	Required
Req'd with Role	Required	Optional	Req'd with Role	Required
Leverage	Required	Optional	Req'd with Role	Required

Some gaps like M203 site and M249 site hard coded, since the solution is already known.



# So how do you solve the problem?

- 4 Pf level metrics
- 70 Alternatives
- 23 Scenarios
- 4 Domains
- 2 Functions
- 3 Environments

	Calculated		Constraint
C1	1.00 =	1	Infantry must have a helmet-mounted sensor for night sensing capability
C2	1.00 =	1	Infantry must have a weapon-mounted sensor for day engaging capability
C3	1.00 =	1	Leader must have a hand held day sensing capability
C4	1.00 =	1	Leader must have a helmet-mounted night sensing capability
C5	1.00 =	1	Leader must be able to sense through obscurants (HH or HM)
C6	1.00 =	1	Leader must have a weapon-mounted sensor for day engaging capability
C7	1.00 =	1	Infantry must be able to leverage night/obscurant long range fires
C8	1.00 =	1	There can only be one Helmet mounted system per Marine
C9	1.00 =	1	Leader must have weapons mounted engagement capability for night
C10	1.00 =	1	Leader must have weapons mounted engagement capability for obscurants
C11	1.00 =	1	MMG must have a weapon-mounted engagement for day/night/obs
C12	1.00 =	1	MMG Leader must have a hand held day sensing capability
C13	1.00 =	1	MMG Leader must have a hand held day sensing capability
C14	1.00 =	1	MMG Leader must have a hand held day sensing capability

System Name	D	N	O	Isr	Number of units required for Marine Rifle Co.								
					121	121	62	62	6	6	6	6	3
					INF-HM	INF-WM	LDR-HH	LDR-HM	MMG-WM	LDR(MMG)-HH	HMG-WM	LDR(HMG)-HH	DRV-HM
Alternative System 1	X				0			0					0
Alternative System 2	X				0			0					0
Alternative System 3			X		0			0					0
Alternative System 4	X				0			0					0
Alternative System 5	X	X			0			0					0
Alternative System 6	X	X			1			0					0
Alternative System 7	X	X	X		0			0					0
Alternative System 8		X			0			1					0
Alternative System 9	X						0			0		0	
Alternative System 10	X						0			0		0	
Alternative System 11	X						1			0		0	
Alternative System 12	X						0			0		0	
Alternative System 13	X						0			0		0	
Alternative System 14		X					1			0		0	
Alternative System 15	X						0			0		0	
Alternative System 16	X						0			1		0	
Alternative System 17	X						0		0	0		0	
Alternative System 18	X						0			0		0	
Alternative System 19	X						0			0		1	
Alternative System 20		X					0		0			1	
Alternative System 21	X						0					0	
Alternative System 22	X						0					0	

- ▶ Linear Program
  - 70 Alternative
  - 119 Decision Variables
  - 27 Constraints
  - Up to Four Objective Functions
- ▶ VBA Macro was used to



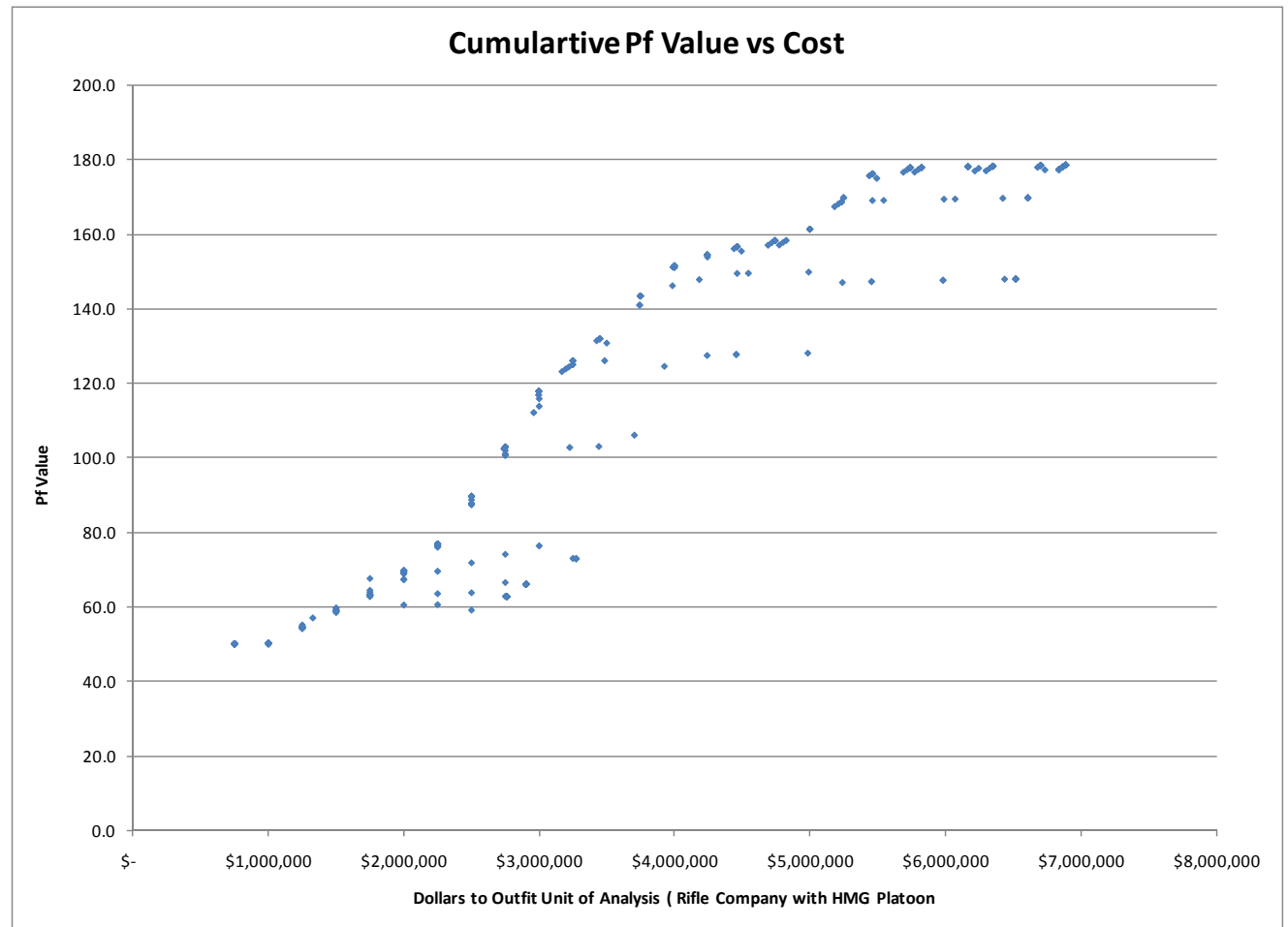
## Optimization Runs

- ▶ Many calibration runs were conducted to refine the model structure and determine trade space.
- ▶ Optimization was run in a batch of 360 runs.
  - Cost for Unit of Analysis constrained was varied from \$750k to \$8m, but increments of \$250k,
  - Number of unique systems to outfit unit of Analysis was varied from 16 to 25.
- ▶ Subsequent runs were conducted to determine the Pf that fulfilled all the capabilities at lowest cost.
- ▶ Current systems (Pf 2007) and Status Quo (Pf 2010, if not changes to procurement plan were made) were also added.
- ▶ Overall analysis looked at 363 separate Pfs.
- ▶ Model recorded Pf compositions, Value Score, Cost, Risk, Total Weight, Total Unique Systems and whether it passed all the constraints.

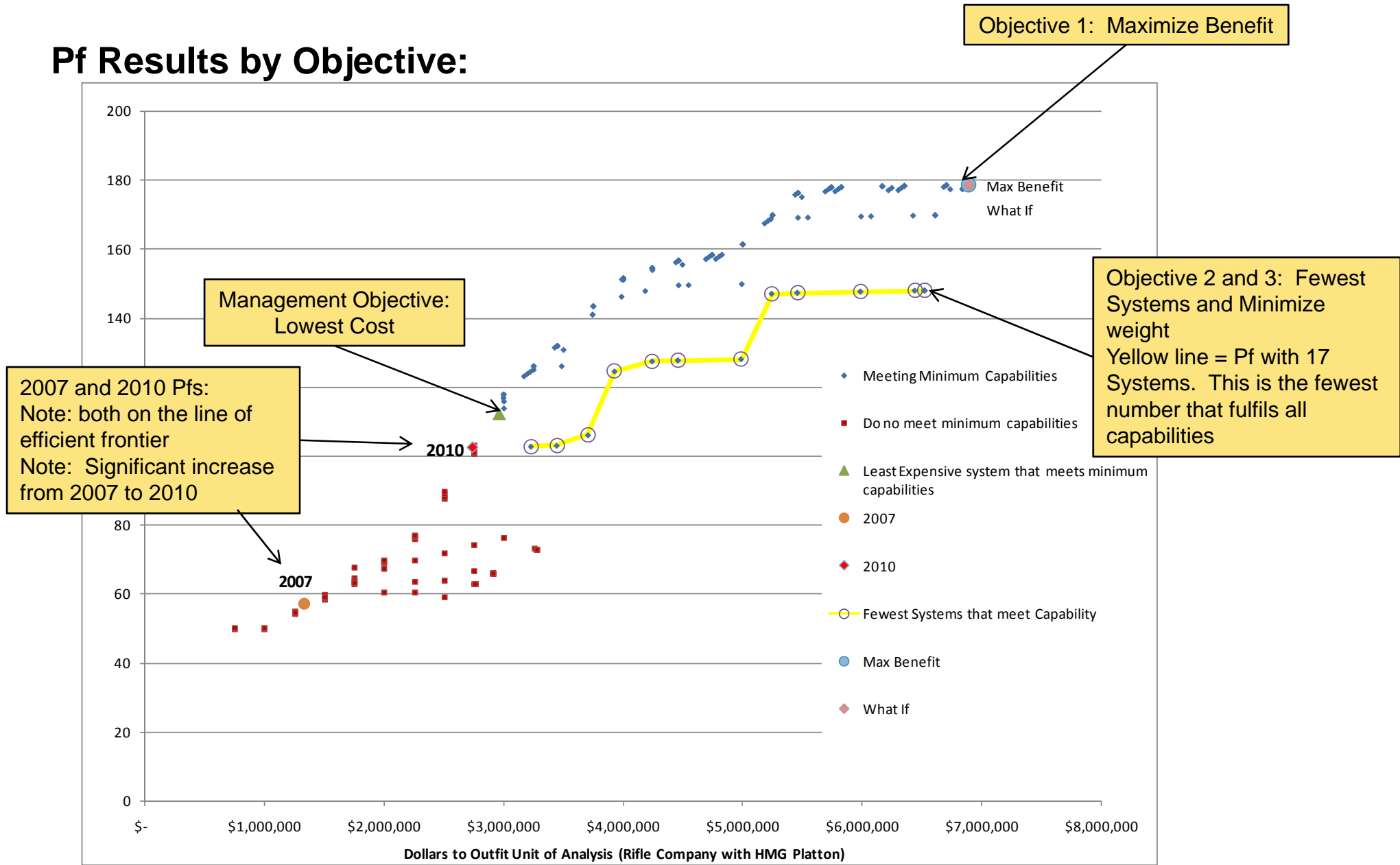


# Optimization Output

- ▶ Initial output was messy to display and difficult to interpret.
- ▶ The data were stratified to lend some clarity.



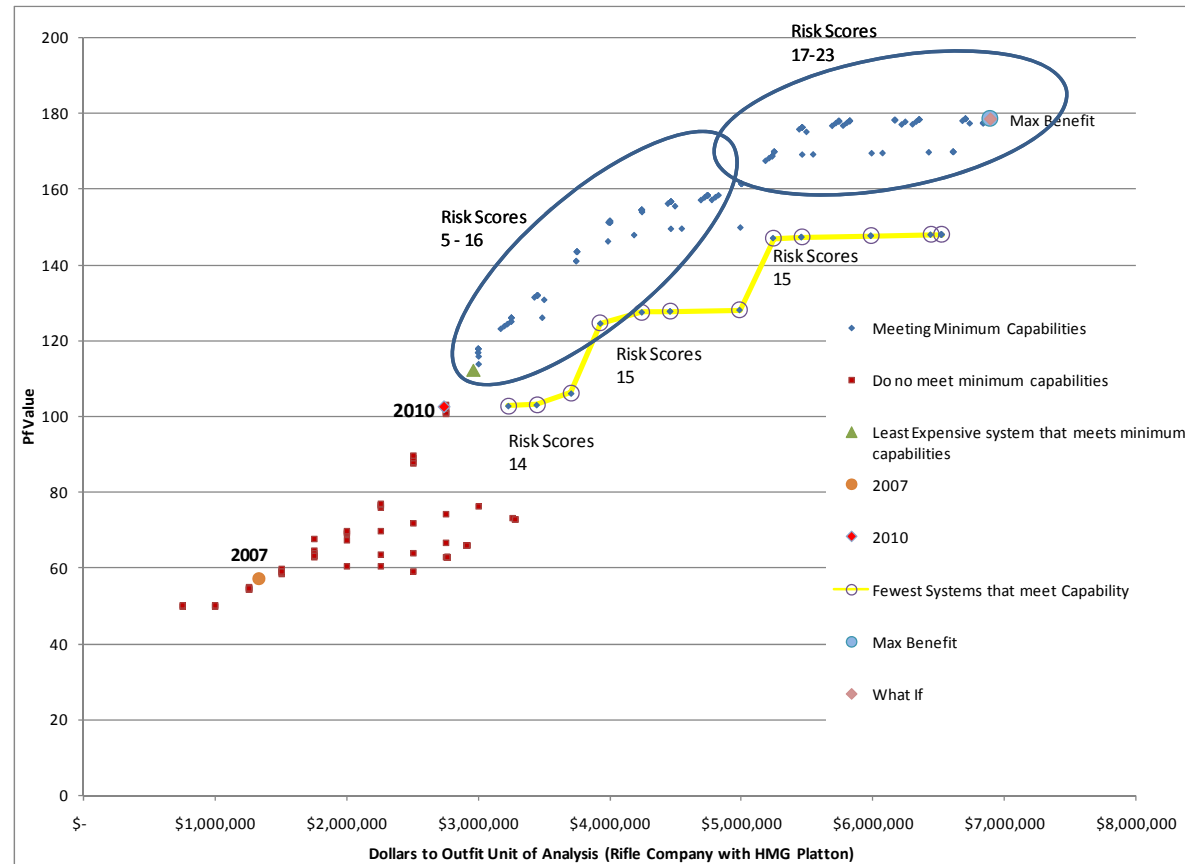
# Pf Results by Objective:



# Risk Analysis

- ▶ As risk index was developed for each Pf. This number used a linear scale assigned to level of maturity. These numbers were summed within a Pf to gain an indication of relative risk. Risk was treated as a dependent variable, thus was never a binding constraint within the Pf optimization.
- ▶ In general, as Pf increased in effectiveness they were also an increased in risk, however within each circle there was not a linear relationship.

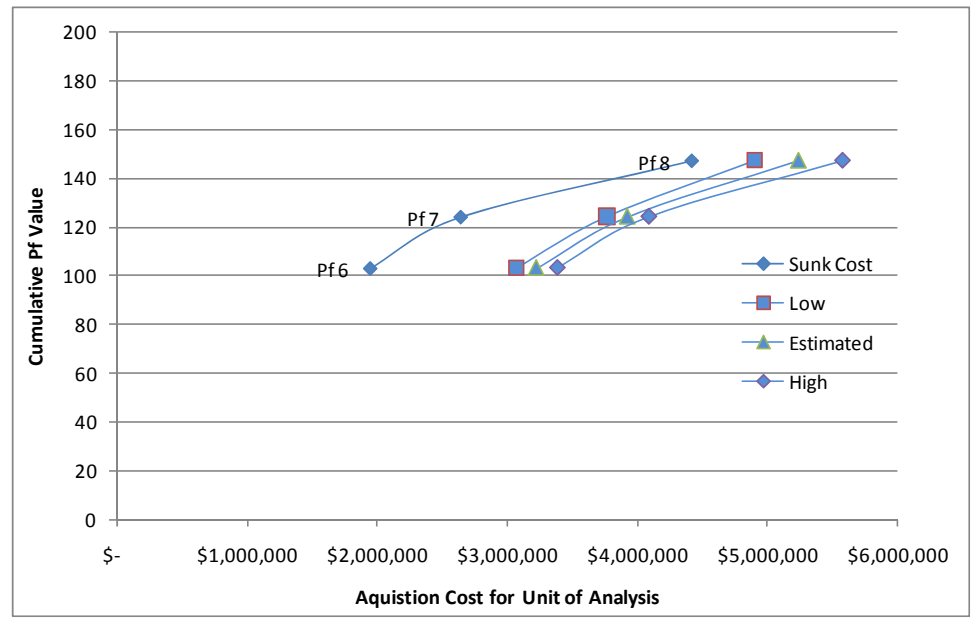
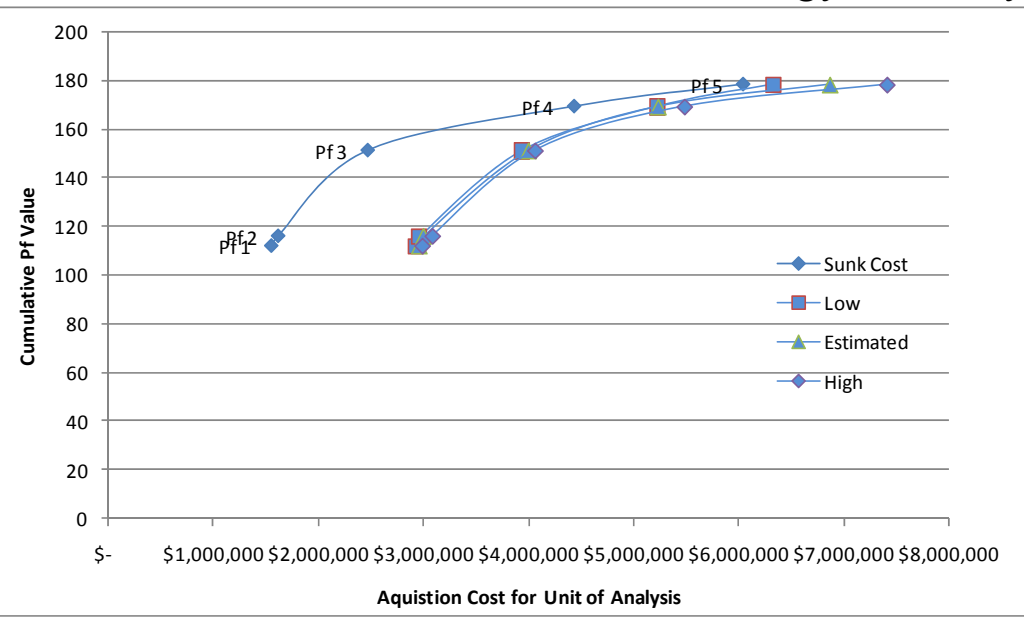
TRL	Risk Score
fielded	0
Requisitioned or 9	1
8	2
7	3
6	4
5	5
4	6
3	7
2	8
1	9



TRL	Percent Variation
4	20%
5	20%
6	20%
7	15%
8	10%
9	0%

# Sensitivity Analysis

- ▶ Two Types of Cost Sensitivity were complete
  - Sensitivity with respect to technology maturity
  - Sensitivity with respect to sunk cost
  
- ▶ Pfs that are on the LOEF are sensitivity to either sunk cost or technology maturity depending on their placement on the curve.
  
- ▶ Pfs that achieve capabilities with fewer number of systems (right hand graph) are not sensitive to both technology maturity and sunk cost.



## Lessons Learned and Areas of Further Study

- ▶ Process needed to be iterative
  - Draft results, take them all the way through, check, iterate.
  - Many calibration runs were conducted. First time through was always wrong.
  
- ▶ Pf Level Capabilities
  - System level objectives and capabilities were determined early
  - Pf level objectives were determined early, but not the capabilities
  
- ▶ Stakeholder involvement essential
  - PM, Tech, Cost, DA, operator; all brought something to the table
  
- ▶ Vary Pfs from the Points on Interest.
  - Further trades could be made from run of 363 Pfs



## ► Questions



